

Municipal Advisory Board

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MAB Generic Electrofusion Procedure for Field Joining of 14 Inch to 30 Inch Polyethylene (PE) Pipe

(MAB-02-2023)



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FOREWORD

This procedure was developed by the Municipal Advisory Board (MAB) and published with the help of the members of the Plastics Pipe Institute, Inc. (PPI).

The purpose of this technical report is to provide important information on particular aspects of larger diameter polyethylene pipe electrofusion to engineers, users, contractors, code officials, and other interested parties. More detailed information on its purpose and use is provided in the document itself.

This report has been prepared by MAB members and associates as a service to the industry. The generic information in this report is offered in good faith and believed to be accurate at the time of its preparation, but is offered “as is” without any express or implied warranty, including WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. Consult the manufacturer for more detailed information about the particular joining procedures to be used with its piping products. Any reference to or testing of a particular proprietary product should not be construed as an endorsement by the MAB or PPI, which do not endorse the proprietary products or processes of any manufacturer. The information in this report is offered for consideration by industry members in fulfilling their own compliance responsibilities. MAB and the PPI assume no responsibility for compliance with applicable laws and regulations.

The MAB serves as an independent, non-commercial adviser to the Municipal & Industrial (M & I) Division of the PPI. Once adopted, MAB will consider revising this report from time to time, in response to comments and suggestions from users of the report. Please send suggestions of improvements to Camille George Rubeiz, PE, F.ASCE at crubeiz@plasticpipe.org.

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HISTORY

In 2014, representatives of the Municipal Advisory Board (MAB) requested assistance in creating greater uniformity in the joining procedures utilized by utilities in the electrofusion of polyethylene (PE) piping products for water and waste water applications. Users reported the proliferation of similar but slightly varying joining procedures from individual electrofusion fitting and equipment producers. The slight differences in the various procedures made it more difficult for system operators and installers to qualify persons with appropriate training and experience in the use of these procedures. It was even more difficult for system operators to inspect for and enforce that proper joining procedures were being followed. To address these issues, MAB established a task group and then published in 2015 the *MAB Generic Electrofusion Procedure for Field Joining of 12 Inch and Smaller Polyethylene (PE) Pipe*.

In 2016 and following the successful implementation and use of the above-referenced electrofusion document, MAB established a new task group to develop this generic procedure for installing larger diameter (14 inch to 30 inch) electrofusion fittings per the sizes shown in AWWA C906-15. Due to the magnification and multitude of installation procedures of large diameter electrofusion fittings, the MAB agreed to create this new document. Based on the results of the survey of the large diameter electrofusion manufacturers, the MAB TG (Task Group) unanimously agreed to take a conservative approach and adopt the most stringent installation requirements so that the document could be used with any product regardless of the manufacturer. This conservative approach may not be justified in all cases and the user of this document is encouraged to contact the electrofusion fitting manufacturer to obtain specific advice for the fittings being used.

In the spirit of complying with the above request, companies that manufacture larger diameter (14 inch to 30") electrofusion products and equipment manufacturers reviewed existing procedures, agreed on common leading practices, and combined experiences and knowledge to educate and train installers. Thus, this publication provides a uniform electrofusion joining procedure to provide greater consistency, and to facilitate the pipeline operator's efforts to qualify the installer, and simplify inspections. Refer to Appendix A for a list of electrofusion companies that endorsed these generic practices for use with their large diameter electrofusion fittings.

SCOPE

The program undertaken by the MAB TG combined common installation practices shared by multiple manufacturers into a single format. The goal is to provide clear direction and common procedures for proper pipe preparation, fitting-to-pipe assembly, and installation of electrofusion fittings 14 inch to 30 inch diameters; refer to the manufacturer for larger sizes. An additional goal is to provide clear inspection criteria for installer qualification, installation acceptance by inspection, and answers to frequently asked questions. This document replaces PPI TN-34. For installation of 12 inch and smaller pipe diameters refer to MAB Generic Electrofusion Procedure Manual for Field Joining of 12 Inch and Smaller Polyethylene (PE) Pipe (MAB-1-2015).

INTRODUCTION

It is incumbent on all owners of HDPE piping systems to insure that all persons responsible for installation are qualified to perform fusion. Inadequate fusions can compromise the expected high level of HDPE material performance.

Proper installation techniques, installer understanding of and training to these techniques, and effective examination before installation are key to a successful installation. This document provides detailed instructions for each key step to a successful installation, why each step is important, and the means of how to tell if the requirements of each step have been accomplished.

The inherent value of greater uniformity will provide all the incentive necessary for companies to evaluate the procedure as a first option for electrofusion joining of its large diameter PE piping products. MAB recommends the use of this procedure and every electrofusion fitting producer, equipment manufacturer, and pipeline operator retains the option of developing different procedures for its particular products and pipelines. However, MAB believes that its work in developing this procedure as a candidate for widespread acceptance throughout the industry will lead to greater efficiency, simplicity, and understanding, to promote the use of effective, qualified procedures for electrofusion joining of large diameter PE pipe.

Electrofusion joining of PE pressure pipe has been commonly used in North America for over 30 years. ASTM standard specifications for materials (ASTM D3350), performance (ASTM F1055), and installation practice (ASTM F1290) have been in publication for many years. All electrofusion fittings shall be marked to indicate that they meet the material and performance requirements of ASTM F1055 before being considered for use. Additional markings may be included to indicate that other performance and health effect requirements are satisfied, such as ANSI/AWWA C906 and NSF 61. Since each fitting manufacturer may have slightly varying geometrical designs, and each manufacturer is responsible for establishing safe installation temperature limits, it is also common that installation instructions can vary from one manufacturer to another. Although instructions can vary, all fittings share some common requirements for installation and all manufacturer's instructions include these same requirements. By successful completion, persons trained and qualified to these MAB documents have also demonstrated knowledge and understanding of the general procedures and techniques of ASTM F1290.

PRINCIPLES OF ELECTROFUSION

Polyethylene (PE) Electrofusion fittings are manufactured with a precision-designed resistance wire heating coil mechanism.

The electrofusion process works by introducing a controlled electrical voltage to the heating coil, which in turn generates heat to melt the fitting and pipe surfaces. As the polyethylene surfaces melt they also expand in volume to close allowable gaps between the pipe and fitting, then after the gaps are closed, the continuing melt expansion generates pressure within the heated zones. The expanding melt reaches “cold zones” within the fitting where the melt flow fronts cool and solidify, thereby blocking any further melt movement or material escape. The heating process continues for a predetermined time so that substantial pressure is reached through continued melt expansion in the contained melt pool of the pipe and fitting surfaces. Under pressure, the molten surfaces will join. Upon completion of the heating phase, the assembly is held stationary as the melted materials begin to immediately cool and co-crystallize into a single and solid monolithic structure between the pipe and fitting. (Figure a)

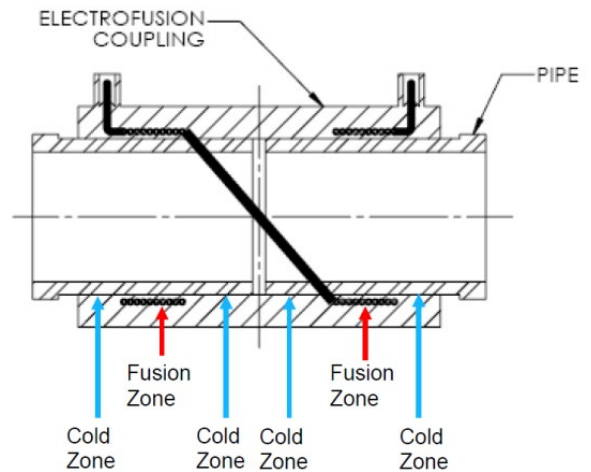


Figure a – Principals of Electrofusion

Equally as important as the heating phase of the fusion cycle, the cooling phase is a defined part of the electrofusion process. Because polyethylene is a thermoplastic, the material softens when heated and is therefore vulnerable to stresses from external forces such as the weight of the pipeline and bending forces from pipe curvature or misalignment while it is still hot. Fittings must be held stationary and in alignment during the fusion and cooling process by external clamps to protect against inadvertent disturbance of the molten PE until the assembly has cooled and regained its material strength. Once completely cooled, the surfaces are permanently joined together and cannot be separated.

Electrofusion manufacturers offer multiple cooling times. However, this generic electrofusion procedure only references one Cooling Time. Observe this Cooling Time prior to removal of clamps, movement, backfilling, pressure testing, tapping or placing the fitting in service. (See Table X-a and X-b for Cooling Time associated with these fittings).

I. JOBSITE PREPARATION

A. Safety: Fully understand and observe jobsite safety requirements. Electrofusion fittings and equipment are not intended to be, and are not “Explosion Proof”. If used in a volatile environment, additional ignition concerns may be present and are not addressed in this document. When danger of electrical shock due to moisture at the fusion site is a concern, connect the leads to the fitting before the control unit is energized. Take safety precautions to prevent exposure to electrical shock hazards.

B. Control Flow: 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. In moderate wet conditions, accomplish dewatering using portable submersible pumps (Fig. I-a). Saddle type fusions can be performed on mains under pressure.



Figure I-a – Portable submersible pump (not visible)

In repair or cut-in situations, flowing water in the pipe may be present due to leakage of valves. Avoid flowing water in contact with the fusion surfaces during the assembly or fusion cycle as water will contaminate and hinder the fusion process and/or cause voids and pockets in the fusion surfaces as the moisture turns into expanding steam during the fusion process. Dry ice placed in the pipe upstream of the fusion location can temporarily freeze small amounts of flowing water until the fusion process is completed.

C. Ambient Temperature: Observe manufacturer’s recommended minimum and maximum installation temperatures for electrofusion fittings.

1. Install electrofusion fittings in ambient temperatures as recommended by the manufacturer. A typical qualified temperature range for installation is 14°F minimum to 113°F maximum based on ISO standard 12176-2. 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.
2. The control box relies on the ambient temperature reading from sensors; it is important not to impact sensors with external heat sources such as generators emitting heat, or direct sun light that may affect the temperature of the processor.
3. Large diameter couplings may use a temperature specific fusion time or a pre-heat cycle prior to fusion.
4. Protect the fusion work site in case of inclement weather such as rain or snow. The use of a temperature controlled welding tent (or similar structure) may be required.

II. 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 at the time of 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. Always store fittings indoors in their original packaging until installation.

Black electrofusion fittings contain a 2% to 3% carbon black additive to protect against other UV effects and if stored indoors in their original packaging have potentially unlimited shelf life.

- ⚠ **Evaluate fittings with an unknown storage history or those exposed to questionable storage conditions through destructive testing of sample fusions. If fusion quality is shown to be affected, discard the fittings in question.**

Inspect fittings for damage before installing to ensure that connection points such as terminal pins have not been damaged by handling, that there is no visible damage to fusion surfaces or heating wires, and that no foreign materials are present on or near the fusion surfaces.

Clean fittings if incidental contact is made with the fusion surface. Use a suitable cleaning agent that contains no additives to hinder the fusion process. 96% (or greater) concentration of Isopropyl alcohol, with no additional additives except water, is recommended. Other cleaning agents may be acceptable and the fitting manufacturer should be consulted. All surfaces must be dry before fusion; see Sec. X- A.5 to avoid contaminating the clean surfaces. Note: ASTM F2620 and F1290 allow 90% concentration or greater.

- ⊘ **Do not use denatured alcohol – Denatured alcohols may contain additives that can prevent fusion and shall not be used.**

III. 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:

- A. **Measuring Tools:** A tape measure (Figure III-a) 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. A caliper is used to determine the out-of-roundness of the pipe for side wall fittings. Use a Carpenter's Square to ensure square cut of pipe ends. A time measuring device must also be available to installers to monitor appropriate Cooling Times.

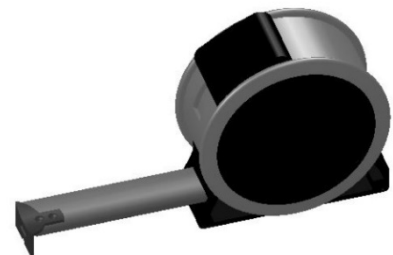


Figure III-a –Measuring Tape

- B. **Markers:** The system owner is encouraged to specify / approve a permanent non-petroleum based visible

marker to ensure consistency. Markers should be visible on the pipe color (Figure III-b) 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 contaminate a prepared pipe surface. Use marks to locate insertion depths and as a guide for pipe scraping effectiveness. Also use markers to denote fusion Cooling Time.



Figure III-b – Marking

⊘ Do not use markers that are slow-drying or contain oils that could be spread onto fusion surfaces.

C. Cutting Tools: Use a suitable saw (without lubricants, including oil or graphite based) and a guide or guide marks; 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. Make cutting marks around the pipe using a 4” or wider strap or encirclement clamp as a guide so that the pipe can then be cut along the line as shown in Figure III-c.

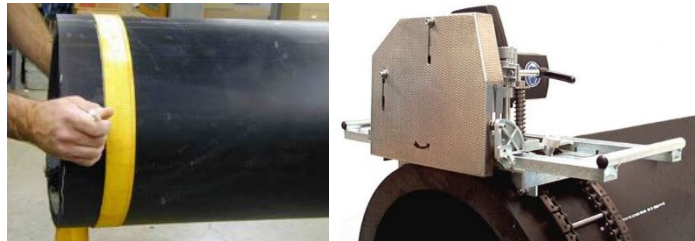


Figure III-c – Marking and cutting larger diameter pipes

D. Scraping Tools – Tools that are approved for scraping pipe for electrofusion joining are those that remove material uniformly and avoid contamination from surrounding area to expose a clean virgin surface. MAB recommends the use of “Peeler” type tools that remove a continuous and measurable ribbon of at least 0.007” in thickness from the pipe surface. The advantages of these tools are:

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

NOTE: Avoid the use of hand tools when peelers are commercially available for the fitting being installed. Hand tools such as paint scrapers and scrapers with serrated blades have been used historically with good success. They can be used effectively especially in situations where confined working space or pipe scratches or gouges require a hand tool. It must be recognized by the user that they require more effort and diligence to ensure the entire area is being scraped adequately. Uniform scraping is more difficult to achieve with hand tools. Experience of the operator is required in order to know that adequate pipe surface material has been removed when using a hand scraper. The majority of failed fusions can be attributed to improper or inadequate pipe scraping.

E. Fitting and Alignment Clamps

- Alignment / Restraining Clamps - 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. Polyethylene is also a thermoplastic that softens when heated and the fusion assembly must be held stationary during both the melt and cool phases. As the materials cool and co-crystallize into a solid state again, the structures cannot be disturbed. Alignment and restraint clamps offer protection during both the melt and cooling cycles to prevent pipe and joint movement. Full encirclement type alignment clamps may provide the added benefit of re-rounding pipe ends, but chain or strap-type clamps will not provide re-rounding. The primary goal of clamping is to ensure that the pipe and fitting assembly are aligned, stable, free of external stresses, and immobile until the Cooling Time has been observed. **Always use** alignment / restraining clamps to install electrofusion couplings. Where alignment/restraining clamps are not commercially available, other means of joint stabilization may be utilized such as blocking and/or rigid timber and ratchet straps to prevent assembly movement.
- Saddle Clamps – **Always use** clamps when fusing saddles. The clamps provide the necessary attachment to the pipe and resist melt expansion forces to achieve the intended melt pressure on the pipe. Saddle clamps may be an external mechanical clamp that is re-usable or an integrated and permanent bolt-on clamp or strap. An underclamp (or strap) is a clamp that “pulls” the fitting base onto the pipe. A top loading clamp “pushes” the fitting downward onto the pipe. Each saddle fitting has a specific clamp(s) designed and qualified for its use. Substitutions are not acceptable and may result in fusion failures. Do not remove saddle clamps until Cooling Time has expired.

F. Blocking and Supports – If cribbing or pipe stands are needed to support the pipeline during the electrofusion process, ensure that the supports are placed on both sides of the fitting so that no weight is being supported by the electrofusion fitting and that no bending stresses are exerted on the joint area. See also the caution against attaching appurtenances (Section XIII, item H).

G. Coupling Puller – Due to the required tight diameter tolerance fit between the EF coupling and the pipe, mechanical pulling tools are available from several manufacturers to assist with coupling placement. (Figure III-d)



Figure III-d - Mechanical Pulling Tool

H. Full Encirclement Re-rounding Tools – These tools must always be used before and during installation to re-round the pipe. Several tools are available for both internal and external re-rounding.

