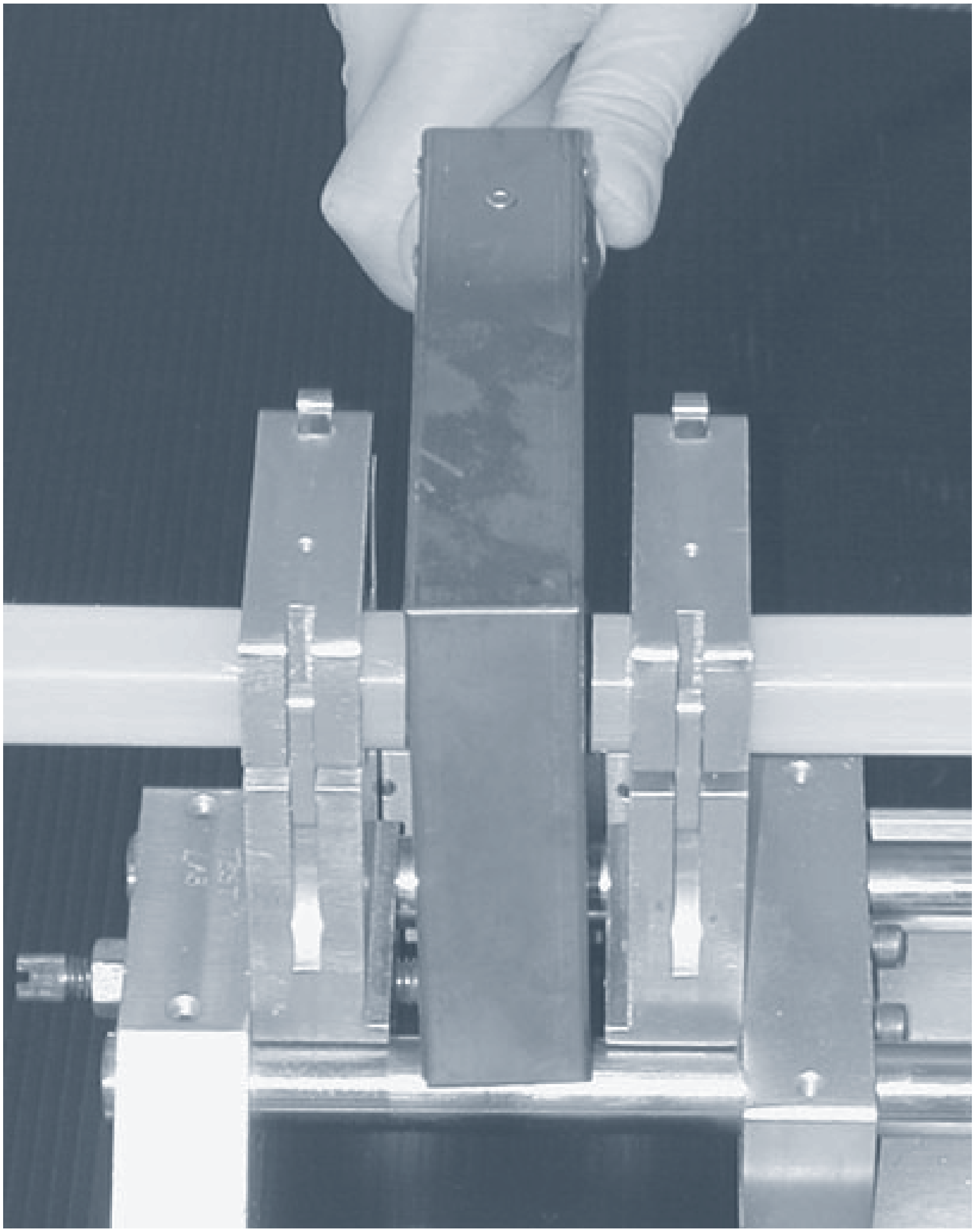
PureBond® Welding Tool

Operations manual



Entegris

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INTRODUCTION

PureBond® pipe components were the first weld-able pipe products of PFA. Entegris developed these products in response to industry requests for a pipe system that is totally leak proof and has all of the chemical inertness of PFA. We used our expertise with PFA and fluid handling to design and produce PureBond pipe products using a total system approach. Entegris developed a complete line of system components including Schedule 40 pipe, Schedule 80 pipe, fittings, valves, and accessories.

During the development of PureBond pipe products, design considerations included versatility and ease of installation. As a result, PureBond pipe welding equipment is portable, lightweight, and easy to use.

PureBond pipe components are manufactured from PFA so they are chemically resistant and inert. PureBond pipe will not deteriorate or leach; thus, they will not contaminate your process chemicals or pure water.

PATENTED PROCESS

Entegris has designed a unique PureBond pipe welding process. Because PFA does not adapt well to conventional welding techniques, a PureBond pipe weld is made with a patented noncontact welding method (U.S. patent no. 4,929,293). The PureBond pipe welding tool heats the ends of the pipe, fitting, or valve to be joined to a molten state, and presses them together.

Our PureBond pipe welding process eliminates installation variables. The PureBond pipe welding tool holds pipe, fittings, and valves in alignment. A facing tool presets the distance the parts extend into the welding tool, and welding tool guides ensure the heater is centered. Preset locking prevents molten ends from being pressed too far together. The result of the PureBond pipe welding process is bonds of consistent quality.

The PureBond pipe weld eliminates threads so there is no danger of cold flow and its resultant leakage. These welds are as strong as the pipe, giving you a safer system than you get with a threaded system.

Entegris has technical personnel available to consult regarding PureBond pipe custom component and assembly design.

NOTE: PureBond weldable pipe products are specifically designed, tested, and characterized from a material standpoint to work with PureBond fitting and pipe components manufactured by Entegris. Customer assumes the risk of proper fit and weld connection integrity if PureBond weldable pipe products are connected to components manufactured by third parties. Further, customer will assume the risk of proper fit and weld connection integrity if PureBond weldable pipe products are joined using tools that are not either manufactured by or endorsed in writing by Entegris.

BUTT WELDING METHOD

The butt welding method used on PureBond pipe products is an uncomplicated, visual procedure with straightforward instructions. No timing cycles are necessary. The visual procedure allows the operator to concentrate on the work rather than a clock. Visually, the operator can tell when the ends have melted to the required degree for welding.

The principle behind the butt welding method is to heat two surfaces using a noncontact heater to a welding temperature, make contact between the two surfaces, and allow the two surfaces to fuse by application of pressure. The pressure causes flow of the melted materials, which affects mixing and thus welding. Upon cooling, the original interfaces are gone and the two parts are united. Nothing is added to or changed chemically between the two joined pieces.

For consistently strong welds, you must adhere to the following procedures. Entegris recommends that no person weld PureBond pipe products for service unless that person fully understands the welding procedures.

FACILITIES AND ENVIRONMENT

Use the tool in a clean, dry area that is protected from drafty conditions. Normal workplace ventilation is usually acceptable. Drafts may cause uneven heating of the pipe ends resulting in poor weld quality. (See *Guide to the Safe Handling of Fluoropolymer Resins, Society of the Plastics Industry, Inc.*)

To reduce weld contamination and create an operator-safe environment, use the tool on a flat, clean bench or cart. Always use specified voltage to connect heater (see table below). If possible, connect to a voltage that is within ±5% of rating.

