United Poly Systems

HDPE Fusion

United Poly Systems pipe can be joined through heat fusion using industry accepted ASTM F2620 procedures for butt-fusion and saddle fusion. Electro-fusion and mechanical couplings are compatible as well. The fittings manufacturers installation procedures should be followed.

United Poly Systems recommends following procedures and standards for fusion and installation as outlined by the Plastic Pipe Institute's Handbook on Polyethylene Pipe. The handbook can be found at www.plasticpipe.org

Additional materials from the plastic pipe institute have been included here to assist in the joining process.

HDPE Pipe OD	Min Melt Bead Size
< 2.37"	1/32"
≥2.37 to < 3.5"	1/16"
> 3.5 to < 8.62"	3/16"
> 8.62 to < 12.75"	1/4"
> 12.75 to ≤ 24"	3/8"
>24 to < 36"	7/16"
> 36 to ≤65"	9/16"

Chapter 9

PE Pipe Joining Procedures

Introduction

An integral part of any pipe system is the method used to join the system components. Proper engineering design of a system will take into consideration the type and effectiveness of the techniques used to join the piping components and appurtenances, as well as the durability of the resulting joints. The integrity and versatility of the joining techniques used for PE pipe allow the designer to take advantage of the performance benefits of PE in a wide variety of applications.

General Provisions

PE pipe or fittings are joined to each other by heat fusion or with mechanical fittings. PE pipe may be joined to other pipe materials by means of compression fittings, flanges, or other qualified types of manufactured transition fittings. There are many types and styles of fittings available from which the user may choose. Each offers its particular advantages and limitations for each joining situation the user may encounter. Contact with the various manufacturers is advisable for guidance in proper applications and styles available for joining as described in this document. The joining methods discussed in this chapter cover both large and small diameter pipe. Large diameter PE pipe is considered to be sizes 3" IPS (3.500" OD, Iron Pipe Size) and larger. All individuals involved in the joining PE pipe systems, whether it be using the typical heat fusion methods or employing mechanical connections, should be fully trained and qualified in accordance with applicable codes and standards and/or as recommended by the pipe or fitting manufacturer. Those assigned to making joints in PE pipe for gas applications must meet the additional requirement of compliance with U.S. Department of Transportation Pipeline Safety Regulations(10). The equipment used in the process of making heat fused joints must be designed to operate for the selected pipe and fusion procedures. Additionally, the equipment should be well maintained and capable of operating to specification.

Thermal Heat Fusion Methods

There are three types of conventional heat fusion joints currently used in the industry; Butt, Saddle, and Socket Fusion. Additionally, electrofusion (EF) joining is available with special EF couplings and saddle fittings.

The principle of heat fusion is to heat two surfaces to a designated temperature, then fuse them together by application of a sufficient force. This force causes the melted materials to flow and mix, thereby resulting in fusion. When fused according to the pipe and/or fitting manufacturers' procedures, the joint area becomes as strong as, or stronger than, the pipe itself in both tensile and pressure properties and properly fused joints are absolutely leak proof. As soon as the joint cools to near ambient temperature, it is ready for handling. The following sections of this chapter provide a general procedural guideline for each of these heat fusion methods.

Butt Fusion

The most widely used method for joining individual lengths of PE pipe and pipe to PE fittings is by heat fusion of the pipe butt ends as illustrated in Figure 1. This technique produces a permanent, economical and flow-efficient connection. Quality butt fusion joints are produced by using trained operators and quality butt fusion machines in good condition.

The butt fusion machine should be capable of:

- Aligning the pipe ends
- Clamping the pipes
- Facing the pipe ends parallel and square to the centerline
- Heating the pipe ends
- Applying the proper fusion force

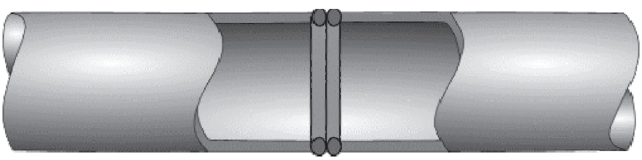


Figure 1 A Standard Butt Fusion Joint

The six steps involved in making a butt fused joint are:

1. Clean, clamp and align the pipe ends to be joined
2. Face the pipe ends to establish clean, parallel surfaces, perpendicular to the center line
3. Align the pipe ends
4. Melt the pipe interfaces
5. Join the two pipe ends together by applying the proper fusion force
6. Hold under pressure until the joint is cool

Butt Fusion of PE Pipe Products with Different Wall Thicknesses

PE pipes of the same outside diameter but having different specified wall thicknesses, that is, different DR designations, may be butt fused to each other under special conditions. Since this represents a special situation, it is subject to limitations. Therefore, the user is advised to consult with the pipe manufacturer to determine if the special procedures can be applied to the pipe components involved in the particular installation in question. If so, a written copy of the applicable assembly recommendations should be obtained.

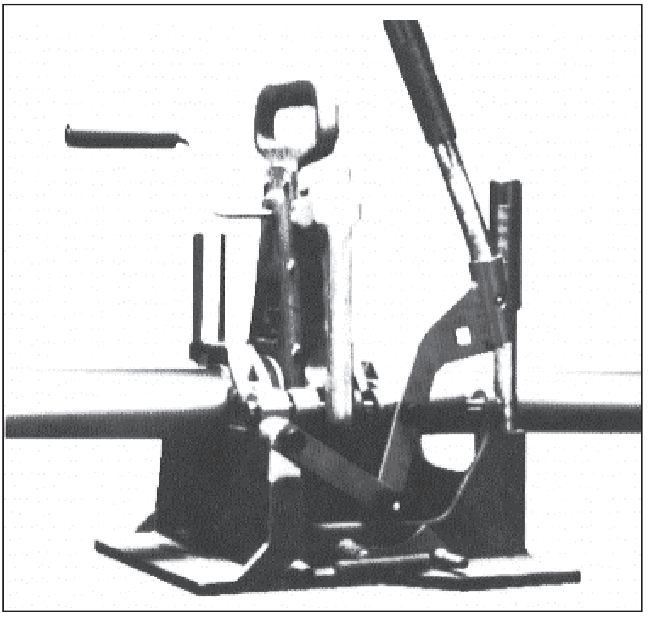


Figure 2 Typical Butt Fusion Machine for Smaller Diameter Pipe
(Butt Fusion machines are available to fuse pipe up to 65 inches in diameter)

Most pipe manufacturers have detailed parameters and procedures to follow. The majority of them helped develop and have approved the PPI Technical Report TR-33 for the generic butt fusion joining procedure for PE pipe [15] and ASTM F 2620.

Optional Bead Removal

In some pipe systems, engineers may elect to remove the inner or outer bead of the joint. External, or both beads are removed with run-around planing tools, which are forced into the bead, then drawn around the pipe. Power planers may also be used, but care must be taken not to cut into the pipe's outside surface.

It is uncommon to remove internal beads, as they have little or no effect on flow, and removal is time-consuming. Internal beads may be removed from pipes after each fusion with a cutter fitted to a long pole. Since the fusion must be completely cooled before bead removal, assembly time is increased slightly.

Saddle/Conventional Fusion

The conventional technique to join a saddle to the side of a pipe, illustrated in Figure 3, consists of simultaneously heating both the external surface of the pipe and the matching surface of the "saddle" type fitting with concave and convex shaped heating tools until both surfaces reach proper fusion temperature. This may be accomplished by using a saddle fusion machine that has been designed for this purpose.

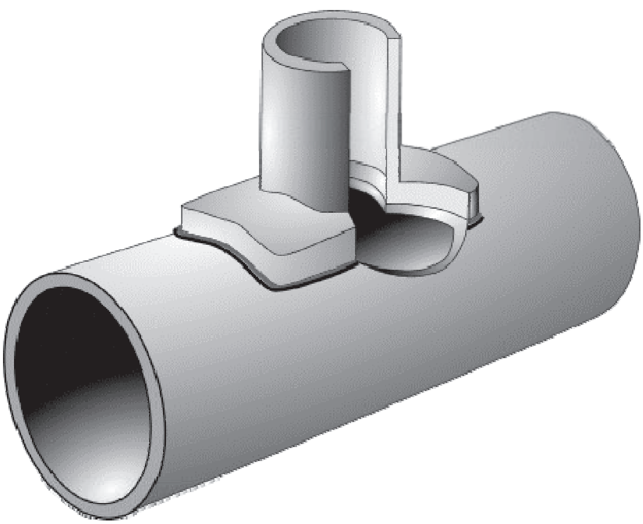


Figure 3 Standard Saddle Fusion Joint

Saddle fusion using a properly designed machine, provides the operator better alignment and force control, which is very important to fusion joint quality. The Plastics Pipe Institute recommends that saddle fusion joints be made only with a mechanical assist tool unless hand fusion is expressly allowed by the pipe and/or fitting manufacturer.[16]

There are eight basic sequential steps that are normally used to create a saddle fusion joint:

1. Clean the pipe surface area where the saddle fitting is to be located
2. Install the appropriate size heater saddle adapters

3. Install the saddle fusion machine on the pipe
4. Prepare the surfaces of the pipe and fitting in accordance with the recommended procedures
5. Align the parts
6. Heat both the pipe and the saddle fitting
7. Press and hold the parts together
8. Cool the joint and remove the fusion machine

Most pipe manufacturers have detailed parameters and procedures to follow. The majority of them helped develop and have approved the PPI Technical Report TR-41 for the generic saddle fusion joining procedure for PE pipe [16] and ASTM 2620.

Socket Fusion

This technique consists of simultaneously heating both the external surface of the pipe end and the internal surface of the socket fitting until the material reaches the recommended fusion temperature, inspecting the melt pattern, inserting the pipe end into the socket, and holding it in place until the joint cools. Figure 4 illustrates a typical socket fusion joint. Mechanical equipment is available to hold both the pipe and the fitting and should be used for sizes larger than 2” CTS to help attain the increased force required and to assist in alignment. Most pipe manufacturers have detailed written procedures to follow. The majority refer to ASTM F 2620.

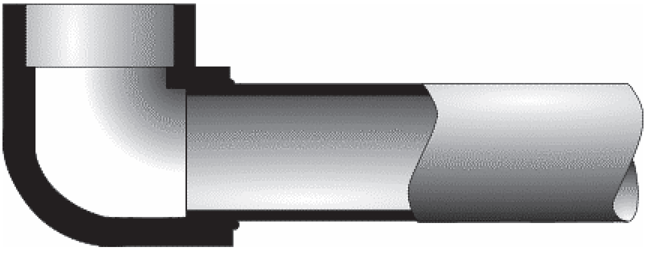


Figure 4 Standard Socket Fusion Joint

Follow these general steps when performing socket fusion:

1. Thoroughly clean the end of the pipe and the matching inside surface of the fitting
2. Square and prepare the pipe end
3. Heat the parts

4. Join the parts
5. Allow to cool

Equipment Selection

Select the proper size tool faces and heat the tools to the fusion temperature recommended for the material to be joined. For many years, socket fusion tools were manufactured without benefit of any industry standardization. As a result, variances of heater and socket depths and diameters, as well as depth gauges, do exist. More recently, ASTM F1056[7] was written, establishing standard dimensions for these tools. Therefore, mixing various manufacturers' heating tools or depth gauges is not recommended unless the tools are marked "F1056," indicating compliance with the ASTM specification and, thereby, consistency of tooling sizes.

Square and Prepare Pipe

Cut the end of the pipe square. Chamfer the pipe end for sizes 1¼"-inch diameter and larger. (Chamfering of smaller pipe sizes is acceptable and sometimes specified in the instructions.) Remove scraps, burrs, shavings, oil, or dirt from the surfaces to be joined. Clamp the cold ring on the pipe at the proper position, using the integral depth gauge pins or a separate (thimble type) depth gauge. The cold ring will assist in re- rounding the pipe and provide a stopping point for proper insertion of the pipe into the heating tool and coupling during the fusion process.

Heating

Check the heater temperature. Periodically verify the proper surface temperature using a pyrometer or other surface temperature measuring device. If temperature indicating markers are used, do not use them on a surface that will come in contact with the pipe or fitting. Bring the hot clean tool faces into contact with the outside surface of the end of the pipe and with the inside surface of the socket fitting, in accordance with pipe and fitting manufacturers' instructions.

Joining

Simultaneously remove the pipe and fitting from the tool using a quick "snap" action. Inspect the melt pattern for uniformity and immediately insert the pipe squarely and fully into the socket of the fitting until the fitting contacts the cold ring. Do not twist the pipe or fitting during or after the insertion, as is the practice with some joining methods for other pipe materials.

Cooling

Hold or block the pipe in place so that the pipe cannot come out of the joint while the mating surfaces are cooling. These cooling times are listed in the pipe or fitting manufacturer's instructions.

Electrofusion (EF)

This technique of heat fusion joining is somewhat different from the conventional fusion joining thus far described. The main difference between conventional heat fusion and electrofusion is the method by which the heat is applied. In conventional heat fusion joining, a heating tool is used to heat the pipe and fitting surfaces. The electrofusion joint is heated internally, either by a conductor at the interface of the joint or, as in one design, by a conductive polymer. Heat is created as an electric current is applied to the conductive material in the fitting. Figure 5 illustrates a typical electrofusion joint. PE pipe to pipe connections made using the electrofusion process require the use of electrofusion couplings.

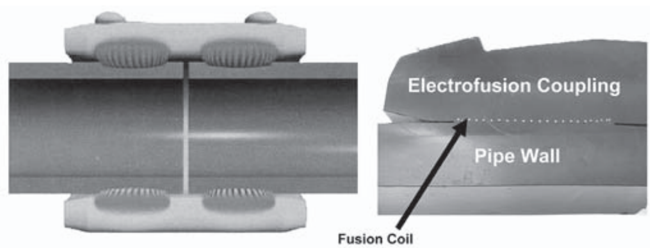


Figure 5 Typical Electrofusion Joint

General steps to be followed when performing electrofusion joining are:

1. Prepare the pipe (scrape, clean)
2. Mark the pipe
3. Align and restrain pipe and fitting per manufacturer's recommendations
4. Apply the electric current
5. Cool and remove the clamps
6. Document the fusion process

Prepare the Pipe (Clean and Scrape)

Assure the pipe ends are cut square when joining using electrofusion couplings. The fusion area must be clean from dirt or contaminants. This may require the use of water or 90% isopropyl alcohol (NO ADDITIVES OR NOT DENATURED). Next, the pipe surface in the fusion must be scraped, that is material must be removed to expose clean virgin material. This may be achieved by various special purpose tools available from the fitting manufacturer.

Mark the Pipe

Mark the pipe for stab depth of couplings or the proper fusion location of saddles. (Caution should be taken to assure that a non-petroleum marker is used.)

Align and Restrain Pipe or Fitting Per the Manufacturer's Recommendations

Align and restrain fitting to pipe per manufacturer's recommendations. Place the pipe(s) and fitting in the clamping fixture to prevent movement of the pipe(s) or fitting. Give special attention to proper positioning of the fitting on the prepared pipe surfaces. Large pipe diameters may need re-rounding prior to the electrofusion process.

Apply Electric Current

Connect the electrofusion control box to the fitting and to the power source (see Figure 6). Apply electric current to the fitting as specified in the manufacturer's instructions. Read the barcode which is supplied with the electrofusion fitting. If the control does not do so automatically, turn off the current when the proper time has elapsed to heat the joint properly.

Figure 6 Typical Electrofusion Control Box and Leads with Clamps and Fittings

Cool Joint and Remove Clamps

Allow the joint to cool for the recommended time. If using clamps, premature removal from the clamps and any strain on a joint that has not fully cooled can be detrimental to joint performance.

Consult the fitting manufacturer for detailed parameters and procedures.

Documenting fusion

The Electrofusion control box that applies current to the fitting also controls and monitors the critical parameters of fusion, (time, temperature, & pressure). The control box is a micro- processor capable of storing the specific fusion data for each joint. This information can be downloaded to a computer for documentation and inspection of the days work.

Heat Fusion Joining of Unlike PE Pipe and Fittings

Research has indicated that PE pipe and fittings made from unlike resins can be heat-fused together to make satisfactory joints. Some gas companies have been heat-fusion joining unlike PEs for many years with success. Guidelines for heat fusion of unlike materials are outlined in TN 13, issued by the Plastics Pipe Institute. Refer to Plastics Pipe Institute Technical Reports TR-33 and TR-41, ASTM F 2620 and the pipe and fitting manufacturers for specific procedures.

As mentioned earlier, fusion joints, whether they involve the conventional butt, socket or saddle heat fusion assembly procedures or the electrofusion procedure, should only be made by personnel fully trained and qualified in those procedures. The equipment used shall be designed to operate for the selected pipe and fusion procedures. The equipment should be well maintained and capable of operating to specification. In addition, it is important that only the specified or recommended joining procedures be followed at all times during assembly operations.

Mechanical Connections

As in the heat fusion methods, many types of mechanical connection styles and methods are available. This section is a general description of these types of fittings.

The Plastics Pipe Institute recommends that the user be well informed about the performance attributes of the particular mechanical connector being utilized. Fitting selection is important to the performance of a piping system. Product performance and application information should be available from the fitting manufacturer to assist in the selection process as well as instructions for use and performance limits, if any. Additional information for these types of products is also contained in a variety of specifications such as ASTM F1924, F1973, and AWWA C219.

PE pipe, conduit and fittings are available in outside diameter controlled Iron Pipe Sizes (IPS), Ductile Iron Pipe Sizes (DIPS), Copper Tubing Sizes (CTS) and Metric Sizes. There are also some inside diameter controlled pipe sizes (SIDR-PR). Before selecting mechanical fittings, establish which of the available piping system sizes and types are being installed to ensure proper fit and function. The pipe manufacturer can provide dimensional information, and the fitting manufacturer can advise on the correct fitting selection for the application.

Mechanical Compression Couplings for Small Diameter Pipes

This style of fitting comes in many forms and materials. The components, as depicted in Figure 7, are generally a body; a threaded compression nut; an elastomer seal ring or O-ring; a stiffener; and, with some, a grip ring. The seal and grip rings, when compressed, grip the outside of the pipe, effecting a pressure-tight seal and, in most designs, providing pullout resistance which exceeds the yield strength of the PE pipe. It is important that the inside of the pipe wall be supported by the stiffener under the seal ring and under the gripping ring (if incorporated in the design), to avoid deflection of the pipe. A lack of this support could result in a loss of the seal or the gripping of the pipe for pullout resistance. This fitting style is normally used in service lines for gas or water pipe 2" IPS and smaller. It is also important to consider that three categories of this type of joining device are available. One type provides a seal only, a second provides a seal and some restraint from pullout, and a third provides a seal plus full pipe restraint against pullout.

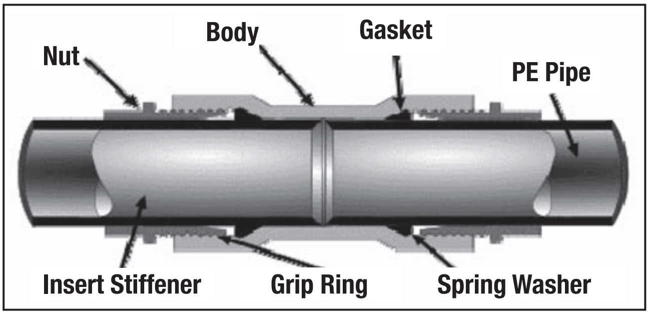


Figure 7 Typical Compression Nut Type Mechanical Coupling for Joining PE Pipe to PE Pipe

Stab Type Mechanical Fittings

Here again many styles are available. The design concept, as illustrated in Figure 8, is similar in most styles. Internally there are specially designed components including an elastomer seal, such as an "O" ring, and a gripping device to effect pressure sealing and pullout resistance capabilities. Self-contained stiffeners are included in this design. With this style fitting the operator prepares the pipe ends, marks the stab depth on the pipe, and "stabs" the pipe in to the depth prescribed for the fitting being used. These fittings are available in sizes from ½"CTS through 2" IPS and are all of ASTM D2513[2] Category I design, indicating seal and full restraint against pullout.

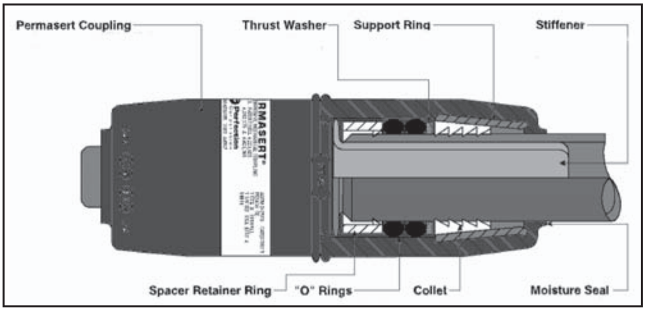
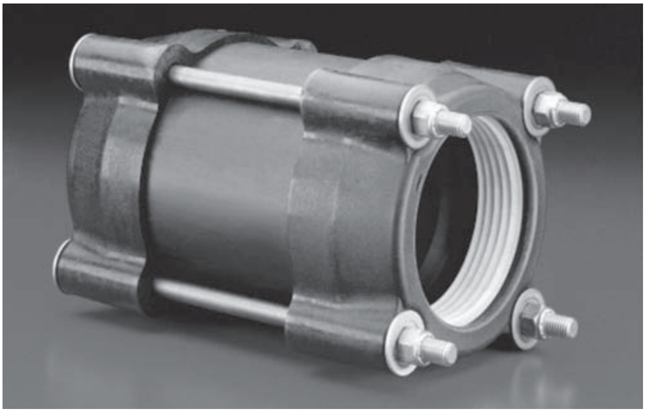


Figure 8 Stab Type Fitting

Mechanical Bolt Type Couplings

There are many styles and varieties of "Bolt Type" couplings available to join PE to PE or other types of pipe such as PVC, steel and cast iron in sizes from 1¼" IPS and larger. Components for this style of fitting are shown in Figure 9. As with the mechanical compression fittings, these couplings work on the general principle of compressing an elastomeric gasket around each pipe end to be joined, to form a seal. The gasket, when compressed against the outside of the pipe by tightening the bolts, produces a pressure seal. These couplings may or may not incorporate a grip ring, as illustrated, that provides pullout resistance sufficient to exceed the yield strength of the PE pipe. When PE pipe is pressurized, it expands a little and shortens slightly due to Poisson's effect. In a run of PE pipe, the cumulative shortening may be enough to cause separation of unrestrained mechanical joints that are in-line with the PE pipe. This can be a particular concern where transitioning from PE pipe to Ductile Iron pipe. Joint separation can be prevented by installing external joint restraints (gripping devices or flex restraints; see Figure 16) at mechanical connections, or by installing in-line anchors or a combination of both. Additional restraint mechanisms are available to supplement the pull resistance of these types of fittings if needed. The fitting manufacturer can help guide the user with that information. Use of a stiffener is needed in this fitting style to support the pipe under the area of the seal ring and any gripping devices incorporated for pullout resistance.



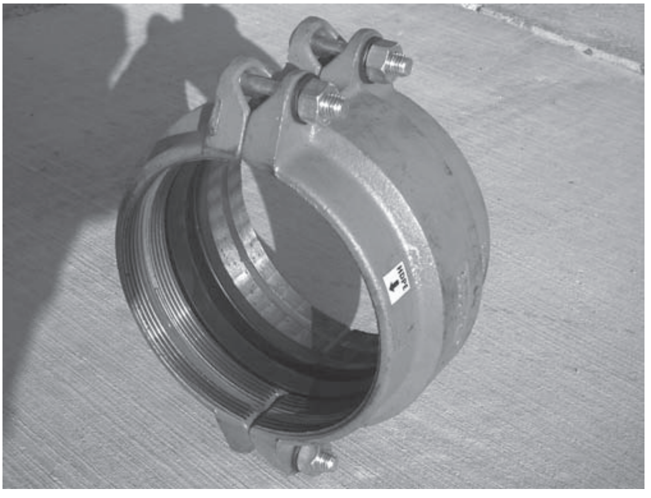


Figure 9 Mechanical Bolt Type Coupling for Joining Steel Pipe to PE or for Joining Two PE Pipes

Stiffener Installation Guidelines

When connecting PE pipe to the bell end of a ductile iron or PVC pipe, it is recommended that a stiffener be added to the ID of the pipe to insure a good connection between the seal in the bell and the pipe. Check the pipe for toe in. If it is severe, cut the pipe back to remove it. If possible, have some means to press the stiffener into place. Lubricant will minimize the insertion effort required. A detergent or silicone grease is recommended.

There are two types of stiffeners available on the market. One type is a fixed diameter stiffener that matches the ID of the pipe being repaired (see Figure 10). Caution should be used when using fixed diameter stiffeners to be sure they are sized properly to obtain the proper press fit in the PE pipe. These are mainly used with smaller diameter service lines.

Figure 10 Fixed Diameter Stiffener for PE Pipe

Figure 11a Split Ring Stiffener for PE Pipe

The other type of stiffener is a split ring stiffener (see Figure 11a). These are normally made of stainless steel and provide a thin yet strong pipe wall reinforcement without disturbing the flow characteristic of the pipe. The easy installation instructions are shown in Figure 11b.

