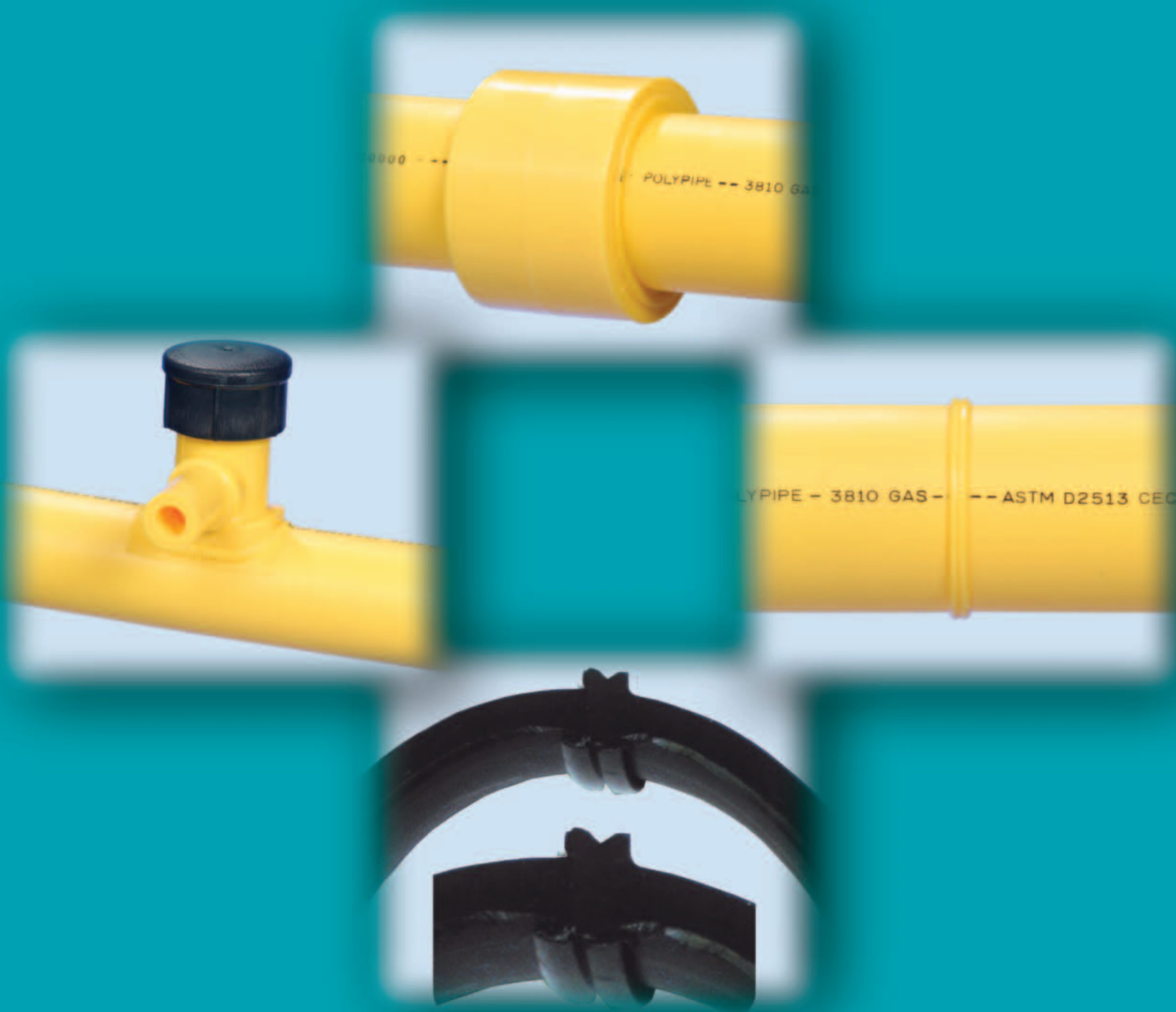
PolyPipe®

RECOMMENDED

Heat Fusion Joining Procedures



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The statements and technical data given in this brochure were developed on the basis of conservative test measures and are believed to be accurate. The information is meant to serve only as a general guide; however, the individual user is encouraged to verify the specific parameters of each application. Due to wide variations in service conditions, quality of installation, etc., no warranty or guarantee, expressed or implied, is given in conjunction with the use of this material.

In addition, this procedure does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

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 polyethylene pipe allow the designer to take advantage of the performance benefits of polyethylene 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 fusion procedures that follow have been proven to consistently produce sound fusion joints when used correctly and are recommended for the joining of PolyPipe® products. The recommended procedures for butt and saddle fusions are consistent with the Plastic Pipe Institute (PPI) TR-33, Generic Butt Fusion Procedures and TR-41, Generic Saddle Fusion Procedures.

POLYPIPE® PRODUCTS	
GAS DISTRIBUTION	**M&I, WATER AND SPECIALTY**
POLYPIPE® GDB50 (GB50) POLYPIPE® GDB40 (GB40) POLYPIPE® GDB30 (GB30) POLYPIPE® GDY20	POLYPLUS™ POLYPIPE® EHMW PLUS POLYPIPE® EHMW POLYPIPE® PW POLYPIPE® DUCT POLYPIPE® LIGHTVIEW™

FEDERAL REGULATIONS

Individuals who are involved in joining gas piping systems must note certain qualification requirements of the U.S. Department of Transportation Pipeline Safety Regulations. The U.S. Department of Transportation, D.O.T., requires that all persons who make fusion joints in polyethylene gas piping systems must be qualified under the operator's written procedures (49 CFR, Part 192, §192.293(a)), and require that gas system operators ensure that all persons who make fusion joints are qualified (49 CFR, Part 192, §192.285(d)).

These fusion joining procedures, when used to join PolyPipe® gas pipe and fittings, are qualified in accordance with U.S. Department of Transportation Regulations.

- D.O.T. regulations require that written procedures for butt fusion, saddle fusion and socket fusion joining of polyethylene gas piping must be qualified before use by subjecting specimen joints to required test procedures (CFR 49, Part 192, §192.283(a)).