IV. Pre-installation Requirements:

- A. Pipe Diameter – Ensure that the pipe diameter is within the tolerances, at the specified temperature, of the applicable pipe standard (ASTM F714, AWWA C906, etc.) (see Table V-a). Standard tolerances are determined at 73°F. Measure pipe diameter with a Pi tape (Figure IV-a) at 2” and 6” from the pipe end to determine diameter. Pipe toe-in (See Appendix F for more info on Pi tape and toe-in) or reduction in diameter, is a condition that occurs at the pipe end and should be checked to ensure that the pipe diameter is within tolerance at 2” from the end. Severe toe-in (i.e. pipe diameter is less than the minimum pipe diameter), may require the removal of up to one pipe diameter from the pipe end.



Figure IV-a - Measuring pipe diameter with Pi tape

- B. Pipe Out-of-Roundness (OOR). Check if OOR condition exists even after use of re-rounding tools. Measure the pipe diameter (See Figure V-a in Section V) to determine the amount of OOR. Always use re-rounding tools.

- C. Cut pipe ends squarely to 90° with a ½ inch maximum gap as measured from Carpenter’s Square (one inch maximum allowable gap between butted pipe ends; Figure IV-b). Use a 4” or wider sling or strap as a guide to mark the pipe for cutting (see Appendix G).



Figure IV-b - Measuring allowable gap with Carpenter's Square

- D. Pipe alignment – Pipe alignment and clamping are required for proper fusion. Inspect alignment to ensure that no stresses are present in the assembly that might cause movement during fusion. Support pipe (See Figure VI-b).
- E. Power Source – An adequate power source is required. Ensure that power source is capable of delivering power for entire coupling fusion time without interruption (check generator for full fuel supply). Ensure that all connections are tight and clean. Loose connections can result in arcing or blown fuses.
1. 110 Volt: A minimum 7000 watt **continuous** supply generator capable of delivering 115 volts to 135 volts at 55 Hz to 65 Hz to the control box. Minimum 30 amp breaker with “slow blow” or time delay fuse. .
 2. 220 Volt: A minimum 7000 watt **continuous** supply generator capable of delivering 180 volts to 300 volts at 55 Hz to 65 Hz to the control box. Minimum 30 amp breaker with “slow blow” or time delay fuse.
 3. Do not connect other electrical devices to the generator during fusion.
 4. Insure that the generator is fully warmed up prior to attempting electrofusion procedure.
- F. Extension Cords – Typically, a single extension of up to 25 ft. is permitted between the generator and the control box. The minimum wire gauge is #8/3 AWG for extension lengths up to 25 ft.; consult the fitting and equipment manufacturer for specific recommendations on the use of longer length cords.

- G. Control Box – Use a 24 digit barcode compatible control box conforming to ISO 12176-2 to deliver the required energy to the coupling.
 1. The control box must be capable of delivering 80 amperes average (up to 105 amps peak) at 8 to 48 volts output.
 2. The control box must be capable of reading the coupling barcode and applying the correct fusion parameters, including automatic temperature compensation, to the fitting without operator intervention.
 3. The control box must be capable of reading ambient temperatures at the fusion site.
 4. The control box must include fusion data recording capabilities for installed fittings.

- H. Scraping Tools – PIPE PREPARATION IS VERY CRITICAL TO THE ELECTROFUSION PROCESS. GIVE CAREFUL ATTENTION TO CLEANING AND SCRAPING PROCEDURES TO REMOVE CONTAMINATION AND SURFACE OXIDATION FROM THE PIPE SURFACE.
 1. Only use mechanical type scraping tools designed specifically for electrofusion preparation to prepare the pipe surface. Alcohol will not remove oxidation.
 2. Do not use abrasives such as grinders, emery cloth, or sandpaper.
 3. Exercise care in the maintenance and storage of scraping tools to ensure proper operation. Verify before each use that the scraping tool is operating properly.

- I. Markers – Ensure that insertion depth and pipe scrape area markings are made with a non-greasy, non-petroleum based, fast-drying, permanent marker or paint pen.

- J. Cleaning agent / wiping cloth – Commercially available pre-packaged 96% (or greater) isopropyl alcohol impregnated disposable wipes without additives are recommended to clean pipe surfaces. **Denatured alcohol may contain other impurities and is NOT suitable.** Under no circumstances should a coupling fusion be made with any liquid (water, oil, sewage, etc.) flowing through the fusion area. The fusion zone must be clean and dry before and during fusion.

- K. Weather Conditions – Observe manufacturer’s recommended minimum and maximum installation temperatures for electrofusion fittings.
 1. The typical ambient installation temperature range is 14°F to 113°F maximum based on ISO standard 12176-2 but can vary above and below that range depending on the manufacturer. If ambient temperatures are outside this range, consult the equipment and fitting manufacturer for a specific recommendation.
 2. The fusion processor relies on ambient temperature reading from sensors; it is important not to impact sensors with external heat sources (such as generators emitting heat, or direct sun light) that may affect the temperature of the processor.
 3. Large diameter couplings may use a temperature specific fusion time or a pre-heat cycle prior to fusion.
 4. Protect the fusion work site in case of inclement weather such as rain or snow.
 5. Pipe and fittings surfaces must be dry.

V. PIPE PREPARATION

- A. Measuring pipe:
 1. Diameter: Electrofusion fittings are designed for use on pipe made to standard diameters in dimensions for Iron Pipe Size (IPS) and Ductile Iron Pipe Size (DIPS). Do not use pipe that is outside of the diameter tolerance band of the appropriate pipe standard. Use the following table (Table V-a) for reference when measuring pipe diameter to ensure that the pipe is within tolerance.
Standard tolerances are determined at 73°F. Measure pipe diameter with a Pi tape (see Appendix F) at 2” and 6” from the pipe end to determine diameter. Pipe toe-in or reduction

in diameter, is a condition that occurs at the pipe end and should be checked to ensure that the pipe diameter is within tolerance (Table V-a) at 2" from the end. Severe toe-in (i.e. pipe diameter is less than the min. pipe diameter) may require the removal of minimum of 12" from the pipe end.

**Table V-a – Standard PE 4710 IPS and DIPS Pipe Dimensions (AWWA C906/ASTM F714)
(Dimensions apply to pipe at 69.8–77.0°F (21-25°C))**

PE 4710 OUTSIDE DIAMETERS (OD) AND TOLERANCES FOR IPS SIZES			PE 4710 OUTSIDE DIAMETERS (OD) AND TOLERANCES FOR DIPS SIZES		
PIPE SIZE	AVERAGE OD	TOLERANCE	PIPE SIZE	AVERAGE OD	TOLERANCE
14" IPS	14.000"	±0.063	14" DIPS	15.300"	±0.069
16" IPS	16.000"	±0.072	16" DIPS	17.400"	±0.078
18" IPS	18.000"	±0.081	18" DIPS	19.500"	±0.088
20" IPS	20.000"	±0.090	20" DIPS	21.600"	±0.097
22" IPS	22.000"	±0.099	24" DIPS	25.800"	±0.116
24" IPS	24.000"	±0.108	30" DIPS	32.000"	±0.144
26" IPS	26.000"	±0.117			
28" IPS	28.000"	±0.126			
30" IPS	30.000"	±0.135			

(NOTE: For sizes 12 inch and smaller, See MAB-1-2015)

2. Roundness: Polyethylene is a flexible material. A number of conditions can affect pipe roundness; these conditions include manufacturing process, storage/stacking, and soil load for buried installations (Figure V-a).

- Out-of-roundness is the difference in the maximum measured diameter minus the minimum measured diameter. Measure the pipe with a tape measure or calipers to find the maximum (d1) and minimum (d2) diameter points. Calculate the out-of-roundness as d1-d2 as measured in the field. Use calipers to measure out-of-roundness for side wall fitting installations. If calipers (or other OOR measurement devices) are not available, installers shall use cold ring clamps to re-round the pipe.

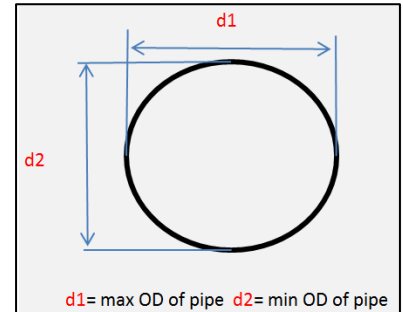


Figure V-a - Roundness Measurement

If severe enough (>1/4"), pipe out-of-roundness can have a negative effect on electrofusion joint quality. If the pipe is out-of-round, and is not corrected by full encirclement clamp, the amount of gap between the pipe and fitting can be too large for the melt expansion to close. Pipe out-of-roundness may also increase the difficulty of sliding the fitting onto the pipe.

For sizes equal to or larger than 14 inch IPS / DIPS, always use re-rounding tools on either side of an electrofusion saddle or coupling.

- B. Pre-Cleaning: Clean the inside and outside of both pipe ends by removing dirt, mud and other debris. USE clean water for initial cleaning of pipe surfaces prior to scraping.

C. Cleaning: It is important to clean the fusion area with 96% disposable isopropyl wipes and avoid recontamination of these areas prior to scraping.

⚠ Pipe that has been installed by directional boring where drilling lubricants such as bentonite have been used require particular attention to pre-cleaning before scraping as well as any cleaning after scraping. Drilling lubricants, even when dried, can be difficult to see and are easily spread by wiping. Use extra caution to only wipe over areas that were previously cleaned with isopropyl alcohol to prevent spreading onto prepared surfaces.

D. Scraping: Pipe preparation is perhaps the most important and least understood aspect of making a sound electrofusion joint. Improper pipe preparation is overwhelmingly the leading cause of unsuccessful electrofusion joint attempts; in these cases, the installer may not completely understand the goal of pipe scraping, which is to remove a thin layer of the outer pipe surface (see FAQ section and Appendix H for more details) to expose clean virgin material beneath.

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 effectively. Simply roughing the pipe surface is not sufficient. To achieve fusion, remove this layer. Even new pipe must be 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 (Figure V-b) is just seven thousandths of an inch (0.007"). That thickness is approximately the same as two sheets of ordinary paper. The maximum amount of removed material shall not exceed forty thousandths of an inch (0.040"). Care shall be taken to avoid compromising the minimum wall requirement of the pipe when scraping.



Figure V-b - Scraping Measurement

⊘ Never use sand paper, emery cloth, or other abrasives to prepare a pipe surface for electrofusion. Abrasives have been proven to be ineffective for electrofusion because they do not adequately remove material, they can redistribute contaminants on the surfaces, and because they can leave behind a grit residue that forms another barrier that prevents fusion.

✔ There are many tools used for pipe scraping, however they are not all the same and care must be used depending on the type of tool selected. The only tools that should be used for surface preparation are those that are specifically designed for electrofusion scraping and peeling:

Examples of acceptable tools that “peel” the pipe surface to a controlled depth are most commonly referred to as “peelers” (Figure V-c).



Figure V-c – Acceptable “Peelers”

- No matter what type of tool is used, make witness marks 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 and that more scraping is required. (Figure V-d)

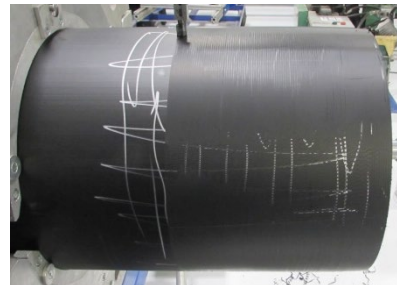


Figure V-d – Inadequate Removal of Witness Marks

- Another type of tool is referred to as a “hand scraper”. Except as noted below (see hand tool), avoid the use of these hand scrapers due to inconsistent surface preparation and difficulty in mastering skills required for uniform surface preparation. (Figure V-e).



Figure V-e – Not Recommended “Hand Scrapers”

- ⚠ **Gouges that are deeper than the scrape depth may also require extra attention when scraping the pipe to ensure the removal of any debris or contaminants embedded in the gouges; use of a hand tool to scrape the gouge may be necessary. If the gouge exceeds 10% of the pipe wall thickness, cut out and replace that pipe section to maintain the maximum pressure rating of the pipe.**
- ⚠ **Pipe scratches and/or gouges: Installation of pipe can cause surface scratches or gouges. Smaller scratches from dragging or normal handling are not problematic and will normally be removed during the pipe preparation process by scraping. Avoid surface damage when installing pipe with use of rollers or other devices that separate the pipe from sharp surfaces. If surface damage is questionable and cannot be removed by scraping, contact the fitting manufacturer.**
- ⚠ **Wood rasps and metal files are not acceptable scraping tools.**

VI. FITTING CLAMPING AND ALIGNMENT

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. Polyethylene is a thermoplastic that softens when heated. As a result, install all electrofusion fittings with the use of alignment and restraining clamps (Figure VI-a).



Figure VI-a - Fitting Clamps

Use clamps on all coupling installations to restrain the pipe ends from moving and keep the pipes in alignment.

⚠ Check pipe end alignment to ensure that there is no bind or stress exerted on the coupling during fusion and until Cooling Time is complete. Support for the pipe is necessary to prevent stresses or sagging that may develop as heat is applied during fusion.

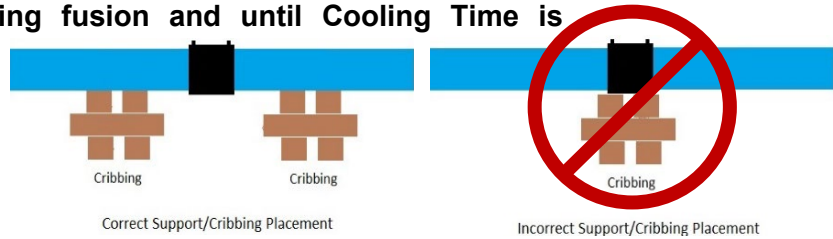


Figure VI-b - Cribbing placement

Saddles require clamping 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. Other designs include a clamp that is re-usable (Figure VI-c along with top loading tools that cannot be removed until observance of the Cooling Time). Some manufacturers specify allowable gaps between the underside of saddles and pipe OD. Consult saddle manufacturer for allowable gap dimension.



Figure VI-c - Reusable saddle clamps

Note: Consult manufacturer for nylon type strap tools that are intended for multiple use regarding frequency of strap replacement interval.

VII. CONTROL BOX

Electrofusion control boxes, sometimes referred to as processors, perform vital functions during the fusion process. The control box 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 confirms the dimensions of the fitting to be installed and automatically adjusts the fusion parameters for that particular fitting based on the manufacturer's requirements and field ambient temperature.

- ✔ 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.
- ✔ Let the control box acclimate to the jobsite 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 or available in the associated operator's manual 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, Bluetooth or other wireless connection. Displayed error codes are unique to each manufacturer - refer to manufacturer's user manual for interpretation. System operators should retain these down-loaded fusion records and associate them with installed fittings in the project records.

Change or adapt control box fusion cable tips to fit the size of the connecting pins on the electrofusion fitting. There are two sizes of fitting connecting pins, 4.7mm and 4.0mm.

The control box manufacturer recommends regular calibration intervals, typically every 1 to 3 years, 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 installer at power-up, but will continue to function when acknowledged.

Minimum Requirements for Control Box

- Use a 24 digit barcode compatible control box conforming to ISO 12176-2 to deliver the required energy to the coupling.
- The control box must be capable of delivering 80 amperes average (up to 105 amp peak) at 8 to 48 volts output.
- The control box must be capable of reading the coupling barcode and applying the correct fusion parameters, including automatic temperature compensation, to the fitting without operator intervention.
- The control box must be capable of reading ambient temperatures at the fusion site.

Additional Control Box Data: Some control boxes also include GPS (Global Positioning System) positional location data associated with the location of the installed fitting. This information can also be retained, along with the fusion record, as an attribute for the installed fitting in the Owner's GIS (Geographic Information System) system.

VIII. POWER REQUIREMENTS

Control boxes are typically available in 120v 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 code 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 fusion process.

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. A minimum 7000 watt continuous output generator is recommended.

Job site conditions may dictate placement of the generator at a distance further than the length of the provided power supply cord; in this instance an extension cord may be needed. Avoid the use of Extension cords; however, if necessary, the wire gauge should not be less than #8/3 AWG for the maximum length of 25 feet.

An adequate power source is required. Ensure that power source is capable of delivering power for entire coupling fusion time without interruption (check generator for full fuel supply). Ensure that all connections are tight and clean. Loose connections can result in arcing or blown fuses.

- 120 Volt: A minimum 7000 watt **continuous** supply generator capable of delivering 115 volts to 135 volts at 60 Hz to the control box. Minimum 30 amp breaker with “slow blow” or time delay fuse.
- 240 Volt: A minimum 7000 watt **continuous** supply generator capable of delivering 180 volts to 300 volts at 60 Hz to the control box. Minimum 30 amp breaker with “slow blow” or time delay fuse.
- Do not connect other electrical devices to the generator during fusion

Consult the control box manufacturer for further details on recommended generator requirements.

