Electrofusion Guide
Using the CalderSafe Best Practice System

A Global Electrofusion System.

Caldervale Technology
and North American
Partner UPSCO
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**CalderSafe**

**Best Practice System**

Connecting technology and precisely engineered tooling and machinery to provide a complete electrofusion solution.

Allowing utilities, infrastructure authorities and contractors to manage and maintain operations in an informed quality controlled environment.

Reducing costs, carbon emissions and re-working with real time operational analysis.

Getting the job done right every time continuously, and being able to prove it.

CalderSafe provides both Contractor and Manufacturer’s the scientific analysis of their products and staff’s performance in real time.

This guide acts as a general reference guide for electrofusion practices and does not supersede any fitting manufacturers installation instructions and in line with any local codes of practice where applicable.
SECTION 01
Getting Started

Jobsite Preparation

All heat fusion joining methods require that there is no water flowing or standing in the pipe that can reach the fusion surfaces. De-watering of the site may be required to prevent ground water from reaching the fusion and contaminating the surfaces to be joined. De-watering can be accomplished using portable pumps.

Electrofusion fittings can be installed in ambient temperatures as recommended by the manufacturer. A typical qualified temperature range for installation is 14°F minimum to 113°F maximum. Some manufacturers have lower and/or higher temperature limits and will state their qualified range in the technical specifications, contact the fitting manufacturer to verify.

Fitting Storage and Handling

Electrofusion fittings are packaged in sealed plastic bags as protection against accumulation of dust, dirt, and contamination. The bag should remain in place during normal handling and should only be removed during installation.

Fittings are also typically boxed to protect against other sources of degradation, such as oxidation due to UV exposure over long periods of storage. Fittings should always be stored indoors in their original packaging until installation.

Fittings can be cleaned if incidental contact is made with the fusion surface. A suitable cleaning agent that contains no additives to hinder the fusion process must be used. 96% or greater concentration of isopropyl alcohol, with no additional additives except water, is universally accepted as a good cleaning agent. Other cleaning agents may be acceptable and the fitting manufacturer should be consulted in case of questions.

DO NOT USE DENATURED ALCOHOL
Denatured alcohols may contain additives that can prevent fusion and should not be used.

Required Tools

Proper tools are essential to a successful electrofusion installation. Tools include devices for measuring, marking, cutting, scraping, cleaning, clamping (which includes aligning and securing), re-rounding, and power delivery. At minimum, the following items should be accessible during installation:

- Marking Pen - Non Oil Based
- Pipe Cutting Tool(s)
- Preparation/Scraping Tool(s)
- Clamps
- Electrofusion Control Unit (Welding Box)
- Reliable Power Source
- Fitting(s) and/or Coupling(s)
- Preparation Surface Cleaning Items
- Squeeze off Tool(s)
SECTION 02
Measuring + Cutting

A tape measure or ruler for measurement of insertion (stab) depth of pipe ends inside a coupling. A circumferential wrap Pi tape for measurement of pipe diameter is also recommended.

Measuring Pipe

Electrofusion fittings are designed for use on pipe made to standard diameters in dimensions for Iron Pipe Size (IPS), Copper Tube Size (CTS), and Ductile Iron Pipe Size (DIPS). Pipe that is outside of the diameter tolerance band of the appropriate pipe standard should not be used. The following table can be used for reference when measuring pipe diameter to ensure that the pipe is within tolerance.

### Copper Tube Size (CTS) ASTM D2737

<table>
<thead>
<tr>
<th>Tube Size</th>
<th>Nominal Diameter (Inches)</th>
<th>Tolerance (±)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4” CTS</td>
<td>0.875</td>
<td>0.004</td>
</tr>
<tr>
<td>1 1/4” CTS</td>
<td>1.375</td>
<td>0.005</td>
</tr>
<tr>
<td>2” CTS</td>
<td>2.125</td>
<td>0.006</td>
</tr>
</tbody>
</table>

### Ductile Iron Pipe Size (DIPS) ASTM F714

<table>
<thead>
<tr>
<th>Tube Size</th>
<th>Nominal Diameter (Inches)</th>
<th>Tolerance (±)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4” DIPS</td>
<td>4.8</td>
<td>0.022</td>
</tr>
<tr>
<td>8” DIPS</td>
<td>9.05</td>
<td>0.041</td>
</tr>
<tr>
<td>12” DIPS</td>
<td>13.2</td>
<td>0.059</td>
</tr>
</tbody>
</table>

