PP-R and PP-RCT
pressure piping systems

SOCKET, OUTLET, REPAIR PIN AND BUTT
FUSION MANUAL

For U.S. & Canada Distribution

CT Piping Solutions, Inc.

Address:
P.O. Box 516
221 S. Perry Street,
Titusville, PA 16354
United States

Phone:
P: 814.827.8034
F: 814.827.0297

e-mail:
info@ctpipingsolutions.com
web site:
www.ctpipingsolutions.com

Technical Support and Warranty

Pestan North America, LLC

Address:
Warranty Department
P.O. Box 26
Titusville, PA 16354
e-mail:
warranty@pestanpipes.com
F: 888.213.4342

Technical Support
P.O. Box 45
Titusville, PA 16354
e-mail:
support@pestanpipes.com

web site: www.pestanpipes.com

PESTAN WORLDWIDE

PESTAN consistently produces the most advanced plastic piping systems made from Polypropylene (PP-R and PP-RCT), Polyethylene (PE) and Poly Vinyl Chloride (PVC).

Founded in 1989, PESTAN is a privately held company that takes enormous pride in employing 750 people locally and an additional 200 employees worldwide. Utilizing an in-house logistics system and transportation fleet, our products are shipped to over 5,000 distribution centers in 50 countries around the world.

PESTAN's production facilities are located in Central Europe on the banks of the Pestan River. To preserve and protect this environment, we developed and implemented an environmental management system which is certified to ISO 14001. The guiding principals of this environmental protection management system are deeply rooted in all of PESTAN's operations.

Now, PESTAN products are available through our North American partner, CT Piping Solutions, Inc.

Based in Titusville, PA. At CT, our focus is to provide premium quality PP-R and PP-RCT piping solutions which is why we partnered with PESTAN. We stock an extensive inventory of polypropylene products in our Distribution Center for prompt, on-time deliveries. In addition, we offer fusion training as well as customer service and technical support.

This manual is designed to be a job site reference for certified PESTAN pipe installers. Only person certified by PESTAN, CT Piping Solutions, Inc. or our affiliates should conduct heat fusion.
PESTAN pipes should be joined by heat fusion. They cannot be joined using cements, solvents, solders or glues.

Safety Measures

When conducting heat fusions, you are handling tools, pipe and fittings that are heated to temperatures up to 500°F. It is important that safety guidelines be followed.

- Always wear the applicable Personal Protective Equipment.
- Be aware of your environment and verify that it is a safe space to operate fusion equipment.
- Understand proper operation and safety procedures for the equipment you are using.
- Insure all fusion tools are in proper working order.
- Never leave heated fusion tools unattended.
- When unplugged, fusion tools should be properly stored.
- When using electric fusion tools follow recommended electrical safety practices.
- Never start fusion process without posting a warning sign.

PESTAN PP-R(CT) Pipe and Fittings

Applications include but are not limited to the following systems:

Hot and Cold Potable water
Food Processing,
Heating, Cooling and chilled water,
Geothermal,
Industrial,
Compressed Air and Vacuum,
Rain, Gray and Reclaimed Water

PESTAN pipe and fittings are made to DIN Standards and follow ASTM D 2657 guidelines for heat fusion.

PESTAN PP-R(CT) Pipe and Fittings shall be joined using socket fusion for the sizes up to 4” [125mm]. Socket fusions can be done manually, with hand held heating tools, but it is highly recommended to use “machine assisted” fusion tools when fusing 2” pipe and larger.

When PESTAN PP-R(CT) pipe is to be joined to another manufacturers pipe or another piping material, transition fittings or flanges may be used. PESTAN offers an extensive line of transition fittings as well as flange adapters and flange back-up rings.

Product Handling

The installation of a piping system begins with product handling By following a few precautions, you can insure the integrity of the system.

Protect the ends of the pipe, dropping or stepping on them can cause micro-fractures in the pipe wall.
If the pipe is dropped or crushed, check for the damage. Damage needs to be identified, marked and eliminated.

Cold weather makes pipe less flexible and more susceptible to impact damage. Use caution when handling and installing in cold weather. Installation in temperatures below -5° F is not recommended.

Use caution when using a forklift. Do not drape the pipe over the forks or insert the forks into the ends of the pipe.

When shipping, load on a flat or supported surface and only strap in supported areas to prevent pipe deformation.

Keep fittings in their original bags for ease of identification.

Frequently Asked Questions

QUESTION: Where can PP-R and PP-RCT pipe be used?
ANSWER: Polypropylene pipe can be used anywhere where copper, steel, or stainless steel pipes are used. PP-R(CT) pipe is a better choice in many applications where chemicals are transported via piping systems. It is not recommended for systems that exceed 180 F, or steam systems.

QUESTION: Can PP-R or PP-RCT pipe be glued?
ANSWER: No, you do not glue PP-R or PP-RCT pipe. Socket fusion and/or butt fusion creates a permanent, monolithic, leak free bond that is stronger than the pipe.

QUESTION: Are there fittings available to transition from PP-R(CT) to other types of piping systems?
ANSWER: Yes, PESTAN offers a complete line of brass or steel transition fittings and flange adapters.

QUESTION: How safe is PP-R and PP-RCT pipe?
ANSWER: Very Safe! The material is certified for drinking water. It is hydrophobic meaning that it does not leach into or react with water.
If burned, it releases only water vapor and CO_2. In a fire situation fire fighters are recommended to wear respirators. According the USCG, 1999 there is no apparent toxicity.

Fusion Equipment

Fusion joints on PESTAN pipe and fittings have to be performed according to the guidelines in this manual. More information is available in ASTM D2657 – Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings.

We will be discussing 4 types of fusion: Socket Fusion, Repair Pin, Saddle Outlet Fusion and Butt Fusion.

There are several styles of fusion tools to choose from based on the pipe size, type of fusion and the location of the installation. Tools can be categorized as follows:
Hand-Held Irons, Bench Top models and Portable Fusion Machines

The quality of the fusion equipment will affect the quality of the fusions. Currently, there are three fusion equipment manufactures that are approved for use when fusing PESTAN Pipe:
McElroy, Ritmo and Widos.

All fusion equipment must be in proper working order. Consult the manufacturer's operating manual for maintenance and service procedures.

Do not use defective equipment!

HDPE vs. PP-R(CT) Fusion Equipment

QUESTION: If I already have fusion equipment for joining HDPE pipe, can I use it on PP-R(CT) pipe?

The answer is maybe, but not without some changes being made to the equipment.

PESTAN pipe is metric, the HDPE pipe that you have been fusing is Imperial Pipe Size.
So if you are going to be doing socket fusion, you will need to switch out the heater faces from IPS to metric sizing.
If you are going to be doing butt fusion, you will need to switch out the inserts in the machine from IPS to metric sized clamps.

HDPE fuses at a different temperature than PP-R(CT) so you will need to be able to adjust the heating temperature on the fusion iron to the recommended heating temperature for PP-R(CT). Refer to the tables in this booklet.

PP-R(CT) is butt fused at a lower interfacial pressure than HDPE. If you are using a hydraulic fusion machine you will need to check with the machine manufacturer to see if it is possible to change the hydraulic cylinders or if they recommend fusing PP-R(CT) with a machine designed for HDPE.

And finally, just because you have been certified in fusion for HDPE, it does not mean that you are certified in fusion for PP-R(CT). Contact your PESTAN representative to learn how you can become certified.








