

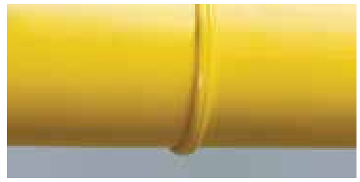


HEAT FUSION JOINING PROCEDURES

PolyPipe®

dura·line

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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 pipe and appurtenances, as well as the durability of the resulting joints. The integrity and versatility of the joining techniques used for polyethylene (PE) pipe allow the designer to take advantage of the performance benefits of PE in a wide variety of applications.

There are three types of heat fusion joints currently used in the industry: butt, saddle and socket fusion. Additionally, there are two methods for producing the socket and saddle fusion joints. In addition to the fusion procedures that follow, electrofusion is recognized as an acceptable method of producing socket and saddle fusions but is not addressed in this document. The user of electrofusion products should contact the provider of those products for details on use in joining pipe.

The fusion procedures that follow have been proven to consistently produce sound fusion joints in bench trials when used correctly and are recommended for the joining of PolyPipe® products. The recommended procedures for butt and saddle fusions are consistent with the Plastics Pipe Institute (PPI) Technical Reports (TR) **TR-33, Generic Butt Fusion Procedures and TR-41, Generic Saddle Fusion Procedures and ASTM F2620: Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings. Bench trials have been conducted to show that PolyPipe products can be joined per the following procedures to meet the requirements of 49 CFR Part 192.283.**

POLYPIPE® PRODUCTS
GAS DISTRIBUTION
PolyPipe® **PolyTough1**™
PolyPipe® GDY20
PolyPipe® GDB50

FEDERAL REGULATIONS

Federal regulations require that all operators qualify both their joining procedures and the personnel installing pipe. The Pipeline Safety Regulations, issued by the U.S. Department of Transportation (DOT) Pipeline and Hazardous Materials Safety Administration, are found at 49 CFR Part 192. Pursuant to 49 CFR 192.283(a), an operator is required to qualify heat fusion joining procedures before the procedure is used in the field. Further, 49 CFR Part 192.285 requires that an operator qualify the personnel who will be making heat fusion joints in the field. Additional Federal regulations may apply, and State regulations that are corollaries to the Pipeline Safety Regulations also apply, as may additional, more stringent, state regulations.

The operator is responsible for ensuring that all aspects of their fusion joining processes and procedures are in compliance with the requirements of 49 CFR, Part 192 and ASTM standards.

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The operator is responsible for ensuring that all aspects of their fusion joining processes and procedures are in compliance with the requirements of 49 CFR, Part 192 and ASTM standards.

HEAT FUSION

The principle behind heat fusion is to heat two surfaces to a designated temperature, and then fuse them together by application of the required force. This applied force joins the melted surfaces resulting in a permanent, monolithic fusion joint. PolyPipe® fusion procedures require specific tools and equipment for the fusion type and for the sizes of pipe and fittings to be joined.

Butt Fusion – This technique consists of heating the squared ends of two pipes, a pipe and fitting, or two fittings by holding them against a heated plate, removing the plate when the proper melt is obtained, promptly bringing the ends together and allowing the joint to cool while maintaining the appropriate applied force.

Butt Fusion

Saddle Fusion – This technique involves melting the concave surface of the base of a saddle fitting, while simultaneously melting a matching pattern on the surface of the pipe, bringing the two melted surfaces together and allowing the joint to cool while maintaining the appropriate applied force.

Saddle Fusion

Socket Fusion – This technique involves simultaneously heating the outside surface of a pipe end and the inside surface of a fitting socket, which is sized to be smaller than the smallest outside diameter of the pipe. After the proper melt has been generated at each face to be mated, the two components are joined by inserting the pipe into the fitting. The fusion is formed at the interface resulting from the interference fit. The melts from the two components flow together and fuse as the joint cools.

Socket Fusion

Properly fused PE joints do not leak. If a leak is detected during pneumatic or hydrostatic testing, it is possible for a system failure to occur. Caution should be exercised in approaching a pressurized pipeline and any attempts to correct the leak should not be made until the system has been depressurized.

Note: PE cannot be joined by solvent bonding or threading. Extrusion welding or hot air welding is not recommended for pressure applications.

INCLEMENT WEATHER

PE has reduced impact resistance in sub-freezing conditions. Additional care should be exercised while handling in sub-freezing conditions. In addition, PE pipe will be harder to bend and/or uncoil.

For recommended guidelines when fusing in inclement weather, refer to the Plastics Pipe Institute, PPI, Technical Note **TN-42: Recommended Minimum Training Guidelines for PE Pipe Butt Fusion Joining Operators for Municipal and Industrial Projects.** **http://plasticpipe.org/pdf/tn-42-min-training-guide-pe-butt-fusion.pdf** These guidelines apply to all applications.

Additional information concerning cold weather procedures is available in ASTM F2620, Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings, Annex A1.

The operator should ensure that its qualified fusion procedures take into account and are adapted for all potential inclement weather conditions in which the operator may be fusing polyethylene pipe.

NOTES ON FUSION CONFIDENCE

Reliable fusion joints of PE piping systems can be accomplished under reasonable latitude of conditions. The operator should qualify its own procedures for every condition under which it will be fusing polyethylene pipe. Additionally, the operator should qualify all personnel who will responsible for performing fusions of polyethylene pipe.

The following is a listing of general notes to help ensure proper equipment and techniques are utilized:

1. The fusion operator must have adequate training and understanding of the equipment and tools and the fusion procedure.

Improper understanding of the operation of the equipment and tools can produce a fusion of poor quality. The operator must understand thoroughly how to use the equipment and tools, their function and operation. The operator should adhere to the equipment manufacturer's instructions.

Fusion pressures and heating/cooling cycles may vary dramatically according to pipe size and wall thickness. Operators should not rely exclusively on automated fusion equipment for joint qualification. In addition, visual inspection and qualification should always be made. If necessary, test fusions should be made to determine correct pressures and heat/cool cycle times. Destructive test methods, such as bend back tests, may be necessary to formulate correct pressures and heat/cool cycle times (refer to Qualification Procedures).

2. Pipe and fitting surfaces must be clean and properly prepared.

Any contaminants present on the surfaces or poor preparation of the surfaces can produce a poor quality fusion joint. Ensure that all pipe and fitting surfaces are clean. If surfaces are reintroduced to contaminants, they should be cleaned again.

3. Heater plates must be clean, undamaged and the correct surface temperature.

Heater surfaces are usually coated with a non-stick material. Cleaning techniques should be used accordingly. If a solvent is deemed necessary, do not use gasoline or other petroleum products. Refer to the equipment manufacturer's instructions for proper cleaning products. It is important to regularly clean the heater surface to remove any buildup of PE material that will degrade due to extended contact with the heater.

Recommended heating tool temperatures are specified for each procedure. This temperature is indicative of the surface temperature, not the heating tool thermometer. The surface temperature should be verified daily by using a surface pyrometer. If a crayon indicator (melt stick) is used, it should not be used in an area that will be in contact with the pipe or fitting.

If the heater plate is not in use, it is recommended that it be stored in an insulated holder. This not only protects the heater surfaces from contaminants, but it can also prevent inadvertent contact, which can result in serious injuries.

4. Proper equipment and condition of tools and equipment for the job

Each type of fusion requires special tools and equipment. Fusions performed with the incorrect fusion equipment, materials or tools and/or with fusion equipment that has not been properly maintained can result in a poor fusion. Any non-working equipment components should be replaced or repaired prior to fusing pipe.

FUSION CHECKLIST

- Inspect pipe lengths and fittings for unacceptable cuts, gouges, deep scratches or other defects. Damaged products should not be used. Refer to PolyPipe® InfoBrief No. 2 for allowable surface damage according to the Plastics Pipe Institute (PPI) and the American Gas Association (AGA).

- The fusion contact area must be free of any defects or surface disruption.

- Be sure all required tools and equipment are on site and in proper working order.

- Pipe and fitting surfaces where tools and equipment are fitted must be clean and dry. Use **clean**, dry, non-synthetic (cotton) cloths or paper towels to remove dirt, snow, water and other contaminants. If alcohol is used, >90% isopropyl alcohol is recommended.

- Shield and/or cover fusion equipment and surfaces from inclement weather and winds. A temporary shelter over fusion equipment and the fusion operation may be required.

- Relieve tension in the line before making connections.

