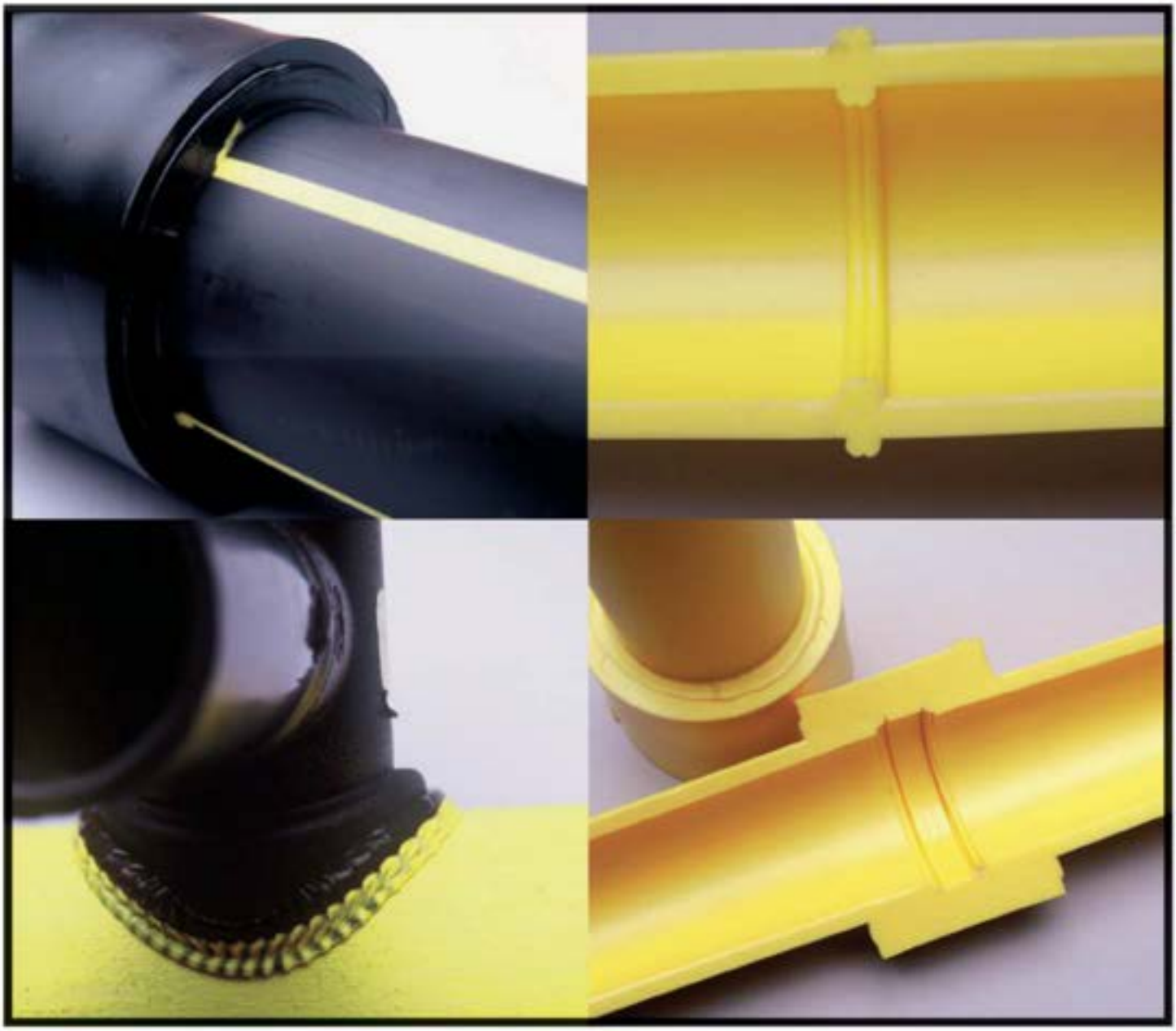
PERFORMANCE PIPE

A DIVISION OF CHEVRON PHILLIPS CHEMICAL COMPANY LP

Heat Fusion Joining Procedures and Qualification Guide

Gas Distribution (MDPE & HDPE) Products
Water, M&I and Specialty Products
Energy Products



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HEAT FUSION JOINING PROCEDURES

INTRODUCTION

Performance Pipe, a Division of Chevron Phillips Chemical Company LP, is the functional successor to the operations of PLEXCO® and DRISCOPIPE®. Performance Pipe began operations on July 1, 2000, and effective July 1, 2000, the products of the former PLEXCO and DRISCOPIPE companies became the products of Performance Pipe. Performance Pipe products may have the markings of the former and current companies, that is, “PLEXCO”, “DRISCOPIPE” or “DRISCOPLEX” markings.

Material performance characteristics and product fusion characteristics have not changed as a result of the joint venture and creation of Performance Pipe. Modifications to the content of the print-line on the product do not affect fusion procedures. Therefore, joining procedures that are qualified for PLEXCO products and for DRISCOPIPE products are joining procedures that are qualified for Performance Pipe products. Furthermore, operator (utility) specific joining procedures, which are already qualified, continue to be qualified for use with products from Performance Pipe. Department of Transportation regulations require 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)). (See below: **Federal Regulations for Gas Pipe Joining**.)

Where qualified procedures are already in-use by an operator in compliance with Department of Transportation regulations, these recommended fusion procedures do not constitute a requirement for that operator to change to these recommended fusion procedures.

This Bulletin describes recommended procedures and guidelines for joining Performance Pipe™ polyethylene pipe and fittings using butt fusion, saddle fusion and socket fusion joining techniques. Butt fusion procedures are consistent with PPI TR-33 *Generic Butt Fusion Procedures.*

USE THESE PROCEDURES WITH THESE PRODUCTS

The procedures in this bulletin are recommended for joining the following Performance Pipe™ products to themselves or to each other:

GAS DISTRIBUTION PRODUCTS:

DRISCOPLEX™ 6500† Piping	DRISCOPLEX™ 6800 Piping	DRISCOPIPE® 8100 Piping
Plexco® Yellowpipe PE 2406† Piping	DRISCOPIPE® 6800 Piping	Plexco® Yellowstripe PE 3408 Piping
DRISCOPIPE® 6500 Piping	Plexco Plexstripe II PE 3408 Piping	YELLOWSTRIPE® 8300 Piping

† Includes fusing DRISCOPLEX™ 6500 or Plexco Yellowpipe PE 2406 installed within DRISCOPLEX™ 6600 (formerly Plexco Plexshield). **Do not join Driscopipe® 7000 or 8000 using these procedures.**

Water, M&I and Specialty Product Piping Systems:

DRISCOPLEX™ 1700	DRISCOPLEX™ 1000	DRISCOPLEX™ 8700	DRISCOPLEX™ 6400
DRISCOPLEX™ 1500	DRISCOPLEX™ 5100	DRISCOPLEX™ 4000	DRISCOPLEX™ 4100
DRISCOPLEX™ 4200	DRISCOPLEX™ 4300	DRISCOPLEX™ 4600	DRISCOPLEX™ 4700
DRISCOPLEX™ 1200	DRISCOPLEX™ 1400	DRISCOPLEX™ 4400	DRISCOPLEX™ 4500
DRISCOPLEX™ 4800	DRISCOPLEX™ 6400	DRISCOPLEX™ 5300	DRISCOPLEX™ 9200
Plexco® EHMW PE 3408	Driscopipe® 1000	Driscopipe® 5300	Driscopipe 6400
Plexco® Bluestripe PE 3408	Driscopipe® 4000	Driscopipe® 4100	Driscopipe 4400
Plexco® Greenstripe PE 3408	Driscopipe® 4200	Plexco® Purplestripe PE 3408	Plexco® Plexvue
Driscopipe® 4300	Driscopipe® 8700	Driscopipe® 4500	Driscopipe® 1000 FM
	Driscopipe® 1200	Driscopipe® 1400	
Plexco® Redstripe FM PE 3408	Plexco® PE 3408 Oil & Gas Gathering Pipe		Plexco® Bluestripe FM PE 3408
Do not join Driscopipe® 7600 or 8600 using these procedures.			

OVERVIEW

In heat fusion joining, mating surfaces are prepared, simultaneously melted with a hot-plate heater, the heater is removed, and the melted surfaces are pressed together and held under pressure. As the molten materials cool, they mix and fuse into a permanent, monolithic joint. Performance Pipe fusion procedures require specific tools and equipment for the fusion type and for the sizes of pipe and fittings being joined.

- Butt fusion is used to make end-to-end joints between "butt" or plain end pipes and fittings that have the same outside diameter and like wall thickness[1].
- Saddle (sidewall) fusion is used to install a branch outlet fitting to the top or side of a main pipe. Tapping tee fittings are usually installed on top of the main, and branch or service saddle fittings on the side of the main. After the joint has cooled, the main pipe wall is pierced (tapped) to enable flow through the branch. "Hot tapping" is saddle fusion to a "live" or pressurized main.
- Socket fusion is used to join 4" IPS and smaller tubing and pipe to socket fittings. Socket fittings are available for certain Performance Pipe PE materials.

FEDERAL REGULATIONS FOR GAS PIPE JOINING

When used to join Performance Pipe™ polyethylene gas pipe and fittings, Performance Pipe fusion joining procedures are qualified in accordance with U.S. Department of Transportation Regulations.

✓ 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 test or experience to produce strong gastight joints (49 CFR, Part 192, §192.273(b)).

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[1] "*Like wall thickness*" means that the pipe or fitting ends being butt fused do not exceed one SDR difference, for example, SDR 9.0 to SDR 11.0. Per ASTM, standard dimension ratio, SDR, value is when the outside diameter divided by the minimum wall thickness equals one of the following values: 6.0, 7.3, 9.0, 11.0, 13.5, 17.0, 21.0, 26.0, 32.5 or 41.0. Between adjacent SDR's, the difference in minimum wall thickness varies from about 21.7% to about 26%.

- ✓ 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 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).

CAUTION — Performance Pipe polyethylene piping products cannot be joined with adhesives or solvent cement. Joining by hot air (hot gas) welding or extrusion welding techniques and joining by pipe threading are not recommended for pressure service.

