Hydraulic Butt Fusion Machine Procedure

ISCO INDUSTRIES

McELROY

Hydraulic Butt Fusion Machine Procedure

The principle of heat fusion is to heat two surfaces to a designated temperature, and then fuse them together by application of force. This pressure causes flow of the melted materials, which causes mixing and thus fusion. When the polyethylene material is heated, the molecular structure is transformed from a crystalline state into an amorphous condition. When fusion pressure is applied, the molecules from each polyethylene part mix. As the joint cools, the molecules return to their crystalline form, the original interfaces are gone, and the two pipes have become one homogeneous unit.

The principle operations include:

Cleaning	The pipe ends must be clean and free of any dirt, debris or other contaminants
Clamping	The pipe pieces held axially to allow all subsequent operations to take place.
Facing	The pipe ends must be faced to establish clean, parallel mating surfaces perpendicular to the centerline of the pipes.
Alignment	The pipe ends must be aligned with each other to minimize mismatch or high-low of the pipe wall.
Heating	A melt pattern that penetrates into the pipe must be formed around both pipe ends.
Joining	The melt patterns must be joined with a specified force. The force must be constant around the interface area.
Holding	The molten joint must be held immobile with a specified force until adequately cooled.

BUTT FUSION OF PIPES AND COMPONENTS WITH DIFFERENT WALL THICKNESSES

When Butt Fusion is used to join pipes and other components together they must have the same outside diameter and the difference between minimum wall thickness dimensions for the two components being joined should not exceed 26%.

Example: You have a pipe or fitting that has a wall thickness of 25 mm (1”). You can weld that pipe to pipes or fittings that have a wall thickness of 20 mm (3/4”) min. or 32 mm (1-1/4”) max.

Important:

- The pipe line is only as strong as its weakest link.
- The fusion pressure used to join two different wall thicknesses is always that of the thinner.

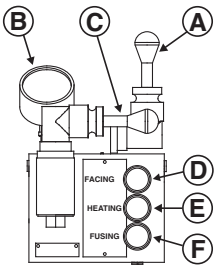
Hydraulic Butt Fusion Machine Procedure

Hydraulic Manifold Block

Mounted on this block are a carriage directional control valve, a selector valve, three pressure reducing valves, and a pressure gauge.

A) The carriage control value, mounted on the top of the manifold, determines whether the carriage is moving left, right, or in neutral.

B) A pressure gauge is mounted on top of the manifold.



C) The selector valve, mounted on the front of the manifold, selects a pressure from one of the pressure reducing valves. Each pressure reducing valve is labeled with a different function.

D) The top valve adjusts facing pressure, normally 3 to 7 Bar (50-100 psi) gauge pressure.

E) The middle valve adjusts heating pressure, always 0 Bar (0 psi) or backed all the way out turning knob counterclockwise. The drag pressure may have to be compensated for when working with more than one joint of pipe on the movable side or with tie-ins.

F) The bottom valve adjusts fusion pressure, this pressure must be determined.

Install Clamping Inserts

Select and install appropriate clamping inserts for the pipe that is being fused.

Hydraulic Butt Fusion Machine Procedure

Check Hydraulic Pressure

The pressure gauge on the manifold block indicates the pressure of the carriage valve. How much pressure depends on the position of the selector valve and the pressure set on the specific pressure reducing valve. With the selector valve up, the facing pressure can be set. It may be necessary to adjust the carriage speed, while facing, with the top pressure-reducing valve to control facing speed.

Shift the selector valve to the center position, heating, and set the pressure reducing valve at its lowest setting, or the drag pressure, whichever is higher.

With the selector valve in the down position, the fusion pressure can be set.

The fusion pressure can be calculated using the Fusion Pressure Calculator (shown on the next page or by using the formula on the next page, or they can be found in the reference section.)

An approximate 2 Bar (30 psi) drag factor should compensate for seal, and pipe drag with one joint of pipe on a pipe stand. If additional lengths of pipe are being moved by the movable jaws, the actual drag pressure should be determined using the following procedure:

After facing the pipe, move the carriage so that the pipe ends are approximately 50 mm (2") apart.

Shift the carriage control valve to the middle (neutral) position, select the heating mode, and adjust the middle pressure reducing valve to its lowest pressure by turning the valve counterclockwise.

Shift the carriage control valve to the left.

Gradually increase the pressure by turning the heating valve clockwise. Increase the pressure until the carriage moves.

Quickly reduce the heating pressure valve counterclockwise until the carriage is just barely moving.

