Arctic Insulation & Manufacturing

The Pre-Insulated Pipe People

Saddle Fusion Process for McElroy
Hand Operated Equipment
Sidewinder Fusion Machine Up To 4” Branch Saddles

II. Scope

The program undertaken by the PPI Task Group for the testing of representative materials under a generic set of conditions was designed to reflect the fusion conditions and parameters specified in most joining procedures recommended by pipe producers and qualified by pipeline operators. It produced a PPI Technical Report (TR-33/99) that reflects a Generic Butt Fusion Procedure that most of the Polyethylene Gas Pipe manufacturer's recommend. At the conclusion of the butt fusion phase of the program, the task group started its testing to develop a Generic Saddle Fusion Procedure that is based on common interfacial pressures and heater adapter surface temperatures. In anticipation of a change in the Maximum Allowable Operating Pressure (MAOP) and the design factor from .32 to .40, it was felt that this procedure was needed to insure safety in saddle fusion on live gas mains. It was intended to provide a technical basis for the development of a proposed generic saddle fusion procedure (see Appendix A) that can be offered to the industry for use with selected PE piping products. The procedure would be available for use by pipeline operators who would determine whether the procedure is appropriate for their use with the PE piping products they employ. Pipeline operators may consider recommendations and testing performed by others in their efforts to comply with the fusion procedure qualification requirements of 49 C.F.R. § Part 192.283 (Plastic pipe; qualifying joining procedures).

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 saddle 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 saddle 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 saddle 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 sawsalls 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 non synthetic rags or heavy duty cotton paper towels, isopropyl alcohol 70% / 30% concentration minimum with water only. 50-60 grit utility cloth (NOT SAND PAPER), 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
- Flexible heat shield.
- Pipe supports such as adjustable pipe rollers, pipe stands or blocking.

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 for dirt, rocks and foreign material imbedded in fusion area

- The operator will need the melt bead size of the pipe to be fused from table 1.

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 ∧ (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 line 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. A small amount of isopropyl alcohol on the cloth helps in static environments (USE ONLY ISOPROPYL ALCOHOL 70/30 % MINIMUM MIXED WITH WATER ONLY)

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 adjust and align fitting, 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^{o}F to 510^{o}F (254^{o}C to 266^{o}C).
- Ensure the heating surfaces are clean.
- Determine the saddle fusion force from the fitting label or by calculation.

A. Check heater temperature at the surface of the adapter plates, clean heater adapters with clean dry nonsynthetic cloth then 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:

C. When fusing with a flexible heat shield, place the heating tool on the main centered beneath the Fitting base, and then place the flexible heat shield between the heating tool and the fitting base. (This step usually requires an assistant to handle the flexible heat shield).
Move the fitting against the flexible heat shield, apply initial heat force, and observe the melt bead Formation on the main all around the heating tool faces. When the melt bead is first visible on the Main all around the heating tool faces, in a quick continuous motion, release the initial heat force, Raise the fitting slightly, remove the flexible heat shield, move the fitting against the heating tool Face, apply initial heat force and start the heat time. When a melt bead is first visible all around The fitting base (usually about 3 to 5 seconds) immediately reduce applied force to the heat soak Force (usually zero). Maintain the heat soak force until the total heat time ends.

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 (do not slam) 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 by turning the drive screw as necessary to maintain the specified force until the gauge pressure stabilizes approximately 5 minutes on 1-1/4" IPS and for
10 minutes for larger sizes. Three beads should be visible around the base of the fitting. 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.