WELDING TOOLS ORDERING INFORMATION

25.4 mm (1") benchmount kit

Part number*	Voltage	Cycles	Power
213-67	120 VAC	50/60 Hz	1280 Watts
213-68	100 VAC	50/60 Hz	1280 Watts
213-69 †	230 VAC	50/60 Hz	1280 Watts

Replacement parts

Part number*	Description
213-47	25.4 mm (1") facing tool
1223-014	Right replacement blade
1223-015	Left replacement blade
213-33	12.7 mm (½") gauging tool
213-34	19.05 mm (¾") gauging tool
213-35	25.4 mm (1") gauging tool
213-42	Pipe shear with spacer plate
213-31	Heater holder
213-48	Thin clamp assembly
1220-003	12.7 mm (½") inserts – standard
1220-004	19.05 mm (¾") inserts – standard
213-28	25.4 mm (1") kit with all parts
1220-079	12.7 mm (½") inserts – thin
1220-078	19.05 mm (¾") inserts – thin
213-44	120 VAC heater
213-45	100 VAC heater
213-46 †	230 VAC heater
1220-179	6.35 mm (¼") inserts – thin
213-84	6.35 mm (¼") kit with all parts
1223-027	Replacement chain for 25.4 mm (1") facing tool
215-164 shears	Replacement spring for standard pipe
213-212	Heat shield

50.8 mm (2") benchmount kit

Part number*	Voltage	Cycles	Power
213-70	120 VAC	50/60 Hz	1280 Watts
213-71	100 VAC	50/60 Hz	1280 Watts
213-72 †	230 VAC	50/60 Hz	1280 Watts

Replacement parts

Part number*	Description
213-51	50.8 mm (2") facing tool
1223-018	Replacement blades (need 2)
213-33	12.7 mm (½") gauging tool
213-34	19.05 mm (¾") gauging tool
213-35	25.4 mm (1") gauging tool
213-52	50.8 mm (2") gauging tool
213-30	Pipe shear – standard
1223-021	Replacement blades (set)
213-53	Pipe shear – 50.8 mm (2") pipe
213-31	Heater holder
1220-205	12.7 mm (½") inserts
1220-206	19.05 mm (¾") inserts
1220-207	25.4 mm (1") inserts
213-55	120 VAC heater
213-56	100 VAC heater
213-57 †	230 VAC heater
1223-028	Replacement chain for 50.8 mm (2") facing tool
215-164 shears	Replacement spring for standard pipe
213-212	Heat shield

Replacement parts available from the factory upon request.
**To lease a PureBond welding tool, add an "R" to the end of the part number.*
† *Heater is CE marked per Low Voltage Directive 73/23/EEC (EN60335-1 and EN60335-2-45).* CE

NOTE: Power supply cord on heater cannot be replaced. If cord is damaged, the appliance should be scrapped.

EQUIPMENT SETUP

25.4 MM (1") AND 50.8 MM (2") BENCHTOP WELDING TOOLS

1. Locate the heater stand in the heat shield to protect work surface and surroundings from intense heat. (Heat shield included with 230 VAC units; optional for other units.) Place the infrared heater in the stand **upside down** with bracket up (see Photo 1). (By storing the heater upside down, the heat will rise when you set the heater right side up in the welding tool, creating a more uniform heating surface.)

CAUTION: Remove all flammable objects within 60 cm (24") of the heater/heat shield.

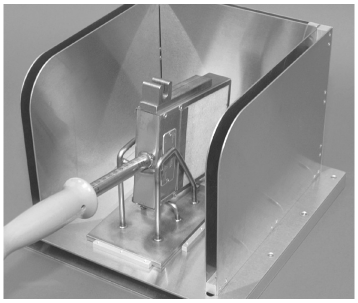


Photo 1.

2. To prevent heater damage, never allow either side of the heater's infrared surface to become blocked from radiating.
3 Be careful not to drop the heater as the quartz surfaces can crack. Also, be careful setting heater back in holder, as internal heater components can be damaged by repeated shock. If quartz plates become cracked, return heater to factory for repair.
4. Apply proper voltage to the heater. Adequate ampere service (15 ampere minimum) is required. Allow a minimum of 15 minutes for the heater to heat up.
5. Bolt or clamp the bench mount welding tool to a workbench or cart.
6. Install the proper size inserts onto the welding clamps for joining pipe and fittings (see Photo 2). If using 25.4 mm (1") tool, inserts are not needed for welding 25.4 mm (1") size components. No insert is needed on the 50.8 mm (2") tool when welding 50.8 mm (2") components.

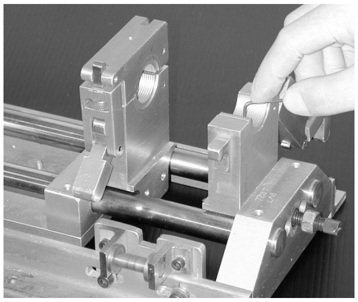


Photo 2.

25.4 MM (1") PUREBOND WELDING TOOL WITH STANDARD CLAMPS

Tool Maintenance

The PureBond welding tools require very little maintenance. A drop of oil on the sliding components is all that is required. The facing tools typically maintain their sharp edge for a long time and should not require sharpening. If blades do become dull or chipped, we recommend replacement. The welding tool can come slightly out of adjustment. The following instructions describe the steps necessary to bring the tool back to proper working order.

Welding Open Dimension

If uneven top to bottom heating occurs or the heater does not easily rotate out of place after welding pipe ends, the welding open dimension may need adjustment.

1. Loosen lock nut on open distance setscrew.
2. Adjust open distance setscrew to allow for precisely 50.8 mm (2") open dimension between clamps. Measure open dimension from inside edge of clamp jaws (see Photo 3).
3. Lock setscrew in place with lock nut.

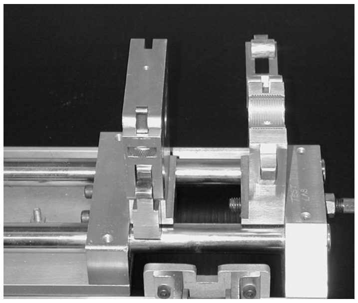


Photo 3.

Heater Bracket Adjustment

If the two sides of the pipe weld do not heat up evenly, an unacceptable, uneven weld will result. The heater bracket may need adjustment.

1. Install pipe into welding tool, gauge and face off.
2. Rotate nonenergized cold heater into position and observe alignment.
3. If the heater does not sit perpendicular to the pipe ends, gently apply pressure to the heater in the direction required. This will gradually form the sheet metal housing the bracket is connected to and will correct misalignment (see Photo 4).

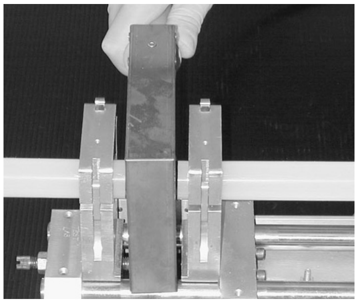


Photo 4.

4. Should the heater not be equidistant between the pipe ends, loosen the cap screws holding the angle brackets to the welding tool. Adjust in the direction required and retighten (see Photo 5).

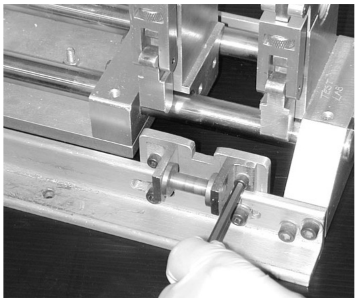


Photo 5.

5. Should the heater still not be equidistant or come in contact with the pipe when it is swung into place, loosen the cap screws holding the bracket to the heater (see Photo 6).
6. Adjust the heater in the direction required and retighten the bracket locking it in place.

Photo 6.

Pipe/Fitting Alignment

If the ends are not aligned properly while clamped in the welding tool, an unacceptable offset weld will result. The clamps holding the pipe may need alignment.