### Iron Pipe Size (IPS) ASTM D335/F714

<table>
<thead>
<tr>
<th>Tube Size</th>
<th>Nominal Diameter (Inches)</th>
<th>Tolerance (±)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4” IPS</td>
<td>1.050</td>
<td>0.004</td>
</tr>
<tr>
<td>1 1/4” IPS</td>
<td>1.660</td>
<td>0.005</td>
</tr>
<tr>
<td>2” IPS</td>
<td>2.375</td>
<td>0.006</td>
</tr>
<tr>
<td>4” IPS</td>
<td>4.500</td>
<td>0.020</td>
</tr>
<tr>
<td>8” IPS</td>
<td>8.625</td>
<td>0.039</td>
</tr>
<tr>
<td>8” IPS</td>
<td>12.750</td>
<td>0.057</td>
</tr>
</tbody>
</table>
Pipe Roundness

Polyethylene is a flexible material. Pipe roundness can too be affected by a number of conditions to include manufacturing process conditions, coiling, storage/stacking, and soil load if buried.

The condition of pipe roundness can be expressed in two ways, “out-of-roundness” or “ovality”, while both are referencing the same basic condition, it can sometimes be confusing.

Out-of-roundness is the difference in the maximum measured diameter minus the minimum measured diameter. The pipe can be measured with a tape measure or calipers to find the maximum (d1) and minimum (d2) diameter points. The out-of-roundness is calculated as d1 – d2 as measured in the field.

Ovality is the difference between the maximum and minimum measured outside diameters expressed as a percentage. Ovality is calculated as (d1 – d2) / Average.

If severe enough, pipe out-of-roundness can have a negative effect on electrofusion joint quality. If the pipe is out-of-round, and is not corrected, the amount of gap between the pipe and fitting can be too large for the melt expansion to close and increase the difficulty of sliding the fitting onto the pipe.

Most often, 2” IPS and smaller diameter tubing is flexible enough that the coupling and alignment clamps will provide the necessary rounding forces and no other re-rounding device is needed.

For sizes equal to or larger than 3” IPS / DIPS, re-rounding clamps may be needed on either side of an electrofusion fitting to ensure that the gap between the pipe and fitting is not too large. The following table can be used for guidance when re-rounding clamps are used:

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>d1 - d2</th>
</tr>
</thead>
<tbody>
<tr>
<td>3”</td>
<td>.0625 or 1/16”</td>
</tr>
<tr>
<td>4”</td>
<td>.0625 or 1/16”</td>
</tr>
<tr>
<td>6”</td>
<td>.125 or 1/8”</td>
</tr>
<tr>
<td>8”</td>
<td>.125 or 1/8”</td>
</tr>
<tr>
<td>10”</td>
<td>.125 or 1/8”</td>
</tr>
<tr>
<td>12”</td>
<td>.125 or 1/8”</td>
</tr>
</tbody>
</table>

\[ d1 = \text{max OD of pipe} \]
\[ d2 = \text{min OD of pipe} \]
Cutting

Devices that deliver a relatively clean and square cut (±3 degrees) on the pipe ends are recommended. Many suitable types of pipe cutters are commercially available that can be used for diameters of 12 inch and smaller.

For larger diameters, a suitable saw (without lubricants) and a guide or guide marks can be used; reciprocating saws, circular saws with a coarse-tooth blade, hot saws, chop saws, and chain saws are commonly used for larger pipes with appropriate safety precautions and personal protective equipment. Cutting marks can made around the pipe using a 2 inch or wider strap or encirclement clamp as a guide so that the pipe can then be cut along the line.

“Devices that deliver a relatively clean and square cut (±3 degrees) on the pipe ends are recommended.”
SECTION 03
Pipe Preparation + Scraping

Pipe preparation is perhaps the most important and least understood aspect of making a sound electrofusion joint. Improper pipe preparation is the leading cause of unsuccessful electrofusion joint attempts because the is to remove a thin layer of the outer pipe surface to expose clean virgin material beneath.

