HIGH-PURITY INSTALLATIONS

Installing a high-purity system properly requires preplanning. The installation is more than the welding of components. It requires the proper environment, material inventory, welding equipment, tools, and thorough training.

This guide will concentrate mainly on materials such as PVDF, E-CTFE, and PP, as supplied by Asahi/America, Inc. However, certain sections in regard to fusing PFA are also inserted to assist in the assembly of a Purebond® PFA piping system. Asahi/America and Agru are fully licensed by Entegris to provide IR welding for PFA Purebond® piping components. The SP110 welding tool is the only tool available on the market designed and outfitted to weld PVDF, PP, E-CTFE, and PFA. This means one tool to conduct welding of all materials on an HP installation.

Asahi/America's recommendations for project management follow.

Step 1. Welding Environment
Step 2. Tool Selection
Step 3. Material Handling
Step 4. Training and Preparation
Step 5. Tool Commission and Daily Checks
Step 6. Weld Inspection
Step 7. Hanging
Step 8. System Testing
Step 9. Repair Procedures

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Step 1. Welding Environment

Asahi/America does not set requirements for proper welding environments. As the installer, it is necessary to choose the environment based on the installation type, timing, or quality goal. In all cases, the environment for welding should be monitored to ensure the temperature is in the range of 41° F to 105° F. The humidity should not exceed 70%. If using IR fusion, wind must be avoided.

All Purad™ PVDF components are manufactured and packaged in a cleanroom environment. Great care is taken to ensure that they arrive on the project site in protective packaging to maintain their purity. To be consistent, it is ideal to conduct welds in a clean or cleanroom environment. Particles, dust, or dirt in the air will adhere to the pipe during the welding process. To reduce contamination in the system, as many welds as possible should be conducted in a clean type environment. A class 100 or 1000 room is perfectly suitable. Portable style cleanrooms make for an efficient set up when conducting all the welds on site.

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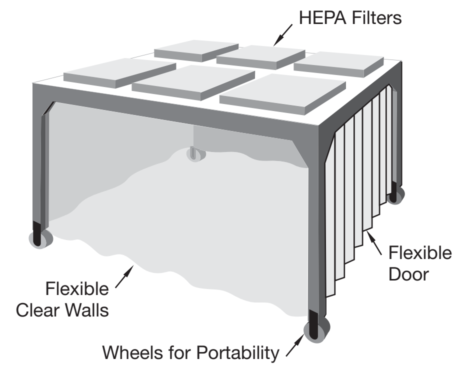

Figure F-36. Portable cleanroom

Within the clean zone it is recommended to build spool pieces. The size and configuration is dependent on the ability to safely transport it to its final destination. The ends of the spool pieces should be prepared for final connection once in the pipe rack. In smaller dimensions, 1/2"–2", the ends should be fitted with unions or sanitary fittings to reduce welds in the pipe rack, as they are more difficult.

One advantage of the Purad PVDF system is the availability of the HPF welding method in 1/2"–2". HPF is a portable welding method designed specifically for Purad. HPF provides a bead free joint, while allowing for welds in extremely tight locations. HPF welds through use of an electric socket, which melts the components together evenly without producing a bead internally. When building spool pieces, plane the ends to be welded prior to placing in the pipe rack. This avoids the need to bring planing equipment into the pipe rack. If components are properly supported once in place, HPF welds can be conducted with one clamp that is no longer than 1 1/2 inches. See Figure F-37 for a sample of a portable fusion.

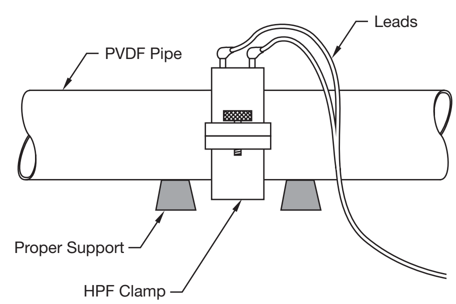

Figure F-37. Portable HPF fusion makes welding in the rack reliable

In sizes larger than 2", it is recommended to build spool pieces with flange connections. This avoids having to conduct difficult butt-fusion welds in tight locations. Flanged spool pieces also offer the benefit of being able to make changes later. In some instances, field welds can or must be conducted in a pipe rack. For these occasions, the use of contact butt-fusion equipment to ensure proper heating for larger diameter pipe is recommended. Consult with Asahi/America's Engineering Department for specific tool selection and weld procedure recommendations.

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Many installations do not require the same level of purity and care as others. Polypropylene is often chosen as a cost effective alternative to PVDF for these installations. In these cases, a cleanroom environment may not be necessary. It is still recommended to have a dedicated welding zone. The welding area should be clean and measures should be taken to reduce foot traffic through the area. Keeping the tools in one location reduces wear and tear, as well as the possibility of physical damage during a transport.

In all HP installations it is necessary to have a set of dedicated tools, such as levels, pipe cutters, tape measures, etc. Keep these tools dedicated to the high-purity installation to avoid cross contamination with other non-purity installations.

Air Movement

Finally, in all cases, it is preferable to weld in ambient temperature environments of 20 to 25 °C. The avoidance of windy areas and fans is also recommended. When using welding methods such as IR fusion, it is absolutely required to avoid air movement in the weld zone. For other methods such as butt or socket, wind is not as troublesome, but should be avoided if possible as it raises the chances of contamination, as well as improper heating of the pipe components.

Step 2. Tool Selection

The selection of the type of welding method conducted on a high-purity project should be based on the following criteria:

- Material
- Sizes to be installed
- Welding location
- Type of installation
- Available expertise
- Required documentation

Materials available for high-purity water and chemical systems are PVDF, polypropylene (natural and pigmented), and Halar™ (E-CTFE). PVDF is the most common choice due to its low ion extractable and surface smoothness. In addition, the Purad PVDF system is available in a wide selection of sizes and pressure ratings, as well as having a full complement of specialty valves and fittings that are specifically designed for ultra pure systems.

Table F-6 identifies by material type welding methods available from Asahi/America. Discussions on each method and the advantages of each method for installing HP systems follows.

Table F-6. Available Welding (by material)

Material	Socket Fusion	Butt Fusion	IR Fusion	HPF
Purad PVDF-HP	*	*	*	*
Proline PP	*	*	*	
PolyPure PP		*	*	
Halar E-CTFE		*	*	
PFA (Purebond)			*	

Socket Fusion

Socket fusion is the oldest and simplest method for assembling thermoplastic materials. Socket fusion is available for welding PVDF (SDR 21) and PP in sizes 1/2"– 4". In socket fusion, material is in direct contact with the heat source. The pipe is inserted into a heated mandrel and the pipe's exterior becomes molten. Fittings are inserted over a mandrel and the interior becomes molten. After proper heat soak time has been accomplished, the two components are forced together until they bottom-out.