1. Loosen the two cap screws that hold the clamp opposite the sliding base plate assembly.
2. Push welding tool handle to the closed position and securely clamp a section of pipe approximately 152.4 mm (6") in length between both clamps (see Photo 7).
3. Retighten the two cap screws to lock the clamp in position. This will ensure proper component alignment during welding.

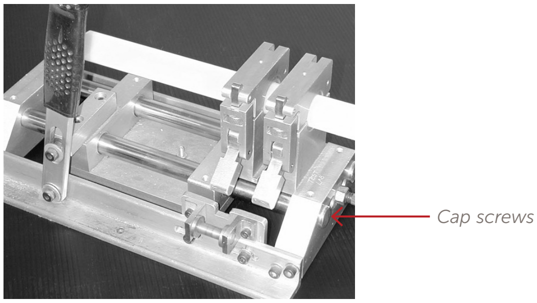


Photo 7.

25.4 MM (1") PUREBOND WELDING TOOL WITH THIN CLAMPS

Installation and Adjustment

1. Remove the standard width clamps from the bench mount welding tool.
2. Assemble the proper thin clamp to sliding base plate assembly and tighten cap screws securely (see Photo 8). Position clamp so as not to cause any binding in sliding base operation.

   NOTE: The two thin clamps are not interchangeable from side to side, and care should be taken to assemble so clamp latches face toward front of tool.

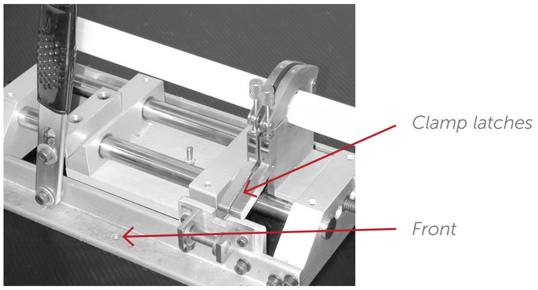


Photo 8.

3. Assemble the other clamp to the bench mount tool but **do not** tighten cap screws.
4. When joining pipe and fittings less than 25.4 mm (1") in size, install pipe inserts in clamps.
5. Push handle to closed position and secure a section of pipe approximately 152.4 mm (6") in length between both clamps. Clamping tension can be adjusted by rotating the thumb wheel on top of the clamp. (Be sure to unclamp pipe prior to adjusting.)
6. Securely tighten two remaining cap screws on clamp opposite the sliding base plate assembly. This will ensure proper component alignment during welding.
7. Remove pipe from clamps and allow sliding base plate assembly to return to open position. The bench mount tool is now ready for shortened welding distance operation.

   NOTE: When reinstalling standard width clamps to bench mount tool, observe same procedure as given for thin clamps installation.

8. Loosen lock nut on open distance setscrew.
9. Adjust setscrew to allow for precisely 42.0 mm (1.65") open dimension between thin clamps. Open dimension should be measured as indicated as shown in Photo 9.

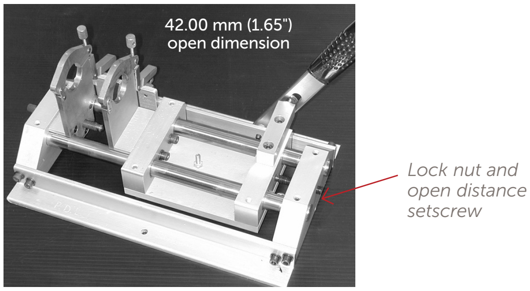


Photo 9.

10. Lock setscrew in place.

50.8 MM (2") PUREBOND WELDING TOOL

The PureBond welding tools require very little maintenance. All of the sliding and rotating components are self-lubricating and do not require additional attention. The facing tool blades typically maintain their sharp edge for a long time and should not require sharpening. If blades do become dull or chipped, we recommend replacement. Although unlikely, the welding tool can come slightly out of adjustment. The following instructions describe the steps necessary to bring the tools back to proper working order.

Welding Open Dimension

If uneven top to bottom heating occurs or the heater does not easily rotate out of place after facing pipe ends, the welding open distance may need adjustment.

1. Loosen lock nut on open distance setscrew.
2. Adjust open distance setscrew to allow for precisely 50.8 mm (2") open dimension between clamps (see Photo 10). Measure open dimension from inside edge of clamp jaws.

3. Lock setscrew in place with lock nut.

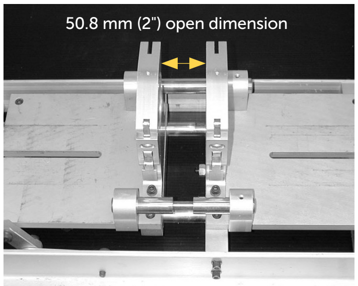


Photo 10.

Heater Bracket Adjustment

If the two sides of the pipe weld do not heat up evenly, an unacceptable weld will result. The heater bracket may need adjustment.

1. Install pipe into bench mount tool clamps, gauge and face off.
2. Rotate nonenergized cold heater into position and observe alignment.
3. If heater does not sit perpendicular to the pipe ends, gently apply pressure to the heater in the direction required. This will gradually form the sheet metal housing and will correct misalignment.
4. Should the heater not be equidistant between the pipe ends, loosen the setscrew on the right front pillow block as shown. Adjust hinging bar in the direction required and retighten (see Photo 11).

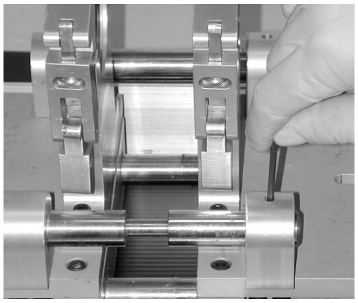


Photo 11.

5. Should the heater still not be equidistant or should the heater come in contact with the pipe when it is swung into place, loosen the cap screws holding the bracket to the heater (see Photo 12).

Photo 12.

6. Adjust heater bracket in the direction required and retighten the bracket locking it in place.

Pipe/Fitting Alignment

If the ends are not aligned properly while clamped in the welding tool, an unacceptable offset weld will result. The clamps holding the pipe may need adjustment.

1. Loosen the two cap screws that hold the clamp opposite the sliding base plate assembly.
2. Push welding tool handle to closed position and secure a section of pipe approximately 152.4 mm (6") in length between both clamps.
3. Retighten the two cap screws to lock the clamp in position. This will assure proper alignment of components during welding.
4. For proper alignment of sliding support clamps, loosen T-slot locking bolt. Place 457.2 mm (18") length of pipe across all four clamp bases, position sliding support clamps as needed and lock clamps in place.
5. Retighten T-slot locking bolt, unclamp and remove pipe.

WELDING STEPS

STANDARD AND MINIMUM WELDS

For standard welds, use the standard width clamps on either the 25.4 mm (1") or the 50.8 mm (2") PureBond welding tool. These clamps are used for general purpose welding and offer the best component support. They should be used for joining long and/or heavy lengths of pipe and fittings where additional support is required.

The thin clamp assemblies, available only on the 25.4 mm (1") PureBond welding tool, will allow users to significantly reduce the physical length between fittings.

NOTE: Thin clamps are the only clamps suitable for welding 6.35 mm (¼") pipe products.

Refer to *"25.4 mm (1") PureBond Welding Tool with Thin Clamps,"* page 6, for thin clamp installation instructions.

The facing and welding operations of the bench mount tool with thin clamps are identical to the standard clamp operation. There are, however, slight differences in the fitting preparation and gauging operation.

GAUGING USING STANDARD CLAMPS

1. Cut pipe to the desired length using the ratchet style pipe shears provided (see Photo 13).

Photo 13.