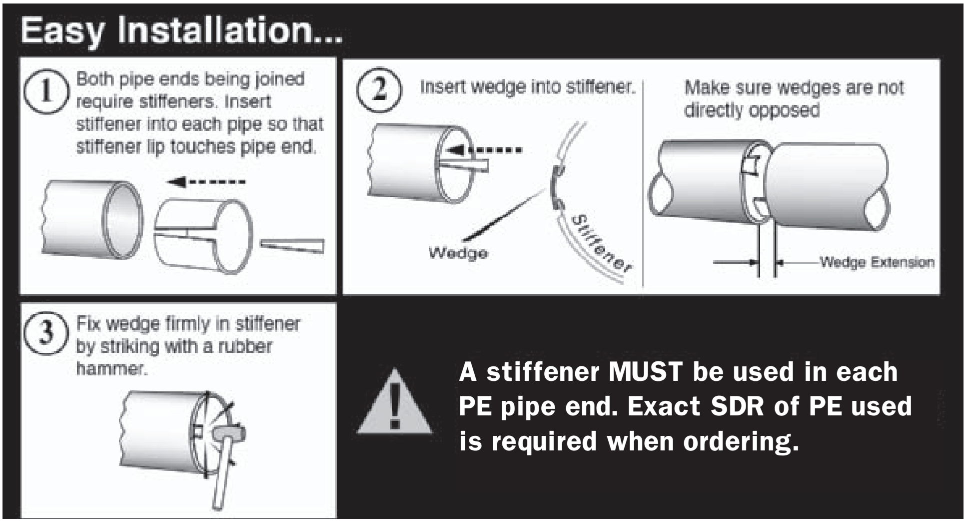


Figure 11b Easy Installation Instructions

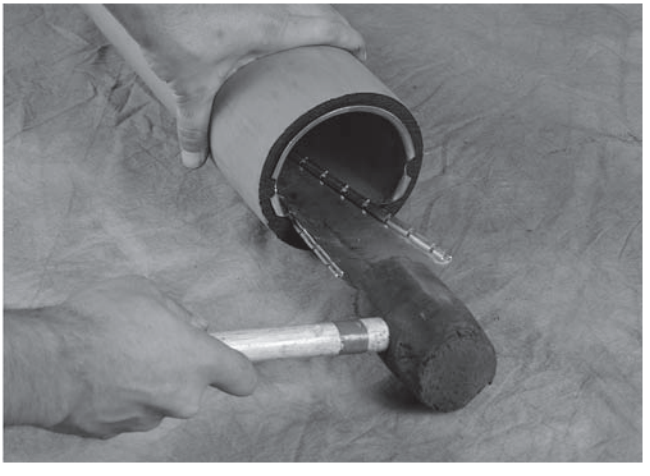


Figure 12 Install Split Ring Stiffener in PE Pipe

Flanged Connections

PE Flange Adapters and Stub Ends

When joining to metal or to certain other piping materials, or if a pipe section capable of disassembly is required, PE flange adapters, as depicted in Figures 13-15, are available. The "Flange Adapter" and its shorter version, the "Stub End," are designed so that one end is sized the same as the PE pipe for butt fusion to it. The other end has been especially made with a flange-type end that, provides structural support, which eliminates the need for a stiffener and, with the addition of a metal back-up ring, permits bolting to a similar flanged end connection — normally a 150-pound ANSI flange.(1)

The general procedures for joining would be:

1. Slip the metal ring onto the PE pipe section, far enough away from the end to avoid interference with operation of the butt fusion equipment.
2. If a stub end is used, first butt-fuse a short length of PE pipe to the pipe end of the stub end. If a "flange adapter" is used, the PE pipe-sized end is usually long enough that this step is unnecessary.
3. Butt fuse the flange adapter to the PE pipe segment.
4. The fusion bead may need to be removed to clear the back-up ring as it is moved against the flange.
5. Position the flanged face of the adapter at the position required so that the back-up ring previously placed on the PE pipe segment can be attached to the metal flange.
6. Install and tighten the flange bolts in a criss-cross pattern sequence (see TN 38), normally used with flange type connections, drawing the metal and PE flange faces evenly and flat. Do not use the process of tightening the flanges to draw the two sections of pipe together.

At lower pressure, typically 80 psi or less, a gasket is usually not required. At greater pressure, the serrated surface of the flange adapter helps hold the gasket in place. The flange face serration's should be individual closed concentric serration's as opposed to a continuous spiral groove which could act as a leak path. Standard Back-Up Rings are AWWA C207 Class D for 160 psi and lower pressure ratings, or Class 150 for higher pressure. Back-up ring materials are steel, primer coated steel, epoxy coated steel, or stainless steel. Ductile iron and fiberglass back-up ring materials are also available. In below ground service, coatings and cathodic protection may be appropriate to protect metal back-up rings from corrosion. One edge of the back-up ring bore must be rounded or chamfered. This edge fits against the back of the sealing surface flange.

An all-PE flange without a back-up ring is not recommended because PE flanges require uniform pressure over the entire sealing surface. Without a back-up ring, a PE flange will leak between the bolts.

Flange adapters differ from stub-ends by their overall length. A flange adapter is longer allowing it to be clamped in a fusion machine like a pipe end. The back-up ring is fitted to the flange adapter before fusion, so external fusion bead removal is not required.

A stub end is short and requires a special stub-end holder for butt fusion. Once butt fused to the pipe, the external bead must be removed so the back-up ring can be fitted behind the sealing surface flange. In the field, flange adapters are usually preferred over stub-ends.

Figure 13 Flange Adapter Assembly

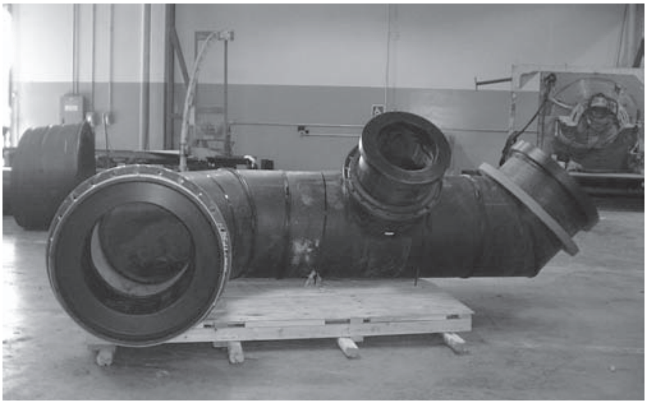


Figure 14 Fused Manifold Assembly with Flange Adapters and Back Up Rings

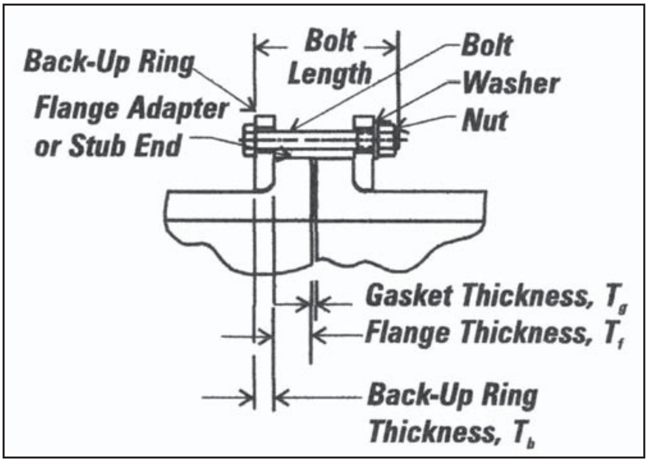


Figure 15 Flange Adapter Bolted Assembly Cross Section

Flange Gasket

A flange gasket may not be required between PE flanges. At lower pressures (typically 80 psi or less) the serrated flange sealing surface may be adequate. Gaskets may be needed for higher pressures and for connections between PE and non-PE flanges. If used, gasket materials should be chemically and thermally compatible with the internal fluid and the external environment, and should be of appropriate hardness, thickness and style. Elevated temperature applications may require higher temperature capability. Gasket thickness should be about 1/8”-3/16” (3-5mm) and about 60-75 Shore A hardness. Too soft or too thick gaskets may blow out under pressure. Overly hard gaskets may not seal. Common gasket styles are full-face or drop-in. Full-face style gaskets are usually applied to larger sizes, because flange bolts hold a flexible gasket in place while fitting the components together. Drop-in style gaskets are usually applied to smaller pipe sizes.

Flange Bolting

Mating flanges are usually joined together with hex bolts and hex nuts, or threaded studs and hex nuts. Bolting materials should have tensile strength equivalent to at least SAE Grade 3 for pressure pipe service, and to at least SAE Grade 2 for non-pressure service. Corrosion resistant materials should be considered for underground, underwater, or other corrosive environments. Flange bolts are sized 1/8” smaller than the blot hole diameter. Flat washers should be used between the nut and the back-up ring.

Flange bolts must span the entire width of the flange joint, and provide sufficient thread length to fully engage the nut.

Flange Assembly

Mating flanges must be aligned together before tightening. Tightening misaligned flanges can cause flange assembly failure. Surface or above grade flanges must be properly supported to avoid bending stresses. Below grade flange connections to heavy appurtenances such as valves or hydrants, or to metal pipes, require a support foundation of compacted, stable granular soil (crushed stone), or compacted cement stabilized granular backfill, or reinforced concrete. Flange connections adjacent to pipes passing through structural walls must be structurally supported to avoid shear loads.

Prior to fit-up, lubricate flange bolt threads, washers, and nuts with a non-fluid lubricant. Gasket and flange sealing surfaces must be clean and free of significant cuts or gouges. Fit the flange components together loosely. Hand-tighten bolts and re-check alignment. Adjust alignment if necessary. Flange bolts should be tightened to the same torque value by turning the nut. Tighten each bolt according to the patterns and torques recommended by the flange manufacturer. PE and the gasket (if used) will undergo some compression set. Therefore, retightening is recommended
about an hour or so after torquing to the final torque value the first time. In criss-cross pattern sequence, retighten each bolt to the final torque value. For high pressure or environmentally sensitive or critical pipelines, a third tightening, about 4 hours after the second, is recommended.

Special Cases

When flanging to brittle materials such as cast iron, accurate alignment, and careful tightening are necessary. Tightening torque increments should not exceed 10 ft.-lbs. PE flange adapters and stub ends are not full-face, so tightening places a bending stress across the flange face. Over-tightening, misalignment, or uneven tightening can break brittle material flanges.

When joining a PE flange adapter or stub end to a flanged butterfly valve, the inside diameter of the pipe flange should be checked for valve disk rotation clearance. The open valve disk may extend into the body of the flange adapter/stub end. Valve operation may be restricted if the pipe flange interferes with the disk. If disk rotation clearance is a problem, a tubular spacer may be installed between the mating flanges, or the pipe flange bore may be chamfered slightly. At the sealing surface, chamfering must not increase the flange inside diameter by more than 10%, and not extend into the flange more than 20% of the flange thickness. If spacer plates are used, the flange bolt length must be increased by the length of the spacer.

Mechanical Flange Adapters

Mechanical Flange Adapters are also available and are shown in Figure 16. This fitting combines the mechanical bolt type coupling shown in Figure 9 on one end with the flange connection shown in Figure 10 on the other. This fitting can provide a connection from flange fittings and valves to plain end pipes. The coupling end of this fitting must use a stiffener when used to join PE pipe. Mechanical flange adapters may or may not include a self-restraint to provide restraint against pipe pullout as part of the design. Alternative means of restraint should be used when joining PE pipe if the mechanical flange adapter does not provide restraint. Contact the manufacturer of these fittings for assistance in selecting the appropriate style for the application.

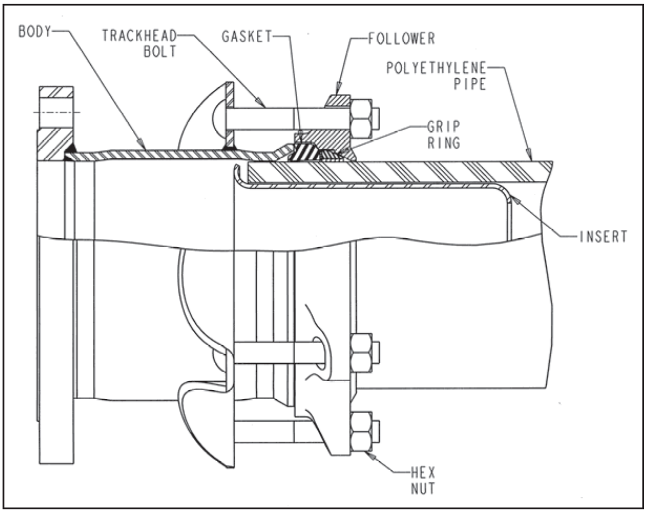


Figure 16 Bolt Type Mechanical Flange Adapter

Solid DI Sleeve Connections to PE pipe

Solid Sleeves are ductile iron fittings designed to connect DI/PVC pipe to other piping materials including PE pipe. They come in a variety of configurations depending on the application. Most solid sleeves have a flange or MJ hub to attach to the PE pipe. On the ductile iron pipe side, a Megalug flange is attached to the pipe and a gasket is installed over the pipe and into the sleeve before bolting the Megalug to the Sleeve flange. A standard PE MJ Adapter kit is used on the PE pipe side to complete the assembly. Be sure to use the manufacturer's recommended bolting procedures for this assembly. (See Figure 17.)

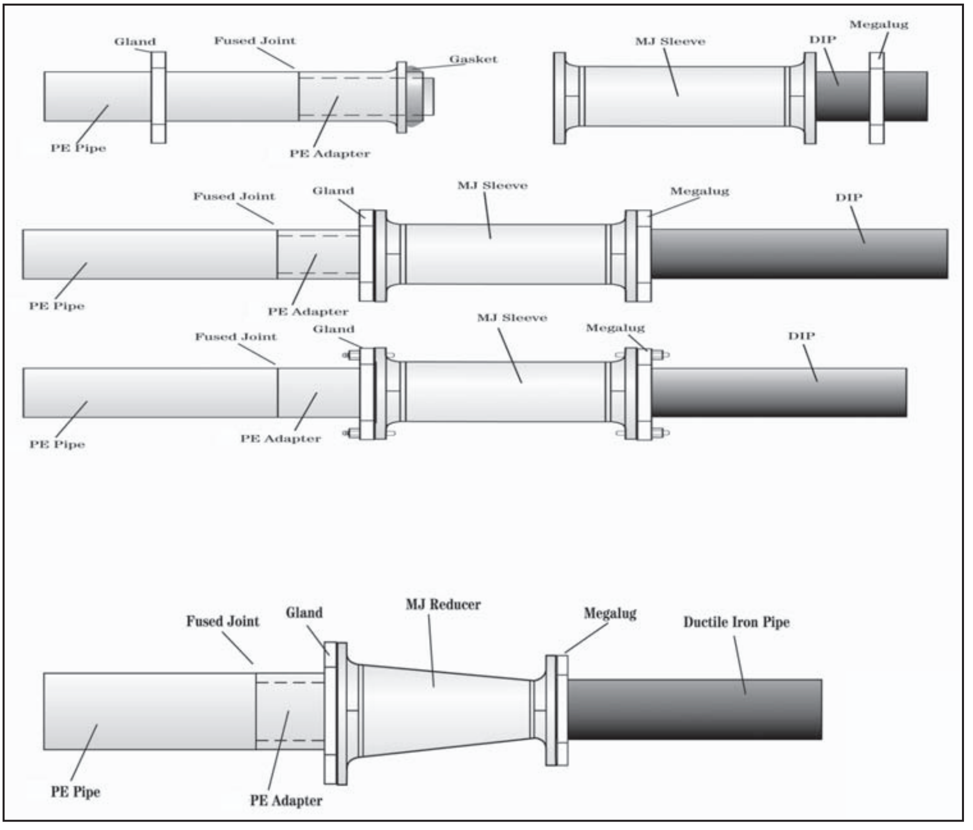


Figure 17 Solid DI Sleeve Connections to PE pipe

Another solid sleeve design is called a "One Bolt" Solid Sleeve and can be used to connect PE pipe to PVC or DI pipe. This is similar to a standard PE mechanical connector but has a special locking ring that grips the PE pipe to prevent pullout. It is recommended to use a stiffener inside the PE pipe, especially if the DR is more than 11. This connection can be installed very quickly in the field and may also be used for repair. Consult with the sleeve manufacturer for application and restraint advice.

Figure 18 One Bolt Solid Sleeve Connection

PE Pipe Connection to DI or PVC Bell End

Another method of restraining the above mentioned connection would be the use of a restraint harness and the attachment of flex restraint sections to the PE pipe. These flex restraint pieces are electro-fused to the PE pipe to achieve the proper stab depth in the PVC or DI bell and the restraint harness plate is attached behind them. The opposite end of the restraint harness is attached behind the DI/PVC hub. Install the PE pipe in the PVC/DI bell until it bottoms out on the flex restraints and tighten the tie rods to prevent the assembly from pulling apart. As discussed above: to maintain proper contact with the seal in the DI/PVC fitting, it is recommended that a stiffener be installed in the PE pipe end.

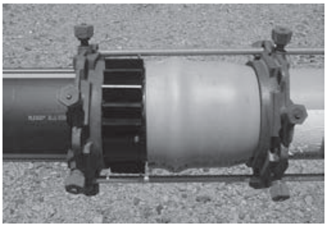


Figure 19 PE Pipe Connection to DI/PVC Bell End Using Flex Restraints on the PE Pipe

PE Bell Adapters to DI or PVC Pipe End

There are PE Bell Adapters available, up to 24” IPS, that are machined to the standard MJ Adapter internal configurations and have an external stainless steel backup ring installed to ensure positive seal contact. This connection incorporates a back-up flange behind the PE Adapter and a Mega-Lug flange on the PVC or DI pipe. Standard MJ seals and bolts are used to connect the assembly.

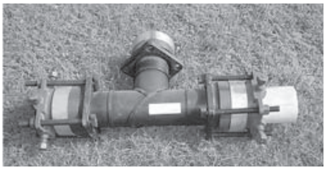


Figure 20 PE Bell Adapter to DI or PVC Pipe End

DI Valve with PE Ends

In most potable water systems, a valve is installed between the main and the hydrant. This can be fused in line using this special valve assembly with PE pipe installed on each side and available up to 12" pipe size. It has an PE ends installed on each side of the valve.

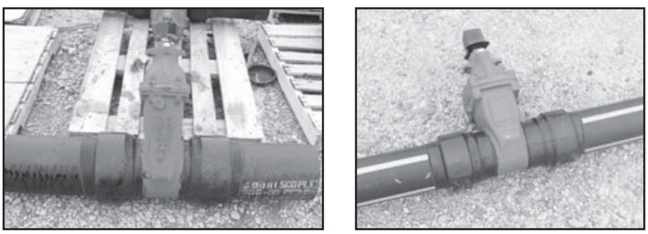


Figure 21 Ductile Iron Gate Valve with PE Ends

Dismantling Joint

Dismantling joints simplify installations and replacement of flanged fittings in retrofitting applications. Dismantling Joints provide the solution for adding, repairing or replacing flanged fittings within a flanged pipe system. In all applications, a restrained dismantling joint is required unless otherwise specified. (See Section titled Restraint Methods.)

Adjustable, slip joint design accommodates either wide gaps or close quarter installations and eliminates the need for precise measurements between flange connections. Available in sizes 2" and larger, for ductile iron or flanged PE piping systems. Standard flanges AWWA C207 Class D Flange. Other flanges are available upon request.

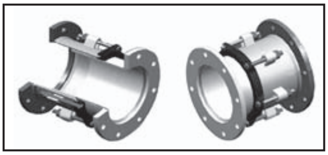


Figure 22 Dismantling Joint

Mechanical Joint (MJ) Adapters

PE pipe can be connected to traditional hydrants, valves and metal pipes using an MJ Adapter. A gland ring is placed behind the adapter before fusing, which can be connected to a standard ANSI/AWWA mechanical joint. When the gland ring is used, restraining devices are not required on the PE pipe.

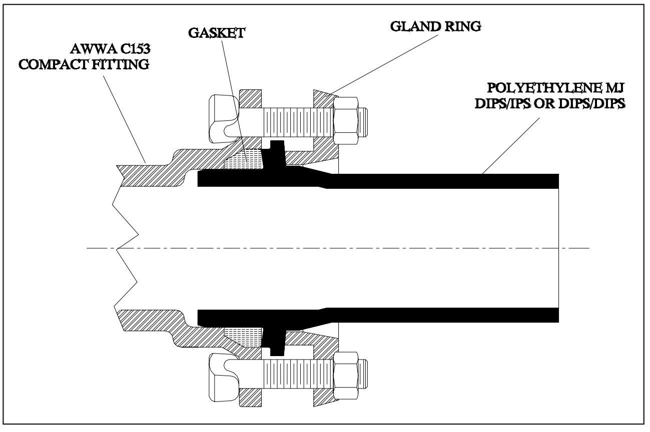


Figure 23 Typical Application of PE MJ Adapter

Transition Fittings

Other methods are available that allow joining of PE to metal. Transition fittings are available which are pre-assembled at the manufacturer's facility. These transition fittings are normally pull-out resistant, seal tight with pressure and have tensile values greater than that of the PE pipe part of a system. However, the user should insist on information from the manufacturer to confirm design capabilities or limitations. Transition fittings are available in all common pipe sizes and PE materials from CTS and larger with a short segment of PE pipe for joining to the PE pipe section. The metal end is available with a bevel for butt welding, with male or female pipe threads, or is grooved for a Victaulic(14) style, or flanged for connecting to an ANSI 150-pound flange.(1)

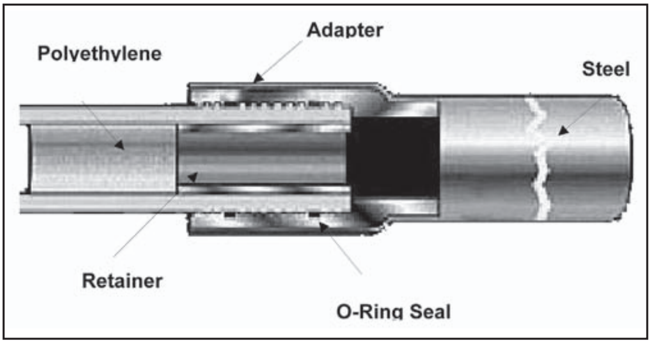


Figure 24 Standard Fitting for PE Pipe to Steel Pipe Transition

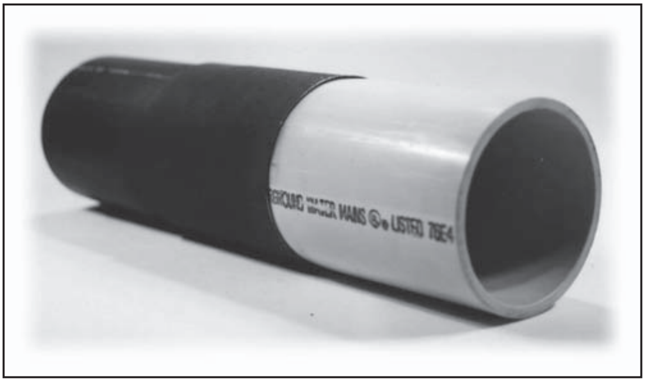


Figure 25 Transition Fitting - PE Pipe to PVC

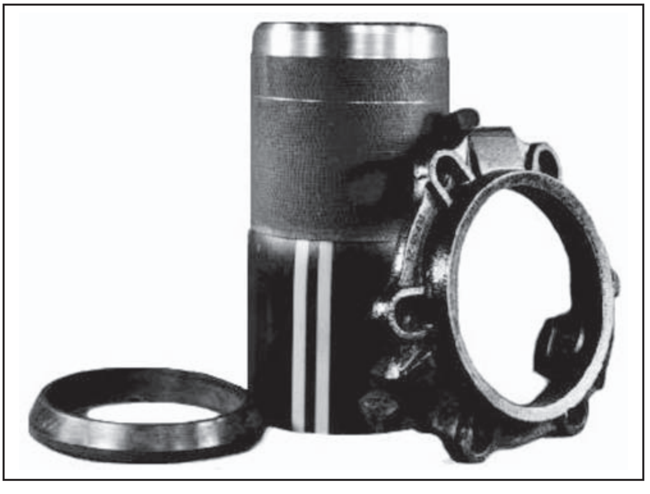


Figure 26 Transition Fitting - PE Pipe to DI with MJ Adapter

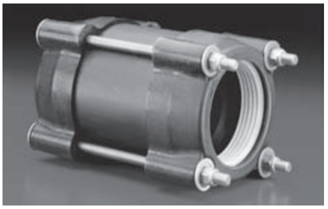


Figure 27 Hydrant Swivel Transition Fitting - PE Pipe to DI

Mechanical Joint Saddle Fittings

Mechanical joint saddle fittings have at least one mechanical joint which may connect the outlet to the service or branch pipe, or may connect the fitting base to the main, or both connections may be mechanical joints. Mechanical joint saddle fittings are made from PE, metals, and other materials.

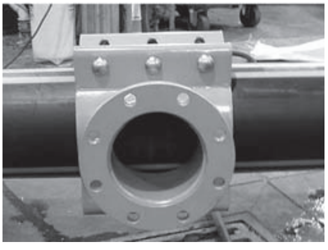


Figure 28 Mechanical Saddle

For mechanical joint outlets, the service or branch pipe is either supported with a tubular stiffener in the pipe ID, or the pipe end is fitted over a spigot (insert) end of the fitting. The outlet joint is completed using mechanical compression around the service or branch pipe OD. Depending upon design, gaskets may or may not be used. Observe the fitting manufacturer's instructions in making the outlet connection.

Plastic outlet pipes must be protected against shear or bending loads by installing protective sleeves or bridging sleeves, or special care must be taken to ensure that embedment materials are properly placed and compacted around the outlet.

The connection between the saddle base and the main may be by hot plate saddle fusion, or by electrofusion, or by mechanical connection. Hot plate saddle fusion and electrofusion have been previously discussed.

Mechanical saddle base connections are clamped or strapped to the side or top of the main pipe. Typically, gaskets or o-rings are used to seal between the saddle base and the main pipe OD surface to prevent leakage when the main wall is tapped. Once secured to the main per the fitting manufacturer's instructions, the main may be pierced to allow flow into the service or branch pipe.

Some mechanical joint saddle fittings can have an internal cutter to pierce the main pipe wall (Fig. 28). "Tapping tees or tapping saddles" (Fig. 29) are generally suitable for installation on a "live" or pressurized main (hot tapping). Branch saddles or service saddles that do not have internal cutters may also be hot tapped using special tapping equipment. Contact equipment manufacturer for information.

Figure 29 PE Tapping Tee with Cutter

Restraint Methods

A pipe section with fully restrained joints such as a long string of butt fused PE pipe will transmit Poisson effect pipe shortening from length to length through the restrained joints along the pipe string. Restrained joints include butt fusions, electro-fusions, socket fusions, bolted flange connections, MJ Adapter connections or other restrained mechanical connections. If an unrestrained bell and spigot or mechanical sleeve joint is in-line with the restrained section, the cumulative Poisson effect shortening and possible thermal expansion/contraction effect may cause in-line unrestrained joints or connections to be pulled apart. Therefore, unrestrained joints or mechanical connections that are in-line with fully restrained PE pipe must be either restrained or otherwise protected against pullout disjoining.