Cleaning
During the initial pipe inspection and prior to scraping, the pipe can be cleaned of mud and debris with clean water. Use no detergents as wetting agents and other substances contained in detergents can be difficult to remove from the pipe and will interfere with the fusion process later. If oils are suspected to be on the pipe surface at this point, additional cleaning with 90% or greater isopropyl alcohol may be necessary.

Marking
A permanent visible marker. Markers should be visible on the pipe color being used. For black pipe, a silver colored Sharpie®, or equivalent, permanent marker works well. The marker dries fast and contains no oils or other ingredients that could accidentally contaminate a prepared pipe surface. Marks are needed to locate insertion depths and to use as a guide for pipe scraping effectiveness.

Markers that are slow-drying or contain oils that could be spread onto fusion surfaces should not be used.

Scraping
Pipe surfaces exhibit surface oxidation from the extrusion process, transportation, and outdoor exposure. Surface oxidation is a normal chemical reaction that results in a physical change to the molecular structure of the polymer chains on the pipe surface. Oxidation acts as a physical barrier and therefore those surfaces cannot be heat fused. Simply roughing the pipe surface is not sufficient. In order to achieve fusion, this layer must be removed. Even new pipe must be properly scraped before a fusion will be successful.

The outer oxidation layer on a pipe surface is very thin. It does not increase in depth of more than a few thousandths of an inch even over long periods of exposure, so regardless of the amount of time the pipe has been stored before scraping, the scraping depth requirement is the same. An adequate minimum amount of material that must be removed is just seven one-thousandths of an inch (.007”). That thickness is approximately the same as two sheets of ordinary paper.

It is strongly recommended that, no matter what type of tool is used, witness marks should be made on the pipe surface with a permanent marker prior to scraping so that any marking that remains after scraping is evidence that areas were missed or that more scraping is required.

“Improper pipe preparation is the leading cause of unsuccessful electrofusion joint attempts.”
Scraping / Peeling Tools

Tools that are approved for scraping pipe for electrofusion joining are those that remove material cleanly. “Peeler” type tools that remove a continuous and measurable ribbon of pipe surface are the preferred scraping tools and should be used whenever possible. The advantages of these tools are:

- The ribbon thickness can be measured to verify that the tool is performing as designed.
- A continuous ribbon ensures that the entire circumference of the pipe is being peeled.
- Any skipped or missed paths between peeler revolutions are easily identified using only lengthwise scribed witness marks.
SECTION 04
Fitting Clamping

Electrofusion fittings generate significant pressure from thermal expansion during the melt phase of the fusion process. This melt pressure is an integral part of the fusion process and a designed function of the fitting and fusion parameter. As a result, all electrofusion fittings shall be installed with the use of alignment and restraining clamps.

Couplings
Use clamps on all coupling installation that will restrain the pipe ends from moving and keep the pipes in alignment. Some coupling clamp designs also serve to re-round the pipe when placed on either side of the fitting.

Saddles
Saddles require clamps to secure the fitting to the main to prevent movement, restrain against generated melt pressure, and in some cases to form the fitting to the contour of the main. Saddles are designed to be used with a particular clamping device. Clamping devices are typically not interchangeable from one fitting design or main size to another. In some cases clamping devices may be distributed as part of the fitting (commonly referred to as under-parts) that are intended to remain in place after fusion but not be used during fusion, a removable/reusable clamping device is to be used with all saddle fittings. Specific instructions for clamping and/or fastener tightening are provided by the fitting manufacturer and must be followed.

It is strongly recommended to use a ‘Top Loading Clamp’ to achieve the saddle the optimum interface pressure for fusion.

“All electrofusion fittings shall be installed with the use of alignment and restraining clamps.”
Electrofusion control units, sometimes referred to as processors, perform vital functions during the fusion process. The unit provides carefully regulated voltage for the required fusion cycle time resulting in the designed energy required for fusion.

During the fusion process, the control box also monitors the power being supplied to the fitting and can detect certain assembly or fitting errors such as shorted heating coils or short-stabbed pipe ends.

When using the fitting barcode, the control box checks the ambient air temperature and automatically adjusts the fusion time for that temperature if the fitting barcode requires it.