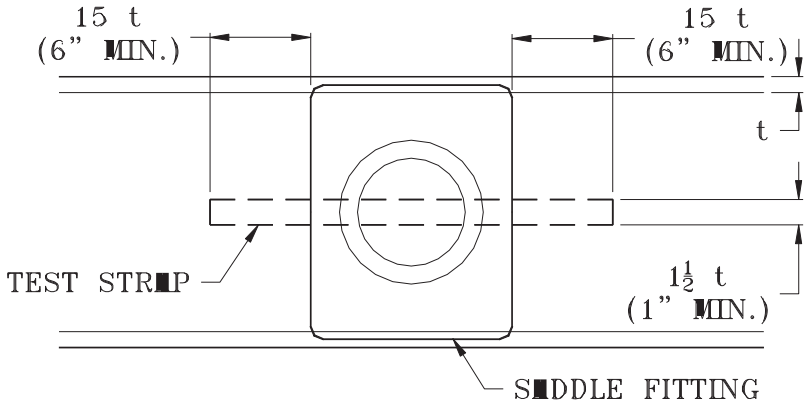
2. Observe the fusion process and verify the recommended procedure for saddle fusion is being followed.

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.

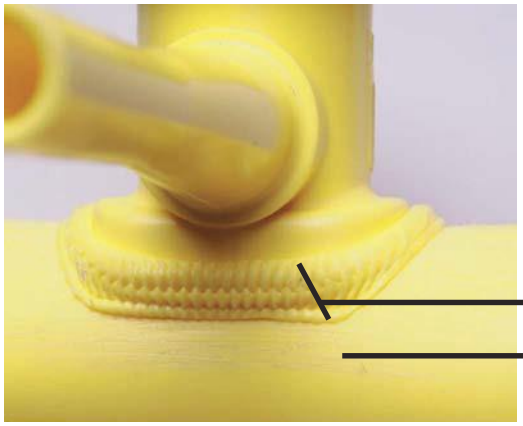
7. Bend each test strap 180° with the inside facing out.

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

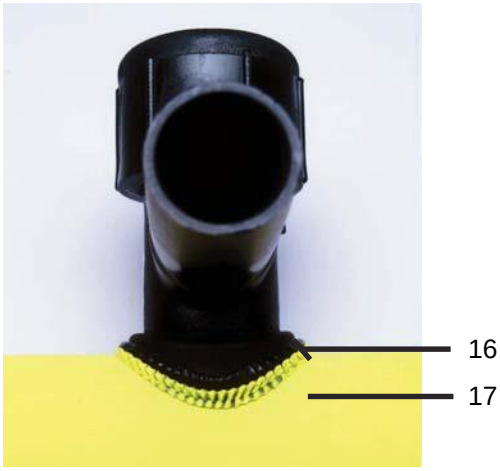
9. Test the other sample joint by impact against the saddle fitting. The failure must occur by either tearing the fitting, bending the fitting at least 45° or by removing a section of the pipe. Failure at the fusion is not acceptable. This test is a federal requirement for qualification of fusion procedures,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