Figure F-38. Hand-held socket fusion for 1/2"–2"

Socket fusion is fairly tolerant to temperature conditions and is simple to do. Untrained personnel can be trained in a short period of time to make consistent and reliable joints. The disadvantage of socket fusion is that it provides the most uneven weld of all the methods. Beads are formed on the pipe and fitting and final stop position is random, depending on the operator. Mechanically the weld is reliable, but smooth, clean welds are more difficult to achieve consistently. Additionally, weld inspection is limited as the weld area is not visible from the outside.

Socket fusion is ideal for smaller systems and is quite simple and practical for welding 1/2" through 1". Systems consisting primarily of 3" (90 mm) and 4" (110 mm) may be better suited for IR or butt fusion.

Butt Fusion

The butt-fusion welding method was pioneered by Asahi/America for use in high-purity systems. Butt fusion offers smaller, cleaner, and stronger welds as compared to socket fusion. Butt fusion allows visual inspection of the weld quality through an examination of the bead formation. It is available in all sizes and all materials offered by Asahi/America. Multiple styles of equipment are available and vary from small, light manual tools to large diameter, hydraulic driven equipment. Butt fusion is ideal for all dimensions, and proves quite practical in sizes 1" through 12". See Figures F-39, F-40 and F-41 for examples of tool types.

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Figure F-39. Shop 4 (1/2" – 4")

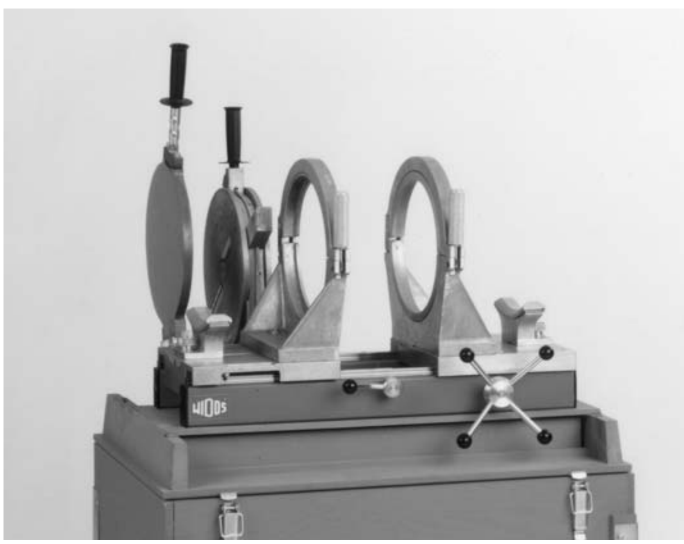

Figure F-40. Shop 12 (1 1/2" – 12")

Figure F-41. Field machine (3" – 12")

During the butt-fusion process, components are forced against a flat heating element or plate to melt the ends for the fusion. At the completion of heating, the materials are joined together at a force proportionate to the welding surface area. The result is a clean, double bead formation. Since the material is in contact with the heating element, there is the slight possibility of contamination if the heat plate is not properly cleaned and maintained throughout the project. In addition, molten plastic can also adhere to the heating plate if not properly released from the plate at the conclusion of the heat soak period.

The advantage of butt fusion is its weld strength. When properly conducted it is a strong, reliable joint. Butt fusion can be done in any size range, reducing the training time at the job start-up. In addition, butt fusion is fairly weather tolerant. This does not mean it can be conducted in any environment, but it will work in conditions other methods will not. An advantage of working with Asahi/America's system is the availability of multiple equipment and methods. For a given project, IR fusion may be the primary welding method; however, if field welds are required, butt fusion is the method of choice in many sizes. It reduces risks when welding outside or in areas with significant air movement.

IR Fusion

IR fusion has become the welding method of choice in ultra pure semiconductor water and chemical systems. It should also be considered for pure water systems in pharmaceutical and biotech applications. IR fusion has many of the advantages of butt fusion, but eliminates the concerns of contacting the heating element. IR fusion is available in sizes 1/2"–10" and multiple styles of equipment. PVDF, polypropylene, and Halar™ can be welded with IR equipment.

IR fusion equipment is highly sophisticated. Asahi/America offers two styles of equipment: the UF2000 series and the new acclaimed SP series. Both tools are computer driven and offer a high level of quality control. Figures F-42 and F-43 depict both styles of tools in terms of traceability and weld documentation.

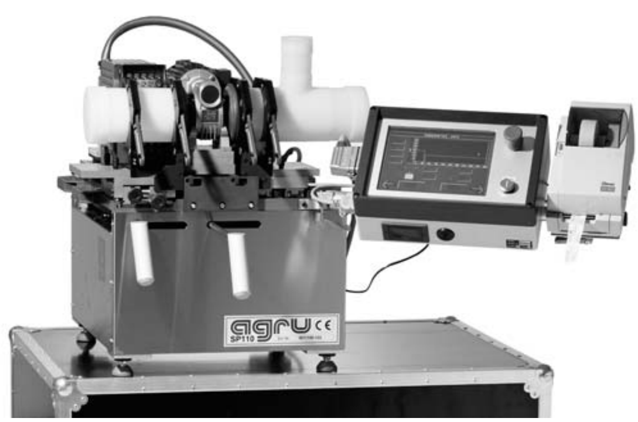

Figure F-42. SP 110 (1/2" – 4")

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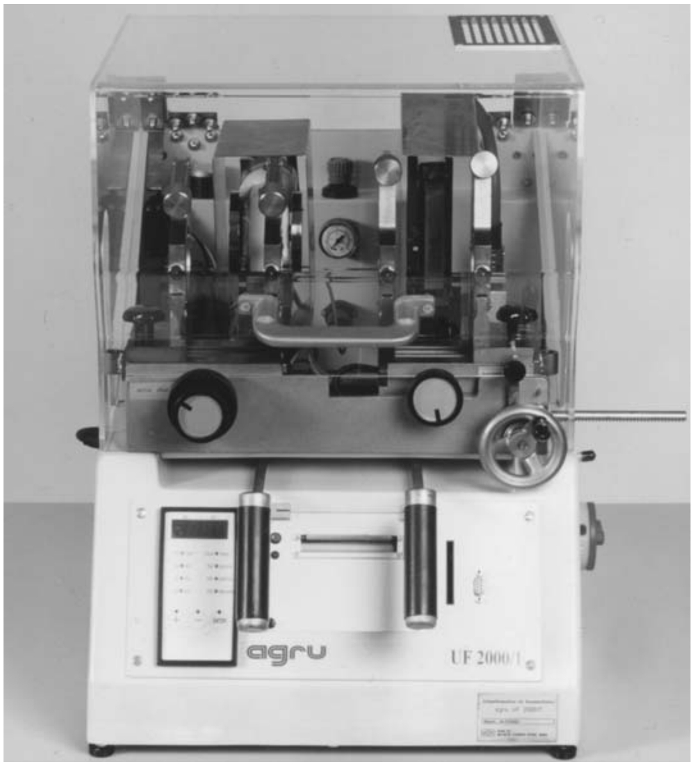

Figure F-43. UF 2000/1 (1/2" – 2")

Built-in printers provide data labels at the end of each weld, identifying the process was properly conducted, the material programmed, and the dimensions welded. Weld labels also provide the date and time of the fusion, as well as the joint number for physical tracking. See Figure F-44.