- D.O.T. regulations require that each joint in a gas piping system must be made in accordance with written procedures that have been proved by testing to produce strong gastight joints (CFR 49, Part 192, §192.273(b)).

- D.O.T. regulations require that all persons who make joints in polyethylene gas piping must be qualified under the operator's written procedures (CFR 49, Part 192, §192.285(a)).

- D.O.T. regulations require that the gas system operator must ensure that all persons who make or inspect joints are qualified (CFR 49, Part 192, §192.285(d) & §192.287).

Where an operator is already using qualified procedures that are in compliance with the D.O.T., these recommended procedures do not constitute a requirement for that operator to change to these fusion procedures.

Qualification Procedure

Due to the requirements of the U.S. Department of Transportation, any person joining polyethylene gas pipe must receive training in each of the fusion procedures (49 CFR, Part 192). Each operator should make a sample joint for each procedure used. Each sample joint must pass the following inspections and tests:

1. Pressure and tensile testing as described in §192.283, CFR,
2. Ultrasonically inspected and found to contain no flaws, or
3. Cut into at least three (3) strips, each of which is:

    (a) Visually examined and found free of voids or discontinuity on the cut surface of the joint.
    (b) Deformed by bending, torque or impact, and if failure occurs, must not initiate in the joint area.

A person must be re-qualified under an applicable procedure during a 12-month period for the following conditions:

1. The individual does not make any joints under the procedure.
2. The individual has three (3) joints or 3% of the joints made, whichever is greater, that are found to be unacceptable by §192.513, CFR.

Each operator shall establish a method to determine that each person making a joint in plastic pipelines in his/her system is qualified in accordance with this section.

HEAT FUSION

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

- ***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.

- ***Socket Fusion*** – This technique involves simultaneously heating the outside surface of a pipe end and the inside 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 one component into the other. 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.

Properly fused polyethylene joints do not leak. If a leak is detected during 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: Polyethylene cannot be joined by solvent bonding or threading. Extrusion welding or hot air welding is not recommended for pressure applications.

INCLEMENT WEATHER

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

In inclement weather and especially in windy conditions, the fusion operation should be shielded to avoid precipitation or blowing snow and excessive heat loss from wind chill. The heating tool should also be stored in an insulated container to prevent excessive heat loss. Remove all frost, snow or ice from the OD and ID of the pipe; all surfaces must be clean and dry prior to fusing.

The time required to obtain the proper melt may increase when fusing in cold weather. The following recommendations should be followed:

1. Maintain the specified heating tool surface temperature. ***Do not increase the tool surface temperature*.**
2. Do not apply pressure during zero pressure butt fusion heating steps.
3. Do not increase the butt fusion joining pressure.

In butt fusion, melt bead size determines heating time; therefore, the procedure automatically compensates when cold pipe requires longer time to form the proper melt size.

The outside diameter of polyethylene pipe and fittings will contract in cold weather conditions. This can result in loose or slipping cold rings. For best results, clamp one cold ring in its normal position adjacent to the depth gage. Shim around the pipe behind the clamp with paper, tape, etc., and place a second cold ring over this area. This cold ring will prevent slippage while the inner cold ring will allow for the pipe to expand during the heating cycle of the fusion process.

The proper cycle time for any particular condition can be determined by making a melt pattern on a piece of scrap pipe using the recommended standard heating time. If the melt pattern is incomplete, increase the heating time by three (3) second intervals until a complete melt pattern is established. Each time the procedure is repeated, a new piece of scrap pipe should be used.

For additional information concerning cold weather procedures, refer to ASTM D2657, Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings, Annex A1.

NOTES ON FUSION CONFIDENCE

Reliable fusion joints of polyethylene piping systems can be accomplished under reasonable latitude of conditions. 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.

Contact 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 cannot produce a 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.

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 can result in a poor fusion.

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. 17 for allowable surface damage according to the Plastics Pipe Institute (PPI) and the American Gas Association (AGA).

- ❒ Any surface damage at pipe ends that could compromise the joining surfaces or interfere with fusion tools and equipment should be removed.

- ❒ 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.

- ❒ Shield heated fusion equipment and surfaces from inclement weather and winds. A temporary shelter over fusion equipment and the 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 (204 – 232°C)

  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 (11°C) for equipment for pipe smaller than 18" diameter, or 35°F (19°C) for larger equipment. Heating tool surfaces must be clean.

- **Interface pressure:** Minimum 60 psi – Maximum 90 psi (414 – 621 kPa; 4.16 – 6.21 bar)

  Interface pressure is used to calculate a fusion joining pressure value for hydraulic butt fusion machines or manual machines equipped with force reading capability. The interface pressure is constant for all pipe sizes and all butt fusion machines. However, fusion joining pressure settings are calculated for each butt fusion machine, which are dependent upon the OD and DR (Dimension Ratio).

  For hydraulic machines, the interface 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 interface 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 to the pipe surface during joining.

Procedure

1. *Secure*
Clean the inside and outside of the component, pipe or fitting ends by wiping with a clean, dry, lint-free cloth or paper towel. Remove all foreign matter. Align the components of 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 outside diameters 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 polyethylene 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.

Table I
Approximate Melt Bead Size

Approximate Wall Thickness, inches		**Melt Bead Size* (Approximate)**	
≤ 0.15	3.8 mm and smaller	1/32” – 1/16”	1 – 2 mm
0.15 – 0.30	3.8 mm – 7.6 mm	1/16”	2 mm
Above 0.30 – 0.75	Above 7.6 mm – 19 mm	1/8” – 3/16”	3 – 5 mm
Above 0.75 – 1.15	Above 19 mm – 29.2 mm	3/16” – 1/4”	5 – 6 mm
Above 1.15 – 1.60	Above 29.2 mm – 40.6 mm	1/4” – 5/16”	6 – 8 mm
Above 1.60 – 2.20	Above 40.6 mm – 55.9 mm	5/16” – 7/16”	8 – 11 mm
Above 2.20 – 3.00	Above 55.9 mm – 76.2 mm	7/16” – 9/16”	11 mm

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.