PRECAUTIONS

STATIC ELECTRICITY

Polyethylene plastic pipe does not readily conduct electricity. A static electricity charge can buildup on inside and outside surfaces, and stay on the pipe surface until some grounding device such as a tool or a person comes close enough for the static electricity to discharge to the grounding device.

Discharging one part of the pipe surface will not affect other charged areas because static electricity does not flow readily from one area to another. Polyethylene pipe cannot be discharged by attaching grounding wires to the pipe.

WARNING – Fire or Explosion – Static electricity discharge can ignite a flammable gas or combustible dust atmosphere.

A static electricity discharge to a person, a tool, or a grounded object close to the pipe surface can cause an electric shock or a spark that can ignite a flammable gas or combustible dust atmosphere causing fire or explosion.

- In gas utility applications, static electricity can be a potential safety hazard. ***Where a flammable gas-air mixture may be encountered and static charges may be present, such as when repairing a leak, squeezing-off an open pipe, purging, making a connection, etc., arc preventing safety precautions are necessary.[2] Observe all Company (pipeline operator, utility, contractor, etc.) procedures for static electricity safety and control, including procedures for discharging static electricity and requirements for personal protection.***
- Take steps to discharge static electricity from the surface of a polyethylene gas pipe. Such steps include wetting the entire exposed pipe surface with a conductive anti-static liquid or a dilute soap and water solution, then covering or wrapping the entire wetted, exposed pipe surface with grounded wet burlap, conductive poly film, or wet tape conductor. The external covering should be kept wet by occasional re-wetting with anti-static solution. The covering or tape should be suitably grounded such as to a metal pin driven into the ground.
- Steps that discharge the outer surface do not discharge the inner surface of the pipe. Squeeze-off, purging, venting, cutting, etc., can still result in a static electricity discharge. When appropriate, ground tools and remove all potential sources of ignition.

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[2] See the *AGA Plastic Pipe Manual For Gas Service 2000*, American Gas Association, 1515 Wilson Boulevard, Arlington, VA 22209.

- Appropriate safety equipment should be used.
- ***Do not use polyethylene pipe for handling dry grain or coal where a static electricity discharge may ignite a combustible dust atmosphere and cause an explosion or fire.***

Polyethylene pipe is not recommended for pneumatic slurry applications.

ELECTRIC TOOLS

WARNING – Fire or Explosion – Electric tools or fusion equipment may not be explosion-proof and may ignite a flammable gas or flammable dust atmosphere.

DO NOT operate electrical devices that are not explosion proof in a flammable gas or flammable dust atmosphere. When a flammable gas-air mixture may be present, observe all gas system operator (pipeline or utility company, and contractor) safety procedures for the use of electric tools and equipment.

PROTECTION AGAINST SHEAR AND BENDING LOADS

Protective measures such as protective sleeves and properly placed, compacted backfill are necessary at a connection where an underground polyethylene branch or service pipe is joined to a branch fitting such as a service saddle, branch saddle or tapping tee on a main pipe. Protective measures are necessary for all types of plastic and non-plastic branch connections including heat fusion, mechanical, and electrofusion types. A protective sleeve and properly placed, compacted backfill are generally used together, but whether or not a protective sleeve is installed, the area surrounding the connection must be embedded in properly placed, compacted backfill to protect the polyethylene pipe against shear and bending loads.

For additional information on protection against shear and bending loads, at branch connections and where PE pipe penetrates a structure or enters or exits a casing, see the *Performance Pipe Engineering Manual*, and ASTM D 2774, *Underground Installation of Thermoplastic Pressure Piping*.

LIQUID HYDROCARBON PERMEATION

When present, liquid hydrocarbons may permeate (solvate) polyethylene pipe. Liquid hydrocarbon permeation may occur when liquid hydrocarbons are present in the pipe, or where soil surrounding the pipe is contaminated with liquid hydrocarbons, or where liquid hydrocarbon condensates can form in gas pipelines. All types of liquid hydrocarbons (aromatic, paraffinic, etc.) have a similar effect, and the relative effect on different polyethylene pipe resins is essentially the same. Heat fusion joining to liquid hydrocarbon permeated pipes may result in a low strength joint.

CAUTION — Once polyethylene pipe has been permeated with liquid hydrocarbons, heat fusion or electrofusion joining is not recommended because liquid hydrocarbons will leach out during heating and contaminate the joint. Liquid hydrocarbon permeated polyethylene pipe should be joined using suitable mechanical connection methods.

Liquid hydrocarbon contamination is indicated by a rough, sandpaper-like, bubbly, or pockmarked surface when a fusion heating iron is removed from the pipe surface, and may be indicated by discoloration or by a hydrocarbon fuel odor. See the *Performance Pipe Engineering Manual* for additional information on permeation and chemical resistance.

Mechanical joining products (fittings, components, etc.) must be installed in accordance with the instructions of the mechanical joining product manufacturer. Obtain these instructions from the

mechanical joining product manufacturer. **The mechanical joining product manufacturer determines the capabilities of his product and its suitability for use with polyethylene pipe.**

LEAKAGE AT FUSION JOINTS

WARNING – Correctly made fusion joints do not leak. When pressurized, leakage at a faulty fusion joint may immediately precede catastrophic separation and result in violent and dangerous movement of piping or parts and the release of pipeline contents under pressure. Never approach or attempt to repair or stop leaks while the pipeline is pressurized. Always depressurize the pipeline before making corrections.

Faulty fusion joints must be cut out and redone.

HANDLING

Polyethylene piping is a tough, robust material, but it is not immune to damage. ***Improper handling or abuse can damage piping, compromise system performance and result in injury or property damage.*** Polyethylene piping should be unloaded and moved with proper handling and lifting equipment. Use fabric slings. Do not use chains or wire ropes. Do not roll or drop pipe off the truck, or drag piping over sharp rocks or other abrasive objects. Store piping so that the possibility of mechanical damage is minimized. See the *Performance Pipe Engineering Manual* for additional information on handling and storage.

FUSION IN COLD WEATHER

In cold weather, polyethylene becomes more sensitive to impact and less flexible. Use additional care in handling. When temperatures are very cold, avoid sharp impact such as dropping the pipe from moderate heights. Cold pipes 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.

Remove all frost, ice, or snow from the OD and ID surfaces of areas to be fused. Surfaces must be clean and dry before fusing.

Polyethylene pipe and fittings will contract slightly in the cold. Most butt and saddle fusion equipment will accommodate the slightly reduced diameter of cold pipe. In socket fusion, it will be more difficult to fit a cold socket fitting on the heating tool socket face. One way to compensate is to warm socket fittings in the cab of the service truck before using them.

In some cases, socket fusion cold ring clamps may fit loosely on cold pipe. Using two cold ring clamps, set the first cold ring clamp to proper distance with the depth gauge. Shim around the pipe behind the clamp with tape, and place a second, backup cold ring clamp over the tape. The backup cold ring clamp prevents slippage, and the inner cold ring clamp allows the pipe to expand to normal dimensions when heated.

When fusing in cold weather, the time required to obtain the proper melt may increase.

- *Maintain the specified heating tool surface temperature.* ***Do not increase heating tool surface temperature.***
- *Do not apply pressure during zero pressure butt or saddle fusion heating steps.*
- *Do not increase butt or saddle fusion joining pressure.*

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

For saddle fusion, establish the necessary cold weather heating time by making trial melt patterns in the field on non-pressurized, excess pipe that is at field temperature. Use the standard heating time plus additional heating time in 3-second increments until the proper melt pattern is established on the pipe. A clean wood board or heat shield ("flyswatter") should be used between the saddle fitting and the heater to avoid heating the fitting when making trial melt patterns.

- *Use only the cold weather heating time required to obtain the proper melt. Avoid excessive heating time.*
- *Do not make saddle fusion trial melt patterns on pressurized pipe.*

In cold weather socket fusion, it takes more time to push a cold socket fitting onto the male socket heater face so trials to develop a heating time for the fitting are not needed. For the pipe, establish the necessary heating time by making trial patterns on excess pipe that is at field temperature. Use the recommended heating time plus additional heating time in three-second increments until the proper melt pattern is established.

Additional information on fusion in cold weather can be found in ASTM D 2657 *Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings*, Annex A1.

KEY FACTORS FOR QUALITY FUSIONS

Quality fusion requires using all of the required tools and equipment, and following all of the steps in the procedure in the correct sequence. The fusion procedure prepares and aligns the surfaces, heats the mating surfaces to the proper melt consistency, joins the surfaces together under pressure, then cools the joint under pressure. Faulty fusion is caused by improper or defective equipment, omitting steps or doing things out of sequence. Faulty fusion may be hazardous.

Training and experience provide knowledge and proficiency in what to do, what to expect, and recognizing potential problems in advance. Inadequately trained or inexperienced persons can produce poor quality fusions, and may expose themselves or others to hazards. Federal safety regulations require that persons making joints in gas systems must be qualified in the pipeline operator's qualified fusion procedures. (See Federal Regulations for Gas Pipe Joining above.)

The key factors below are necessary for quality fusion.

- *Fusion tools and equipment must be correct for the job, and in proper working order;*

Each fusion procedure requires specific tools and equipment to do the job properly. Incorrect or poorly maintained or damaged fusion tools or equipment or using the wrong tools or equipment can cause a poor fusion, and may be hazardous. Use only the correct tools and equipment for the job. Do not use defective or improper tools or equipment. Follow the equipment manufacturer's procedures for equipment maintenance.

- *The fusion operator must be proficient in tool and equipment use and operation, and proficient in fusion procedure;*

The operator should be thoroughly familiar with the tools and equipment, and their use and operation. Improper use or an incorrect operating sequence can cause a poor fusion, and may be hazardous. Know how to use the equipment, and observe the manufacturer's instructions.

- *Pipe and fitting surfaces must be clean and properly prepared;*

Dirty, or contaminated, or poorly prepared surfaces that do not mate together properly cannot produce a quality fusion. Clean and prepare the surfaces before joining. If contamination is reintroduced, clean the surfaces again.

- *Heating tool surfaces must be clean, undamaged and at the correct surface temperature;*

Heating tool faces have non-stick coatings for quick, complete release from melted polyethylene. Dirty or contaminated heating tool faces can cause poor fusion, and damaged coatings may not release properly from the melt. Use only wooden implements, and clean, dry non-synthetic (cotton) cloths or paper towels to clean heating tool faces. Never use spray chemicals or metal tools on heating tool faces.

