Arctic Insulation & Manufacturing

The Pre-Insulated Pipe People

Butt Fusion Process for McElroy
Small Diameter Hand Operated Equipment

MiniMc Fusion Machine ½" CTS – 1" IPS

1 LC Fusion Machine ½" CTS – 1" IPS

2 LC & 2CU Fusion Machine ½" CTS – 2" IPS

14 Fusion Machine 1" IPS – 4" DIPS

26 Fusion Machine 2" IPS – 6"DIPS

SCOPE

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

PE Pipe Sizes and SDR/DR

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

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

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

MACHINE QUALIFICATION

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

1) Safety
2) Operator's manual & checklist
3) Basic maintenance and troubleshooting
4) External power requirements
5) Features
6) Components and how they operate
7) Heater operation and temperature requirements and adjustment

Job Set–up Guidelines

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

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

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

Cold Ambient Temperatures Below 32°F (0° C): **Fusion operations should be conducted within a full enclosure shelter. For temperatures around -4°F (-20°C) and below, a full enclosure shelter with auxiliary heating should be provided**. Pipe ends should be pre-heated using a heating blanket or warm air devices to elevate the pipe temperature to improve the heat cycle starting condition. With pipe mounted in the fusion machine, an alternate method of pre-heating is to position the pipe ends within ¼ to ½ inch of the heater plate face to allow the pipe ends to warm for 30 seconds to 2 minutes. Larger diameter and greater wall thickness should receive the longer preheating time. DO NOT INCREASE THE HEATING TOOL TEMPERATURE TO TRY AND COMPENSATE FOR COLDER WEATHER THE SURFACE TEMPERATURE NEEDS TO BE BETWEEN 400°F - 450°F (204°C – 232°C). Before starting pipe fusion, the operator needs to ensure that the ID of the pipe is clear of moisture possibly due to frost that is being melted during the warming operations.

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

Warm (Hot) Environment, 32° F (0°C) to 120° F(49°C): . Elevated temperature

conditions can be mitigated by shading of the operator and the equipment where applicable.

Wind: Exposure of the fusion heater plate and pipe to wind can result in unacceptable temperature variations during butt fusion and possible joint contamination. When unfavorable wind conditions exist wind speeds 13 MPH and above a wind break or suitable shelter is required to protect the pipe and the fusion heater plate to ensure more consistent work performance. Unfavorable wind conditions can also flow through the pipe bore and cause unacceptable temperature variations during the fusion process, therefore open pipe ends may require plugs or covers to prevent this condition.

Additional Considerations:

Tools and Equipment:

- Pipe cutting tools like sawzalls with course blade, clean **oil free chain** saw designated just for pipe cutting, band saws, hand saws, ratchet sheers, tubing cutters and guillotine type work good. CIRCULAR SAWS ARE NOT RECOMMEDED THEY ARE DANGEROUS BECAUSE OF BINDING AND KICK BACKS.
- Temperature measuring devises such as a **surface pyrometer or infrared thermometer is required** to measure the surface of the heating tool, the thermometer on the heating tool is for reference only.
- Cleaning supply's and tools are needed for pipe preparation and cleaning of heating tool and facer, lot's of clean lint free (Cotton) non synthetic rags or heavy duty cotton paper towels, isopropyl alcohol 70% / 30% concentration minimum with water only and scraping tools to help remove things like ice and urethane foam.
- Plenty of power that meets or exceeds requirements of fusion machine and accessories, the use of a extension cord should also meet the requirements for the amount of power to be used.
- Check the operation of the fusion machine to make sure that it is in good operating condition.
- Pipe supports such as adjustable pipe rollers, pipe stands or blocking should be used when welding lengths of straight pipe and larger fittings.