AGRU SP-110
00263179.W01 1/1
03.05.2001 15:53
SerNo:W11199-179
PP-n/50/4.6/IR
WELD .OK

Figure F-44. Weld label from a SP tool

On-board computers also provide control of the welding process and data logging of each weld. Data can be downloaded on each weld at any time to verify the quality of the system.

IR fusion for Asahi/America systems enhances the weld quality. The bead formation is consistent, making weld inspection more reliable. The bead formation is greatly reduced when compared to socket or contact butt fusion. The welds are smoother, more rounded, due to a reduction of excess molten material and weld force required. The net result is a cleaner and more reliable weld. Figure F-45 is a cross-sectional view of a pipe wall welded with IR fusion.

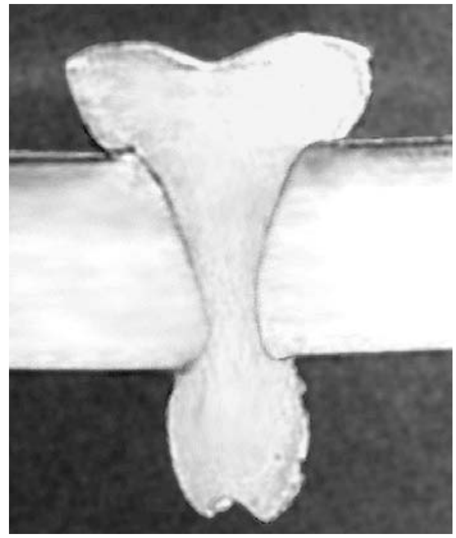

Figure F-45. Cross-sectional view of IR joint

IR fusion is recommended for controlled environments where temperature is consistent and air flow levels can be minimized. IR fusion equipment is designed for bench/shop style work and should not be hoisted into pipe racks.

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HPF Fusion

HPF is portable, bead free fusion method for welding sizes 1/2" through 2". HPF is ideally suited for pure water systems in the Pharmaceutical Industry. In addition, HPF is extremely practical for welding in tight locations, whether in the pipe rack or under a sub floor. HPF is only available currently for PVDF material.

For conducting beadless fusion, HPF is provided with two options: with balloon and without. For beadless and seam free welds, balloons are available. This ensures a smooth weld and no crevice. Joints welded with balloon will have a small wave in the joint due to the weight of the coupling and the outward force of the inflated balloon. Sometimes it is not possible to place a balloon in the weld area and then be able to remove it after, such as in the case of a repair or addition. For this reason, HPF can also be conducted without a balloon. These joints will also be beadless, but will have a small seam around the joint. In comparison to alternatives, such as a union or flange, it provides a smaller seam without a gasket.

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Figure F-46. HPF equipment

HPF uses an electric socket for each weld, and is energized by a computer controlled transformer. Weld parameters are preprogrammed into the control unit and selected via a bar code reader. The HPF is available in a bench type configuration, as well as having accessories for working in tight quarters.

HPF is recommended for welding in or outside of a cleanroom environment. During the weld process, HPF is closed to the external environment, so issues of wind, temperature, and contamination are greatly reduced. HPF is the tool of choice for repairs or additions to an existing system. HPF is available for PVDF in sizes 1/2"–2".

Step 3. Material Handling

Purad™ PVDF and HP Specifications

High-purity Purad components are received from the factory in special packaging to ensure its purity. Fittings and valves are double packaged in a class 100 cleanroom immediately after production and cleaning. Double bagged fittings are shipped in protective boxes. Valves are shipped in individual boxes.

Once on site, fittings should be inspected for damage from the transport. Damaged fittings and/or packaging should be set aside. If welding in a cleanroom or clean environment, remove the outer bag in a staging area and store the fitting inside the cleanroom in the single bag until ready for use. It is recommended to store the fittings in plastic bins within the cleanroom and not to use a cardboard box within a clean environment. Label bins on size and fitting style.

Pipe is also packaged in a class 100 cleanroom environment at the factory. At the final stage of extrusion, pipe is sealed on the end with a piece of PE sheet and a hard PE cap is placed over the end. The pipe is then sleeved in a large single PE bag and heat sealed on both ends. Finally, the entire pipe is placed in a hard HDPE tube and capped. Tubes are labeled appropriately, identifying the product and size inside. See Figure F-47 for a typical pipe package.

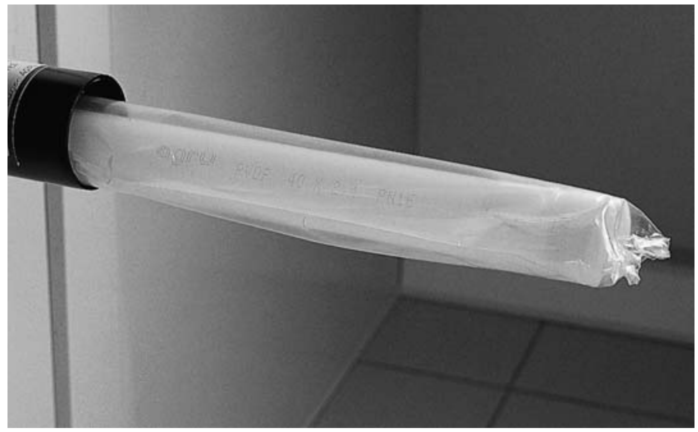

Figure F-47. High-purity PVDF packaging

In sizes 1 1/4" (40 mm) and larger, there is a single pipe per tube. In sizes 1/2"–1", there are multiple pipes per tube. Purad uses hard PE tubes that provide superior protection from contamination in the environment. Hard HDPE tubes provide protection from moisture, dragging, and outside dust and dirt. The use of cardboard tubes has been forbidden due to its nature of particle generation. Cardboard protective tubes will create particles that can contaminate a cleanroom environment.

Preferably, pipe should be stored inside or in a trailer. Care should be taken to properly support pipe during storage. Use the hanging criteria for the proper support distance. Pipe can be stacked during storage. Heavier pipes of larger dimensions should be stored at the bottom; however, it may prove more practical to segregate by size for easier access during the project. Pipe should not be stacked above the maximum height of 4 feet. Storage should be in the HDPE tube.