Heating tool temperatures are specified for each procedure. (Butt fusion and saddle fusion heating tool temperatures are different.) *The specified temperature is the temperature on the surfaces that contact the pipe or fitting being joined, not the heating tool thermometer temperature.* Use a pyrometer or infrared thermometer to check for uniform temperature across both of the component contact surfaces. *(Temperature indication crayons are not preferred. If used, temperature-indicating crayons must never be applied to a surface that contacts a pipe or fitting.)* Uneven temperature may indicate a faulty heater. The heater thermometer measures the internal temperature, which is usually higher than surface temperature, however, heating tool temperature can be verified by checking the thermometer to ensure that the heating tool is maintaining temperature. When checking surface temperature with a pyrometer or infrared thermometer, note the heating tool thermometer reading. Check the heating tool thermometer reading before each fusion to verify that the heating tool is maintaining temperature properly. Incorrect or non-uniform temperature can cause poor fusion; ***low heating tool temperature can lead to a blowout during hot tap saddle fusion***.

BEFORE YOU START:

- ✓ *Inspect pipe lengths and fittings for unacceptable cuts, gouges, deep scratches or other deleterious defects.* Damaged products should not be used.
- ✓ *Toe-in or necking down is normal at pipe ends, but may need to be removed for socket fusion, or butt fusion to fittings.*
- ✓ *Remove surface damage at pipe ends that could compromise the joining surfaces or interfere with fusion tools or equipment.*
- ✓ *Be sure all required tools and equipment are on site, in proper working order and fueled up.*
- ✓ *The 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 contamination.
- ✓ *Shield heated fusion equipment and surfaces from inclement weather and winds.* A temporary shelter over fusion equipment and the fusion operation may be required.
- ✓ *Relieve tension in the line before making connections.*

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

- ✓ *Pipes must be correctly aligned before making connections.*

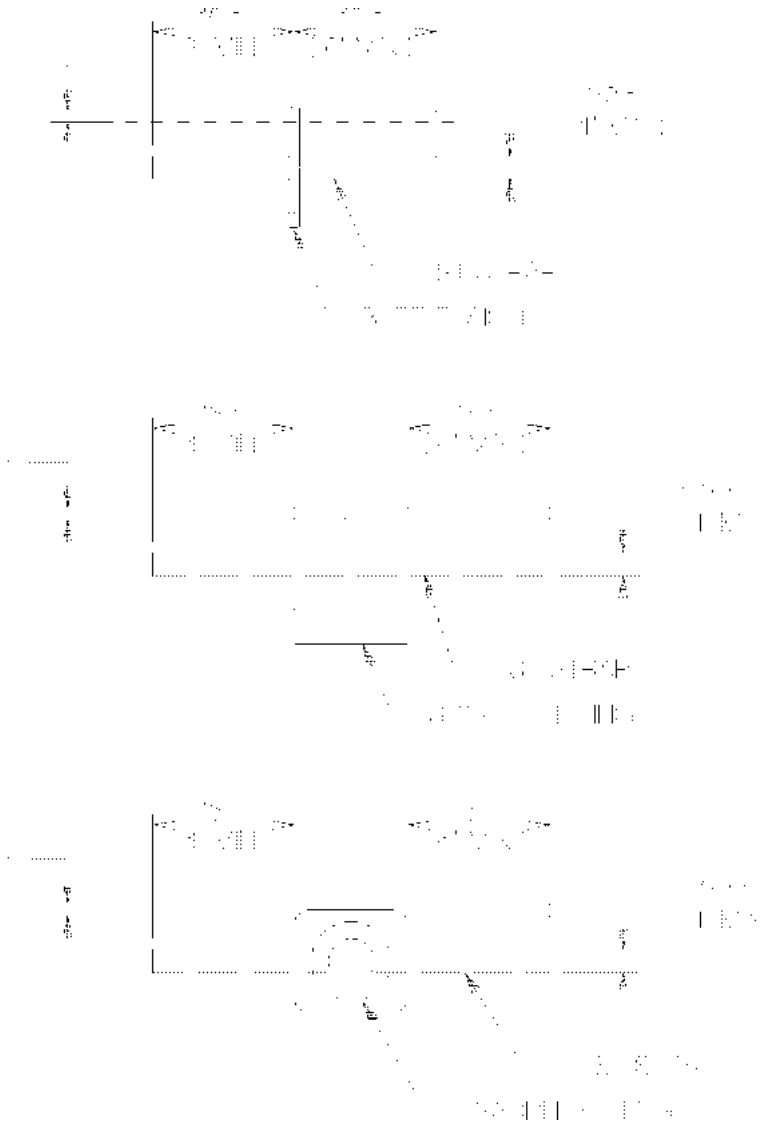
CAUTION – Impact Hazard – Do not bend pipe into alignment against open butt fusion clamps. The pipe may spring out and cause injury or damage. *Pipe must be aligned before placing it into butt fusion equipment.*

✓ *Trial fusions.*

A trial fusion can verify fusion procedure and equipment settings for the actual jobsite conditions. Allow trial fusions to cool completely before cutting straps and testing by bending the straps until the ends touch. Figure 1 illustrates ASTM D 2657 test specimen dimensions for bent strap testing.

Testing of large diameter fusions (≥ 16”) may require special equipment and safety precautions.

Figure 1 ASTM D 2657 Specimens for Bent Strap Tests



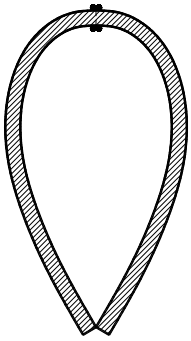


Figure 1 Example

Saddle fusions can be impact tested using ASTM F905.

BUTT FUSION

SET-UP PARAMETERS

HEATING TOOL SURFACE TEMPERATURE — MINIMUM 400°F – MAXIMUM 450°F (204 – 232°C)

Heating tool surfaces must be up to temperature before you begin. 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-in. (450 mm) 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; 4.14 – 6.21 bar)**

When the properly heated mating surfaces are brought together, the force required to make the joint is the force that is necessary to roll the fusion melt beads over to the pipe surface. This is a visual determination.

Interface pressure is used to calculate a fusion joining pressure value for hydraulic butt fusion machines or manual machines equipped with a torque wrench. The same interface pressure is used for all pipe sizes and all butt fusion machines. However, fusion joining pressure settings for the butt fusion machine are calculated for each pipe OD and DR.

For hydraulic machines, the interface pressure, the fusion surface area, the machine's carriage cylinder size and internal drag pressure, and if necessary, the pressure needed to overcome external drag resistance, are used to calculate hydraulic fusion joining pressure gauge settings. The equipment manufacturer's instructions are used to calculate this value.

Interface pressure and fusion machine hydraulic fusion joining pressure gauge settings are not the same!

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 with the machine, place them in the clamps and then close the clamps. *Do not force pipes into alignment against open fusion machine clamps.* (When working with coiled pipe, if possible "S" the pipes on each side of the machine to compensate for coil curvature and make it easier to join.) 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 a minimal distance between the fixed and moveable clamps. Some machines have facing stops. If stops are present, face down to the stops. 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 heating tool is maintaining the correct temperature. Place the heating tool between the component ends, and move the ends against the heating tool. The initial contact should be under moderate pressure to ensure full contact. Hold contact pressure *very briefly* then release pressure without breaking contact. Pressure must be reduced to contact pressure at the first indication of melt around the pipe ends. Hold the ends against the heating tool ***without force***. 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.

   - 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 be indicated.

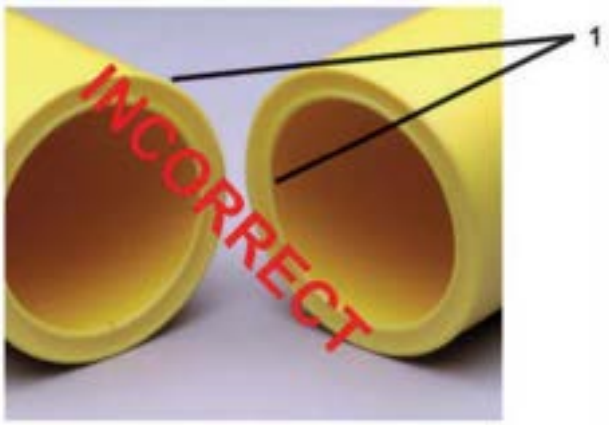
Table 1 Approximate Melt Bead Size

Pipe Size	*Approximate Melt Bead Size*
1-1/4” and smaller (40 mm and smaller)	1/32” – 1/16” (1 – 2 mm)
Above 1-1/4” through 3” (above 40 mm through 90 mm)	About 1/16” (2 mm)
Above 3” through 8” (above 90 mm through 225 mm)	1/8” – 3/16” (3 – 5 mm)
Above 8” through 12” (above 225 mm through 315 mm)	3/16” – 1/4” (5 – 6 mm)
Above 12” through 24” (above 315 mm through 630 mm)	1/4” – 7/16” (6 – 11 mm)
Above 24” through 36” (above 630 mm through 915 mm)	About 7/16”
Above 36” through 54” (above 915 mm through 1300 mm)	About 9/16”

5. ***Join.*** Immediately after heating tool removal, *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. *Do not slam. Apply enough joining force to roll both melt beads over to the pipe surface.*

   A concave melt surface is unacceptable; it indicates pressure during heating. (See Figure 2). Do not continue. Allow the component ends to cool and start over at Step 1.

Figure 2 Unacceptable Concave Melt Appearance



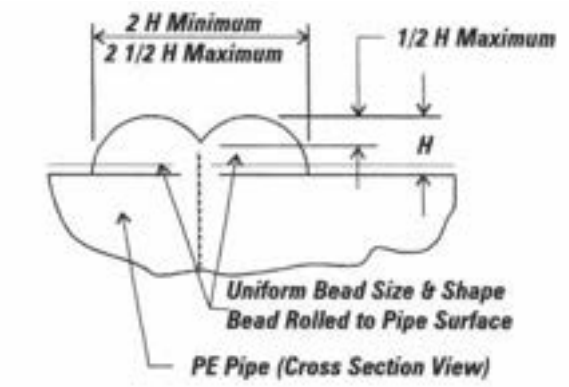
1. Unacceptable concave melt appearance.