Pipe Preparation:

- Check the full lengths of the entire O.D. of the pipe for nicks, cuts and gouges **THEY CANNOT BE MORE THAN 10% OF THE MINIMUM WALL THICKNESS**
  (WHEN IN DOUBT CUT IT OUT)
- Check the inside of the pipe for objects
- Check the nose in on the pipe this might have to be cut off to help pipe alignment a freshly cut piece of pipe and most fittings will not be nosed in.
- The operator will need the melt bead size of the pipe to be fused from table.

Pipe Handling Guidance: The jobsite pipe storage area should be relatively level and smooth. It should be large enough to allow for safe movement of the pipe and pipe handling equipment. The optimum situation is to have the pipe stored in close proximity to where the fusion equipment will be used for joining. The pipe should be placed on wooden beams or other type supports to keep it out of the dirt, mud etc.. Where ground is level, the pipe or bundles of pipe should be stacked no more then 6' tall. Where the ground is not very level, pipe should not be stacked in bundles but should be placed individually next to one another. Likewise, coils of pipe should not be stacked on each other but should be placed individually on protective supports on the ground.

Coils should be stored in such a manner as to prevent any possibility of rolling or falling over.

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

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

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

Field Bending

HDPE pipe is flexible and may be bent in the field to sweep the pipe around curves or to follow terrain contours. In general, field bending to roughly 75 times the pipe diameter can be accomplished with relative ease. Tighter bends down to the minimum acceptable field bending radius and colder temperatures require greater effort. See the PPI Calculator (http://plasticpipe.org/publications/software-ppi-

calculator.html) for field bending information.

Thermal Expansion and Contraction

Expansion and contraction are major considerations for HDPE pipelines
HDPE will change 1" in length per 100' of pipe per 10ºF change in temperature. This expansion and contraction of HDPE is critical when installing. The use of expansion joints or heavily reinforced pipe anchors and their foundations must be implemented into above ground HDPE pipelines.

Pipe Stands and Supports:

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

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

The PolyHorse is for use with PE sizes 3" IPS - 20" OD (90mm - 500mm) and is a new pipe-handling system that consists of a series of adjustable racks to store and help install the pipe on the job site. The PolyHorse can reduce manpower expense, provide an efficient, less hazardous environment for handling pipe bundles and enhance productivity by 150%.

PE pipe is off-loaded from the delivery truck directly onto the PolyHorse, off the ground and out of the way, until needed. In use, the operator rolls the pipe down the rack and onto the integral pipe rollers where it is easily loaded into a McElroy fusion machine. This eliminates the costs for additional lifting equipment and manpower.

Through it's modular design, the PolyHorse can handle any length of pipe by adding additional trusses.

The LineTamer straightens and re-rounds coiled PE pipe, conduit, and duct to meet or exceed ASTM D2513 ovality requirements. It removes coil set for installations on the job site. The 3" to 6" IPS LineTamer comes equipped with 4" to 6" re-rounding rollers, an optional 3" to 4" re-round rollers are also available and the unit is powered by hydraulic controls for ease of operation.

The **2”** IPS LineTamer allows you to straighten and re-round 2’’ IPS PE pipe, conduit, and duct.

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.

Procedure

1. ***Clean install & Clamp***
   Clean the inside and outside of the components, pipe or fitting ends by wiping with a clean, dry, lint-free cloth or paper towel check for rocks or anything embedded in pipe. Remove all foreign matter. Align the components to the machine, check the pipe to see if it is oval shape if it is put longest measurement of the oval vertical in the clamps this will help reround the pipe and then close and tighten the clamps do not over tighten clamps leave room for adjustments. 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. At this point you can check for slippage if the ends of the pipe are square if they are not square put facer in and face just enough to make them square then check for slippage

2. ***Face***

Check the facer to see if it is clean and oil free before placing in machine. Place the facing tool in the machine between the components ends make sure that it is not touching the end of one of the pipes turn on facer and pull pipe into facer with a slow and steady pace until the facer contacts both stops let it spin around a few times to cut off ribbon then turn off facer. Bump facer at handle away from fixed end remove facer. Check ends of pipe for smooth surfaces and complete face off, if not reinstall and start over remove all shavings and ribbons inside and out use a clean dry lint-free cloth or paper towel do not touch the end of the pipe with your hand or blow on them. There is oil on your skin and in your breath if you think or you know that you touched the ends of the pipe with your hands you can use a small amount of isopropyl on a clean dry cloth and just wipe the face of the pipes were it was faced (70% / 30% concentration minimum water only) then close the machine so that pipe ends are touching.