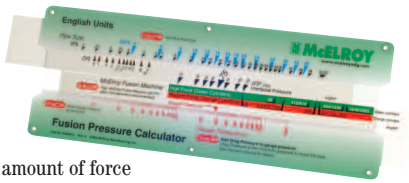
Record this actual drag pressure.

Take the pressure, determined from the Fusion Pressure Calculator, and add the actual measured drag pressure. This will be the actual fusion pressure to set with the bottom pressure reducing valve. If fusion pressures are used from the reference section, you must subtract 2 Bar (30 psi) drag, which is already figured in and then add the actual drag pressure back.

Adjust the middle heating valve to show recorded drag so that pipe ends will stay in contact with heater during heating phase.

Hydraulic Butt Fusion Machine Procedure

Fusion Pressure Calculator



Interfacial Pressure (IFP)
Minimum 4.1 Bar (60 psi)
Optimum 5.2 Bar (75 psi)
Maximum 6.2 Bar (90 psi)

Interfacial Pressure (IFP) = amount of force per sq. inch of the surface area of the pipe end. Interfacial Pressure (IFP) and Fusion machine gauge pressure are not the same.

How to Use the Fusion Pressure Calculator

Step 1: Set DR at Pipe Size.
Step 2: Align McElroy Fusion Machine with IFP.
Step 3: Read Gauge Pressure at red arrow.
Step 4: Add Drag Pressure to gauge pressure.

Determining Fusion Pressure

Variable Definitions
OD = Outside Diameter
t = Wall Thickness
π = 3.1416
DR = Dimensional Ratio
IFP = Recommended Interfacial Pressure (Shown Above)
TEPA = Total Effective Piston Area
DRAG = Force Required to Move Pipe

Example:
Using a McElroy No. 250 Standard Fusion Machine (Low Force, Yellow Cyl.)
OD of Pipe = 200 mm
DR of Pipe = 11
Recommended Interfacial Pressure = 5.2 Bar (75 PSI)
Measured Drag 2 Bar (30 PSI)

Formula: Wall Thickness

$$t = \frac{OD}{DR} = \frac{200\ mm}{11} = 18.2\ mm$$

TEPA = 1077 mm^2 (1.67 in^2) (chosen from the table on page 36)

$$\text{Gauge Pressure} = \frac{(OD - t) \times t \times \pi \times IFP}{TEP\ A} + DRAG$$

$$\text{Gauge Pressure} = \frac{(200 - 18.2) \times 18.2 \times 3.14 \times 5.2}{1077} + 2 = 52\ Bar$$

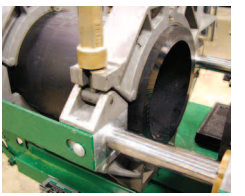
Hydraulic Butt Fusion Machine Procedure

Notice:
See Reference Section, pages 80-85, for fusion pressure charts showing pressures precalculated to include 2 Bar (30 psi) for system drag.

Determining Fusion Pressure (Continued)

	TEPA = Total Effective Piston Area mm^2 (in^2)		
Fusion Machine Model	High Force Standard (Green Cylinders)	Medium Force High Velocity (Orange Cylinders)	Low Force Extra High Velocity (Yellow Cylinders)
250 or T-250	3039 (4.71)	NA	1077 (1.67)
412 or T-412	7600 (11.78)	3877 (6.01)	2026 (3.14)
618 or T-618	7600 (11.78)	3877 (6.01)	2026 (3.14)
T-500 Series I or II	NA	3877 (6.01)	NA
824	19000 (29.44)	9885 (15.32)	6097 (9.45)
1236	19000 (29.44)	9885 (15.32)	6097 (9.45)
T-900	19000 (29.44)	9885 (15.32)	6097 (9.45)
1648	20272 (31.42)	9123 (14.14)	NA
2065	20272 (31.42)	NA	NA

Loading Pipe Into Machine
(No. 412 and No. 618 Used In the Following Illustrations)



Clean the inside and outside of pipe ends that are to be fused.

Open the upper jaws and insert pipe in each pair of jaws with applicable inserts installed.

Let the ends of the pipe protrude more than 25 mm (1") * past the face of the jaws.

* This distance changes with fusion machine type.

Tighten the clamp knobs on the outer jaws to prevent pipe slippage and lightly tighten inner clamp knobs for possible later alignment adjustments.

Hydraulic Butt Fusion Machine Procedure

Facing The Pipe

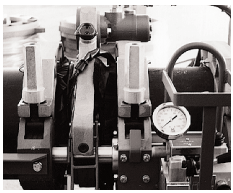
Pivot the facer into place and secure.

Move the carriage to the right.

Open the ball valve on the facer motor.

Assure the selector valve handle is up in the facing position.

Move the carriage to the left.