When ready to transport pipe into the clean zone, open the outer cap on the HDPE tube. Place the tube next to the clean zone entry and slide the pipe directly from the tube into the cleanroom. This will eliminate any need of wiping down the bag prior to entry. In the cleanroom, remove the single bag if ready for immediate usage. If stored in the clean environment, it is preferred to leave the pipe in its original packaging.

When ready for welding, remove all packaging and caps. Remember to save the caps for sealing the ends of prefabricated spool pieces.

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PolyPure and Pure Polypropylene Systems

PolyPure is a natural polypropylene system made available specifically for pure water and chemical systems. PolyPure fittings and valves are single bagged (unless specified otherwise). Fittings are shipped in protective boxes and valves are packed in individual boxes. Pipe is capped and bagged after production. It is shipped wrapped and protected, depending on the quantity of pipes required for the project.

PolyPure fittings should be left in their bag and brought into the clean zone as is. If for some reason the outside of the bag is contaminated, it should be wiped down with IPA prior to entering the clean zone. Valves should be handled in the same manner.

Pipes can remain in their shipping packaging until ready for use or transported into the fabrication cleanroom.

Step 4. Training and Preparation

An ultra pure water or chemical system is a critical utility within a plant's operation. An unplanned shutdown can prove to be more costly than the water piping construction itself. One bad weld can cause hours of repair and frustration, as well as significant lost revenue. For these reasons it is critical to receive training at the time of job start-up and use certified personnel throughout the course of a project. Tool operation is only one of several factors in a thorough training course. Operators, inspectors, and managers need to understand the physical nature of the material: how to properly handle it, how to inspect welds, how to identify potential problems, how to properly maintain equipment, and finally, how best to tie into a line and test it.

All of the above topics are discussed during Asahi/America's certified training sessions. For the installation of a high-purity system, the following training sessions are available:

- Tool Operator Training
- Quality Control Inspection
- Level 3 Operator/Controller (SP equipment only)

In addition to the above on-site training, Asahi/America also offers courses that are held at the corporate office for the following topics:

- Certified Maintenance and Repair (SP and UF equipment only)
- Certified Trainer (prerequisites apply)

Consult with Asahi/America's Engineering Department for dates and availability of corporate programs.

During the on-site training process, Asahi/America certified trainers will set recommendations for the class size based on the tool type. In general, groups of four are recommended for the welding operation portion of the training. Typically, two groups can be certified in one day on the welding portion of the seminar. On simple installations, it may be faster; and on more complex installations, it may be longer. It is important that only personnel who will be conducting the weld operation during the project participate in the training to reduce the distraction within the class. A third party QC should attend the full training course to fully understand the welding process and QC parameters.

Preparation

To best use training time, preparation should be made prior to the trainers' arrival on site. A recommended list of preparations follows.

- Ensure that project material is on site. It is not critical to have all material, but enough to start the project. Once training is complete, it is practical for the trainer to oversee the beginning portion of the installation. Many times new questions and challenges arise once the actual installation starts. In addition, if there is a significant period of time between the training and actual installation, operators may forget portions of the training or different operators may now be slated for the welding operation. Both scenarios require additional training.
- Ensure required tools are on site. Do not open the tools until a certified trainer is present. If more tools are ordered during a project, this is no longer required as proper unpacking and set up of the equipment is covered in the training process.
- Ensure that the correct power is available. Many pieces of equipment require 220 Volt single or three phase power supply. Consult with the factory or distributor at the time of tool ordering.
- If possible, have a conference room with an overhead projector available for the classroom portion of the training. If this is not available, select an area where all personnel will be able to see and hear the trainer for this portion of the discussion.
- Ensure that pipe samples are available for the training session. Asahi/America does not normally provide samples for the training.

Formal training can be the key factor in starting a project off in the right direction. Take advantage of this service while on site. Asahi/America also offers field technicians for hire to oversee project welding and training for any specified amount of time. Contact Asahi/America for more information.

Step 5. Tool Commission and Daily Checks

Checking equipment and welding technique daily is recommended. This is particularly important on larger projects where there are many welders on site. This daily check will allow QA to ensure all welders are up to speed on tool operation, welding technique, and inspection. Most problems in the field occur due to improper usage of equipment, rather than equipment failure.

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During the initial training of the project, many welds are produced in the presence of a qualified trainer. These welds should be kept and used for the daily checks. Each welder should conduct one coupon test weld and submit it to QA. The coupons should be compared to initial samples. Inspection should include bead formation, sizing, and weld label.

It is required to conduct preventive maintenance to the equipment at the beginning of each day. The maintenance recommended varies on each weld tool type. Consult the Operation Manual for items to be checked daily. In all cases, tools need to be kept clean and free of debris. Weld shavings should be removed at all times.

By keeping equipment in good operating condition and ensuring all operators are up to speed, tool problems or welding errors are less lightly to occur.

Step 6. Weld Inspection

To ensure a safe and on-time system start-up, initiating a standard inspection process on each project is recommended. This quality assurance measure can be conducted by third party QC or can be done by each individual operator after each weld. A recommended inspection report for recording quality assurance on each weld is attached at the end of Section F. Use the recommendation of this weld inspection guide in conjunction with the equipment manual to achieve the best project results.

Inspection Labels

IR equipment is designed to help guard against the possibilities of cold welds or incomplete fusion. The label feature should be used in a manner to track all welds. Information can either be handwritten into the log book, or the entire label can be placed into the log. It is important to tag the pipe joint physically with the weld number for traceability. In the case of the SP series, up to three labels can be printed at the time of the weld; one for the book, one for the pipe, and one for other use. An example of a weld label follows:

Figure F-48. SP series label

Using the weld label helps the inspector to ensure the operators are running the equipment in the correct fashion to produce continuous and reliable fusion welds. If the tool was operated incorrectly, the error numbers on the welding label will easily identify it. Any joint with a printed error code is required to be cut and done again.

When inspecting weld labels, items to look for include the following:

- Correct material setup
- Correct OD and wall thickness setup
- Weld parameters indicated as OK

Conventional butt and socket fusion equipment do not provide labels or data recording on each weld. However, using the log in conjunction with an inspection process will decrease the chances of a failure occurring.

HPF equipment also does not generate a label after each weld. The equipment does, however, store the data of each weld. This information can be printed any time on 8 1/2" by 11" paper. Consult the HPF Operation Manual for details on printing weld data.

Bead Formations

Depending on the type of fusion machine being used and the material being joined, the bead formations will vary slightly. However, the basic concept of inspection applies to each weld and material, with only slight differences.