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.

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 to 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.

6. ***Hold***

Hold joining force against the ends until the joint is cool. The joint is cool enough for ***gentle*** handling when the double bead is cool to the touch. Cool for about 30 – 90 seconds per inch of pipe diameter. *Do not try to decrease the cooling time by applying water, wet cloths or the like.*

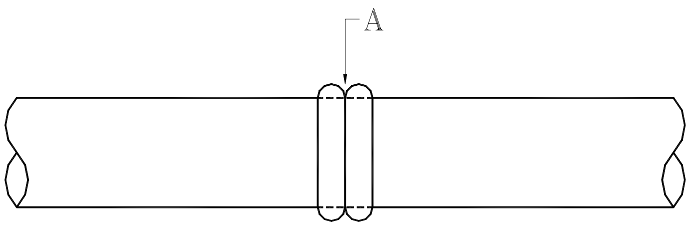
- Avoid pulling, installation, pressure testing and rough handling for at least an additional 30 minutes.

- Heavier wall thickness pipes require longer cooling times.

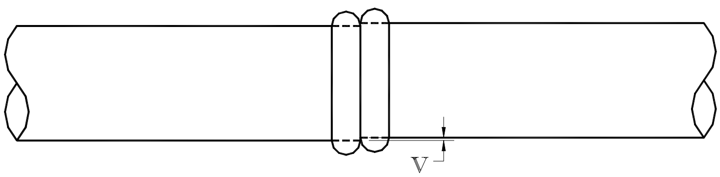
7. ***Inspection***

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 II for general guidelines for bead width, B, for each respective wall thickness.

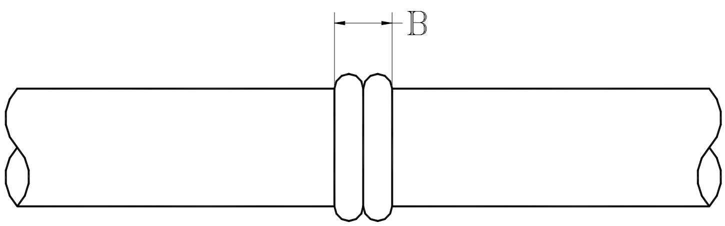


Table II
Bead Widths per Wall Thickness

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 actual bead width (B).

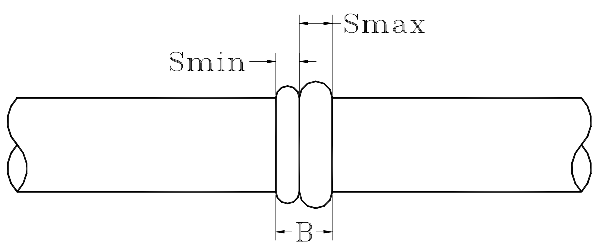
$$X = \frac{S}{B} \times 100$$

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%

S = S_{max} - S_{min}, inches

B = Width of bead, inches



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.

Qualification

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

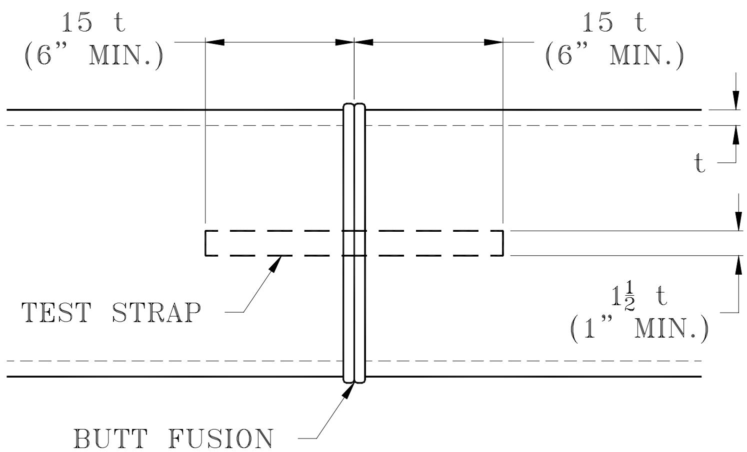
2. Observe the fusion process and verify the recommended procedure for butt fusion is being followed.

3. Visually inspect the sample joint for quality.

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

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.

Figure I
Butt Fusion Bent Strap Test Specimen
(Reference ASTM D2657)