⊘ **Do not use welding generators.**

⚠ **CAUTION:** The rated capacity of a generator is less than the peak generator capacity; use the lower of the two stated capacities. The age of the generator further reduces its capacity. The generator governor control (economy switch) 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. Verify the performance of generators by test sets such as <http://www.sotcher.com/Load Bank Generator Test Sets>. Generator maintenance must be performed on defined schedule; examples include https://www.briggsandstratton.com/na/en_us/buying-guides/portable-generators/portable-generators-101/storage-and-maintenance.html

IX. FUSION PARAMETERS

Enter fusion parameters including but not limited to: fitting manufacturer, fitting size, fusion time, voltage, and cooling time, into the control box by scanning the bar code.

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.

- A. Codes are displayed on the fitting label in an interleaved barcode format that can be read by a barcode wand or hand-held scanner. Keep bar code scanners clean to insure proper working order.
- B. Because of limitations in the number of characters allowed by the barcode standard, DIPS fittings will not display accurately. DIPS sizes will display as the

metric (mm) equivalent, or as non-standard IPS sizes. For DIPS sizes, consult EF processor or fitting manufacturer for further information.

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



Figure IX-a – Barcode with Numerical Value

X. ELECTROFUSION INSTALLATION TRAINING PROCEDURES

A. COUPLING INSTALLATION:

1. Cut the pipe ends (Figure X-a) squarely and evenly.



Figure X-a – Cut Pipe Ends

2. Clean inside and outside of both pipe ends (Figure X-b) by removing dirt, mud, and other debris. USE clean water for initial cleaning of pipe surfaces prior to scraping. Clean the pipe for a length far enough beyond the fusion area to ensure that remaining debris on the pipe surfaces will not be transferred to the area to be prepared during handling. Dry with a clean lint free towel.



Figure X-b – Clean Pipe Ends

3. Measure and mark the stab depth on the pipe ends (Figure X-c). 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 $\frac{1}{2}$ 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 (witness lines) to be scraped with longitudinal and/or circumferential lines.

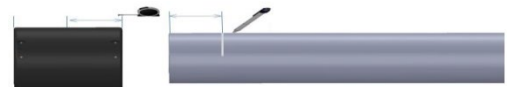


Figure X-c- Measure and mark Stab Depth

Clean surface of EF fitting and fusion area of the pipe with approved alcohol, do not scrape EF Fitting.

When one of the pipes to be joined has limited movement capability, it may be necessary to slide the coupling onto the pipe for its full depth before placing the other pipe in place (Figure X-d). If the full coupling must be placed on one pipe end, clean and scrape that pipe end for a minimum of the full depth of the coupling to avoid contamination. Use the depth mark on the opposite pipe for centering the coupling assuming that the two pipe ends are butted/in contact (Figure X-e).

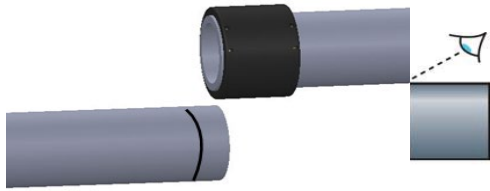


Figure X-d – Limited Movement Example

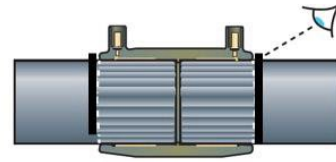


Figure X-e – Center Couplings Between Depth Marks

4. Scrape the outside of the pipe surface to remove oxidation and other contaminants (Figure X-f). 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.



Figure X-f – Pipe Scraping

Re-mark pipe to replace original stab depth marking removed by scraping. Use this mark as visual indication by the installer that the pipe ends are correctly inserted to the center of the coupler. Apply re-rounding tools if alignment clamp does not act as re-rounding tool. (Note: there are large diameter alignment tools that act as re-rounding tools).

⚠ While not common, it is possible to remove too much surface material by repeated scraping. Removal of 0.040” is the maximum recommended. Use caution if scraping multiple times to ensure that the pipe OD is not reduced (by more than the allowable minimum diameter) to the point that the gap between the pipe and fitting is too large.

5. Do not touch the scraped pipe surface or the inside of the coupler as body oils and other contaminants can adversely affect fusion joint quality. Commercially 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. Installer should have a handy source of clean disposable wipes available to avoid reuse/contamination issues. Note: ASTM F2620 and F1290 allow 90% concentration or greater.

⊘ Do not use Denatured Alcohol.

6. Install coupler onto the pipe ends so that the stab depth marks are aligned at the outer edges of the coupler. Chamfer or bevel the pipe ends (if required by manufacturer) to allow for easier insertion into the coupler. Use re-round clamps or other available fittings as anchors for pulling couplers onto pipe with mechanical assist devices such as a hand winch. **Use care not to damage internal wire or terminal pins.** Leave plastic bag over one end of coupler to prevent contamination, and debris from entering the open end. If necessary, use a rubber mallet (or metal hammer and wood blocks) to move coupler onto pipe. (Figure X-g).



Figure X-g – Avoid Contamination During Installation

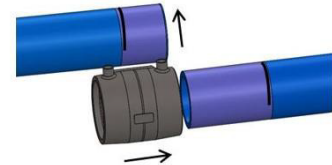
⚠ CAUTION: AVOID ALL POSSIBLE RECONTAMINATION OF THE PREPARED SURFACE. Keep one end of the coupling bagged during this process.

⚠ Note: Chamfer or bevel pipe ends (if required by manufacturer) on the outer edges when installing couplings that incorporate bare exposed heating wires to prevent snagging of wires on pipe edge.

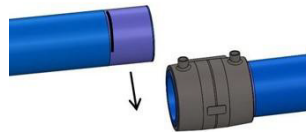
When making a repair, or in situations where the coupling must slide completely over one of the pipe ends, scrape that pipe end for a minimum of the entire length of the coupling (Figure X-h).



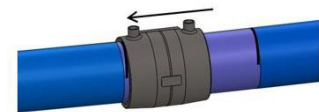
Step 1 - Measure and scrape one end for the full length of the coupling, measure and scrape the other end for ½ the coupling length. Remark stab depths after scraping if necessary.



Step 2 - Install the coupling by moving one pipe end to the side, then slide the coupling over the fully scraped pipe end.



Step 3 - Move the pipe end back into place.



Step 4 - Slide coupling over other pipe end to stab depth markings.

Figure X-h – Repair - Coupling Over Entire Pipe End

7. Clamp the pipe ends to align and secure the assembly (Figure X-i). Coupling and pipe assembly must be immobile during the fusion and cooling cycles.



Figure X-i – Clamp and Secure

8. Connect the fitting to the control box (Figure X-j), enter the fusion parameters (bar code scan the fitting), and fuse the joint. See “Fusion Parameter” section for details.

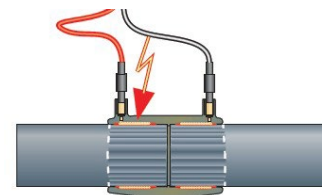


Figure X-j – Connect Fitting to Control Box

9. Mark the time of day on the fitting (or pipe) when the fusion cycle ends. If required by the pipeline owner, note additional information such as: date, fusion record number, installer name and identification number, fusion ID card number, contractor name, fusion machine identification number, time of day when Cooling Time will elapse, etc.
10. Allow the fused fitting and pipe assembly to remain clamped (alignment clamp and rounding clamp) and undisturbed for the Cooling Time (Tables X-a and X-b).

⊘ Cooling is a vital part of the fusion process. Observe Cooling Time and do not disturb fused joints until the Cooling Time has elapsed.

Table X-a: Cooling Time Guidelines for Couplings*

Coupling Sizes and (Pressure Class, psi)	IPS Cooling Time	DIPS Cooling Time
14" - 30" (PC 200)	3 hrs.	3 hrs.

*The Cooling Time must be observed prior to removal of clamps, movement, backfilling, pressure testing, tapping or placing the fitting in service. Consult manufacturer for other Pressure Classes.

B. SADDLE INSTALLATION:

1. Clean the pipe (Figure X-k) 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.



Figure X-k – Clean Pipe

2. Re-rounding Clamps: Installer shall always use 2 re-rounding clamps to re-round the saddle installation location regardless of OOR.
3. Mark the saddle installation area on the pipe (Figure X-l). 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.

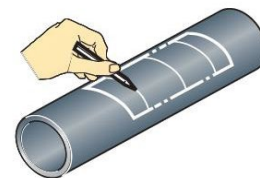


Figure X-l – Mark Installation Area

4. Scrape the outside of the pipe surface (Figure X-m) 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 2. Inspect the entire scraped area to ensure total scraping coverage and removal of witness marks.

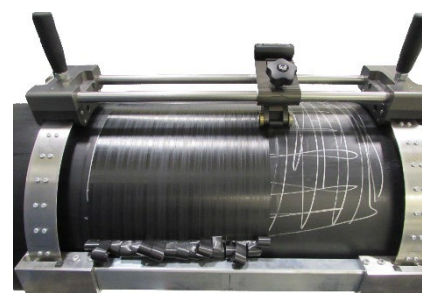


Figure X-m – Scrape Pipe

5. Do not touch the scraped pipe surface or the inside of the saddle fitting as body oils and other contaminants can adversely affect fusion. Commercially 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: ASTM F2620 and F1290 allow 90% concentration or greater.

⊘ Avoid all possible recontamination of the prepared surface

⊘ **Do not use Denatured Alcohol.**

6. Place the saddle over the scraped pipe surface (Figure X-n). Ensure that the fitting fusion surface is only in contact with the scraped pipe surface.



Figure X-n – Place Saddle Over Scraped Surface

7. Secure the saddle-to-pipe assembly with the appropriate clamping mechanism required by the fitting manufacturer. If bolts are used in the clamping device (note not all clamps are associated with bolts-see Figure X-t) make sure they are tightened in the proper sequence and the required amount of torque /engagement per the manufacturers' instructions. See "clamping" section of this guide for further details. Some manufacturers specify allowable gaps between the underside of saddles and pipe OD. Consult saddle manufacturer for allowable gap dimension.

⚠ **Use only the clamps provided or required by the fitting manufacturer. Clamps from one manufacturer's fitting are not interchangeable with another's.**

8. Connect the fitting to the control box (Figure X-o), enter the fusion parameters, and fuse the saddle. See "Fusion Parameter" section for details.

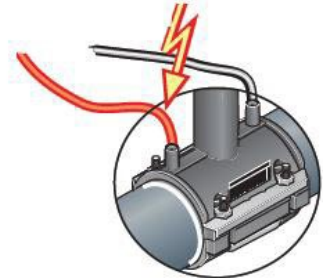


Figure X-o – Connect Fitting to Control Box

9. Allow the fused fitting and pipe assembly to remain clamped and undisturbed for the Cooling Time.

⊘ **Do not tap saddle fittings until after observance of 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.**

11. After the Cooling Time elapses, conduct pressure leakage testing per ASTM standards. Limit the test pressure to a minimum of 1.5 x working pressure (and a maximum of 1.5 x PC). If leakage is observed at a fusion joint, the fitting shall be depressurized and abandoned in place and a new fitting installed. **Do not use end closures or mechanical end caps that are defective or that cannot be fully restrained.** (Figure X-p).



Figure X-p – Pressure Testing

⚠ Pressure testing (Hydrostatic or pneumatic) can be dangerous. Per ASTM F2164/F2786, take measures to structurally restrain all parts of the section under test against movement if failure occurs. Observe manufacturer’s precautions for securing and restraining mechanical end (test) caps.

Table X-b: Cooling Time Guidelines for Saddle Type Fittings

Branch Saddles	Cooling Times
14” to 30”	1 hr. 12 min.

C. INSTALLATION INSPECTION CHECKLIST:

1. **SQUARE CUT:** Cut pipe ends squarely to 90° with a ½ inch maximum gap as measured from Carpenter’s Square. Find the largest gap by rotating the Carpenter’s Square. To obtain minimal gap between the pipe ends the installer may have to use additional tooling to remove high spots (planer).

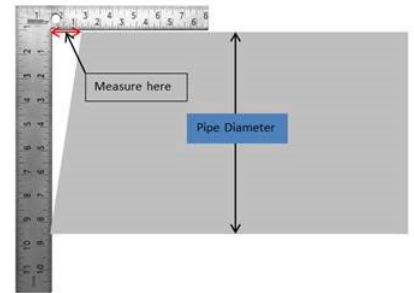


Figure X-q – Check for Square-ness

2. **Re-rounding Clamps:** Installer shall use re-rounding clamps to re-round the pipe regardless of OOR.
3. **SCRAPING:** A properly scraped pipe has a thin outer layer of the pipe surface removed to expose clean virgin PE material for fusion. Witness marks can be very helpful and shall be used in all cases to ensure that the entire surface has been scraped, and that an adequate amount of material has been removed. Marking the pipe surface with a permanent marker is a simple and effective step. Removal of the pipe print line as a depth indicator is also useful, but should not be used as the only means to determine that proper scraping has been accomplished. (Refer to Figure X-r and Figure X-s for correct and incorrect scraping.)



Figure X-r - **Correct Scraping**

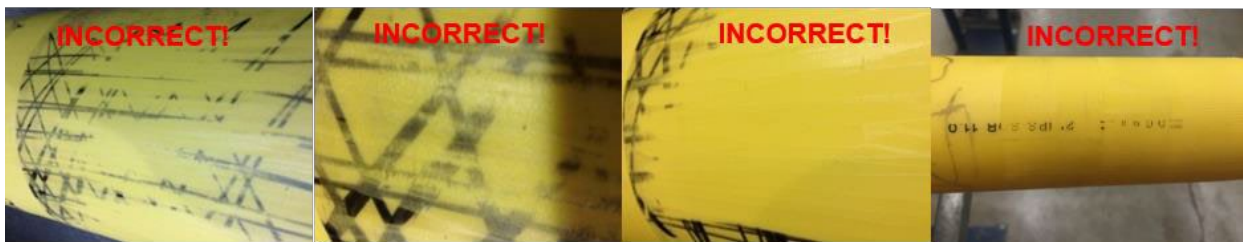


Figure X-s - **Incorrect Scraping!** Improper surface preparation / Not enough material removed, marks still visible.

4. CLAMPING/ASSEMBLY/ALIGNMENT: Clamps are necessary to ensure:
 - a) pipe is properly aligned and re-rounded
 - b) no external stresses are exerted on the fitting or assembly
 - c) blocking to support both the pipe and fitting
 - d) no movement occurs during the melt and cooling phases
 - e) saddle fittings are securely clamped to the main. (Figure X-t)

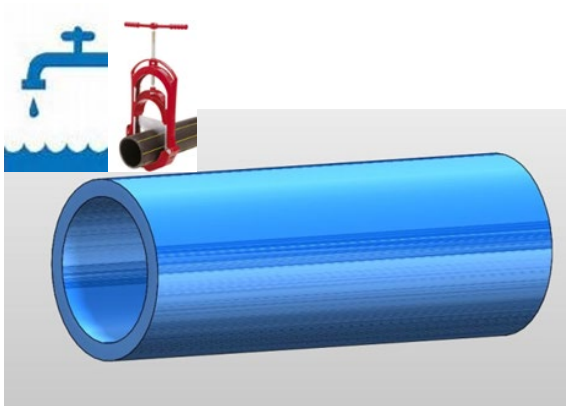


Figure X-t – Saddle Clamp

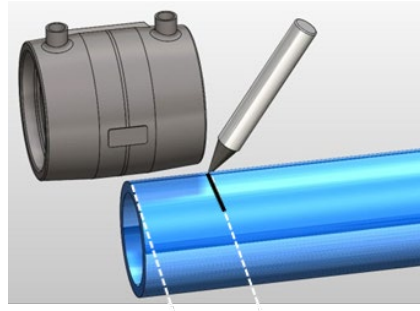
5. FUSION
 - a) Ensure that the generator or power source is adequately sized for the fitting being fused.
 - b) Ensure the generator fuel tank is full.
6. COOLING: Allow the fused fitting and pipe assembly to remain clamped and undisturbed for the Cooling Time. The Installer shall add the Cooling Time to the time observed at the end of the fusion heating cycle and mark it on the pipe to provide a reference for time of day when the Cooling Time will elapse. Observe the Cooling Time prior to removal of clamps, movement, backfilling, pressure testing, tapping or placing the fitting in service.

⊘ Do not move or expose pipe and fitting to stress before the Cooling Time elapses!