   - The correct joining force will form a double bead that is rolled over to the surface on both ends.

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 shorten 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. ***Inspect.*** 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. As illustrated in Figure 3, the double bead width should be 2 to 2-1/2 times its height above the surface, and the v-groove depth between the beads should not be more than half the bead height.

Figure 3 Butt Fusion Bead Proportions



- 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.
- It is not necessary for the internal bead to roll over to the inside surface of the pipe.

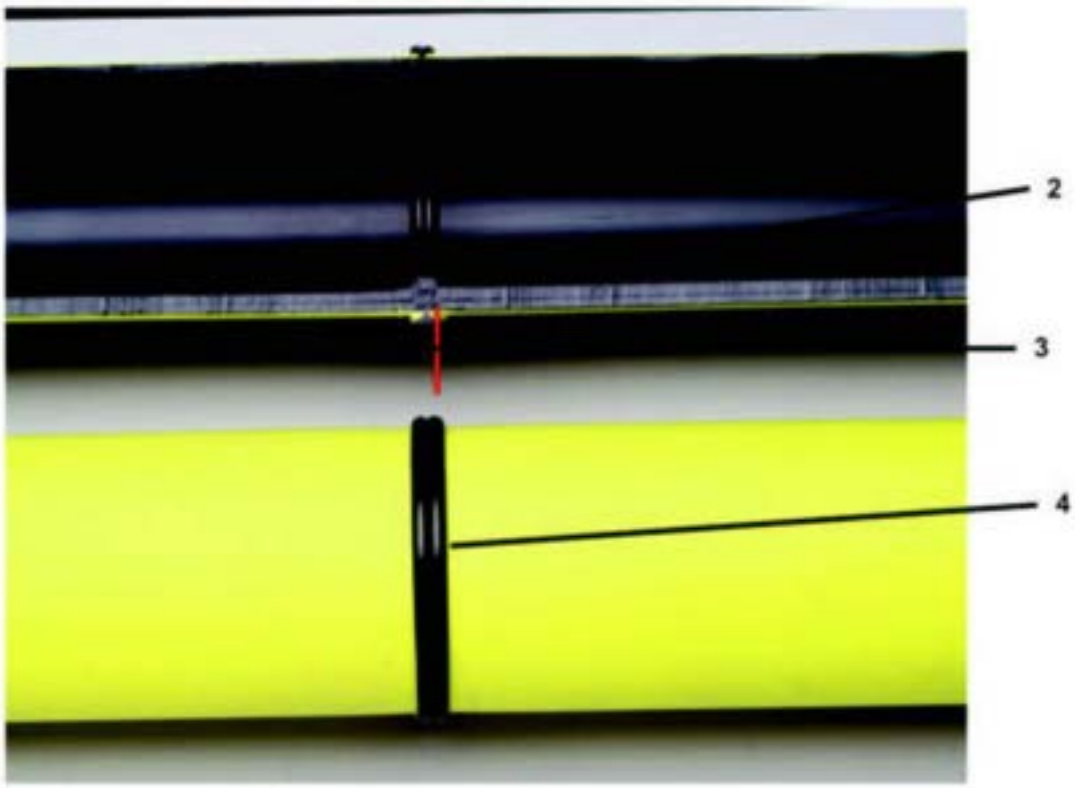
Table 2 Butt Fusion Bead Troubleshooting Guide

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; Defective heating tool; Incomplete facing; Dissimilar material – see note above
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
Squared outer bead edge	Pressure during heating
Rough, sandpaper-like, bubbly, or pockmarked melt bead surface	Hydrocarbon contamination

Butt Fusion Qualifying Procedure

1. Prepare a sample joint. Pipes on either side of the joint should be at least 6” (150 mm) or 15 times the wall thickness in length. Observe the joining process to determine that the correct procedure is being followed.
2. Visually inspect the sample joint and compare it to a sample or picture of an acceptable joint.
3. Allow the sample joint to cool completely – for no less than one hour.
4. Cut the sample joint lengthwise along the pipe into at least three straps that are at least 1” (25 mm) or 1.5 wall thicknesses wide. See Figure 1.
5. Visually inspect the cut surface at the joint and compare to a sample or picture of an acceptable joint. There should be no gaps, voids, misalignment, or unbonded areas.
6. Bend the straps until the ends of the strap touch.
7. If flaws are observed in the joint, compare appearance with pictures of unacceptable joints. Prepare a new sample joint using correct joining procedure, and repeat the qualifying procedure.

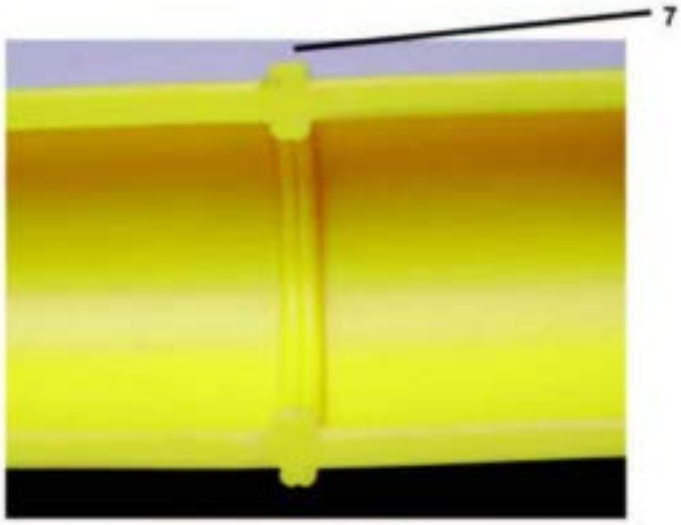
Acceptable Appearance



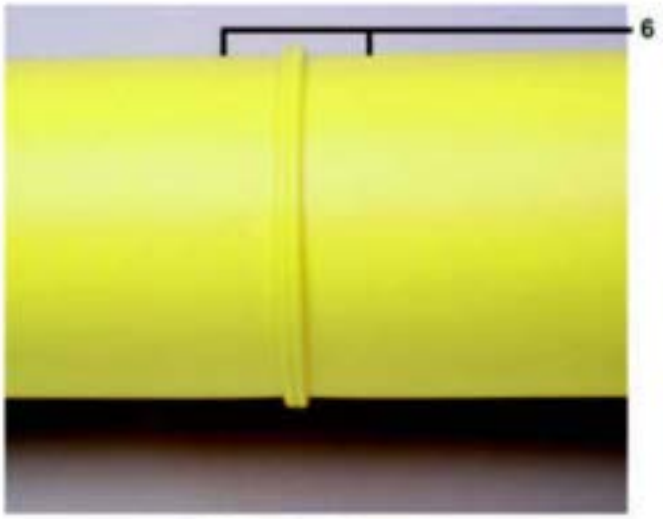
2. Proper alignment - no gaps or voids
3. Proper melt, pressure and alignment
4. Proper double roll-back bead

ACCEPTABLE FUSIONS

5. Proper double roll-back bead
6. Proper alignment



7. Proper double roll-back bead



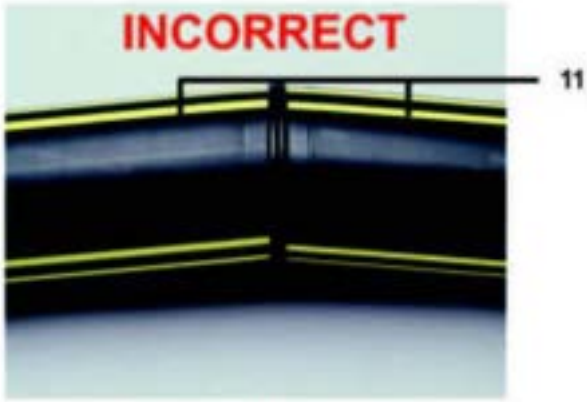
6. Proper alignment

8. No gaps or voids when bent

UNACCEPTABLE FUSIONS

9. Insufficient heat time; melt bead too small

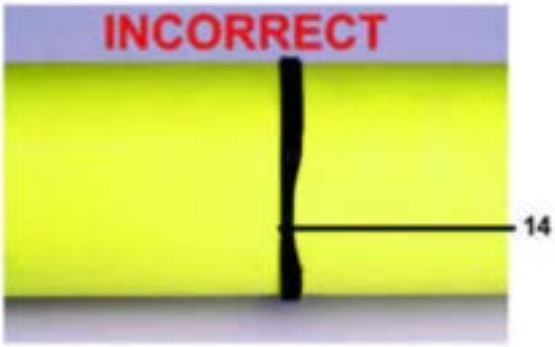
10. Excessive heat time or pressure applied during heating; melt bead too large



11. Pipe angled into fusion unit

12. Improper "High-Low" alignment

13. Incomplete face off or failure to remove faced off ribbons



14. Incomplete face off

SADDLE FUSION

SADDLE FUSION TO A PRESSURIZED MAIN (HOT TAPPING)

As identified in the Introduction, this saddle fusion procedure applies to field fusion of Performance Pipe service saddles, tapping tees and branch saddles.

WARNING: The possibility of gas main blowout increases when internal pressure is higher, when the pipe wall is thinner (higher DR) and when the temperature of the main is elevated.

When saddle fusing to a pressurized gas main, gas main internal pressure must not exceed pressure limits specified in Federal regulations (MAOP).

- *For Federally regulated gas applications in the United States, main pressure must be reduced for elevated temperature when the main temperature exceeds 100°F (38°C).*
- *For Federally regulated gas applications in Canada, main pressure must be reduced for elevated temperature when the main temperature exceeds 23°C (73°F).*

Saddle fusion to pressurized gas mains is not recommended for 3" IPS (89mm) mains with DR's above 13.5 and 4" IPS (110 mm) and larger mains with DR's above 17.

REQUIRED EQUIPMENT

- ✓ A saddle fusion machine (application tool/unit) with appropriate clamps for the main pipe and saddle fitting. Use a main bolster or support for 6" IPS (160 mm) and smaller main pipes.
- ✓ **When saddle fusing to a pressurized main, the saddle fusion machine must have a gauge or mechanism that indicates the force applied when the saddle base is pressed against the heating tool or the main.**
- ✓ A heating tool with faces contoured and correctly sized for the main pipe and the fitting base. Both serrated and smooth heater faces will produce quality saddle fusions with the serrated heater faces being preferred.
- ✓ 50-60 grit utility cloth.
- ✓ Timing equipment such as a stopwatch or watch with a sweep second hand when fusing to 2" IPS and smaller mains.