Bead Formations: PVDF IR Non-Contact Butt Fusion

The Purad PVDF system has a unique and characteristic weld that makes inspection simplified. Details are shown in Figures F-49 and F-50 of normal welds from both a UF2000 and the SP series. In general, the weld formations are similar. The SP equipment has tighter controls, thus allowing for the smallest weld formation on the market.

Figure F-49. UF2000 IR weld-PVDF

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Figure F-50. SP series IR weld-PVDF

When inspecting IR fusion, look for primarily consistent and uniform welding joints. Since both ends of the components being joined are melted, there will be a seam down the middle of the joint with almost equal amounts of bead material on either side. The more sophisticated the tool, such as the SP, the more difficult it is to view the seam. The joints are generally smooth on the outer surface and slightly larger on the outside as compared to the inner bead. Due to the effects of gravity during the melting process, it will be common to see a slight variation on the top and bottom of the pipe after the fusion is complete.

Refer to the individual tool guide for specifics on how and when to reject a fusion weld. Each guide also has a table on the bead size measurements and tolerances. Measuring each weld is not practical, but for welds in question it may prove to be a useful tool.

Bead Formations: PVDF Conventional Butt Fusion

Conventional butt-fusion welds have the same basic formation as an IR weld; however, they are slightly larger and have a pronounced roll back. Contact butt welds have a seam in the middle and a bead on either side. Below is a cross-sectional view of a butt and IR weld to see the difference in bead formation. In butt fusion, the inspection process consists of examining each weld for the double weld 360° around the pipe. The disappearance of the double bead formation and drastic reduction in bead size can indicate that a problem existed during the fusion process.

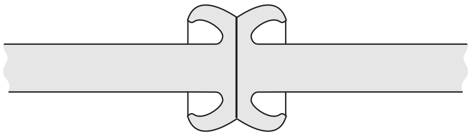

Figure F-51. Butt weld

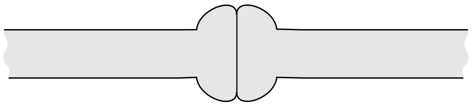

Figure F-52. IR weld

On both IR and conventional butt fusion, there will be a variation in the welds when welding pipe-to-pipe, pipe-to-fitting, and fitting-to-fitting. Since PVDF fittings have a higher melt flow index than PVDF pipe, they tend to flow more when melted. This effect translates into the fitting bead being generally larger than the pipe bead.

Bead Formations: PVDF Socket Fusion

Socket fusion joints can be inspected for bead formation as well. The most important factor of inspecting a socket joint is to ensure the pipe bead and the fitting bead are in contact with each other. After melting the pipe and fitting in the heating mandrels, it is necessary to ensure proper insertion of the pipe into the melted socket fitting. Not meeting the full socket depth can leave a small gap between the pipe and fitting where the pipe has thinned wall thickness due to the melting. In the event of this occurrence, the weld should be rejected and redone. Figure F-53 is a drawing of the proper bead formation in a socket weld.

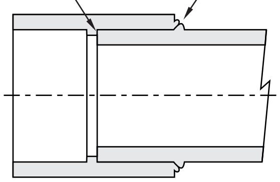

Figure F-53. Proper socket weld

Conducting a sample weld is recommended on a periodic basis, as well as with each new operator. After the sample weld is complete, cut the weld into two pieces and inspect the insertion depth. Since manual socket fusion equipment is available, the results of quality will vary from operator to operator. It is important to verify all welders are not under or over inserting the pipe into the socket fitting.

Bead Formations: PVDF Beadless Fusion

HPF is a non-bead forming weld process. The inspection on HPF is simplified since the socket coupling itself covers the weld. When welding with balloon, the indicator on the side of each fitting can identify proper fusion. The plastic indicator will push out from the HPF coupling due to the heat from the weld. This device, much like a turkey timer, indicates that the fitting has been properly heated. When welding without balloon, the indicator will not necessarily push out.

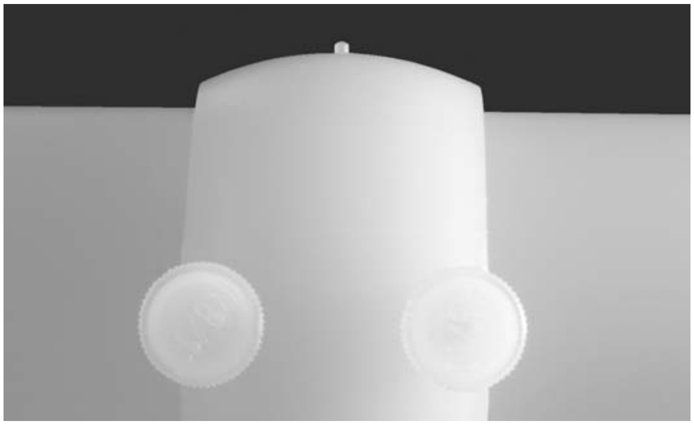

Figure F-54. HPF indicator

The HPF equipment shows the weld count on the screen of each weld. This number should be logged on the supplied charts. In addition, the data from each weld can be printed using a standard dot matrix printer. The tracking of the joint on the pipe, the log, and the tool printout allows quality assurance to track each weld to ensure welds in the system were conducted properly. In addition, the printout will indicate the method of welding on each joint, balloon or without balloon.

Other techniques employed with HPF to ensure proper insertion depth is the marking of the depth. When setting a component into the clamp and centering it, mark the side of the component up tight against the clamp. This mark will allow inspectors to verify the pipe was properly installed into the clamp after the weld is completed. The distance of the mark to the side of the coupling will be identical for each dimensional size. Marks that are too close or too far to the coupling should be rejected. Not carefully inserting the fitting and centering it into the coupling may cause problems. Since the process is controlled with bar coding the parameters and computer control of the heating and cooling, the welding process itself is extremely reliable. The proper set up is the main variable that is the responsibility of the operator.

Bead Formations: Polypropylene and E-CTFE

Polypropylene weld inspection is similar to that of PVDF inspection. In traditional methods, such as butt and socket welding, PP fusion is extremely reliable and simple. Many of the challenges of PVDF, such as material sticking to the heating element, do not occur in polypropylene. The nature of PP makes fusion easier and a more repeatable process. Use the same methods of inspection as in PVDF.

IR fusion with PP is also quite reliable. The inspection process is again the same as PVDF, except that weld beads will be larger in PP due to the thickness of PP pipe. The IR infusion of polypropylene is more difficult than PVDF due to higher joining forces. Closer attention to bead formation and QC is recommended.

Halar® is fused using butt or IR fusion. The weld inspection is also identical to that of PVDF.

Bead Formations: PFA

PFA material, in particular Purebond™ pipe from Entegris, can also be fused using the SP110 IR fusion tool. Welding PFA takes on a slightly different process and, therefore, the bead size and shape is slightly different than that of any material supplied by Asahi/America.