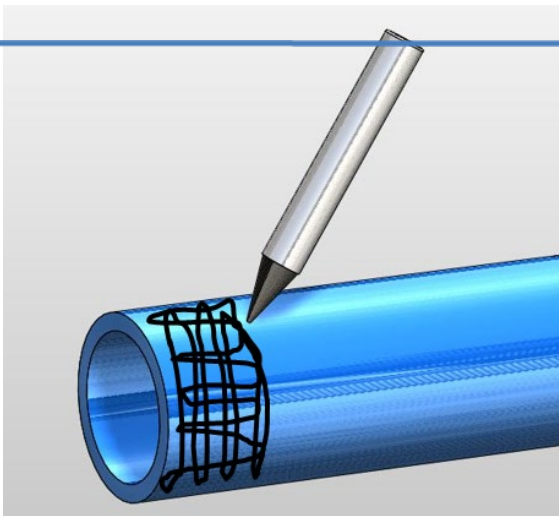
XI. FIELD GUIDE FOR ELECTROFUSION COUPLING INSTALLATION



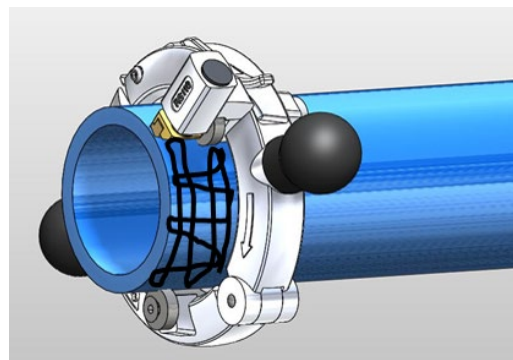
1. Clean pipe ends with clean water and cut as squarely ($\leq \frac{1}{2}$ inch) as possible. See Sections V (B/C) and X-A.2.



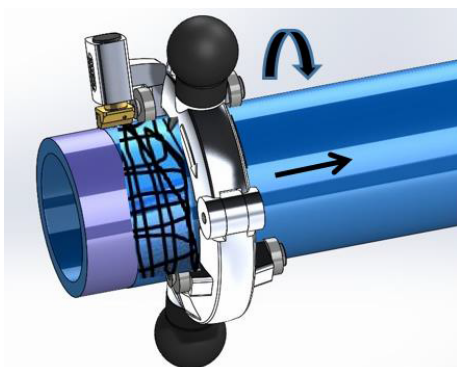
2. Measure and mark the stab depth on both pipe ends



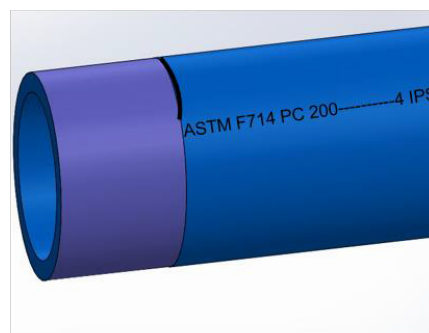
3. Mark the pipe surface to be scraped in a criss-cross pattern.



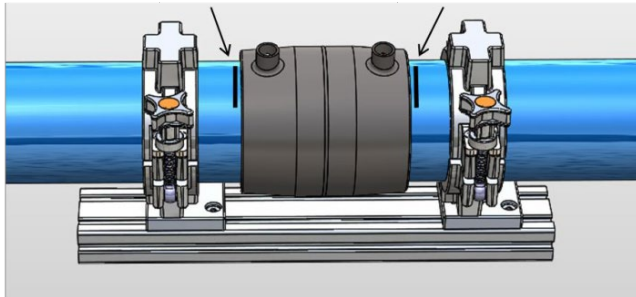
4. Mount the scraper over the area to be scraped.



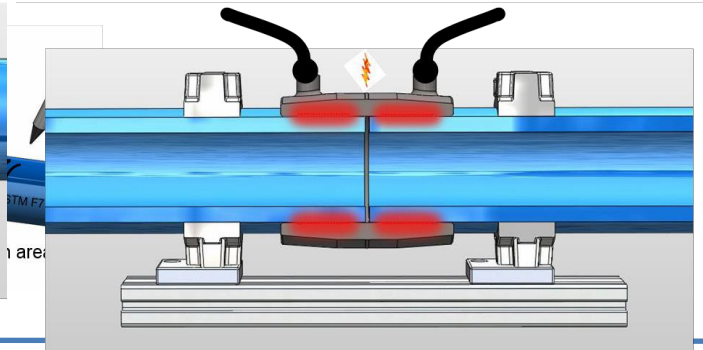
5. Scrape or peel the pipe to remove the surface layer and expose clean virgin pipe beneath.



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

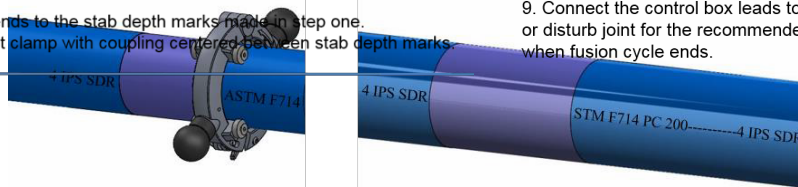


7. Clean surfaces with Isopropyl alcohol if necessary, avoid touching cleaned surfaces.



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

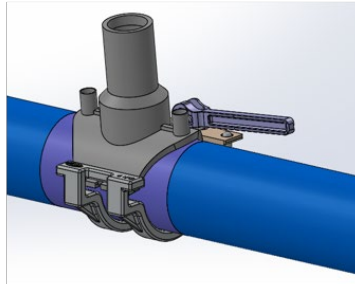
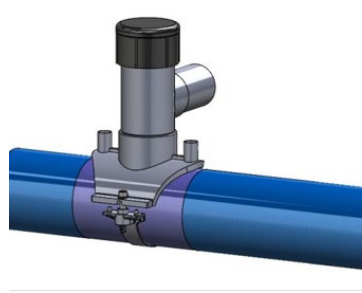
8. Insert the pipe ends to the stab depth marks made in step one. Secure in alignment clamp with coupling centered between stab depth marks.



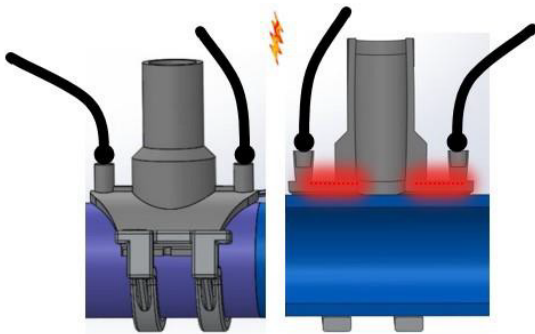
3. Scrape or peel the pipe to remove any surface contaminants and expose clean virgin pipe beneath.

4. Inspect the scraped pipe surface thoroughly to ensure the clean virgin pipe surface is exposed.

XII. FIELD GUIDE FOR ELECTROFUSION SADDLE INSTALLATION



5. Clean surfaces with Isopropyl alcohol, avoid touching cleaned surfaces. Clamp saddle to the scraped pipe using only the clamp provided or recommended by the fitting manufacturer.



6. 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 the time of day on fitting when fusion cycle ends. Picture to left shows clamps to pipe and picture to right shows EF.



7. After observance of cooling time and prior to tapping main, saddle should be pressure leak tested. It is recommended to use hydrostatic testing whenever possible. Care must be exercised during pressure testing of saddles due to the stored energy of the test fluid. Pipe plugs or other sealing mechanisms should be restrained to avoid expulsion and possible safety related issues associated with this procedure. Refer to ASTM F2786 when performing pneumatic tests.

XIII. FREQUENTLY ASKED QUESTIONS

A. What pipes can be fused with electrofusion fittings?

1. Electrofusion fittings are compatible with pipe dimensions conforming to AWWA C906, ASTM D2513, F714 and D3035.
2. Fittings are typically compatible with pipes with a SDR or DR range of 9 to 17. Other wall thickness ranges and pressure ratings may also apply. Consult the specific fitting manufacturer for details.
3. Electrofusion fittings are compatible with PE 2406/2708 and PE3408/3608/3708/3710/4710 pipes.

B. What are the power requirements?

A reliable source of AC power is necessary for a successful fusion.

1. Generator – well maintained generator providing a minimum of 7000 watts continuous output.
 - b. Prior to the electrofusion cycle fill generator with fuel.
 - c. The governor/economy switch should be off so that the throttle is opened all the way in anticipation of the power draw at the start of the fusion cycle.
 - d. Insure that the generator is fully warmed up prior to attempting electrofusion procedure.
1. Provide output voltage in the range that meets the specifications of the applicable processor model.
2. Rated for 60 Hertz.
3. A matching outlet is needed to mate with the plug equipped on the electrofusion processor.

C. Can I use an extension cord with my processor?

Avoid the use of extension cords; in the event an extension cord must be used, a 25 foot cord shall have a minimum wire gauge of #8/3 AWG.

D. Can I use a pigtail or electrical adaptor with my electrofusion processor? **No**, connect the power cord directly from the processor to generator.

E. What are the most common electrofusion failures? Electrofusion has proven to be an extremely reliable joining system. The most common reasons for failure account for more than 95% of all fusion failures:

1. Contamination – inadequate pipe preparation
 - a. Inadequate scraping
 - b. Dirt, mud, dust
 - c. Grease, oils
 - d. Moisture
 - e. Hands (body oil, sunscreen, etc.)
 - f. Solvents, unsuitable wiping fluids
 - g. Unclean or unsuitable wiping rags
2. Geometry – pipe out of round or not cut square
 - a. Alignment Errors
 - i. Pipe Mis-Stab: pipe not cut square and pipe ends not being centered in the fitting.

- ii. Short Stab: can result from improper insertion of the pipe or movement during weld due to incorrect restraint
- iii. Mis-alignment of pipes and fitting
- iv. Flat spots on pipe
- v. Excessive Gap
 - excessive gap between pipe and fitting due to pipe out of roundness, undersized pipe or over scraping of pipe surface.
 - Pipe ends not butted together
 - Pipe ends are not cut square.
- vi. Pipe Movement during Fusion Cycle – due to external forces or forces induced by the welding process, when the pipes are not clamped properly.
- vii. Movement – pipe not properly restrained during fusion process
- viii. Unusual conditions - Contact EF manufacturers if you observe smoke or melt flow outside the fitting.
- ix. Over Scraping (never exceed 0.040 inches)

3. Removal of clamping equipment before observance of minimum Cooling Time.

F. Can I use sandpaper, dragon skin, emery cloth or wipes to scrape the PE pipe?

No, it is very important to never use abrasive materials such as sand paper, dragon skin or emery cloth and wipes in place of an approved scraping tool. Abrasive materials have been proven to be ineffective in the removal of sufficient amounts to surface material needed to achieve an electrofusion bond and in fact have been shown to impede the electrofusion process. See “SCRAPER” section of this document.

 **Wood rasps and metal files are not acceptable for scraping PE pipe.**

G. Why does the fitting need to observe the Cooling Time prior to removal of re-rounding and alignment clamps, movement, backfilling, pressure testing, tapping or placing the fitting in service?

1. It is often assumed that if the fitting is cool enough to touch it must be cool enough to remove the restraint device, pressure test, movement, backfill, tap or return to service. The cooling phase is critical to the success of the electrofusion process. Careful attention shall be given to insure the observance of the stated Cooling Time.
2. When current is applied to the fitting the plastic in the fitting and on the pipe surface begins to melt and form a melt pool. With continued application of current the melt pool deepens at the pipe and fitting interface which in turn forces internal pressure to build up. After the heating phase, the melt pool re-solidifies. This process is known as co-crystallization between the melted pipe and fitting material. The cooling phase provides a controlled environment between the pipe and fitting where solidification can effectively take place. This cooling phase begins immediately following the termination of current being supplied to the fitting and continues for a period of time beyond the point where the PE polymer re-solidifies. This allows ample time for the fusion area to regain the strength and flexibility it exhibited prior to fusion. Any movement or external stresses applied to the fused area during this cooling phase may result in a compromised fusion joint.

H. Do I need to use clamps?

1. Electrofusion couplings:

- a. All electrofusion couplings require the pipe to be restrained and sufficiently supported on each side of the pipe to restrict movement during the fusion and cooling processes and alleviate or eliminate sources of stress and/or strain until both the fusion heating and cooling cycles are complete.
- b. To achieve immobility, use of some form of pipe restraint and support for the primary purpose of controlling and eliminating any movement of the fitting due to fusion pressures generated during the fusion processes or any external forces exerted on the pipe or fitting. The basis for using a pipe restraint system and support when joining two pieces of PE pipe with an electrofusion coupling is to:
 - Minimize potential short stab, mis-stab or binding situations
 - Ensure proper cold zone contact with the prepared fusion area so that sufficient interfacial pressure is built up
 - Eliminate unwanted loss of molten material from the fusion zone
 - Re-round the pipe

2. Electrofusion saddles

Electrofusion saddle fittings include tapping tees, branch saddles, corporation/transition saddles and others. Installation of an electrofusion saddle requires the use of recommended re-rounding clamps and restraint systems for the purpose of:

- a. Holding the fitting in place during the fusion process
- b. Eliminating fitting movement due to material expansion
- c. Ensuring proper cold zone contact with the prepared fusion area so that sufficient interfacial pressure is built up

⚠ To ensure good joint integrity during the fusion process and Cooling Time, the joint must remain stationary and free from stress.

⚠ The installer is cautioned against attaching appurtenances to the outlet of saddle-type fittings before fusion. All appurtenances to the saddle outlet shall be self-supported and only installed after observance of Cooling Time.

⚠ All appurtenances (tees, elbows, services, valves, air relief valves, fire hydrants, etc.), must be independently supported and shall not rely on the pipeline and its connections for this support. Excessive stresses may be encountered when appurtenances are inadequately supported.

I. Can electrofusion couplings be re-fused if I have a power related failure?

1. Electrofusion couplings can be re-fused only in the event of an input power interruption.

- a. Fusion leads were detached during fusion
- b. Generator runs out of gas
- c. Other circumstances that results in processor input power interruption

2. Recommended procedure for re-fusing couplings:

- a. Keep coupling in restrained position.
- b. Allow coupling to cool completely to ambient temperature. Installers shall follow

- the instructions of the manufacturer. Additional instrumentation (pyro meter) is required to determine when the assembly reaches ambient temperature.
- c. Reconnect coupling to the processor.
 - d. Refuse coupling completely for the entire fusion cycle.

⚠ Only use this re-fusion procedure for fusions that terminated due to input power reasons. Remove and discard couplings that fault for any other reason.

XIV. INSTALLER TRAINING AND QUALIFICATION GUIDELINES

Installer Experience: Only properly trained persons, that have a strong working knowledge of polyethylene and heat fusion, and have qualified 14 inch and larger electrofusion joints through destructive testing shall install electrofusion fittings. This document is a guide only, and should not be used in place of training and qualification. Failure to follow all preparation steps can result in joint failure or leakage due to contamination or improper installation resulting in significant financial impact.

Destructive tests are described in ASTM F1055 (latest edition) and can be in the form of burst tests, bend tests, peel tests and other methods useful in determining the quality of a fusion joint. See Section D in XIV for additional information on destructive testing.

⚠ It is the owner's responsibility to specify EF procedures and qualify installers.

A. Scope

This section applies to the Generic Electrofusion Procedure for Field Joining of Polyethylene (PE) Pipe and specifies the method of testing the knowledge and skill of an installer who is authorized to perform electrofusion joining to polyethylene pipe ≥ 14 inch in diameter. The examination of an installer is essential for the assurance of the installer's skills and quality of electrofusion work. The application of this section is intended to ensure that the examination is carried out according to a uniform and standard test method.

B. Training and Qualification

1. Any installer that performs or inspects electrofusion joints on polyethylene (PE) pipe shall successfully complete an annual electrofusion training program or more frequently if required.
2. During the qualification test, the installer shall demonstrate practical skill and knowledge of electrofusion joining methods on PE pipe.
3. The qualification test will be carried out in two parts under the direction of the utility.
 - a. The installer will answer questions relevant to electrofusion qualification testing. The questions will be presented to the installer in written form. The written test will be a True/False and/or multiple choice questionnaire. The installer must answer all questions correctly! 100% is the only passing grade.
 - b. The installer will perform a minimum of two electrofusion joints (one coupler and one saddle) adhering to this Generic Electrofusion Procedure. Use a 14 inch or larger coupling and a 14 inch or larger main size saddle fitting as test specimens. This will qualify the installer for electrofusion joining 14 to 30 inch.
 - i. The utility shall require all tooling to be used in the field for qualification testing of the installer. Installers will supply all tooling, power supplies, fittings and pipe similar to actual field conditions so the utility can inventory tooling, verify quality of tooling and generator performance including any extension cords intended for work. A controlled environment does not represent field conditions.

- ii. The utility shall witness the entire fusion procedure and all required steps to perform fusion. If anything is skipped or inadequately performed, including observing Cooling Time, rejection of the installer is required and the prepared fitting will not be tested. If and only if, all of the required steps are conducted, all of the required tooling is used and is in good working order and the Cooling Time is observed, the fitting is destructively tested per ASTM F1055.
- iii. The installer will make and submit electrofusion joints for approval via the attached destructive testing procedures in Section D. Individuals who successfully complete both sections of the testing will be qualified to perform electrofusion joints on polyethylene piping ≥ 14 inch.
- iv. All installers must requalify annually. If any failures associated with their work are encountered, the installer must be requalified. Fusion failures are defined as leaking connections allowed to be placed into service. If a fitting fails during fusion or by observance after installation but before being placed into service it does not count as a joint failure (it is critical for the fuser to identify and cut out bad joints without penalty).