If the facer stalls, adjust the facing pressure so the facer continues to cut.

Important:
When facing heavy wall pipe, it may be necessary to increase the system pressure.

Important:
When drag pressure exceeds 20 Bar (300 psi) it is necessary to move the carriage to the left bringing the pipe ends into contact with the facer before opening the facer valve.

Let the carriage bottom out at the facer stops. Turn the facer off. Move the carriage to the right so the facer can be removed.

Hydraulic Butt Fusion Machine Procedure

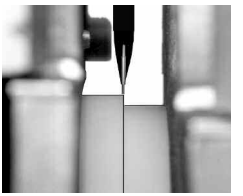
Remove Facer

Pivot the facer out to the storage position.

Remove chips from pipe ends, careful not to touch faced pipe ends.

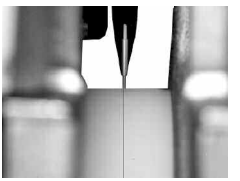
If faced pipe ends are touched, use clean non-synthetic cloth to clean affected area before proceeding.

Move the carriage to the left until ends of pipe butt together. Check pipe joint for proper alignment.



WARNING Do not use finger to check for hi/low (misalignment). The unit is under pressure, and slippage could result in crushed fingers. Always keep hands clear of the jaw area.

If pipe is not lined up, tighten the inner high side jaw to bring into alignment.



Important:
Always tighten the side that is higher, never loosen the low side.

When the pipe is properly aligned tighten outside clamps to insure against slippage.

If clamp knob adjustment has been made, reinstall facer and begin facing procedure again.

Let the carriage bottom out on facer stops. Turn facer off. Move the carriage to the right so the facer can be removed.

Remove chips from pipe ends careful not to touch faced pipe ends.

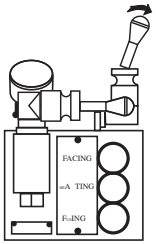
Bring the pipe ends together under fusion pressure to check for slippage. If slippage occurs, return to Loading Pipe Into Machine on page 36.

Notice:
Their should be no more than 10% of the wall thickness in misalignment to maintain full joint strength.

Hydraulic Butt Fusion Machine Procedure

Position Carriage For Heater Insertion

Move carriage to the right to open a gap large enough to insert the heater.



Check Heater Temperature

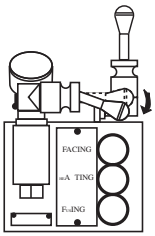
CAUTION Incorrect heating temperature can result in questionable fusion joints. Check heater plates periodically in multiple locations with a pyrometer and make necessary adjustments.

For butt fusion heater surface temperature should be Minimum 205°C (400° F), **Optimum 218°C (425° F)**, Maximum 230°C (450° F).

Important:
The dial thermometer on the heater indicates internal temperature. The dial thermometer can be used as reference once the surface temperature has been verified.

Select the Fusion Position

Move selector valve handle down to the fusing position. Use fusion pressure required from Fusion Pressure Calculator or the formula on page 35 . Also see Reference Section, page 80-85.

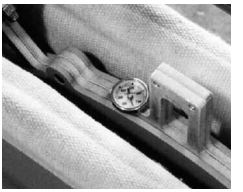


Hydraulic Butt Fusion Machine Procedure

Inserting Heater

⚠ DANGER Heater is Not Explosion Proof. Operation of heater in a hazardous environment without necessary safety precautions could result in explosion and death.

If operating in a hazardous environment, heater should be brought up to temperature in a safe environment,then unplugged before entering the hazardous atmosphere for fusion.



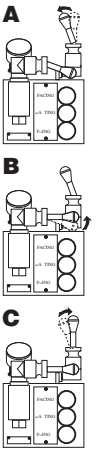
Use a clean non-synthetic cloth to clean the butt fusion heater adapter surfaces.

Check heater plates for coating damage, plastic buildup rings and surface imperfections. These conditions could cause a poor fusion. Replace them if conditions exist.

Verify heater temperature noting the reading on the dial thermometer.

Insert heater between the pipe ends.

Heating The Pipe



A) Move the carriage to the left under the fusion pressure, bringing the heater into contact with both pipe ends, seating pipe ends against heater. At first indication of melt around circumference of pipes, move to step B.

B) Move selector valve to center position, allowing pressure to drop and stabilize at lowest setting, in most cases “0”. When fusing more than one pipe length on the movable side of the fusion unit, drag must be compensated for.