WARNING: Using improper or faulty equipment or failing to follow correct saddle fusion procedure during saddle fusion to a pressurized main can result in death, serious injury or property damage.

Important: Saddle fusion machines, tools and equipment from different manufacturers will operate differently. Follow the machine manufacturer's instructions for proper use and operation of the equipment.

SET-UP PARAMETERS

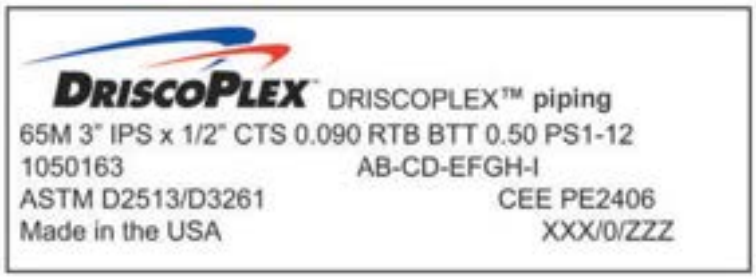
- ✓ Heating tool surface temperature – **minimum 490°F (255°C); maximum 510°F (265°C)**
- ✓ ***Low heating tool temperature can lead to a blowout during saddle fusion to a pressurized main.*** Before you begin, all points on both heating tool surfaces must be within the prescribed

minimum and maximum temperatures where the heating tool surfaces will contact the main or the fitting. Heating tool surfaces must be clean.

SADDLE FUSION PARAMETERS

Saddle fusion bead-up force, heating force and joining force are printed on the fitting label.

Figure 4 Example Fitting Label



Bead-Up Force. During bead-up, force is applied to form an initial melt pattern on the main and the fitting base. Bead-up ends when melt is visible at the top center of the main on both sides of the heating tool. Bead-up force should not be applied for more than about 1/3 of the total heating time. The bead-up force in pounds is the first number on the fitting label.[3] See Figure 4.

Heating Force. The heating force is always zero. During heating, the fitting, heating tool and main are held together, but without applying force. The heating force is the second number on the fitting label (as depicted in Figure 4 as "0").[3 4]

Joining Force. Joining force is applied to the fitting against the main immediately after the heating tool is removed. Joining force is half the bead-up force. The joining force is the third number on the fitting label.[3] See Figure 4. Joining force must be maintained for the duration of the first cooling time period. ***Caution – Never reduce joining force during the first cooling time period. Reducing joining force during the first cooling time period may result in blowout during hot tapping.*** If the saddle fusion machine force gauge reading rises during the minimum cooling time period, allow it to do so. See Table 3 for Minimum Cooling Time.

Maximum Heating Time. Heating time starts when the heating tool is first applied to the main. Heating time ends when the heating tool is removed from in-between the main and the fitting. When hot tapping 2" IPS and smaller mains, a timing device such as a stopwatch or watch with a sweep second hand is necessary for measuring heating time. See Table 3 for Maximum Heating Time.

WARNING – When saddle fusing to a pressurized main, blowout may occur if maximum heating time is exceeded.

Minimum Cooling Time. Cooling time is two successive cooling time periods. During the first cooling time period, joining force is applied with the saddle fusion equipment. ***WARNING – Never reduce joining force during the first cooling time period, even if joining force increases on its own.*** At the end of the first cooling time period, the application tool may be removed. During the second time period, the joint must be allowed to cool undisturbed. After the second cooling time period, the

[3] When using hydraulic combination units for saddle fusion, Bead-Up, Heating or Joining Force (lbs) may be converted to hydraulic gauge pressure (psi) by dividing Bead-Up, Heating or Joining Force by the carriage cylinder piston area. Obtain the carriage cylinder piston area from the combination unit manufacturer.

service or branch line may be connected, or pressure leak tests or tapping may be conducted. See Table 3 for Minimum Cooling Time.

Table 3 Maximum Heating Time and Minimum Cooling Time

Main Size	*Maximum Heating Time*	*Minimum Cooling Time*
1-1/4" IPS all DR's	Stop heating when about 1/16" bead is visible all around fitting base. ***Do not exceed 15 sec when hot tapping.***†	5 min◊ + 20 min∆
2" IPS all DR's	Stop heating when about 1/16" bead is visible all around fitting base. ***Do not exceed 35 sec when hot tapping.***†	10 min◊ + 20 min∆
3" IPS and larger	Stop heating when about 1/16" bead is visible all around fitting base.	10 min◊ + 20 min∆
4" IPS and larger	Typically stop heating when 1/8" bead is visible. On large saddle fittings the melt bead may be larger.	10 min◊ + 20 min∆

† ***Warning – During saddle fusion to a pressurized main, blowout may occur if maximum heating time is exceeded.***
◊ ***Warning – Never reduce joining pressure during the first cooling time period – Main blowout may occur.***
∆ The service or branch line may be connected, and tapping or pressure tests may be conducted after the second cooling time period. Larger base fittings may require additional cooling time.

PROCEDURE

1. Preparation

Determine saddle fitting location – The area of the main pipe where the saddle fusion machine and the fitting will be located must be clean, dry, and free of deleterious nicks, gouges, or cuts[4]. The application tool must fit on the main pipe without interference or restriction from components or appurtenances, fusion beads or the like. Remove dirt and foreign materials from the main pipe surface. If below grade, the excavation must be large enough to install and operate the Saddle Fusion Machine. The main pipe must not be curved tighter than 100 pipe diameters bending radius.

WARNING: Observe all applicable codes, regulations and safety precautions when working in trenches or other excavations and when working with pressurized gas lines.

a) Install the saddle application tool on the main pipe according to the tool manufacturer's instructions. The saddle application tool should be centered at the location where the fitting will be fused.

b) Abrade the fusion surface of the fitting base, and the mating fusion surface of the main pipe with 50-60 grit utility cloth. On the main surface, abrade a surface area that is the size of the fitting base plus about 1/2-in (13 mm) per side all around. It is necessary to completely remove a thin layer of material from both surfaces. After abrading, brush the residue away with a clean, dry cloth. *Do not touch abraded and cleaned surfaces with your hands.*

   Regular replacement of the Utility Cloth is necessary. Worn or dirty utility cloth will not abrade the surface properly. Poor surface preparation can cause poor fusion quality.

[4] If used, alcohol wipes are used only before abrading the surface, never after abrading the surface. The surface should be wiped dry with a clean, dry non-synthetic (cotton) cloth or paper towel after using the alcohol wipe.

c) Install and lightly clamp the fitting in the saddle application tool. (Tapping tee caps may need tightening.) Move the fitting base against the main pipe, and apply moderate force (around 100 lbs) to seat the fitting against the main pipe and in the application tool. It may be necessary to wiggle the fitting a little to be sure it is completely seated and squarely aligned against the main. While maintaining force, secure the fitting in the saddle application tool. Move the fitting away from the main pipe.

2. Heating

WARNING: Heating and fusing must be performed accurately and quickly, especially when saddle fusing to a pressurized main pipe. Overheating or excessive time between actions can cause a blowout.

WARNING: Do not interrupt heating to inspect the melt pattern on the main pipe. When fusing to a pressurized main, this can overheat the main pipe and cause a blowout.

✓ Determine saddle fusion forces from the fitting label.

✓ Verify that the heating tool is maintaining 490-510°F (255-265°C) surface temperature.

✓ Check that heating tool surfaces are clean.

d) ***In a quick, continuous operation***, center the heating tool beneath the fitting base, place the heating tool on the main, move the fitting against the heating tool, apply the Bead-up Force and begin timing. *This operation should take less than 5 seconds.*

e) At the first visual indication of main pipe melt at the curved center of the heating tool face on the main (at the crown of the main), reduce Bead-Up Force to Heating Force. Continue timing.

3. Fusion and Cooling

f) When the heating time ends, ***QUICKLY*** separate the heating tool from the fitting and the main pipe, and remove the heating tool.

- Saddle fusion machines from different manufacturers may require particular techniques for separating the heating tool from the fitting and the main pipe without disturbing the melt. See the saddle fusion machine manufacturer's instructions.
- A melt bead of about 1/16" (1.5 mm) or more should be visible around the fitting.

g) ***QUICKLY*** inspect the melt on the main pipe and the fitting base, and (within 3 seconds) move the fitting against the main pipe, and apply Joining Force. Maintain Joining Force for the first cooling time period.

- *The surfaces of the main and the fitting base should be completely melted.*
- ***Regardless of the main pipe or fitting melt condition, QUICKLY join the fitting to the pipe, and apply and maintain Fusion Joining Force for the first cooling time period.***

WARNING: Blowout – Always join the fitting to a pressurized main pipe after heating. If the fitting is not joined to the main pipe immediately after heating, the pressurized main pipe may rupture.

- ***After Fusion Joining Force has been applied, NEVER reduce Fusion Joining Force until the first cooling time period has ended.*** Do not reduce the application tool Joining Force setting if the value on the application tool gauge rises.
- The saddle fusion machine may be removed after the first cooling time period has ended.

j) Cool undisturbed for an additional 20 minutes (the second cooling time period). During this time, avoid pressure testing, rough handling, tapping and connecting to the branch outlet. *Do not try to shorten cooling time by applying water, wet cloths or the like.*

4. Inspect

- *If the melt on the main pipe or the fitting base was unacceptable, the saddle fusion should not be placed in service.* To prevent use, the fitting should be cut off near the fitting base. Do not attempt to remove the saddle-fitting base. Leave it in place to reinforce the main pipe. Move to a new location on the main pipe, and install a new saddle fitting. Follow the complete saddle fusion procedure when installing the new saddle fitting in the new location.

k) Visually check the fusion bead around the entire fitting base at the main pipe. The fusion bead should be uniformly sized all around the fitting base, and should have a characteristic “three-bead” shape. The first bead is the fitting base melt bead. The second or outermost bead is produced by the edge of the heating tool face on the main. The third or center bead is the main pipe melt bead. The first and third beads should be about the same size all around the fitting base. The second bead is usually smaller, but should also be uniformly sized around the fitting base.