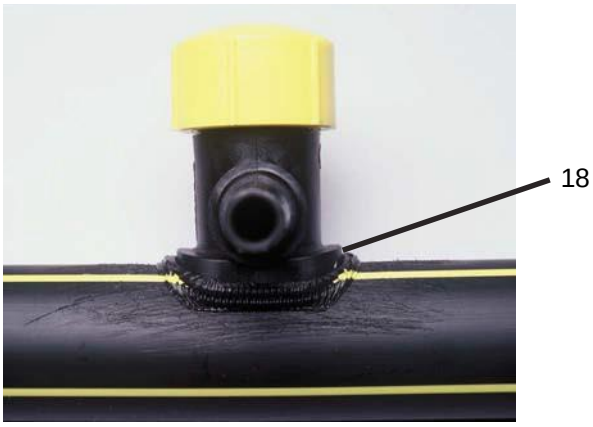
ACCEPTABLE FUSIONS



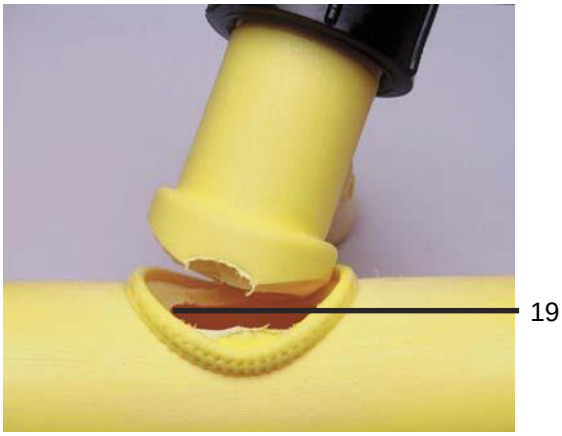
16. Proper alignment, force and melt
17. Proper pipe surface preparation



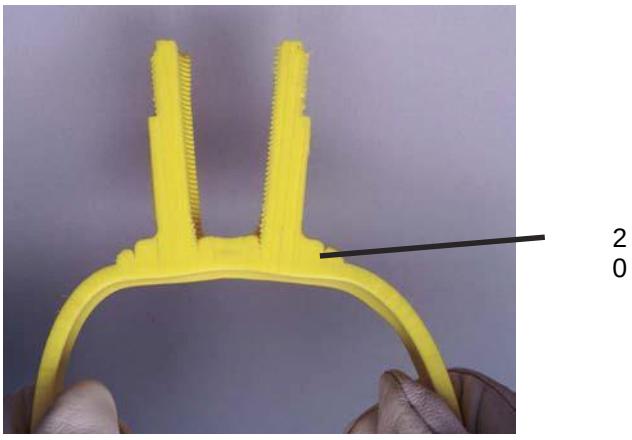
16. Proper alignment, force and melt
17. Proper pipe surface preparation



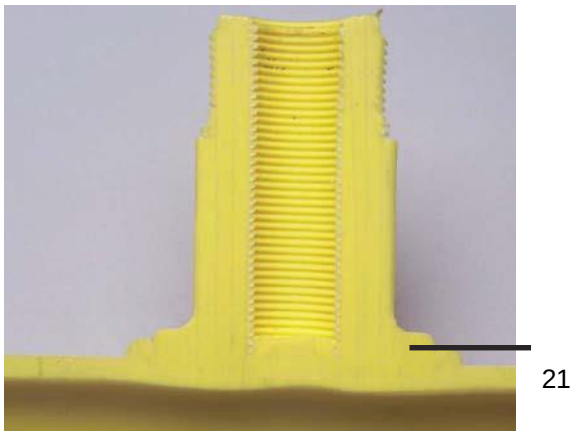
18. Melt bead below or parallel with top of fitting base