  When joining coiled pipe, making an S-curve between pipe coils can relieve tension. In some cases, it may be necessary to allow pipe to equalize to the temperature of its surroundings. Allow pulled-in pipes to relax for several hours to recover from tensile stresses.

- Pipes must be correctly aligned before making connections.

- Trial fusions.

  A trial fusion, preferably at the beginning of the day, can verify the fusion procedure and equipment settings for the actual jobsite conditions. Refer to Qualification Procedures for detailed information on the bend back test procedure.

BUTT FUSION

Heater Surface Temperature: Minimum 400°F – Maximum 450°F

Heating tool surfaces must be to temperature before you begin. All points on both heating tool surfaces where the heating tool surfaces will contact the pipe or fitting ends must be within the prescribed minimum and maximum temperatures and the maximum temperature difference between any two points on the heating tool fusion surfaces must not exceed 20°F for equipment for pipe smaller than 18" diameter, or 35°F for larger equipment. It is a good practice to set the heater plate to 425°F which can help keep normal fluctuations between 400°F and 450°F. Heating tool surfaces must be clean.

Interfacial pressure: Minimum 60 psi – Maximum 90 psi

Interfacial pressure is used to calculate a fusion joining gauge pressure value for hydraulic butt fusion machines or manual machines equipped with force reading capability. The interfacial pressure is constant for all pipe sizes and all butt fusion machines. However, fusion joining gauge pressure settings are calculated for each butt fusion machine, which are dependent upon the outside diameter (OD) and dimension ratio (DR) and the piston area of the fusion machine.

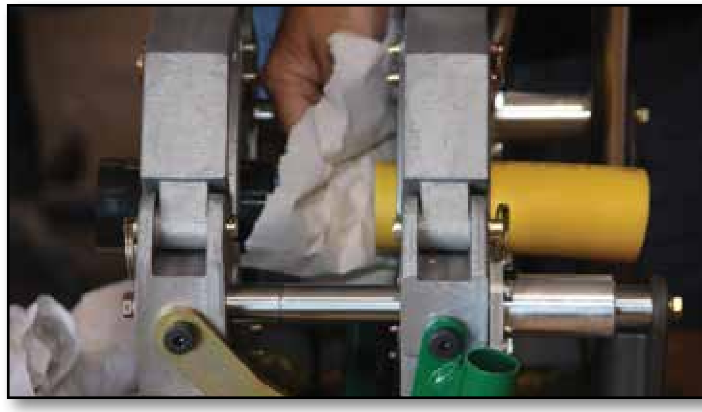
For hydraulic machines, the interfacial pressure, the fusion surface area, the machine's effective piston area and frictional resistance, and if necessary, the pressure needed to overcome external drag resistance, are used to calculate hydraulic fusion joining pressure gauge settings (refer to Appendix A). The equipment manufacturer's instructions are used to calculate this value. The proper amount of force should be verified by visual inspection of the joint.

NOTE: The interfacial pressure and the hydraulic gauge pressure are not the same.

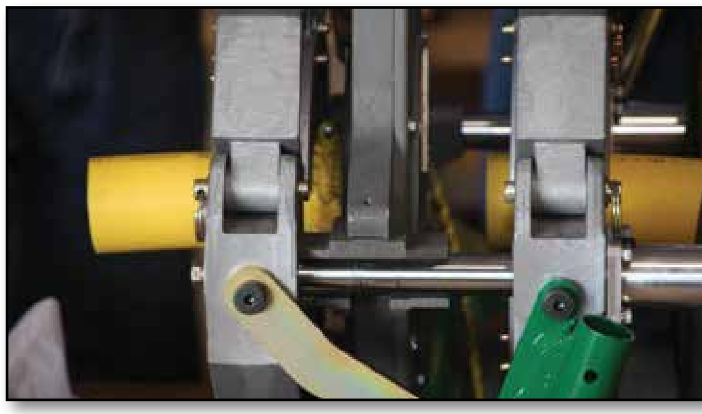
For manual machines without force reading capability, the correct fusion joining force is the force required to roll the melt beads over until they contact the pipe surface as required by the joining procedure.

When joining pipes with different melt properties, such as bimodal MDPE to unimodal MDPE, apply sufficient force to make the bimodal pipe fusion bead roll back and contact the pipe surface. Bimodal MDPE has a lower melt flow ratio than unimodal pipe.

PROCEDURE



1. Secure
Clean the inside and outside of the pipe or fitting (components) ends by wiping with a clean, dry, lint-free cloth or paper towel. Remove all foreign matter. Align the components in the machine, place them in the clamps, and then close the clamps. **Do not force pipes into alignment against open fusion clamps**. Component ends should protrude past the clamps enough so that facing will be complete. Bring the ends together and check high-low alignment. Adjust alignment as necessary by tightening the high side down.



2. Face
Place the facing tool between the component ends, and face them to establish smooth, clean, parallel mating surfaces. Complete facing produces continuous circumferential shavings from both ends. Face until there is minimal distance between the fixed and moveable clamps. If the machine is equipped with facing stops, face down to the stops. Stop the facer before moving the pipe ends away from the facer. Remove the facing tool, and clear all shavings and pipe chips from the component ends. **Do not touch the component ends with your hands after facing.**

3. Align
Bring the component ends together, check alignment and check for slippage against fusion pressure. Look for complete contact all around both ends with no detectable gaps, and ODs in high-low alignment. If necessary, adjust the high side by tightening the high side clamp. Do not loosen the low side clamp because components may slip during fusion. **Re-face if high-low alignment is adjusted.**

4. Melt
Verify that the contact surface of the heating tool is maintaining the correct temperature. Place the heating tool between the component ends, and move the ends against the heating tool. Bring the component ends together under pressure to ensure full contact. The initial contact pressure should be held very briefly and released without breaking contact. Pressure should be reduced when evidence of melt appears on the circumference of the pipe. Hold the ends against the heating tool **without force** (drag force may be necessary to ensure contact). Beads of melted PE will form against the heating tool at the component ends. When the proper melt bead size is formed, quickly separate the ends and remove the

heating tool. The proper bead size is dependent upon the size of the component. Approximate values are shown in Table I.

During heating, the melt bead will expand out flush to the heating tool surface, or may curl slightly away from the surface. If the melt bead curls significantly away from the heating tool surface, unacceptable pressure during heating may have occurred.

TABLE I
APPROXIMATE MELT BEAD SIZE

Approximate Wall Thickness, inches	Melt Bead Size* (Approximate)
≤ 0.15	1/32" – 1/16"
0.15 – 0.30	1/16"
Above 0.30 – 0.75	1/8" – 3/16"
Above 0.75 – 1.15	3/16" – 1/4"
Above 1.15 – 1.60	1/4" – 5/16"
Above 1.60 – 2.20	5/16" – 7/16"
Above 2.20 – 3.00	7/16" – 9/16"

The appearance of the melt swell zone may vary depending on the pipe material. The melt bead width is to be determined by measuring the distance from the heater plate to the melt swell origin.

5. Join

Immediately after the heating tool is removed, **quickly** inspect the melted ends, which should be flat, smooth and completely melted. If the melt surfaces are acceptable, immediately and in a continuous motion, bring the ends together and apply the correct joining force (or fusion pressure). The correct fusion pressure will form a double bead that is rolled over and contacts the pipe surface.the surface on both ends.

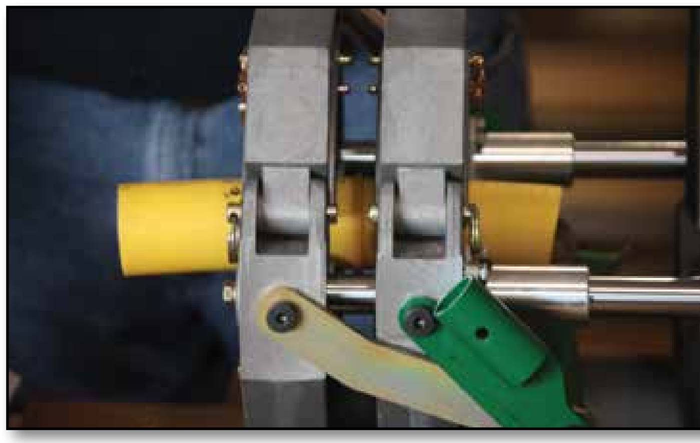
A concave melt surface is unacceptable; it indicates pressure during heating. Do not continue. Allow the component ends to cool and start over with Step 1.