The method for weld tracking and data logging for PP, E-CTFE, and PFA is the same as for welding PVDF in the SP110 welding equipment.

Bubbles in the Joint

In the fusion process, it is possible to find tiny bubbles trapped in the welded region primarily on the outer bead. This may be most noticeable with PVDF, for its clear nature allows it to be visible. These bubbles are a common occurrence in non-contact butt fusion. The bubbles are from one of two sources; either air has been trapped in the weld during the joining process, or small vacuums appear due to material shrinkage during the cooling down time. In either case, the bubbles are not an area of concern and there is no specification for the size of a bubble that would cause a joint failure. The combination of the welding parameters and the melt flow index of the Solef® PVDF resin help to ensure against tiny bubbles affecting the quality of the joint.

Limitations of Inspection

As mentioned in Step 1 (Welding Environment), the IR equipment is designed to assist in preventing against a cold weld. A cold weld is a weld that has either not been heated properly or has been joined together with improper force. In both cases, there is insufficient molten material that is joined together to create a proper fusion of the materials.

The other type of welding error that can occur is incomplete fusion. This type of error occurs typically from the following types of errors:

1. Air movement.
2. Incorrect capping of the joints.
3. Chimney effect in 90° elbows turned upward.
4. Incorrect welding parameters such as OD and wall thickness.
5. Poor planing or alignment.

These errors can usually be identified and replaced prior to system test. To identify these types of welds, look for the following symptoms:

1. Significantly decreased bead size in certain sections of the joint.
2. Significantly decreased bead size all around as compared to other joints of the same size.
3. No bead formation in one section of the weld.
4. Misalignment of open pipe in joint area.

Welds that have the above problems should be cut out and replaced for safety insurance.

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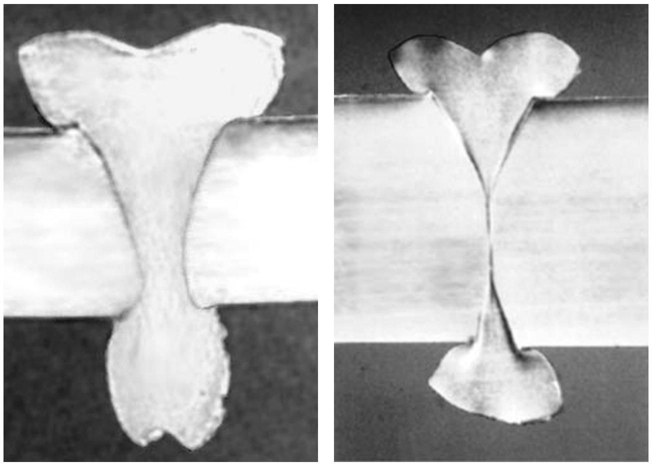
The cold weld is more difficult to identify, and virtually impossible to detect with the naked eye. Two cross-sectional views of a pipe wall that has been welded are shown in Figure F-55. Weld 1 is a good fusion joint, while Weld 2 is a cold weld. Notice in the cold weld there is very little material joined together in the pipe wall area. The molten material has been forced to the outer and inner bead and the unheated sections of the pipe have been forced together in the pipe wall region. In the proper Weld 1, you can see there is material joined together in the pipe wall, as well as in the inner and outer beads.



Weld 1, standard IR joint   Weld 2, cold weld

Figure F-55. Cross-sectional view of wall with weld

The problem with inspecting a cold weld is the outer bead is the same as a good joint. In Figure F-55, the top bead represents the outer look of the weld. It can be seen very clearly that both welds look the same according to the bead formation.

Since the occurrence of a cold weld is difficult to find and inspect, the IR welding equipment from Asahi/America and Agru has been designed to measure the joining force during the fusion process. By measuring the weld force throughout the entire welding process, the possibility of a cold weld is drastically reduced. In the event of over forcing the weld, this will be identified by the tool and marked as an error on the weld label.

Downloading Data/Data Transfer

All computerized IR and HPF welding equipment offered by Asahi/America will store the welding data in its memory. This data can be downloaded and printed for quality assurance purposes. Each tool will have a memory of 1,000 welds. The data on each weld can be transferred to a PC computer using software that is provided by Asahi/America. The data on each weld from a transfer provides an inspector with more information about the weld than what appears on the printout label. Figures F-56 and F-57 show examples of data from the SP series, and UF series welding machines.

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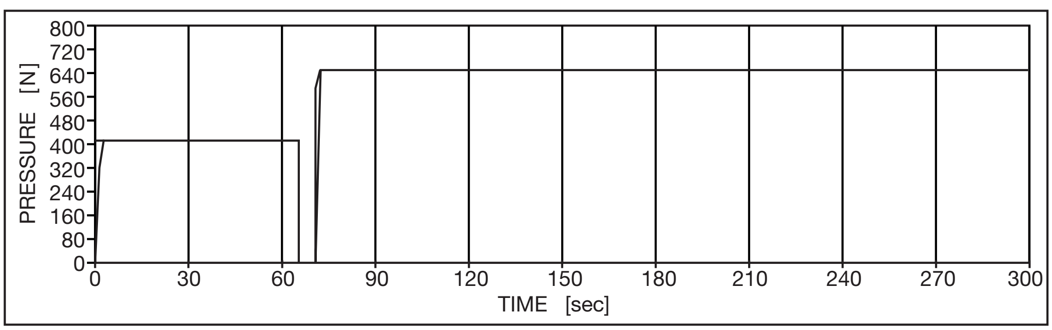
DATAFILE/WELDING NUMBER	SER. NO. [MACHINE]	PRINT-DATE
00526041.W00	W22597-005	08 . 03 . 2001
	SER. NO. [TOUCHPANEL]	
	TP198041	



SOFTWARE	MATERIAL	TEMP-NOM °C	OPERATOR	WAY [mm]
2.11	PVDF	500	agru3-00010	2 . 0
DATE	da [mm]	TEMP-ACT °C	ADDRESS	STATUS
28 . 09 . 2000	250	499	AGRU	WELD . OK
TIME	S [mm]	TEMP-WET °C	ROOM	METHOD
08: 25	11 . 9	22	RAUM	IR

Figure F-56. Weld chart from an SP tool series

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AGRU UF 2000/1
Serial No. 1293005
****

date:	02.09.01/10:58
ident-key	AA01
proj. no:	1265
joint no.	405
dia:	63 mm
wth:	3.0 mm
mat:	PVDF
nitro. Pres:	0.0bar
method:	IRamb
temp:	21 C
des. temp:	480 C
act. temp:	481 C
t(AW)	60 sec
t(U)	2.8 sec
pres ramp:	3.8 sec
des. press:	73 N
act. press:	72 N
t(F)	05:00
error code:	64

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Figure F-57. Weld chart from a UF tool series

The data transfer feature allows the inspector or installer to have back-up documentation on the welds conducted on the tool. Also, by reviewing the welds, it can also be identified if weld counts were reset during the installation, since the tool will record all welds.