2. Place the two parts that are to be welded into the clamps and lock in place. Locking force can be adjusted with thumb wheel. (To adjust the thumb wheel, the clamp must be unlocked.)
3. **25.4 mm (1") Bench Mount**

   Place the proper size gauging tool — 12.7 mm (½"), 19.05 mm (¾") or 25.4 mm (1") — between the two parts to be welded and push the welding tool handle closed. Use gauging tools for standard clamps only.

   50.8 mm (2") Bench Mount

   Place the proper size gauging tool — 12.7 mm (½"), 19.05 mm (¾"), 25.4 mm (1") or 50.8 mm (2") between the two parts to be welded and push the welding tool handle closed.
4. Adjust the pipe/fittings to make sure they are inserted to full depth in the gauging tool, while at the same time keeping the outer faces of the gauging tool flush against the clamps (see Photo 14).

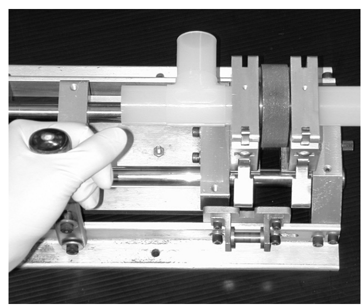


Photo 14.

5. Tighten the clamps securely, release welding tool handle and remove the gauging tool.
6. When fittings such as elbows and tees are involved, be sure they are rotated to the proper orientation (refer to page 11 – *Capping Fittings/Pipe*).
7. Gauging of the parts allows for a repeatable welded assembly dimension. When welded, two parts will be approximately 5.7 mm (0.224") closer than the original length dimension.

GAUGING USING THIN CLAMPS

1. Prior to placing the fittings in the clamps, cut the stub ends back using the special ratchet shears provided (Part number 213-42). (See Photo 15.)
2. Each standard 12.7 mm (½"), 19.05 mm (¾") and 25.4 mm (1") fitting has a shoulder that is approximately 38.1 mm (1.5") or 19.1 mm (0.75") from the stub end. The special spacer plates on the side of

the shears must be held firmly against this shoulder when cutting back the stub ends.

NOTE: 6.35 mm (¼") fittings and minimum weld PureBond fittings do not need to be trimmed.

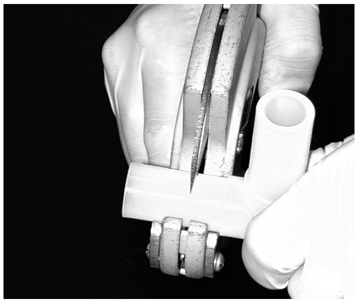


Photo 15.

3. After cutting, the fitting must be placed in the bench tool thin clamp with the shoulder pushed squarely against the clamp. If welding to pipe, an adequate length of pipe must extend through the clamp to allow for proper facing prior to welding.
4. The gauging procedure used with the standard width clamps is not required when using the thin clamps. Simply proceed with the same facing and welding procedures as used with the standard width clamp.

NOTE: Due to the short length of these welds, there is not adequate material to allow for a second welding operation, as is the case with standard length welds.

FACING

1. Insert the facing tool onto the mounting rod by carefully sliding it, from the rear, between the parts to be welded. On the back of the facing tool is a spring-loaded lock that will automatically lock the facing tool in place (see Photo 16).

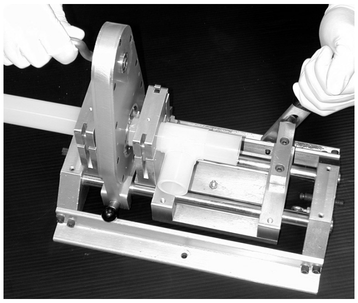
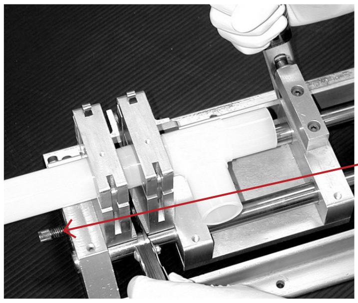


Photo 16.

2. Apply continuous closing pressure on the welding tool handle while turning the facing tool handle clockwise. Continue turning until the welding tool cannot close any further and all excess material has been faced off. The handle will turn freely.
3. Remove the facing tool by pulling up on the spring-loaded lock and carefully sliding the tool out the rear. Verify that the ends are parallel and square to each other by pressing them together with the welding tool handle.
4. Check the alignment of the ends. Slight misalignment can be corrected by adjusting the clamp tightness. If alignment still exists, refer to page 7 for pipe/fitting alignment instructions.
5. Check that the ends are free from dust, dirt, or any other debris. Also, being careful not to touch the faced ends, remove shavings from inside the pipe/fitting that resulted during the facing process.
6. After facing, additional cleaning is typically not necessary. However, should it be required, spray a fine mist of an approved solvent such as isopropyl alcohol (IPA) on the ends.
7. Additional excess debris can be removed with a lint-free wipe wetted with IPA.

25.4 MM (1") WELDING CLOSURE DISTANCE

1. Install pipe into welding tool, gauge, and face component ends.
2. Loosen lock nut on closing travel stop setscrew.
3. Place 0.635 mm (0.025") feeler gauge between the sliding clamp assembly and closing travel stop screw. Close tool so component ends are touching (see Photo 17).



Lock nut and closing travel stop setscrew

Photo 17.

4. Adjust setscrew to a position that allows the pipe ends to touch and the 0.635 mm (0.025") shim to be held snugly between the sliding clasp assembly and closing travel stop screw. Tighten lock nut to maintain adjustment.

If a weld has a very large bead or a sunken/concave weld (see melt bead examples on page 12), the welding closure distance may need adjustment.

50.8 MM (2") WELDING CLOSURE DISTANCE

1. Install pipe into bench mount tool clamp, gauge and face component ends.
2. To allow free movement of sliding base plate assembly, tip bench tool on its side while supporting it (see Photo 18).

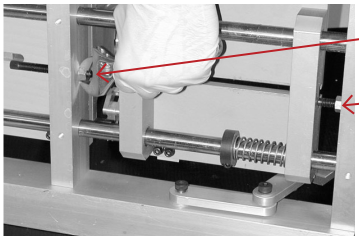


Photo 18.

3. Loosen lock nut on closing distance setscrew.
4. Push handle to closed position until the pipe ends are just touching.
5. Adjust closing distance setscrew to a position that allows for a 0.025" (0.64 mm) gap between the end of the setscrew and the opposing face of the sliding base plate assembly.
6. Tighten lock nut.

If a weld has a very large bead or a sunken/concave weld (see melt bead examples on page 12), the welding closure distance may need adjustment.

WELDING

1. Locate the infrared heater on the welding tool heater bracket and rotate into place. The pipe/fitting ends should be facing the heater faces as shown in Photo 19.

WARNING: At no time during the welding process should the component ends contact the heater.

NOTE: When welding 50.8 mm (2") pipe components, Entegris, Inc. recommends capping or plugging all open ends to improve heating uniformity.

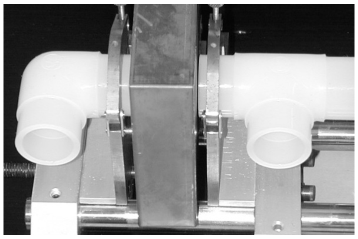


Photo 19.

2. Heating time is determined by visual examination. After approximately 20 – 25 seconds, the ends will begin to turn molten. The molten area will appear clear (see Photo 20).