C. Electrofusion Joint Failures

Electrofusion joint failures that are detected during pressure tests are subject to the provision set forth in Section E.

D. Destructive Testing Procedures for Electrofusion Fitting Qualification

The following test methods are useful as an evaluation of fusion quality between the pipe and fitting. These procedures are based on requirements from current version of ASTM F1055 Standard *Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing* Fusion Evaluation Test section. Refer to ASTM F1055 for more detailed test requirements. These tests can be used as user qualification criteria. As these methods are destructive, they are only useful in determining joint quality of a fitting that was fused for the purpose of testing, and cannot be used for testing of fusions intended for service. One of the following methods should be utilized for destructive testing as outlined in ASTM F1055 (latest edition).

1. **Couplings:**

Bend tests, peel tests, and crush tests are helpful in locating fusion weaknesses. It is desirable to obtain x-ray photographs of the fitting before dissection to locate any possible contact points of the fusion coil.

When large diameter crush tests are impractical, the strip bend back test or other methods (see ASTM F1055) may be utilized.

To prepare a specimen for crush testing, it is necessary to cut the pipe and coupling longitudinally in half as near to the centerline of the pipe and coupling as possible. It is desirable to leave at least 12" (300mm) of pipe length at each end of the coupler.

Place a specimen half in a vise so that the outermost wire of the fusion zone is approximately 1 1/4" (32mm) from the vise jaws. (Figure XIV-a)

Close the vise jaws until the pipe walls meet. (Figure XIV-b)

Repeat this process for each end of both halves of the coupling.

Inspect the crushed specimens for separation of the pipe and fitting in the fusion zone. Some minor separation (up to 15% measured as shown in the following examples) may be seen at the outermost region of the fusion zone, this does not constitute failure. Ductile failure of the pipe, fitting, or PE insulation around the wires is acceptable. There should be no separation at the fusion interface of the pipe and fitting. Passing (Figure XIV-c) and failing (Figure XIV-d) results are shown in the photographs.

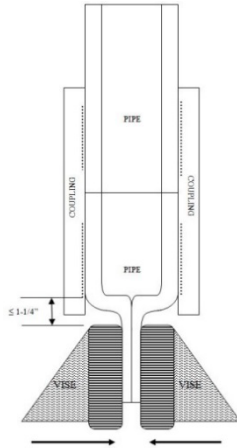


Figure XIV-a

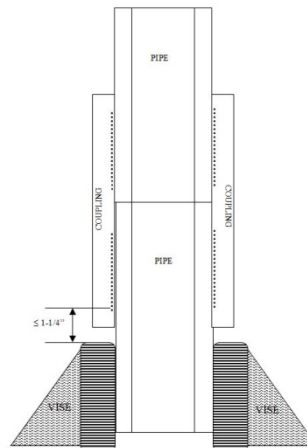


Figure XIV-b

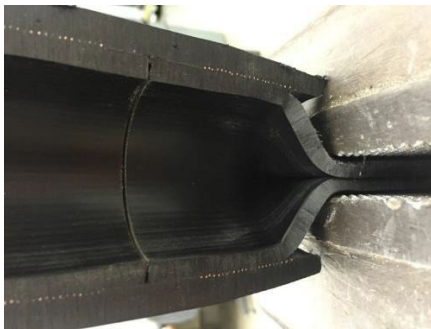


Figure XIV-c - Pass

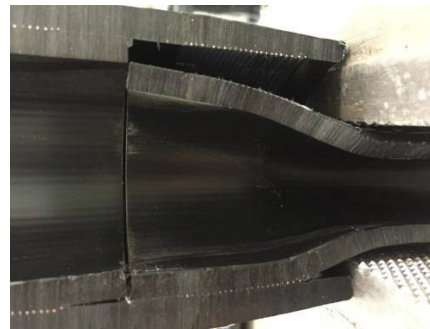


Figure XIV-d - Fail

2. Saddles/Tapping Tees

Leave tapping tees intact for crush testing. Pipe lengths can be cut to the edges of the fitting base.

Place the pipe and fitting into a vise (or suitable press) so that the jaws are within 1/2" (13mm) of the bottom of the saddle (Figure XIV-e). Close the vise until the pipe walls meet (Fig. XIV-f).

Inspect the crushed specimens for separation of the pipe and fitting in the fusion zone. Some minor separation (up to 15%) may be seen at the outermost region of the fusion zone, this does not constitute failure. Ductile failure of the pipe, fitting, or PE insulation around the wires is acceptable. There should be no separation at the fusion interface of the pipe and fitting. Passing (Figure XIV-g) and failing (Figure XIV-h) results are shown in the photographs.

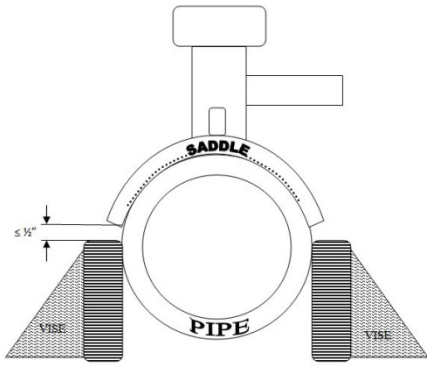


Figure XIV-e

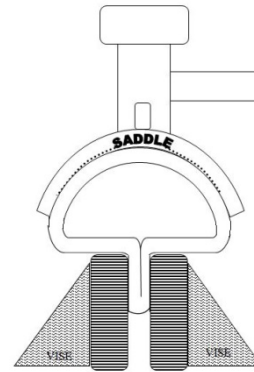


Figure XIV-f

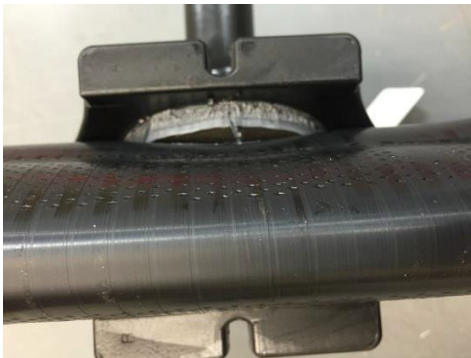


Figure XIV-g - PASS



Figure XIV-h - FAIL

Further evaluations are possible by cutting the fusion area and surrounding pipe and fitting materials in thin longitudinal /cross sectional strips for bend tests. Place the strips into a vise and bend 90 degrees in both directions directly at the fusion interface and evaluate for separation. Use the same visual criteria for fusion evaluation tests and crush tests. (Figure XIV-i)

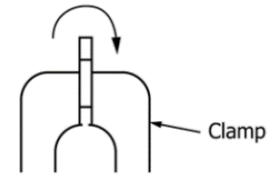


Figure XIV-i

Couplings should have four longitudinal strips cut from the fusion interface at 90 degree intervals as shown (Figure XIV-j). The strips should be approximately 1/8" (3mm) in thickness. Place the strips into a vise and bend 90 degrees in both directions directly at the fusion interface and evaluate for separation.

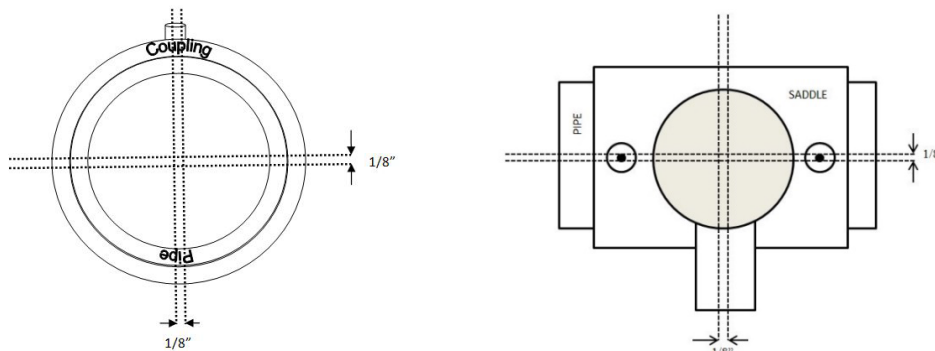


Figure XIV-j

Tapping Tees should have strips cut along the center line of the pipe through the fitting fusion surface and a strip cut from the radial side of each half of the fitting, totaling 4 strips for each sample fusion made. Place the strips into a vise and bend 90 degrees in both directions directly at the fusion interface and evaluated for separation.

E. Required Re-Qualification and Retraining

Failed electrofusion joints determined to be caused by improper installation procedures warrant retraining and/or qualification of the installer. If an installer has failed electrofusion joint(s) under the provision previously listed or is observed using non specified or faulty equipment or not strictly adhering to all fusion procedures that installer will be disqualified from making additional electrofusion joints, their qualification revoked, and will require additional training and requalification before performing any additional fusion joining.

F. Test Result and qualification test certificate

1. Issue the installer a certificate (Qualification Card) upon successful completion of the Generic MAB Electrofusion Installer Qualification Test (See Appendices B and C); the Qualification Card is valid for one year from date of issuance.
2. Successful Completion: Installer cannot miss any questions on the written test.
 - a) Installer who misses two (2) questions or less can re-address the specific questions with the trainer and re-take written test in its entirety.
 - b) In event of fitting failure from destructive testing, the Installer shall prepare an additional specimen (of the same fitting type) for destructive testing.
3. Qualification Test Certificate
Certificate shall contain the following:
 - a) Installers Full Name
 - b) Date, Place of training
 - c) Date of Issue
 - d) Expiration Date of Certificate
 - e) Signature of Authorized Trainer
 - f) Indication of qualified type of fitting(s)
 - g) Owner card number
 - h) Photograph of installer
 - i) Name of utility owner

Appendix A – List of Electrofusion Manufacturing Companies

The following Electrofusion companies (listed alphabetically) endorse this generic electrofusion procedure for use with their Fittings. This list will be updated as needed.

1. Agru America (800) 373-2478 <http://agruamerica.com>
2. Georg Fischer Central Plastics (800) 654-3872 www.gfcp.com
3. Integrity Fusion Products (770) 632-7530 <http://integrityfusion.com>
4. IPEX Inc. (866) 473-9462 <http://www.ipexinc.com/>
5. Plasson USA (800) 241-4175 www.plassonusa.com
6. Strongbridge-Tega (904) 278-7499 <http://strongbridge.us/>

Appendix B – Generic Electrofusion Installer Qualification Test

DESTRUCTIVE TESTING

Installer Name: _____ Date: _____ Location: _____

Electrofusion Coupling 14 inch to 30 inch

Fitting Size:
Fitting Manufacturer:
Fitting Fusion Time:
Fitting Cooling Time:

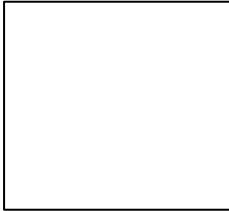
PASS/FAIL: _____

Electrofusion Saddle Fitting 14 inch to 30 inch

Fitting Size:
Fitting Manufacturer:
Fitting Fusion Time:
Fitting Cooling Time:

PASS/FAIL: _____

Authorized Trainer: _____ Date: _____

Qualification Test Certificate	Qualification Card No: ####	Insert Photo
(Installer Name) _____ has successfully completed the training requirements for qualifications to install 14 – 30 inch Electrofusion Fittings according to (Utility Name) _____ Department Standards		
<input type="checkbox"/> Couplings <input type="checkbox"/> Saddles		
I have instructed and tested the above in all requirements and procedures related to installation of Electrofusion Fittings according to (Utility Name) Department Standards.		
Authorized Instructor	Date Issued	Expiration Date
_____	_____	_____

Appendix C – Sample Test

The following is a sample written qualification test.

Users should modify this test to address their unique operating environment.

Generic Electrofusion Installer Training & Qualification Section

Installer Name: _____ **Date:** _____

Location: _____

Answer all Questions with either T for True or F for False. The installer must answer all questions correctly! 100% is the only passing grade.

1. The purpose of scraping is to remove the oxidized layer of PE pipe from the pipe surface prior to electrofusion.
 - a. True
 - b. False
2. For out of round pipe it is acceptable to scrape the high points until the pipe fits into the electrofusion coupling.
 - a. True
 - b. False
3. Sand paper, dragon skin, emery cloth, and other abrasives are acceptable for scraping.
 - a. True
 - b. False
4. If the pipe becomes re-contaminated with dirt after scraping it is acceptable to use Isopropyl Alcohol for cleaning purposes.
 - a. True
 - b. False
5. It is acceptable to perform an electrofusion with a slight trickle of water running across the fusion area.
 - a. True
 - b. False
6. The Cooling Time for 14" to 30" couplings is 3 hrs.
 - a. True
 - b. False
7. Perform pressure testing, movement, backfill, tapping and return to service immediately after the electrofusion power cycle is complete
 - a. True
 - b. False
8. Cut pipe ends square within $\pm 1/2$ " for coupling installation
 - a. True
 - b. False

9. A 2500 watt continuous output generator is recommended for fusing electrofusion couplings (14 inch to 30 inch).
 - a. True
 - b. False
10. Do not use slow drying markers that contain oils when marking the pipe for scraping.
 - a. True
 - b. False
11. If the electrofusion coupling is to be pushed completely over one pipe, it is necessary to scrape the entire length of the coupling onto one of the pipes.
 - a. True
 - b. False
12. A standard metal file is acceptable for scraping the pipe surface.
 - a. True
 - b. False
13. There is no need to support hanging pipe ends during fusion.
 - a. True
 - b. False
14. Installers must re-qualify annually or if they make any bad joint.
 - a. True
 - b. False
15. Observance of pipe print line under saddle fitting fusion area after scraping is acceptable.
 - a. True
 - b. False
16. A gouge or scratch in the pipe of more than 10% of the wall thickness is acceptable.
 - a. True
 - b. False
17. It is acceptable to pressure test a saddle fitting prior to tapping.
 - a. True
 - b. False
18. Always use alignment clamps with electrofusion couplings.
 - a. True
 - b. False
19. Check the generator prior to electrofusion to make sure it is full of gas.
 - a. True
 - b. False
20. Keep electrofusion fittings in original packaging until installed.
 - a. True
 - b. False

Number Correct: _____

Authorized Trainer: _____ **Date:** _____

APPENDIX D – ELECTROFUSION COUPLING INSTALLATION INSPECTION CHECKLIST

Location / Job # _____ Station # _____ Date/Time _____
 Fusion Technician _____ Company _____ Certificate Card # _____
 Installer Credential Issue Date _____ Credential issued by _____
 Pipe Manufacturer _____ Material Type _____
 Pipe Size _____ DR _____
 EF Coupling Manufacturer _____ Part # _____ Description _____
 EF Processor Model _____ Serial Number _____
 Generator Make & Model _____ Serial Number _____
 Temperature / Weather _____ Trench Conditions _____

General:	
Inspect the equipment for cleanliness and proper operation.	
Verify that the generator / power source is adequately sized.	
Check that the generator is full of gas.	
Verify that the generator eco throttle / economy setting is turned off.	
Verify that the extension cord is adequately rated for the fusion machine and coupling	25' cord: #8/3 AWG
Is EF fitting still in original packaging? If so, inspect the coupling for damage. If not, discard fitting.	
Let the EF processor acclimate to the jobsite weather conditions for a minimum period of 15 minutes before beginning the fusion process.	
Couplings:	
Cut pipe ends squarely and evenly (+/- 1/2 inch). Check the squareness of the cut by placing a square at the end of the pipe at its longest point and measuring the resulting gap between the Carpenter's Square and shortest point of the cut. Maximum measured gap is less than 1/2 inch as measured from Carpenter's Square:	
Clean pipe ends of dirt and debris prior to scraping with clean water and lint-free rag	
Measure and mark one of the pipe ends for the full length of the coupling. Measure and mark the other pipe end for half the coupling length. Mark the entire pipe area to be scraped with an approved marker.	
Verify that the pipeline out-of-roundness is within tolerance. Maximum Out-of-Roundness is 1/4" for all sizes 14 inch to 30 inch.	
Mount the scraper over the area to be scraped. Scrape the outside of the pipe to remove the surface layer and expose clean virgin material beneath. Remark stab depths after scraping if necessary. This should remove at least 0.007" of the pipe surface material. Do not remove more than 0.040" on 14 inch to 30 inch pipe sizes.	
Bevel the pipe ends if required by fitting manufacturer.	
Inspect the scraped pipe surface thoroughly to ensure that all witness marks are removed and only virgin surface material is exposed. Do not touch the scraped pipe surface or the inside of the coupling to avoid contamination.	
Clean surfaces with approved pre-impregnated disposable wipes.	
Insert the pipe ends to the stab depth marks. Leave plastic bag over coupler to prevent contamination and debris from entering the open end. Use caution not to damage internal wire or terminal pins. Mechanical assist tools are also available for moving couplings on large diameter piping systems. If necessary, place a block of wood over the coupling end and use a hammer to drive the coupling onto the pipe.	
Secure assembly with an alignment clamp, with coupling centered between stab depth marks.	
Provide adequate support/blocking of pipe on either side of coupling.	
Connect the control box leads to the fitting. Scan the numerical barcode on the fitting.	
Verify that the fitting was read correctly and initiate the fusion cycle.	
Verify that the EF processor indicated a complete fusion cycle.	
Did the EF processor indicate a cycle failure? If yes, see * below. If no, see * below.	Yes No

* Was the failure due to an input power interruption? If yes, see (A) below. If no, see (B) below. Examples of input power interruption include the following: (i) fusion leads were detached during fusion, (ii) generator ran out of gas, or (iii) other circumstances that resulted in processor input power interruption.		Yes	No
(A) If failure was due to an input power interruption, the coupling must be re-fused. 1. Coupling should remain in restrained position. 2. Allow the coupling to completely cool to ambient temperature. 3. Reconnect coupling to the processor. 4. Completely refuse coupling for the entire fusion time.			
(B) Remove and discard coupling that faults for any other reason and install new coupling.			
Fusion cycle	Time of day:	Time of day when Cooling Time will elapse:	
Mark end of cooling time. Add cooling time to Time of day and mark result on pipe or fitting. Do not remove clamps, move assembly, pressure test, backfill, or return to service until completion of Cooling Time. Mark name and installer's certificate card ID number.			
Was this coupling accepted?		Yes	No

Comments _____

Inspector _____ Company _____ Employee # _____
Inspector Credential Issue Date _____ Credential Issued by _____ Date _____

Note: At the end of the project, download and review the EF data. Provide EF Data Report for review and filing.