The maximum recommended time allowed for heater plate removal is indicated in Table II.

TABLE II MAXIMUM HEATER PLATE REMOVAL TIMES	
Pipe Wall Thickness, in	**Max. Heater Removal Time, sec**
0.20 to 0.36	8
>0.36 to 0.55	10
>0.55 to 1.18	15
>1.18 to 2.5	20
>2.5 to 4.5	25

6. Hold

Maintain fusion gauge pressure until the joint is cool. The joint is cool enough for gentle handling when the double bead is cool to the touch. Cool for a minimum of 11 minutes per inch of pipe wall. Do not try to decrease the cooling time by applying water, ice, wet cloths or the like.



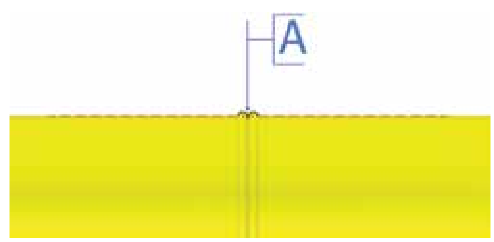
Avoid pulling, installation, pressure testing and rough handling for at least an additional 30 minutes.

For ambient temperatures above 100°F, longer cooling times may be required.

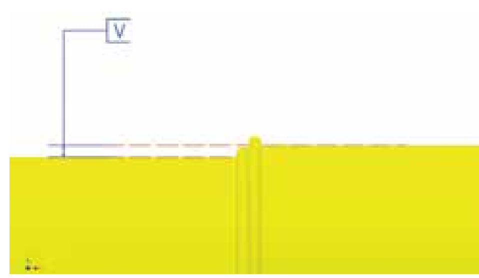
7. Inspection

On both sides, the double bead should be rolled over to the surface, and be uniformly rounded and consistent in size all around the joint.

1. The gap (A) between the two single beads must not be below the fusion surface throughout the entire circumference of the butt joint.



2. The displacement (V) between the fused ends must not exceed 10% of the pipe/fitting minimum wall thickness.



3. Refer to Table III for general guidelines for bead width, B, for each respective wall thickness.

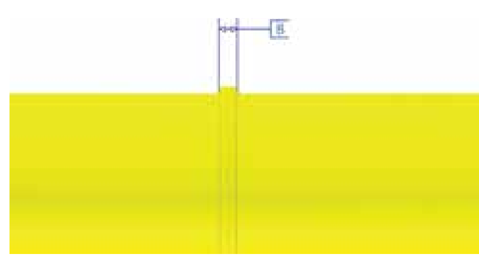
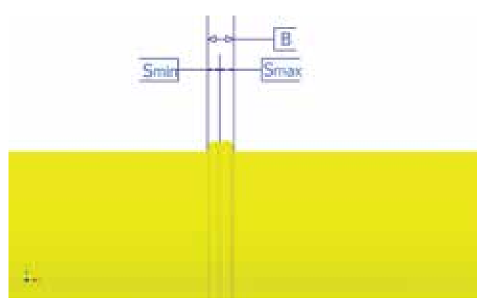


TABLE III BEAD WIDTHS PER WALL THICKNESS					
Minimum Wall Thickness, in.	**Approximate Bead Width (B), in.**		**Minimum Wall Thickness, in.**	**Approximate Bead Width (B), in.**	
	Minimum	Maximum		Minimum	Maximum
.118	5/32	1/4	1.06	19/32	25/32
.157	5/32	9/32	1.18	5/8	13/16
.197	3/16	5/16	1.34	21/32	7/8
.246	1/4	11/32	1.57	11/16	29/32
.315	9/32	3/8	1.77	25/32	1
.354	5/16	7/16	1.97	7/8	1-1/16
.433	11/32	1/2	2.16	15/16	1-3/16
.512	3/8	9/16	2.36	1	1-1/4
.630	7/16	19/32	2.56	1-1/8	1-7/16
.710	1/2	5/8	2.76	1-3/16	1-1/2
.750	1/2	11/16	2.95	1-1/4	1-9/16
.870	1/2	11/16	3.15	1-5/16	1-11/16
.940	9/16	3/4	3.35	1-3/8	1-3/4
			3.54	1-1/2	1-13/16

Instructions: Determine the wall thickness of the pipe/fitting. Find the wall thickness above. If the exact wall thickness is not shown, use the next lowest wall thickness for determination of bead width.

4. The size differential ($S_{max} - S_{min}$) between two single beads shall not exceed X% of the combined bead width (B).

$$X = \frac{\Delta S}{B} \times 100$$



Where:

X = Percent difference of bead width, %

Pipe to pipe, maximum X = 10%

Pipe to fitting, maximum X = 20%

Fitting to fitting, maximum X = 20%

$\Delta S = S_{max} - S_{min}$, inches

B = Combined width of both fusion beads, inches

NOTE:

1. When butt fusing pipe to molded fittings, the fitting side bead may have an irregular appearance. The different manufacturing processes used (extrusion vs molding) will cause the bead appearance to be different when it rolls back. This is acceptable, provided the pipe side bead is correct. (See Images 1 & 2.)
2. When fusing unimodal MDPE pipe to bimodal MDPE pipe or HDPE pipe, the unimodal MDPE pipe bead may be slightly larger than the bimodal MDPE or HDPE pipe bead. This occurs because of the different melt properties of the resins. (See Images 3 & 4)
3. PolyPipe PolyTough1™ has been successfully fused to a variety of pipes that may be in use in existing gas pipe systems. Photos of these fusions are provided for visual reference. (See Images 5 thru 16)

QUALIFICATION

The following summarizes the ASTM methods to which the operator and/or user should refer for specific qualification requirements

1. Prepare a sample joint. Sample lengths should be at least 6" or 15 times the minimum wall thickness (see Figure I).

2. Observe the fusion process and verify the recommended procedure for butt fusion is being followed.

3. Visually inspect the sample joint for quality.

4. Allow the joint to cool completely.

5. Prepare the sample as shown in Figure I. The sample should be cut lengthwise into at least three longitudinal straps with a minimum of 1" or 1.5 times the wall thickness in width. It is recommended that four equally spaced strips be cut, one from each quadrant of the pipe.

6. Visually inspect the cut joint for any indications of voids, gaps, misalignment or surfaces that have not been properly bonded.

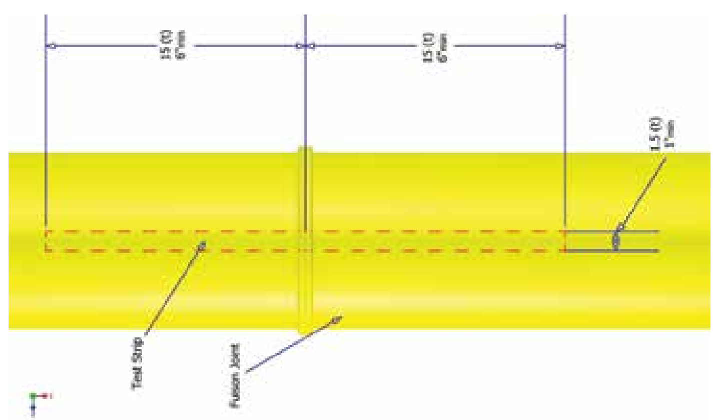
7. Bend each sample at the weld with the inside of the pipe facing out until the ends touch. The inside bend radius should be less than the minimum wall thickness of the pipe. In order to successfully complete the bend back, a vise may be needed. For thick (>1") wall pipe, contact PolyPipe® Engineering for recommended procedures and test apparatus.

8. The sample must be free of cracks and separations within the weld location. If failure does occur at the weld in any of the samples, cut another sample adjacent to the position the failed sample came from and retest. If the second sample fails, then the fusion procedure should be reviewed and corrected. After correction, another sample fusion should be made per the new procedure and re-tested.