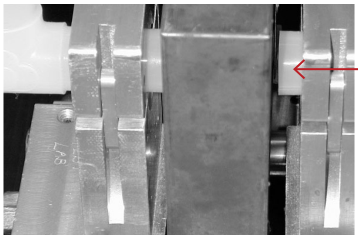


Photo 20.

3. As soon as the molten area reaches approximately 0.8 mm (0.03") in length on each part, the heating cycle is complete.
4. Rotate the heater out of place and, using the welding tool handle, press the ends together. Make sure the sliding base plate assembly contacts the nylon closing distance stop.
5. Hold in that position until the weld area returns to its original appearance. This will take approximately 15 to 20 seconds. This will allow the weld time to cool enough for gentle handling.
6. Unlock the clamps and remove the welded part from the tool.
7. Allow the weld to cool to room temperature (15 to 20 minutes) before rough handling or pressurizing. Weld may be cooled down faster by running cold water over it.

SUPPORTING PIPE LENGTHS

Support long and/or heavy lengths of pipe and fittings. Do not allow the bench mount welding tool to act as the only support or part misalignment may occur. Use the additional set of sliding support clamps on the 50.8 mm (2") PureBond welding tool when possible (see Photo 21). Putting the long, heavy side of an assembly on the right, stationary side of the welding tool also helps support the assembly and facilitates external material supports.

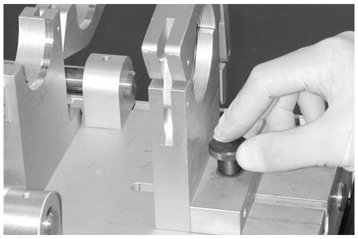


Photo 21.

CAPPING FITTINGS/PIPE

If possible, avoid welding fittings and pipe that extend vertically upward from the welding tool. This may cause uneven heating. Orient these parts so the legs point either to the side or downward. If this is not possible, cover the opening in the vertical section.

PROTECTING VALVES

When welding valves using thin clamps, cover the actuator with aluminum foil to reflect heat and prevent melting the actuator housing. Actuators **must not** be removed when welding valve bodies.

When welding pneumatic or manual sampling valves, make certain to cap the open port to minimize heat transfer to the closing orifice. Also note, manual sampling valves are to remain in the open position during welding.

WELD INSPECTION AND QUALIFICATION

To qualify a weld, two inspections are required: visual and flex. A weld is qualified if it passes both inspections as outlined below. Always perform a weld qualification on the first weld each day to ensure that the equipment is operating properly.

WELD VISUAL INSPECTION

Perform a visual inspection on 100 percent of welds.

1. Observe the weld area to verify that the distinctive beads exist at the weld line, 360° around the pipe.
2. Compare the external melt bead to the examples shown in Figure 1.
3. Check the weld area for a large number of air bubbles. This is an indication of either dust/debris in the weld or overheating.
4. If the weld does not display the required bead around the pipe/fitting or exhibits a large number of air bubbles, cut that area out, cool to room temperature and weld again using the proper procedures.

WELD FLEX INSPECTION

After performing weld flex inspection as instructed below in Steps 1–5, repeat the inspection at the beginning of each shift and with any operator change.

1. Cut the sample leaving 50.8 mm (2") of pipe on either side of the weld.
2. Cut the pipe lengthwise sectioning the weld in three equally wide strips. (When sectioning 50.8 mm [2"] pipe, each strip should be about 25.4 mm [1"] wide.)
3. Bend the ends of the strip, as shown, once in each direction to check the inside and outside of the weld (see Photo 22).
4. Inspect the weld area. If there are any cracks or voids evident, the weld is defective.
5. If the weld is faulty in appearance, check the probable reason using the examples shown in Figure 1 and make another weld.

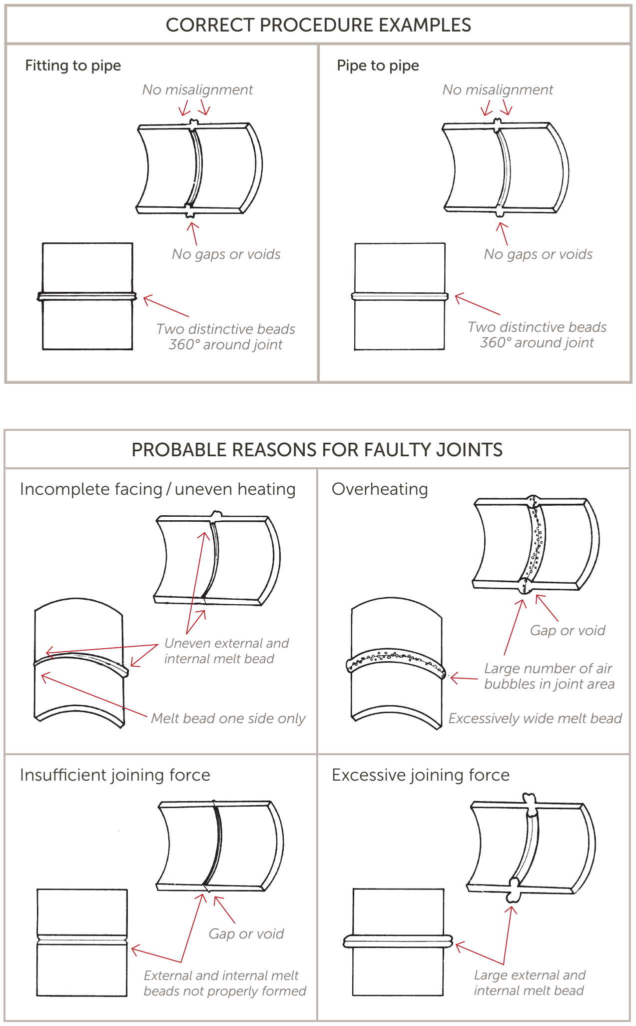


Figure 1. Melt bead examples.

Photo 22.

DIMENSIONAL WELDING

Dimensional welding is the practice of building an assembly to meet predetermined dimensions. Commonly done for plumbing installed on a skid or in a cabinet, dimensional welding assumes the operator's ability to make acceptable welds and requires an understanding of component dimensions, measuring, and weld sequencing.

WELD TYPES

Four weld types may be required for dimensional welding, see Figures 2a and 2b.

Standard Weld

This is a weld made on a 25.4 mm (1") or 50.8 mm (2") welding tool using the full length of the as-manufactured component.

NOTE: By facing and welding the original component the length will be reduced by 2.8448 mm (0.112") on each end, or 5.6896 mm (0.224") for the weld.

Minimum Weld

A minimum weld is made using the thin clamps on the 25.4 mm (1") weld tool. It achieves the shortest distance between components.

NOTE: The weld length between the shoulders of two adjacent fittings is 23.368 mm (0.92") (2 × 11.684 mm [0.46"]).

Special Weld

A special weld is a hybrid where the weld dimension is altered from the standard or minimum weld. Prior to facing, the ends of one or both components are cut to a specific length.

NOTE: The required pipe length can be determined in several ways.

Add-On Pipe Weld

To achieve a length greater than that of the fitting or valve ends, a section of pipe is welded between the fittings or valves.

NOTE: To account for facing and welding, the required pipe length for welding must be 5.6896 (0.224") longer than the desired dimension.