Adjustment of the fusion time for higher or lower ambient temperature is referred to as “temperature compensation”. Not all fittings require temperature compensation, but all barcodes contain two characters that define whether the feature is used or not. If in doubt, use the barcode.

The control box needs to acclimate to the job site weather conditions for minimum period of 15 minutes to ensure that it accurately measures ambient temperatures before beginning the fusion process.

The control box will terminate a fusion process when any defined protocol is out of range and will display an error message. Control boxes have a list of error message definitions affixed to the unit for reference if an error occurs. A record of each fusion, as well as the result of the fusion cycle, is stored and is downloadable via a USB connection. Displayed error codes are unique to each manufacturer—refer to manufacturer’s user manual for interpretation. The control box manufacturer recommends regular calibration intervals, typically every 12 months, to ensure that all monitored parameters are measured accurately and the control box is functioning normally. Units that are past their calibration interval will normally alert the operator at power-up, but will continue to function when acknowledged.

“The control box manufacturer recommends regular calibration intervals, typically every 12 months.”

Pegasus™ Electrofusion Welder
SECTION 06

Power Source

Control boxes are typically available in 110v or 240v versions. The control box monitors the energy input from the power source to ensure that fluctuations from the generator are within designed tolerances and alerts the installer when parameters fall out of range.

Control boxes are typically tolerant to small fluctuations in input voltage or frequency, however not all generators or inverters are equal. When an assembly is known to have been completed correctly, and there is an error or failure, the cause can usually be traced to the power supply. It is important to ensure that the power supply is in good working order and capable of supplying the required energy for the fitting being fused.

Each electrofusion fitting has an integral heating coil that requires a defined amount of energy input to achieve the designed results. Heating coils are engineered specifically for a fitting size or configuration and power requirements will vary from one manufacturer to another for the same size fitting.

The fitting manufacturer can provide specific requirements for its particular products, but the table below can be used as a guide for most fittings that are commonly available. Only CalderSafe extension cords can be used, however the wire gage should not be less than that shown in the previous table for the maximum length.

Consult the control box manufacturer for further details on recommended generator or inverter needs. Note: Do not use a welding generator to power the fusion processor.

CAUTION: The rated capacity of a generator is less than the peak generator capacity; use the lower of the two stated capacities. Capacity is further reduced by the age of the generator. The generator governor control must be turned off and the warmed up generator running at full speed before fusion begins to provide constant generator electrical output. Users must verify/qualify the output of generator on a minimum annual basis, or at the start of each contractor’s project and approved/tagged accordingly. Generators are a potential source of inadequate fusion due to inadequate power supply.

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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Socket*</td>
<td>3/4” to 2”</td>
<td>2500</td>
<td>15 / 15 AMP</td>
<td>#10/3</td>
<td>#8/3</td>
</tr>
<tr>
<td>Socket*</td>
<td>3” to 12”</td>
<td>5000</td>
<td>30 / 20 AMP</td>
<td>#10/3</td>
<td>#8/3</td>
</tr>
<tr>
<td>Saddle</td>
<td>All</td>
<td>2500</td>
<td>15 / 15 AMP</td>
<td>#10/3</td>
<td></td>
</tr>
</tbody>
</table>
Fusion parameters such as fusion time, voltage, and cooling time, can be entered into the control box by various means.

Barcode

All electrofusion fittings have a barcode attached that contains all of the information needed by the control box to perform the fusion process. Barcodes contain additional information about the fitting manufacturer, fitting size, fitting resistance, and temperature correction values if required by the fitting manufacturer.

- Codes are displayed on the fitting label in an interleaved barcode format that can be read by a barcode wand or hand-held scanner. Barcode scanners should be kept clean to insure proper working order.

- Because of limitations in the number of characters allowed by the barcode standard, DIPS fittings may not accurately display sizing standard (DIPS) on EF processor. DIPS sizes may display as the metric (mm) equivalent, or as IPS. Consult EF processor or fitting manufacturer for further information.

- The 24-digit numerical value is also printed on the label, either directly above or below the barcode that can be entered into the control box in the event that the code cannot be scanned.

Identification Resistors

Identification resistors are supplied in some fitting designs that can be read by a compatible control box to automatically set the fusion time, voltage, and cooling time. The resistor pin is usually identified by a colored insert in the centre of the pin that can be matched to a colored end of the control box cable.