RITMO

Model	Fusion Type	Fusion Size Range [in]	Fusion Size Range [mm]	Recommendations	Notes
Hand Held Iron R25	Socket Fusion	½ - ¾	20 - 25	For tight spaces and making closely-spaced manifolds	Steel Case needed for storage and protection
Hand Held Iron R63	Socket Fusion	½ - 2	20 - 63	For everyday installations, accomodates up to 2 fusion head sizes at once	Steel Case needed for storage and protection
Hand Held Iron R125	Socket Fusion	½ - 4	20 - 125	For everyday installations, accomodates up to 4 fusion head sizes at once. Used in conjunction with jigs	Steel Case needed for storage and protection
Prisma Jig	Socket Fusion	2 - 4	63 - 125	For over-head, tight-spaces and vertical installations. On the stand, it can be used as a mobile, on-site pre-fab station	Hand held iron and power drill needed additionaly
Prisma 125 Lite	Socket Fusion	2 - 4	63 - 125	Used as a mobile, on-site pre-fab station, can be secured on a scissor lift for over-head installations	Comes with fusion iron, stand and mounts
Prisma 125	Socket Fusion	½ - 4	20 - 125	Used as a precise and time saving pre-fab station both on the site and in the shop	Comes with the pipe stand, wheel base and fusion iron
Delta Dragon 160	Butt Fusion	4 - 6	125 - 160	Used for overhead, tight-space and vertical installations. On the ground, it can be used as a pre-fab station	Comes with the stand, needs inserts for 4" pipe
Gamma 160	Butt Fusion	4 - 6	125 - 160	For over-head, tight-spaces and vertical installations. On the stand, it can be used as a mobile, on-site pre-fab station and back up fitting fabrication.	Does not come with the heating plate
Delta Dragon 315B	Butt Fusion	4 - 12	125 - 315	On the ground, in the ditch and as a pre-fab station. Able to weld fittings like elbows, tees, Y branches and flanges necks	On request, Machine body trolley, Tool for flange necks, Attachable pipe rollers
Delta Dragon 355L	Butt Fusion	4 - 12	125 - 315	Worksite machine for pre-insulated pipes, can be used in for overhead and vertical installations.	Needs clamp inserts for Ø 125 to 315 mm with 250 mm master adapter and tool for flange necks.
Delta Dragon 355B	Butt Fusion	4 - 12	125 - 315	On the ground, in the ditch and as a pre-fab station. Able to weld fittings like elbows, tees, Y branches and flanges necks	Available ony in the 230 V version. On request, machine body trolley, tool for flange necks, attachable pipe rollers

WIDOS

Model	Fusion Type	Fusion Size Range [in]	Fusion Size Range [mm]	Recommendations	Notes
Hand Held Iron WeldIt	Socket Fusion	½ - 2	20 - 63	For everyday installations, accomodates up to 2 fusion head sizes at once	Steel Case needed for storage and protection
Hand Held Iron WeldIt	Socket Fusion	½ - 4	20 - 125	For everyday installations, used in conjunction with jigs	Steel Case needed for storage and protection
Jig	Socket Fusion	2 - 4	63 - 125	For over-head, tight-space and vertical installations. On the stand it can be used as a mobile, on-site pre-fab station	Hand held iron and power drill needed additionaly
7511	Socket Fusion	½ - 2½	20 - 75	Used as a mobile, on-site pre-fab station	Comes with fusion iron and stand (protective case used as stand)
3511	Socket Fusion	½ - 4	20 - 125	Used as a precise and time saving pre-fab station both on the site and in the shop	Comes with fusion iron and stand (protective case used as stand)
Maxiplast	Socket Fusion	2 - 4	63 - 125	For over-head, tight-space and vertical installations. On the stand, it can be used as a mobile, on-site pre-fab station	Hand held iron and power drill needed additionaly
4400	Butt Fusion	4 - 6	125 - 160	Used for overhead, tight-space and vertical installations. On the ground it can be used as a pre-fab station	Comes with the stand, needs inserts for 4" pipe
4600	Butt Fusion	4 - 12	125 - 315	Used for on-ground installations (can be used in certain situations for overhead and vertical installations)	Needs pipe inserts for sizes under 12"







McELROY					
Model	Fusion Type	Fusion Size Range [in]	[mm]	Recommendations	Notes
Hand Held Iron kit (ASW21301)	Socket Fusion	½ - 2	20 - 63	For everyday installations, accomodates up to 2 fusion head sizes at once	
Hand Held Iron kit (ASW21701)	Socket Fusion	½ - 4	20 - 125	For everyday installations, accomodates up to 4 fusion head sizes at once.	Used in conjunction with Spider 125
Spider 125 (w/ chain and inserts)	Socket Fusion	2 - 4	63 - 125	For over-head, tight-space and vertical installations. If used in conjunction with a pipe stand and clamps, it can be used as a mobile, on- site pre-fab station	Requires a hand held iron. Inserts are needed for every size. If using as a pre-fab station, a pipe stand and clamps are required.
Spider 125 (w/ universal clamps)	Socket Fusion	2 - 4	63 - 125	For over-head, tight-space and vertical installations. When used in conjunction with a pipe stand and clamps, it can be used as a mobile, on-site pre-fab station	Requires a hand held iron. If using as a pre-fab station, a pipe stand and clamps are required.
Pit Bull 26	Butt Fusion	4 - 6	125 - 160	Used for "on the ground" butt fusion	
Acrobat 160	Butt Fusion	4 - 6	125 - 160	Used for overhead, tight-space and vertical installations. On the ground it can be used as a pre-fab station	Comes with the stand and 4" size pipe inserts. Configures from 4 jaws to 3 jaws without tools.
DynaMc 250	Butt Fusion	4 - 10	125 - 250	Used in small working areas	Available in 2 and 4 jaw. Comes w/ Electric Pump HPU which uses a hydraulic accumulator.
Pitt Bull 250	Butt Fusion	4 - 10	125 - 250	Used for "on the ground" butt fusion	Powered by Hydraulic Power Unit (HPU), sold separately.
Rolling 250	Butt Fusion	4 - 10	125 - 250	Used for long runs	Wheeled chassis for easy maneuvering on the jobsite
Track Star 250	Butt Fusion	4 - 10	125 - 250	Self-contained, self-propelled, all-terrain	On-board generator for powering heater and other devices.Carriage can be easily removed for close-quarter use.
DynaMc 412	Butt Fusion	8 - 12	200 - 315	Used in small working areas	
Pitt Bull 412	Butt Fusion	8 - 12	200 - 315	Used for "on the ground" butt fusion	Powered by Hydraulic Power Unit (HPU), sold separately.
Rolling 412	Butt Fusion	8 - 12	200 - 315	Used for long runs	Wheeled chassis for easy maneuvering on the jobsite. Gas-powered self-contained or electric models available.
Track Star 412	Butt Fusion	8 - 12	200 - 315	Self-contained, self-propelled, all-terrain	On-board generator for powering heater and other devices. Carriage can be easily removed.

Tool and Job Site Preparation

Using the manufacturers instructions, assemble the required socket fusion tools.

If preforming Socket Fusion, verify that the fusion heads, depth gauge/chamfer tool and cold ring are compatible with the pipe size. Fusion irons come in three sizes. Attach the fusion heads to the fusion iron insuring full surface contact between the head and the iron. If you use a fusion iron that is too small, it will not be able to generate enough power to evenly heat larger connections.

Make sure that the iron and/or socket heads are clean and free from any contaminants. If dirty, clean with a soft clean, natural, dye free, lint free cloth and 80% isopropyl alcohol, taking care not to scratch the Teflon coating.

Connect the heating tool to the power supply
Pre-heat the iron to 480-500°F (248-260°C). The power supply needs to be compatible with the fusion iron. Insufficient power supply can cause cold fusions.

Clear surrounding area and move away items that are flammable or that could melt.

PESTAN PP-RCT piping systems CANNOT be “dry fit”.
If not properly planned, the installer can end up in a situation where there will not be enough space and flexibility for the last connection in a series.

Never leave fusion equipment unattended!

Before Starting

Prepare the area for fusion.
Think about safety!

- Wear your personal safety protection gear at all times.
- Make sure all approved tools are in proper working order and that they are clean.
- Verify that you are using fusion equipment strictly designed to follow DVS 2208 Standard.
- Verify the power source is adequate and consistent.
- Inspect the pipe for damage.
- Verify the temperature of the fusion head has reached the 480°- 500°F (248°- 260°C) range. The use of a pyrometers, tempilstick or any other thermal detection devices is recommended.
- Consult temperature and time charts to be sure that proper guidelines are being met.
- Perform a trial fusion at the start of each day.
- Shield fusing equipment from inclement weather and winds.
- Place the warning sign adjacent to the hot iron.

Preparation and Cutting of the Pipe

- Make sure that the pipe has not been damaged. Double check the pipe ends which are more susceptible to damage. If damage is noted, remove the damaged section of the pipe.
- Measure and mark the length of pipe needed.
- Use pipe supports when cutting and fusing to prevent pipe movement.

Cut the pipe using following methods:

- For pipe up to 2”, use ratchet cutters with a sharp blade. A dull blade can affect the ovality of the pipe.
- Use hand wheel cutters for larger diameter pipe

- if using a handsaw, the teeth should be safe for plastic
- Band saws and reciprocating saws may be used. Thinner blades produce a better cut with fewer shavings.

- When using electric saws, use a circular hardwood blade with 60 to 100 carbide teeth.

Note: Do not use circular saws if the ambient temperature is less than 40°F

SOCKET FUSION with hand held iron

Socket Fusion - Marking

When performing socket fusion, there are three methods to determine how far the pipe should be pushed into the fusion iron:

- The use of a chamfer tool with depth gauge along with cold rings is recommended. These are available exclusively through CT Piping.
- You may use a marking guide provided by PESTAN/CT Piping
- You may also use the chart below to reference the appropriate stab depth and then use a measuring tape to mark it on the pipe.