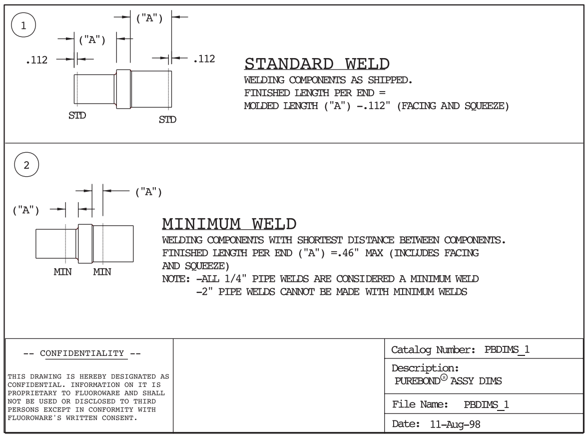


Figure 2a.

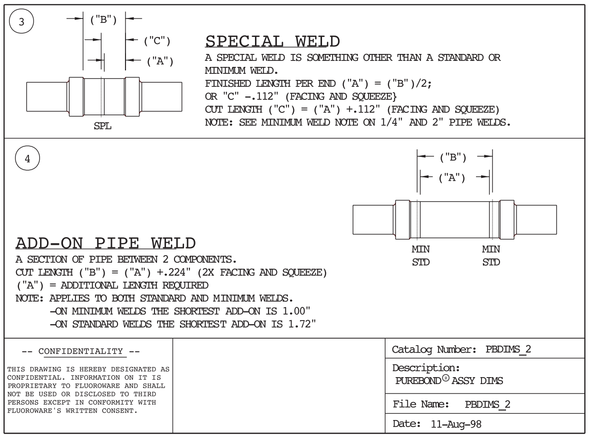


Figure 2b.

COMPONENT DIMENSIONS

All four weld styles use the shoulder on the fitting or valve end as the measuring starting point. Entegris' *Fluid Handling Products Catalog* shows the overall dimension for all fittings, valves, pipe sizes, and miscellaneous components. Visit *www.entegris.com* for specific information.

Generally speaking, the PureBond component stubs (the length on the end of all fittings and valves between the end and the shoulder) are the same lengths for all components with the same outside diameter.

WELD SEQUENCING

When welding complex shapes, it is very important to plan your work. Without adequate forethought, it is possible to get to a position that the weld simply cannot be made. The most common oversights are:

- trying to weld two subassemblies with shapes that cannot be clamped into the welding tool
- trying to weld two subassemblies but damaging the structure with the heater

WELDING TIPS

- Be sure to note valve and filter housing inlet and outlet orientation.
- When possible, weld big, heavy components such as filter housings, tanks, large valves, and ANSI flanges last.
- For tight "U" assemblies, weld the two halves of the "U" last

HELPFUL HINTS

Consider the following helpful hints during the fabrication of a pipe system.

1. Prior to actually welding PureBond pipe components, check to see that the tools are adjusted properly. To do this, simulate the actual process before energizing the heater. Simply gauge, face-off, and rotate the heater into place. Check that the heater does not come into contact with the pipe/fitting and that an equal spacing exists on either side of the heater. If an adjustment is necessary, refer to the *Tool Maintenance* section on page 4.
2. Always perform a *Weld Qualification* on the first weld each day to ensure the equipment is operating properly (see page 12).
3. All infrared heaters require connection to the exact rated voltage (i.e., 100, 120, 230 VAC). If possible, connect to a voltage that is within ±5% of rating.
4. If possible, avoid welding fittings and pipe that extend vertically upward from the welding tool. This may cause uneven heating on the pipe/fittings ends. Instead, orient these parts so the legs point either to the side or downward. If this is not possible, cover the opening in the vertical section.

WELDED SYSTEM REQUIREMENTS

INSTALLED PIPE SUPPORT

To provide trouble-free service and minimize the stress and strain put on the pipe wall, long lengths of PureBond weldable pipe must be supported. The minimum recommended distance between pipe supports was calculated by taking into account the weight of the pipe, its contents and an allowable stress. As shown in Table 1, the distance between supports is also affected by pipe size and temperature.

Table 1.

Size	23°C (73°F)	100°C (212°F)	177°C (350°F)
6.35 mm (¼")	68 cm (26.9")	55 cm (21.5")	37 cm (14.5")
12.7 mm (½")	82 cm (32.4")	67 cm (26.4")	46 cm (18.0")
19.05 mm (¾")	91 cm (36.0")	73 cm (28.8")	49 cm (19.2")
25.4 mm (1")	101 cm (39.6")	79 cm (31.2")	55 cm (21.6")
50.8 mm (2")	122 cm (48.0")	98 cm (38.4")	64 cm (25.2")

The specific gravity of a fluid in excess of 1.0 can adversely affect the pipe support spacing. The recommended spacing distance should be multiplied by the factor indicated in Table 2, resulting in shorter distances between supports.

Table 2.

Specific Gravity	Factor
1.00	1.00
1.25	0.94
1.50	0.89
1.75	0.86
2.00	0.82
2.25	0.79
2.50	0.76
2.75	0.74
3.00	0.72

NOTE: These recommendations are intended to ensure the pipe will function to specification. Sagging between hangers may occur. To avoid sagging, the pipe should be continuously supported.

The pipe supports specified should not be the type that clamp the pipe tightly and restrict movement, especially when thermal expansion and contraction is involved. By not using this type of clamp, you will prevent abrading and damaging the pipe wall. An alternative to intermittent pipe supports is to continuously support the pipe by laying it in a trough. Commonly extruded shapes such as angles, channel, and conduit work well as a trough.

Vertical sections of pipe, referred to as risers, must also be supported. The top and base of the risers should always be supported in addition to having brackets at 1.5 m (5') vertical intervals.

Accessory items such as valves, filter housings, etc., should not be fully supported by the pipe. Individual supports should be specified for all heavy components connected to a pipe system.

THERMAL EXPANSION AND CONTRACTION

Thermal expansion and contraction of PureBond weldable pipe should be considered during the design and installation stages of a pipe system. If the working temperature is higher than the installation temperature the pipe becomes longer. If the working temperature is lower than the installation temperature the pipe will become shorter. Consequently, the installation temperature as well as the maximum and minimum working temperatures must be considered when designing a system. One common guideline is to install the pipe when it is within -12.22°C to -9.44°C (10°F to 15°F) of its operating temperature. When this is not practical, thoroughly examine the pipe layout.

Small length changes can be tolerated by the pipe because of its modulus of elasticity and inherent property of stress relaxation of PFA. When large changes are present, they should be compensated for in the pipe layout. To determine the amount of length change, a formula is used that takes into account the coefficient of linear thermal expansion of the specific material (see Formula 1).

Formula 1 – Accommodations for Thermal Expansion

$\Delta L = L \bullet \Delta T \bullet C$

Where:

ΔL = Length change, inches

L = Original length, inches

ΔT = Change in temperature, °C (°F)

C = Coefficient of thermal expansion, In/In/°C (°F) for PFA

21.11°C – 100°C (70°– 212°F) = 6.7×10^{-5}

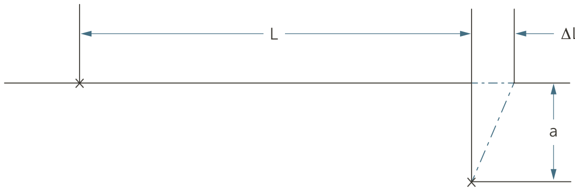
100°C – 148.89°C (212°– 300°F) = 9.4×10^{-5}

148.89°C – 208.89°C (300°– 408°F) = 11.1×10^{-5}

An easy rule of thumb for estimating the length change is to assume that for every -12.22°C (10°F) change, a change of one inch will occur in any 30.48 m (100 foot) linear length. When substantial length changes are evident, they must be compensated for by the use of flexible sections, expansion loops, expansion welds, etc. If this is a concern in your pipe system, contact Entegris for advice in properly incorporating these options.