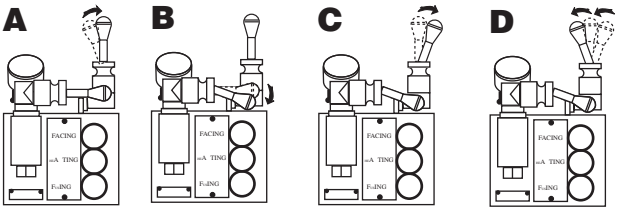
C) Return carriage control valve to neutral (middle) position. The pipe ends are now heating at “0” pressure or the pressure to compensate for drag, allowing the pipe ends to remain in contact with the heater.

Hydraulic Butt Fusion Machine Procedure

Fusing The Pipe

CAUTION Failure to follow the proper shift sequence, verify proper melt pattern and achieve proper cooling time may result in a bad joint.

After proper melt pattern has been established, use the **Approximate Melt Bead Size** chart on page 42 to determine the proper size, then:



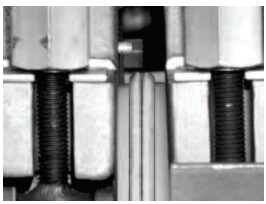
A) Shift carriage control valve to neutral position if not in this position already.

B) Shift the selector valve down to fusion position.

C) Move the carriage to the right just enough to remove the heater. The stripper bar on the heater should help "pop" heater loose. Quickly remove the heater without coming into contact with melted pipe ends.

D) Quickly inspect pipe ends, which should be flat, smooth, and completely melted. Concave pipe ends are unacceptable, see page 42. If acceptable, shift carriage control valve to the left immediately bringing ends together and apply fusion pressure, calculated from page 35 or obtained from fusion pressure charts in Reference Section, pages 80-85.

Notice:
Bring pipe ends together being careful not to exceed the **Approximate Dwell/Transfer Times** shown on page 42.



Hydraulic Butt Fusion Machine Procedure

Approximate Melt Bead Size (Pipe Ends)

Pipe Size	Approximate Melt Bead Size
40 mm (1-1/4") - 90 mm (3")	About 2 mm (1/16")
90 mm (3") - 200 mm (8")	3 mm (1/8") - 5 mm (3/16")
200 mm (8") - 315 mm (12")	5 mm (3/16") - 6 mm (1/4")
315 mm (12") - 630 mm (24")	6 mm (1/4") - 11 mm (7/16")
630 mm (24") - 900 mm (36")	About 11 mm (7/16")
900 mm (36") - 1600 mm (63")	About 14 mm (9/16")

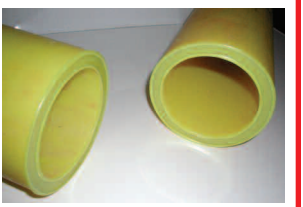
Approximate Dwell/Transfer Times

Pipe Size	Max. Transfer Time
90 mm (3") & smaller	4 sec.
110 mm (4") to 315 mm (12")	6 sec.
340 mm (13") to 630 mm (24")	9 sec.
710 mm (28") to 900 mm (36")	12 sec.
1000 mm (40") & Up	15 sec.

Unacceptable Concave Melt Appearance

What Causes This?

Answer - Heating under pressure.



Notice:
A concave melt surface is unacceptable; it indicates pressure during heating. Do not continue. Allow the melted ends to cool and start over.

Hydraulic Butt Fusion Machine Procedure

Cooling Of The Fusion Joint

The fusion joint must be kept under fusion pressure until joint is cool. This time will vary with pipe size, wall thickness, heater plate temperature setting and environmental conditions.

There are three acceptable methods that can be used individually or combined.

1) Cool to the touch.

⚠CAUTION If using this method, do not place hand or fingers in between jaws. The joint has pressure applied and the jaws could still slip at this point. Use a tool like a long handled screwdriver that can be used to probe weld bead. If tool makes an impression in weld bead, the weld bead is soft and has not cooled enough.

2) **Timing "Guidelines Only"**

Wall Thickness	**Cooling Time at 23° C (74° F)**
Up to 5 mm (0.2")	5 minutes
5 mm (0.2") to 10 mm (0.4")	5 to 10 minutes
10 mm (0.4") to 15 mm (0.6")	10 to 15 minutes
15 mm (0.6") to 20 mm (0.8")	15 to 20 minutes
20 mm (0.8") to 30 mm (1.2")	20 to 30 minutes
30 mm (1.2") to 40 mm (1.6")	30 to 40 minutes
40 mm (1.6") to 51 mm (2.0")	40 to 50 minutes
51 mm (2.0") to 61 mm (2.4")	50 to 60 minutes
61 mm (2.4") to 71 mm (2.8")	60 to 70 minutes
71 mm (2.8") to 81 mm (3.2")	70 to 80 minutes

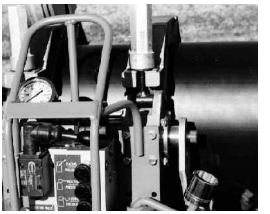
3) Use a pyrometer to measure temperature of the weld bead and compare it to the temperature of the pipes and or the fittings being fused. If the temperatures are the same, the cooling requirement has been met.