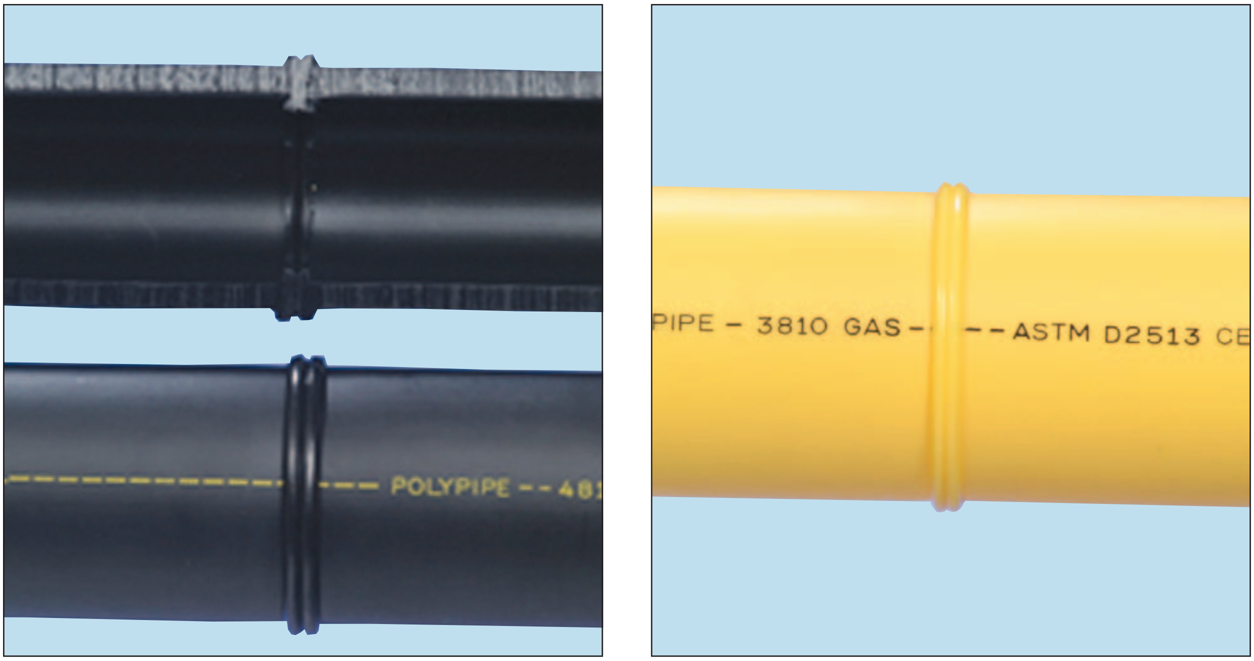


6. Visually inspect the cut joint for any indications of voids, gaps, misalignment or surfaces that have not been properly bonded.

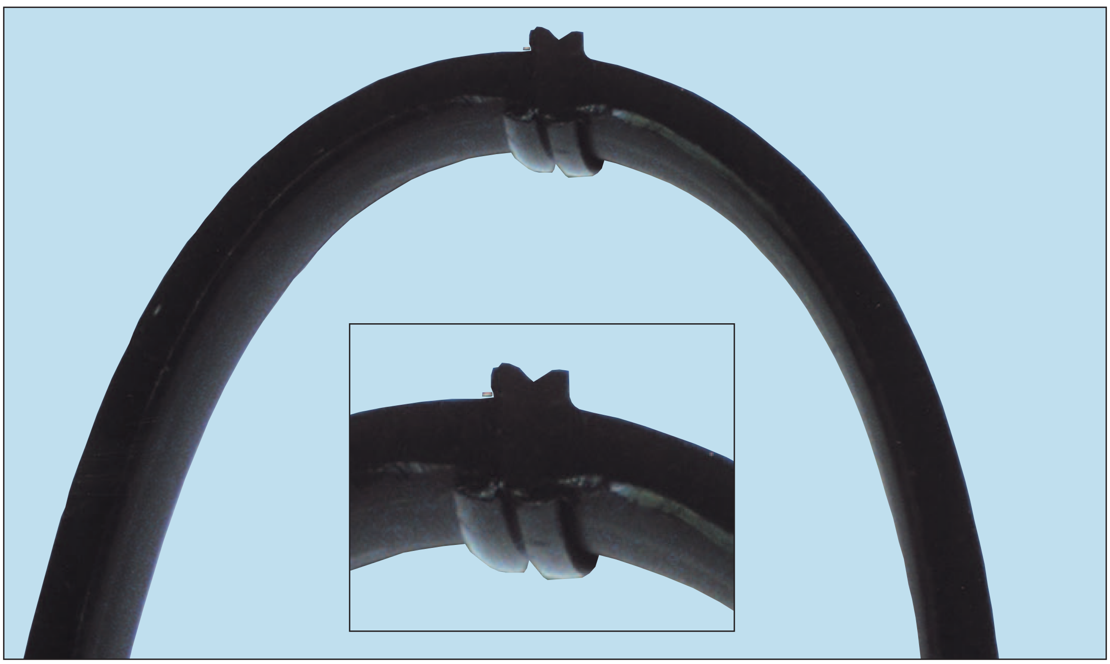
7. Bend each sample at the weld with the inside of the pipe facing out until the ends touch. The inside bend radius should be less than the minimum wall thickness of the pipe. In order to successfully complete the bend back, a vise may be needed. For thick wall pipe, a hydraulic assist may be required.

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, then the fusion procedure should be reviewed and corrected. After correction, another sample weld should be made per the new procedure and re-tested.

ACCEPTABLE FUSIONS

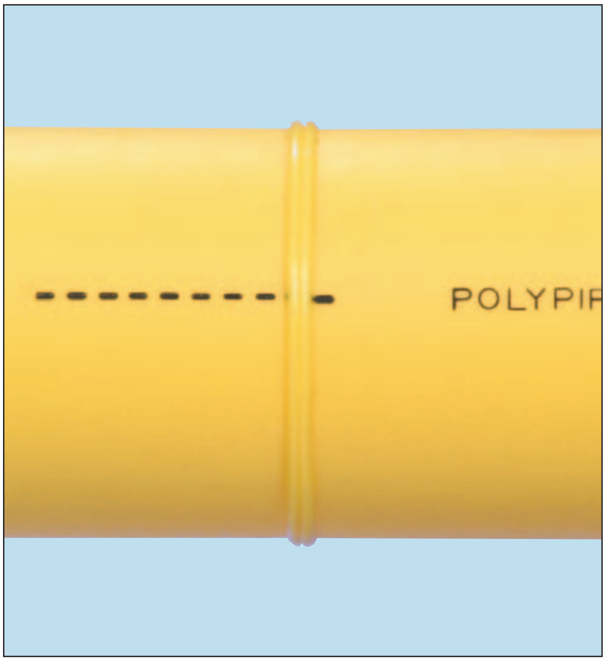


Proper alignment and double roll-back bead.