Formula 2 – Accommodations for Thermal Expansion

Changes in pipe lengths during working conditions can be accommodated using fixed brackets and flexible sections. Flexible sections are designed to move to compensate for thermal expansion and contraction of tubing and pipe. Most commonly, it is a 90° bend or a U-bend. The figure below shows how a flexible section accommodates the length change.



The length of flexible section can be calculated using the following formula:

$a = k(\Delta L \bullet D)^{1/2}$

Where:

a = length of flexible section, inches

k = constant (k = 25 for PFA)

ΔL = change in tubing/pipe length, inches

D = tubing/pipe outside diameter, inches

Example

A 10 foot length of 25.4 mm (1") outside diameter tubing is installed at 70°F and will have a working temperature of 200°F. Determine the change in length from installation to working conditions, and the amount of flexible section required to accommodate this change in length.

Using **Formula 1**:

L = 10 ft = 120 inches

ΔT = 200° - 70°= 130°F

$C = 7.6 \times 10^{-5}$ in/in/°F

$\Delta L = 120 \bullet 130 \bullet 7.6 \times 10^{-5}$ = 1.19 inches

Using **Formula 2**:

k = 25

ΔL = 1.19 inches (calculated using Formula 1)

D = 1 inch

$a = 25(1.19 \bullet 1)^{1/2}$ = 27.2 inches

MODIFYING A WELDED SYSTEM

REWELDING BEFORE COMMISSIONING

Except when minimum weld clamps are used, a butt weld can be easily cut out of a PureBond pipe component and remade. Entegris designed PureBond fittings to be welded more than once, if necessary, so the fitting does not need to be discarded.

REWELDING AFTER COMMISSIONING

Although rewelding after commissioning may be possible when certain fluids are used, Entegris generally does not recommend rewelding used components. To discuss this further, contact your local Entegris distributor or Entegris, Inc.

SAFETY CONSIDERATIONS DURING WELDING AND AFTER INSTALLATION

MATERIAL INFORMATION

In the last half century, experience has shown that no reported cases of serious injury, prolonged illness, or death have resulted from the handling of fluoropolymer resins. Tests further indicate that the resins may be taken in food without ill effect, and that the resins are nonirritating and nonsensitizing to the skin. There have been no known instances of dermatitis, allergy, or other ill effects caused by handling unheated fabricated forms of material resins.

In the case of human exposure to heated fluoropolymer resins, no lethal effect has been observed. Instead, such exposure has merely caused a temporary flu-like condition called *Polymer Fume Fever*. The symptoms do not ordinarily occur until about two or more hours after exposure and pass off within 36 to 48 hours, even in the absence of treatment. Observations indicate that these attacks have no lasting effect and that the effects are not cumulative.

When such an attack occurs, it usually follows exposure to vapors evolved from the polymer at high temperatures used in resin processing operations. PFA processing and welding are examples of operations during which vapors can be liberated.

To verify that there is no lethal effect of exposure to heated fluoropolymer resins, an investigation was made by an independent laboratory into the potential for generation of fluoride decomposition products during welding. Air samples were collected for one hour directly above the weld point to determine if any particulate or gaseous decomposition products were being generated.

The testing was done in stagnant air to simulate worst-case conditions. No decomposition products, measured as hydrolyzable fluoride, were detected during this time. The lower detection limit of this test was 0.3 parts per million. These test results show that there is little potential for generation of hazardous decomposition products during the normal welding process.

WARNING

As a matter of good industrial practice, we strongly urge you to practice proper ventilation to eliminate this potential problem and the resultant operator discomfort. Questions about ventilation in cases of processing, welding, or other applications at temperatures at or above 200°C (392°F) should be directed to Entegris. To further safeguard against the potential discomforts of *Polymer Fume Fever*, do not smoke tobacco while processing, welding, or flaring PFA material. This will reduce the possibility of inhaling any decomposition products, although small in quantity that may be over-heated by drawing them though a lit cigarette.

Entegris has strategically placed warning labels on the welding tool. Please be advised and aware of these warnings.

HEATING ELEMENT SAFETY

Since PFA has a very high melting point, it is necessary to exceed that temperature to weld. The heating element's white quartz face and metal supports are **very hot**—over 537.78°C (1000°F)! Handle it with care and only by the handle. When not in use, the heating element should be placed in its holder/heat shield, well away from combustible materials. Ensure the holder/heat shield has a minimum of 610 mm (24") space above to allow for proper heat dissipation. The 230 VAC heater is CE marked per Low Voltage Directive 73/23/EEC (EN60335-1 and EN60335-2-45).

The heating element takes a long time to cool after being unplugged. On average, allow the heating element to cool for an hour before handling or packing.

WELD COOLING

PFA conducts heat very slowly. The new weld is strong enough to be moved and support its own weight approximately 15–20 seconds after welding. However, the weld area will be hot enough to burn flesh for about 1 minute.

The new weld will cool to room temperature and have full strength in 15–20 minutes.

⚠ **WARNING: To prevent burns, DO NOT touch the weld area during cooldown.**

ELECTRICAL SHOCK

As with any electrical device, the heating element has the potential for delivering an electrical shock. Take normal care to be sure the plug, power cord, and heating element are kept in good repair. Entegris does not recommend use around water or other liquids.

INSTALLED SYSTEM SAFETY

All PureBond components have operational ratings. These ratings were developed through extensive testing. Entegris does not recommend that an installed system be operated in excess of the published ratings. Ratings and test procedures can be found in Entegris' *Fluid Handling Products Catalog*. Visit *www.entegris.com* for specific information.

Although PFA is a very tough material, Entegris does not recommend that heavy objects be supported by the PureBond welded system.

TECHNICAL INFORMATION

CREEP RESISTANCE

One important determination in designing a pipe system is to specify a material that exhibits a low creep rate at the intended stress. Of all the fully fluorinated fluoropolymers, PFA displays the highest resistance to creep.

At room temperature with a stress of 500 psi, the degree of creep after 10,000 hours is 1.2%. Similarly, at 100°C (212°F) the creep rate measures 4%. Even at 200°C (392°F) the creep rate is only 6.3%. This is important because a high creep rate should be avoided and may result in unpredictable and premature failures.

LONG-TERM PIPE STRENGTH

The long-term hydrostatic strength of PFA used in PureBond pipe was determined in accordance with the test procedures outlined in ASTM D2837, *Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials*. This analysis has assigned a 100,000 hour long-term strength value of 1600 psi at 23°C (73°F) for PureBond pipe.

The following is a simplified summary of how this value was determined.

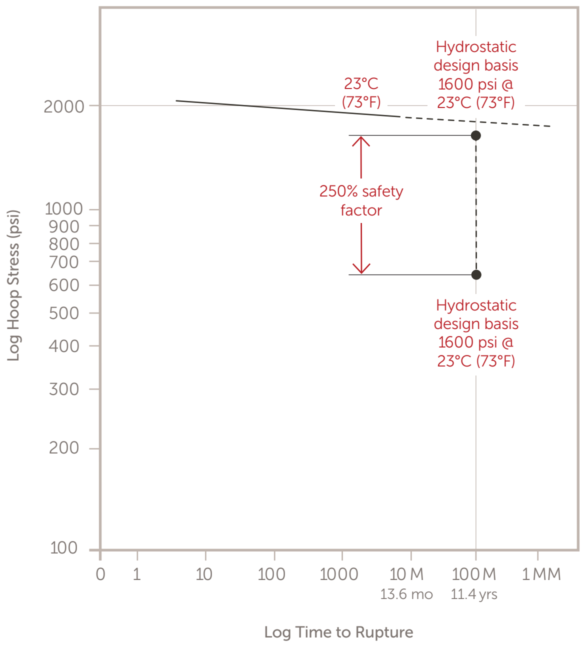
1. PFA pipe specimens are subjected to constant internal water pressure at different pressure levels and the time-to-rupture is measured. Stress on each specimen is calculated from the pressure by means of a pipe design equation.