Table 4 Saddle Fusion Bead Troubleshooting Guide

Observed Condition	*Possible Cause*
Non-uniform bead size around fitting base	Misalignment; Defective heating tool; Loose or contaminated heating tool saddle faces; Worn equipment; Fitting not secured in application tool; Heating tool faces not within specified temperature
One bead larger than the other	Misalignment; Component slipped in clamp; Worn equipment; Defective heating tool; Loose or contaminated heating tool saddle faces; Heating tool faces not within specified temperature
Beads too small	Insufficient heating; Insufficient joining force
Beads too large	Excessive heating time; excessive force
No second bead (or outermost bead)	Incorrect pipe main heating tool face
Serrated bead appearance	Normal for serrated heating tool faces
Smooth bead appearance	Normal for smooth heating tool faces
Pressurized main pipe blowout (beside base or through fitting center)	Overheating; Incorrect heating tool faces; Heating tool faces not within specified temperature; Taking too much time to start heating (Step 2e), or to remove the heating tool and join the fitting to the main pipe (Step 3g);
Rough, sandpaper-like, bubbly, or pockmarked melt bead surface	Hydrocarbon contamination
No third (or center) bead	Insufficient joining force

Saddle Fusion Qualifying Procedure

1. Prepare at least two sample joints. The main pipe length should not be less than 2’ (610 mm) or seven times the maximum saddle fitting base dimension, whichever is greater. Center the fitting on

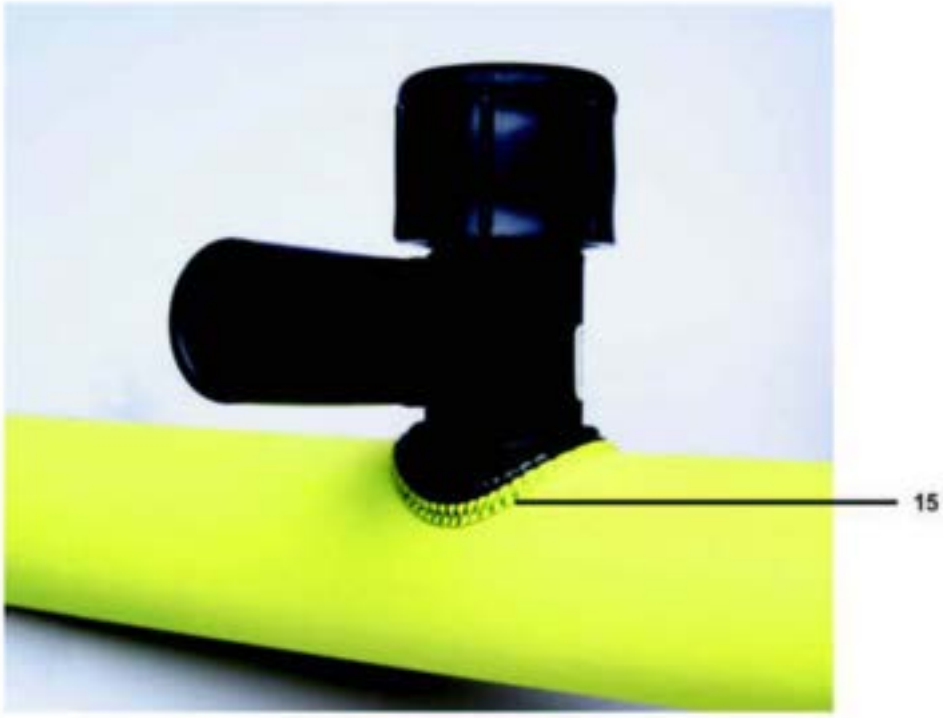
the main pipe length. Observe the joining process to determine that the correct procedure is being followed.

2. Visually inspect the sample joints and compare them to a sample or picture of an acceptable joint.
3. Allow the sample joints to cool for no less than one hour. Do not tap (pierce) the main through the saddle fitting center hole.
4. Cut one sample joint lengthwise along the main pipe and through the saddle fitting to prepare a strap. The cuts should be made near the edge of the fitting center hole so the resulting strap is not quite as wide as the center hole.
5. Visually inspect the cut surface at the joint and compare to a sample or picture of an acceptable joint. There should be no gaps, voids, misalignment, or unbonded areas.
6. Bend the strap 180° until the ends touch.
7. If flaws are observed in the sample joints, compare appearance with pictures of unacceptable joints. Prepare new sample joints using correct joining procedure, and repeat the qualifying procedure.

Alternate Saddle Fusion Qualifying Procedure

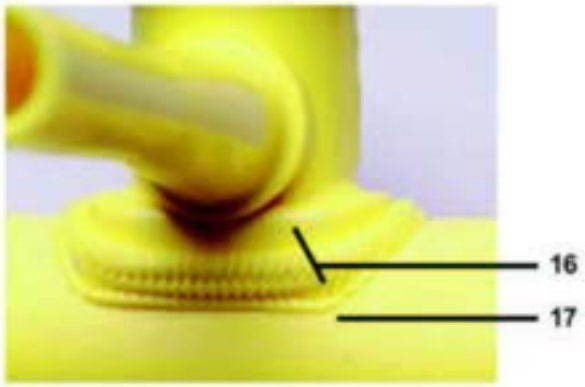
1. Test a sample joint by impact against the saddle fitting. Failure must occur by tearing the fitting or bending the fitting at least 45º or removing a section of wall from the main pipe. Failure along the fusion bond line is not acceptable. (Federal regulations require impact tests for procedure qualification, but not for individual qualification.) Refer to ASTM F905.