Mark the required insertion depth on the pipe in several places for better guidance of the connection line up.

Stab Depth Table

Pipe O.D.	.50” 20 mm	.75” 25 mm	1.00” 32 mm	1.25” 40 mm	1.50” 50 mm	2.00” 63 mm	2.50” 75 mm	3.00” 90 mm	4.00” 125 mm
Stab Depth (inches)	.47	.51	.57	.63	.71	.94	1.02	1.14	1.57

Socket Fusion – Heating Pipe and Fittings

Use pyrometers to confirm that the fusion heads have reached 480-500°F (248-260°C).

When socket fusing, you will be heating the outside of the pipe and the inside of the fitting.

- The pipe and fitting are simultaneously pushed (no twisting) on the fusion head which is attached to the heating iron.
- As the pipe and fitting soften, you will be able to push them further on the fusion head.
- When you reach the point on the pipe that you marked, stop pushing.
- Continue to push the fitting until it reaches the base of the fusion head
- The heating time starts when both the pipe and fitting have reached their maximum insertion points.

Socket Fusion - Heating Time

The following heating times are recommendations based on temperatures above 40°F. Actual required heating times may vary based on ambient conditions, continuity of power supply, etc. PESTAN recommends that you perform a test fusion in order to identify optimum heating times.

Note: If working in cold weather conditions, you should increase the fusion heat times (for exact times contact PESTAN technical department). When cutting the pipe in cold conditions, use rolling or ratchet cutters (circular saws are not recommended).

Heating Times Table

Pipe O.D.	.50" 20 mm	.75" 25 mm	1.00" 32 mm	1.25" 40 mm	1.50" 50 mm	2.00" 63 mm	2.50" 75 mm	3.00" 90 mm	4.00" 125 mm
Heating Time (sec.) >40 F	5	7	8	12	18	24	30	40	60

Socket Fusion – Joining the Pipe and the Fitting

- Once the Heating Times have been realized, remove the pipe and fitting from the fusion head. Do not twist them off, pull them straight away.
- Quickly inspect the melt on both.
- Align the pipe with the fitting and insert the end of the pipe into the fitting until the bead on the pipe touches the edge of the fitting.
- Do not twist the pipe or fitting. This can displace the molten material and affect the integrity of the joint.

Socket Fusion - Correction Time

Once the pipe has been inserted into the fitting, you have a few seconds to adjust the angle of the pipe up to 10° in order to properly align it with the fitting.

Correction Times Table

Pipe O.D.	.50" 20 mm	.75" 25 mm	1.00" 32 mm	1.25" 40 mm	1.50" 50 mm	2.00" 63 mm	2.50" 75 mm	3.00" 90 mm	4.00" 125 mm
Correction Time (sec.)	3	3	6	6	6	8	8	8	10

Socket Fusion - Hold Times

The connection must be held in place until the joint cools and the fusion is set. Recommended Hold Times are ¼ of the Cooling Time, based on pipe size and may vary based on ambient temperature.

Socket Fusion - Cooling Times

After the Hold Time has been met, the joint should be allowed to rest for a few more minutes before being used. The following are Cooling Time recommendations. Do not try to accelerate the cool times by using water.
After the cooling times have been met, the joint is ready for use.

Cooling Times Table

Pipe O.D.	.50” 20 mm	.75” 25 mm	1.00” 32 mm	1.25” 40 mm	1.50” 50 mm	2.00” 63 mm	2.50” 75 mm	3.00” 90 mm	4.00” 125 mm
Cool time (min.)	2	2	4	4	6	6	6	6	8

SOCKET FUSION ASSISTED BY FUSION MACHINE

For the socket fusion connections of 2” and above, it is recommended to do “Machine Assisted” fusions. Using fusion machines will help installers make faster and more precise connections.
There are two major types of fusion machines: “Portable” and “Bench” fusion machines. Fusions done with Socket Fusion Machines follow the same basic fusion preparation steps as those done with hand held fusion irons.
PESTAN recommends that prior to making a system connection, the operator conduct a test fusion to verify that the machine is in proper working order.

Portable Fusion Machine and Jigs

Portable Fusion Machines and Jigs are mobile and are designed for job site fusion connections of 2” and above. They can be freestanding or fastened to available surfaces and used in a pre-fab station. These units consist of a sliding carriage with a light metal body, a built-in or removable heating plate, clamping jaws and mounting clamps. These types of fusion machines are ideal for vertical, overhead and tight space installations.

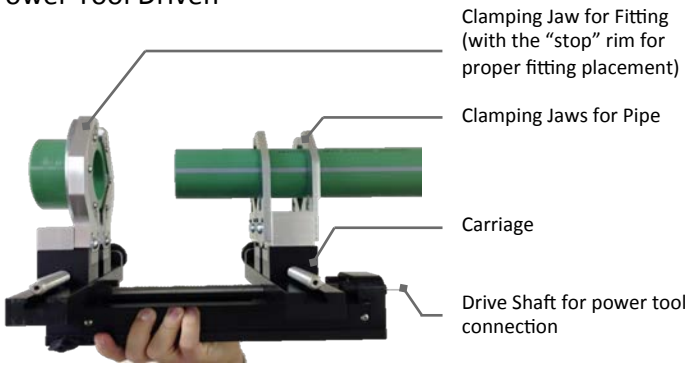
Bench Fusion Machine

Bench fusion machines are designed for socket fusion connections of 2” pipe and larger. These machines assist the installer by holding the pipes in place, making for precise and consistent fusion joints. They are available in both table top and portable models.

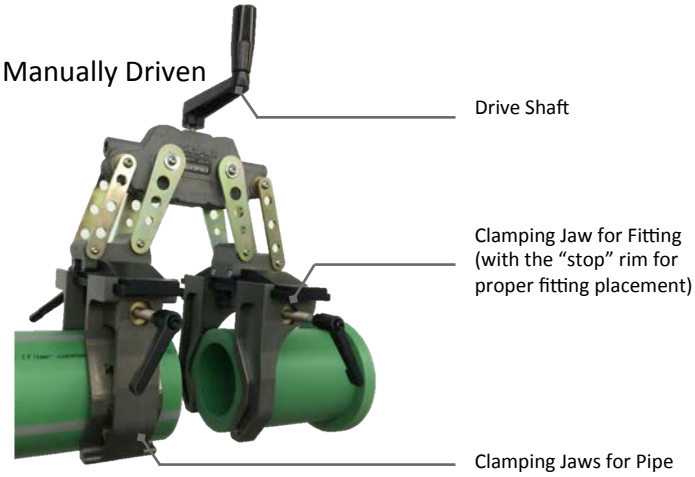
Instructions for Jig Assisted Socket Fusion

Jigs are light and have a compact design, allowing installers to accomplish connections in tight spaces or when working on over-head installations.
Furthermore, jigs can be used on the ground as a prefabrication station for uniform and consistent connections. When performing Jig assisted Socket Fusion, follow all the safety measures.

Power Tool Driven

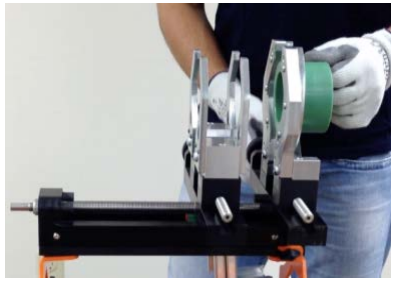


Manually Driven

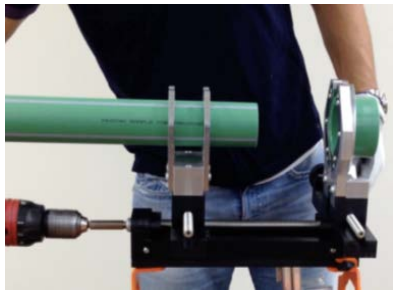


Fusion Procedures Using a Jig

- Verify that the fusion heads match the size of the pipe and fittings. Install the fusion heads on the heater face.
- Plug in the fusion tool into the power source and verify the temperature of the fusion heads after it indicates that the desired temperature of 480 - 500˚F (248 - 260˚C) has been reached.
- Cut the pipe to the desired length.
- Measure and mark the insertion depth (page 11) on the pipe in multiple points around the pipe O.D.
- Place the fitting in proper jaws flushed with the jaws integrated stop rim.