BEND BACK TESTING - NO GAPS OR VOIDS

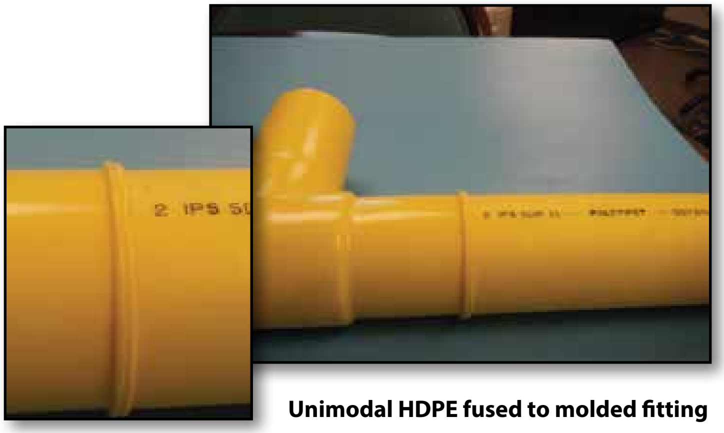
(See Figure 1)

Figure I
Butt Fusion Bent Strap Test Specimen
(Reference ASTM F2620)

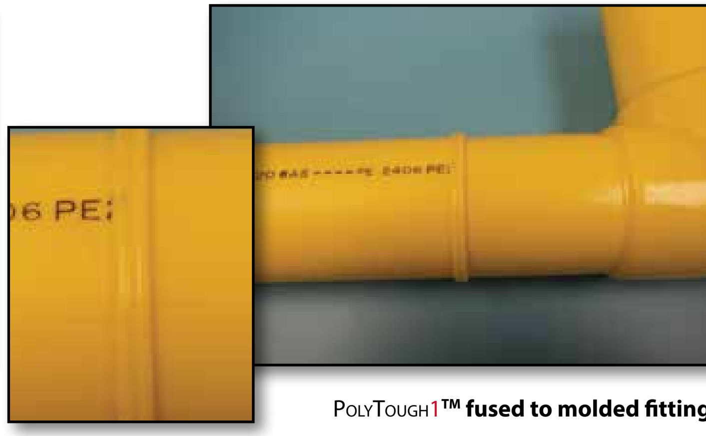


ACCEPTABLE FUSIONS

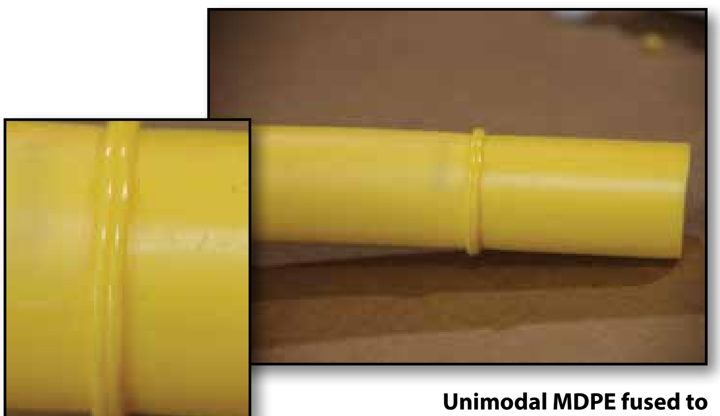
BUTT FUSION



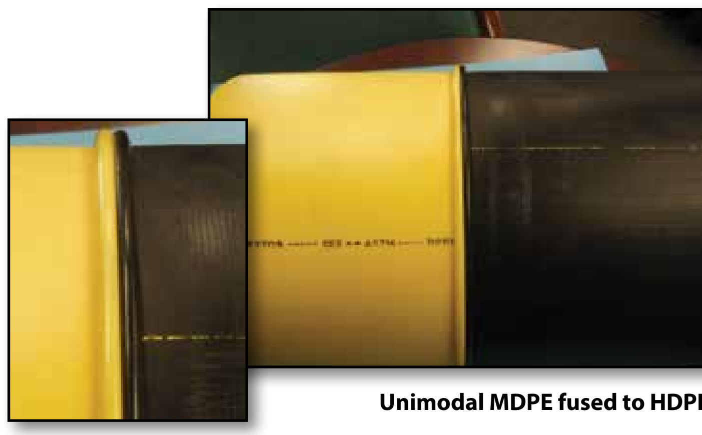
Unimodal HDPE fused to molded fitting



PolyTough1™ **fused to molded fitting**



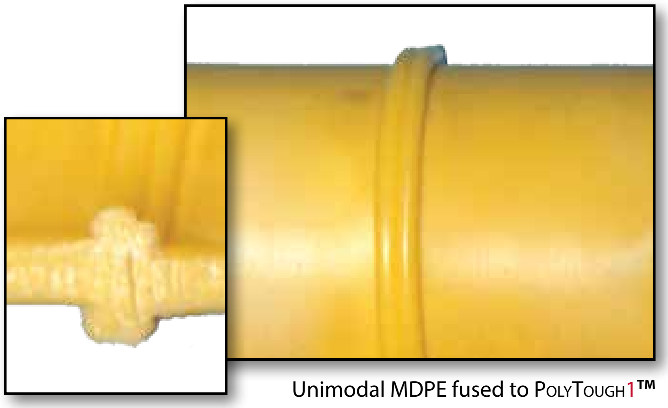
Unimodal MDPE fused to
PolyTough1™ **bimodal MDPE**



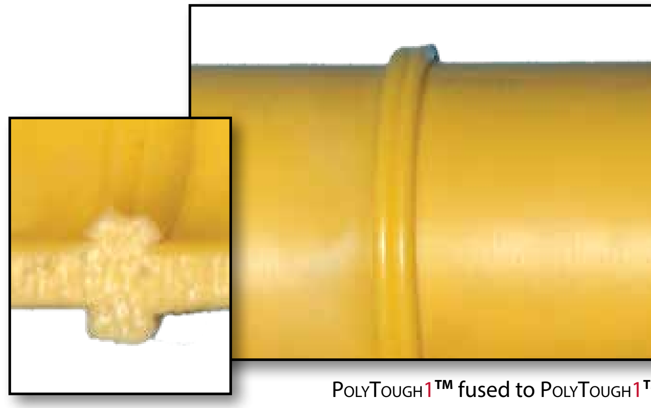
Unimodal MDPE fused to HDPE

PROPER ALIGNMENT AND DOUBLE ROLL-BACK BEAD

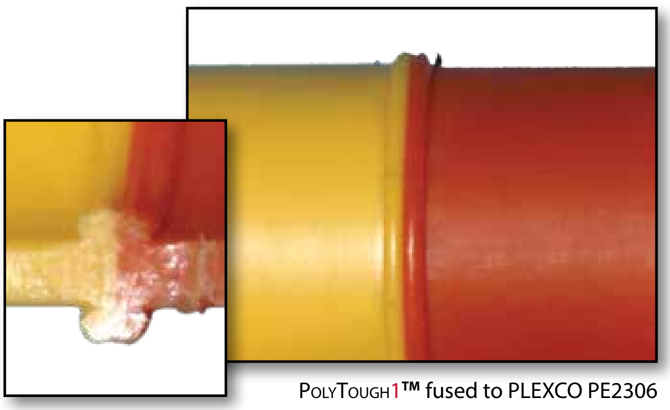
PolyTough1™ BIMODAL MDPE JOINED TO VINTAGE AND CURRENT MATERIALS