Bend back testing. No gaps or voids. (See Figure I)

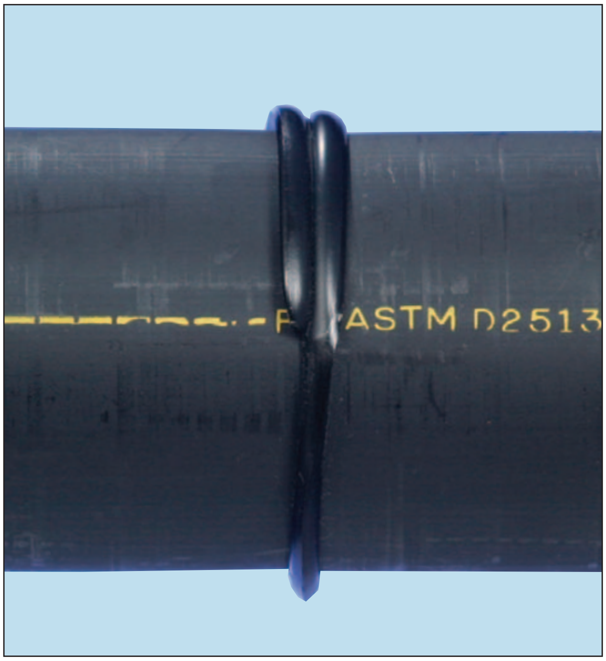
UNACCEPTABLE FUSIONS



Melt bead too small due to insufficient heat time.

Melt bead too large due to excessive heating and/or over-pressurizing of joint.

Misalignment.



Incomplete facing.

Table III
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
▪ 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
▪ 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:** Minimum 490°F - Maximum 510°F (254 – 266°C)

  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 (372 – 455 kPa ; 3.72 – 4.55 bar)

Definitions

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

Initial Heat Force (Bead-up Force)
The force (pounds) applied to establish a melt pattern on the main pipe. The Initial Heat Force is determined by multiplying the fitting base area (in^2) by the initial heat interfacial pressure (psi).

Heat Soak Force
The force (pounds) applied after an initial melt pattern is established on the main pipe. The Heat Soak Force is the minimum force (essentially zero) that ensures the fitting, heater and main 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 (in^2) by the fusion interfacial pressure (psi).

Total Heat Time
A time that begins when the heater is placed on the main 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 120°F (49°C). The Fusion Force must be maintained for 5 minutes on 1-1/4" IPS or 10 minutes for all other main 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 main or joining to the branch outlet. Recommended minimum cooling times are shown in Table IV.

Table IV
Maximum Heating/Minimum Cooling Times

Main 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 main, rounding the main 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 main 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 main. A main bolster or support is recommended under the pipe on 6” IPS and smaller main pipe sizes.

B. Abrade the surface of the main, 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 main 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 (254°C to 266°C).
- 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 main 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 main 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 main with a quick, snapping action. Quickly check for an even melt pattern on the pipe main and heated fitting surfaces (no unheated areas). The Total Heat Time ends when one of the following conditions are met:

i. When the Total Heat Time expires for a pressurized 1-1/4" IPS or 2" IPS main, or
ii. When a melt bead of approximately 1/16" is visible around the fitting base for a 1 1/4" IPS or 2" IPS non-pressurized main, or a larger pressurized or non-pressurized main.

3. *Fusion and Cooling*

Regardless of whether the melt patterns are satisfactory, quickly press the fitting onto the main 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. Cool the assembly for an additional 30 minutes before rough handling or tapping the main.

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 main 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 main pipe. The third bead, or center bead, is the main 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

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

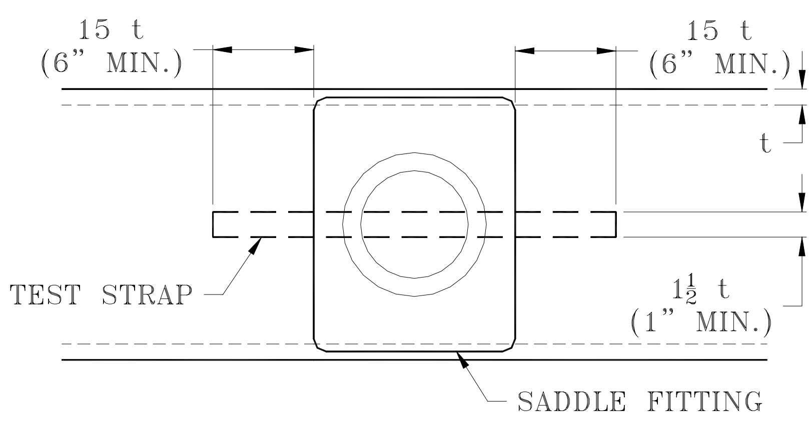
2. Observe the fusion process and verify the recommended procedure for saddle fusion is being followed.

3. Visually inspect the sample joint for quality.

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

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

Figure II
Saddle Fusion Bent Strap Test Specimen
(Reference ASTM D2657)



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.

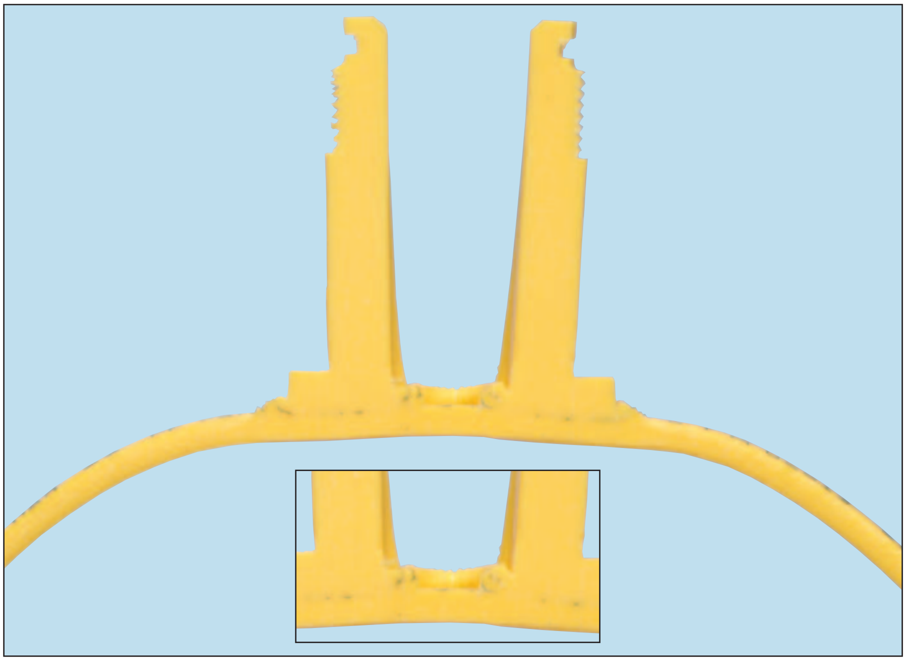
8. The fusion joint must be free of cracks, voids, gaps and separations.