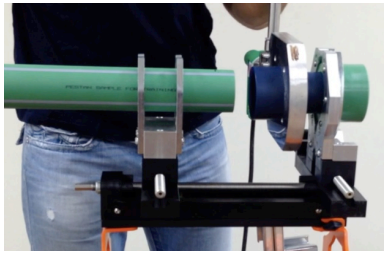
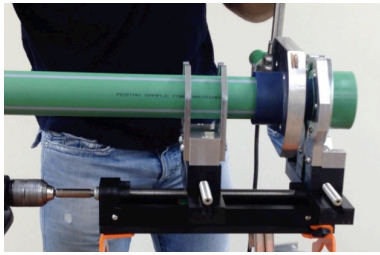
- Place the pipe in the smaller set of clamping jaws, ½" to 1" after the measured mark of insertion.
- Verify the distance between pipe and the fitting in the jaws will be enough for the iron to be placed when carriage is fully open. Make sure that pipe and fitting are tight enough to prevent movement.



- Reverse the carriage, backing the pipe and fitting apart so that the fusion iron can be inserted between them.

- Insert Fusion Iron between pipe and the fitting and align it.

- Advance the carriage forward moving the pipe and fitting into the fusion head. Continue to advance until the marked insertion depth is reached. When fusing larger pipe diameter, it is recommended to advance the carriage in short bursts, allowing the fusion heads to melt the pipe and the fitting.

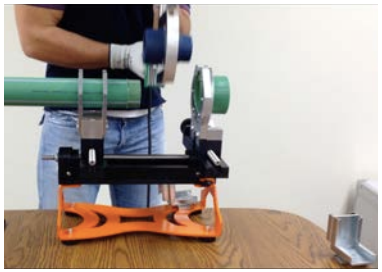
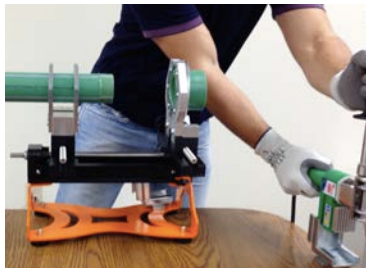



- Heating time starts when both pipe and fitting are fully inserted into the fusion heads. Be sure to hold the fusion iron in the position during the heating time, to prevent it from twisting around the melted pipe and fitting.

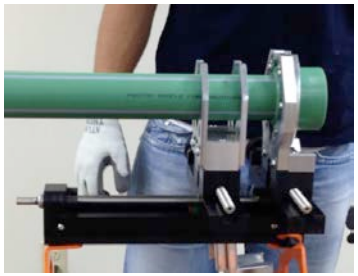
Heating Times Table

Pipe O.D.	.50” 20 mm	.75” 25 mm	1.00” 32 mm	1.25” 40 mm	1.50” 50 mm	2.00” 63 mm	2.50” 75 mm	3.00” 90 mm	4.00” 125 mm
Heating Time (sec.) >40 F	5	7	8	12	18	24	30	40	60

- When the heating time is met, reverse the carriage moving the pipe and fitting away from the fusion iron. Be careful not to damage the fusion bead or disturb the melt when removing the fusion iron.
- Set the fusion iron back on its stand.

- Immediately advance the carriage forward, moving the pipe and fitting together until the pipe is inserted into the fitting.
- Do not over-insert, stop when the melted beads meet. The insertion mark should still be visible.

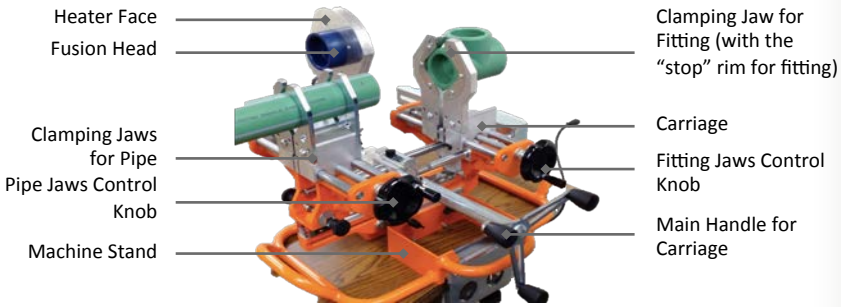



- The connection remains in this position for minimum of ¼ of the cooling time.

Cooling Times Table

Pipe O.D.	.50” 20 mm	.75” 25 mm	1.00” 32 mm	1.25” 40 mm	1.50” 50 mm	2.00” 63 mm	2.50” 75 mm	3.00” 90 mm	4.00” 125 mm
Cool time (min.)	2	2	4	4	6	6	6	6	8

Instructions for Bench and Portable Fusion Machines



- Clear the surrounding area where the welding machine will be placed, level and secure the machine, so there is no possible movement during operation.

- Verify that the fusion heads match the size of the pipe and fittings. Install the fusion heads on the heater face. If not attached, attach the fusion tool to the machine and leave it in its "resting" position.

- Plug in the fusion tool into the power source and verify the temperature of the fusion heads after it indicates that the desired temperature of 480 - 500˚F (248 - 260˚C) has been reached.

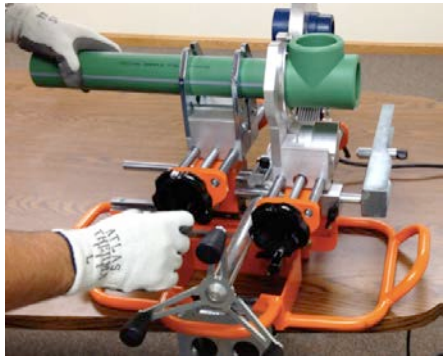
- Cut the pipe to the desired length.

- Measure and mark the insertion depth (page 11) on the pipe in multiple points around the pipe O.D.

Note: Some machines have a calibration knob that can be set for the designated pipe size and will assist with proper stab depths.

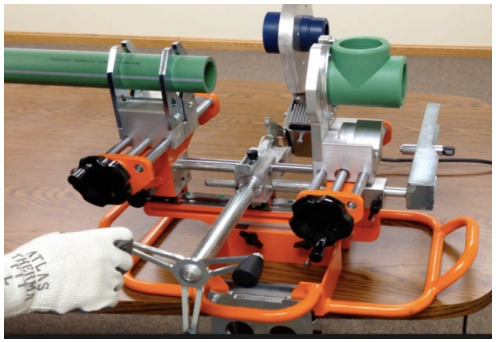
- Install the inserts jaws on the carriage. Insure that the clamping jaw inserts are the proper size for the pipe and fittings to be fused.
- Place the fitting in the clamping jaws, so that the "stop" rim is flush with the face of the fitting.

- Place the pipe in the other clamping jaws but do not tighten.
- Turn the main handle to advance the carriage forward so that the pipe and fitting are in the proper position for fusion.
- Check for alignment and spacing of the pipe and fitting.



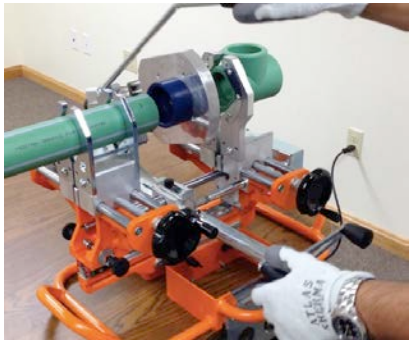
- Once aligned, secure the pipe and fitting in the clamping jaws and use jaw knobs to tighten them to sufficiently prevent slipping.

- Using the main handle, reverse the carriage, backing the pipe and fitting apart, making appropriate space for fusion iron to be inserted between them.



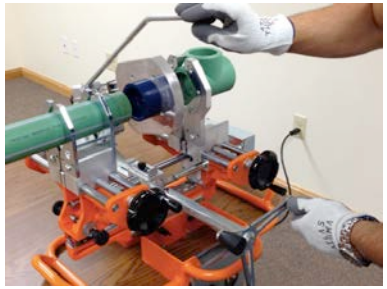
- Lower the fusion iron to align fusion heads with pipe and fitting.

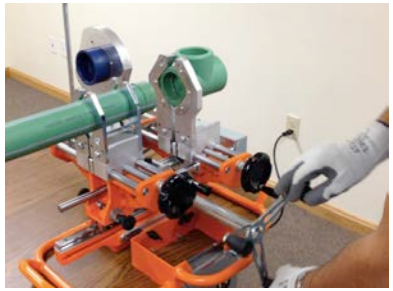
- Advance the carriage forward moving the pipe and fitting to the fusion heads. Continue to advance until the marked insertion depth is reached.



Note: Do not force the pipe or fitting onto the fusion head. Use steady, easy pressure and allow the pipe and fitting to melt onto the fusion heads.