Wall Anchor

A typical pullout prevention technique is to restrain the transition connection by butt fusing a Wall Anchor in the PE pipeline close to the connection and pouring a concrete anchor around it as shown in Figure 30. Refer to the pipe manufacturer's recommendations on anchor size and pull out loads.

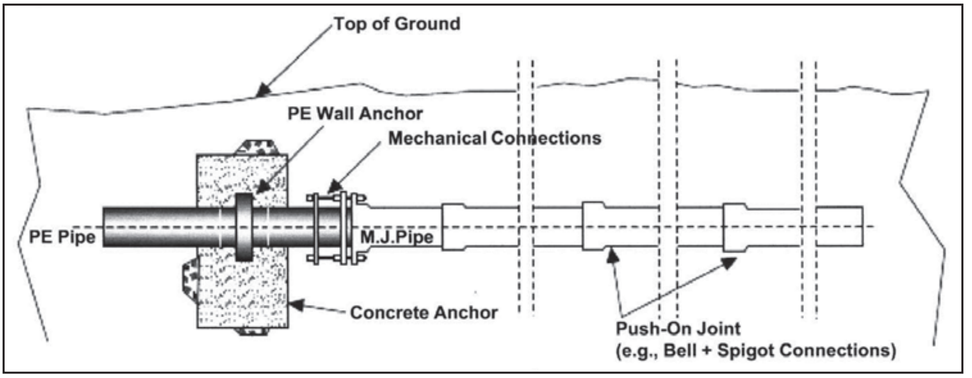


Figure 30 Wall Anchor Diagram

Another method of anchoring this connection is to electro-fuse several Flex Restraints to the PE pipe instead of butt fusing a wall anchor to the line as shown in Figure 31.

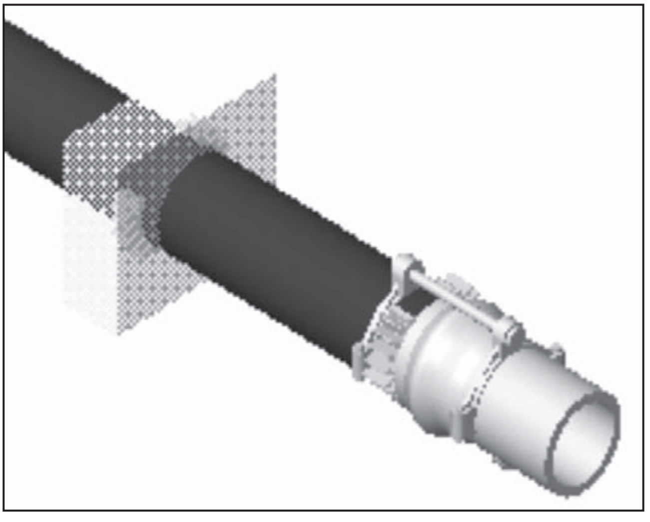


Figure 31 Flex Restraint Anchor

Mechanical Restraint Anchor

A typical pullout prevention technique is to restrain the transition connection and several non-PE bell and spigot joints down line from the transition connection as shown in Figure 32.

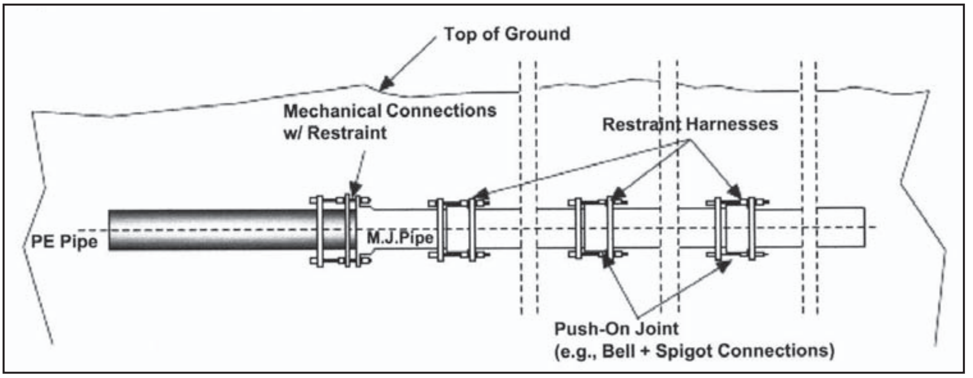


Figure 32 Mechanical Restraint of Existing Pipeline when Attaching to PE Pipe

Buried Poly Anchor

This product is designed to be buried in the soil and resist any linear movement that might occur with PE pipe without pouring a concrete anchor around it. In order to mobilize its buried anchoring restraint action, the Poly-Anchor simply requires at least 85% standard Proctor Density soil compaction in-situ to the top of the plate. Consult with the fitting manufacturer to ensure that the anchor size is adequate for the bearing capacity of the soil.

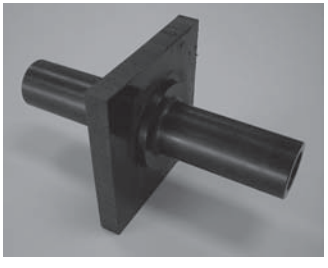


Figure 33 Buried Poly Anchor

Above Ground Pipeline Anchor

The above ground anchor fitting is commonly used to manage PE pipe from thermal expansion and contraction. The fitting is fused into the pipe-line, and a metal band (C-Clamp) is secured over the anchor fitting in the middle, and securely bolted to an I-beam, support bracket, or embedded into a concrete block up-to the spring-line with C-clamp over the pipe crown and bolted to the block . The metal band attaches the pipeline to the anchoring point; the OD rings prevent the pipeline from moving in expansion or contraction in either direction. The width of the center groove can be made as wide as required so as to get sufficient grip on the PE pipe for the thermal excursions expected.

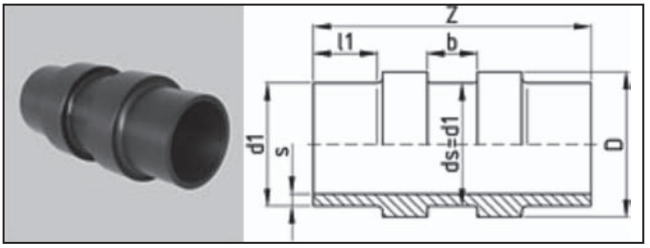


Figure 34 Above Ground Pipeline Anchor

PE to PVC Slip-Joint Anchor Fitting

A gasketed PVC pipe bell to plain end PE pipe should be restrained against PE thermal contraction and pressure thrust, to avoid possible long-term joint separation. The PVC-Bell slip-Joint Anchor Fitting (PVC-SJA Fitting) with internal stiffener to support gasket load, provides the restrained connection from PE pipe to bell-end PVC pipe. (For plain-end PVC, refer to Section titled PE Bell Adapters to DI or PVC Pipe End). When the restraint rings with tie-rod option is specified, the rods and rings are supplied separately from the SJA fitting.

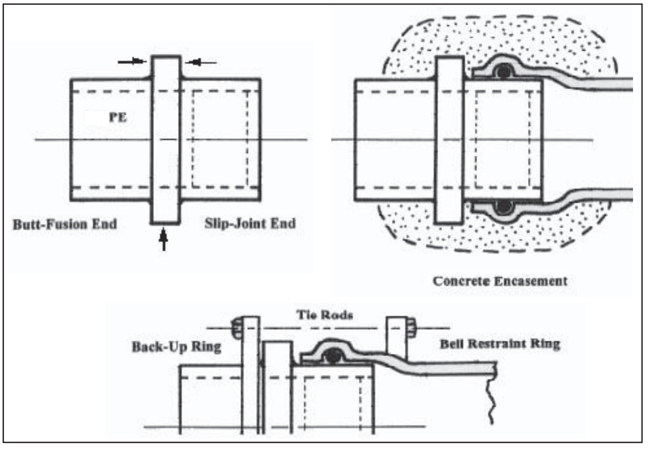


Figure 35 PE to PVC Slip-Joint Anchor Configurations

Summary

The applications for PE piping products continue to expand at an accelerating rate. Gas distribution lines, potable water systems, submerged marine installations, gravity and force main sewer systems, and various types of above-ground exposed piping systems are but a few of the installations for which PE pipe and fittings have been utilized.

As piping products applications expand, so does the use of new and existing joining methods expand.

A key element to this continued success is the diversity of methods available to join PE pipe and fittings. The integrity of the butt and socket fusion joining technique has been proven by the test of time in a variety of applications. The manufacturers of PE pipe and fittings have made every effort to make the systems as comprehensive as possible by producing a variety of fittings and components to insure compatibility with alternate piping materials and system appurtenances.

The purpose of this chapter has been to provide the reader with an overview of the various methods by which PE piping materials may be joined. As a result the reader has developed a further appreciation for the flexibility, integrity, and overall utility afforded in the design, installation, and performance of PE piping systems and components.

It should be noted that this chapter does not purport to address the safety considerations associated with the use of these procedures. Information on safe operating procedures can be obtained from the manufacturers of the various types of joining equipment or PE products.

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Municipal Advisory Board

Established May 1, 2008 at the University of Texas, Arlington

MAB Generic Electrofusion Procedure for Field Joining of 12 Inch and Smaller Polyethylene (PE) Pipe

First edition approved by Municipal Advisory Board on Nov. 5, 2015, in Casselberry, FL.

CONTENTS

FOREWORD

This procedure was developed by the Municipal Advisory Board and published with the technical help of the members of the PPI (Plastics Pipe Institute, Inc.). The members have shown their interest in quality products by assisting independent standards-making and user organizations in the development of standards, and also by developing reports on an industry-wide basis to help engineers, code officials, specifying groups, and users.

The purpose of this technical report is to provide important information available to the Municipal Advisory Board (MAB) on particular aspects of 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.

The Municipal Advisory Board serves as an independent, non-commercial adviser to the M & I Division of the Plastics Pipe Institute. Once adopted, MAB intends to revise this report from time to time, in response to comments and suggestions from users of the report. Please send suggestions of improvements to Camille Rubeiz at crubeiz@plasticpipe.org.

ACKNOWLEDGEMENTS

The Municipal Advisory Board would like to acknowledge the excellent contributions of the MAB Electrofusion Task Group for developing and leading this project:

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9. **Andrew Schipper**, **PE**, City of Ft. Wayne, IN
10. **Greg Scoby, PE**, City of Palo Alto, CA (past) and Crossbore Consultants, CA
11. **Jeff Wright**, Georg Fischer Central Plastics, Shawnee, OK

HISTORY

In 2014, representatives of the Municipal Advisory Board (MAB) requested assistance in creating greater uniformity in the joining procedures utilized by municipal 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.

In response to this request, MAB established a task group to develop a generic electrofusion procedure for the joining of polyethylene piping and a guide for inspection to ensure that proper procedures are in place and being followed. The result of that task group effort is this document.

In the spirit of complying with the above request, companies that manufacture electrofusion products and equipment reviewed existing procedures, agreed on common best 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, reduce cost, and simplify inspections. Refer to Appendix A for a list of electrofusion companies that endorsed these generic practices for use with their fittings.

SCOPE

The program undertaken by the MAB Task Group 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 on 12 inch or smaller pipe. An additional goal is to provide clear inspection criteria for installer qualification, installation acceptance by inspection, and answers to frequently asked questions. The size range was limited to 12 inch or smaller due to differences in installation procedures for larger diameters, commonly accepted as 14 inch or larger. For installation of larger electrofusion couplings, the user can reference PPI TN-34 *INSTALLATION GUIDELINES FOR ELECTROFUSION COUPLINGS 14 INCH AND LARGER.*

The Municipal Advisory Board hopes that 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 PE piping products. Use of this procedure is obviously not mandatory, 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 in this area and promote the use of effective, qualified procedures for electrofusion joining of PE pipe.

I. INTRODUCTION

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 should be marked to indicate that they meet the design 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 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 fitting designs share some common requirements for installation and all manufacturer's instructions include these same requirements.

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 how to tell if the requirements of each step have been accomplished.

II. JOBSITE PREPARATION

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

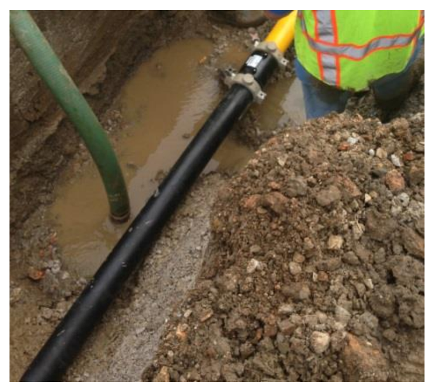


Figure II-a – Submersible pump

In repair or cut-in situations, flowing water in the pipe may be present due to leakage of valves. Flowing water in contact with the fusion surfaces during the assembly or fusion cycle must be avoided as it can 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. PE squeeze-off tools can be used to control flow of water in cases where a valve is not present or will not shut off completely; refer to ASTM F1041. Some practical temporary methods for accomplishing this, while avoiding the need to disinfect the line, are the use of organic absorbent materials, such as bread, which can later be flushed from the system at downstream hydrants. Dry ice placed in the pipe upstream of the fusion location will temporarily freeze small amounts of flowing water until the fusion process can be completed. In smaller diameter pipes inflated latex balloons also provide good temporary stoppage of trickling water. The balloon will burst during pressure testing and can be flushed from the system at a downstream outlet.

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

III. FITTING STORAGE AND HANDLING

Electrofusion fittings are packaged in sealed plastic bags as protection against accumulation of dust, dirt, and contamination. The bag should remain in place during normal handling and should only be removed during installation. Fittings are also typically boxed to protect against other sources of degradation, such as oxidation due to UV exposure over long periods of storage. Fittings should always be stored indoors in their original packaging until installation.

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 a virtually unlimited shelf life.

⚠ **Fittings with an unknown storage history or that have been exposed to questionable storage conditions should be evaluated through destructive testing of sample fusions. If fusion quality is shown to be affected, the fittings in question should not be installed.**

Fittings should be inspected for damage before installing to ensure that connection points such as terminal pins have not been damaged from 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.

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

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

IV. 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: A tape measure (Fig. IV-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.

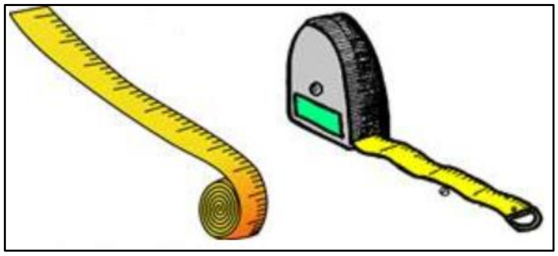


Figure IV-a –Measuring Tape

B. Marking: A permanent visible marker. Markers should be visible on the pipe color (Fig. IV-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 accidentally contaminate a prepared pipe surface. Marks are needed to locate insertion depths and to use as a guide for pipe scraping effectiveness.

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

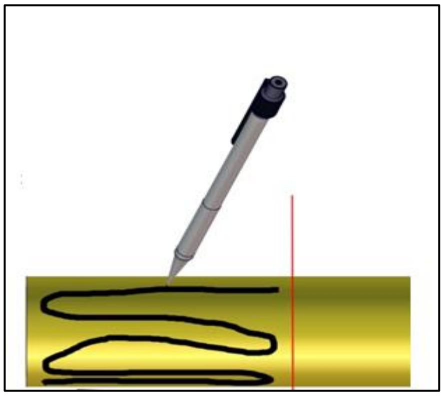


Figure IV-b - Marking

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

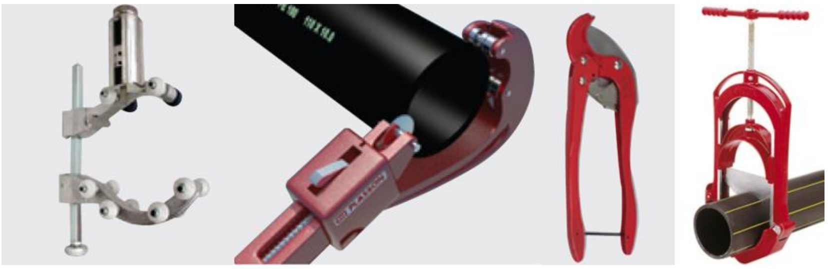


Figure IV-c – Pipe cutters (rotational, ratcheting, and guillotine style)

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

Figure IV-d – Marking and cutting larger diameter pipes

D. Measuring pipe:

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

Table IV-a – Standard Pipe and Tubing Dimensions

IRON PIPE SIZE (IPS) ASTM D3035/F714		
PIPE SIZE	Nominal Diameter (inches)	Tolerance (±)
3/4 IPS	1.050	0.004
1 IPS	1.315	0.005
1 1/4 IPS	1.660	0.005
1 1/2 IPS	1.900	0.006
2 IPS	2.375	0.006
3 IPS	3.500	0.016
4 IPS	4.500	0.020
6 IPS	6.625	0.030
8 IPS	8.625	0.039
10 IPS	10.750	0.048
12 IPS	12.750	0.057

COPPER TUBE SIZE (CTS) ASTM D2737		
TUBING SIZE	Nominal Diameter (inches)	Tolerance (±)
3/4 CTS	0.875	0.004
1 CTS	1.125	0.005
1 1/4 CTS	1.375	0.005
1 1/2 CTS	1.625	0.006
2 CTS	2.125	0.006

DUCTILE IRON PIPE SIZE (DIPS) ASTM F714		
PIPE SIZE	Nominal Diameter (inches)	Tolerance (±)
3 DIPS	3.960	0.018
4 DIPS	4.800	0.022
6 DIPS	6.900	0.031
8 DIPS	9.050	0.041
10 DIPS	11.100	0.050
12 DIPS	13.200	0.059

(NOTE: For sizes larger than 12 inch, See PPI TN-34)

2. Roundness: Polyethylene is a flexible material. Pipe roundness (Fig III-e) can be affected by a number of conditions to include manufacturing process conditions, coiling, storage/stacking, and soil load if buried.

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

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

- Ovality is the difference between the maximum and minimum measured outside diameters expressed as a percentage. Ovality is calculated as $(d1 – d2) / D_{average} \times 100$.

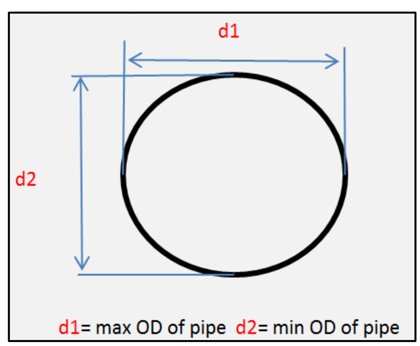


Figure IV-e - Roundness Measurement

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

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

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

Table IV-b – Maximum Out-of-Roundness (IPS/DIPS)

PIPE SIZE	d1 - d2
3"	.0625 or 1/16"
4"	.0625 or 1/16"
6"	.125 or 1/8"
8"	.125 or 1/8"
10"	.125 or 1/8"
12"	.125 or 1/8"

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.

⚠ **Gouges that are deeper than the scrape depth may also require extra attention when scraping the pipe to ensure that any debris or contaminates embedded in the gouges are removed; use of a hand tool to scrape the gouge may be necessary. If the gouge exceeds 10% of the pipe wall thickness, that pipe section should be cut out and replaced to maintain the maximum pressure rating of the pipe.**

V. PIPE PREPARATION

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 because the installer may not completely understand the goal of pipe scraping, which is to remove a thin layer of the outer pipe surface (see trouble-shooting section 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. Simply roughing the pipe surface is not sufficient. In order to achieve fusion, this layer must be removed. Even new pipe must be properly scraped before a fusion will be successful.

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

Figure V-a - Scraping Measurement

⚠ **Sand paper, emory cloth, or other abrasives should never be used to prepare a pipe surface for electrofusion. Abrasives have been proven to be ineffective for electrofusion because they don't adequately remove material, they can redistribute contaminates on the surfaces, and because they can leave behind a grit residue that forms another barrier that will also prevent fusion.**

There are many tools that can be 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 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" (Fig. V-b).

Figure V-b – Acceptable "Peelers"

- Tools with serrated blades are also available (Fig. V-c); these tools physically scrape the pipe surface by pulling the serrated blade across the pipe in a perpendicular position. Serrated blades sometimes mask the pipe surface by leaving behind score marks that make it difficult to visually tell if all of the original surface material has been removed.

Figure V-c - Examples of serrated type blade scrapers

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

- Another type of tool is referred to as a "hand scraper". **These scrapers are not recommended** (Fig. V-d) due to inconsistent surface preparation and difficulty in mastering skills required for uniform surface preparation.

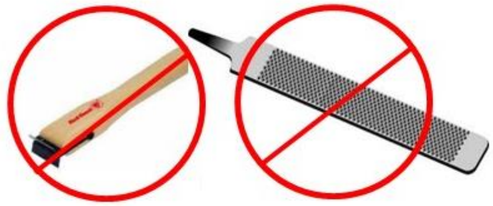


Figure V-d – Not Recommended "Hand Scrapers"

⚠ **Wood rasps and metal files are not acceptable scraping tools.**

VI. FITTING CLAMPING

Electrofusion fittings generate significant pressure from thermal expansion during the melt phase of the fusion process. This melt pressure is an integral part of the fusion process and a designed function of the fitting and fusion parameter. Polyethylene is also a thermoplastic that softens when heated. As a result, all electrofusion fittings shall be installed with the use of alignment and restraining clamps. (Fig. VI-a)

Figure VI-a - Fitting Clamps

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

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

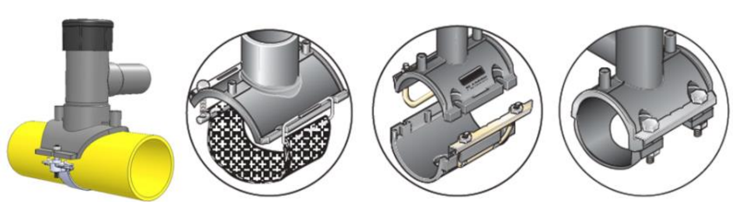


Figure VI-b - Integral saddle clamps that remain in place after fusion

Other designs include a clamp that is re-usable (Fig. VI-c) and is removed after the fitting is cooled.

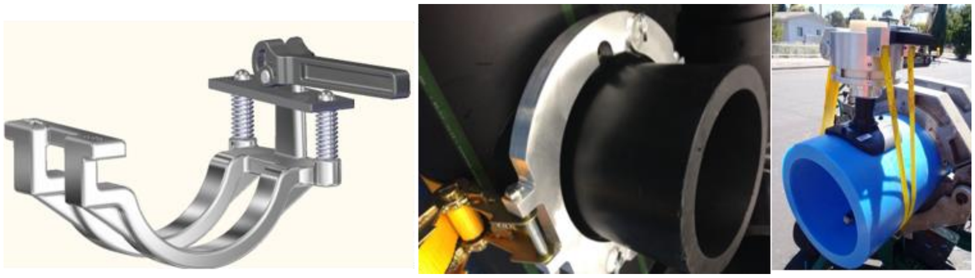


Figure VI-c - Reusable saddle clamps

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 checks the ambient air temperature and automatically adjusts the fusion time for that temperature if the fitting barcode requires it.

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

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 for reference if an error occurs. A record of each fusion, as well as the result of the fusion cycle, is stored and is downloadable via a USB connection. Displayed error codes are unique to each manufacturer- refer to manufacturer’s user manual for interpretation.

Control box fusion cables tips can be changed or adapted 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 operator at power-up, but will continue to function when acknowledged.

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 or failure, the cause can usually be traced to the power supply. It is important to ensure that the power supply is in good working order and capable of supplying the required energy for the fitting being fused.

Each electrofusion fitting has an integral heating coil that requires a defined amount of energy input to achieve the designed results. Heating coils are engineered specifically for a fitting size or configuration and power requirements will vary from one manufacturer to another for the same size fitting. The fitting manufacturer can provide specific requirements for its particular products, but Table VIII-a can be used as a guide for most fittings that are commonly available:

Table VIII-a – Input Power Requirements

FITTING TYPE	FITTING SIZE	GENERATOR MINIMUM (WATT)	BREAKER MINIMUM 120v / 240v	EXTENSION CORD 25 ft.	EXTENSION CORD 50 ft.
SOCKET*	3/4" to 2"	2500	15 / 15 AMP	#10/3	#8/3
SOCKET*	3" to 12"	5000	30 / 20 AMP	#10/3	#8/3
SADDLE	ALL	2500	15 / 15 AMP	#10/3	#8/3

*Socket includes couplings, tees, elbows, reducers, and caps.

Extension cords can be used, however the wire gage should not be less than that shown in Table (VIII-a) for the maximum length.

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

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

IX. FUSION PARAMETERS

Fusion parameters such as fusion time, voltage, and cooling time, can be entered into the control box by various means:

A. 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.

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

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

   3. 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 in the event that the code cannot be scanned.

EF COUPLING 1 CTS FT30sCT5M 12062462
951320308152401207030114

Figure IX-a – Barcode with Numerical Value

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

Figure IX-b – Identification Resistor

C. Manual entry of fusion time and voltage entry may be possible if printed on the fitting label (Fig. IX-c). The fusion time is typically preceded by the word "WELD" or "FUSE" and displayed in seconds. The voltage is displayed and followed by "V". It is always preferable to use the bar code method. All PE EF fittings are manufactured using PE 4710/PE100 and must be fusible to the piping system.

EF CPLG,8,IPS,,BLK,PE3408/PE4710,CEC,4.
7R,40V,FUSE 500S,COOL 20M,,,ASTM
D2513/F1055 – GAS,AWWA C906 FM 1613 CL200

Figure IX-c – Label for Manual Entry of Fusion Values

X. ELECTROFUSION INSTALLATION TRAINING PROCEDURES

A. COUPLING INSTALLATION:

1.) Cut the pipe ends (Fig X-a) squarely and evenly. (±3 degrees)

Figure X-a – Cut Pipe Ends

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

Figure X-b – Clean Pipe Ends

3.) Measure and mark the stab depth on the pipe ends (Fig. 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 ½ the length of the coupling. This mark is used as visual indication by the installer that the pipe ends are correctly inserted to the center of the coupler. Check the pipe surface for any embedded debris that may cause damage to scraping tools, and once more make sure that the outer pipe surface is clean and free of any dirt or mud that could re-contaminate the scraped pipe surfaces. Mark the entire pipe surface to be scraped with longitudinal and/or circumferential lines.