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, but is not a requirement for individual qualification.

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 weld should be made per the new procedure and re-tested.

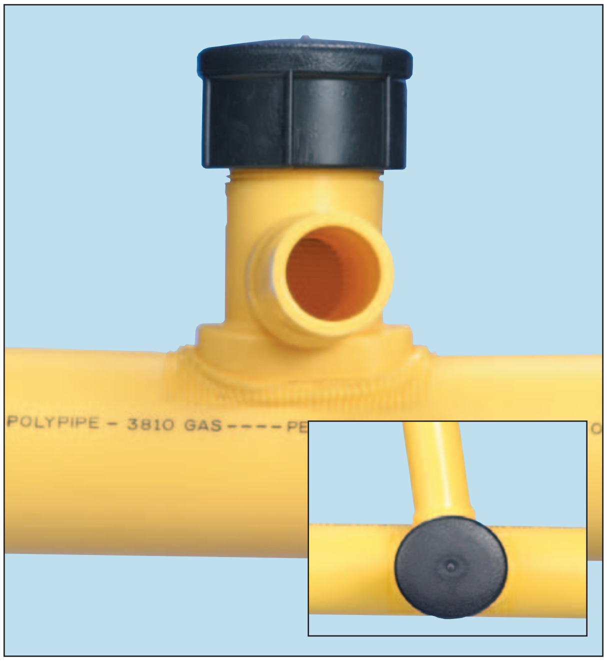
ACCEPTABLE FUSIONS

Proper alignment, melt and force.



Bend back testing. No gaps or voids. (See Figure II)

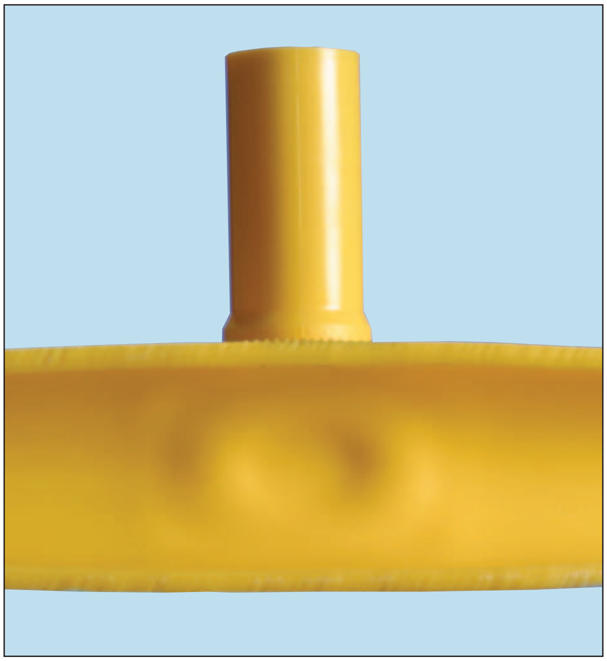
UNACCEPTABLE FUSIONS



Fitting misaligned on pipe.

Excessive heating and/or over-pressurizing of joint.

Insufficient melt.



Excessive force.

Table V
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 (254 – 266°C)

  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 (490°F – 510°F).

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 VI. 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 VI.

Table VI
Socket Fusion Time Cycles

Pipe Size	PE2406		PE3408	
	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

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 VI.

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 (ie., 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

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.

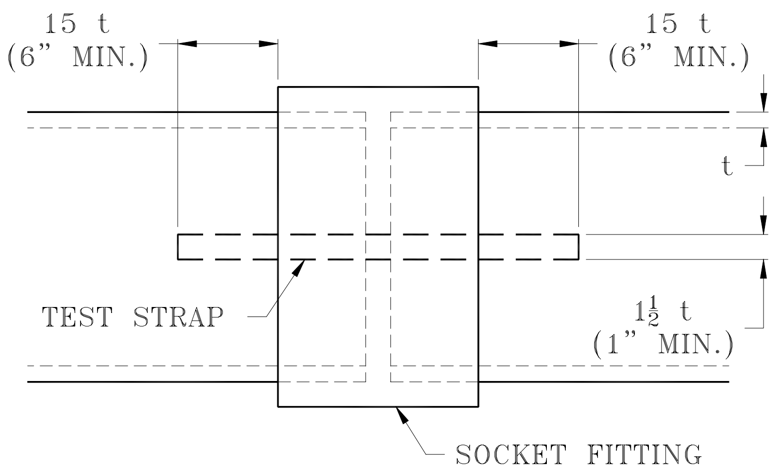
2. Observe the fusion process and verify the recommended procedure for socket fusion is being followed.

3. Visually inspect the sample joints for quality.

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

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.

Figure III
Socket Fusion Bent Strap Test Specimen
(Reference ASTM D2657)