- The heating time starts when the pipe and fitting are completely inserted in the fusion head.
- When the heating time is met, reverse the carriage moving the pipe and fitting away from the fusion iron. Be careful not to damage the fusion bead or disturb the melt when removing the fusion iron.
- Move the fusion iron back to its “resting” position, away from the pipe and fitting.





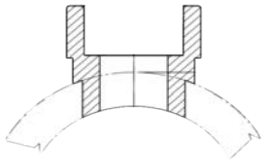
- Immediately advance the carriage forward, moving the pipe and fitting together until the pipe is inserted into the fitting.
- Do not over-insert, stop when the melted beads meet. The insertion mark should still be visible. Machines with calibration knobs will prevent over-insertion of the pipe into the fitting.

- The pipe remains in this position until cooled. Refer to the recommended cooling time table on page 14.

Note: Some Types of Fusion Machines have lock system to hold connection during the cooling time.

SADDLE OUTLET FUSION (using Hand Held Irons)

With Socket or Butt Fusion, the end of the pipe is being heated and fused. With Saddle Outlet Fusion, the fusion welds are in the wall of the pipe as well as on the curved surface of the pipe and fitting.



Cross-section of the Saddle Outlet Fusion Connection

This makes it ideal for installing branch lines off the main, manifolds, insertion of the gauges, etc. These connections can even be made after the main lines have been installed. Using saddle outlet connections when building manifolds saves fabrication time and money. Also, saddle outlet connections have lower pressure loss than a reducing tee.

Saddle Outlet Fusion – Preparation

Before you begin the Saddle Outlet Fusion process, follow the Basic Preparation Steps outlined on pages 8, 9 and 10. Mark the location of the bore on the wall of the pipe. When drilling the outlet bore, PESTAN recommends using a special drill bit designed by CT Piping Solutions. It will provide exact hole sizing needed and take out the cuttings created during the boring process. If the drill bits are larger than 2”, a drill press is required.

It is important to drill at a precise 90° angle. The fusion heads must fit flush against the pipe. Double-check to ensure that no extra material or burrs are left inside the pipe once you have drilled the hole. Make sure to remove any pipe shavings that are still attached.

Saddle Outlet Fusion - Heating Process

Verify that the temperature on the fusion head has reached 480-500°F (248-260°C). Use of pyrometers, Tempilstiks, or any other thermal detection devices are recommended.

- Insert the heating tool into the borehole of the pipe.
- Use a wooden dowel or other heat resistant device to push down on the heating tool, melting it into the borehole.
- When the fusion head is completely inserted into the borehole, place the saddle fitting on the fusion head and apply pressure. Be careful not to move or twist the heating tool.
- When the saddle fitting is completely on the fusion head, begin the heating time of 30 seconds.

- When the heating time is met, pull the heating tool straight out of the borehole and the saddle fitting straight off the fusion head. Do not twist off.

Saddle Outlet Fusion - Connecting the Fitting to the Pipe

As soon as you remove the saddle fitting from the fusion head, insert it vertically into the borehole. Do not twist the fitting into the borehole. Twisting the fitting can displace the molten material and affect the integrity of the fitting. Immediately check the placement of the fitting on the pipe and use a level to insure it is placed properly. The installer has only a couple of seconds to correct the position of the saddle.

Saddle Outlet Fusion - Hold Times and Cooling Period

Once the fitting has been installed on the pipe and any required corrections have been made, the connection must be held in place until the joint cools and the fusion is set.

After 10 minutes, the connection is ready to operate under pressure.

Note: To visually inspect the connection, look for full melt circle around the pipe and fitting.

Pipe Repair Techniques

If PP-R(CT) pipe is punctured by a nail or screw, the pipe can be repaired. For holes that are 3/8” or less in diameter, use a repair pin. For larger punctures or cuts, repair with a saddle.

Saddle Repairs

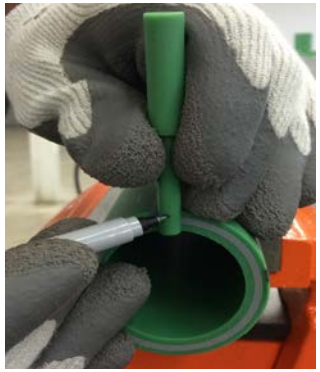
A Saddle Repair is used for holes too large to be fixed using the repair pin. The procedure is simple;

- Drill out the hole with a drill bit that just slightly larger than the damage in the pipe.
- Use appropriate saddle for the size of the hole and the repair pipe size.
- Follow the instructions for Saddle Outlet Fusion found on page 25-28.
- Cap a short length of pipe and then fuse it into the saddle fitting using socket fusion method.

Repair Pin

- First assemble the tools required for making the repair. Attach the fusion repair head onto the fusion iron. The repair head comes in two sizes: 1/4” and 7/16”. If the hole is too small then the installer should drill it out with a ¼” bit for the ¼” repair tool or a 3/8” bit for the 7/16” repair tool. If the hole is larger than the 7/16” repair tool, then a saddle repair should be done.

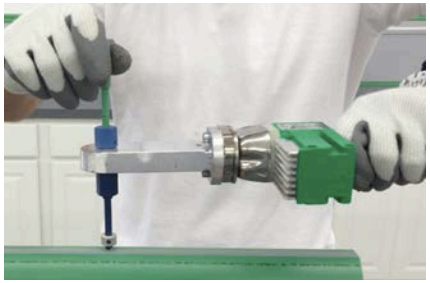
- Find the correct wall thickness for the size and SDR of the pipe (table at the end of the booklet). If the repair pin fusion head has a depth marker, slide the stop to the appropriate depth before heating iron to temperature. Mark repair pin with wall thickness of the pipe and add 1/8” to it.

- Remove the penetrating object from the pipe and clear the hole. Wipe away any dirt or debris and insure that the pipe is completely dry.

- Connect the fusion iron to the power supply. When the fusion repair head has reached 480-500°F (248-260°C), insert the repair pin into the repair head and insert the repair head into the hole in the pipe.

- Heat both the hole and the pin for 5 seconds.




- Remove the fusion repair head and insert the repair pin into the hole to the pre-marked depth of insertion. Do not twist.
- Hold the pin in place.


- Once the pin has set, remove the unused portion of the Repair Pin by carefully holding the end of the pin in place while cutting it with pipe cutters.

- Use caution when cutting off excess pin and be sure that your fingers are clear of the cutter blade.
- Pressure test the system following the repair.

BUTT FUSION

Butt fusion is used to accomplish connections of 4” or larger pipes and/or fittings. There are many models of butt fusion machines, each designed for specific pipe size range. Some are light weight for use in overhead installations, other are designed to be used on the ground as part of a pre-fabrication station. To insure you have the proper equipment for the job, please consult with PESTAN support or with an approved PESTAN equipment manufacturer.

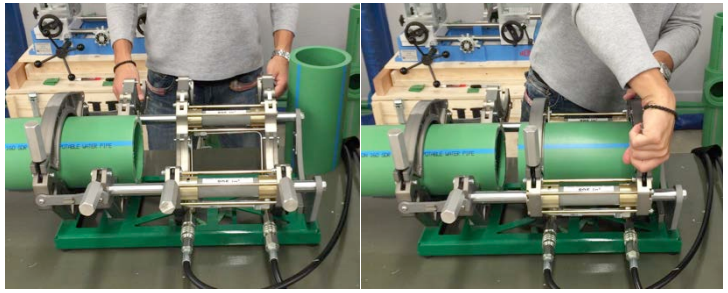
There are two main types of butt fusion machines, Manual and Hydraulic (shown in the photo above). The difference in the two is pressure regulation: one uses manual force, the other uses a hydraulic power unit. The basic principles of fusion is the same for both types of fusion machines.
Before performing butt fusion, read the fusion machine manual. Familiarize yourself with the operation of the fusion machine and follow all safety measures and recommendations.

Verify the sizes of the inserts are compatible with the pipe and/or fitting size. Secure the inserts into the machine clamps. Clean the heating plate with lint free, non-synthetic cloth or paper towel.

Plug the fusion machine and heating plate into the power source and verify the temperature of heating plate reached 410°F (210°C), with maximum variance of +/-15°F. Make sure power supply is sufficient for the machine used. Insufficient power supply can cause cold fusions that will fail. If using extension cords, insure that cord is capable of delivering the required power and that you are within a reasonable distance from the power supply.