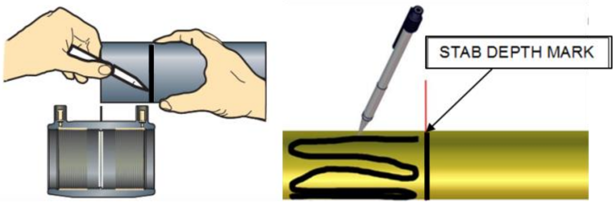


Figure X-c- Measure and mark Stab Depth

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

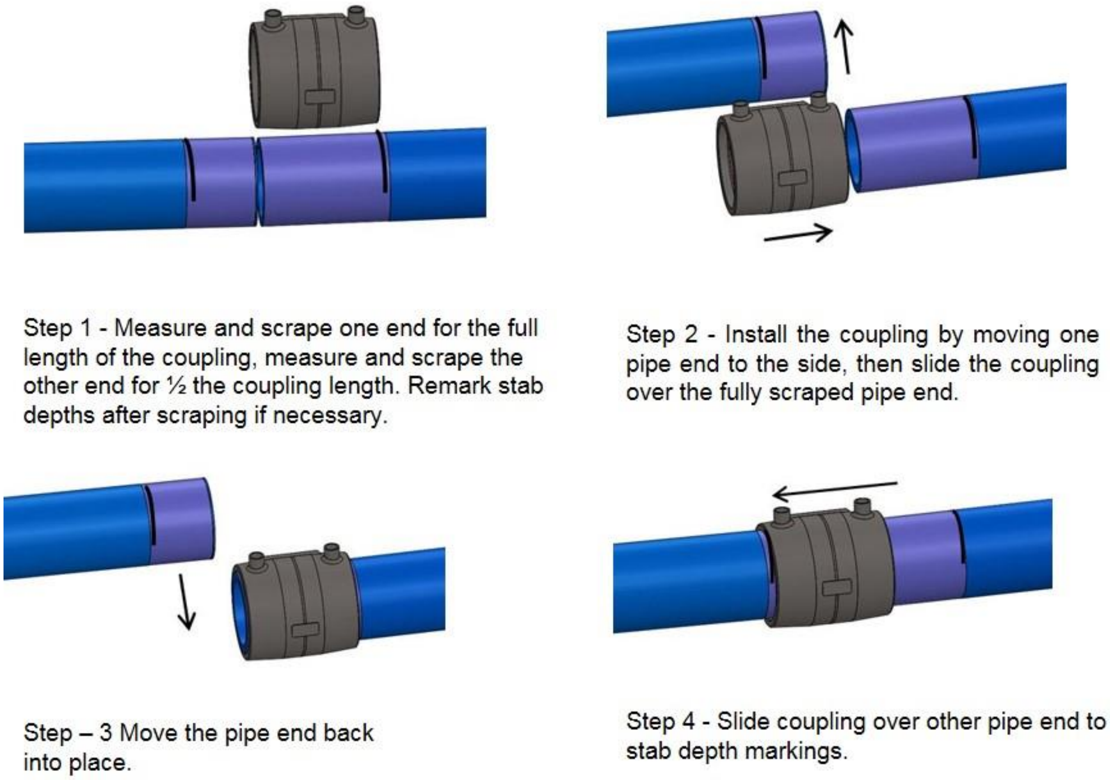


Figure X-d – Repair of Couplings Over Entire Pipe End

4.) Scrape the outside of the pipe surface to remove oxidation and other contaminates (Fig. X-e). 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.

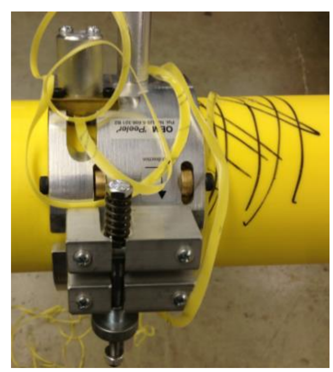


Figure X-e – Pipe Scrapping

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

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

⚠ **CAUTION: AVOID ALL POSSIBLE RECONTAMINATION OF THE PREPARED SURFACE.**

⚠ **Do not use Denatured Alcohol.**

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

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

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. If the full coupling must be placed on one pipe end, that pipe end should be cleaned and scraped for the full depth of the coupling to avoid contamination. The depth mark on the opposite pipe can be used for centering the coupling assuming that the two pipe ends are in contact (Fig X-f).

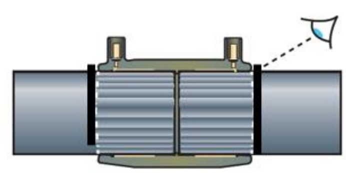


Figure X-f – Center Couplings Between Depth Marks

7.) Clamp the pipe ends to align and secure the assembly (Fig. X-g).

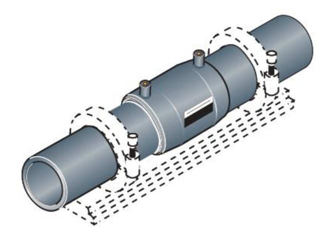


Figure X-g – Clamp and Secure

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

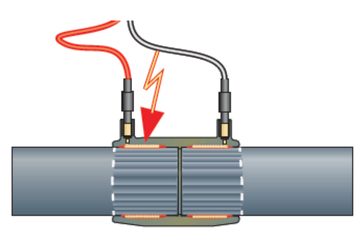


Figure X-h – Connect Fitting to Control Box

9.) Mark the time of day on the fitting when the fusion cycle has ended.

10). Allow the fused fitting and pipe assembly to remain clamped and undisturbed for the minimum recommended cooling time.

⚠ **Cooling is a vital part of the fusion process. Proper cooling times must be observed and fused joints should not be disturbed until the proper cooling time has elapsed. See "clamping" section of this guide for further details.**

B. SADDLE INSTALLATION:

1.) Clean the pipe (Fig. X-i) by removing dirt, mud, and other debris. Clean water can be used for initial cleaning of pipe surfaces prior to scraping. Clean the pipe for a length far enough beyond the area to be fused to ensure that remaining debris on the pipe surface will not be transferred to the area to be prepared during handling.

Figure X-i – Clean Pipe

2.) Mark the area on the pipe where the saddle is to be installed (Fig. X-j). This mark is used by the installer to indicate the approximate size of the area to be prepared. 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 surface. Mark the entire pipe surface to be scraped with longitudinal and/or circumferential lines.

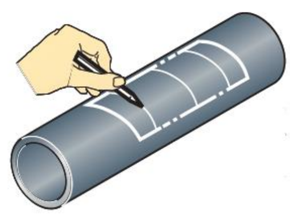


Figure X-j – Mark Installation Area

3.) Scrape the outside of the pipe surface (Fig. X-k) to remove oxidation and other contaminates. Use an appropriate scraping tool as described in the PIPE PREPARATION section of this guide. Scrape the pipe surface until the outer layer or "skin", at least .007" thick, of the pipe has been removed to expose a clean, virgin pipe material. Remove longitudinal or circumferential markings made in step 3. Inspect the entire scraped area to ensure total scraping coverage.

Figure X-k – Scrape Pipe

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

⚠ **CAUTION: AVOID ALL POSSIBLE RECONTAMINATION OF THE PREPARED SURFACE.**

⚠ **Do not use Denatured Alcohol.**

5.) Place the saddle over the scraped pipe surface (Fig. X-l). Ensure that the fitting fusion surface is only in contact with the scraped pipe surface.

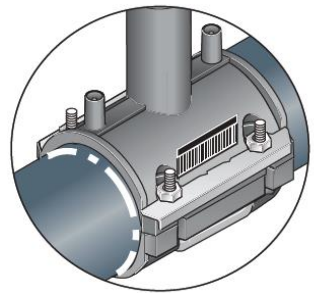


Figure X-l – Place Saddle Over Scraped Surface

6.) Secure the saddle-to-pipe assembly with the appropriate clamping mechanism required by the fitting manufacturer. If bolts are used in the clamping device, 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.

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

7.) Connect the fitting to the control box (Fig. X-m), enter the fusion parameters, and fuse the joint. See "Fusion Parameter" section for details.

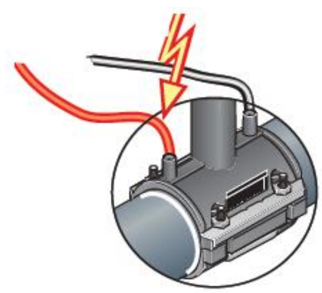


Figure X-m – Connect Fitting to Control Box

8.) Allow the fused fitting and pipe assembly to remain undisturbed for the minimum recommended cooling time.

⚠ **Do not tap saddle fittings until after observance of minimum cooling time**

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

⚠ **Cooling is a vital part of the fusion process. Proper cooling times must be observed. See "clamping" section of this guide for further details.**

C. INSTALLATION INSPECTION CHECKLIST:

1. SQUARE CUT (±3 Degrees)
The square-ness of the cut can be checked (if needed) by placing a square at the end of the pipe at its longest point and measuring the resulting gap between the square and shortest point of the cut (Fig. X-n). Table (X-a) indicates the resulting maximum measured gap when the cut angle is approximately 3 degrees from square.

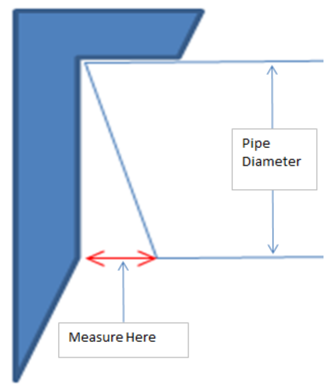


Figure X-n – Check for Square-ness

Table X-a – Maximum Measured Gap

Pipe or tubing size	Gap between square and pipe end to result in approximately 3 degree angled cut
1/2 CTS / IPS to 1 1/4 CTS / IPS	1/16"
1 1/2 & 2 CTS / IPS	1/8"
3 IPS / DIPS	3/16"
4 IPS / DIPS	1/4"
6 IPS / DIPS	3/8"
8 IPS / DIPS	1/2"
10 IPS / DIPS	9/16"
12 IPS / DIPS	5/8"

2. SCRAPING
A properly scraped pipe has a thin outer layer of the pipe surface removed to expose clean virgin PE material for fusion. Visual indicators can be very helpful to ensure that all of the surface has been scraped, and that an adequate amount has been removed. Marking the pipe surface with a permanent marker is a simple and effective step. Using 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 Fig. X-o and Fig. X-p for correct and incorrect scraping.)

Mark insertion depth | Mark entire surface to scrape | Scrape surface | Marks completely removed

Figure X-o - Correct Scraping

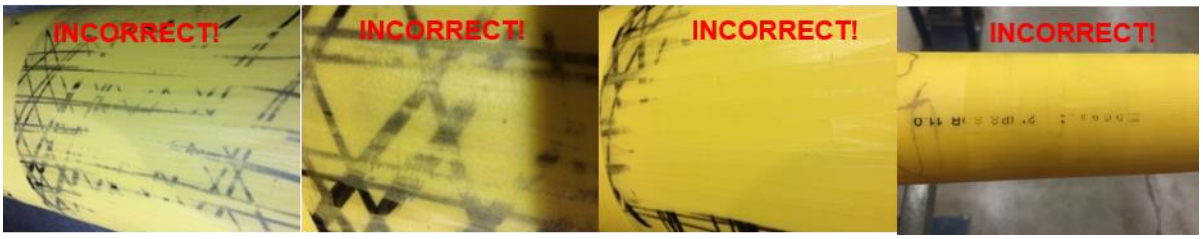


Figure X-p - Incorrect Scraping! Improper surface preparation / Not enough material removed, marks still visible.

3. CLAMPING/ASSEMBLY/ALIGNMENT
   Clamps are necessary to ensure that the pipe ends are properly aligned and rounded, that no external stresses are exerted on the fitting or assembly, that no movement occurs during the melt and cooling phases, and that saddle fittings are held in place with the correct amount of pressure (Fig. X-q)

Stab depth is correct | Alignment clamps used | Appropriate saddle clamp used

Figure X-q

4. FUSION
   - Ensure that the generator or power source is adequately sized for the fitting being fused.
   - Ensure that the power source has an adequate supply of fuel to complete the fusion cycle.

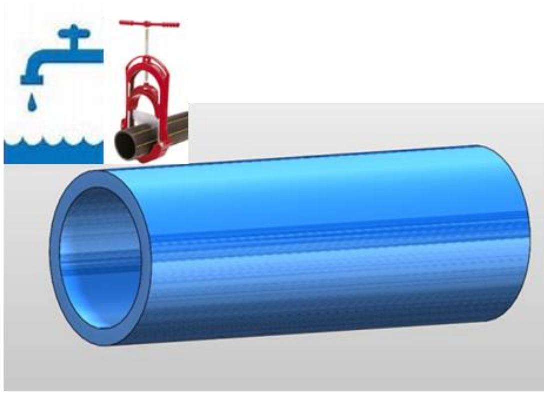
- Ensure that any extension cords are appropriately sized for the fitting being fused. See previous comments on generator.

5. CLAMPING
Ensure that the proper clamps are in use and that the joint assembly is properly aligned.

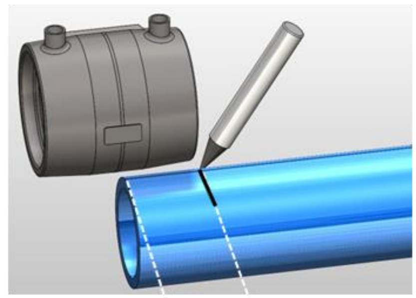
6. COOLING
Mark the time on or near the fitting to indicate when the minimum cooling time has elapsed. This will prevent inadvertent movement or removal of the assembly and/or clamps. If required by the pipeline owner, include installer and installation information such as the date, operator identification number, fusion ID card number, contractor name, fusion machine identification number, etc.

⚠ **Do not allow pipe and fitting to be moved or exposed to stress before the minimum cooling time has elapsed!**

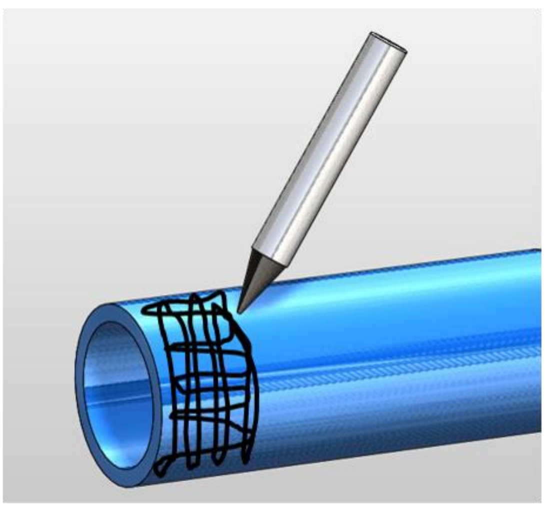
XI. FIELD GUIDE FOR ELECTROFUSION COUPLING INSTALLATION



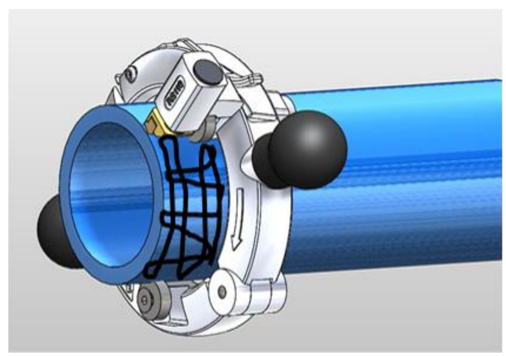
1. Clean pipe ends with clean water and cut as squarely (± 3 degrees) as possible.



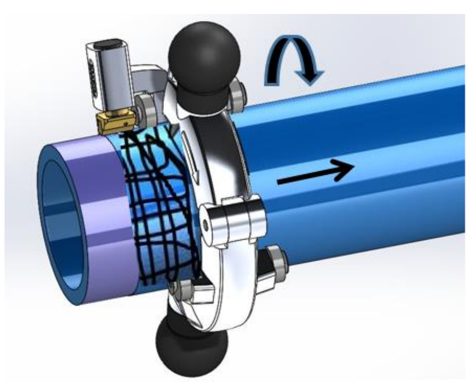
2. Measure and mark the stab depth on both pipe ends



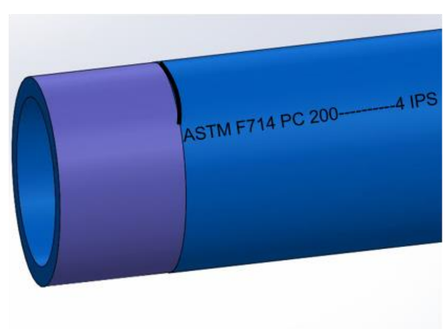
3. Mark the pipe surface to be scraped in a criss-cross pattern.



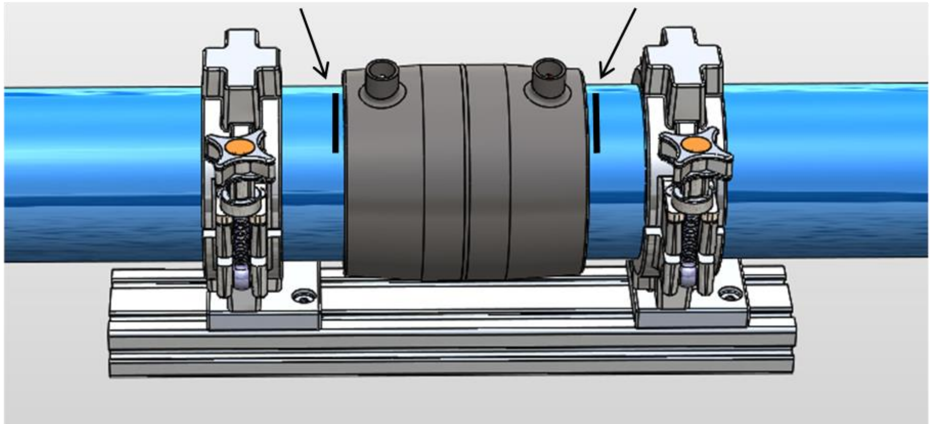
4. Mount the scraper over the area to be scraped.



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

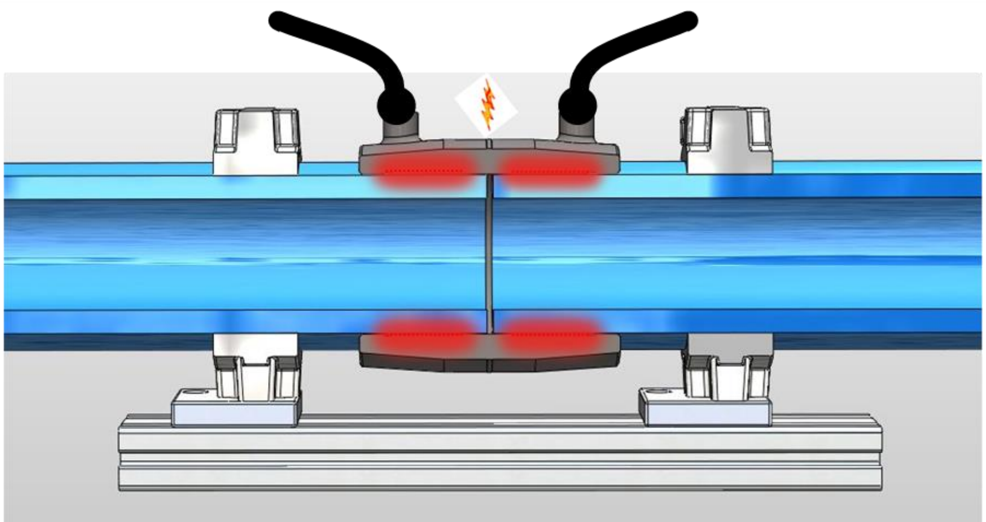


6. Inspect the scraped pipe surface thoroughly to ensure that all marks are removed and that only virgin pipe surface is exposed.



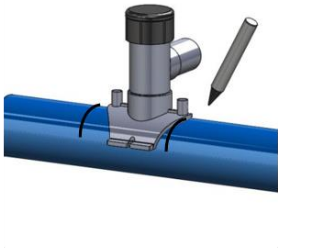
7. Clean surfaces with Isopropyl alcohol if necessary, avoid touching cleaned surfaces.

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.

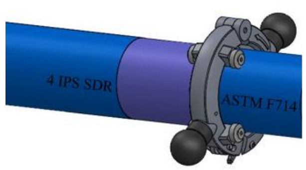


9. Connect the control box leads to the fitting and fuse the joint. Do not move or disturb joint for the recommended cooling time. Mark time of day on fitting when fusion cycle ends.

XII. FIELD GUIDE FOR ELECTROFUSION SADDLE INSTALLATION

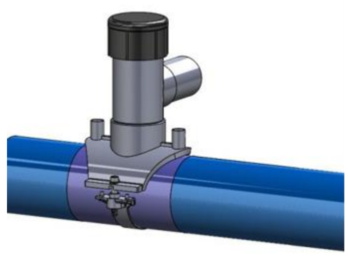


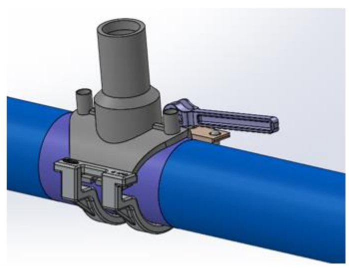
1. Mark position of saddle on pipe. 2. Mark pipe surface in area to be scraped.



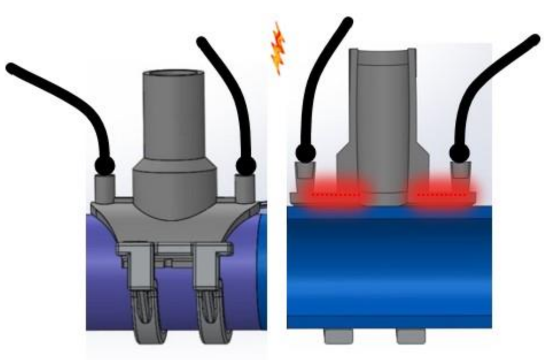
3. Scrape or peel the pipe to remove the surface layer and expose clean virgin pipe beneath.

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





5. Clean surfaces with Isopropyl alcohol if necessary, 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.

XIII. FREQUENTLY ASKED QUESTIONS

A. What pipes can be fused with electrofusion fittings?
   1. Electrofusion fittings are compatible with pipe dimensions conforming to 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 fusible to PE 2406/2708 and PE3408/3608/3708/3710/4710 pipes.

B. What are the power requirements?
   1. A reliable source of AC power is necessary for a successful fusion.
      a. Generator – well maintained generator meeting the capacity requirements shown in the Table under "POWER REQUIREMENTS".
         i. Generator should have enough fuel to complete the electrofusion cycle.
         ii. 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.
      b. Provide output voltage in the range that meets the specifications of the applicable processor model.
      c. Operate within a frequency range of 50 to 60 Hertz.
      d. A matching outlet is needed to mate with the plug equipped on the electrofusion processor. 110V/120V models – 30 Amp, 125 Volt, NEMA L5 twist lock.

C. Can I use an extension cord with my processor?
   1. The use of extension cords should be avoided;
      a. In the event an extension cord must be used a 25 foot cord should have a wire gage of #10/3 and a 50' cord should have a wire gage of #8/3.

D. Can I use a pigtail with my electrofusion processor? Not for field installations.

E. What are the most common electrofusion failures?
   1. 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:
      a. Contamination – poor pipe preparation
         i. Poor scraping
         ii. Dirt, mud, dust
         iii. Grease, oils
         iv. Moisture
         v. Hands (body oil, sunscreen, etc.)
         vi. Solvents, unsuitable wiping fluids
         vii. Unclean or unsuitable wiping rags
         viii. Over Scraping

b. Geometry – pipe out of round or not cut square
    i. Alignment Errors
        a) Pipe Mis-Stab – pipe not cut square and pipe ends not being centered in the fitting.
        b) Short Stab – can result from improper insertion of the pipe or movement during weld due to incorrect restraint
        c) Excessive Gap – excessive gap between pipe and fitting due to pipe out of roundness, undersized pipe or over scraping of pipe surface.
        d) Pipe Movement during Fusion Cycle – due to external forces or forces induced by the welding process, when the pipes are not clamped properly.
        e) Movement – pipe not properly restrained during fusion process
        f) Unusual conditions - Contact EF manufacturers if smoke or melt flow outside the fitting is observed.

c. Removal of clamping equipment before observance of minimum cooling times.