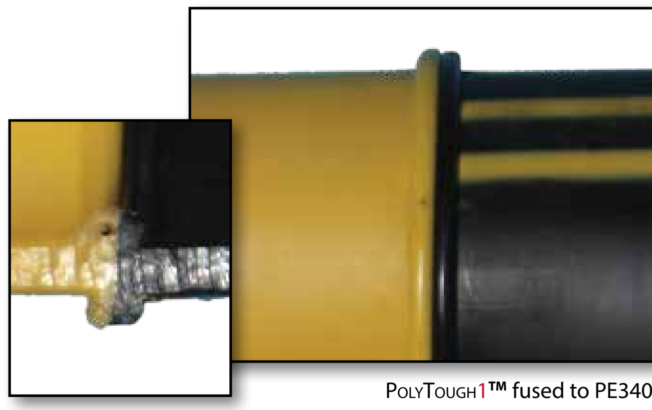
Unimodal MDPE fused to PolyTough1™



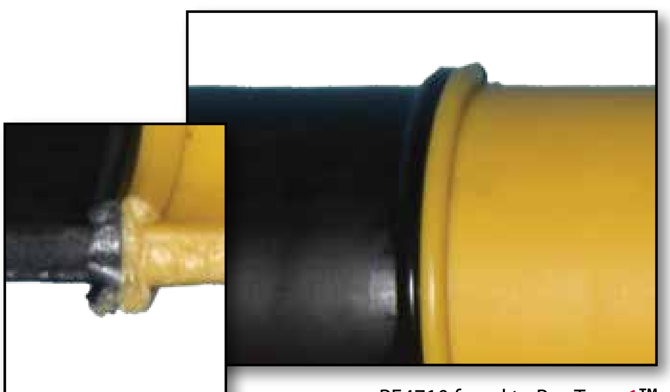
PolyTough1™ fused to PolyTough1™



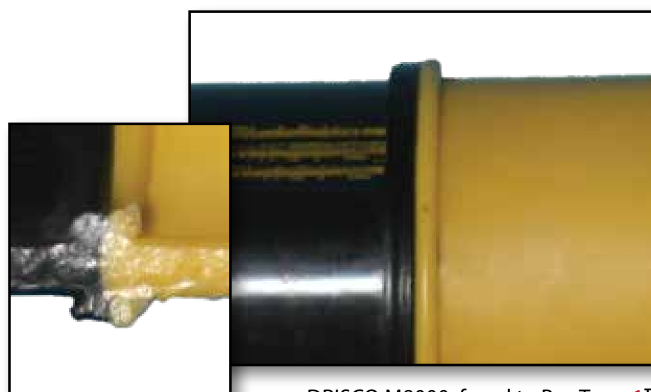
PolyTough1™ fused to PLEXCO PE2306



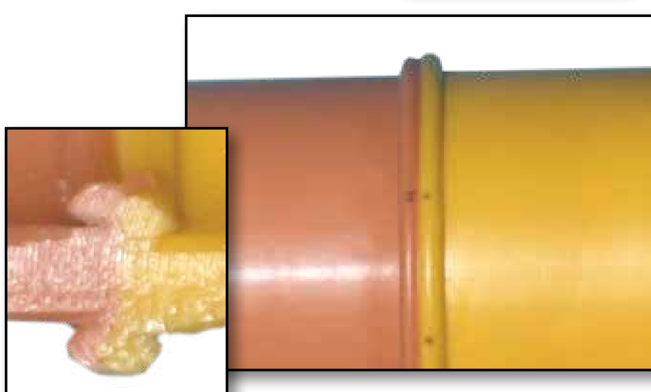
PolyTough1™ fused to PE3408



PE4710 fused to PolyTough1™



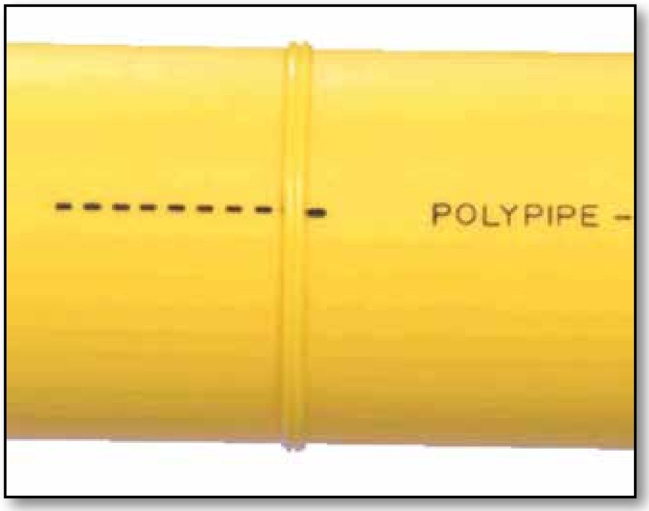
DRISCO M8000 fused to PolyTough1™



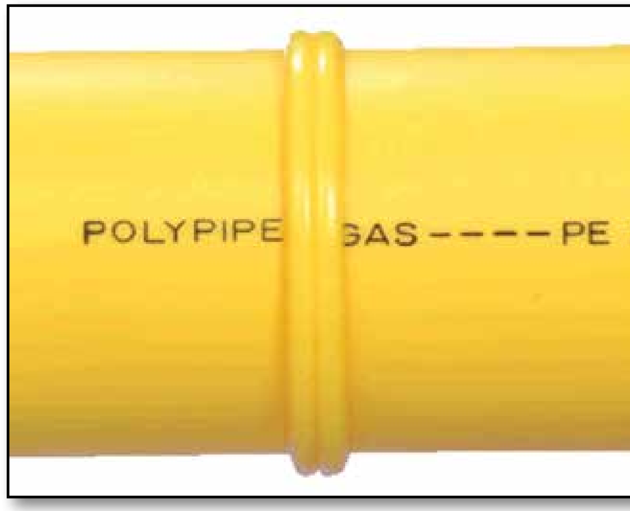
DUPONT ALDYL A PE2306 fused to PolyTough1™

UNACCEPTABLE FUSIONS

BUTT FUSION



Melt bead too small due to insufficient heat time



Melt bead too large due to excessive heating and/or over pressurization of joint

Misalignment

Incomplete Facing

Pressure fluctuation, misalignment over pressurization

TABLE IV
BUTT FUSION TROUBLESHOOTING GUIDE

Observed Condition	Possible Cause
• Excessive double bead width	• Overheating • Excessive joining force
• Double bead v-groove too deep	• Excessive joining force • Insufficient heating • Pressure during heating
• Flat top on bead	• Excessive joining force • Overheating
• Non-uniform bead size around pipe	• Misalignment • Defective heating tool • Worn equipment • Incomplete facing
• One bead larger than the other	• Misalignment • Component slipped in clamp • Worn equipment • Heating iron does not move freely in the axial direction • Defective heating tool • Incomplete facing • Also possible when fusing bimodal pipes to unimodal pipes
• Beads too small	• Insufficient heating • Insufficient joining force
• Bead not rolled over to surface	• Shallow v-groove – Insufficient heating & insufficient joining force • Deep v-groove – Insufficient heating & excessive joining force • Bead on bimodal pipe may have slight gap to the pipe surface
• Beads too large	• Excessive heating time
• Square type outer bead edge	• Pressure during heating
• Rough, sandpaper-like, bubbly, or pockmarked melt bead surface	• Hydrocarbon (gasoline vapors, spray paint fumes, etc.) contamination

SADDLE FUSION

Heater Surface Temperature: **500ºF ± 10ºF** (Minimum 490ºF - Maximum 510ºF)

Heater tool surfaces must be up to temperature before you begin. All points on both heating tool surfaces where the heating tool surfaces will contact the pipe and fitting must be within the prescribed minimum and maximum temperatures. Heater tool surfaces must be clean.

Interface Pressure: Minimum 54 psi – Maximum 66 psi

DEFINITIONS

Initial Heat (Bead-up)
The heating step used to develop a melt bead on the pipe.

Initial Heat Force (Bead-up Force)
The force (pounds) applied to establish a melt pattern on the pipe. The Initial heat force is determined by multiplying the fitting base area (in2) by the initial heat interfacial pressure (psi).

Heat Soak Force
The force (pounds) applied after an initial melt pattern is established on the pipe. The heat soak force is the minimum force (essentially zero) that ensures the fitting, heater and pipe stay in contact with each other.

Fusion Force
The force (pounds) applied to establish the fusion bond between the fitting and the pipe. The fusion force is determined by multiplying the fitting base area (in2) by the fusion interfacial pressure (psi).

Total Heat Time
A time that begins when the heater is placed on the pipe and initial heat force is applied and stops when the heater is removed. Maximum heating times are shown in Table IV for both pressure (hot tapping) and non-pressure fusion applications.

Cool Time
The time required to cool the joint to approximately 120ºF ± 10ºF. The Fusion Force must be maintained for 5 minutes on 1-1/4" IPS or 10 minutes for all other pipe sizes, after which the saddle fusion equipment can be removed. The joint must be allowed to cool for an additional 30 minutes before tapping the pipe or joining to the branch outlet. Recommended minimum cooling times are shown in Table IV.

TABLE V MAXIMUM HEATING/MINIMUM COOLING TIMES		
Pipe Size	**Maximum Heating Time**	**Minimum Cooling Time**
1-1/4" IPS	1/16" melt pattern visible around the base of the fitting. ***Do not exceed 15 seconds when hot tapping.***	5 min + 30 min
2" IPS	1/16" melt pattern visible around the base of the fitting. ***Do not exceed 35 seconds when hot tapping.***	10 min + 30 min
3" IPS & larger	1/16" melt pattern visible around the base of the fitting.	10 min + 30 min

INTERFACIAL AREA

- Rectangular base fittings

  The major width times the major length of the saddle base, without taking into account the curvature of the base or sides, minus the area of hole in the center of the base.

