Butt fusion welding of polyethylene

Installers and installation equipment

Installation personnel should be trained and technically competent for this jointing method. Training for installers is available free of charge on request from our technical department.

The tools required for the job should be assembled and checked prior to commencing any work. When assembling longer runs or large size Polypropylene pipes, the use of guides, pipe rollers or supports, is recommended to reduce the drag forces involved.

The work crew should be equipped with equipment to enable safe handling of the pipes on site, together with appropriate hand tools. In addition, it is recommended that the following tools are used during the jointing process. Using tools designed specifically for plastic piping systems greatly improves the performance of the installation team and reduces the risk of bad joints being made.

Pipe Cutting

Item	Pipe Diameter	Part Number
Rotary Cutter	6 - 63mm	04124
Rotary Cutter	10 - 90mm	04134
Rotary Cutter	48 - 114mm	04144
Rotary Cutter	102 - 168mm	04164
Rotary Cutter	159 - 254mm	04170
Rotary Cutter	160 - 315mm	04470
Rotary Cutter	355 - 500mm	04475
Rotary Cutter	355 - 630mm	04480
Rotary Cutter	355 - 800mm	04485
Saw	Up To 75 mm	04512
Saw	Up To 100mm	04510
Saw	Up To 150mm	04517
Saw	Up To 200mm	04519

In addition to everyday pipe fitters tools the installation of Polypropylene piping requires a fusion-welding machine of the appropriate size and type. Care should be taken to consider the advantages and disadvantages of each jointing method prior to commencement on site. In some cases, a combination of welding methods may prove to be the most cost-effective solution. Our technical department can advise on suitable jointing methods.

Details of the 'Requirements for Machines and Equipment Used for Fusion Jointing Thermoplastics' can be found in DVS 2208 Instructions Part 1.

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Preparation of the work area

Assemble the welding equipment according to the manufacturer's instructions, with due provision for safe working practices. When working outdoors, the area used for jointing must be protected from rain, snow and wind. The preferred ambient working temperature for welding is in the range of +5°C to +45°C. Protecting the fusion welding area with a tent or similar device can help maintain an even temperature in the work area.

Pipe cutting and preparation

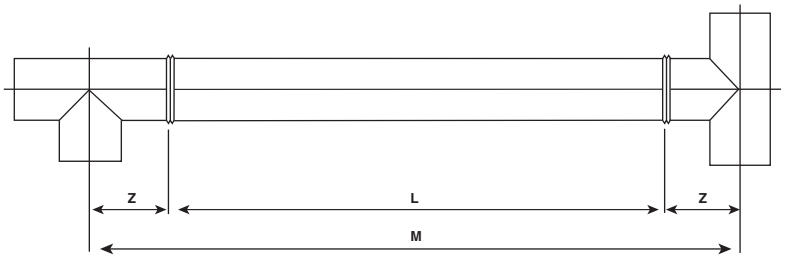
Before cutting, pipes should be conditioned to reach the ambient working temperature under which installation and jointing will take place.

Pipe should always be cut to length using tools specifically designed for use with plastic pipe. A rotary pipe cutter with the correct blade or wheel appropriate for the pipe wall thickness is recommended, as they provide a high degree of accuracy in the finished cutting length, and also produce a square cut to the pipe. Power tools such as band saws, or circular saws may also be used - however they should have blades that are specifically designed for use with plastic pipe. Handsaws with blades suitable for use with plastic pipe may be used, however it is recommended that a mitre box be used to ensure a square cut is achieved.

Once the cutting process is completed, the pipe length should be checked for accuracy, and any internal or external burrs should be removed using a deburing tool specifically designed for use with plastic pipe. Any plastic chips or swarf should also be removed from the inside of the pipe. The jointing area of the parts to be welded must be free from damage or contamination.

The installation of Polyethylene piping systems makes use of so-called "Z" dimension of the fitting. An explanation of the use of the "Z" dimension is shown in the following example:-

Explanation:
M = Distance mid-mid fitting
L = Cutting length of pipe
Z = Z-dimension of fitting



The Z dimension for Polyethylene pipe fittings that is used to calculate pipe cutting lengths can be found in the detailed dimensional information.