F. Can I use sandpaper, dragon skin or emory cloth to clean the PE pipe?

1. No, it is very important to note that abrasive materials such as sand paper, dragon skin or emory cloth should never be used 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, metal files, or paint scrapers are not acceptable for cleaning PE pipe.**

G. Why does the fitting need to observe the entire cooling time prior to pressure test or backfill?

1. One of the most misunderstood and often ignored components of the entire electrofusion process is the cooling phase. It is often assumed that if the fitting is cool enough to touch it must be cool enough to remove the restraint device or even pressure test the connections. The cooling phase is critical to the success of the electrofusion process and careful attention should be given to insure that the stated cooling times are properly adhered to (refer to fitting manufacturer for specific fitting cooling times).
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 (also known as clamping time). 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. Electrofusion couplings (regardless of manufacturer) require the pipe to be restrained or sufficiently supported on each side of the pipe to restrict movement during the fusion and cooling process and alleviate or eliminate sources of stress and/or strain until both the fusion cycle and the cooling cycle are completed.
   b. To achieve this we recommend the use of some form of pipe restraint and/or support for the primary purpose of controlling and eliminating any movement of the fitting due to fusion pressures generated during the fusion process and/or any external forces exerted on the pipe or fitting. The basis for using a pipe restraint system and/or support when joining two pieces of PE pipe with an electrofusion coupling is to:
      i. Minimize potential short stab, mis-stab or binding situations
      ii. Ensure proper cold zone contact with the prepared fusion area so that sufficient interfacial pressure is built up
      iii. Eliminate unwanted loss of molten material from the fusion zone
2. Electrofusion saddles
   a. Electrofusion saddle fittings include tapping tees, branch saddles, corp saddles and others. Installation of an electrofusion saddle requires the use of recommended restraint systems for the purpose of:
      i. Holding the fitting in place during the fusion process
      ii. Eliminating fitting movement due to material expansion
      iii. 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 recommended cooling time, the joint must remain stationary and free from stress and strains.**

I. Can electrofusion fittings be re-fused if I have a power related failure?
1. Electrofusion fittings 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 fittings:
   a. Fitting should remain in restrained position
   b. Fittings should be allowed to cool to ambient temperature
   c. Fitting should be reconnected to the processor
   d. Fitting should be completely refused for the entire fitting fusion time

⚠ **This re-fusion procedure should only be used for fusions that terminated due to input power reasons. <u>Fittings that fault for any other reason should be removed or abandoned.</u>**

XIV. OPERATOR TRAINING AND QUALIFICATION GUIDELINES

A. Scope

1. 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 operator who is authorized to perform electrofusion joining to polyethylene pipe up to 12” in diameter. The examination of an operator is essential for the assurance of the operator’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 operator that performs or inspects electrofusion joints on polyethylene (PE) pipe should successfully complete an annual electrofusion training program or more frequently if required.
2. During the test, the operator shall demonstrate practical skill and knowledge of electrofusion joints on PE pipe.
3. The test will be carried out in two parts under the direction of the utility or operator qualifying organization.
    a. The operator will answer questions relevant to electrofusion qualification testing. The questions will be presented to the operator in written form. The written test will be a True/False and/or multiple choice questionnaire. The operator must answer all questions correctly! 100% is the only passing grade.
    b. The operator will perform a minimum of two electrofusion joints adhering to the Generic Electrofusion Procedure. A 2 inch or larger coupling and 2 inch or larger main size saddle type fitting are recommended. This will qualify the operator for electrofusion joining up to and including 12 inch.
        i. The utility or operator qualifying organization will provide a suitable environment for qualification testing of the operator. The utility or operator qualifying organization will supply the operator with all necessary fittings and tools for electrofusion joining and testing. At owners’ discretion, Contractors should supply all tooling, power supplies, fittings and pipe similar to actual field conditions so the Owner can inventory tooling, verify quality of tooling and generator performance including any extension cords intended for work. A controlled environment is not a field condition.
        ii. Owner 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 operator is required and the prepared fitting will not be failure tested. If and only if all of the required steps are conducted, all of the required tooling is used and in good working order and proper cooling time observed is the fitting failure tested.
        iii. The fuser will make and submit electrofusion joints for approval via the attached destructive testing procedures in Section D.

4. Individuals who successfully complete both sections of the testing will be qualified to perform electrofusion joints on polyethylene piping up to and including 12 inch.
   Operators must requalify annually, or more frequently if any failures are encountered since the last qualification. Fusion failures are defined as connections not allowed to be put into service. If a fitting fails during fusion or by observance after installation but before being put into service it does not count as a joint failure (it is okay and encouraged for the fuser to cut out bad joints).

C. Electrofusion Joint Failures
   1. Electrofusion joint failures that are detected during air pressure tests or connection bubble tests are subject to the provision set forth in Section E.
   2. The utility or pipeline owner may elect to perform additional testing or require the electrofusion joint (saddle only) to be abandoned in place or cut out at its discretion.

D. Destructive Testing Procedures for Electrofusion Fitting Qualification
   The following test methods are useful as an evaluation of bonding strength and fusion quality between the pipe and fitting. These procedures are based on requirements from 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 defined in DOT CFR 49 Part 192.283 and 192.285. 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.

   1. Couplings:
      After all relevant information is gathered, the fitting should be cut and subjected to joint evaluation tests. 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.

      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 3"(75mm) to 5"(125mm) 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. (Fig. XIIV-a)

Close the vise jaws until the pipe walls meet. (Fig. XIIV-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 (Fig. XIIV-c) and failing (Fig. XIIV-d) results are shown in the photographs.

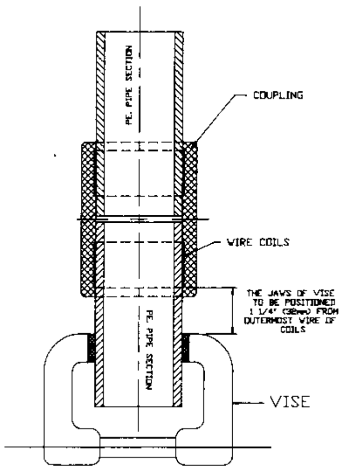


Figure XIV-a

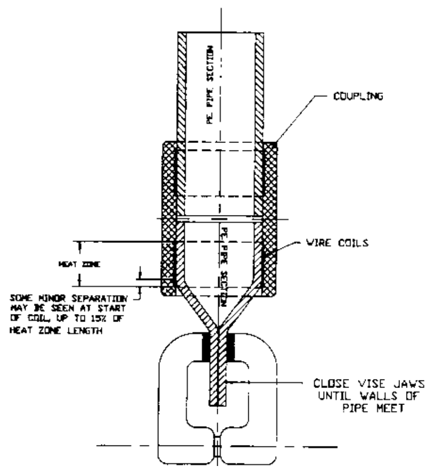


Figure XIV-b

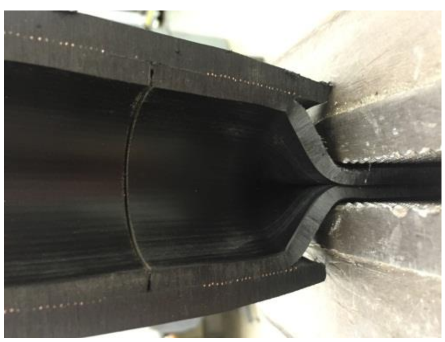


Figure XIV-c - Pass

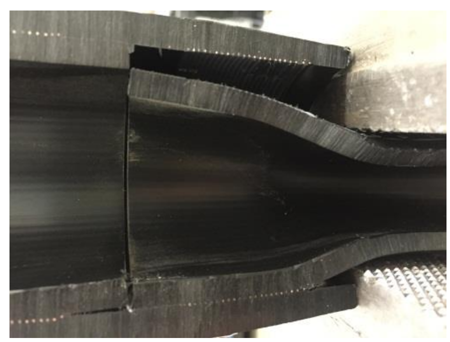


Figure XIV-d- Fail

2. Saddles/Tapping Tees

Tapping tees should be left 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 (Fig. 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 (Fig. XIV-g) and failing (Fig. XIV-h) results are shown in the photographs.

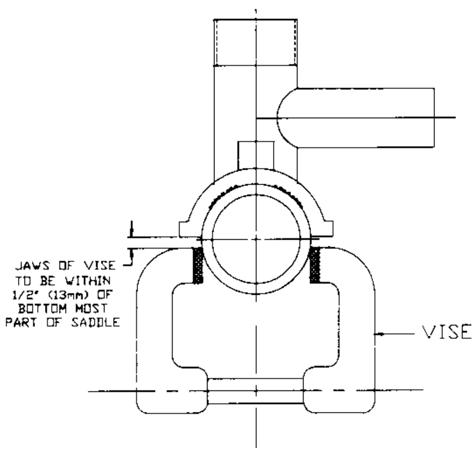


Figure XIV-e

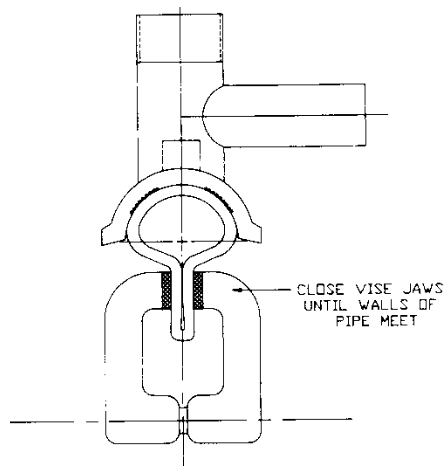


Figure XIV-f

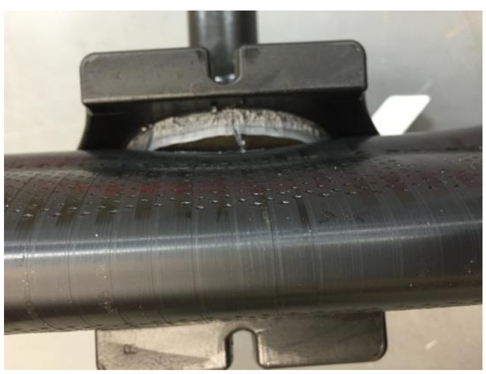


Figure XIV-g – Pass

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. The strips are then placed into a vise and bent 90 degrees in both directions directly at the fusion interface and evaluated for separation. The same visual criteria are used for fusion evaluation tests as is used for crush tests (Fig. XIV-i).

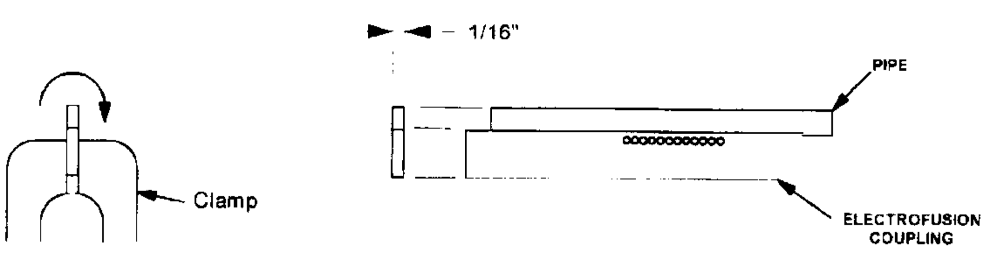


Figure XIV-i

Couplings should have four longitudinal strips cut from the fusion interface at 90° intervals as shown (Fig. XIV-j). The strips should be approximately 1/16"(1.5mm) to 1/8"(3mm) in thickness. The strips are then placed into a vise and bent 90 degrees in both directions directly at the fusion interface and evaluated for separation.

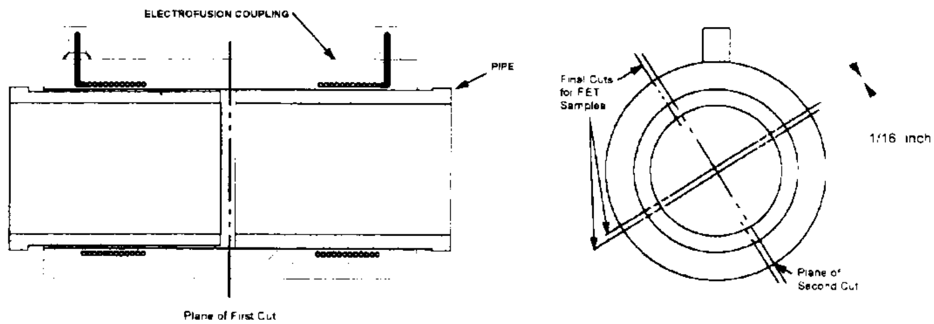


Figure XIV-j

Tapping Tees should have strips cut along the center line of the pipe (Fig. XIV-k) 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. The strips are then placed into a vise and bent 90 degrees in both directions directly at the fusion interface and evaluated for separation.

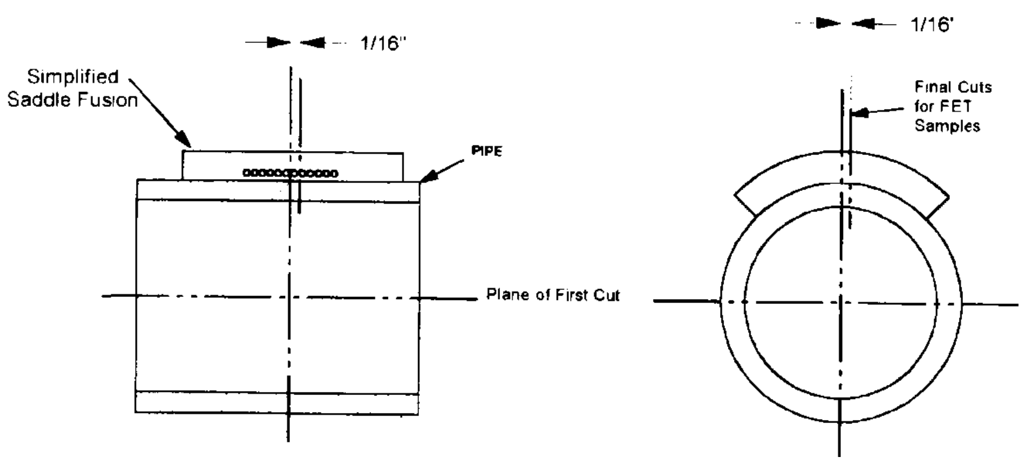


Figure XIV-k

E. Required Re-Qualification and Retraining
   Failed electrofusion joints determined to be caused by improper installation procedures may warrant retraining and/or qualification of the installer. If an operator 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 operator will be disqualified from making additional electrofusion joints and will require additional training and requalification before performing any additional fusion joining.

F. Test Result and qualification test certificate
   1. The operator shall be presented with a completion certificate (or card) upon successful completion of the MAB Electrofusion Operator and Training & Qualification test valid for one year from date of issuance.
      a. Successful Completion
         i. Operator cannot miss any questions on the written test.
            a) Operator 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) Operator who misses more than two (2) questions must re-take both the written and re-submit two (2) additional test specimens for destructive testing.
         ii. Operators must pass the destructive testing on all submitted electrofusion joints.
   2. Qualification Test Certificate
      a. Certificate shall contain the following:
         i. Operators Full Name
         ii. Date, Place of Training
         iii. Date of Issue
         iv. Expiration Date of Test Certificate
         v. Signature of Authorized Trainer
   3. Failed electrofusion or written Test
      a. Operator shall undergo further education and training prior to re-taking the qualification test.

Appendix A – List of Electrofusion System Manufacturing Companies

The generic Electrofusion procedure has been endorsed by the following Electrofusion companies (listed alphabetically) for use with their Fittings. This list will be updated quarterly if 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.	**M.T. Deason Company**	(800) 633-7131	http://mtdeason.com
6.	**Nupi Americas**	(281) 590-4471	www.nupiamericas.com
7.	**Plasson USA**	(800) 241-4175	www.plassonusa.com
8.	**Strongbridge-Tega**	(904) 278-7499	http://strongbridge.us/

Appendix B - Generic Electrofusion Operator Training & Qualification Section

DESTRUCTIVE TESTING

Operator Name:___________________ Date:_____________________ Location:________________

Electrofusion Coupling

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

PASS/FAIL:_______________________________

Electrofusion Saddle Fitting

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

PASS/FAIL:_______________________________

Authorized Trainer:________________________ Date:________________

Operator Training Card **Card No. #xxx**
(Operator Name)_______________________________
has successfully completed the training requirements for qualifications to **fuse Electrofusion Fittings** according to **(Utility Name)** Department Standards with no restrictions.

Insert Photo

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

<u>The following is a sample written qualification test.</u>

<u>Users should modify this test to address their unique operating environment.</u>

<u>Generic Electrofusion Operator Training & Qualification Section</u>

Operator Name: ____________________ **Date:** _____________________

Location: ________________

All Questions should be answered with either T for True or F for False. The operator 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, emory cloth, and other abrasives are acceptable for scraping.
   a. True
   b. False
4. If the pipe becomes re-contaminated 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. In case of an input power interruption only, an electrofusion fitting can be refused for the entire fusion time after it has been allowed to cool completely.
   a. True
   b. False
7. Pressurizing, testing, and backfill can be performed immediately after the electrofusion has been completed.
   a. True
   b. False
8. Pipe ends can be cut to within 10° of being completely square.
   a. True
   b. False

9. A 2500 watt generator is recommended for fusing electrofusion couplings (12" and smaller).
   a. True
   b. False
10. Slow drying markers that contain oils should not be used 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. Operators must re-qualify annually or if they make any bad joint.
    a. True
    b. False
15. Observance of pipe printline 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. An electrofusion joint should not be started if the processor incorrectly identifies the fitting fusion parameters.
    a. True
    b. False
18. Alignment clamps should be used only if the pipes do not line up.
    a. True
    b. False
19. The generator should be checked prior to electrofusion to make sure it is full of gas.
    a. True
    b. False
20. Electrofusion fittings should be kept in original packaging until installed.
    a. True
    b. False

Number Correct: _______

Authorized Trainer: ________________________ **Date:**________________

Recommended Minimum Training Guidelines for PE Pipe Butt Fusion Joining Operators for Municipal and Industrial Projects TN-42 / March 2013

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Foreword

This technical note was developed and published with the technical help and financial support of the members of the PPI (Plastics Pipe Institute, Inc). The members have shown their interest in quality products by assisting independent standards-making and user organizations in the development of standards, and also by developing reports on an industry-wide basis to help engineers, code officials, specifying groups, and users.

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The Plastics Pipe Institute, Inc.

www.plasticpipe.org

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PURPOSE

The purpose of this document is to provide a general outline of PPI's recommended minimum guidelines for training an operator in properly and safely making good quality butt- fusion joints in PE pipe systems. This training guide is intended to recommend a consistent minimum level of fusion operator proficiency; certain installations may require additional operator training and proficiency.

SCOPE

Butt fusion joining of PE pipe is a relatively simple, forgiving, and dependable process. However, as with any kind of pipe installation, proper procedures and diligence must always be used to consistently make satisfactory joints. Fusion machine operators should demonstrate an aptitude for using mechanical equipment and be generally familiar with laying pipe. They should have a demonstrated ability to follow procedures and be conscientious in their work. The amount of time it takes to provide the specified training can vary greatly and depends on the number of individuals being trained as well as their aptitude and willingness to follow directions. However, participants shall not be considered "trained" until they have demonstrated proficiency on at least two test joints made under circumstances and field conditions representative or similar to those of the project.

PE Pipe Sizes and SDR/DR

PE pipe for use in industrial and municipal applications is produced in accordance with applicable industry standards (ASTM, AWWA, API). In AWWA, the pipe outside diameters (ODs) conform to the OD dimensions of iron pipe IPS, or to equivalent OD for DI pipe (DIOD). In general, pipes are manufactured and measured based on OD (outside diameter) and wall thickness. The ratio of outside diameter to minimum wall thickness defines the pipe's SDR (Standard Dimension Ratio) or DR (Dimension Ratio) number. These numbers also define the pipes pressure rating at 80^{o}F (27^{o}C) in AWWA standards. And, because of the importance of the information these numbers convey, they are required to be included in the pipe markings specified by the applicable industry standard. These standards require that all pipes be clearly marked at specified intervals with the following information:

- Name or trademark of the manufacturer
- Production code number to identify location and date of manufacture.
- Nominal pipe size
- IPS or DIPS
- SDR or DR number, or pressure rating, or both

- The applicable industry standard(s) with which the pipe complies e.g. ASTM, AWWA, API or a combination of those specifications to which the pipe may have been manufactured, (e.g. ASTM F714 / AWWA C-906).
- Use the Pipe Size and SDR/DR to determine the proper fusion pressures applicable for the fusion machine and product being joined. In the event this information is not immediately available the user is advised to consult with either the fusion equipment or pipe supplier.

Links to PPI and the major equipment suppliers are listed as follows:

- Plastics Pipe Institute www.plasticpipe.org
- Connectra Fusion Equipment http://www.connectrafusion.com/fusion-calculator.php
- McElroy Manufacturing Fusion Equipment http://www.mcelroy.com/fusion/calculate.htm
- RITMO America http://www.ritmoamerica.com

MACHINE QUALIFICATION

The selected fusion equipment shall be capable of meeting all parameters of the job. The equipment shall have jaws or reducing inserts designed to properly hold the size of the pipes being fused, and it shall have enough hydraulic force to reach the required fusion pressure during all fusion conditions. The fusion operator shall be thoroughly familiar with and trained on the equipment being used. Such training shall include at least the following:

1) Safety
2) Operator's manual & checklist
3) Basic maintenance and troubleshooting
4) External power requirements
5) Features
6) Components and how they operate
7) Hydraulic operation (if applicable)
8) Determining required fusion pressure and how to set on machine
9) Heater operation and temperature requirements and adjustment
10) Data logging device (if applicable)

Job Set–up Guidelines

<u>Weather Guidelines</u>: Successful butt fusions can be accomplished in a broad range of weather temperatures. Pipe ends and the fusion equipment must be dry and sheltered from rain and wind. The limitations are driven by products and the equipment being used.

While PE pipe has very good impact resistance even in sub-freezing conditions; nonetheless its impact strength is reduced as temperatures drop into these ranges. Therefore, avoid dropping pipe in sub-freezing conditions. Also, keep in mind that butt fusion, when temperatures are below -4^{o}F (-20^{o}C), generally requires special provisions such as portable shelters or trailers or other suitable protective measures with auxiliary heating. Here are some general guidelines to address different weather conditions:

<u>Cold Temperatures, Down to 32^{o}F (0^{o}C):</u> When butt fusing PE pipe under these conditions, it is recommended that a temporary wind barrier be set up around the operator and fusion equipment. It is also recommended that the pipe ends be closed off by use of end caps or other means to prevent the flow of cold air. These measures will help greatly to reduce the heat loss in the heater plate and provide for a more uniform heating cycle and improved operator efficiency.

<u>Cold Ambient Temperatures Below 32^{o}F (0^{o} C)</u>: In addition to the above, the following preparations should be undertaken before fusing pipes. Pipe ends should be pre-heated using a heating blanket or warm air devices to elevate the pipe temperature to improve the heat cycle starting condition. With pipe mounted in the fusion machine, an alternate method of pre-heating is to position the pipe ends within ¼ to ½ inch of the heater plate face to allow the pipe ends to warm for 30 seconds to 2 minutes, depending on the pipe size and wall thickness. Before starting pipe fusion, the operator needs to ensure that the ID of the pipe is clear of moisture possibly due to frost that is being melted during the warming operations.

Notice: The use of direct application open flame devices, such as torches, for heating PE pipe is prohibited due to the lack of adequate heating control and the possibility of oxidative damage to the pipe ends and even ignition of the pipe. The warming temperature should not be continuous nor exceed 120^{o}F (49^{o}C).

<u>Warm (Hot) Environment, 32^{o} F (0^{o}C) to 120^{o} F(49^{o}C):</u> . Elevated temperature conditions can be mitigated by shading of the operator and the equipment where applicable.

Wind: Exposure of the fusion heater plate and pipe to wind can result in unacceptable temperature variations during butt fusion and possible joint contamination. When unfavorable wind conditions exist, the provision of a suitable shelter is required to protect the pipe and the fusion heater plate to ensure more consistent work performance. Unfavorable wind conditions can also flow through the pipe bore and cause unacceptable temperature variations during the fusion process, therefore open pipe ends may require plugs or covers to prevent this condition.

Additional Considerations:

- PE pipe and fittings will expand and contract with changes in temperature so in such an event be prepared to make necessary adjustments.
- Where pipes are to be clamped in the fusion machine, make sure pipe, fitting and clamp surfaces are dry, clean and free of ice, frost, snow, dirt and other contamination.
- When butt fusion is done in cold weather, DO NOT INCREASE THE HEATING TOOL SURFACE TEMPERATURE to attempt to compensate. THE REQUIRED SURFACE TEMPERATURE MUST BE WITHIN THE SPECIFIED RANGE BETWEEN 400-450^{o}F (204-232^{o}C) with 425^{o}F (218^{o}C) being the target temperature. Some butt fusion equipment is operated hydraulically through the use of motor and hydraulic oils. When operating such hydraulically assisted equipment at ambient temperature extremes, read operators manuals to make necessary viscosity adjustments to aide in the equipment's performance. The same holds true for generators supporting the butt fusion equipment.
- In cold conditions, it will take longer to develop an indication of melt around the pipe circumference at fusion pressure and longer to develop the final bead size in the heat soak cycle.
- DO NOT apply "fusion pressure" during the heat soak cycle. When proper melt has been obtained, the pipe and heater should be separated in a rapid, snap-like motion on manually operated equipment. The melted surfaces should be inspected (looking for a smooth melted surface) then be joined immediately in one smooth motion so as to minimize cooling of the melted pipe ends.
- See Annex A1 Cold Weather Procedures in ASTM F2620 Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings for additional information and guidance.

Pipe Handling Guidance: The jobsite pipe storage area should be relatively level and smooth. It should be large enough to allow for safe movement of the pipe and pipe handling equipment. The optimum situation is to have the pipe stored in close proximity to where the fusion equipment will be used for joining. The pipe should be placed on wooden beams or other type supports to keep it out of the dirt, mud etc. Where ground is level, the pipe or bundles of pipe can be stacked as high as about 6 ft. but not more. Where the ground is not very level, pipe should not be stacked in bundles but should be placed individually next to one another. Likewise, coils of pipe should not be stacked on each other but should be placed individually on protective supports on the ground. Coils should be stored in such a manner as to prevent any possibility of rolling or falling over.

DANGER: Coils, bundles, and even individual lengths of pipe are very heavy and by falling or rolling over can result in property damage, serious injury or even death.

For lifting pipe whether it be single pieces, coils or bundles it is extremely important to use only properly weight rated fabric slings capable of handling the load. DO NOT use wire rope or chains to lift or move pipe, they will damage it.

Special care should be taken when cutting tie bands on coils or on bundled pipe. As mentioned earlier, falling, rolling, or springing pipe can be extremely dangerous. First, cut only the bands on the outside and work carefully to extract the pipe pieces as needed.

Pipe Stands and Supports:

When butt fusing lengths of pipe it is necessary that pipe support stands be used. These pipe support stands work best when they are positioned on either side of the fusion machine approximately 20' from the pipe ends. Adjust the height of the stands so that the pipes are level; this will help to reduce pipe drag. The more stands that are used the more freely the pipe(s) move into and through fusion machine.

Other devices such as carts, racks etc. can be used to aide in supporting and feeding pipe into and through fusion units.