- Round base fittings

  The radius of the saddle base squared times π (3.1416), without taking into account the curvature of the base or sides, minus the area of the hole in the center of the base.

FITTING LABELS

The initial heat force, heat soak force and fusion force will be listed in the lower right-hand corner of the fitting label for the majority of saddle fusion fittings. This eliminates the need to calculate the information in the field. For example, 80/0/40 represents the initial heat force, heat soak force and fusion force, respectively. If this information is not located on the fitting, please contact the fitting manufacturer for the correct fusion parameters.

PROCEDURE

1. Preparation

This procedure requires the use of a saddle fusion tool. This tool must be capable of holding and supporting the pipe, rounding the pipe for proper alignment between the pipe and fitting, holding the fitting, and applying and indicating the proper force during the fusion process.

A. Install the saddle fusion tool on the pipe according to the manufacturer's instructions. The tool should be centered over a clean, dry location where the fitting will be fused. Secure the tool to the pipe. A support is recommended under the pipe on 6" IPS and smaller pipe sizes.

B. Abrade the surface of the pipe, where the fitting will be joined, with a 50–60 grit utility cloth until a thin layer of material is removed from the pipe surface. The abraded area must be larger than the area covered by the fitting base. After abrading, clean the residue away with a clean, dry cloth.

C. Abrade the fusion surface of the fitting with 50-60 grit utility cloth. Remove all dust and residue with a clean, dry cloth. Insert the fitting in the saddle fusion tool loosely. Using the saddle fusion tool, move the fitting base against the pipe and apply about 100 pounds-force to seat the fitting. Secure the fitting in the saddle fusion tool.

2. Heating

The heating and fusing process must be performed with accuracy and efficiency, especially when fusing to a pressurized main pipe.

WARNING: Overheating or excessive time between these two processes can have detrimental effects, including pipeline rupture.

- ○ The heater must be fitted with the correct heater adapters.
- ○ The heater adapter fusion surface must be between 490°F to 510°F.
- ○ Ensure the heating surfaces are clean.
- ○ Determine the saddle fusion force from the fitting label or by calculation.

A. Place the heating tool on the pipe centered beneath the fitting base. Immediately move the fitting against the heater faces, apply the initial heat force (see fitting label) and start the heat time. Apply the initial heat force until melt is first observed on the crown of the pipe main. "Initial heat" is the term used to describe the initial heating (bead-up) step to develop a melt bead on the pipe and is usually 3-5 seconds, and then reduce the force to the heat soak force (bead-up force) (see fitting label). Maintain the heat soak force until the total heat time is complete.

B. At the end of the total heat time, remove the fitting from the heater and the heater from the pipe with a quick, snapping action. Quickly check for an even melt pattern on the pipe and heated fitting surfaces (no unheated areas). The total heat time ends when one of the following conditions are met:

i. Total heat time expires for a pressurized 1-1/4" IPS or 2" IPS pipe, or

ii. A melt bead of approximately 1/16" is visible around the fitting base for a 1 1/4" IPS or 2" IPS non-pressurized pipe, or a larger pressurized or non-pressurized pipe.

3. Fusion and Cooling

Press the fitting onto the pipe (within 3 seconds) after removing the heater and apply the Fusion Force (see the fitting label). Maintain the fusion force on the assembly for 5 minutes on 1-1/4" IPS and for 10 minutes for larger sizes. When this initial cooling time has expired, the saddle fusion equipment may be removed. Allow the assembly to cool for an additional 30 minutes before handling or Tapping.

If the melt pattern was not satisfactory or if the fusion bead is unacceptable, cut off the saddle fitting above the base to prevent use, relocate to a new section of main, and make a new saddle fusion using a new fitting.

NOTE: The fusion force may need to be adjusted during the initial cooling period; however, the fusion force should never be reduced.

4. Inspection

Visually inspect the fusion bead around the entire base of the fitting at the pipe. The fusion bead should be of uniform size. The fusion should have a "three-bead" shape, which is characteristic of this type of fusion. The first bead is the fitting base melt bead. The second or outermost bead is the result of the heater tool face on the pipe. The third bead, or center bead, is the pipe melt bead. All beads should be of uniform size with the first and third beads approximately 1/8" and the second bead being generally smaller.

QUALIFICATION

The following summarizes the ASTM methods to which the operator and/or user should refer for specific qualification requirements

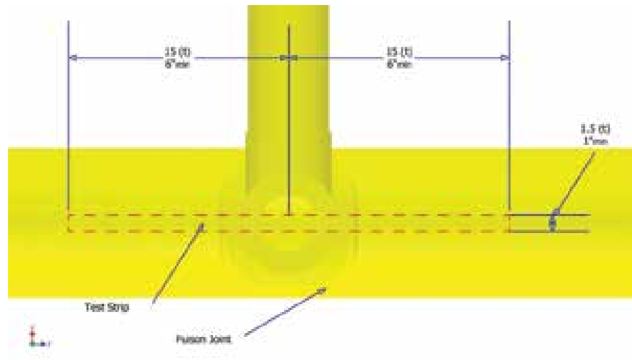
1. Prepare at least two sample joints. The pipe length should be a minimum of 2' or seven times the maximum saddle fitting base dimension, whichever is greater.

2. Observe the fusion process and verify the recommended procedure for saddle fusion is being followed.

3. Visually inspect the sample joint for quality.

4. Allow the joint to cool completely (minimum of one hour). The pipe sample should not be tapped for this qualification process.

Figure II
Saddle Fusion Bent Strap Test Specimen



5. Prepare test straps as shown in Figure II. Cut the joint lengthwise along the main pipe and through the saddle fitting.

6. Visually inspect the joint for any voids, gaps, misalignment or surfaces that have not been properly bonded.

7. Bend each test strap 180° with the inside facing out.

8. The fusion joint must be free of cracks, voids, gaps and separations.

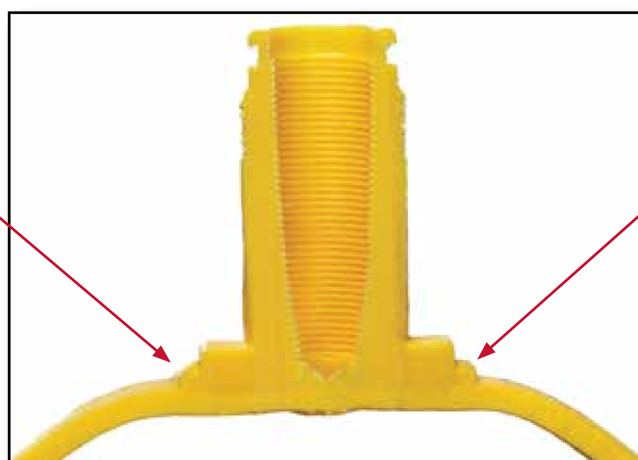
9. Test the other sample joint by impact against the saddle fitting. The failure must occur by either tearing the fitting, bending the fitting at least 45° or by removing a section of the pipe. Failure at the fusion is not acceptable. This test is a Federal requirement for qualification of fusion procedures.

10. If failure does occur at the weld in any of the samples, then the fusion procedure should be reviewed and corrected. After correction, another sample fusion should be made per the new procedure and retested.