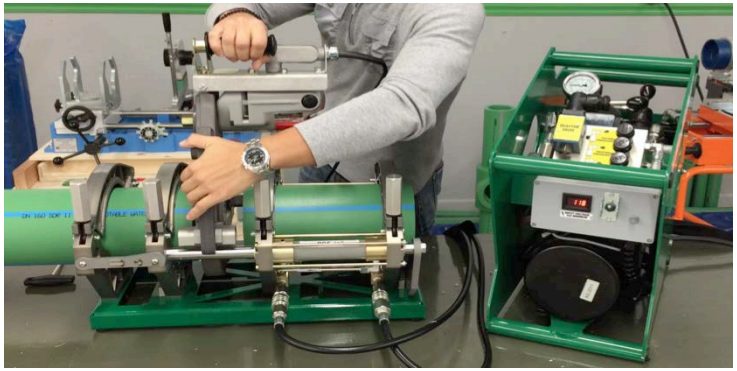
Cut the pipe to the desired length. Make sure to cut as squarely as possible.

Place pipes and/or fitting into the clamps of the fusion machine, leaving approximately 1” from the edge of the pipe to the clamp. Adjust second clamp of the fusion machine to accommodate length of the pipe/fitting. If there is ovality in the pipe/fitting, place the long side vertically, so the clamps help re-round the pipe.

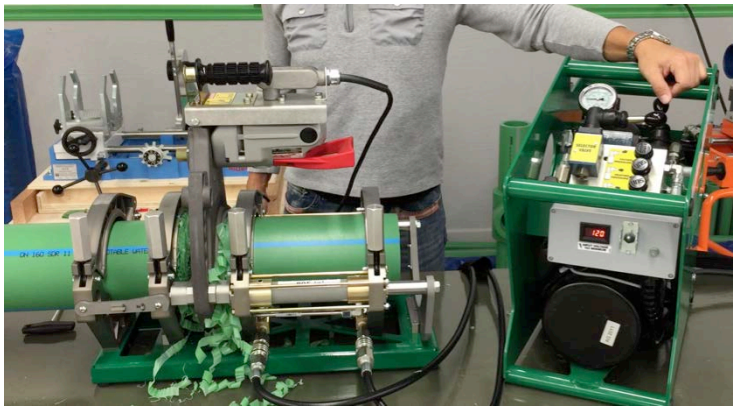


Note: if two pipes are being fused, line up the print lines on both pipes. If print line is not available, line up the stripes on the pipe.

Insert Facer. Make sure facer is not touching the pipe and/or fitting, turn it on and let it reach full speed.



Slowly increase the pressure control valve until carriage with pipes and/or fittings move towards each other and trim until the jaws come in contact with the facer stops.

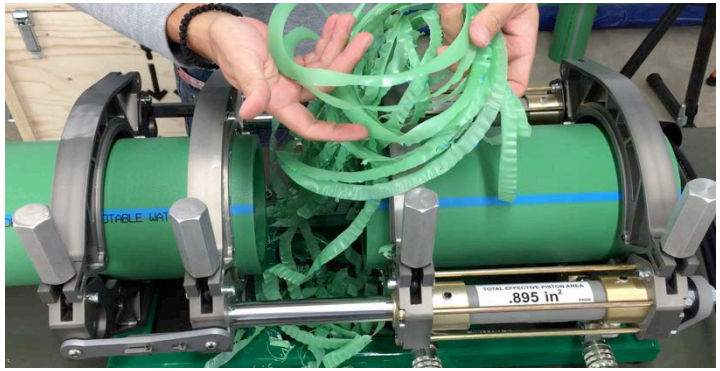


Note: if facer motor stalls, decrease the pressure.

When trimming is achieved, drive the carriage away from the facer and then turn the facer off.
Remove facer and place it in the holder.

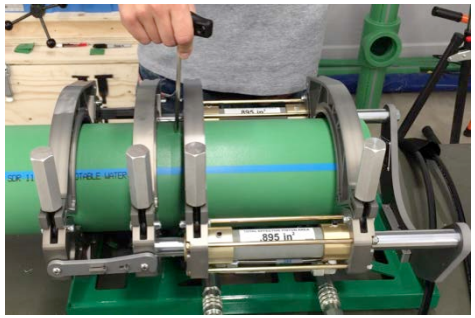
Clear shavings from the pipes and the fusion space. Clean faced ends of the pipe and/or fitting with the lint free non-synthetic cloth or paper towel.

Inspect shavings ribbons for at least one complete ribbon from both ends. This ensures that the pipe faces are clean and parallel.



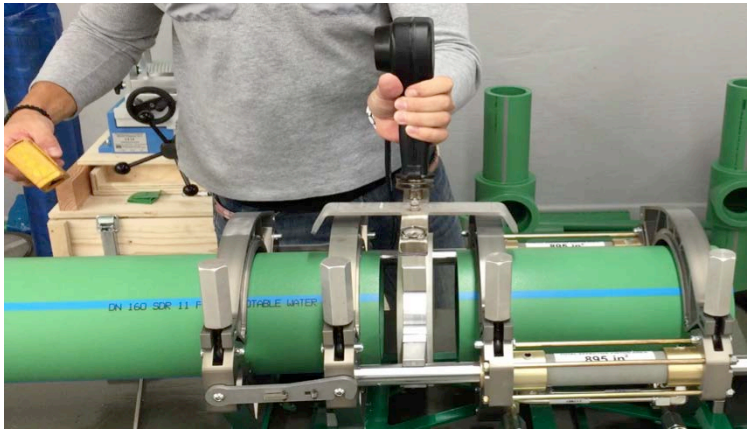
Slowly increase the pressure until the carriage starts moving, then back the pressure down until the carriage is barely moving. This is your Drag Pressure.

Close the carriage, visually check for the vertical alignment of the faced ends. If needed, tighten the inside clamp on the high side to bring ends into the alignment and re-face the pipe.



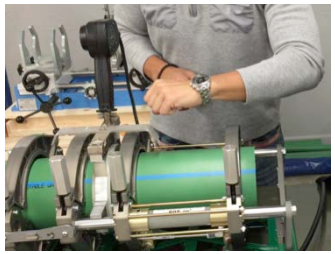
Note: Pen/marker or other slim flat edged instrument can also be used to check if the ends are vertically aligned.

Once facing is completed and both faced ends are aligned, set the Fusion Pressure to recommended pressures depending on the pipe size, wall thickness and machine model. Fusion Pressures can be found in the tables on pages 41-44 or online at www.pestanpipes.com. Bring pipe ends together to insure that pipe doesn't slip in clamps. Open carriage with the space between faced ends with 2-3" gap and insert the heating plate. Bring the faced ends onto the heating plate using the Fusion Pressure.

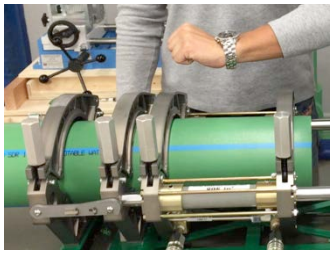


Watch closely for the formation of the beads where the pipe/fitting touches the heating plate. When a thin line of melt appears all the way around the pipe, drop the pressure down to 0 if the machine has locking carriage, otherwise drop the pressure to Drag pressure and start measuring the required Heating Time.

Wait for the entire Heating Time to elapse (Table on pg. 41). Shift the fusion machine into fusion pressure.
After reaching the proper Heating Time, Open the carriage and carefully remove the heating plate. Quickly (within 3 seconds) inspect heated ends for contamination, concave pipe/fitting face and a consistent melt bead.
After the inspection, use the Fusion Pressure to close the carriage and start the Cooling Time (Table xx).



Leave the fusion machine running for the entire Cooling Time. Depending on the type of fusion machine you may need to periodically check the pressure gauge, and adjust to keep the required Fusion Pressure.



Note: Do not pour water onto the connecting to shorten the Cooling Time. If both ends of the pipes and/or fittings continues to be supported, then Cooling Times can be reduced by 50%.

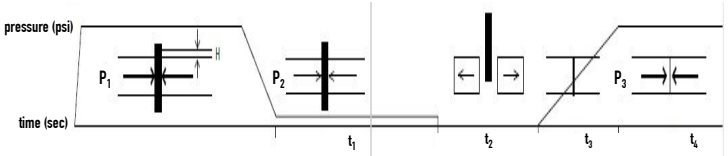
After reaching Cooling Time, bring pressure to 0 and release pipes and or fittings from the clamps.
Inspect the joint for any contamination, uniform bead size, no double-bead formation.

The following table gives the times for the heating phase, fusion phase and cooling phase of a butt fusion. The heating, Fusion and cooling times are based on the size and SDR of the pipe. These values do not change from one fusion machine to the next.