Do's and Don'ts in Pipe Handling:

DO's

- Make sure the pipe is secure and balanced prior to moving
- Store pipe on a level surface prior to use if possible
- Read and adhere to all published safety procedures on the subject of PE pipe handling
- When installing PE pipe do take into consideration that in locations that may experience large temperature swings between day and night, exposed pipe that is not restrained will change in length due to expansion and or contraction. For the condition of a drop in temperature, the pipe contraction could affect any lateral connections installed in the line; if the line contains bell and spigot or mechanical joints with insufficient pull-out resistance, then there exists the potential for joint separation. Exposed pipe that is anchored has a different response to the condition of a drop in temperature; namely, the generation of longitudinal loads that result in increased tensile stress. Temperature increases have the opposite and other effects. Therefore, it is very important that the effects of thermal change be taken into account when installing pipe. For additional information on this subject the reader is referred to the PPI PE Handbook, Chapter 6 - Section 4. Once the pipe is buried and

compacted in the ditch, (not free floating or unrestrained) temperature change has very little effect on the pipe.

- Before pulling pipe, do check for its maximum allowable pulling load. The safe pulling load depends on the pipe's OD its wall thickness and material grade. For the recommended safe values the user is referred to the Tables on this subject in Chapter 12 in the PPI PE Handbook.

DON'TS

- While PE pipe is an extremely tough material it can be scratched or gouged, therefore, it should not be pulled or dragged over sharp objects. Pipe is generally not acceptable for installation if it contains damage that exceeds about 10% of the minimum wall thickness of the pipe designed for the application. For more details on this subject, the reader is referred to the PPI's PE Handbook, Chapter 2, section entitled 'Damage Inspections' or consult with the pipe manufacturer.
- Ignore recommended handling and installation procedures
- Bury the pipe with large sharp rocks, tree roots or other rigid objects against the surface of the pipe
- Kink the pipe during handling or installation.
- Perform rough handling of a fusion joint for at least 30 minutes after it has come out of the fusion machine. Additional time may be required for pipes with wall thicknesses greater than 2 inches, especially if the prevailing ambient temperature is above 90^{o}F.
- Stick the forklift forks into the side of the pipe.
- Stand under or anywhere close to the pipe while it is being unloaded from a truck
- Fuse pipe in a dust storm without a shelter (Dust can contaminate the fusion joint)(1)
- Fuse pipe in a rain storm without a shelter (Water can contaminate the fusion joint)(1)

(1) For additional information on this topic please refer to the discussion under the Job Set-up Guidelines Section

Safety

- PE Pipe is an inert substance that poses no known health risk. Polyethylene (PE) is used to wrap the food you eat and PE pipe is used extensively for transporting potable water, so touching the pipe is completely safe.
- Always wear personal safety gear including hard hat, steel toed shoes and safety glasses.
- Do not stand in the path of the pipe being loaded or moved. Miss-handled, rolling or falling pipe can result in serious injury or death.
- Before starting or performing any work with the fusion equipment, it is very important that the operator carefully read and accept the equipment manufacturer's instructions on safety and operation that are published in the Manufacturer's Owners Manual. This is emphasized particularly because of the fact that while most heat fusion equipment is electrically powered, it is not explosion proof. Therefore, special attention is needed when performing fusions in an atmosphere that may be volatile, such as when gas or coal / grain dust may be present. Also, handling of the heating irons deserves special care insofar as they are very hot, greater than 400^{o}F (204^{o}C).
- Before unloading, reloading or moving pipe or equipment, carefully read and adhere to all published procedures and safety related documents. (PPI's PE Pipe Handbook, PPIs Materials Handling Guide publication and the pipe manufacturers literature,)
- Keep hands out of harm's way when loading pipe into, or removing it from the fusion machine. Likewise, for working with any other related pipe assembly or installation equipment, carefully follow all established safety procedures

Butt Fusion – A Six Step Process

This section outlines the Butt Fusion Procedure, per ASTM F2620, Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings. See PPI TR-33, Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe for the testing completed to verify the use of the procedure in ASTM F2620.

Please read carefully and fully understand equipment set-up and all six steps before beginning the fusion process. Also, before operating the fusion equipment, carefully read and understand the equipment manufacturer's published instructions on safety and operation and refer also to the highlights listed under the preceding Safety Section of this document.

Butt Fusion Machine Set-up

The operator should be familiar with these concepts before starting the 6-step Butt Fusion Procedure.

Heating Pressure: Carriage pressure during the heating process is a two step process. Initial contact is made at the pre-set fusion gauge pressure. After a melt bead is observed all around the pipe, this pressure should be lowered to the drag pressure (called "soak pressure") for the remainder of the heat cycle. During this time the hydraulic valve system should "lock" the carriage into position where it can neither move forward nor backward.

Facing Pressure: With pipe ends clamped into the fusion unit, apply just enough pressure to bring the two pipes into contact with the rotating facer, being careful not to slam into and possibly bog down or jam the facer unit.

Fusing Pressure: Take the drag pressure and add it to the calculated fusion pressure to obtain the fusion gauge pressure; see ASTM F 2620 and/or pipe distributor.

Drag Pressure: Drag Pressure is something that needs to be considered when butt fusing PE pipes and or fittings together. Drag is the amount of gauge pressure needed to overcome the frictional resistance of the hydraulic unit itself (called "static drag," and usually amounts to around 30-50 psi) combined with the amount of pressure needed to overcome the resistance of the pipe that is being pulled into the facer and heater (called "dynamic drag"). This amount can vary from very little to an amount that could potentially exceed the hydraulic capacity of the fusion unit (e.g., if fusing a long spool of pipe that is not well supported). The amount of drag pressure in PSI needs to be added to the theoretical fusion pressure to get the final calculated fusion gauge pressure. After facing the pipes, move the carriage so that the pipe ends are approximately 2" apart. To determine the drag pressure, adjust the pressure on the carriage so that it is not moving at all. Gradually increase the pressure until the carriage barely moves, observing the pressure gauge. Repeat if necessary. The pressure being indicated to just move the carriage is the drag pressure. (If fusion conditions change, this procedure must be repeated.)

<u>Butt Fusion Procedure</u>

NOTE: When using hydraulic fusion equipment, correct operation of hydraulic controls for carriage movement and pressure regulator selection is essential to produce quality butt fusions. Improper hydraulic control operation can seriously compromise butt fusion joint quality.

<u>STEP 1 - Securing the Pipe</u> SECURE THE PIPE IN THE JAW CLAMPS OF THE FUSION MACHINE TO ENSURE CORRECT ALIGNMENT. THERE SHOULD BE NO SLIPPAGE OR UNINTENDED MOVEMENT OTHERWISE CORRECT FACING WILL NOT BE ACHIEVED.

a) **Adjust, Align and Secure**.
   i) Adjust and align the pipe ends to minimize any parallel misalignment (high / low) or angular misalignment when the pipe ends are brought together.
   ii) Adequately tighten the clamps so as to prevent any unintended movement or slippage of the pipe when the pipe ends are brought together.
   iii) On a four-jaw fusion machine, first clamp the outer-jaws to secure the pipes, then the inner-jaws to allow for high / low adjustment during "<u>Step 2 Facing the Pipe Ends</u>".

b) **Clean, Clean and Clean**
   i) Clean the exposed pipe ends approximately three inches back along the pipe's inner and outer walls.
   ii) Clean to remove any surface contaminants. See ASTM F2620 Appendix X1.7.1 for additional guidance.
   iii) Always use a clean, dry cotton cloth when cleaning pipe ends to be fused.
   iv) Never use a synthetic cleaning cloth; a lint-free cotton cloth is required.
   v) All fusion surfaces must be completely clean and dry to achieve a proper fusion.

c) **Allow for the pipe ends to extend through the jaw clamps to permit complete facing**.
   i) Assure that pipes are cut as square as possible so as not to damage facer pivot arms.

<u>STEP 2 - Facing the Pipe Ends</u> TO PREPARE FOR HEATING IN STEP 4, THE PIPE ENDS MUST BE PREPARED BY FACING OFF MATERIALS TO PROVIDE SMOOTH, PARALLEL AND CLEAN MATING SURFACES.

a) Position the facing tool into the fusion machine between the secure and aligned pipe ends.

b) Activate the facing tool.

c) Bring the pipe ends into contact with the rotating facing tool.

i. With manual machines use only minimal pressure to initiate and maintain the cutting process between the pipe ends and the rotating surface of the facing tool. Hydraulic machines should be set to “facing pressure”.

Note - Excessive pressure may create too much of a load on the facer motor causing the facing tool to “bog down”, and potentially damaging both the facing tool and the fusion equipment.

ii. The correct facing process will have complete ribbons of polyethylene that are shaved from the pipe ends.

d) Facing is complete when:

i. Complete ribbons of polyethylene have been shaved from the pipe ends, **AND**

ii. The pipe ends have smooth, clean and parallel surfaces, **AND**

iii. The “stops” on the facing tool and the jaw clamps are in contact, **AND**

iv. The rotating surface on the facing tool is able to “freewheel”; there is no resistance from the facer blades being in contact with the pipe ends.

e) Stop the facer motor and move the pipe ends away from the facer.

f) Remove the facing tool and clear away all shavings, cuttings and debris. Lightly brush away loose debris from the pipe ends with a clean lint-free cotton cloth.

g) Avoid any contact with the pipe ends other than above step “f” during and after the facing process.

i. Any contact with the faced, fusion surface other than the facing tool or the cleaning device requires the operator to repeat the cleaning process as described in Step 1 “Securing the Pipe”.

- ALWAYS FACE TO THE STOPS!
- AVOID ANY CONTAMINATION of the faced pipe’s ends.

STEP 3 - Aligning the Pipe Ends ALIGNING THE PIPE ENDS VERIFIES THAT THEY ARE READY FOR THE FUSION PROCESS.

a) Bring the newly faced pipe ends together at facing pressure to check for parallel alignment (high / low), angular alignment, slippage and unintended movement.

i) Inspect the contact of the two pipe ends to ensure that there are no gaps or voids.

ii) Visually check for any misalignment (high/low) around the complete outer surface at the point of contact between the two pipe ends.

iii) Use a clean straight edge tool to check for any outer surface misalignment (high/low) between the outer surfaces of the two pipe ends.

b) Adjust any misalignment (High / Low) by tightening the "High"-side jaw clamp. Never loosen the low-side.

c) NOTE: If **ANY** adjustments are made, redo Step 2 "Facing the Pipe Ends"..

d) Bring the pipe ends together at the calculated fusion pressure to check for possible slippage or unintended movement. NOTE: If **ANY** slippage or unintended movement occurs, redo Step 2 "Facing the Pipe Ends".

e) NEVER ATTEMPT TO HEAT OR FUSE PIPE THAT IS NOT CORRECTLY ALIGNED. Misalignment that exceeds 10% of the pipe wall thickness is incorrect and is not acceptable.

STEP 4 - Melting the Pipe Ends MELTING THE PIPE ENDS AT THE RECOMMENDED TEMPERATURE FOR THE REQUIRED DURATION IS REQUIRED TO CREATE A STRONG, ACCEPTABLE FUSED JOINT.

a) Check the heater tool surface temperature with a calibrated infrared or surface pyrometer to insure the temperature is within the recommended range: 400°F – 450° F (204^0C – 232^0C). Follow the manufacturer's instructions.

b) Clean the heater surfaces with a clean lint free cotton cloth.

c) Follow the correct Butt Fusion Joining Procedures for the fusion equipment and pipe material on the jobsite ASTM F2620 is the Standard Practice for Polyethylene pipe.

i) Bring the pipe ends into contact with the heating tool surfaces at the fusion pressure.

ii) Maintain fusion pressure” only until first indication of melt is visible around the complete outer edge of both pipe ends indicating that the pipe ends are in full contact with the heater plate around the full circumference.

iii) Immediately reduce pressure from “fusion pressure” to drag pressure without releasing contact between the melted pipe ends and the heating tool surfaces. Once the pressure is at drag pressure, lock the movable carriage so it can’t move in either direction for the “heat soak cycle”. On pipe sizes 14” and larger, maintain the heat soak for a minimum of 4.5 minutes per inch of wall thickness. On manual machines, this will be only enough pressure to maintain contact between the pipe ends and the heating surfaces.

Caution: Care should be taken that pressure never exceeds the drag pressure during the heat soak cycle. THIS IS CRITICAL FOR A GOOD FUSION. During the heat soak cycle the melt bead will form due to the thermal expansion of the melted ends, NOT by any external pressure being applied to the heater plates.

iv) Maintain contact between the pipe ends and the heating tool surfaces until an acceptable melt bead is achieved per Table 1.

Table 1: Minimum Melt Bead Size (Pipe Ends)

Pipe OD	**Minimum Melt Bead Size**
< 2.37”	1/32”
≥ 2.37” ≤ 3.50”	1/16”
> 3.50” ≤ 8.62”	3/16”
>8.62” ≤ 12.75”	¼”
>12.75” ≤ 24”	3/8”
>24” ≤ 36”	7/16”
>36” ≤ 65”	9/16”

STEP 5 - Joining the Pipe Ends THE PROCESS OF BRINGING THE PIPE ENDS TOGETHER USING the PRE-SET PRESSURE.

a) When the correct melt bead is formed, per the ASTM standard summarized in Table 1, ***QUICKLY*** separate the pipe ends from the heating tool and remove the heating tool without coming into contact with the melted pipe ends. Next, ***QUICKLY*** inspect the pipe ends, which should be flat, smooth, free of contamination and completely melted. Concave pipe ends (caused by heating under pressure) are **UNACCEPTABLE** – see Figure A for a photograph representative of this condition. If acceptable, QUICKLY bring pipe ends together and apply fusion pressure. The maximum time allowed for opening the machine, removing the heater and bringing the pipe ends together is shown in Table 2. For tubing sizes, the maximum open/close time is 4 seconds. For manual machines, apply enough force to have the melted ends roll back to the pipe surface. Hold that force until the pipe ends cool to the touch per ASTM F2620.

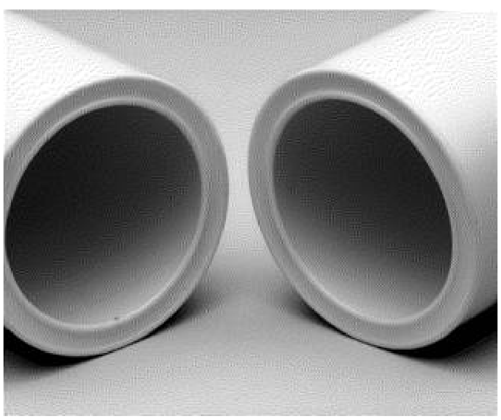

Figure A. UNACCEPTABLE APPEARANCE – Improper Concave Melt Surfaces after Heating; probably caused by heating under pressure.

b) If there is any indication of an incorrect melt or contamination, ***DO NOT CONTINUE***.

i) Allow the pipe ends to cool and start over with Step 1 “Securing the Pipe”.

c) A good fusion will form a double roll-back bead onto the pipe surface. Refer to Figure B for bead appearance evaluation.

Table 2: Maximum Heater Plate Removal Time (sec)

Pipe Wall Thickness (in)	Maximum Removal Time (sec)
.17” to .36”	8
>.36” to .55”	10
>.55 to 1.18”	15
>1.18” to 2.5”	20
>2.5” to 4.5”	25

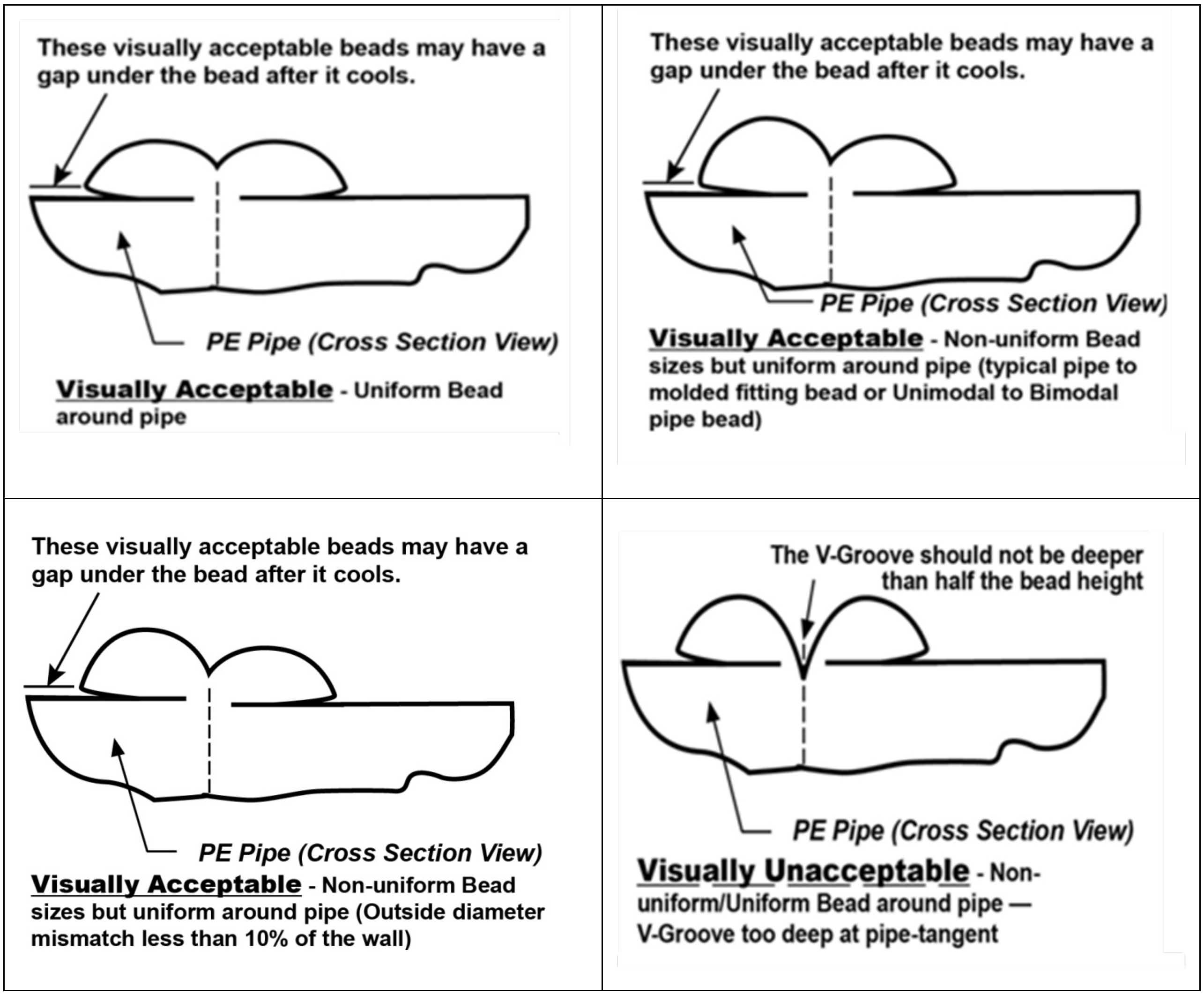

Figure B: Butt Fusion Bead Acceptance Guide

d) If the visual inspection of the fusion joint is not as described, it should be cut out and the process should begin again with Step 1 “Securing the Pipe”.

STEP 6 - Holding the Pipe HOLDING THE PIPE, AND ALLOWING IT TO COOL COMPLETELY, IS NECESSARY FOR JOINT STRENGTH.

a) Maintain the correct fusion pressure until the joint has cooled.

   i) Allow the joint to cool for 11 minutes per inch of pipe wall thickness. For ambient temperatures 100° F and higher, additional cooling time may be needed. Note that in accordance with ASTM F 2620 recommendations, “Pouring water or applying wet cloths to the joint to reduce cooling time is not acceptable. Applying chilled air is acceptable only as part of a controlled cooling cycle procedure where testing demonstrates that acceptable joints are produced using the controlled cooling cycle procedure.”

b) Avoid pulling, installation, pressure testing, or rough handling of the fused pipe for an additional 30 minutes or longer past completion of the last joint in the pipeline.

c) Re-inspect the butt fusion joint.

   i) Both sides of the double roll-back bead should be rolled to the pipe surface. See Figure B above for proper bead appearance

Making and Testing Sample Butt Fusion Joints.

In order to verify the quality of the fusion process, including fusion operator skills and machine function, it is required that sample fusion joints be made for testing using the fusion procedures described in ASTM F2620~~-06~~ and in PPI TR 33 in conjunction with those outlined in this document. These test samples are for pipe with a wall thickness of 1” or less. For thicker wall applications, contact the pipe manufacturer for the appropriate test. The following describes the preparation of the test samples and the details of the testing procedure

1) Complete a minimum of two butt fusion joints for test using the procedures described in in this document,
2) Complete a visual inspection of the joints to confirm their suitability for testing

3) Allow the fusion joint samples to cool to a temperature ranging between 65^{o}F (18^{o}C) and 80^{o}F (27^{o}C).
4) Cut a strip from each of the sample fusion joints for testing.
   a) The fusion joint should be in the middle of the cut length specimen.
   b) The overall length of the strip should be 15x the wall thickness (a minimum of 6") on each side of the fusion
   c) The overall width of the strip should be no less than 1-1/2x the wall thickness (a minimum of 1").
5) Bend the strips in a "back and forth" motion, with the ends touching each other at the completion of each motion.

A correct fusion joint should not crack or fail, or produce gaps or voids during this testing procedure However, It should be noted that if testing is performed when the temperature of the samples is outside the 65^{o}F to 80^{o}F range specified in 3) above, a false result may be obtained.

Training Record per PPI TN 42-2013 Recommended Minimum Training Guidelines for PE Pipe Butt Fusion Joining Operators for Municipal and Industrial Projects

Date of Training: ________________

Name of Trainer: ____

Name of Trainer's Company or Employer: _____________________________________

Name of Trainee Fusion Operator: ____

Name of Trainee Fusion Operator's Employer: __________________________________

Name and Location of Project: ____

Fusion Machine(s) Used:

1. **Manufacturer: __________________ Machine: _____________Serial No.:______________**
2. **Manufacturer: ___________________Machine: ______________Serial No.:______________**

Pipe Samples Fused:

1. **OD__________ SDR/DR__________ Product ID/Manufacturer_____________________**
2. **OD_________ SDR/DR ___________Product ID/ Manufacturer_____________________**

Training Completed

Number of Joints Tested: ___ Number Passed Test: ____Number Failed Test_______________

Training on Butt Fusion above ground_________ Training on Butt Fusion in ditch_____

Operator __________________________ Date: _______________

Trainer _____________________________ Date: _______________

NOTES: 1. A Copy of this fully completed Training Record must be retained by the Fusion Operator and be available for inspection at all times while performing fusion joining operations on the project.

2. The Trainer must also retain a fully completed file copy of this Training Record for future reference.

APPENDIX

Butt Fusion Joints – Visual Appearance Guidelines

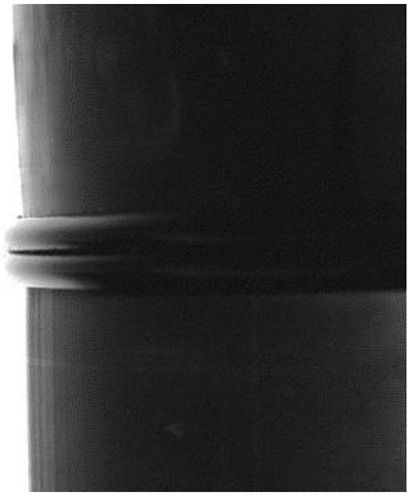

Figure 1. ACCEPTABLE APPEARANCE - Proper Double Roll–back Bead and Proper Alignment

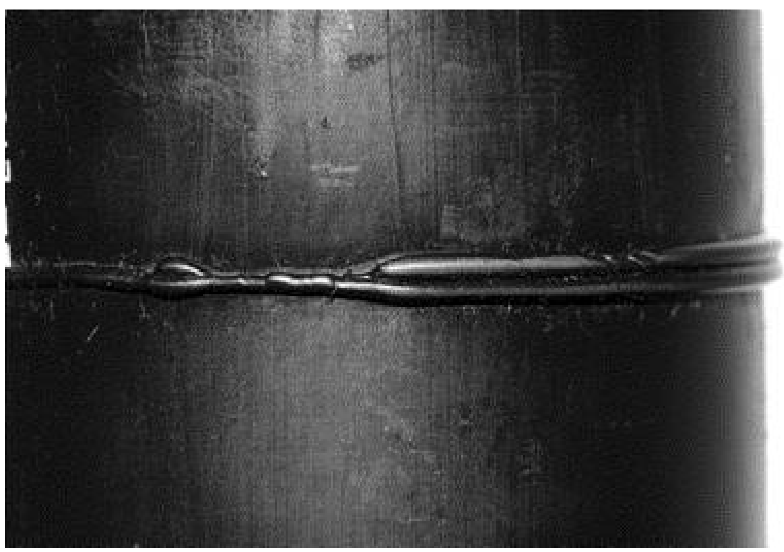

Figure 2. UNACCEPTABLE APPEARANCE – Incomplete Face-off

Figure 3. UNACCEPTABLE APPEARANCE – Mitered Joint – Improper 'High-Low' Pipe Alignment

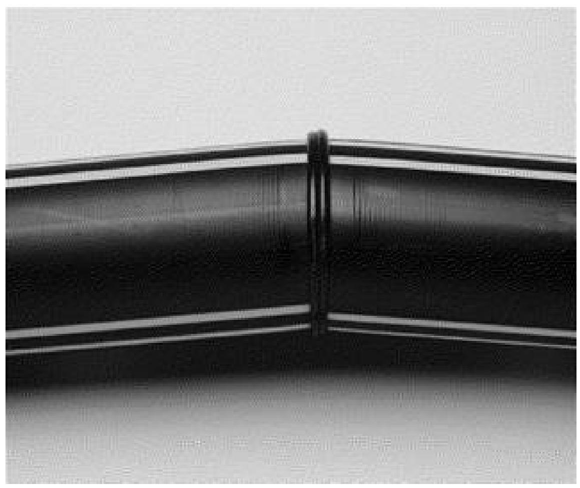

Figure 4. UNACCEPTABLE APPEARANCE – Unintentional Mitered Joint – Improper Alignment in Fusion Machine

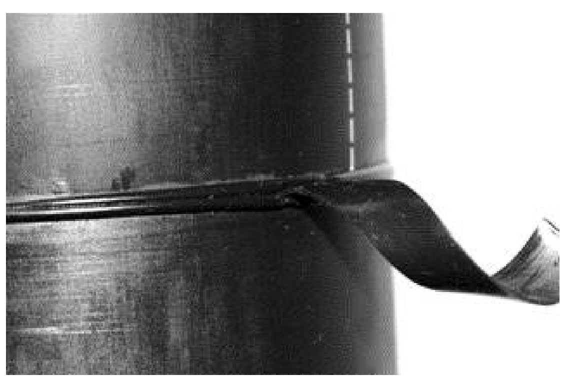

Figure 5. UNACCEPTABLE APPEARANCE – Contamination in Joint

Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe

TR-33

2012

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Contents

FOREWORD

GENERIC BUTT FUSION JOINING PROCEDURE FOR FIELD JOINING OF POLYETHYLENE PIPE

This report was developed and published with the technical help and financial support of the members of the PPI (Plastics Pipe Institute, Inc.). The members have shown their interest in quality products by assisting independent standards-making and user organizations in the development of standards, and also by developing reports on an industry-wide basis to help engineers, code officials, specifying groups, and users.