Manual Entry

Manual entry of fusion time and voltage entry may be possible if printed on the fitting label. The fusion time is typically preceded by the word “WELD” or “FUSE” and displayed in seconds. The voltage is displayed and followed by “V”. It is always preferable to use the bar code method. All PE EF fittings are manufactured using PE 4710/PE100 and must be fusible to the piping system.
SECTION 08
Electrofusion Installation Procedure

Coupling Installation

1. Cut the pipe ends squarely and evenly. (±3 degrees).

2. Clean the pipe ends by removing dirt, mud, and other debris. Clean water can be used for initial cleaning of pipe surfaces prior to scraping. Clean the pipe for a length far enough beyond the area to be fused to ensure that remaining debris on the pipe surface will not be transferred to the area to be prepared during handling. Dry with a clean cotton towel.

3. Measure and mark the stab depth on the pipe ends. If stab depth marks are not indicated on the outside of the coupling, measure the total length of the coupling to be installed and make a mark on both pipe ends equal to ½ the length of the coupling. This mark is used as visual indication by the installer that the pipe ends are correctly inserted to the center of the coupler. Check the pipe surface for any embedded debris that may cause damage to scraping tools, and once more make sure that the outer pipe surface is clean and free of any dirt or mud that could re-contaminate the scraped pipe surfaces. Mark the entire pipe surface to be scraped with longitudinal and/or circumferential lines.

4. Scrape the outside of the pipe surface to remove oxidation and other contaminants. Use an appropriate scraping tool as described in the Pipe Preparation section of this guide. Scrape the pipe surface until the outer layer or “skin”, at least .007” thick, of the pipe has been removed to expose a clean, virgin pipe material. Remove longitudinal or circumferential markings made in step 3. Inspect the entire scraped area to ensure total scraping coverage. See image below.

While not common, it is possible to remove too much surface material by repeated scraping. Removal of .020” on 4” or smaller, or .040” on larger sizes is the maximum. Use caution if scraping multiple times to ensure that the pipe OD is not reduced to the point that the gap between the pipe and fitting is too large.

When making a repair, or in situations where the coupling must slide completely over one of the pipe ends in order to fit on the pipes, scrape that pipe end for the entire length of the coupling to avoid contamination. The depth mark on the opposite pipe can be used for centering the coupling assuming that the two pipe ends are in contact.
“The most common failures in EF Jointing are associated with poor surface preparation and contamination failures.”

5. Avoid touching the scraped pipe surface or the inside of the coupling as body oils and other contaminates can affect fusion joint performance. If the surfaces become contaminated, clean thoroughly with a clean, lint free towel and a minimum 96% concentration of isopropyl alcohol and allow to dry before assembling. Do not use alcohol with any additives other than water.

**CAUTION:**
- Avoid all possible recontamination of the prepared surface.
- Do not use denatured alcohol.

6. Slide the coupling over the scraped pipe ends to the stab depth markings. If the pipe is out of round, a clamp can be used to re-round before sliding the coupling onto the pipe. If needed, a block of wood can be placed over the coupling end and a hammer can be used to drive the coupling onto the pipe. Use caution that the connecting pins are not damaged.

**Note:** Pipe ends should be beveled on the outer edges when installing couplings that incorporate bare exposed heating wires to prevent snagging of wires on pipe edge.

7. Clamp the pipe ends to align and secure the assembly. Coupling and pipe assembly must be immobile during the fusion and cooling cycle. See opposite image.

8. Connect the fitting to the control box enter the fusion parameters (bar code scan the fitting), and fuse the joint. See **Fusion Parameters** section of this booklet for details.

9. Mark the time of day on the fitting when the fusion cycle has ended. If required by the pipeline owner, include installer and installation information such as the date, operator identification number, fusion ID card number, contractor name, fusion machine identification number, etc.

10. Allow the fused fitting and pipe assembly to remain clamped (alignment clamp and rounding clamp) and undisturbed for the Cooling time. Cooling is a vital part of the fusion process. Proper cooling times must be observed.