ACCEPTABLE FUSIONS

Proper Alignment, Melt and Force

Area where likely gaps and voids might occur



Area where likely gaps and voids might occur

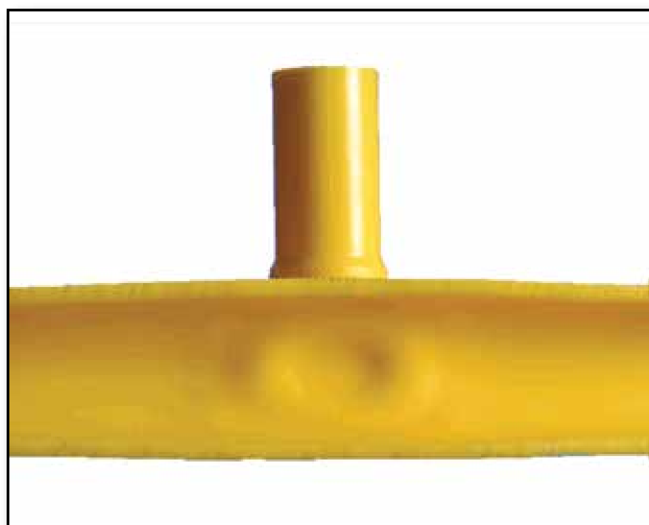
Bend Back Testing - No Gaps or Voids (See Figure II)

UNACCEPTABLE FUSIONS

Fitting Misalignment on pipe

Excessive Heating and/or Overpressurization of joint

Insufficient Melt



Excessive Force

TABLE VI SADDLE FUSION TROUBLESHOOTING GUIDE	
Observed Condition	**Possible Cause**
• Non-uniform bead size around fitting base	• Misalignment • Defective heating tool • Fitting not secured in heating tool • Heating temperature not within specified range
• One bead larger than the other	• Misalignment • Heating temperature not within specified range • Fitting slipped in clamp • Defective or worn equipment
• Beads too small	• Insufficient heating • Insufficient joining force
• Beads too large	• Excessive heating time • Excessive joining force
• Absence of third bead, or third bead widely separated from center bead	• Incorrect pipe main heating tool Insufficient joining force
• Pressurized main blowout (beside base or through fitting base)	• Excessive heating • Heating temperature not within specified range • Incorrect heating tool faces • Excessive time to start heating or in joining the fitting to the main pipe after heating time cycle
• Rough, sandpaper-like, bubbly, or pockmarked melt bead surface	• Hydrocarbon (gasoline vapors, spray paint fumes, etc.) contamination

SOCKET FUSION

Equipment Requirements

In order to produce a quality socket fusion, the following equipment is required for this procedure:

- *Apparatus* – Socket fusion tools manufactured in accordance with ASTM F1056.
- *Heating tool faces* – Consisting of two parts, a male end for the interior socket surface and a female end for the exterior pipe surface.
- *Rounding clamps (cold ring)* - Device to maintain the roundness of the pipe and control the depth of pipe insertion into the socket during the joining operation.
- *Depth gauge* – Proper positioning of the rounding clamp.
- *Chamfering tool* – Device to bevel the end of the pipe. The depth gauge and chamfering tool may be combined into a single tool.
- *Holding tools* – Recommended for socket fusion of 2"IPS and larger pipe and fittings.

Heater Temperature

- *Heater Surface Temperature:* Minimum 490°F – Maximum 510°F

  In order to obtain a proper melt, a uniform temperature must be maintained across the heating surface. All points on both heating surfaces where the heating surfaces will contact the pipe and fitting must be within the prescribed minimum and maximum temperatures. Heating tool surfaces must be clean.

Procedure

1. Preparation

A. Verify heating temperature is within the specified temperature range (490ºF – 510ºF).

B. Cut the pipe end squarely, and clean the pipe end and fitting, both inside and out with a clean, dry, lint-free cloth. Do not touch cleaned surfaces with your hands.

C. Chamfer the outside edge of the pipe end slightly. The pipe should be free of debris and burrs.

D. Place the cold ring on the pipe as determined by the depth gauge – Place the depth gauge over the chamfered end of the pipe. Clamp the cold ring immediately behind the depth gauge.

2. Heating

A. Review the recommended heating times in Table VII. The heating time begins after Step C has been completed.

B. Insert the fitting onto the male heating face. The fitting should be held against the back surface of the male heater face.

C. Insert the pipe into the female heating face. The female socket heating face should be against the cold ring clamp.

D. Hold the pipe and fitting in place against the heater faces for the recommended heating time as shown in Table VII.

TABLE VII SOCKET FUSION TIME CYCLES				
Pipe Size	**PE2708** **PolyPipe® GDY20 &** PolyTough1™ fused to unimodal MDPE fittings		**PE4710** **& PolyPipe®** PolyTough1™ **PE27081** fused to HDPE fittings	
	Heating Time seconds	**Cooling Time seconds**	**Heating Time seconds**	**Cooling Time seconds**
1/2" CTS	5 – 6	30	8 – 10	30
3/4" CTS	7 – 8	30	10 – 12	30
1" CTS	9 – 10	30	12 – 14	30
1/2" IPS	5 – 6	30	8 –10	30
3/4" IPS	8 – 10	30	12 – 14	30
1" IPS	10 – 12	30	14 – 16	30
1-1/4" IPS	12 – 14	45	18 – 20	60
1-1/2" IPS	12 – 14	45	18 – 20	60
2" IPS	16 – 20	45	22 – 26	60
3" IPS	20 – 25	60	25 – 30	75
4" IPS	25 – 30	60	30 - 35	75

Notes: If an incomplete bead rollout is noticed when joining PolyTough1 to unimodal socket fittings, PolyPipe® recommends the use of bimodal MDPE fittings HDPE fittings or other means of joining the pipe.

3. Fusion and Cooling

A. At the end of the heating time, simultaneously remove the pipe and fitting straight out from the tool using a "snap" action. Do not torque or twist the pipe or fitting during removal.

B. A QUICK inspection should be made of the melt pattern on the pipe end and fitting socket. If there is evidence of an incomplete melt pattern, do not continue with the fusion procedure.

C. Immediately insert the pipe straight into the socket of the fitting so that the cold ring is flush against the end of the fitting socket. While cooling, pressure should be maintained on the fusion per the recommended cooling time shown in Table VII.

D. Allow the joint to cool an additional five (5) minutes before removing the cold ring. An additional 10 minutes of cooling time is recommended before exposing the joint to any type of stresses (i.e., burial or testing).

4. Inspection

Visually inspect the weld. A complete impression of the rounding clamp should be visible in the melt pattern at the end of the socket. There should be no gaps, voids or unbonded areas.

Qualification

The following summarizes the ASTM methods to which the operator and/or user should refer for specific qualification requirements

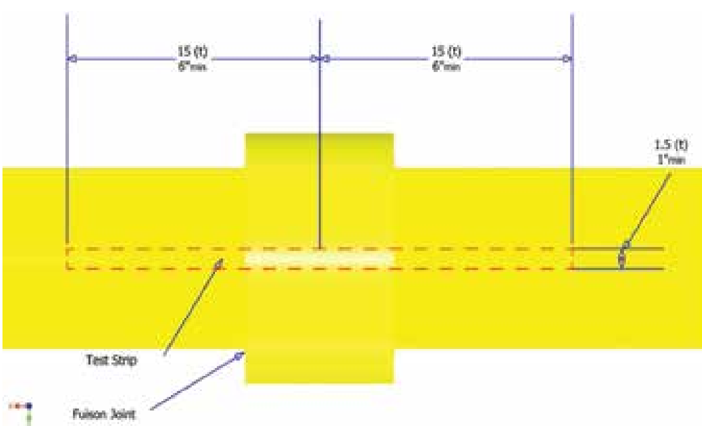
1. Prepare a sample joint such as a coupling with pipe socket fused to both ends. The pipe should be at least 6" or 15 times the wall thickness in length.

2. Observe the fusion process and verify the recommended procedure for socket fusion is being followed.

3. Visually inspect the sample joints for quality.

4. Allow the sample to cool completely (minimum of one hour).

Figure III
Socket Fusion Bent Strap Test Specimen



5. Prepare test straps as shown in Figure III. Cut the joints lengthwise into at least three longitudinal straps with a minimum of 1" or 1.5 times the wall thickness in width.