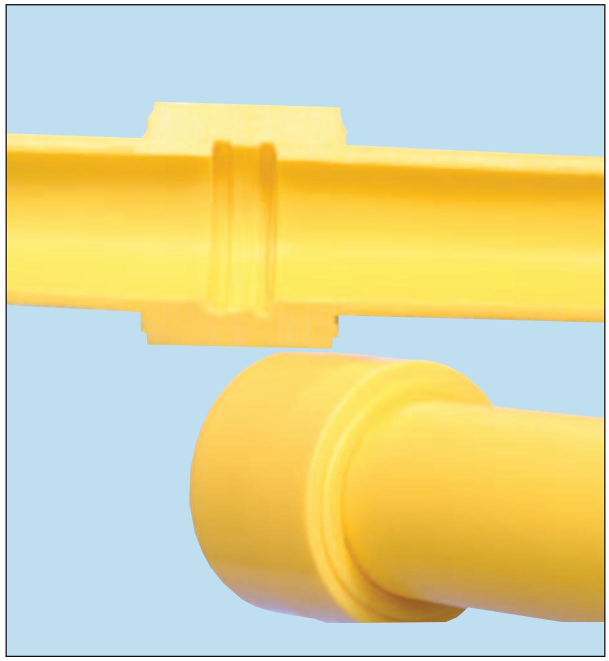


6. Visually inspect the cut joint for any indications of voids, gaps, misalignment or surfaces that have not been fused.

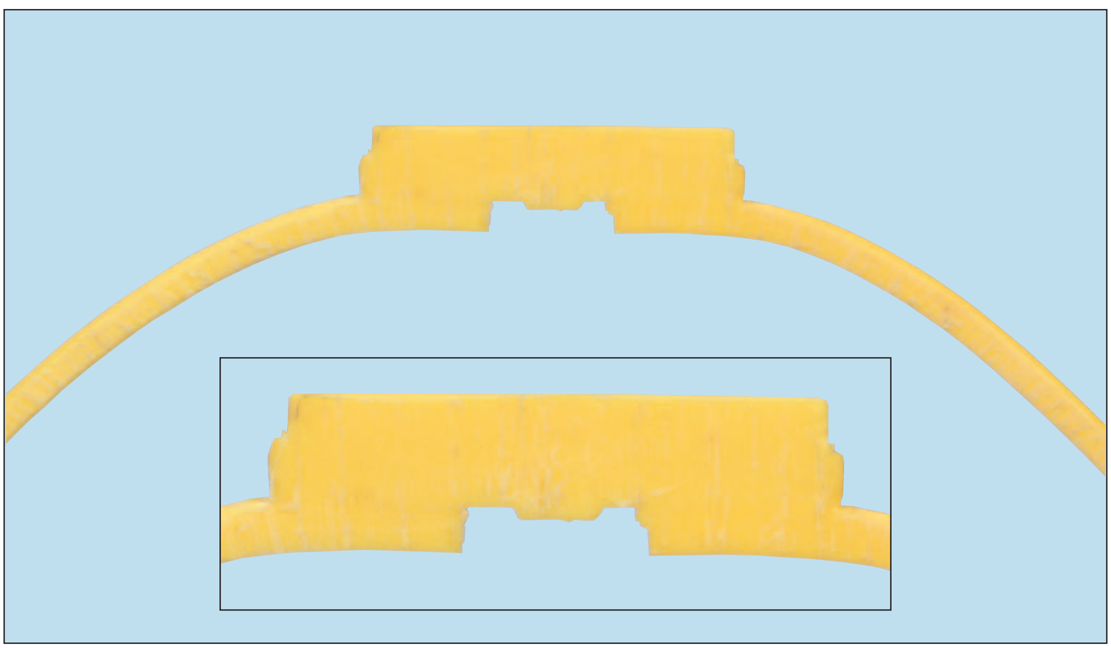
7. Bend each test strap 180^{o} with the inside of the pipe facing out.

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 re-tested.

ACCEPTABLE FUSIONS

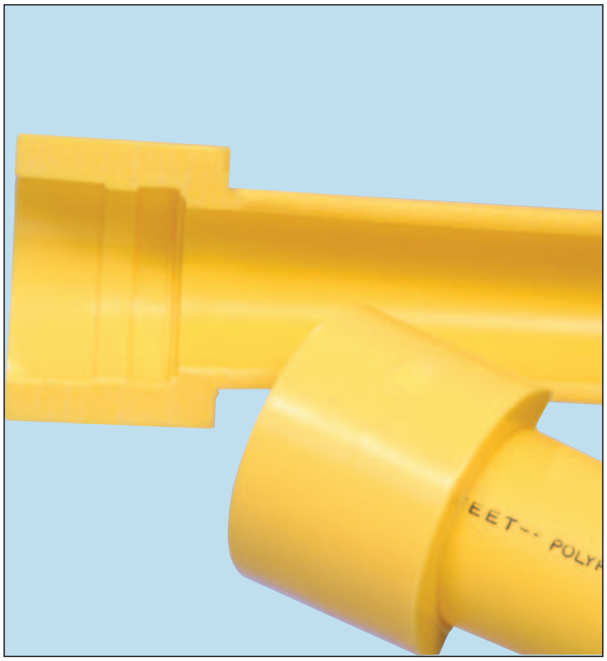


Proper alignment and stab depth. Melt bead flattened due to cold ring. No gaps or voids.

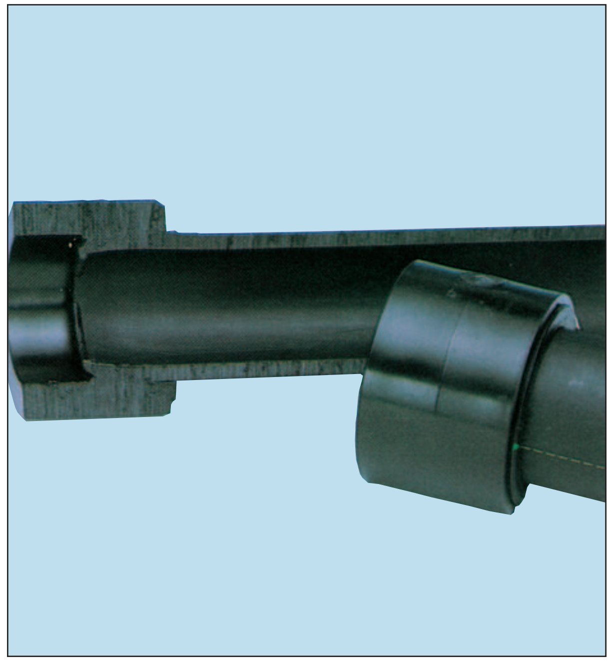


Bend back testing. No gaps or voids.
(See Figure III)