Refer to Table X-a for Cooling Time Guidelines for Couplings

APPENDIX E – ELECTROFUSION SERVICE SADDLE INSTALLATION INSPECTION CHECKLIST

Location / Job # _____ Address / Tap # _____ Date/Time _____
 Fusion Technician _____ Company _____ Certificate Card # _____
 Installer Credential Issue Date _____ Credential issued by _____
 Pipe Manufacturer _____ Material Type _____
 Pipe Size _____ DR _____
 EF Saddle Manufacturer _____ Part # _____ Description _____
 EF Processor Model _____ Serial Number _____
 Generator Make & Model _____ Serial Number _____
 Temperature / Weather _____ Trench Conditions _____

General:		
Inspect the equipment for cleanliness and proper operation.		
Verify that the generator / power source is adequately sized		
Check that the generator is full of gas.		
Verify that the generator eco throttle / economy setting is turned off.		
Verify that the extension cord is adequately rated for the fusion machine and saddle.		25' cord: #8/3 AWG
Is EF fitting still in original packaging? Is so, inspect the service saddle for damage.		
Let the EF processor acclimate to the jobsite weather conditions for a minimum period of 15 minutes before beginning the fusion process.		
Service saddles:		
Install re-rounding clamps on both sides of location where saddle will be installed.		
Clean the pipe of dirt and debris prior to scraping with clean water and lint-free rag.		
Mark the area to be fused with an approved marker.		
Scrape the area to be fused with an approved scraping tool.		
Remark the saddle location to be fused with an approved marker.		
Clean the pipe area to be fused with approved pre-impregnated disposable wipes		
Clean the fitting to be fused with with approved pre-impregnated disposable wipes		
Secure the saddle to the pipe with the manufacturer recommended clamping mechanism.		
Scan the numerical barcode on the fitting		
Verify that the fitting was read correctly.		
Verify that the EF processor indicated a complete fusion cycle.		
Did the EF processor indicate a cycle failure? Abandon saddle and install new saddle.		<input type="checkbox"/> Yes <input type="checkbox"/> No
Fusion cycle	Time of day:	Time of day when Cooling Time will elapse:
Mark end of cooling time Add cooling time to Time of day and mark result on pipe or fitting. Do not pressure test, backfill, tap or return to service until completion of Cooling Time Mark name and installer's certificate card ID number Mark the pipe with the house # / tap # (if required)		
Perform hydrostatic test after Cooling Time elapses. Test saddle at 1.5 times working pressure or a maximum of 1.5 times PC for 5 minutes. - If saddle leaks during pressure test, remove outlet /abandon saddle and install new saddle next to failed saddle. Once saddle passes test, the saddle is acceptable for tapping.		
Was this saddle accepted?		Yes No

Comments _____

Inspector _____ Company _____ Employee # _____
 Inspector Credential Issue Date _____ Credential Issued by _____ Date _____


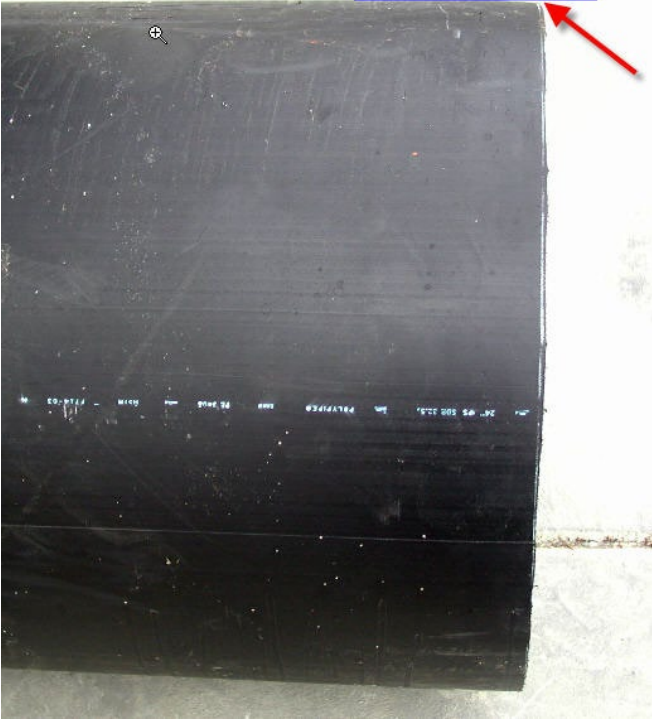
Note: At the end of the project, download and review the EF data. Provide EF Data Report for review and filing. Refer to Table X-b for Cooling Time Guidelines for Saddle Type Fittings

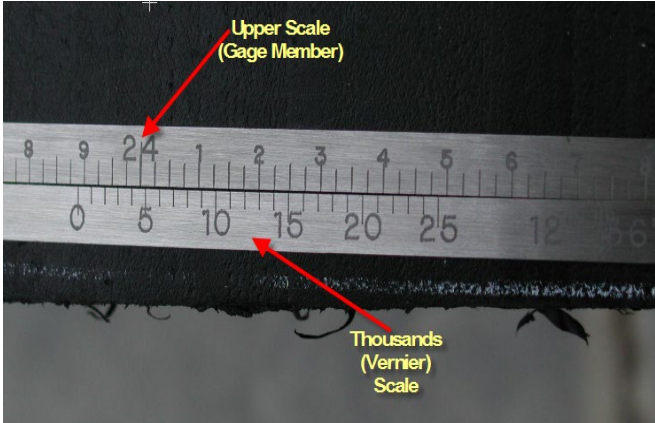
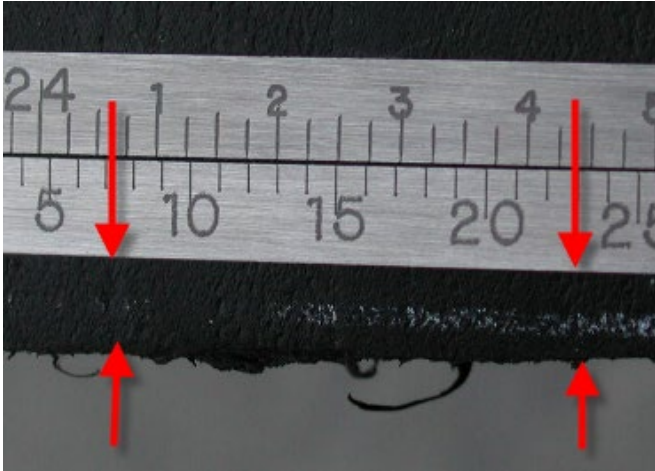
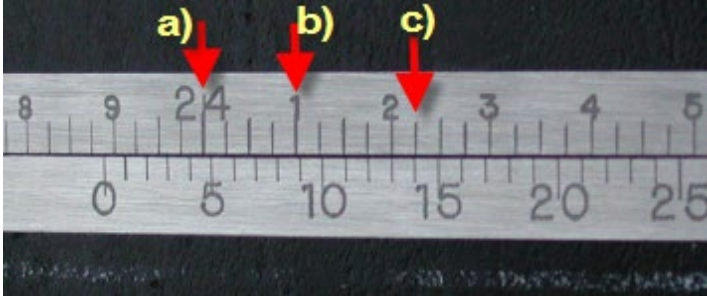
APPENDIX F – How to Measure Diameter using a Pi Tape

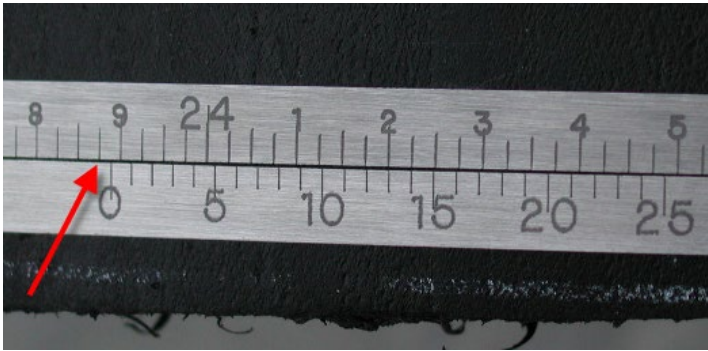
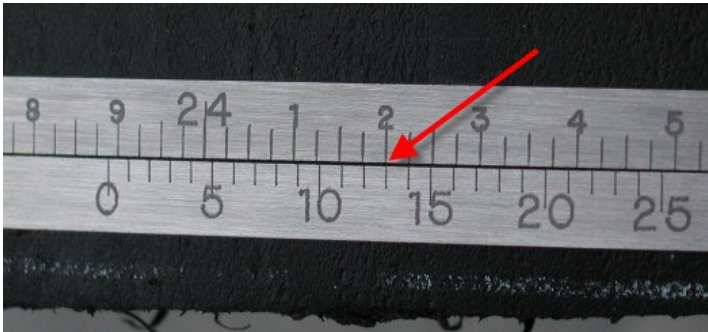
Purpose To accurately measure the true diameter of pipe &/or fittings

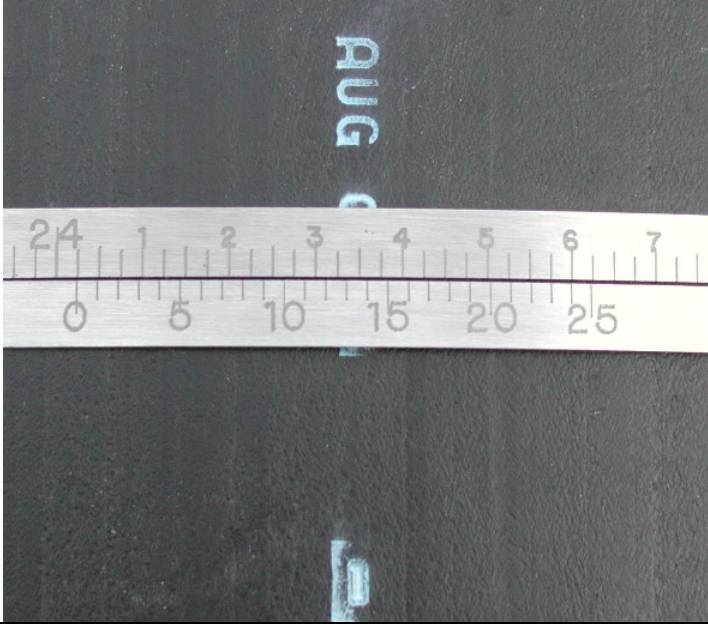
Start To determine if material is made to ASTM F-714 or AWWA C906 specifications, or to qualify pipe or fitting for Electrofusion Coupling use

Materials Correct sized Decimal Pi Tape, Pipe &/or Fitting to be measured, paper & pencil or calculator.

Actions:	Do this:
<p>1. Determine correct Pi Tape</p> 	<p>a. Locate the properly sized Pi Tape, based upon the size pipe or fitting to be measured</p> <p>b. A decimal tape is required instead of a fractional tape, as it gives greater accuracy</p>
<p>2. Identify the area of toe-in (see gap at arrow)</p> 	<p>a. Toe-in (Tapered end) usually takes place within the first 2"-3" from end of large diameter HDPE pipe & fittings</p> <p>b. The diameter may be smaller at this location than at any other point along the pipe or fitting</p>

Actions:	Do this:
<p>3. Place Pi Tape around pipe or fitting</p> 	<p>a. The Upper Scale (Gage Member) is placed above the Thousands (Vernier) Scale</p> <p>Identify typical distance to measure from end of pipe</p>
<p>4. Correctly locate Pi Tape around pipe or fitting</p> 	<p>a. To make an accurate measurement, make sure the Pi Tape is evenly placed around the circumference</p> <p>Note: When measuring away from the end, make sure to mark the distance at (4) locations around the circumference</p>
<p>5. What markings on Upper Scale mean</p> 	<p>View upper part of scale</p> <p>a. 24 represents the closest diameter in inches Example a) = 24.000"</p> <p>b. The 1, 2, 3, 4, 5, etc. represent the .100" decimal, or 1/10th inch increments. Example b) = 24.100"</p> <p>c. Broken into (4) graduations, each mark represents .025" Example c)= 24.225"</p>

Actions:	Do this:
<p>6. Measure diameter – Part 1</p> 	<p>View lower part of scale</p> <p>a. Using the “0” on the Thousands (Vernier) Scale, write down the measurement on the Upper Scale to the left of the “0” Example: arrow measure 23.875”</p>
<p>7. Measure diameter – Part 2</p> 	<p>a. On the Thousands Scale, each indentation represents 0.001”. The range is from .001” to .025”</p> <p>b. Visually locate where the marks on the Upper Scale match up with the marks on the Thousands Scale</p> <p>c. Reading the Thousands Scale, write down the number of thousands where the lines match Example: .013”</p>
<p>8. Determine the actual diameter</p>	<p>Add the (2) measurements together Example: 23.875”</p> $\begin{array}{r} \phantom{\text{Actual Diameter}} \quad .013'' \\ \hline \text{Actual Diameter} \quad 23.888'' \end{array}$

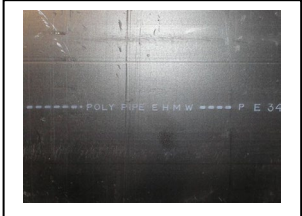

Actions:	Do this:
<p>9. For Reference only. Same Pipe as above, but measured 11.8" from pipe end</p> 	<p>a. Since "0" on the Thousands Scale does not perfectly line up with the line above it: 1st Measurement = 24.000"</p> <p>b. An indentation on both scales match up on the Thousands Scale at .024"</p> <p>c. Adding 24.000" + 0.024" = 24.024" actual OD</p>
<p>Result True diameter accurately measured</p> <p>Task standards</p> <ul style="list-style-type: none"> • Tape measurement is read correctly • Tape is placed on material at proper location 	

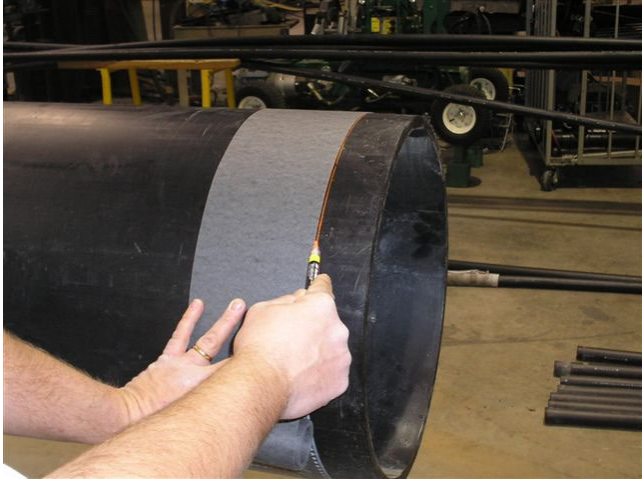
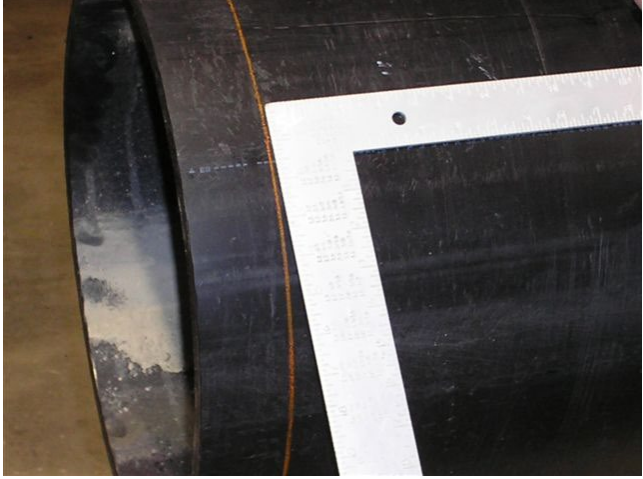
APPENDIX G – Make a Square Cut with a Pipe Wrap

Purpose Make a square on HDPE Pipe by using a 4” wide pipe wrap for marking.