The procedures for transferring the data is explained individually in the tool's operation manuals.

Step 7. Hanging

Hanging any thermoplastic system is not that much different than hanging a metal system. Typically, the spacing between hangers is shorter due to the flexibility of plastic. In addition, the type of hanger is important.

Hangers should be placed based on the spacing requirements provided in Tables F-7, F-8, and F-9. Since thermoplastic materials vary in strength and rigidity, it is important to select hanging distances based on the material you are hanging. Also, operating conditions must be considered. If the pipe is operated at a higher temperature, the amount of hangers will generally be increased. Finally, if the system is exposed to thermal cycling, the placement of hangers, guides, and anchors is critical. In these cases, the hanger locations should be identified by the system engineer and laid out to allow for expansion and contraction of the pipe over its life of operation.

When selecting hangers for a system, it is important to avoid using a hanger that will place a pinpoint load on the pipe when tightened. For example, a U-bolt hanger is not acceptable for high-purity thermoplastic piping systems. See Figure F-58.

Table F-7. PVDF Support Spacing Recommendation (feet)

Nominal Size (inches)	68° F 20° C	86° F 30° C	104° F 40° C	122° F 50° C	140° F 60° C	158° F 70° C	176° F 80° C
1/2	3.0	2.5	2.5	2.0	2.0	2.0	2.0
3/4	3.0	3.0	2.5	2.5	2.5	2.5	2.0
1	3.5	3.0	3.0	3.0	3.0	2.5	2.5
1 1/2	4.0	3.5	3.0	3.0	3.0	3.0	3.0
2	4.5	4.0	4.0	3.5	3.0	3.0	3.0
2 1/2	5.0	4.5	4.0	4.0	3.5	3.0	3.0
3	5.5	5.0	4.0	4.0	4.0	3.5	3.5
4	6.0	5.0	5.0	4.0	4.0	4.0	4.0
6	7.0	6.0	6.0	5.0	5.0	4.5	4.5
8	7.5	7.0	6.0	6.0	5.5	5.0	5.0
10	8.5	7.5	7.0	6.5	6.0	6.0	5.5
12	9.5	8.5	8.0	7.0	7.0	6.5	6.0

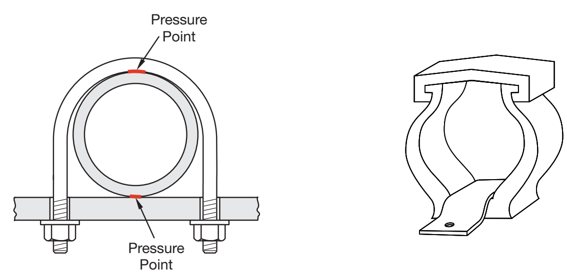
Table F-8. Polypropylene SDR 11 Support Spacing Recommendation (feet)

Nominal Size (inches)	68° F 20° C	86° F 30° C	104° F 40° C	122° F 50° C	140° F 60° C	158° F 70° C	176° F 80° C
1/2	3.0	2.5	2.5	2.0	2.0	2.0	2.0
3/4	3.0	3.0	2.5	2.5	2.5	2.5	2.0
1	3.5	3.0	3.0	3.0	3.0	2.5	2.5
1 1/2	4.0	3.5	3.0	3.0	3.0	3.0	3.0
2	4.5	4.0	4.0	3.5	3.0	3.0	3.0
2 1/2	5.0	4.5	4.0	4.0	3.5	3.0	3.0
3	5.5	5.0	4.0	4.0	4.0	3.5	3.5
4	6.0	5.0	5.0	4.0	4.0	4.0	4.0
6	7.0	6.0	6.0	5.0	5.0	4.5	4.5
8	7.5	7.0	6.0	6.0	5.5	5.0	5.0
10	8.5	7.5	7.0	6.5	6.0	6.0	5.5
12	9.5	8.5	8.0	7.0	7.0	6.5	6.0
14	10.0	8.5	8.0	7.5	7.0	6.5	6.5
16	10.5	9.5	8.5	8.0	7.5	7.0	6.5
18	11.5	10.0	9.0	8.5	8.0	7.5	7.0

Table F-9. E-CTFE Support Spacing Recommendation (feet)

Nominal Size (inches)	68° F 20° C	248° F 140° C
1	3.60	2.50
2	5.00	3.00
3	5.75	3.75
4	6.00	4.00

Notes:
1. Supports must be spaced according to the highest possible temperature the pipes will encounter even if the extreme condition is only temporary.
2. Support spacing is based on a liquid with a specific gravity of 1.0. Spacing should be reduced by 10% for liquids having 1.5 specific gravity, 15% for 2.0 s.g., and 20% for 2.5 s.g.



U-bolts not recommended

Recommended for high-purity systems

Figure F-58. Selection of hangers for piping systems

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Hangers that secure the pipe 360° around the pipe are preferred. Thermoplastic clamps are also recommended over metal clamps, as they are less likely to scratch the pipe in the event of movement. If metal clamps are specified for the project, they should be inspected for rough edges that could damage the pipe. Ideally, if a metal clamp is being used, an elastomeric material should be used in between the pipe and the clamp. This is a must for PVDF and E-CTFE systems, which are less tolerant to scratching. Valves in a pipe system can also add significant weight and stress to a pipe system. Valves, especially metal butterfly valves and heavy diaphragm valves, must be individually supported. For more details on hanging Asahi/America systems, consult Section C, *Engineering Theory and Design Considerations*.

Step 8. System Testing

Prior to pressure testing, the system should be examined for the following items:

1. Pipe should be completed per drawing layout with all pipe and valve supports in place.
2. Pipe, valves, and equipment should be supported as specified, without any concentrated loads on system.
3. Pipe should be in good condition, void of any cracks, scratches, or deformation.
4. Pipe flanges should be properly aligned. All flange bolts should be checked for correct torques.
5. All joints should be reviewed for appropriate welding technique.

   Butt: To have two beads, 360° around the joint.

   Socket: To have two beads on the end of the fitting and on the outside of the pipe in contact, 360° around the joint.

   IR: Labels should identify weld certification by the print "welding OK." Joints should have two beads 360° around the joint. Also, refer to manufacturer's separate weld inspection criteria, supplied separately by Asahi/America.

   HPF: Conducted with balloon should be inspected for the fusion pin being popped out on all balloon joints.

If any deficiencies appear, the quality control engineer should provide directions/repair.