The purpose of this technical report is to provide important information available to PPI on a particular aspect of polyethylene pipe butt fusion 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 PPI as a service of the industry. The information in this report is offered in good faith and believed to be accurate at the time of its preparation, but is offered without any warranty, expressed or implied, 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 PPI, which does 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. PPI assumes no responsibility for compliance with applicable laws and regulations.

PPI intends to revise this report from time to time, in response to comments and suggestions from users of the report. Please send suggestions of improvements to the address below. Information on other publications can be obtained by contacting PPI directly or visiting the web site.

The Plastics Pipe Institute, Inc.

www.plasticpipe.org

This Technical Report, TR-33, was first issued in October 1999, and was revised in 2006, and in June 2012.

SECTION I – GENERIC BUTT FUSION PROCEDURE TESTING FOR FIELD JOINING OF ASTM D2513 GAS PIPING MATERIALS[1]

1.0 INTRODUCTION

In 1994, representatives of the U.S. DOT (Department of Transportation), Office of Pipeline Safety requested that the Plastics Pipe Institute (PPI) assist in promoting greater uniformity in the joining procedures utilized by gas utilities in the butt fusion of polyethylene (PE) gas piping products. DOT reported that it had encountered a proliferation of similar but slightly varying joining procedures from individual PE pipe producers. The slight differences in the various procedures made it more difficult for pipeline operators to qualify persons with appropriate training and experience in the use of these procedures. It was even more difficult for DOT to enforce the joining requirements in § 192.283 (Plastic pipe, qualifying joining procedures) of the C.F.R. (Code of Federal Regulations) Title 49.

In response to DOT's request, PPI established a task group to examine the differences among the varying joining procedures, to identify similarities in those procedures, and to determine whether there were a sufficient number of common elements to provide a basis for a more uniform, or "generic" joining procedure that could be qualified by pipeline operators for most applications. A more uniform joining procedure would bring greater consistency to this aspect of gas pipeline installation, facilitate the pipeline operator's efforts to qualify the procedure, reduce costs, and simplify DOT's enforcement duties.

2.0 SCOPE

The program undertaken by the PPI Task Group for the testing of representative materials under a generic set of conditions was designed to reflect the fusion conditions and parameters specified in most joining procedures recommended by pipe producers and qualified by pipeline operators. It was intended to provide a technical basis for the development of a generic butt fusion procedure (see Appendix A) that can be offered to the industry for use with selected PE (polyethylene) piping products. The procedure would be available for use by pipeline operators who would determine whether the procedure is appropriate for use with the PE piping products it employs. Pipeline operators could consider the recommendations and testing performed by others in their effort to comply with the fusion procedure qualification requirements of 49 C.F.R. § 192.283 (Plastic pipe, qualifying joining procedures).

It is important to emphasize that the testing performed by the PPI Task Group was intended only to establish a technical basis for developing and proposing a more generic fusion joining procedure that would offer the maximum opportunity to be qualified and used by pipeline operators with a broad range of polyethylene piping products. The testing was not intended to qualify the

[1] Dupont Aldyl A MDPE, Uponor Aldyl A MDPE and Phillips Driscopipe 7000 and 8000 HDPE are not included in this procedure.

procedure for use with any particular pipe product, and PPI offers no opinion on whether the procedure is properly qualified for use with any particular PE pipe product. PE pipe producers remain solely responsible for any representations that they may make about the use of this generic procedure or any other joining procedure with their proprietary PE piping products, and pipeline operators remain solely responsible for compliance with the requirements of 49 C.F.R. § 192.283 (Plastic pipe, qualifying joining procedures) when qualifying any procedure for use with the products it selects for its pipelines. PPI member pipe manufacturers have endorsed this generic procedure for joining their product to itself and to other commercially available pipe materials. Pipe producer compliance letters are in Appendix B for gas pipe applications and Appendix D for all other applications. A typical illustration of a properly made butt fusion joint is in Appendix D.

PPI hopes that the inherent value of greater uniformity will provide all the incentive necessary for companies to evaluate the generic procedure in Appendix A as a first option for butt fusion joining of its PE piping products. Use of this procedure is obviously not mandatory, and every PE pipe producer and pipeline operator retains the option of developing different procedures for its particular products and pipelines. However, PPI believes that its work in developing this generic procedure as a candidate for widespread acceptance throughout the industry will lead to greater efficiency, simplicity, and understanding in this area and promote the use of effective, qualified procedures for butt fusion joining of PE pipe.

3.0 TESTING PROGRAM TO EVALUATE USE OF GENERIC JOINING PROCEDURE WITH POLYETHYLENE GAS PIPING PRODUCTS

The Task Group collected and examined a large number of diverse procedures now in use by gas pipeline operators or recommended by pipe producers for specific PE piping products. It then identified those conditions and fusion parameters that were common to the majority of those procedures. The Task Group proposed the following fusion parameters as representative of the conditions in the individual procedures that they reviewed:

Heater Surface temperature	**400 - 450° F (204-232°C)**
Interfacial Pressure	**60-90 psi (4.14-6.21 bar)**

From its review of the different procedures collected from PE gas pipe producers, the Task Group further developed the generic joining procedure set out in Appendix A, based on its assessment of the common elements in the individual procedures. It was agreed that proprietary products such as Uponor Aldyl A MDPE products and Phillips Driscopipe® 8000 HDPE piping products were sufficiently different from the remainder of the materials being discussed that they were not included in the test program.[2] The manufacturers should be contacted for more information on particular joining procedures for those

[2] Uponor Aldyl-A and Phillips Driscopipe 8000 are no longer manufactured.

products. Only current commercially available products from PPI member companies were included in this test program. For information on older or other products, please contact the manufacturer of those products.
Using these parameter ranges and procedures, the Task Group initiated a 3-part test program to evaluate whether a representative cross-section of marketed PE gas piping products would qualify under the qualification requirements of Part 192 when joined in accordance with this generic joining procedure. The evaluation was conducted using pipe from MDPE and HDPE materials deemed suitable for fuel gas applications per ASTM D2513. These materials have a grade designation, in accordance with ASTM D3350, of PE24 and PE34, respectively.

Grade	Density (Grams/cc)	Melt Index (Grams/10min.)	Pipe Marking
PE 24	.926 - .940	.15 to .40	PE 2406
PE 34	.941 - .955	.05 to .15	PE 3408

After fusion of the samples, tensile and quick-burst tests were conducted in accordance with the requirements of 49 C.F.R. § 192.283 (Plastic pipe, qualifying joining procedures). Non-destructive ultrasonic inspections and high speed tensile impact testing were also conducted on each fusion combination. Additional testing conducted only on 8” pipe samples, included 176° F (80°C), 1,000-hour long-term hydrostatic testing at 580 psi (40 bar) hoop stress. The results of the test program are described in the following sections. PPI’s Conclusions and Recommendations, based on the Task Group’s work, are found at the end of this section. Test data are maintained at PPI headquarters.

Part 1 - Pipe Fusion and Testing - 2" IPS DR 11 (Like Materials)

Part 1 of this project was to evaluate the generic procedure for use in fusing a PE pipe producer’s product to itself (e.g., Phillips MDPE to Phillips MDPE). The Task Group members supplied 2" SDR 11 pipe samples for fusion joining.

A total of 24 sample fusions, like material to like material, were made for each MDPE and HDPE pipe product. The total number of sample pieces was 72 and the total number of fusion joints made was 290. To evaluate the fusion parameters initially selected by the Task Group, all combinations of min/max heater surface temperatures 400 - 450°F (204 -232°C) and min/max interfacial pressures 60—90 psi (4.14-6.21 bar) were used in this testing. In addition, sample fusions at heater face temperatures (375°F and 475°F) (191°C and 246°C) and interfacial pressures (50 and 100 psi) (3.45 and 6.90 bar) were made and tested to examine conditions for fusion outside the initially generic parameters. The Task Group agreed to use these same fusion parameters for both the MDPE and HDPE.

The results of testing these fusion samples were 100% positive. All of the fusion joints (including those made under the extended parameters) passed every test conducted. As noted above, these tests included tensile testing, quick burst testing, high speed tensile impact testing and 100% ultrasonic inspection.

Part 2 - Pipe Fusion and Testing -2" IPS DR11 (Unlike Materials)

Part 2 of this project was to evaluate the generic procedure, the fusion temperature range, and the interfacial pressure range for cross fusions of unlike materials (e.g., Phillips MDPE to PLEXCO MDPE or Uponor MDPE to KWH Pipe HDPE).

Again 2" IPS SDR11 PE pipe was chosen. The Task Group members reviewed the information presented in *Table* 1. Overview of Polyethylene Plastic Gas Pipe Materials and decided that the cross fusion program could be simplified by selecting representative materials only. For MDPE materials it was decided that two materials could be selected to represent the two main families of MDPE materials (chromium oxide/slurry loop produced MDPE and Unipol Gas Phase MDPE). The two specific materials selected were Phillips Marlex TR-418 and Union Carbide DGDA 2400. The testing of these two materials would help to assess the appropriateness of the generic conditions for cross fusion of all MDPE plastic pipe gas compounds commonly being used today. The Task Group decided to use the same joining parameters as in Part 1 in these tests, based on the view that successful fusions under these conditions would cover all the other materials under the generic ranges. The chosen combinations of joining parameters were (1) 475°F/100 psi (246°C/6.90 bar) and (2) 375°F/50 psi (191°C/3.45 bar). The remainder of the fusion procedures remained the same as Part 1. Fusion joints between Phillips TR-418 and Union Carbide DGDA 2400 were prepared. There were nine (9) joints made at each joining parameter, for total of (18) joints.

For HDPE materials, the Task Group selected three (3) HDPE materials for evaluation: Chevron 9308, Novacor HD2007-H and Fina 3344. There were nine (9) joints made at each of the selected combinations of fusion parameters and combinations of materials, for total of (54) joints.

For MDPE to HDPE joints, the Task Group elected to fuse Union Carbide 2400 to Fina 3344 to establish the cross fusion procedure for the fusion of MDPE to HDPE. Nine (9) joints were made at each of the two extended parameter combinations, for total of (18) joints.

The results of testing these fusion samples were 100% positive. All of the fusion joints passed every test conducted. As noted above, these tests included tensile testing, quick burst testing, high speed tensile impact testing and 100% ultrasonic inspection.

Part 3 - Pipe Fusion and Testing - 8" IPS DR11 (Unlike Materials)

Part 3 of this project was to test 8" IPS SDR 11 PE pipe to establish a range of pipe sizes where the generic procedure could be used. For MDPE materials, the Task Group identified five different medium density polyethylene materials which can be classed into two main types based on catalyst family, production process and melt index:

A. Phillips Marlex TR-418, Chevron 9301, 9302, Solvay Fortiflex K38-20-160
B. Novacor Chemical HD-2100, Union Carbide 2400

The Task Group agreed to make (10) joints of each of the following combinations:

UCC2400 to Phillips Marlex TR-418
UCC2400 to Chevron 9301
UCC2400 to Solvay Fortiflex K38-20-160

The joints were made at the same parameters as before with five (5) made at 475°F/100 psi (246°C/6.90 bar) interface and five (5) made at 375°F/50 psi (191°C/3.45 bar) interface. In effect, this would provide representative results for all medium density polyethylene except Uponor Aldyl A MDPE. Thus, this portion of the testing program would require 30 joints in total. It was also decided that if there were any failures with joints made under these parameters, then the fusions should be duplicated under the generic parameters 400 - 450°F/60-90 psi (204-232°C/4.14
6.21 bar).

For HDPE materials, the Task Group identified seven different high density polyethylene materials which could be classed into three main categories based on catalyst family, production process and melt index:

A. Chevron 9308, Phillips TR 480 and Solvay Fortiflex K44-15-123.
B. Novacor Chemical HD-2007-H, Chevron 9346 and UCC2480
C. Fina 3344

The HDPE cross fusion testing covered 10 joints for each of the following combinations: A to A, B to B, C to C, A to B, B to C, and A to C, for a total of 60 fusion joints. The representative materials selected from each category were the Fina 3344, UCC2480 and Phillips TR480.

For MDPE to HDPE cross fusions, the Task Group decided to use the same materials as were used for the cross fusion of 2" pipe; i.e., Fina 3344 and Union Carbide 2400. This portion of the testing program would involve A to B fusions of the two materials, for a total of 10 joints.

In addition to the tensile testing, high speed tensile impact testing, quick burst testing and 100% ultrasonic inspection, each fusion combination described in

Part 3 was subjected to a long- term 176°F (80°C), 1000 hour test using 580 psi (40 bar) hoop stress. As with the 2" IPS testing, all joints passed every test conducted.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The results of this study indicate that there is a single fusion procedure with defined ranges of acceptable heater surface temperature, 400-450°F (204-232°C), and interfacial pressure, 60-90 psi (4.14-6.21 bar), for fusing most of the PE gas pipes on the market today. The PE pipes used in these tests were selected PE2406 and PE3408 materials, which were deemed suitable for fuel gas applications (per ASTM D2513) and which have a grade designation, in accordance with ASTM D3350, of PE24 and PE34, respectively, excluding Uponor Aldyl A MDPE and Phillips Driscopipe 8000 HDPE. The results further indicate that there is a strong likelihood that the generic fusion procedure used in this testing (see Appendix A) could be qualified by gas pipeline operators under DOT's regulations in Part 192 for use with most of these PE gas piping products. To the extent that this PPI generic procedure in Appendix A can be qualified for use with more and more of the PE pipe products in the marketplace, the closer the industry can move to meeting DOT's objective of greater uniformity, efficiency, and simplicity in the area of fusion procedures.

5.0 ACKNOWLEDGEMENTS

This document has been produced by an industry Task Group from equipment, fitting, pipe, and resin manufacturers from the following companies.

Performance Pipe (formerly Phillips Driscopipe and PLEXCO)
PolyPipe Central Plastics US Poly (formerly Uponor)
Charter Plastics
BP Solvay
Total Petrochemicals (formerly Fina)
KWH Pipe
McElroy Manufacturing
Connectra Fusion Technologies, LLC

Table 1. Overview of Polyethylene Plastic Gas Pipe Materials

Company	Resin	Melt Index (MI) Grams/10 min.	High Load MI Grams/10 min.
Phillips	TR480	.11	13
Solvay	K44-15-123	.12	13
Solvay	K44-08-123	.08	8.5
Chevron	9346	.08	10
Chevron	9308	.10	10
Novacor Chem.	HD-2007-H	.07	8.5
Union Carbide	2480	.10	12
Fina	3344	.10	8
Phillips	TR418	.12	
Chevron	9301	.20	
Solvay	K38-20-160	.20	
Novacor Chem.	2100	.15	
Union Carbide	2400	.20	

Note: Some resins may no longer be produced, or company names may have changes. This information is for historical purposes for the types of resin utilized in this report.

SECTION II – GENERIC BUTT FUSION PROCEDURE TESTING FOR FIELD JOINING OF ASTM F714, ASTM D3035, AWWA C-901, AWWA C-906 AND PE PIPING FOR OTHER APPLICATIONS.

1.0 SCOPE

This program, undertaken by a different PPI Task Group, than the Task Group that established the Generic Butt Fusion Procedures for Polyethylene Gas Pipe (TR33/2001) for the testing of representative materials under a generic set of conditions, was designed to reflect the fusion conditions and parameters currently specified in TR-33/2001, Generic Butt Fusion Joining Procedure for Polyethylene Gas Pipe. While it is recognized that these fusion conditions do not include some parameters currently specified by some pipe producers for their Municipal and Industrial products, it was selected in an attempt to bring uniformity of fusion parameters to the industry. Additionally, as part of the overall goal of the Task Force, it was intended to provide a technical basis for the development of a generic butt fusion procedure (see Appendix A) that can be offered to the industry for use with selected PE (polyethylene) piping products. The procedure would be available for use by pipeline operators who would determine whether the procedure is appropriate for use with the PE piping products it employs.

It is important to emphasize that the testing performed by the PPI Task Group was intended only to establish a technical basis for developing and proposing a more generic fusion joining procedure that would offer the maximum opportunity to be qualified and used by pipeline operators with a broad range of polyethylene piping products. The testing was not intended to qualify the procedure for use with any particular pipe product, and PPI offers no opinion on whether the procedure is properly qualified for use with any particular PE pipe product. PE pipe producers remain solely responsible for any representations that they may make about the use of this generic procedure or any other joining procedure with their proprietary PE piping products. PPI member pipe manufacturers have endorsed this generic procedure for joining their products to themselves and to other commercially available pipe materials. A generic endorsement for the range of resins that have been proven to be successfully joined by this method is detailed in Appendix C along with a list of many product standards that utilizes these resins. An illustration of a properly made butt fusion joint is in Appendix D.

PPI hopes that the inherent value of greater uniformity will provide all the incentive necessary for companies to evaluate the generic procedure in Appendix A as a first option for butt fusion joining of its PE piping products. Use of this procedure obviously is not mandatory, and every PE pipe producer and pipeline operator retains the option of developing different procedures for its particular products and pipelines. However, PPI believes that its work in developing this generic procedure as a candidate for widespread acceptance throughout the industry will lead to greater efficiency, simplicity and understanding in this area and promote the use of effective, qualified procedures for butt fusion joining of PE pipe.

2.0 TESTING PROGRAM TO EVALUATE USE OF GENERIC BUTT JOINING PROCEDURE FOR FIELD JOINING OF POLYETHYLENE PIPING PRODUCTS

The Task Group looked at the Generic Butt Fusion Procedure previously released in TR-33 (2001) and other procedures approved by pipe manufacturers for butt fusing PE pipe products that satisfy the ASTM F714, ASTM D3035, AWWA C-901, and AWWA C-906 Pipe Specifications. Since there was overlap in the main fusion parameter areas, the Task Group proposed the same butt fusion parameters previously released in TR-33 (2001) for PE gas piping products be utilized, recognizing that the selected interfacial pressure range does not include all of the interfacial pressures that are promoted on a global basis. Interfacial fusion pressure recommendations typically range from a low of 21.7 psi (1.5 bar) to a maximum of 150 psi (10.34 bar). In spite of this broad range, the fact still remains that properly conducted fusions, across this range of interfacial pressures result in quality fusions that cannot always be differentiated by the various available testing techniques.

Heater Surface temperature	**400-450ºF (204-232ºC)**
Interfacial Pressure	**60-90 psi (4.14-6.21 bar)**

From its review of the different procedures collected from the PE pipe producers, the Task Group further developed the Generic Butt Joining Procedure set out in Appendix A., based on its assessment of the common elements in the individual procedures. The only exception to this was that fusion pressure was used to seat the pipe against the heater plate and this pressure remained until an indication of melt around the circumference of the pipe was observed. Then the pressure was reduced to drag pressure and the carriage control valve shifted to the middle position to keep the carriage from moving. It was agreed that proprietary products such as Phillips Driscopipe 8000/8600 series HDPE piping products were sufficiently different from the remainder of the materials being discussed that they were not included in the test program[3]. The manufacturer should be contacted for more information on particular joining procedures for those products. Only current commercially available products from PPI member companies were included in this test program. For information on older or other products, please contact the manufacturer of those products.

Using these parameters and procedures, the Task Group initiated a 2-part test program to evaluate butt fused samples joined at the extremes of the parameters. After the samples were fused, they were cut into tensile test specimens where high speed tensile testing was conducted on each specimen. PPI's Conclusions and Recommendations, based on the task group's work, are found at the end of this section. Test data are maintained at PPI headquarters.

[3] Phillips Driscopipe 8000 and 8600 are no longer manufactured.

Part 1 – Pipe Fusion and Testing – (5) different pipe manufacturers pipe samples with various wall thickness.

The pipe samples we tested were:

KWH Pipe –12” IPS DR11
KWH Pipe – 12” IPS DR6
Phillips – 14”IPS DR 9
Plexco – 12”IPS DR 9
Plexco – 12” IPS DR 9 Yellowpipe

Like pipe to like pipe was fused in this evaluation. There were (4) joints made at the following parameters for each pipe size to be tested:

400º F and 60 psi interface
400º F and 90 psi interface
450º F and 60 psi interface
450º F and 90 psi interface

We recorded the following times and bead sizes in the fusion process:

- Time to get indication of melt
- Soak time to heater removal
- Bead size per side at the time of heater removal
- Total bead size after fusion
- Cooling time under pressure
- Bead temperature at the time of pipe removal

The fused samples were joined and allowed to cool under pressure until cool to the touch using 30-90 seconds per inch of diameter as a cool time guideline. The samples were allowed to cool for an additional 24 hours before cutting into the tensile test sample configuration.

A tensile test sample was cut from each fused pipe interface at 12:00, 3:00, 6:00 and 9:00 positions. The test samples were machined to the attached configuration and a high speed tensile impact test was conducted on all samples.

The results of testing these fusion samples were 100% positive. All of the fusion joints failed in a ductile mode outside the joint area.

Part 2 – Pipe Fusion and Testing – Compare tensile test results using different interfacial pressures.

The heavy wall pipe samples we tested were:

PolyPipe 16” IPS DR 7
KWH Pipe 22” IPS DR11

We fused like pipe to like pipe in this evaluation. There was (1) joint made at the following parameters for each pipe size to be tested:

425º F and 25 psi interface
425º F and 40 psi interface
425º F and 75 psi interface

We recorded the following times and bead sizes in the fusion process:

- Time to get indication of melt
- Soak time to heater removal
- Bead size per side at the time of heater removal
- Total bead size after fusion
- Cooling time under pressure
- Bead temperature at the time of pipe removal

The fused samples were joined and allowed to cool under pressure until cool to the touch using 30-90 seconds per inch of diameter as a cool time guideline. The samples were allowed to cool for an additional 24 hours before cutting into the tensile test sample configuration.

A tensile test sample was cut from each fused pipe interface at 12:00, 3:00, 6:00, and 9:00 positions. The test samples were machined to a dog-bone configuration that is recommended by the British WIS 4-32-08 standard. This test is designed to cause failure in the joint area. We pulled the samples in a high-speed tensile impact machine at a rate of 4” per second. The energy in ft-lbs at yield and failure, the samples pull area and the amount of energy per square inch of area was recorded for all three interfacial area samples. The beads were removed on all samples. In order to mask actual values derived in the test that might allow one to compare strengths between materials, the results are shown as percentages of increased or decreased average strength as compared to that material’s joint strength at 25 psi interfacial.

The results of these tests were:

Pipe 1	25 psi	Average	100%
Pipe 1	40 psi	Average	104%
Pipe 1	75 psi	Average	105%

Pipe 2	25 psi	Average	100%
Pipe 2	40 psi	Average	97%
Pipe 2	75 psi	Average	101%

For both pipe sizes tested, the nominal 75 psi interface pressure joints proved to have a higher tensile strength before failure than 40 or 25 psi interface.

3.0 CONCLUSIONS AND RECOMMENDATIONS

The results of this study indicate that it is possible to standardize on a single set of butt fusion parameters that can be used for fusing most of the polyethylene gas pipe and municipal and industrial pipe available on the market today. We recognize that the recommended parameters utilized are a small subset of the various fusion parameters utilized today, but believe in the benefit of moving towards a common standardized fusion procedure. The more the industry can move to greater uniformity, efficiency and simplicity in the area of fusion procedures, the more acceptance it will receive in the different industries.

PPI hopes that the inherent value of greater uniformity will provide all the incentive necessary for companies to evaluate the generic procedure in Appendix A as the preferred option for butt fusion joining of PE piping products. Use of this procedure obviously is not mandatory, and every PE pipe producer and pipeline operator retains the option of developing different procedures for its particular products and pipelines.

Other Acceptable Fusion Procedures

It must be recognized that there are many other different procedures and fusion parameters used throughout the world that have been proven to make effective, reliable joints. The pipeline operator and ever pipe producer retains the option of developing different fusion procedures for its particular products and pipelines. In certain cases, due to operating conditions, weather, or the characteristics of the joining equipment, it may be necessary or even advisable to use another procedure.

PPI believes that its work in developing this generic procedure as a candidate for widespread acceptance throughout the industry will lead to greater efficiency, simplicity and understanding in this area and promote the use of effective, qualified procedures for butt fusion joining of PE pipe.

SECTION III – BUTT FUSION PROCEDURE TESTING FOR FIELD BUTT FUSION OF PE 4710 PIPE FOR ALL APPLICATIONS.

1.0 SCOPE

A PPI Task Group was developed to make butt fusion joints on PE4710 piping products to the procedures and parameters outlined in ASTM F2620 and do the testing of those joints to qualify the procedure for that piping material. The procedure would be available for use by pipeline operators who would determine whether the procedure is appropriate for use with the PE piping products it employs.

It is important to emphasize that the testing, performed by the PPI Task Group, was intended only to show that the procedures and parameters in ASTM F2620 could be used to butt fuse PE 4710 piping material. This procedure would offer the maximum opportunity to be qualified and used by pipeline operators with a broad range of polyethylene piping products. PE pipe producers remain solely responsible for any representations that they may make about the use of this procedure or any other joining procedure with their proprietary PE piping products.