Butt fusion welding of polyethylene

Making a butt fusion joint - introduction

Heating element butt fusion welding is the most common method of jointing polypropylene piping systems. Butt-welding is an extremely versatile welding technique that can be used in both the workshop and on site. Following preparation, the parts to be joined are aligned under a regulated pressure in direct contact with a flat-plate heating element for a controlled time period. At the end of this period the contact pressure is released, the heating element is removed, and the jointing surfaces of the parts to be fused are brought into contact with each other under controlled pressure for a pre-determined cooling period. The welding method is documented in DVS 2207 Part 1 - Polyethylene.

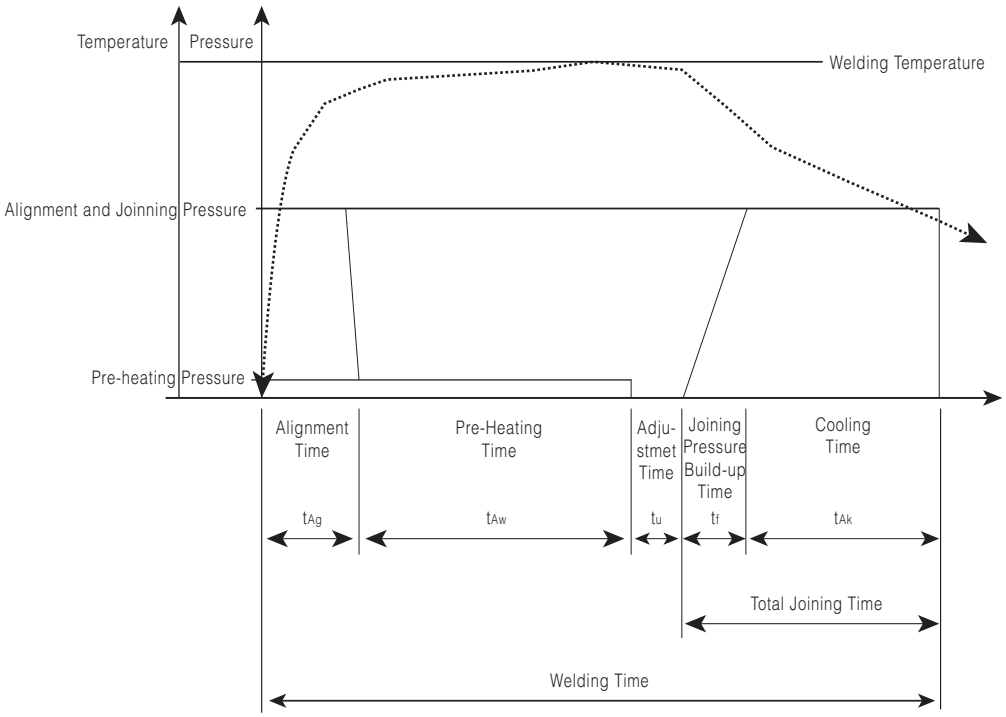
Butt fusion welding is most commonly used for larger size piping, especially on pipe sizes that are larger than 63mm outside diameter. However, spigot ended fittings for butt fusion welding are also available in smaller sizes and this jointing method will produce excellent quality welds with a pleasing aesthetic appearance in every size.

Butt fusion tool with hydraulic operation

Butt-fusion welding machines in a range of styles to suit different working conditions are available for rental or purchase. The simplest machines are bench mounted for workshop use. They are equipped with a thermostatically controlled heating plate and electric planning tool, but require the hand operation of all functions including the opening and closing of the pipes to make the butt- welded joint. Larger machines for site or workshop use may include many additional features, including hydraulic control on the welding pressures and semi or fully automatic welding operations.

The 'timeline' of the welding process is visually displayed in the following chart. It provides a schematic representation of the various stages of the welding process: alignment time, pre-heating time, adjusting time, jointing pressure build up time, and cooling time.

Timeline for the butt welding process



Butt fusion welding of polyethylene

Welding parameters

The guidelines of DVS2207 part 11 provide accurate advice for successful butt welding, and it should be adhered to at all times. The following table gives the reference values for Polypropylene heating element butt welding, assuming an ambient temperature of 20°C, and low air speeds.