Butt Fusion Heating and Cooling Times					
Dimension		Heating	Fusion		Cooling
SDR	ND (OD)	Heating time (sec) t_1	Max.transition time (sec) t_2	Time of pressure build-up (sec) t_3	Cooling time (min) t_4
9	6"(160mm)	315	9	16	28
11	6"(160mm)	277	8	13	24
17.6	6"(160mm)	204	6	9	15
9	8"(200mm)	364	10	19	35
11	8"(200mm)	320	9	16	29
17.6	8"(200mm)	237	7	11	19
9	10"(250mm)	415	12	24	43
11	10"(250mm)	367	10	20	35
17.6	10"(250mm)	272	8	13	23
9	12"(315mm)	471	14	30	53
11	12"(315mm)	412	12	24	44
17.6	12"(315mm)	317	9	16	28

However, each machine will have a different gauge pressure for adjustment and fusion, based on the mechanical advantage of that machine. That value should be calculated using the machine's operator manual.

The second table includes that value from some of the commonly available machines in Pestan's systems for quick reference. This data is based on information from the respective manufacturers of these tools. These pressures also depends on the size and SDR of the pipe. When using other fusion machines, the pressures P_1, P_2 and P_3 must be adjusted. Following diagram shows physical meaning of parameters (times and pressures), which are used in first and second table in this section.



Butt Fusion Adjustment and Heating Pressures (psi)

Ritmo machines

Dimension		Adjustment pressure P_1 (psi)		Heating pressure P_2 (psi)	
SDR	ND (OD)	Ritmo Delta Dragon 315B	Ritmo Delta Dragon 355B	Ritmo Delta Dragon 315B	Ritmo Delta Dragon 355B
9	6"(160mm)	189	87	15	15
11	6"(160mm)	160	73	15	0
17.6	6"(160mm)	102	44	15	0
9	8"(200mm)	308	131	29	15
11	8"(200mm)	261	102	29	15
17.6	8"(200mm)	160	73	15	0
9	10"(250mm)	479	203	49	15
11	10"(250mm)	406	160	44	15
17.6	10"(250mm)	261	102	29	15
9	12"(315mm)	753	319	75	29
11	12"(315mm)	638	261	64	29
17.6	12"(315mm)	406	174	44	15

Butt Fusion Adjustment and Heating Pressures (psi)
Widos machines

Dimension		Adjustment pressure P_1 (psi)					Heating pressure P_2 (psi)				
SDR	ND (OD)	WI 4400	WI 4600	WI 4900	WI 5100& 5500	WI 6100	WI 4400	WI 4600	WI 4900	WI 5100& 5500	WI 6100
9	6" (160mm)	463	222	205			46	22	20		
11	6" (160mm)	392	188	174			40	19	20		
17.6	6" (160mm)	261	131	116			27	15	15		
9	8" (200mm)		342	308	137			35	30	15	
11	8" (200mm)		290	261	116			29	27	15	
17.6	8" (200mm)		188	174	73			20	17	0	
9	10" (250mm)		547	479	205			55	48	20	
11	10" (250mm)		464	406	174			47	40	17	
17.6	10" (250mm)		305	261	116			30	26	15	
9	12" (315mm)			755	326	257			75	33	26
11	12" (315mm)			640	276	218			64	28	22
17.6	12" (315mm)			421	174	145			42	18	15



Butt Fusion Adjustment and Heating Pressures (psi)
McElroy machines

Dimension		Adjustment pressure P_1 (psi)					Heating pressure P_2 (psi)				
SDR	ND (OD)	28 Low force	Acrobat 160	DM 250 EP	412& 618 Low force	824& 1236 Low force	28 Low force	Acrobat 160	DM 250 EP	412& 618 Low force	824& 1236 Low force
9	6" (160mm)	110	196	110	58		15	20	15	0	
11	6" (160mm)	93	167	93	49		15	15	15	0	
17.6	6" (160mm)	60	108	60	32		0	15	0	0	
9	8" (200mm)	171		171	91	31	15		15	15	0
11	8" (200mm)	145		145	77	26	15		15	0	0
17.6	8" (200mm)	94		94	50	17	0		15	0	0
9	10" (250mm)			257	141	47			25	15	0
11	10" (250mm)			218	120	40			25	15	0
17.6	10" (250mm)			142	78	26			15	0	0
9	12" (315mm)				225	74				25	0
11	12" (315mm)				191	63				25	0
17.6	12" (315mm)				124	41				15	0



Pressure Test

Pressure testing is critical to a successful pipe installation and should be performed while the system is fully accessible, allowing access to the segments of the system in need of the attention. The unique property of PP-R(CT) allow the pipe to be tested with water, air, or with a mixture of both.

Note: When pressure testing with air, the contractor must exercise extreme caution. Accidents can occur due to a sudden release of energy such as unrestrained sections of pipe whipping about or piping system components blowing off. PESTAN recommends hydrostatic or hydrostatic/pneumatic testing over pneumatic.

During pressure testing, the pipe, fittings and connections must be able to sustain the Test Parameter (**TP**) = 15O% of the Operating Pressure (OP) or 150 psi, whichever is greater.

Note: When pressure testing PP-R(CT) systems, components rated lower than 150 psi, should be isolated from the pressure test.

The pressure test consists of three phases: **Initial, Principal** and **Final** test.

For **Initial** testing, the system must be pressurized up to **TP**. Because of the expansion of the pipe and changes in temperature the system pressure might drop below **TP**, during this test. Pressure must be maintained at **TP** for 10 minutes.

If necessary, increase pressure until the system is stabilized at **TP**. When the system is stable, begin the 30 minute test.

During the 30 minute period the system is not allowed to lose more than 9 psi (0.6 bars). If leaks are detected, the test must be stopped and leaks repaired. Then, the test must be restarted. Once the Initial test is successfully completed, proceed immediately with the Principal test.

The **Principal** test requires monitoring the system for 2 hours to ensure that it does not lose more than 3 psi (0.2 bars) during that period. After a successful completion of the Principal test, the pressure must be brought down to zero.

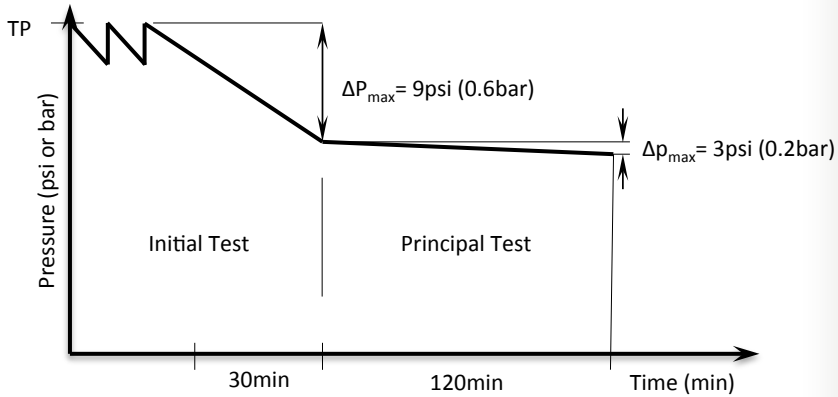
In the **Final** Test the system is re-pressurized up to Test Parameter (**TP**). After 2 minutes with no pressure loss, the system is to be brought down to 15% of the OP. After 2 more minutes with no pressure loss, the system is brought back to 0 psi. This process is repeated 4 more times, with the fourth cycle interval being 5 minutes. Successfully completed pressure tests are proof that all connections are properly installed.

Note: During the testing of large installations, small leaks may take longer to manifest as a pressure loss.

How to Measure Pressure Test
The pressure test must be performed with a pressure gauge that measures in 0.5 psi increments. When testing a multi-story installation, the pressure test should be conducted at the lowest point of the piping system that can be accessed.

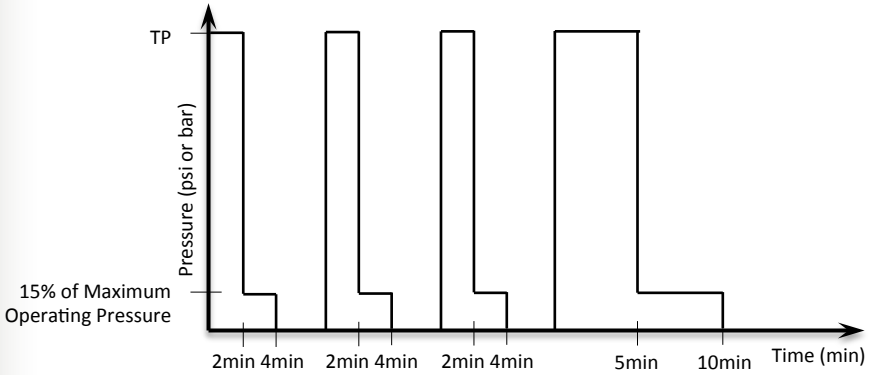
Initial and Principal Test:

1. Initial Test: Bring pressure in system up to 150% of the operating pressure (OP) or 150 psi, whichever is greater (Test Parameter = **TP**).
2. Wait 10 minutes then read pressure. When system pressure decreases due to pipe expansion, pressure it back to **TP**.
3. Repeat step 2 until the system has stabilized.
4. When stable, begin 30 minute test period, then read pressure. Pressure must not lose more than 9 psi (0.6 bars). If it passes, begin the Principal Test.
5. Principal Test: Begin the 120 minutes (2 hours) test period. Pressure must not drop more than 3 psi (0.2 bars) during the two hour period.
6. Once the system has met the requirements of steps 4 and 5 the final test can be performed.
7. If the system pressure fails to stabilize or fails to meet the requirements of steps 4 and 5, inspect the system for possible leaks. Make any necessary repairs and restart the testing process.