PPI hopes that the inherent value of greater uniformity will provide all the incentive necessary for companies to evaluate the procedure in ASTM F2620 as a first option for butt fusion joining of its PE piping products. Use of this procedure obviously is not mandatory, and every PE pipe producer and pipeline operator retains the option of developing different procedures for its particular products and pipelines. However PPI 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 in this area and promote the use of effective, qualified procedures for butt fusion joining of PE pipe.

2.0 TESTING PROGRAM TO EVALUATE THE USE OF ASTM F2620-11 BUTT JOINING PROCEDURES FOR FIELD JOINING OF PE 4710 POLYETHYLENE PIPING PRODUCTS

The Task Group looked at the ASTM Standard Butt Fusion Procedure F2620 and decided to use similar parameters and procedures for the Three Phase Test Program for different pipe sizes of PE 4710 pipe. Parts of the procedure were further clarified so it is easier to monitor the procedure used and inspect the joints. A minimum heat soak time was added to pipe sizes 14” and larger to insure that the thicker wall pipes receive enough heat before joining. This minimum heat soak time is 4.5 minutes per inch of wall thickness. A maximum open/close (dwell) time was established by wall thickness to make sure the fusion machine is opened, the heater removed and the pipe ends brought together at the fusion pressure in a prompt time. The cool time under fusion pressure was changed from 30-90 seconds per inch of pipe diameter to 11 minutes per inch of wall thickness. This better clarifies the cool time required for pipes of all wall thicknesses and is easier to monitor. All of these changes are outlined in ASTM F2620-11e1.

The three phase program was focused on pipes in different size ranges:

Phase I --- 2” IPS DR11 PE 4710 pipe from different manufacturers and resins for cross fusion compatibility testing

Phase II --- 8” IPS PE 4710 pipe fused to other PE 4710 pipes and also to PE 3608 pipe and PE 2708 pipe for compatibility testing.

Phase III --- 6”IPS DR11, 12” IPS DR11, 20” DIPS DR 11, 28” IPS, DR11 and 36” IPS DR9 PE 4710 pipe sizes were fused to validate the parameters and procedures for a variety of pipe sizes and wall thicknesses.

Phase I --- Pipe Fusion and Testing – 2” IPS pipe size

Five (5) different PE 4710 pipe resins were used to make (10) different cross-fusion combinations for tensile testing and quick burst testing.

All pipe sizes were 2” IPS DR11. The combinations fused and tested were:

CP Chem 9346P8 to Dow DGDA 2490
CP Chem 9346P8 to Total XT 10N
CP Chem 9346P8 to Ineos TUB 121
CP Chem 9346P8 to Equistar Alathon L4904
Dow DGDA 2490 to Total XT 10N
Dow DGDA 2490 to Ineos TUB 121
Dow DGDA 2490 to Equistar Alathon L4904
Total XT 10N to Ineos TUB 121
Total XT 10N to Equistar Alathon L4904
Ineos TUB 121 to Equistar Alathon L4904

The Task Group decided to use parameters that were outside the ASTM F2620 procedure to make sure we had a safety zone around the actual parameters recommended. The parameters used for these fusions were:

375 degree F Heater Surface Temperature and 50 psi interfacial pressure
375 degree F Heater Surface Temperature and 100 psi interfacial pressure
500 degree F Heater Surface Temperature and 50 psi interfacial pressure
500 degree F Heater Surface Temperature and 100 psi interfacial pressure

We recorded the following parameters during the fusion process of each joint:

- Time to get an indication of melt
- Soak time to heater removal
- Pressure during the heat soak cycle
- Total open/close (dwell) time for heater removal
- Fusion pressure
- Cooling time at fusion pressure

The samples were allowed to cool for at least an additional 24 hours before cutting test specimens and conducting the tensile and quick burst tests.

Three separate task group companies made the fusion joints and three task group companies did the tensile tests on these samples. Twelve fusion joints at each parameter condition were made with (24) tensile test specimens made for each condition. The tensile tests were conducted per ASTM F2634 and D638. A total of 250 + tensile tests were conducted in Phase 1. All joints passed the tensile tests in a ductile manner outside the fusion zone.

Twelve fusion joints at each parameter condition were made and quick burst tested per D1599. A total of 40 quick burst tests were conducted in Phase 1 with three fusion joints in each test pipe. All joints passed the quick burst tests with failures in the pipe and not the fusion joint.

Phase II --- Pipe Fusion and Testing – 8” IPS pipe size

The Task Group continued testing of PE 4710 piping material with a larger diameter and heavier wall pipe size. The fusion joints were made between different resins of PE 4710 and between PE 4710 and standard PE 3608 and PE 2708 piping materials. These joints were tested using tensile tests and sustained pressure tests at elevated temperatures. The combinations fused and tested were:

8” IPS DR 11 Equistar L4904 PE 4710 to 8” IPS DR 9 PE 3608 pipe
8” IPS DR 13.5 Dow DGDA 2490 PE 4710 to 8” IPS DR 13.5 Ineos TUB 121 PE 4710
8” IPS DR 11 Total XT10N PE 4710 to 8” IPS DR 11 PE 2708 pipe

The Task Group decided to use parameters that were outside the ASTM F2620 procedure to make sure we had a safety zone around the actual parameters recommended. The parameters used for these fusions were the same as in Phase 1:

375 degree F Heater Surface Temperature and 50 psi interfacial pressure
375 degree F Heater Surface Temperature and 100 psi interfacial pressure
500 degree F Heater Surface Temperature and 50 psi interfacial pressure
500 degree F Heater Surface Temperature and 100 psi interfacial pressure

We recorded the following parameters during the fusion process of each joint:

- Time to get an indication of melt
- Soak time to heater removal
- Pressure during the heat soak cycle
- Total open/close (dwell) time for heater removal
- Fusion pressure
- Cooling time at fusion pressure

The samples were allowed to cool for at least an additional 24 hours before cutting test specimens and conducting the tensile and 80° C sustained pressure tests.

Three separate task group companies made the fusion joints and three task group companies did the tensile tests on these samples. Six fusion joints at each parameter condition were made with (24) tensile test joints made for each condition. Three fusion joints at each parameter condition were made for each pipe combination. The tensile tests were conducted per ASTM F2634 and D638. A total of 312 tensile tests were conducted in Phase II. All joints passed the tensile tests in a ductile manner outside the fusion zone. We then conducted elevated temperature (80º C) sustained pressure testing per ASTM D3035 or F714. We tested a total of 36 joints with all passing the requirements in the D3035 or F714 standards.

<u>Phase III</u> --- Pipe Fusion and Testing – Variety of pipe sizes from 6” to 36” and up to 4” wall thickness

The Task Group continued testing of PE 4710 piping material with a larger diameter and heavier wall pipe size. The fusion joints were made on pipe made from PE 4710 resins and were made using the following pipe sizes and at the following parameters. These joints were fused by two different member companies and tested by performing tensile impact testing per ASTM F2634 on the samples from these joints. We also tested the parent pipe to compare the tensile strength between the joint and the pipe.

The Task Group decided to use parameters that were outside the ASTM F2620 procedure to make sure we had a safety zone around the actual parameters recommended:

375 degree F Heater Surface Temperature and 50 psi interfacial pressure
375 degree F Heater Surface Temperature and 100 psi interfacial pressure
475 degree F Heater Surface Temperature and 50 psi interfacial pressure
475 degree F Heater Surface Temperature and 100 psi interfacial pressure

We recorded the following parameters during the fusion process of each joint:

- Time to get an indication of melt
- Soak time to heater removal
- Pressure during the heat soak cycle
- Total open/close (dwell) time for heater removal
- Fusion pressure
- Cooling time at fusion pressure

The pipes tested are listed below:

6” IPS DR11	Total XT10N PE 4710 Resin
12” IPS DR11	CP Chem H516HP PE 4710 Resin
20” DIPS DR11	Total XT10N PE 4710 Resin
28” IPS DR11	Equistar L4904 PE 4710 Resin
36” IPS DR9	Dow DGDA 2492 PE 4710 Resin

Pipe Size	**No. of Joints**	**Heater Surface Temp º F**	**Interfacial Pressure PSI**	**Total No. of Tensile Tests**
6” IPS DR11	2	425	75	8
12” IPS DR11	1	375	50	4
12” IPS DR11	1	375	100	4
12” IPS DR11	1	475	50	4
12” IPS DR11	1	475	100	4
12” IPS DR11	2	425	75	8
20” DIPS DR11	1	375	50	4
20” DIPS DR11	1	375	100	4
20” DIPS DR11	1	475	50	4
20” DIPS DR11	1	475	100	4
20” DIPS DR11	2	425	75	8
28” IPS DR11	2	425	75	8
36” IPS DR9	1	375	50	8
36” IPS DR9	1	375	100	8
36” IPS DR9	1	475	50	8
36” IPS DR9	1	475	100	8
36” IPS DR9	2	425	75	16

The fused joints in the 36” pipe were over 4” in wall thickness and were machined to approximately 2” in wall in order to test in the tensile machine. There were (22) joints made with 112 tensile tests on the joints and 32 tensile tests on the pipe. The results showed all the joints failed in a ductile manner.

3.0 CONCLUSIONS AND RECOMMENDATIONS

The results of this study indicate that when the butt fusion procedure, outlined in ASTM F2620-11e1 Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings, is used to join PE 4710 piping material, the pipeline owner can expect leak free butt fusion joints that are as strong as, if not stronger than, the pipe when subjected to pressurization, tension and/or bending. As the polyethylene industry moves to broader uniformity, efficiency and simplicity in the area of fusion procedures, the more acceptance PE will receive in the different piping markets.

APPENDIX A

Generic Butt Fusion Joining Procedure for Field Joining PE (Polyethylene) Pipe

Note: The procedure, outlined in Appendix A, was used to make the joints in Section I and Section II of this document. The procedure shown in ASTM F2620 -11e1 Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings was used in making the joints in Section III with the parameter exceptions shown in that Section. ASTM F2620 is a refined and expanded copy of this Appendix and should be used as the guide for further qualification.

This Appendix is intended to be used only in conjunction with PPI's Technical Report TR-33 that more fully explains the background, scope and purposes of the PPI generic procedure. This procedure has not been qualified for use with any particular piping product or combination of piping products and must be qualified for use in accordance with 49 CFR Part 192 prior to its use to join PE pipe in a gas pipeline. Any copying or reproduction of this procedure without this footnote and the accompanying TR-33 is a violation of the copyright.

This procedure is intended for butt fusion joining of PE fuel gas pipe produced in accordance with (ASTM D2513), excluding Dupont Aldyl A MDPE, Uponor Aldyl A MDPE and Phillips Driscopipe 7000 and 8000 HDPE[4]. It also is intended for butt fusion joining of PE potable water, sewer and industrial pipe manufactured in accordance with ASTM F714, ASTM D3035, AWWA C-901 and AWWA C-906, as well as other PE pipe and fitting standards listed in Appendix C.

Butt Fusion Procedure Parameters:

Generic Fusion Interface Pressure Range[5]	60-90 psi (4.14-6.21 bar)
Generic Heater Surface Temperature Range	400 - 450°F (204-232ºC)

Butt Fusion Procedures:

The principle of heat fusion is to heat two surfaces to a designated temperature, then fuse them together by application of a sufficient force. This force causes the melted materials to flow and mix, thereby resulting in fusion. When fused according to the proper procedures, the joint area becomes as strong as or stronger than the pipe itself in both tensile and pressure properties.

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[4] Dupont Aldyl A MDPE, Uponor Aldyl-A and Phillips Driscopipe 7000 and 8000 were not included in the study.

[5] Interfacial pressure is used to determine fusion joining pressure settings for hydraulic butt fusion machines when joining specific pipe diameters and DR's. Interfacial pressure in NOT the gauge pressure.

Field-site butt fusions may be made readily by trained operators using butt fusion machines that secure and precisely align the pipe ends for the fusion process. The six steps involved in making a butt fusion joint are:

1. Securely fasten the components to be joined
2. Face the pipe ends
3. Align the pipe profile
4. Melt the pipe interfaces
5. Join the two profiles together
6. Hold under pressure

1.0 SECURE

Clean the inside and outside of the pipe to be joined by wiping with a clean lint-free cloth. Remove all foreign matter.

Clamp the components in the machine. Check alignment of the ends and adjust as needed.

2.0 FACE

The pipe ends must be faced to establish clean, parallel mating surfaces. Most, if not all, equipment manufacturers have incorporated the rotating planer block design in their facers to accomplish this goal. Facing is continued until a minimal distance exists between the fixed and movable jaws of the machine and the facer is locked firmly and squarely between the jaw bushings. Open the jaws and remove the facer. Remove any pipe chips from the facing operation and any foreign matter with a clean, lint-free cotton cloth. Bring the pipe ends together with minimal force and inspect the face off. A visual inspection of this operation should verify that faces are square, perpendicular to the pipe centerline on each pipe end and with no detectable gap.

3.0 ALIGN

The pipe profiles must be rounded and aligned with each other to minimize mismatch (high-low) of the pipe walls. This can be accomplished by tightening clamping jaws until the outside diameters of the pipe ends match. The jaws must not be loosened or the pipe may slip during fusion. Re-face the pipe ends and remove any chips from re-facing operation with a clean, lint-free cotton cloth.

4.0 MELT

Heating tools that simultaneously heat both pipe ends are used to accomplish this operation. These heating tools are normally furnished with thermometers to measure internal heater temperature so the operator can monitor the temperature before each joint is made. However, the thermometer can be used only as a general indicator because there is some heat loss from internal to external surfaces, depending on factors such as ambient temperatures and wind conditions. A pyrometer or other surface temperature-measuring device should be used before the first joint of the day is made and periodically throughout the day to insure proper temperature of the heating tool face that contacts the pipe or fitting ends. Additionally, heating tools are usually equipped with suspension and alignment guides that center them on the pipe ends. The heater faces that come into contact with the pipe should be clean, oil-free and coated with a nonstick coating as recommended by the manufacturer to prevent molten plastic from sticking to the heater surfaces. Remaining molten plastic can interfere with fusion quality and must be removed according to the tool manufacturer's instructions. Never use chemical cleaners or solvents to clean heating tool surfaces.

The surface temperatures must be in the temperature range 400-450°F (204-232°C). Install the heater in the butt fusion machine and bring the pipe ends into full contact with the heater. To ensure that full and proper contact is made between the pipe ends and the heater, the initial contact should be under moderate pressure. After holding the pressure very briefly, it should be released without breaking contact. On larger pipe sizes, initial pressure may be maintained until a slight melt is observed around the circumference of the pipe before releasing pressure. Continue to hold the components in contact with each other, without force, while a bead of molten polyethylene develops between the heater and the pipe ends. When the proper bead size is formed against the heater surfaces all around the pipe or fitting ends, remove the heater. Melt bead size is dependent on pipe size. See table below for approximate melt bead sizes.

Table 2. Approximate Melt Bead Size

Pipe Size	Approximate Melt Bead Size
1 ¼" and smaller (40mm and smaller)	1/32" – 1/16" (1-2mm)
Above 1 ¼" through 3" (above 40mm-90mm)	About 1/16" (2mm)
Above 3" through 8" (above 90mm-225mm)	1/8"-3/16" (3-5mm)
Above 8" through 12" (above 225mm-315mm)	3/16"-1/4" (5-6mm)
Above 12" through 24" (above 315mm-630mm)	1/4"-7/16" (6-11mm)
Above 24" through 36" (above 630mm-915mm)	About 7/16" (11mm)
Above 36" through 63" (above 915mm-1600mm)	About 9/16" (14mm)

5.0 JOINING

After the heater tool is removed, quickly inspect the pipe ends (NOTE: If a concave melt surface is observed, unacceptable pressure during heating has occurred and the joint will be low quality. Do not continue. Allow the component ends to cool completely, and restart at the beginning. Except for a very brief time to seat the components fully against the heater tool, do not apply pressure during heating.), then immediately bring the molten pipe ends together with sufficient fusion force to form a double rollback bead against the pipe wall.

For larger manual and hydraulic butt fusion machines, fusion force is determined by multiplying the interfacial pressure, 60-90 psi, by the pipe area. For manually operated fusion machines, a torque wrench may be used to apply the proper force. For hydraulically operated fusion machines, the fusion force can be divided by the total effective piston area of the carriage cylinders to give a hydraulic gauge reading in psi. The gauge reading is theoretical; internal and external drags are added to this figure to obtain the actual fusion pressure required by the machine. The hydraulic gauge reading is dependent upon pipe diameter, DR and machine design. Interfacial pressure and gauge reading are not the same value.

6.0 HOLD

Hold the joint immobile under fusion force until the joint has cooled adequately to develop strength. Allowing proper cooling times under fusion force prior to removal from the clamps of the machine is important in achieving joint integrity. The fusion force should be held between the pipe ends for approximately 30-90 seconds per inch of pipe diameter or until the surface of the melt bead is cool to the touch.

Avoid pulling, installation or rough handling for an additional 30 minutes. Additional time may be required for pipes with a wall thickness greater than 2”.

7.0 VISUAL INSPECTION

Visually inspect and compare the joint against the manufacturer’s recommended appearance guidelines. Visually, the width of butt fusion beads should be approximately 2-2 ½ times the bead height above the pipe and the beads should be rounded and uniformly sized all around the pipe circumference. The v-groove between the beads should not be deeper than half the bead height above the pipe surface. When butt fusing to molded fittings, the fitting-side bead may display shape irregularities such as minor indentations, deflections and non-uniform bead rollover from molded part cooling and knit lines. In such cases, visual evaluation is based mainly on the size and shape of the pipe-side bead. (See Appendix D for bead configuration). Visually unacceptable joints should be cut out and re-fused using the correct procedure. (See manufacturer’s visual inspection guidelines)

Figure A-1. Visually unacceptable mitered joint

Visually mitered (angled, off-set) joints should be cut out and re-fused (straight or coiled pipe).

Coiled pipe is available in sizes through 6” IPS. Coiling may leave a bend in some pipe sizes that must be addressed in the preparation of the butt fusion process. There are several ways to address this situation:

1. Straighten and re-round coiled pipe before the butt fusion process. (ASTM D2513 requires field re-rounding coiled pipe before joining pipe sizes larger than 3” IPS.)

2. If there is still curvature present, install the pipe ends in the machine in an “S” configuration with print lines approximately 180° apart in order to help gain proper alignment and help produce a straight joint. See Figure A-2.

3. If there is still a curvature present, another option would be to install a straight piece of pipe between the two coiled pipes.

Every effort should be made to make the joint perpendicular to the axis of the pipe.

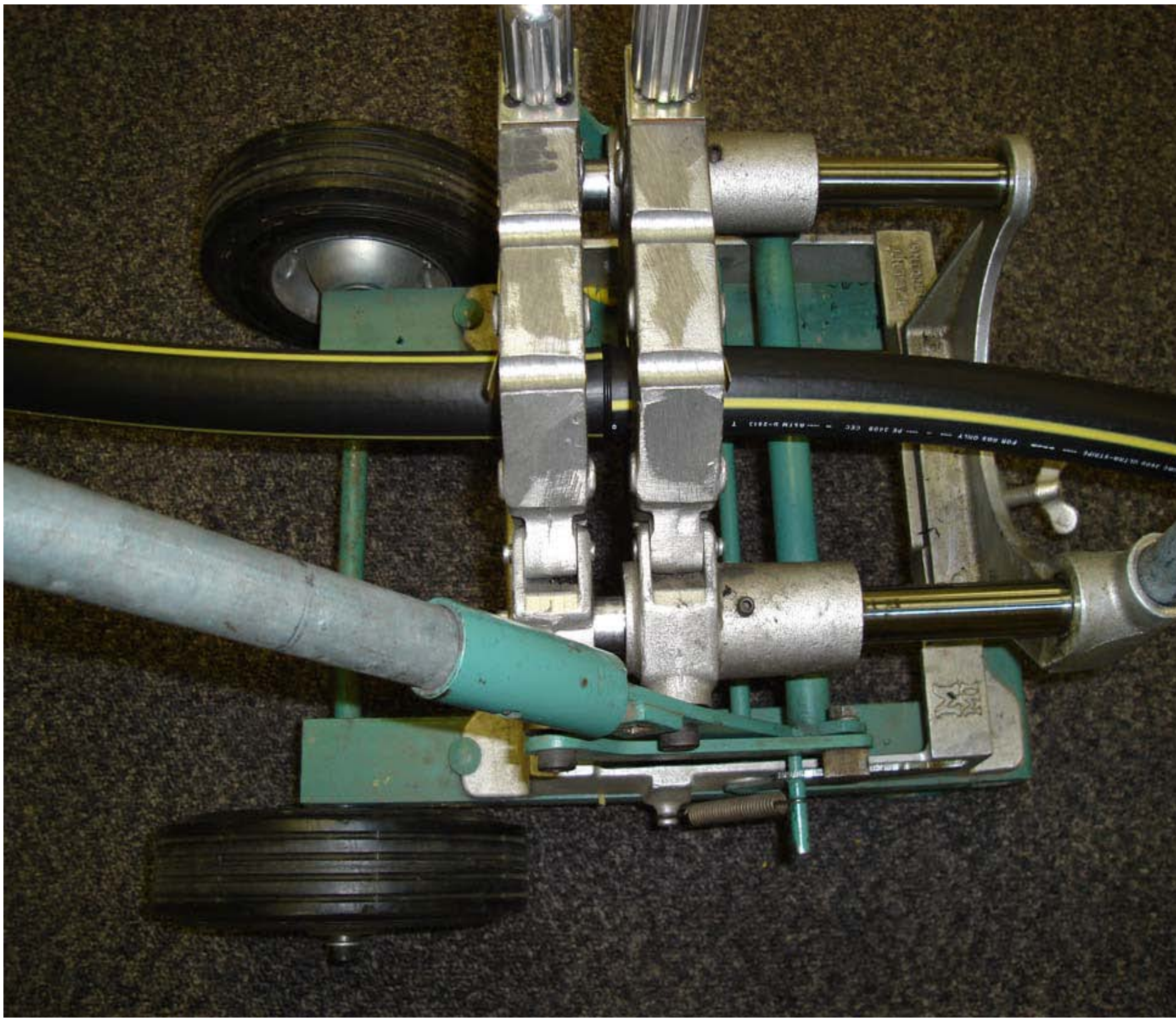


Figure A-2. Alignment of Coiled Pipe Ends Through a Butt Fusion Machine

APPENDIX B

LETTERS OF COMPLIANCE FROM PPI MEMBER COMPANIES FOR 49 CFR §192.283 FOR PIPE INTENDED FOR GAS DISTRIBUTION APPLICATIONS

Please contact the pipe or fittings manufacturer for letters of compliance.

APPENDIX C

Municipal and Industrial Applications

Materials that have been pre-qualified to be joined by this generic fusion procedure are within the nominal melt index range of 0.05 to 0.25 gm/10 minutes (190°C/ 2.16 Kg), or a high load melt flow of 6 to 17 gm/10 minutes (190°C/21.6 Kg), and a nominal density range of 0.936 to 0.955 gm/cc.

Materials within this melt index and density range were included in the study and can be joined by this methodology. However, PE materials outside of this range may also be able to be joined by this generic method, but they have not been included in this study. Contact the manufacturer to verify that their products can be joined by this generic method.

Qualified materials are typically used in the production of pipe and/or fittings that are manufactured according to the following standards:

ASTM
D2104 Polyethylene (PE) Plastic Pipe, Schedule 40

D2239 Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter

D2447 Polyethylene (PE) Plastic Pipe, Schedules 40 to 80, Based on Outside Diameter

F2620 Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings

F2634 Standard Test Method for Laboratory Testing of Polyethylene (PE) Butt Fusion Joints using Tensile-Impact Method

D3035 Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Controlled Outside Diameter

D3261 Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing

F714 Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Outside Diameter

F771 Polyethylene (PE) thermoplastic high-pressure Irrigation Pipeline Systems F 810 Smooth wall Polyethylene (PE Pipe for Use in Drainage and Waste Disposal Absorption Fields

AWWA

C-901 Polyethylene (PE) Pressure Pipe, Tubing, and Fittings, 1/2“through 3” for Water Service

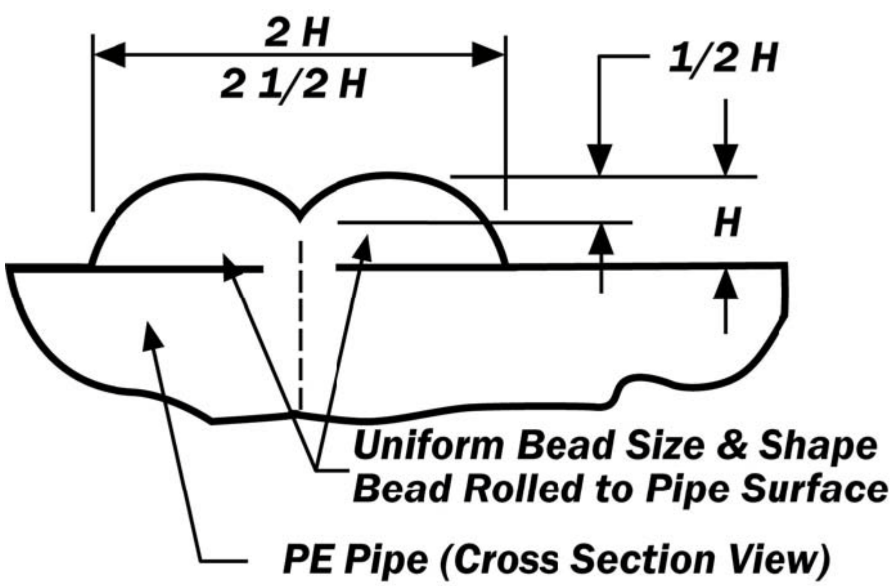
C-906 Polyethylene (PE) Pressure Pipe and Fittings, 4” through 63” for Water Distribution

CSA

B 137.1 Polyethylene Pipe, tubing and Fittings for Cold Water Pressure Services

APPENDIX D

ILLUSTRATION OF A PROPERLY MADE BUTT FUSION JOINT



Note: When butt fusing to molded fittings, the fitting side bead may have an irregular appearance. This is acceptable provided the pipe side bead is correct.

This bead configuration DOES NOT apply to joints made with Dupont Aldyl A MDPE, Uponor Aldyl A MDPE or Phillips Driscopipe 7000 and 8000 HDPE.