Acceptable Appearance

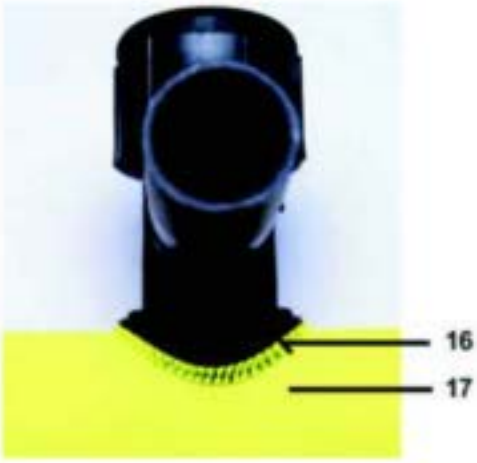


15. Proper alignment, force and melt

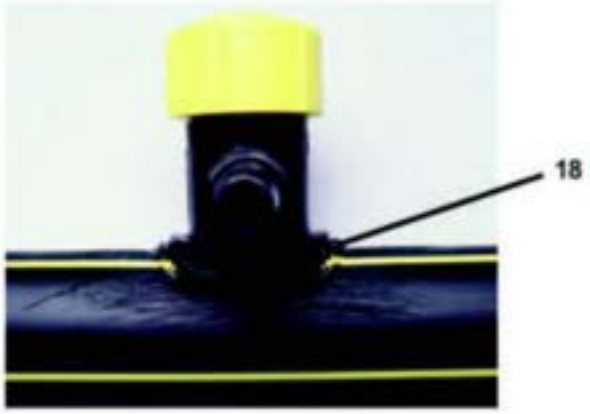
ACCEPTABLE FUSIONS



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

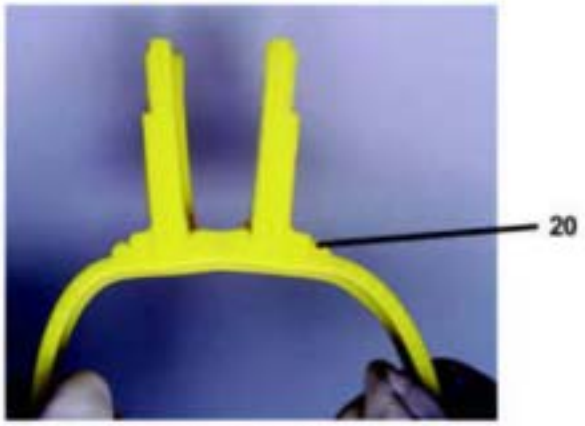


16. Proper alignment, force and melt
17. Proper pipe surface preparation

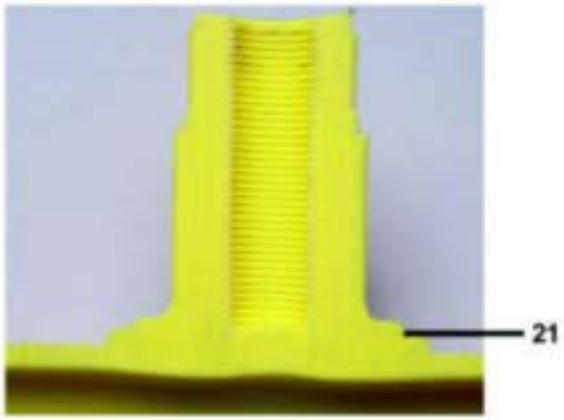


18. Melt bead below or parallel with top of fitting base

19. Material pulled from pipe when impact tested



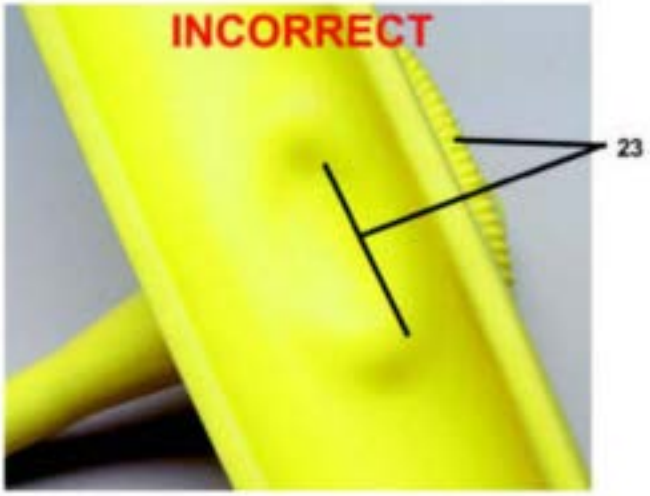
20. No gap or voids when bent



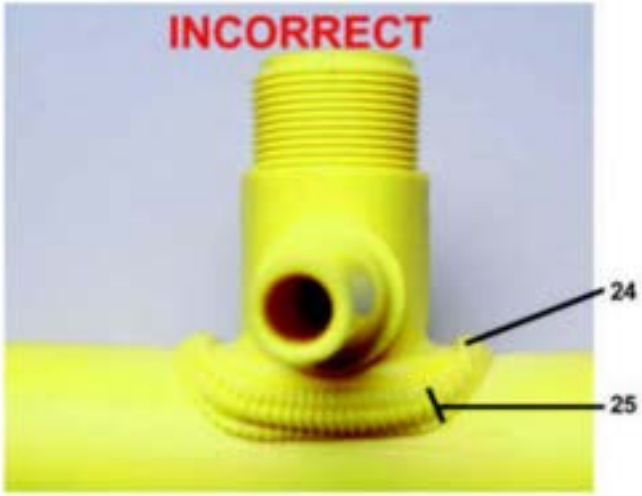
21. No gap or voids at fusion interface

UNACCEPTABLE FUSIONS

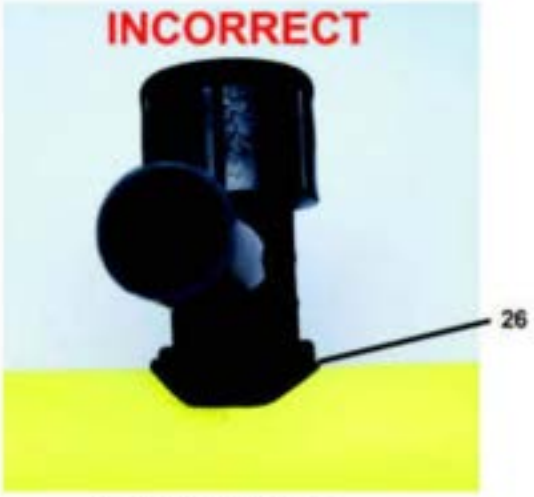
22. Insufficient melt and misaligned



23. Excessive melt and force



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



26. Insufficient melt

SOCKET FUSION

Required Equipment

This procedure requires: Chamfering Tool, Depth Gauge (some manufacturers combine Chamfering Tool and Depth Gauge), Cold Ring Clamp, Heating Tool with male and female socket faces, timing equipment (such as a watch with a second hand). Holding tools are desirable for 2" IPS (90 mm OD) and larger pipe and fittings. Clean work gloves are suggested.

- Heating tool male and female socket faces should meet ASTM F 1056 *Socket Fusion Tools for Use in Socket Fusion Joining Polyethylene Pipe or Tubing and Fittings*.

SET-UP PARAMETERS

HEATING TOOL SURFACE TEMPERATURE – MINIMUM 490°F (255°C); MAXIMUM 510°F (265°C)

✓ Where heating tool surfaces will contact the main or the fitting, all points on both heating tool surfaces must be within the prescribed minimum and maximum temperatures before you begin.

✓ Molten PE material may be cleaned from heating tool faces with a wooden implement such as a tongue depressor. To remove burned or charred material from socket faces, heat the faces, insert a short length of pipe or tubing into the female face, and a socket fitting onto the male face, then unplug the heating iron and let it cool completely. When the pipe or tubing and the fitting are removed from the cold heating tool, the burned or charred material will come off with them.

Procedure

1. Preparation

✓ Heating Tool Socket Faces at specified temperature – 490-510°F (255-265°C). The male and female socket faces on the heating tool must be clean.

✓ Square end cut - The pipe or tubing end must be squarely cut. If the end is not squarely cut, use a plastic pipe cutter or hand saw and cut the pipe or tubing end squarely.

- When using a wheel-type pipe cutter, be sure the cutter wheel does not thread down the pipe – cut off all partial cuts before fusion.
- On larger pipes, toe-in may need to be removed before fusion.

a) Chamfer OD - For all pipe and tubing sizes, chamfer the end to remove the sharp outer edge on the OD. Remove all burrs from inside of pipe ends. Make sure the pipe or tubing end is clean, dry, and free of foreign substances. Wipe with a clean, dry, lint-free cloth or paper towel. Do not touch cleaned surfaces with your hands.

b) Install Depth Gauge & Cold Ring Clamp - Place the Depth Gauge snugly over the chamfered end of the pipe, and clamp the Cold Ring Clamp on the pipe or tubing OD immediately behind the Depth Gauge. Remove the Depth Gauge.

c) Clean fitting socket - Wipe the fitting socket with a clean, dry, lint-free cloth or paper towel. Do not touch cleaned surfaces with your hands.

d) Review Table 6 for recommended heating and cooling times.

✓ In socket fusion, there is an interference fit between the pipe or tubing and the socket, that is, the socket is slightly smaller than the pipe. They won't fit together cold.

- ✓ Heating tool faces are tapered which produces a tapered melt. Therefore, the pipe or tubing and the fitting will tend to push away from the heating tool during heating, and will tend to push apart when first joined together. It is necessary to hold the pipe and fitting against the heater faces during heating, and to hold them together when fusing.
- ✓ When using a socket coupling to join coiled pipe, if possible "S" the pipes on either side of the coupling to compensate for coil curvature and make it easier to join the second pipe to the coupling.

2. Heating

e) Verify that the heating tool is maintaining the correct temperature.

f) Push the socket fitting onto the male socket face. The socket fitting must bottom out completely and be held against the back surface of the male heater face.

g) Push the pipe or tubing end into the female socket face. The Cold Ring Clamp must be completely against the female socket face, and held in place.

h) Heating time starts when the cold ring is against the female heater face.

i) Hold the fitting and the pipe or tubing in place against the heater faces for the Table 6 heating time. **DO NOT TWIST PIPE, FITTING, OR HEATING TOOL.**

3. Fusing

j) At the end of the heating time, ***QUICKLY*** remove the pipe from the Heating Tool, then the fitting from the Heating Tool. **Snap them straight off** with a sharp rap on the Heating Tool handle.

- *Important:* Remove the pipe and the fitting straight out from the Heating Tool faces. Do not displace the melt. If the pipe or fitting are removed at an angle or twisted, melt can be displaced, and the joint may leak or fail. Grasp the pipe behind the cold ring clamp. Pulling on the cold ring clamp handle can cause slippage or displace the melt.

k) ***QUICKLY*** check the melt pattern on pipe end and the fitting socket. The surfaces should be 100% melted with no cold spots.

- If the melt is not complete, do not continue with the joint. Cut off the melted pipe end, use a new fitting and start over from Step 1. *Do not re-use a melted fitting.* If the melt is correct, continue the joining procedure.

l) Within 3 seconds after removing from the Heating Tool, firmly push the pipe end and the fitting socket straight together until the Cold Ring Clamp makes firm contact with the end of the fitting socket.

- Grasp the pipe behind the cold ring clamp. Pushing on the cold ring clamp handle can cause slippage or a crooked joint.

m) Hold the pipe and fitting firmly together for the Table 6 cooling time. **DO NOT TWIST PIPE OR FITTING.**

- *Important:* Push the pipe and fitting straight together. If joined at an angle or misaligned, the joint may leak or fail.

4. Cool

n) Holding force may be relaxed when Table 6 cooling time ends. After an additional 3 minutes undisturbed cooling time, the Cold Ring Clamp may be removed. Allow an additional l0 minutes undisturbed cooling time before testing, backfilling, or stressing the joint.

- Total cooling time is the Table 6 cooling time (joint held together firmly), plus 13 minutes.

o) Clean heater faces carefully after each fusion with a wooden implement such as a tongue depressor to remove any molten PE from the male and female socket faces.

Table 6 Socket Fusion Heating & Cooling Times

Pipe Size	*PE 2406*		*PE 3408*	
	Heating Time, seconds	*Cooling Time, seconds*	*Heating Time, seconds*	*Cooling Time, seconds*
1/2" CTS	6 – 7	20	6 – 10	30
3/4" CTS	6 – 7	20	6 – 10	30
1" CTS	9 – 10	20	9 – 16	30
1-1/4" CTS	10 – 12	20	10 – 16	30
1/2" IPS	6 – 7	20	6 – 10	30
3/4" IPS	8 – 10	20	8 – 14	30
1" IPS	10 – 12	30	15 – 17	40
1-1/4" IPS	12 – 14	30	18 – 21	40
1-1/2" IPS	14 – 17	30	20 – 23	40
2" IPS	16 – 19	30	24 – 28	40
3" IPS	20 – 24	40	28 – 32	50
4" IPS	24 – 29	40	32 – 37	50

5. Inspect

p) Inspect the end of the socket fitting at the pipe. There should be a clear impression of the Cold Ring Clamp into the melt ring at the end of the fitting, with no visible gaps or voids around the pipe at the socket melt ring.

q) The pipe and fitting should be aligned straight with each other.

Table 7 Socket Fusion Troubleshooting Guide

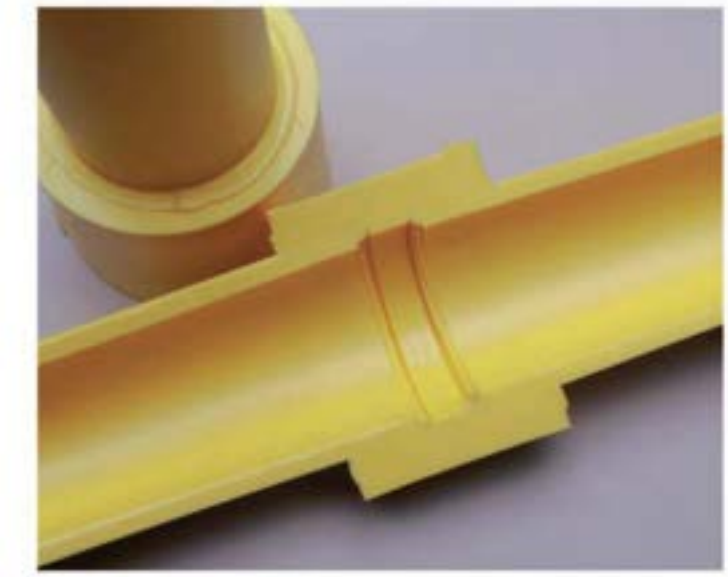
Observed Condition	*Possible Cause*
No cold-ring impression in socket fitting melt bead	Depth gauge not used; Cold ring not used, or set at incorrect depth; Insufficient heat time
Gaps or voids around pipe at socket fitting edge	Pipe or fitting not removed straight from heater face (twisting or removing from heater face at an angle); Pipe or fitting not inserted straight into each other when fusing; Joining together at an angle; Twisting while joining pipe and fitting together; Cold ring not used or set too deep
(When viewed from inside, or when qualifying lengthwise cut joint) Wrinkled or collapsed pipe or tubing end	Incorrect heating sequence – always push the pipe or tubing into the heater ***after*** the fitting has been pushed on the heater (inserting the tubing first heats the tubing too long); Cold ring set too deep; Cold ring not used
(When qualifying lengthwise cut joint) voids in fusion bond area	Pipe or fitting not removed straight from heater face (twisting or removing from heater face at an angle); Pipe or fitting not inserted straight into each other when fusing; Joining together at an angle; Twisting while joining pipe and fitting together; Cold ring not used or set too deep
(When qualifying lengthwise cut joint) Unbonded area on pipe or tubing at end of pipe or tubing	Cold ring not used or set too deep