Pressure Test

Test fluid should be deionized water, with quality level set by the quality control engineer or system owner. In all cases, tests must be done hydrostatically. Air is not acceptable.

1. Filling the system: Open the valves and vents to purge the system of any air. Slowly inject the water into the system, making sure that air does not become trapped in the system.
2. Begin pressurizing the system in increments of 10 psi. Bring the system up to 100 psi and hold. Allow system to hold pressure for a minimum of two hours and up to a recommended 12 hours. Check pressure gauge after one hour. Due to natural creep effects in plastic piping, the pressure may have decreased. If drop is less than 10 psi, pump the pressure back up. At this time, the system may be fully pressurized to desired test pressure.
3. If after one hour the pressure has decreased more than 10% and ambient conditions are steady, consider the test a failure. Note the 10% value may need to be greater for larger systems. Also note that Step 2 may need to be conducted several times if there are significant thermal changes.
4. If the pressure drops less than 10% after one hour, pump the pressure back up to the test pressure. This is normal due to creep. If after 2 or 3 hours, the pressure does not drop, consider the test a success.
5. Test is to be witnessed by the quality control engineer, and be certified by the contractor.
6. Obvious leaks can be found by emptying the system and placing a 10 psi charge of clean, dry nitrogen on the system. Each joint should then be individually checked using a soapy water solution or an ultrasonic leak detection gun. Leak detection guns are available from Asahi/America. Consult factory for usage of U.S. leak detection guns. Some limitations do apply.

Step 9. Repair Procedures

If a leak is found or an addition is required to an existing system, there are several options on how to make the repair. In most systems, socket or butt fusion, there is a requirement for pipe movement when making a weld. To conduct a butt or IR weld, one side of the tool moves in order to accommodate the planer, the heating element, and the final joining force. In a repair procedure, the need for movement of the existing pipe makes for the simplest repair. In all cases, weld areas and pipe components must be cleaned as in the original installation.

Flexible Pipe System

If the pipe is in an area where it can be moved, standard butt fusion or socket fusion equipment can be used.

1. Cut out the section in need of repair. It is best to conduct new tie-in welds on straight runs of pipe for easier alignment.
2. If several welds are required, prefab a spool piece on a bench and conduct only a few tie-in welds in the pipe rack.
3. Attach the tool to the existing pipe and properly support the machine to avoid sagging or stressing the pipe.
4. Conduct standard butt-fusion weld per operating procedures. It may be necessary to flex one end of the existing pipe out of the way.
5. Conduct final weld using the flexible side of the pipe system in the moving clamp.

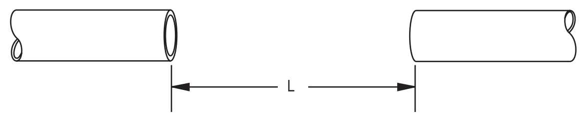

Figure F-59. Remove damaged section

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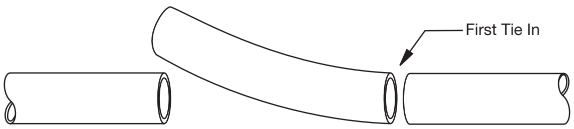

Figure F-60. Install new spool

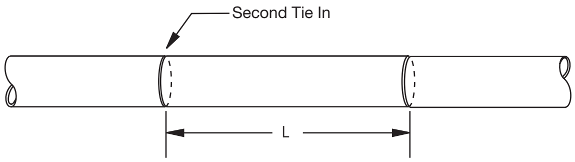

Figure F-61. Butt weld spool to existing pipe line

Non-Flexible Pipe System

Depending on the size and material, repairs can also be made to systems without any movement. For Purad systems in sizes 1/2"– 2", HPF welds can be conducted in place with minimal need for movement.

1. Remove the damaged section of piping. For easier alignment, it is best to conduct new tie-in welds on straight runs of pipe.
2. If several welds are required, prefab a spool piece on a bench setup and conduct only a few tie-in welds in the pipe rack.
3. Using either the large or the small alignment rack, fix two wide clamps to the existing pipe line and to the new spool piece. Make sure all components are level and properly supported.
4. Plane the ends perfectly square. It is recommended to pre-plane both ends of the spool and both ends of the existing pipe line at this point. It is also necessary to slide the second HPF coupling onto the spool at this point to avoid difficulty of placing it on the pipe after one weld is complete.
5. Slide the coupling into place using the third wide clamp and center the existing pipe in the clamp using the mechanical stop. Now bring the spool piece into the clamp until it is up tight against the existing pipe line.
6. Conduct the HPF weld per procedure for the equipment.
7. Measure the thickness of the coupling. Take half of the thickness and mark this distance from the end of the pipe. This mark identifies the location of the end of the coupling and helps to center the coupling on the two final components to be joined. Lock in place using the wide clamp.
8. Conduct the final weld according to procedure.

For systems in PP or larger diameter PVDF, HPF is not available. If there is no flex for movement of the existing pipe in the region of the damaged pipe, the repair can be done using flanges or unions.

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1. Remove the section to be repaired.
2. Weld flanges or unions on both ends of the existing piping.
3. Measure the distance from face to face and build a spool to fit into place.
4. Connect spool into place.

Figure F-62. Remove damaged section

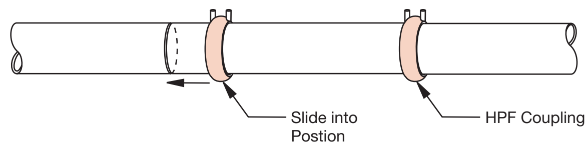

Figure F-63. Slide second coupling into place and conduct first weld at joint seam

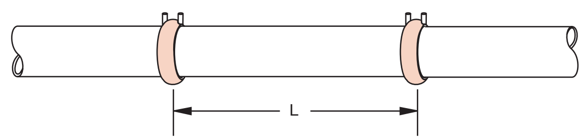

Figure F-64. Conduct final weld

Figure F-65. Remove damaged section

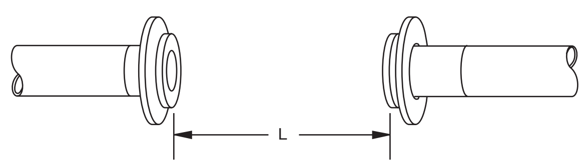

Figure F-66. Weld flanges or unions into place

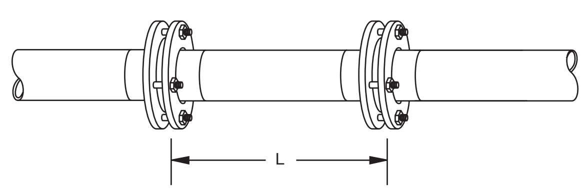

Figure F-67. Place spool into place

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