3. ***Align***

Bring the two ends of the pipes together and check the alignment of the two pipes and check for slippage again with fusion pressure. Look for complete contact of pipe surfaces and gaps between the faces and high / low alignment. If you need to adjust the high / low always tighten the clamp on the high side. Do not loosen the low side clamp because slippage may happen under fusion pressure. If any adjustments are made always re-face. If slippage occurs, return to clean install and clamp. The alignment cannot be more than 10% of the minimum wall thickness. There are several different ways to attain the wall thicknesses of the pipe. The manufacturer has a chart, it can be measured with calipers, tape measurer or measure the O.D. of the pipe and divide it by the dimension ratio, example 4.5” divide by DR 11 = .409 minimum wall thickness.

4. ***Heat***

Verify that the contact surfaces of the heating tool is maintaining the correct temperature (minimum 400°F – maximum 450°F) the thermometer on the heater is for reference only it reads the internal temperature of the heating tool. Use a clean non-synthetic cloth to clean the heating tool surfaces before placing the heating tool between the component ends, and move the ends against the heating tool. Bring the component ends together under fusion pressure to ensure full contact. This is called the initial contact. The initial contact pressure should be held very briefly and released without breaking contact at this point slowly engage the locking cam. On the MiniMc fusion machine there is not a locking cam and the 2CU does not have one either and on the 1LC the locking cam is used for the fusion process only on these machines you will have to hold the ends against the heating tool without force. Beads of melted polyethylene will form against the heating tool at the component ends. The proper bead size is dependent upon the size of the component. If the bead sizes are different make sure that the smallest one meets minimum size. Molded fittings will melt differently than the pipe. If fusing piped with the same O.D. but with different DRs let the one with the smaller wall thickness achieve the maximum size bead. Approximate values are shown in Table I.

Table I Approximate Melt

Bead Size

Pipe Size	Melt Bead Size* (Approximate)
1 ¼" and smaller	1/32" – 1/8"
1 ¼" – 3"	About 1/16"
3" – 8"	1/8" – 9/16"
8" – 12"	3/16" – 1/4"
12" – 24"	1/4" – 7/16"
24" – 36"	About 7/16"
36" – 65"	About 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. ***Fuse***

After the proper melt bead size is achieved, Open the movable jaw remove the heating tool quickly do not try and put the heating tool back into holder hold it in your hand and quickly inspect pipe ends for proper melt pattern, they should be flat and 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).This process should take no longer than 9 seconds for 3" to 24" pipe. The correct fusion pressure will form a double bead that is rolled over to the surface on both ends hold that pressure for at least 10 seconds. After 10 seconds the locking cams will hold the force during the cooling cycle. On the 1LC after 10 seconds engage the locking cam. On the MiniMc and the 2CU the fusion force will have to be held manually for the entire cooling cycle. When fusing pipe with the same O.D. but with different wall thickness use enough fusion force to just achieve the double roll over on the thinner wall pipe the thicker wall pipe may not roll over all the way back onto the pipe.

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. Or 120°F – 130°F 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.

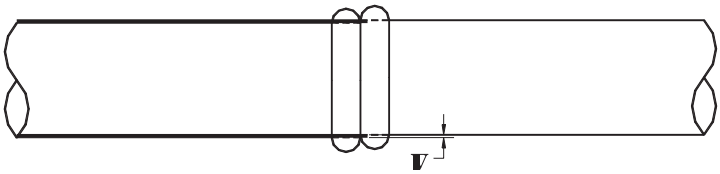
⌒ Heavier wall thickness pipes require longer cooling times.