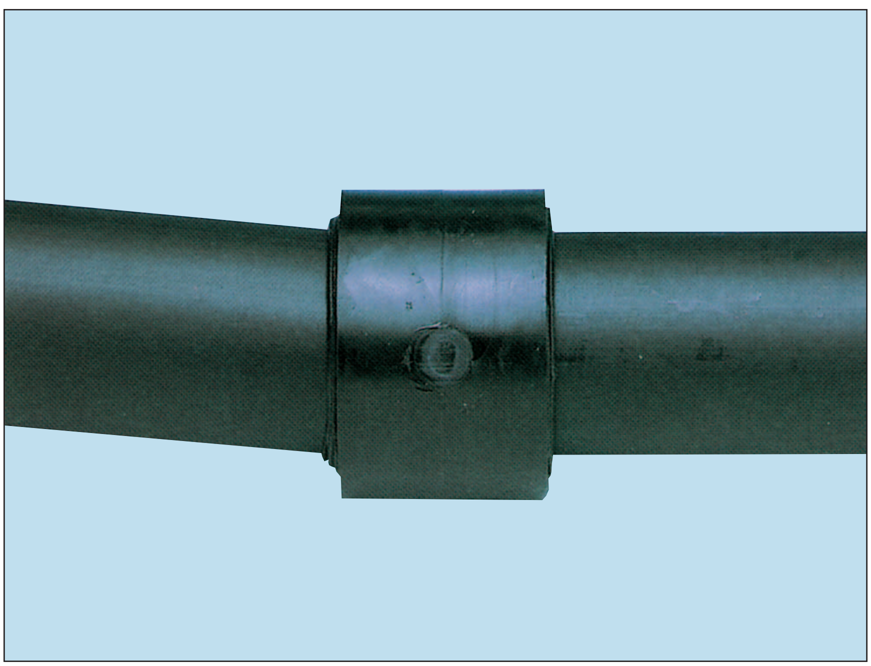
UNACCEPTABLE FUSIONS



Short stab depth caused by failure to use a depth gauge.



Excessive stab depth caused by failure to use a cold ring.



Misalignment.

Table VII
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:

$$P_G = \frac{0.785 \times \left(OD^2 - ID^2\right) \times P_I}{A_P} + DF^*$$

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).

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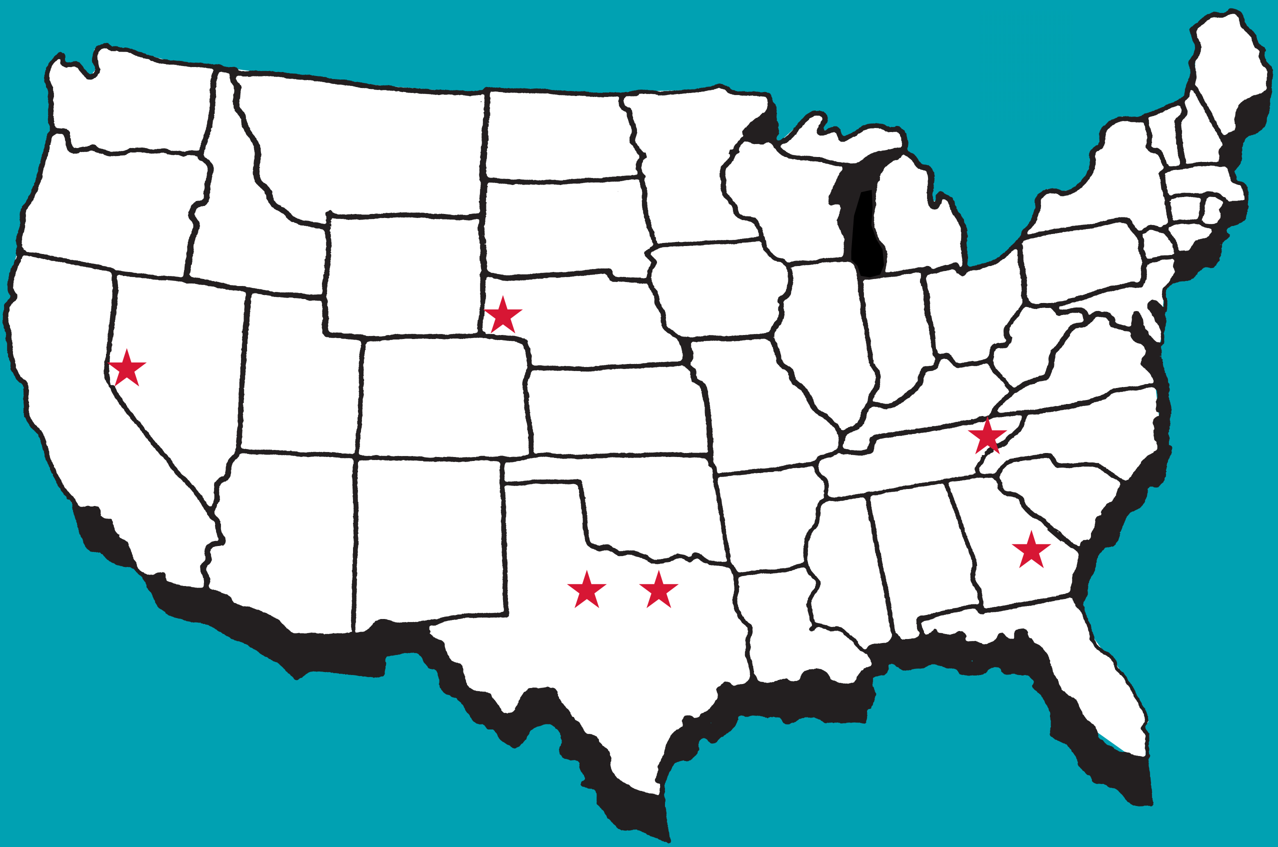
3. Plastics Pipe Institute. Polyethylene Joining Procedures, March 1998.

4. ASTM D2657-97. Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings. Volume 8.04. American Society of Testing and Materials. Baltimore, 2002.

5. ASTM F1056-97. Standard Specification for Socket Fusion Tools for Use in Socket Fusion Joining Polyethylene Pipe or Tubing and Fittings. Volume 8.04. American Society of Testing and Materials. Baltimore, 2002.

6. Pipeline Safety Regulations. U.S. Department of Transportation. CFR 49. Washington, 2002.



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