Final Test

1. Bring the system up to 150% of the operating pressure (OP) or 150 psi, whichever is greater. (Test Parameter = **TP**) and wait 2 minutes.
2. After 2 minutes with no pressure loss, reduce pressure to 15% of OP and wait 2 minutes.
3. After 2 minutes with no pressure loss, drop pressure to 0 psi.
4. Immediately bring system pressure back up to **TP** and repeat steps #2, #3 and #4, four more times.
5. When testing for the fourth time, drop pressure to 15% OP and wait 5 minutes. After 5 minutes with no press loss, drop pressure to 0 psi.
6. Immediately bring system pressure back up to **TP** and wait for 5 minutes.
7. Drop pressure to 15% OP and wait for another 5 minutes. Drop pressure to 0 psi.
8. No leakage is allowed to occur at any point of the tested installation. This test is designed to expose any possible cracks and to detect bad pipe connections.



Test Record

All PESTAN installations must be pressure tested and documented on the official PESTAN Pressure Test Form. The Pressure Test is required in order to identify any potential issues including manufacturing defects and installation errors.

It is acceptable to pressure test the system in phases providing that every heat fused connection is tested and that each phase is properly documented on a Pressure Test Form. The entire form must be completed and signed by the Installer. Both the client and contractor should keep a copy of the pressure test record.

Completion and submittal of the Pressure Test form is required by PESTAN in order for the warranty to be valid. These tests do not replace any local, state or federal requirements nor supersede them, rather they are recommended as the addition to all of requirements and testing. PESTAN requires this testing to be performed, documented and submitted before the system becomes operational.

PRESSURE TEST FORM

Project Name		
Project Owner		
Project Address		
City, State Zip		
Type of System Installed		
Units	feet or meters	psi or bar

Length of pipe used on the project	.50" 20mm	.75" 25mm	1" 32mm	1.25" 40mm	1.50" 50mm	2" 63mm	2.50" 75mm	3" 90mm	4" 125mm
Maximum Operating Pressure									

TEST PARAMETER* = 150% of operating pressure or 150psi whichever is GREATER

Initial Test	Test Parameter*		Pressure Drop (ΔP) after 30 Minute	
Principal Test	Principal Test Parameter*	Time Elapsed	Test Pressure Drop (ΔP) (after minimum of 120 minutes)	
Final Test (Depressurize the pipe between each cycle)	1	Test Parameter* (2 minute minimum)	Then	15% of Operating Pressure (2 min)
	2	Test Parameter* (2 minute minimum)	Then	15% of Operating Pressure (2 min)
	3	Test Parameter* (2 minute minimum)	Then	15% of Operating Pressure (2 min)
	4	Test Parameter* (5 minute minimum)	Then	15% of Operating Pressure (5 min)
Timing (minutes)	Date	Start Time	Time Elapsed	Test Duration

What liquid/gas was used for the Pressure Test? ◯ Water ◯ Air ◯ Mixture of Water and Air ◯ Other (specify)

What Manufacturer of Fusion Equipment was used? ☐ McElroy ☐ Ritmo ☐ Widos ☐ Other (specify)

Was flushing of the system performed before or after the Pressure Test?	◯ before ◯ after
What chemicals were used for flushing of the piping system?	

Certified Installer Responsible for Testing First Name, Last Name, Company	
Pestan Certification ID Number	
Phone and Email	

Date	Certified Installer Signature

Signature

Additional Information (optional)

Other Material Pipe Sizes, Elements and materials used on project _____

Was Manufacturers Rep present on job Site? ◯ Yes ◯ No

PRESSURE TEST FORM MUST BE SUBMITTED TO Pestan North America Warranty Department WITHIN 3 DAYS OF SUCCESSFUL TEST COMPLETION via email Warranty@PestanPipes.com, Fax (888) 213-4342 or mail to P.O. Box 26 Titusville, PA 16354

Office Use Only: Date Received Reviewed By

Always use latest edition of Pressure Test Form, available at www.pestanpipes.com/technical-information/

All personnel which has been certified as having been trained by Pestan or a Pestan affiliate are required to maintain a Fusion Log. This log must be kept up to date and readily available to be shown on demand to Inspectors and Pestan and/ or Pestan affiliates. Additional pages are available on following websites:

www.PestanPipes.com
www.CTpipingSolutions.com

Log Book No.

_____

Name _____
Signature_____Date_____
Phone_____email_____
Company_____
Department_____
Address_____

_____

City_____State_____Zip_____
Date Log Started_____Date Log Completed_____

NOTES:

LOG BOOK NO. (continued) _____

INSTALLER'S CERTIFICATION NO. _____

DATE OF THE FUSION	NAME OF THE PROJECT	LOCATION OF THE PROJECT	TYPE OF FUSION EQUIPMENT USED	NUMBER OF FUSIONS PERFORMED	TYPE OF FUSION	SIZE OF PRODUCT FUSED

LOG BOOK NO. (continued) ____________________

INSTALLER'S CERTIFICATION NO. ____________________

DATE OF THE FUSION	NAME OF THE PROJECT	LOCATION OF THE PROJECT	TYPE OF FUSION EQUIPMENT USED	NUMBER OF FUSIONS PERFORMED	TYPE OF FUSION	SIZE OF PRODUCT FUSED

LOG BOOK NO. (continued) ____________________

INSTALLER'S CERTIFICATION NO. ____________________

DATE OF THE FUSION	NAME OF THE PROJECT	LOCATION OF THE PROJECT	TYPE OF FUSION EQUIPMENT USED	NUMBER OF FUSIONS PERFORMED	TYPE OF FUSION	SIZE OF PRODUCT FUSED

SOCKET FUSION DIMENSIONS AND TIMES

Pipe Diameter		Stab Depth		Heating Time Above 40°F	Hold Time	Cooling Time
ND (inches)	OD (mm)	(Inch)	(mm)	(sec)	(sec)	(min)
.50"	20	9/16	14	5	4	2
.75"	25	5/8	15	7	4	2
1"	32	11/18	16	8	6	4
1.25"	40	3/4	18	12	6	4
1.5"	50	13/16	20	18	6	4
2"	63	15/16	24	24	8	6
2.5"	5	1	26	30	8	8
3"	90	11/18	29	40	8	8
4"	125	1 9/16	40	60	10	9

DIMENSIONS FOR REPAIR PIN

Thickness of the Pipe (for Insertion Depths of the Repair Pin)			
	Size	mm	inch
SDR 7.4	.50" - 20mm	2.8	0.11
	.75" - 25mm	3.5	0.14
SDR 9	1" - 32mm	3.6	0.14
	1.25" - 40mm	4.5	0.18
	1.50" - 50mm	5.6	0.22
	2" - 63mm	7.1	0.28
	2.50" - 75mm	8.4	0.33
	3" - 90mm	10.1	0.40
	4" - 125mm	14	0.55
	6" - 160mm	17.9	0.71
	8" - 200mm	22.4	0.88
	10" - 250mm	27.9	1.10
	12" - 315mm	35.2	1.39
SDR 11	1" - 32mm	2.9	0.12
	1.25" - 40mm	3.7	0.15
	1.50" - 50mm	4.6	0.18
	2" - 63mm	5.8	0.23
	2.50" - 75mm	6.8	0.27
	3" - 90mm	8.2	0.33
	4" - 125mm	11.4	0.45
	6" - 160mm	14.6	0.58
	8" - 200mm	18.2	0.72
	10" - 250mm	22.7	0.89
	12" - 315mm	28.6	1.13
SDR 17.6	4" - 125mm	7.1	0.28
	6" - 160mm	9.1	0.36
	8" - 200mm	11.4	0.45
	10" - 250mm	14.2	0.56
	12" - 315mm	17.9	0.71