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.

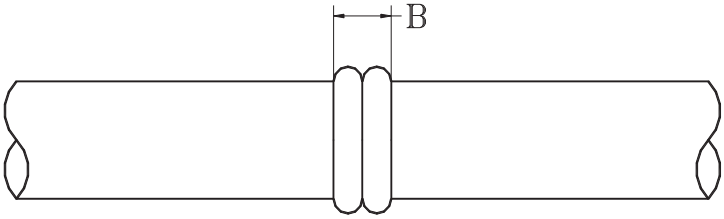


Table II
Bead Widths per Wall Thickness

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).

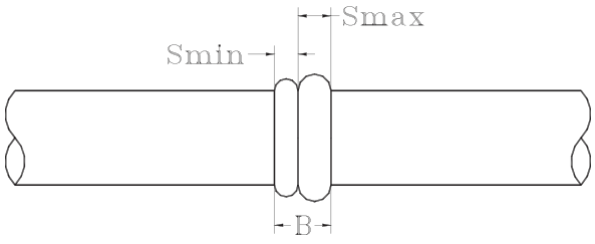
$$X \quad \frac{S}{B} \text{u} 100$$

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%

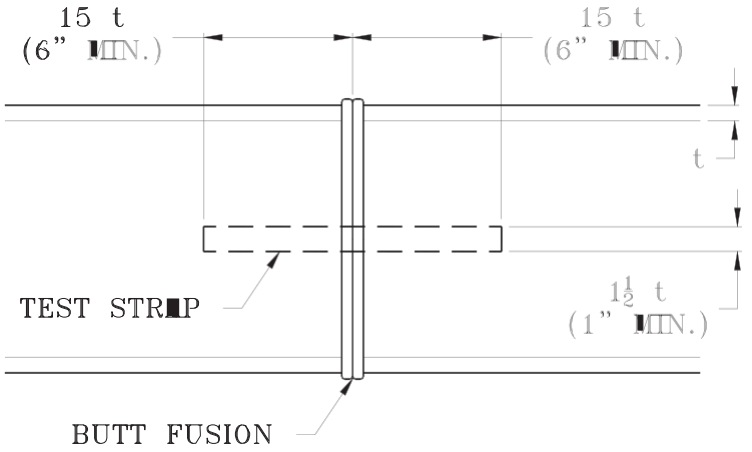
S = S_{max} - S_{min}, inches

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.

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

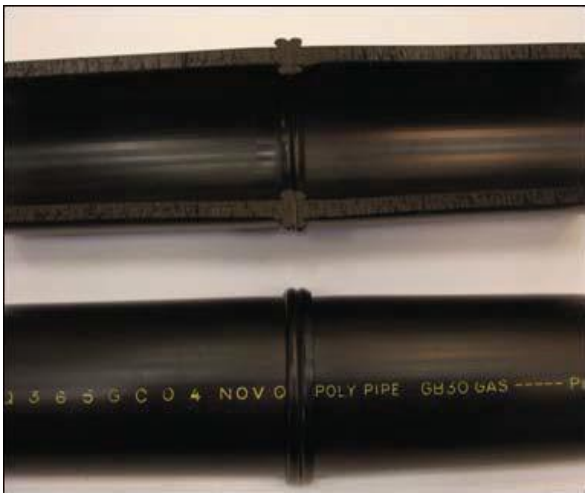


6. Visually inspect the cut joint for any indications of voids, gaps, misalignment or surfaces that have not been properly bonded.

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.