   Formula 3:

   $$S = \frac{P(D-t)}{2t}$$

   Where: S = Stress, psi
   P = Pressure, psig
   D = Average outside diameter, inches
   t = Minimum wall thickness, inches

   Testing is continued for 10,000 hours (approximately 13.6 months) according to the rigid specifications in ASTM D2837. An accurate, reproducible linear plot of hoop stress vs. time-to-rupture on log-log coordinates is generated as shown in Graph 1.
2. The stress rupture data is analyzed by statistical regression to generate a hoop stress vs. time equation. This equation is extrapolated mathematically one decade of time to 100,000 hours (approximately 11.4 years) to obtain a 100,000 hour design stress, which is the first step in the determination of the working stress.
3. The next step makes use of a division of the entire design stress scale into continuous increments, one of which is approximately 25% larger than the one below it. These increments in psi are 800, 1260, 1600, 2000, 2500, etc. PFA is assigned the threshold value of the increment in which its 100,000 hour design stress falls, called the *hydrostatic design basis*. This becomes the fundamental stress from which working stress is calculated. The findings of this evaluation have resulted in a hydrostatic design basis for PureBond pipe of 1600 psi at 23°C (73°F).



Graph 1.

SAFETY FACTOR FOR PIPE

The PureBond pipe product line has been developed with the end user's safety in mind. The manufacture of the pipe, fittings and related components, and the quality assurance measures taken ensure you the utmost in system integrity. To compensate for the number of variables involved in each application, a safety (design) factor has been incorporated. This allows for:

- Occasional pressure surges/water hammer
- Improper pipe installation and/or support, to some extent
- Stresses due to thermal expansion and contraction
- Longitudinal stresses in the pipe

The hydrostatic stress committee of the Plastic Pipe Institute (PPI) recommends a minimum safety (design) factor of 200% based on the hydrostatic design basis. Keeping in mind the severity of the applications in which the PureBond pipe products will be used, Entegris, Inc. feels that a Safety Factor of 250% would better accommodate these types of services. Therefore, the hydrostatic design stress would be:

$$\text{HDS} = \frac{1600 \text{ psi}}{2.5}$$

$$\text{HDS} = 640 \text{ psi}$$

The hydrostatic design stress is defined as the maximum hoop stress in the pipe wall due to internal hydrostatic pressure that can be applied continuously with a high degree of certainty that pipe failure will not occur within a long period of time. A service life of 50 years is generally accepted as the minimum for a pipe system evaluated in this manner.

WELD STRENGTH

The PureBond pipe components are joined by a butt weld. This style of connection has proven itself for many years as strong and safe. Entegris chose the butt weld for PureBond pipe components for many reasons, some of which include:

- The internal contour of a butt weld has only one small melt bead. Large obstructions and voids that can trap particulate and restrict flow are not present.
- The PureBond butt welding technique is a fast, simple, visual procedure with straightforward instructions. The variables typically associated with welding pipe have been addressed in the welding tool designs. The noncontact, noncontaminating heater provides consistent high-quality welds.
- The butt weld configuration is a structurally sound connection. By design, the stresses initiated by pipe deflection are dispersed throughout the pipe rather than concentrated at the weld.
- The PureBond weld does not affect the safety factor or ratings of the pipe, fittings, valves, or other components. This has been evidenced by the following tests conducted at 23°C (73°F).

SHORT-TIME BURST

ASTM D1599, *Short-time Hydraulic Failure Pressure of Plastic Pipe, Tubing and Fittings*. This standard calls for pressurizing the specimens in a uniform and continuously increasing manner until failure occurs (see Photo 23). Failure must occur between 60 to 70 seconds. Many specimens of each size (12.7 mm [½"], 19.05 mm [¾"], and 25.4 mm [1"]) were evaluated and in all cases the welds proved to be fully resistant to failure. The average failure pressures are as follows:

6.35 mm (¼")	71 bar (1030 psig)
12.7 mm (½")	51 bar (741 psig)
19.05 mm (¾")	42 bar (608 psig)
25.4 mm (1")	36 bar (529 psig)
50.8 mm (2")	24 bar (357 psig)

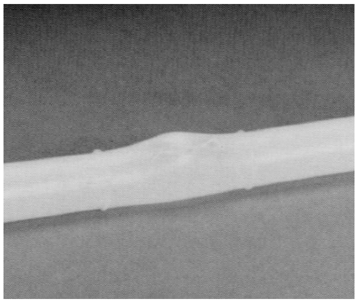


Photo 23.

CYCLIC SHOCK TEST

In addition to all sizes of pipe and welded fittings, the welds are fully resistant to failure in excess of one million cycles, to a cyclic pressure of 0 – 12.9 bar (0 – 187 psig) at a rate of 30 cycles per minute.

TENSILE TEST

An Instron tensile pull test was conducted on many specimens of 12.7 mm (½"), 19.05 mm (¾"), and 25.4 mm (1") PureBond welded pipe in an effort to separate the weld. At a rate of one-inch pull per minute, no weld failures were experienced. The maximum amount of pull at failure is recorded as follows:

6.35 mm (¼")	110 kg (243 lb)
12.7 mm (½")	228 kg (502 lb)
19.05 mm (¾")	307 kg (676 lb)
25.4 mm (1")	441 kg (973 lb)

These test results are only useful in predicting the behavior of pipe and fittings, and should not be used as long-term ratings. To achieve these results, adhere to the proper welding procedures for PureBond pipe components.

DEFINITIONS

Component end – that part of a weldable fitting, valve, or pipe that is suitable for PureBond welding.

Creep – the change in shape caused by an internally or externally applied stress.

Dimensional welding – the practice of building an assembly to meet a predetermined dimension.

Facing – the process of preparing the components to be welded by shaving off their ends with a special tool.

Flexible section – the portion of a welded system, generally perpendicular to the main run, that accommodates the thermal expansion/contraction of the pipe system.

Gauging – the process of correctly positioning the components in the welding tool.

Heater – the infrared heat source used to melt PFA for welding. For better cleanliness, the white face of the heater is quartz and, therefore, breakable.

⚠ **CAUTION: The heater reaches temperatures greater than 537.78°C (1000°F).**

Minimum weld – made using the thin clamps on the 1" welding tool. A minimum weld achieves the shortest distance between components.

Polymer Fume Fever – the temporary flu-like condition occasionally caused by exposure to vapors from high-temperature PFA. Smoking while welding enhances the possibility of experiencing polymer fume fever.

Shoulder – the step on the outside of the fitting or valve where the component's main body meets the pipe dimensioned end.

Special weld – a weld made with at least one of the components being cut and faced to a specified length.

Thermal expansion – the change in a pipe (or other component) length resulting from heating or cooling it. PFA thermal expansion is considerably greater than stainless steel thermal expansion.

Thin clamps – thin clamps replace the standard clamps on the 1" welding tool and are used to hold the components during the welding process. The thin clamps allow minimum welding.

Weld – the junction of two welded components.

Welding – the process of simultaneously heating both ends of the components and then pressing the molten ends together.

Welding closure distance – sometimes referred to as the "squeeze," this is the amount the molten components are allowed to overlap during the joining process. It is measured as the distance from the inside edge of the sliding clamp side to the travel stop setscrew while the tool is closed. This distance is 0.635 mm (0.025").

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