Pipe ends are aligned, clamped and immobile
Field Guide for Electrofusion Coupling Installation

1. Clean pipe ends with clean water and cut squarely (±3 degrees) as possible.

2. Measure and mark the stab depth on both pipe ends.

3. Mark the pipe to be scrapped in a crisscross pattern.

4. Mount the scrapper over the area to be scrapped.

5. Scrape or peel the pipe to remove the surface layer and expose clean virgin pipe beneath.

6. Inspect the scraped pipe surface thoroughly to ensure that all marks are removed and that only virgin pipe surface is exposed.

7. Clean surfaces with Isopropyl alcohol if necessary. Insert the pipe ends to the stab depth marks made in step one. Secure in alignment clamp with coupling centered between stab depth marks.

8. Connect the control box leads to the fitting and fuse the joint. Do not move or disturb the joint for the recommended cooling time. Mark time of day when fusion cycle ends.
Saddle Installation

1. Clean the pipe by removing dirt, mud, and other debris. Clean the pipe for a length far enough beyond the fusion area. Use clean water for initial cleaning of pipe surfaces prior to scraping to ensure that remaining debris on the pipe surface will not be transferred to the area to be prepared during handling.

2. Re-rounding Clamps: Installer shall always use two re-rounding clamps to re-round the saddle installation location regardless of OOR.

3. Mark the saddle installation area on the pipe. Use the bagged fitting as a template for marking. The installer may use these marks to indicate the approximate size of the preparation area. Check the pipe surface for any embedded debris that may cause damage to scraping tools, and to make sure that the outer pipe surface is clean and free of any dirt or mud that could re-contaminate the scraped pipe surface. Mark the entire pipe surface (witness marks) to be scraped with longitudinal and/or circumferential lines.

4. Scrape the outside of the pipe surface to remove oxidation and other contaminates. Use an appropriate scraping tool as described in the Pipe Preparation section of this guide. Scrape the pipe surface until the outer layer or “skin”, at least .007” thick, of the pipe has been removed to expose a clean, virgin pipe material. Remove markings made in step 2. Inspect the entire scraped area to ensure total scraping coverage and removal of witness marks.

CAUTION:
- Avoid all possible recontamination of the prepared surface.
- Do not use denatured alcohol.

5. Do not touch the scraped pipe surface or the inside of the saddle fitting as body oils and other contaminates can adversely affect fusion. Commerically available pre-packaged 96% (or greater) isopropyl alcohol impregnated disposable wipes without additives are recommended to clean pipe surfaces. Do not use alcohol with any additives other than water. Discard the wipes after each use. Installer should have a readily available source of clean disposable wipes. Do not scrape EF Fitting.

Note: PASTM F2620 and F1290 allow 90% concentration or greater.

6. Secure the saddle-to-pipe assembly with the appropriate clamping mechanism. See Fitting Clamping section of this guide for details.

7. Place the saddle over the scraped pipe surface. Ensure that the fitting fusion surface is only in contact with the scraped pipe surface.

8. Connect the fitting to the control box, enter the fusion parameters, and fuse the saddle. See Fusion Parameter section for details.

9. Allow the fused fitting and pipe assembly to remain clamped and undisturbed for the cooling time.

10. Mark the date, time and fusion record number on the fitting when the fusion cycle ends. If required by the pipeline owner, include installer and installation information such as the date, installer identification number, fusion ID card number, contractor name, fusion machine identification number, time of day when cooling time will elapse, etc. Cooling is a vital part of the fusion process. Observe Cooling Times and do not disturb fused joints until the Cooling Time elapses.
Field Guide for Electrofusion
Saddle Installation

1. Clean pipe ends with clean water and cut squarely (±3 degrees) as possible.

2. Mark position of saddle on pipe.

3. Mark pipe surface in area to scrapped in a crisscross pattern.

4. Mount the scrapper over the area to be scrapped.

5. Scrape or peel the pipe to remove the surface layer and expose clean virgin pipe beneath.

6. Inspect the scraped pipe surface thoroughly to ensure that all marks are removed and that only virgin pipe surface is exposed.

7. Clean surfaces with Isopropyl alcohol if necessary, avoid touching cleaned surface. Clamp saddle to the scrapped pipe.

8. Connect the control box leads to the fitting and fuse the joint. Do not move or disturb the joint for the recommended cooling time. Mark time of day when fusion cycle ends.