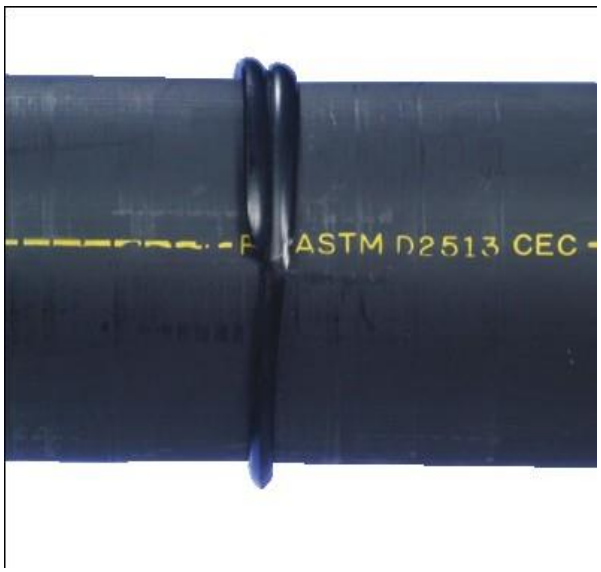
Bend back testing. No gaps or voids. (See Figure I)

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.

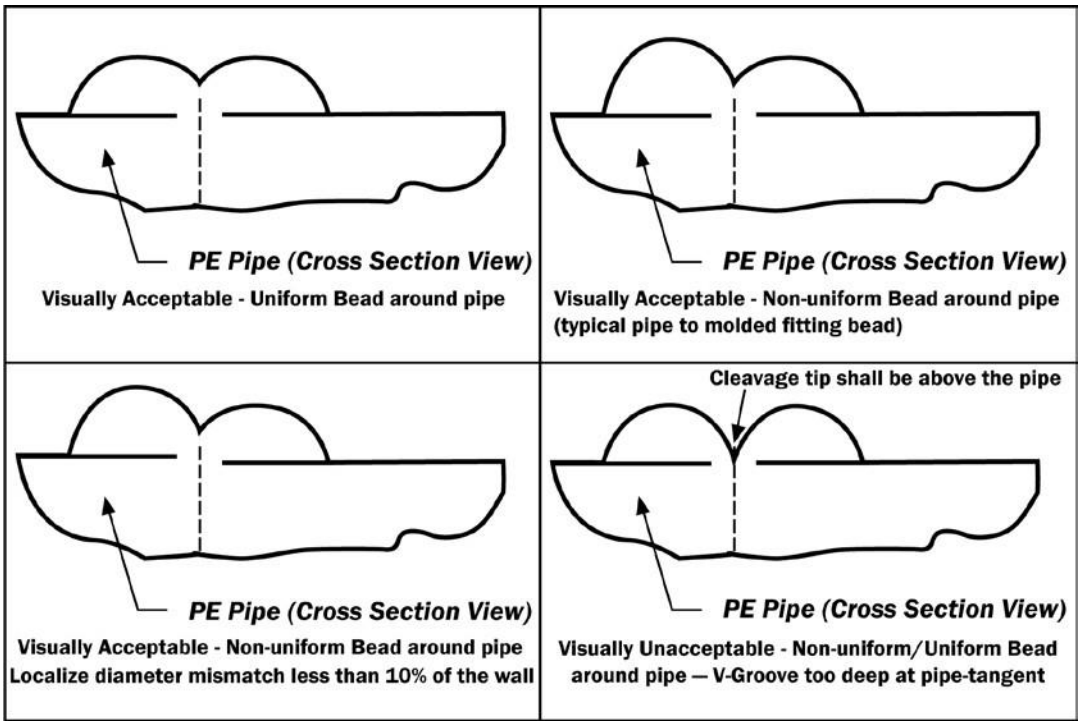


Figure B: Butt Fusion Bead Acceptance Guideline

Notes to Figure B:

- When fusing PE 4710, a slight gap may be present between the pipe OD and the bottom of the bead after cooling. When fusing PE 4710 to PE 3608/3408, the bead on the PE 3608/3408 pipe may roll all the way over the pipe wall, but the bead on the PE 4710 may not roll out completely.
- The top right quadrant in Figure B might also be seen if fusing pipes with different DRs

Table III
Butt Fusion Troubleshooting Guide

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

Safety

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