Observed Condition	*Possible Cause*
(When qualifying lengthwise cut joint) Socket melt extends past end of pipe or tubing	Cold ring set too shallow
Rough, sandpaper-like, bubbly, or pockmarked melt bead surface	Hydrocarbon contamination

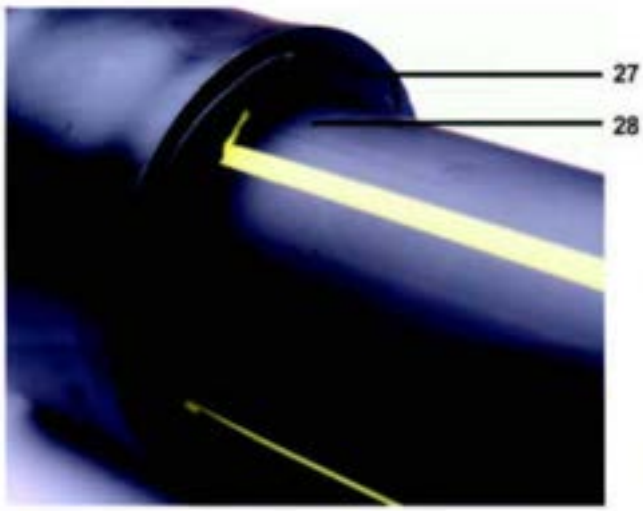
Socket Fusion Qualifying Procedure

1. Prepare a sample such as a coupling with pipe or tubing socket fused to both ends. Pipes on either side should be at least 6” (150 mm) or 15 times the wall thickness in length. Observe the joining process to determine that the correct procedure is being followed.
2. Visually inspect the sample joint(s) and compare to a sample or picture of an acceptable joint.
3. Allow the sample joint(s) to cool for no less than one hour.
4. Cut the sample joint lengthwise along the pipe into at least three straps that are at about 1” (25 mm) or 1.5 wall thicknesses wide.
5. Visually inspect the cut surface at the joint and compare to a sample or picture of an acceptable joint. There should be no gaps, voids, misalignment, or unbonded areas.
6. Bend the straps 180°.
7. If flaws are observed in the joint, compare appearance with pictures of unacceptable joints. Prepare a new sample joint using correct joining procedure, and repeat the qualifying procedure.

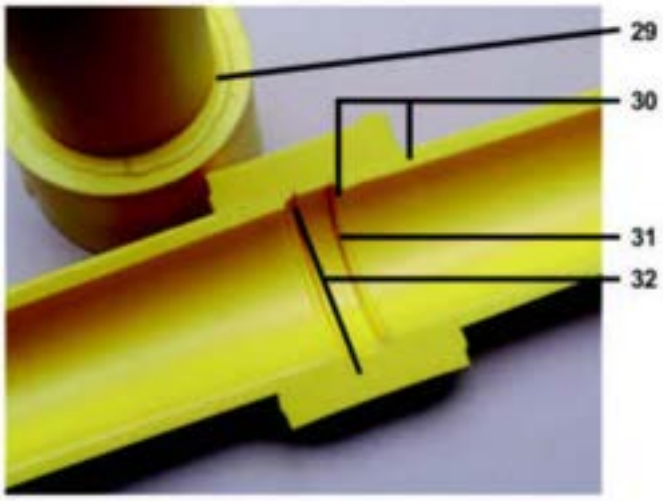
Acceptable Appearance



ACCEPTABLE FUSIONS

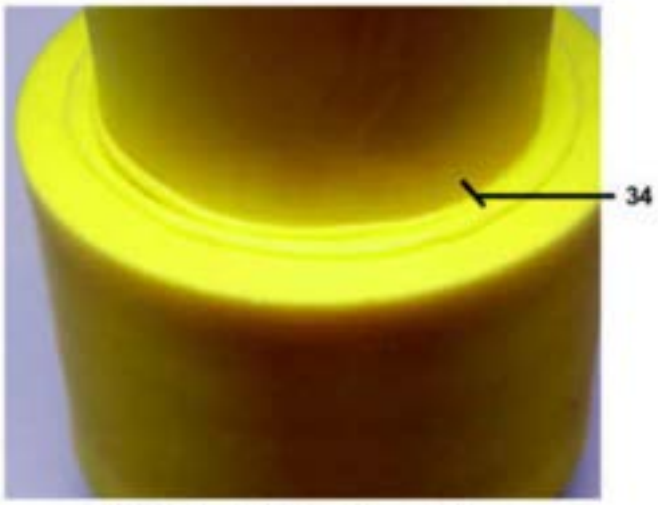


27. Melt bead flattened by cold ring
28. No gaps or voids



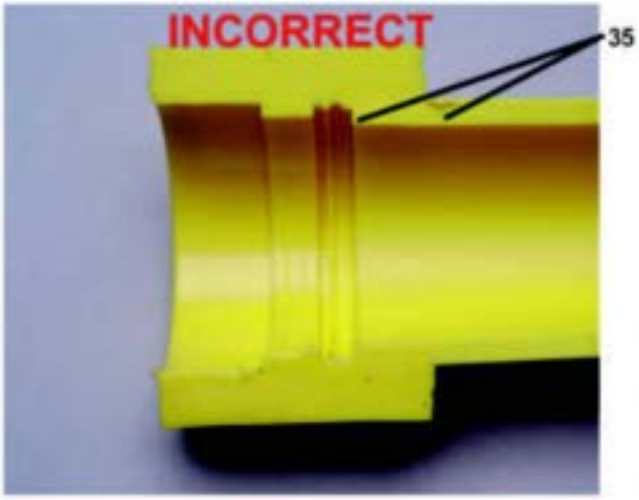
29. No gap or voids
30. Proper insertion depth
31. Acceptable internal fusion bead
32. Complete internal melt bead

33. No gap or voids

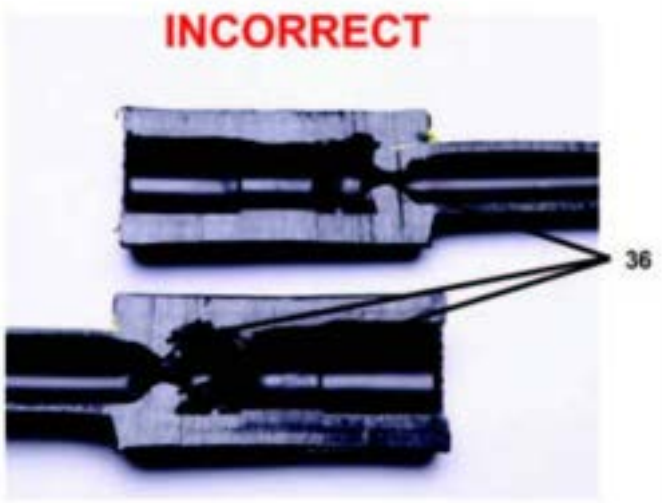


34. Melt bead flattened by cold ring

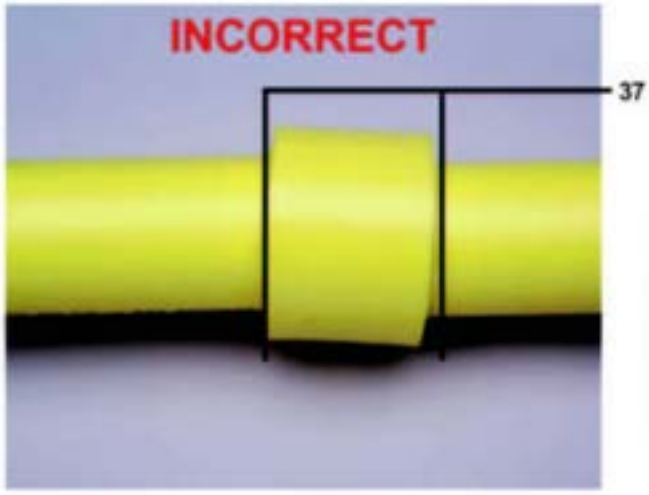
UNACCEPTABLE FUSIONS



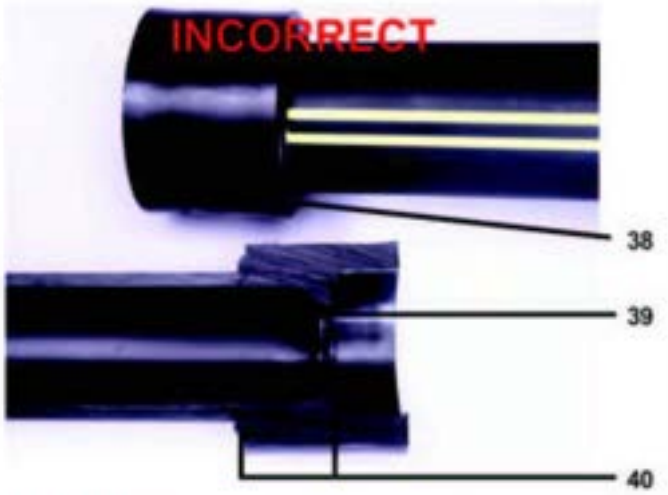
35. Improper insertion depth/short stab depth



36. Excessive heating



37. Misalignment



38. Melt bead not flattened against fitting/no cold ring
39. Improper insertion depth/no cold ring
40. Excessive heating

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* Additional product literature will be available upon completion. Visit www.driscoplex.com for the latest completed literature.