Notice:
Heavier wall thickness pipes require longer cooling times.

You must allow the joint to cool an additional thirty minutes minimum outside of the fusion machine before subjecting the fusion joint to any rough handling or severe bending.

Hydraulic Butt Fusion Machine Procedure

Opening Movable Jaws

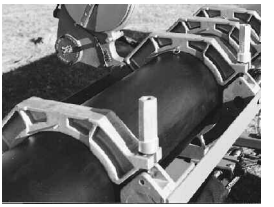


After the joint has cooled for the recommended time, shift the carriage control valve to the neutral position.

Loosen all clamp knobs, and move carriage to the right far enough to open the jaw nearest the facer.

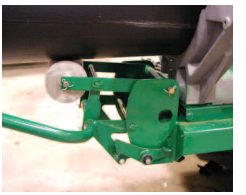
Open the movable jaws.

Opening Fixed Jaws



Open the fixed jaws

Raise Pipe



Raise the joined pipe using the pipe lift(s).

Pull Pipe through machine, and prepare for making next fusion. Inspect joint and if it has to be redone, use Trouble Shooting Guides on page 45 and 46 to determine problem and make adjustments before next fusion.

Hydraulic Butt Fusion Machine Procedure

Butt Fusion Joint Troubleshooting Guide

The Inspection Of The Fusion Joint

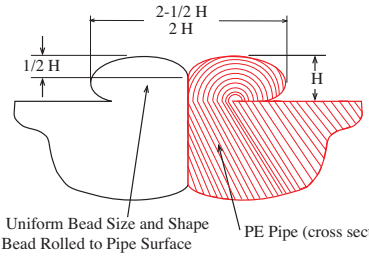
Golden Rule: If in doubt, cut it out and redo.

The double bead should be rolled over onto the adjacent surfaces, and be uniformly rounded and consistent in size all around the joint. As illustrated in the Figure below, the double bead width should be 2 to 2-1/2 times its height above the surface, and the v-groove depth between the beads should not be more than half the bead height.

When butt fusing to molded fittings, the fitting side bead may have an irregular appearance. This is acceptable provided the pipe side bead is correct.

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

Butt Fusion Bead Proportions



Note: This is a "guideline" only and should not be taken solely as pass or fail. The bead may be in various configurations but they must satisfy the following requirements:

- There shall be no evidence of cracks or incomplete fusion.
- Joints shall not be visually mitered (angled, off-set). The ovality offset shall be less than 10% of the minimum wall thickness of the fused components.
- The cleavage between fusion beads shall not extend to or below the outside pipe diameter pipe surface.

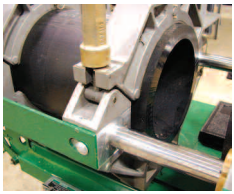
Hydraulic Butt Fusion Machine Procedure

Butt Fusion Joint Troubleshooting Guide

What Is Present	Attributing Factors
One bead larger than the other	Misalignment, component slipped in clamp, worn equipment, incomplete facing
Bead not rolled over to surface	Shallow v-groove - insufficient heating & insufficient joining force, deep v-groove - insufficient heating & excessive joining force
Squarish outer bead edge	Pressure during heating
Excessive double bead width	Overheating, excessive joining force
Flat top on bead	Excessive joining force, overheating
Beads too small	Insufficient heating or joining force
Beads too large	Excessive heating time
Rough, sand-paper like, bubbly, or pockmarked melt bead surface	Hydrocarbon contamination
Double v-groove too deep	Excessive joining force, insufficient heating, pressure during heating
Non-uniform bead size around pipe	Misalignment, defective heating tool, worn equipment, incomplete facing
A third bead	Excessive joining force

Hydraulic Butt Fusion Machine Procedure

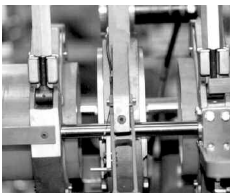
Position Pipe For Next Joint



Move the fusion machine to the end of pipe, or pull the pipe through the jaws until the end of the pipe is protruding more than 25 mm (1") * past the jaw face of the fixed jaw.

* This distance changes with fusion machine type.

Install Next Piece Of Pipe



Insert a new piece of pipe in the movable jaws and repeat all previous procedures.