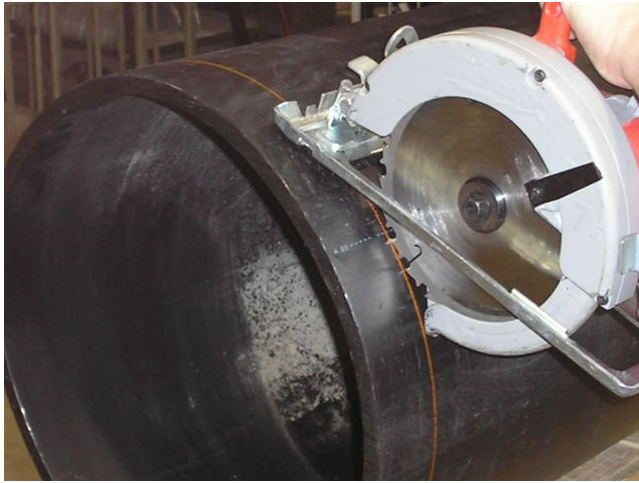
Start Use when square cut on pipe is required: Electrofusion coupling installation requires a square cut, use the pipe wrap to mark pipe for installation of a coupling

Materials Pipe to be cut, pipe wrap for pipe size, pi tape and non-greasy marker

Actions:	Do this:
<p>1. Determine diameter of pipe</p>  	<ul style="list-style-type: none"> • Check print line on pipe and verify with pi tape • If you cannot read print line, use pi tape to determine diameter of pipe
<p>2. Based on diameter of pipe, select pipe wrap of correct length</p>	<p>Place pipe wrap around pipe. Pipe wrap must be long enough to reach around the pipe more than the circumference. Pipe wraps are usually 1.25 to 1.5 times the circumference of the pipe.</p>

Actions:	Do this:
<p>3. Place pipe wrap around pipe</p>	<ul style="list-style-type: none"> • When pipe wrap is pulled tightly around pipe, it will be perpendicular to the end of the pipe. • Visually check alignment of wrap. Adjust until there is no slack and wrap appears to be square.
<p>4. When pipe wrap appears to be tight and square, make line around pipe with non-greasy marker.</p> 	<p>Carefully mark a line around pipe with marker.</p>
<p>5. Use square or tee to check that line is perpendicular</p> 	<p>Check line. Is line square? Is line completely around pipe?</p>

6. Cut pipe to provide square cut using circular saw with wood cutting blade.



Follow line around pipe with saw.

7. Check cut for square cut.



Check line. Is line square with $\leq \frac{1}{2}$ " gap?

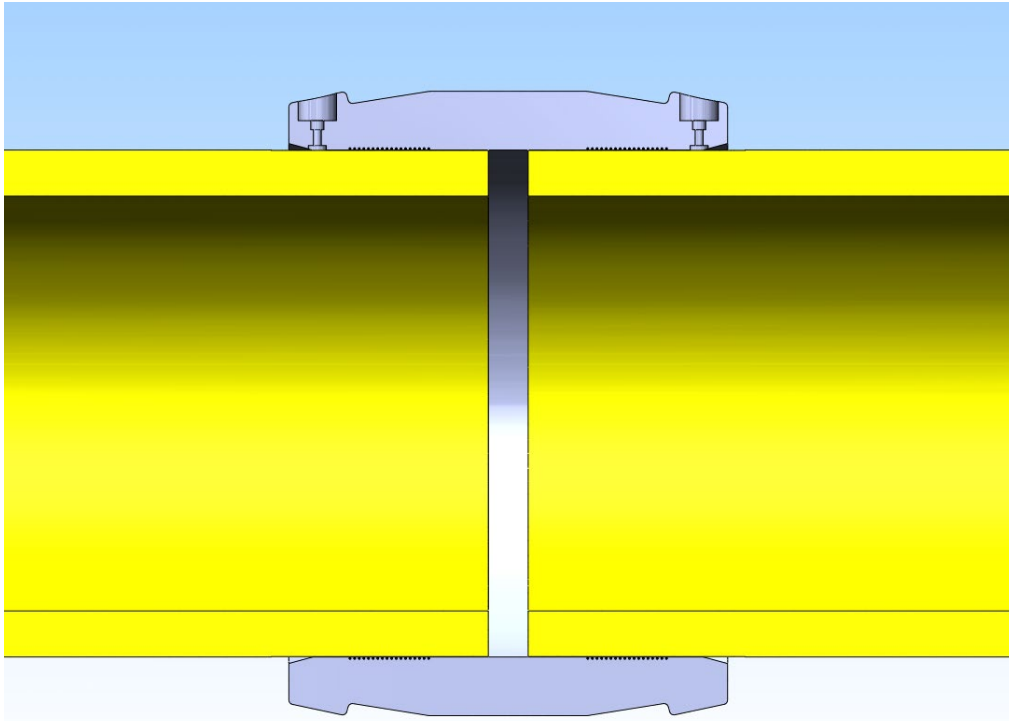
8. Surface Planer



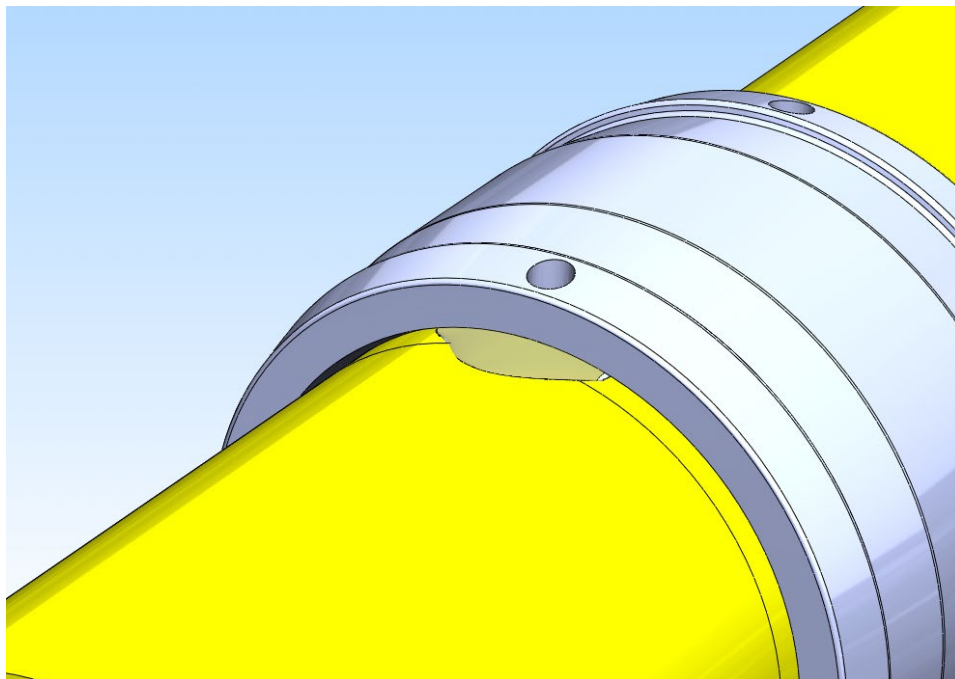
Resurface with a surface planer until an acceptable square cut is achieved.

APPENDIX H – Acceptable and Unacceptable EF Joints

The following are illustrations of acceptable and unacceptable electrofusion joints
(Refer to Manufacturer when in doubt)

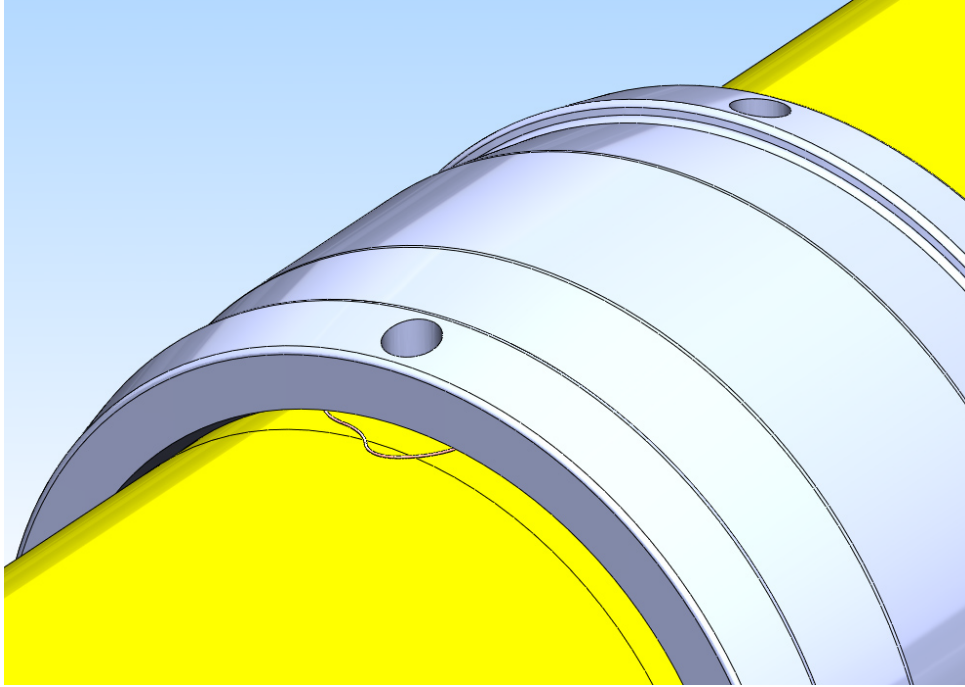


Good Fusion Acceptable- However, Installer Must Butt Pipe Ends Together

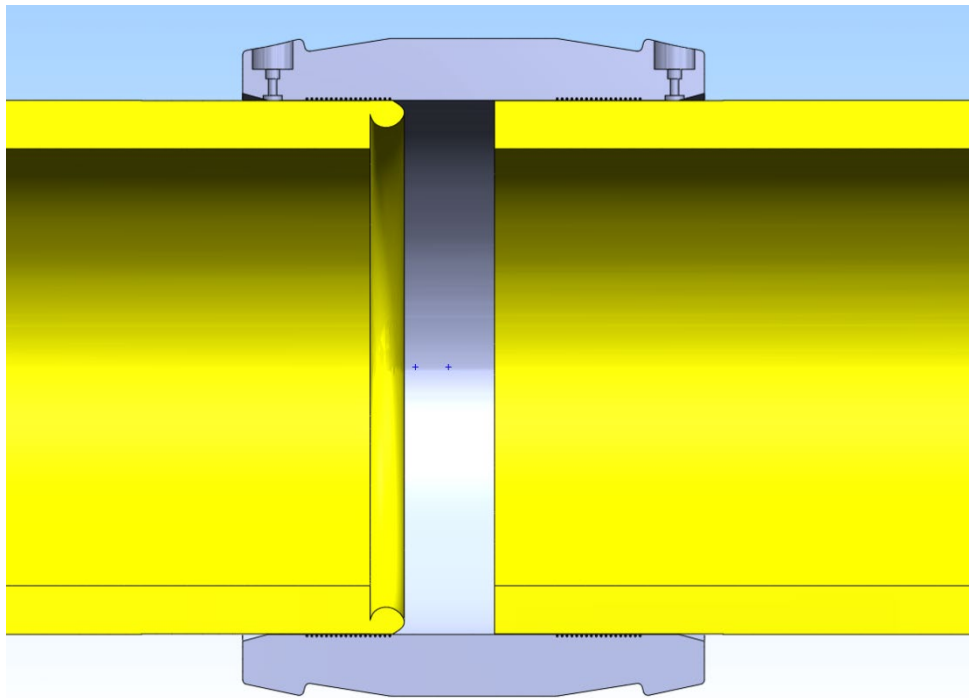


Melt Out Unacceptable:

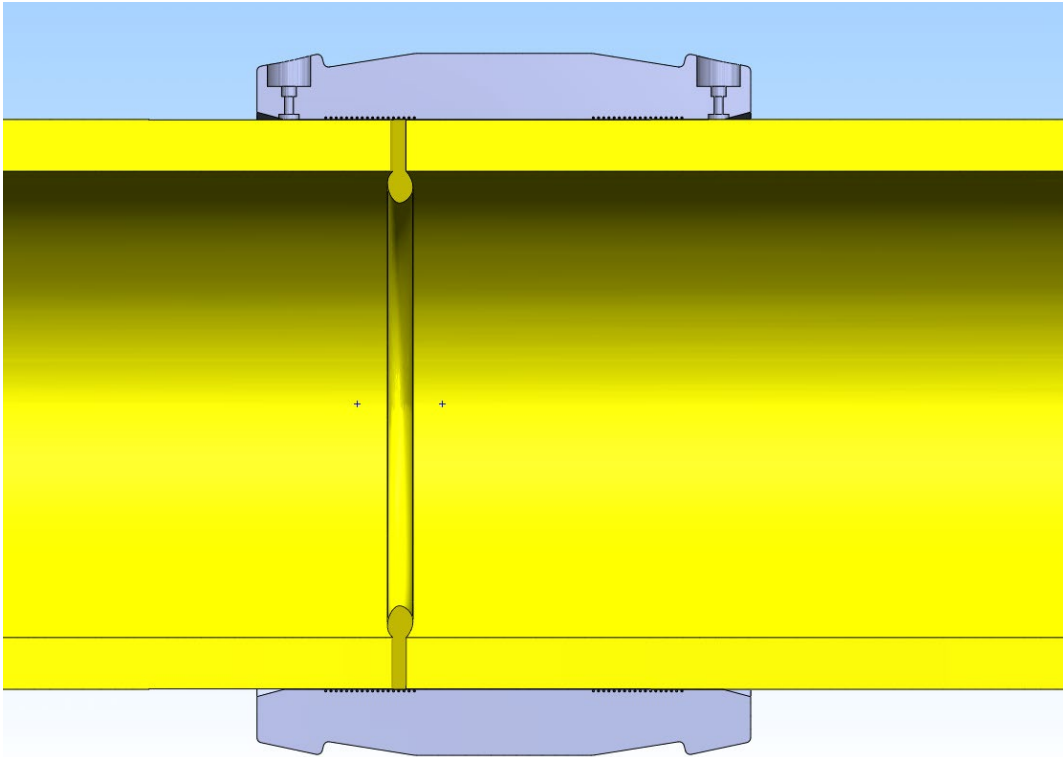
Possible Causes: Pipe Out-of-Roundness, Flat Spots, Undersized Pipe, and Binding



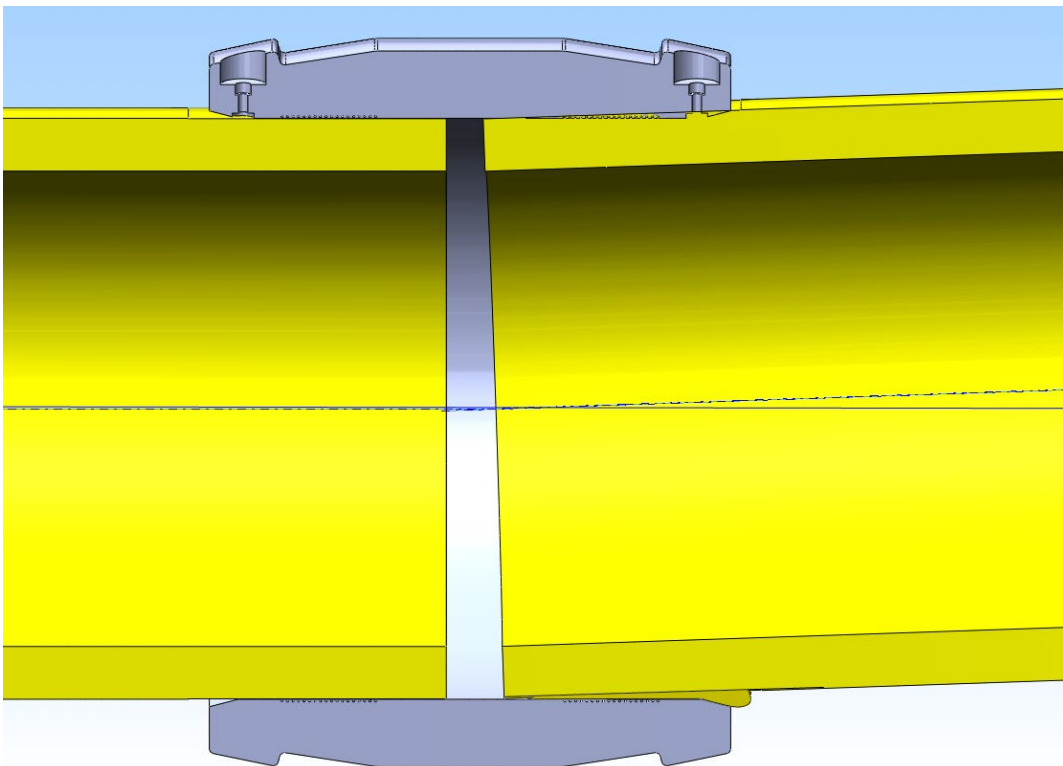
Exposed Wire Unacceptable
Possible Causes: Pipe OOR, Flat Spots, Undersized Pipe or Binding