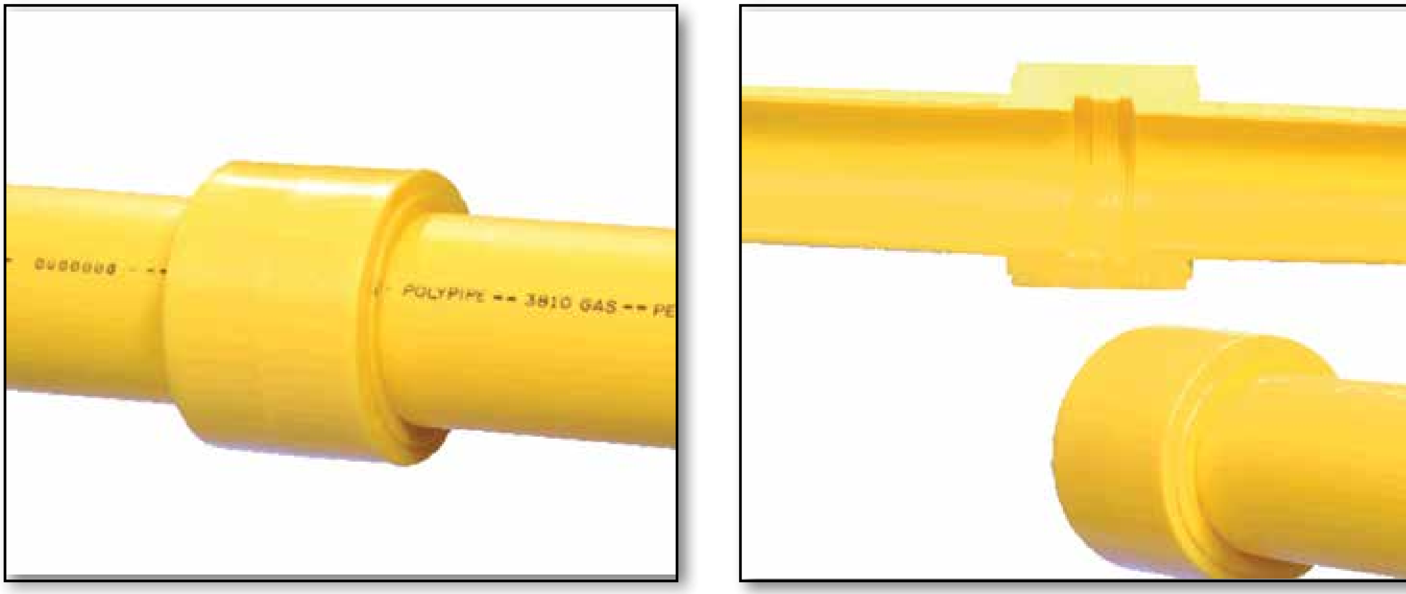
6. Visually inspect the cut joint for any indications of voids, gaps, misalignment or surfaces that have not been fused.

7. Bend each test strap 180° with the inside of the pipe facing out.

8. The fusion joint must be free of cracks, voids, gaps and separations. If failure does occur at the weld in any of the samples, then the fusion procedure should be reviewed and corrected. After correction, another sample weld should be made per the new procedure and retested.

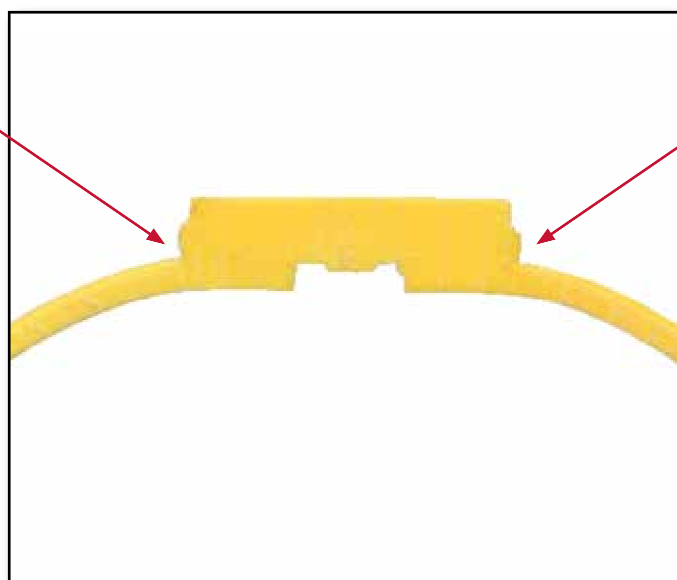
ACCEPTABLE FUSIONS

SOCKET FUSION



Proper Alignment and Stab Depth
Melt Bead Flattened Due to Cold Ring - No gaps or voids

Area where likely gaps and voids might occur



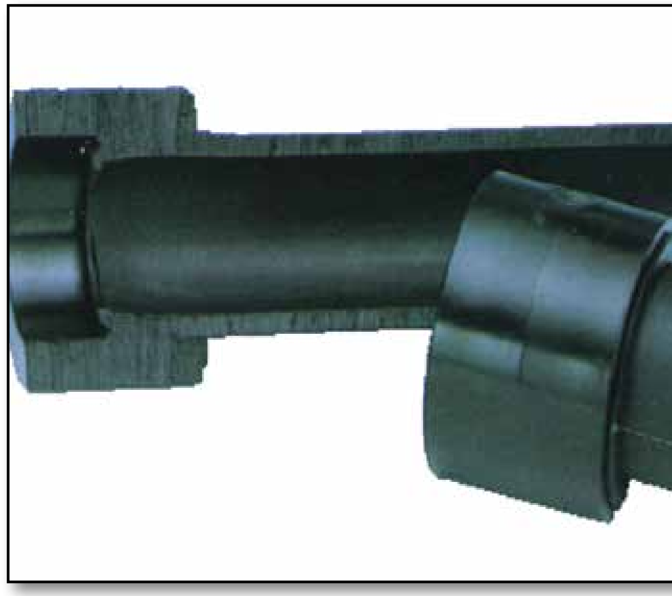
Area where likely gaps and voids might occur

Bend Back Testing - No Gaps or Voids
(See Figure III)

UNACCEPTABLE FUSIONS

SOCKET FUSION

Short Stab Depth
Caused by Failure to Use a Depth Gauge



Excessive Stab Depth
Caused by Failure to Use a Cold Ring

Socket Fusion

TABLE VIII SOCKET FUSION TROUBLESHOOTING GUIDE	
Observed Condition	**Possible Cause**
• No evidence of cold-ring impression in socket fitting melt bead	• Insufficient heating time •Depth gauge not used • Cold ring not used • Cold ring set at incorrect depth
• Gaps or voids around the pipe at the socket fitting edge	• Pipe or fitting not removed straight from heater face • Components not joined together straight when fusing • Cold ring not used • Cold ring set at incorrect depth
• Wrinkled or collapsed pipe end	• Cold ring not utilized • Cold ring set at incorrect depth • Incorrect heating sequence
• Voids in fusion bond area	• Pipe or fitting not removed straight from heater face • Components not joined together straight when fusing • Cold ring not used • Cold ring set at incorrect depth
• Unbonded area on pipe at end of pipe	• Cold ring not used • Cold ring set too deep
• Socket melt extends past end of pipe	• Cold ring set too shallow
• Rough, sandpaper-like, bubbly, or pockmarked melt bead surface	• Hydrocarbon (gasoline vapors, spray paint fumes, etc.) contamination

APPENDIX A

HYDRAULIC FUSION MACHINE GAUGE PRESSURE

The manufacturer of the fusion machine should be consulted for guidance in determining the proper conversion of PolyPipe®'s recommended interfacial pressure to the gauge pressure. The effective hydraulic piston area must be available in order to calculate the required hydraulic gauge pressure. The calculation for hydraulic gauge pressure is as follows:

$$P_G \frac{0.785 \text{ x } (OD^2 - ID^2) \text{ x } P_1}{A_P} + DF^*$$

Where	P_G	=	Hydraulic gauge pressure, psi
	OD	=	Pipe outside diameter, inches
	ID	=	Pipe inside diameter, inches
	P_I	=	Required interfacial pressure, psi
	A_P	=	Total hydraulic piston area, in^2
	DF	=	Hydraulic fusion pressure required to move the carriage holding the pipe (generally accepted minimum is 30 psi).

* The drag factor is an important parameter easily overlooked. If two long pieces of pipe are being fused, the drag factor can easily reach several hundred pounds per square inch (psi).

Example Calculations

Fusion Machine: McElroy Manufacturing 28 High Force Machine
Hydraulic piston area is provided by the fusion equipment manufacturer.
Total hydraulic piston area for this machine is 4.71 in2

Desired Interfacial Pressure: 75psi

For 2" IPS SDR 11:

$$P_G \frac{0.785 \text{ x } (2.375^2 - 1.917^2) \text{ x } 75}{4.71} + 30 \cong 54psi$$

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5. ASTM F1056-11. Standard Specification for Socket Fusion Tools for Use in Socket Fusion Joining Polyethylene Pipe or Tubing and Fittings. www.astm.org

6. Pipeline Safety Regulations. U.S. Department of Transportation. CFR 49. Washington, June 2011. http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&tpl=/ecfrbrowse/Title49/49cfr192_main_02.tpl

NOTES

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NOTES

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DURA-LINE IS AN ACTIVE MEMBER OF THE PLASTICS PIPE INSTITUTE, AWWA, AGA, ASTM

(Revised 07/30/2015)