19. Material pulled from pipe when impact tested

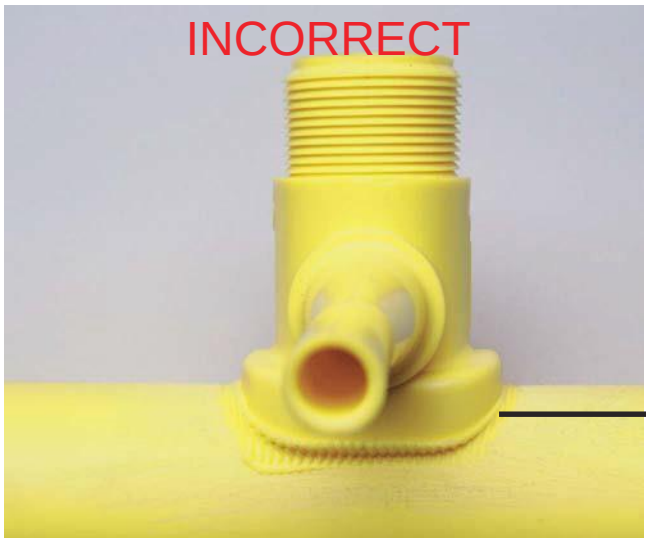


20. No gap or voids when bent

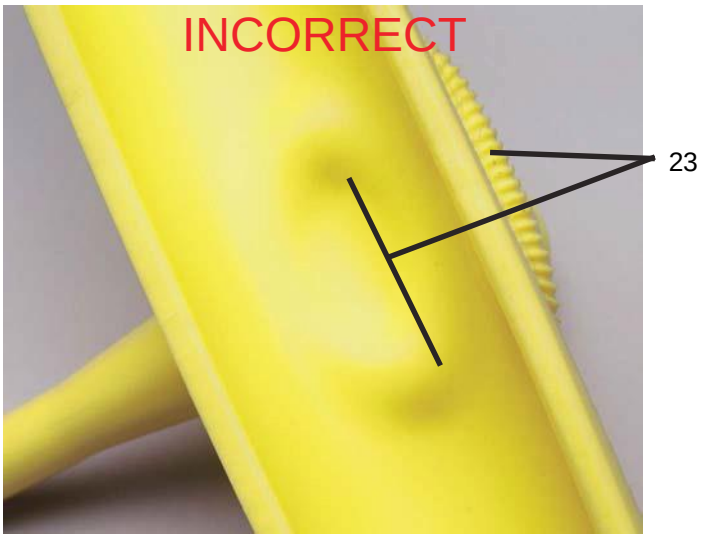


21. No gap or voids at fusion interface

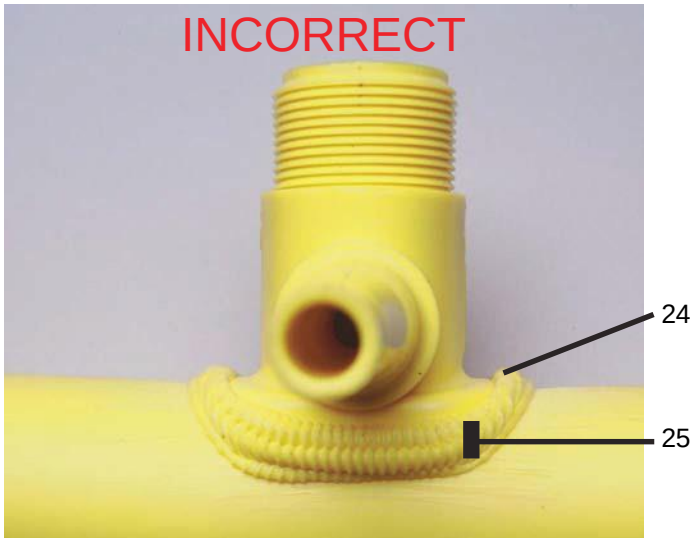
UNACCEPTABLE FUSIONS



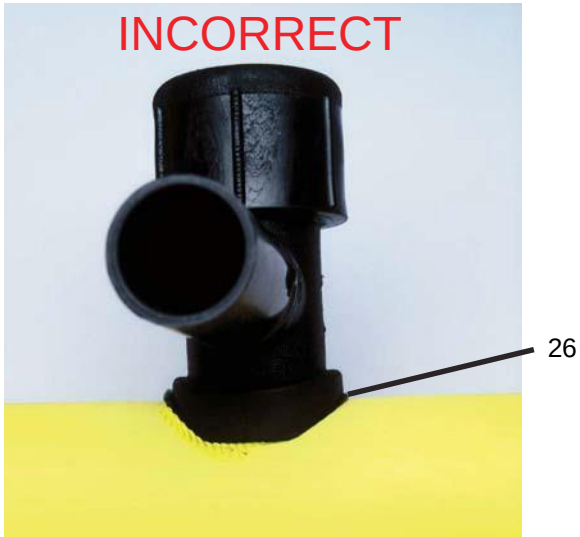
22. Insufficient melt and misaligned



23. Excessive melt and force



24. Bead above base of fitting
25. Excessive melt and force



26. Insufficient melt

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