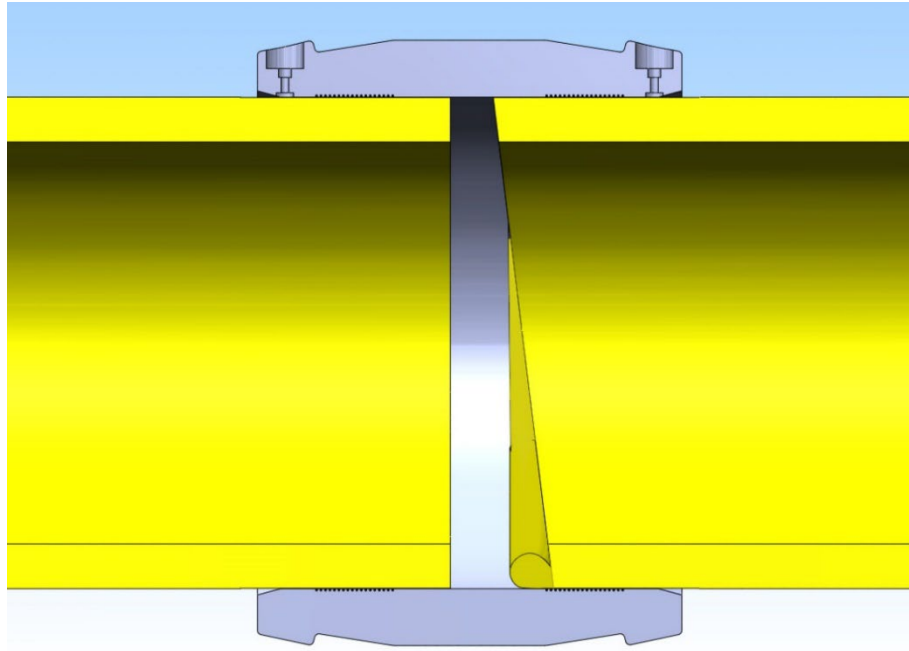
Short Stab Unacceptable
Possible Cause: Failure to Mark or Monitor Stab Depth



Mis-Stab Unacceptable
Possible Cause: Failure to Mark or Monitor Stab Depth

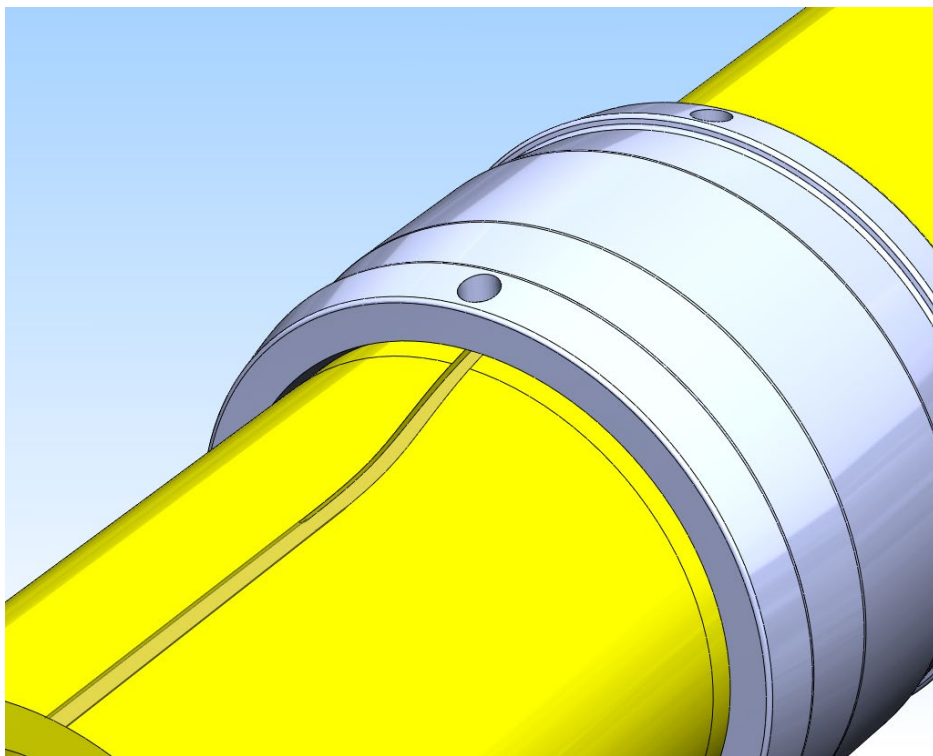


Misalignment Unacceptable
Possible Cause: Inadequate Clamping or Restraint During Fusion



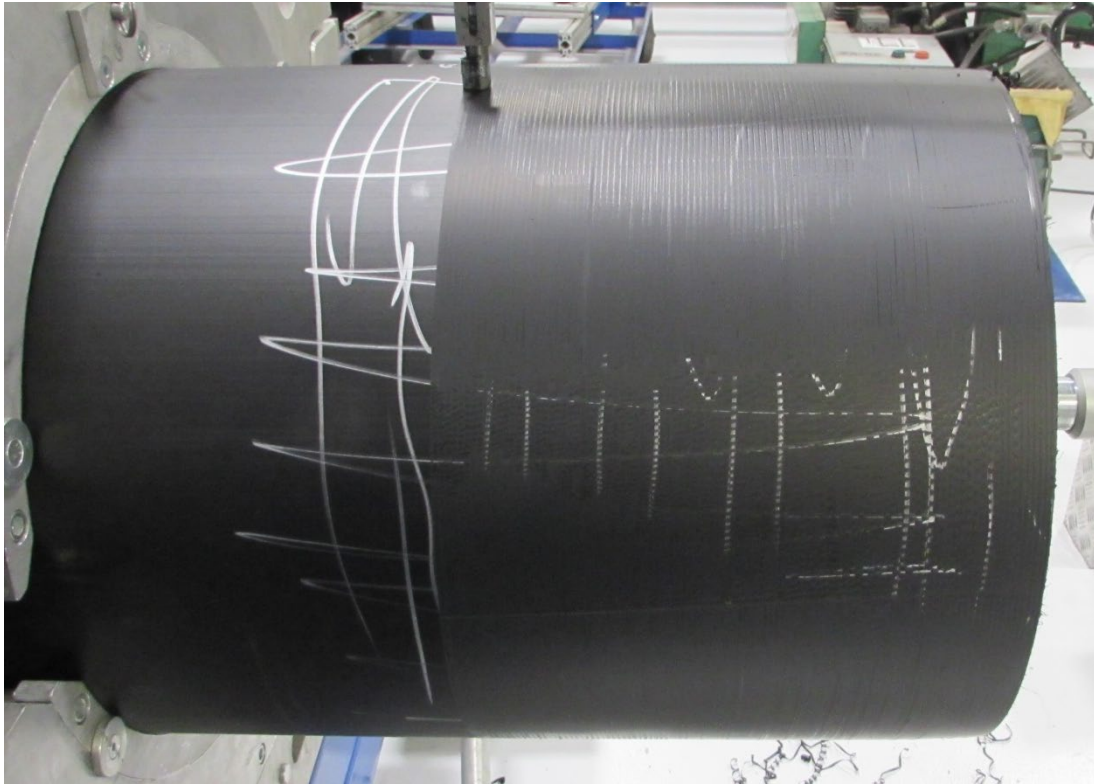
Mis-cut Unacceptable

Possible Cause: Failure to cut Pipe End Perpendicular to The Axis of The Pipe

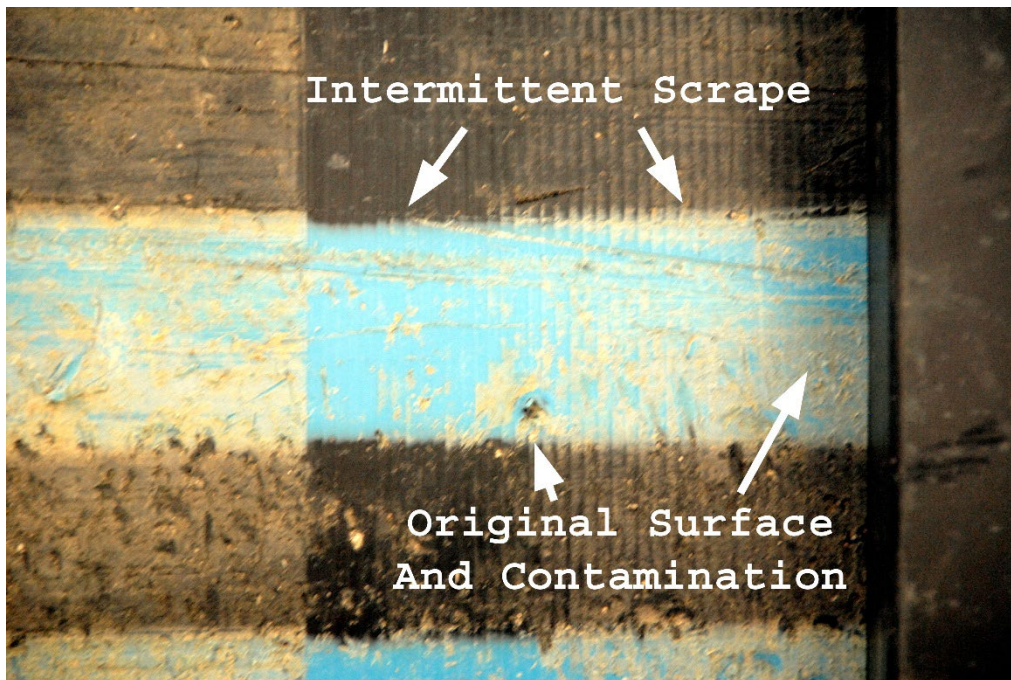


Gouges and Scratched (that exceed 10% wall) Unacceptable

Possible Cause: Damage During Transportation or Handling of The Pipe



Poor Scrape Unacceptable

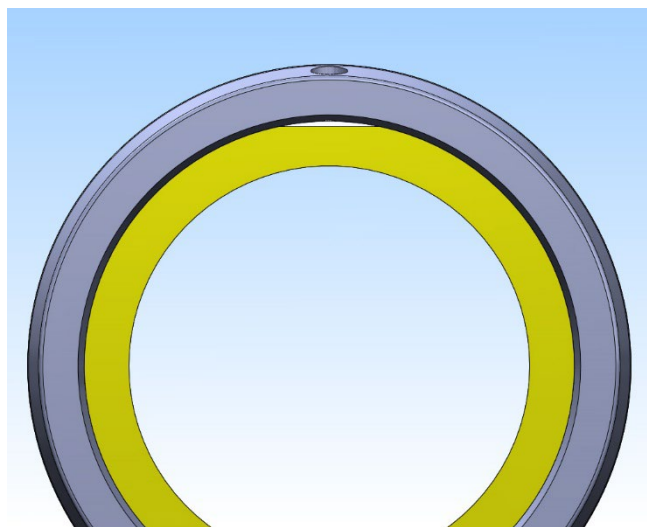
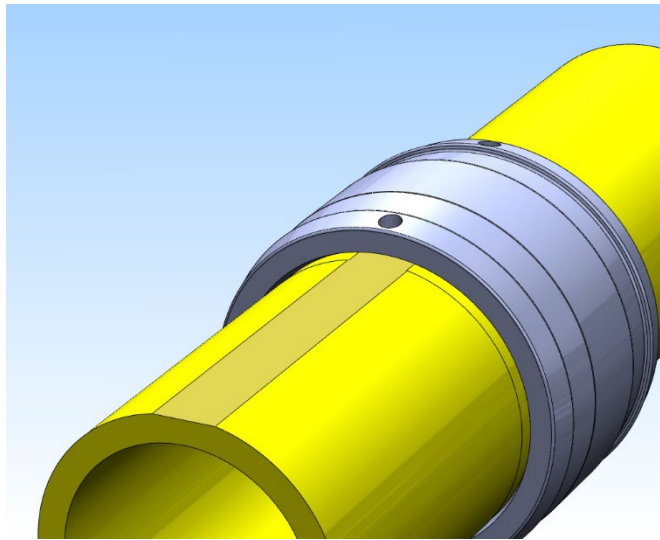


Poor Scrape Unacceptable

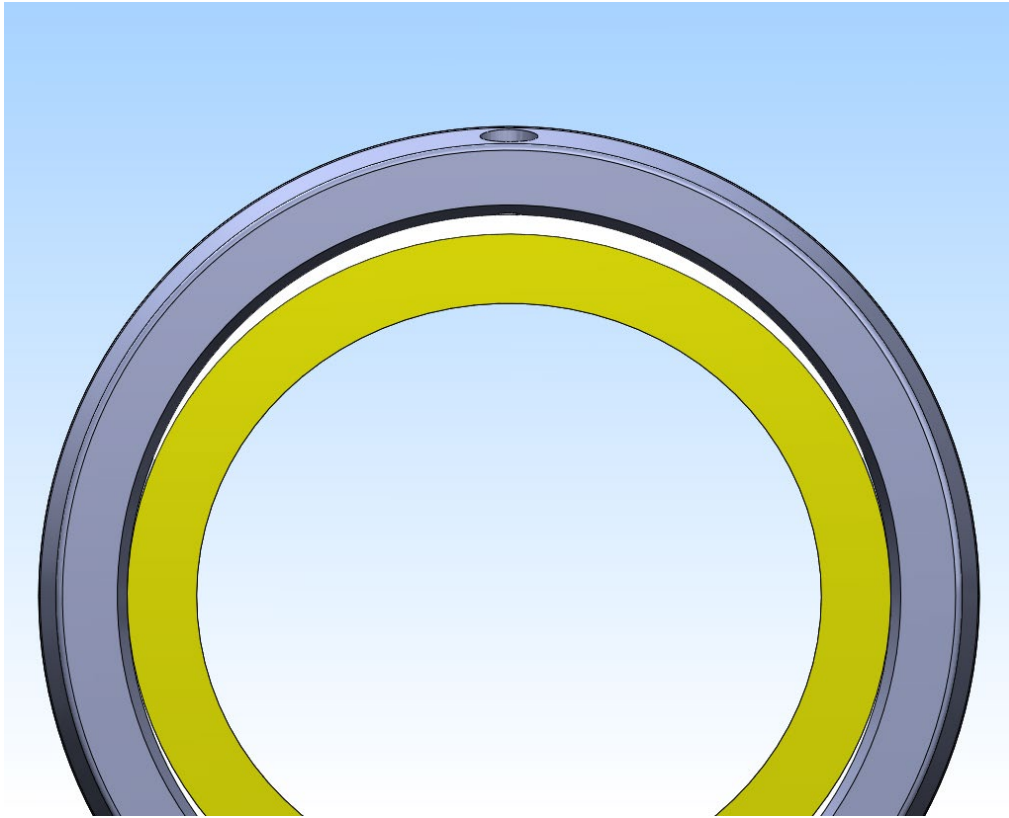
Possible Causes: Incorrect Scraper, Poorly Maintained Scraper, Inadequate Number of Passes With Scraper, or Ineffective Evaluation of Scraping



Over Scrape Unacceptable
Possible Causes: Incorrect Scraper, Poorly Maintained Scraper, Excessive Number of Passes With Scraper, or Ineffective Evaluation of Scraping



Pipe Flat Spots Unacceptable (>10% wall thickness)
Cause: Damage During Transportation or Handling of The Pipe



Pipe Out of Round Unacceptable
Possible Causes: Manufacturing Defect, or Transportation or Storage Damage or
Non-Use of Full Encirclement Rounding Clamps