Polyethylene butt welding parameters

Wall Thickness (mm)	Alignment Bead Height min. (mm)	Pre-heating Time (sec)	Adjusting Time max. (sec)	Build-up Pressure Time (sec)	Cooling Time min. (min)
> 4.5	0.5	135	5	5	6
4.5 - 7.0	1.0	45 - 70	5 - 6	5 - 6	6 - 10
7.0 - 12.0	1.5	70 - 120	6 - 8	6 - 8	10 - 16
12.0 - 19.0	2.0	120 - 190	8 - 10	8 - 11	16 - 24
19.0 - 26.0	2.5	190 - 260	10 - 12	11 - 14	24 - 32
26.0 - 37.0	3.0	260 - 370	12 - 16	14 - 19	32 - 45
37.0 - 50.0	3.5	370 - 500	16 - 20	19 - 25	45 - 60
50.0 - 70.0	4.0	500 - 700	20 - 25	25 - 35	60 - 80
Welding Pressure	0.10 N/mm²	0.02 N/mm²	-	0.15 N/mm²	

In most cases, the heating pressure and the jointing force can be obtained from reference plates that are to be found on the welding equipment itself. However, it is sometimes necessary to make supplementary calculations at the work site to account for additional factors such as drag or heating pressures.

Calculating specific heating pressure

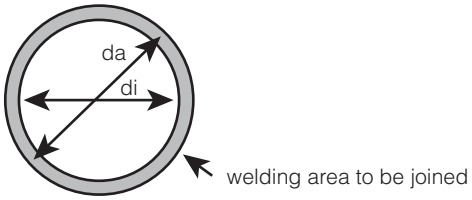
If the pressure data is not known, the heating pressure (bar) or the heating force (N) can be calculated using the following method:

First calculate the welding area of the pipe to be joined:

$$A_{pipe} = \frac{(da^2 - di^2) \cdot \pi}{4}$$

Where

A_{pipe} = pipe surface area in mm²
da = pipe outside diameter in mm
di = pipe inside diameter in mm
π = constant (3.142)



Example:
PE100 pipe diameter 110mm SDR 11/S-5/PN16 (10mm wall thickness)

$$A_{pipe} = \frac{(da^2 - di^2) \times \pi}{4}$$

$$A_{pipe} = \frac{(110^2 - 90^2) \times 3.142}{4}$$

$$A_{pipe} = \frac{12568}{4} \qquad A_{pipe} = 3412 \text{ mm}^2$$

Next multiply the value of A_{pipe} by the welding pressures from the table above:

Alignment pressure = 3412 x 0.15 N/mm² (from table) = 511.8 N/mm²

Heating pressure = 3412 x 0.01 N/mm² (from table) = 68.2 N/mm²

Build-up and cooling pressure = 3412 x 0.15 N/mm² (from table) = 511.8 N/mm²

Note: 1N/mm² = 10 Bar

Butt fusion welding of polyethylene

Making a butt fusion joint

Plannin the pipe

Checking alignment

- Make sure that the welding equipment is located on a stable level work area, capable of withstanding the forces generated during planning and welding. Consider the use of pipe rollers, guides and supports especially for large diameter pipes.
- Before heating, thoroughly inspect the heating plate for signs of damage or contamination Clean carefully with non-fraying paper or a clean cloth, and if necessary replace any unacceptable parts.
  The position of the heating plate must be checked to ensure that it is plane-parallel. Only a small amount of out-of-alignment is permissible:-

Diameter (mm)	Permitted Deviation (mm)
< 250	≤ 0.0
250-500	≤ 0.4
> 500	≤ 0.8

Connect the tools to a relaible power source and switch on.

- Set the welding temperature on the fusion-welding tool to 195°C-205°C. Prior to each weld verify the temperature using a digital thermometer with surface sensor. Protect the heating plate from wind and moisture during all working operations.
- Cut the pipe ends squarely using tool suitable for plastic pipe. A wheel-type rotary cutter is ideal. If a saw is used, a mitre box is recommended to ensure a square cut. Power saws may be used with care.
- Remove the internal burr from the pipe, and clean up any cutting debris or swarf.
- Insert the parts to be joined into the fusion welding machine, and plane the ends parallel to each other until good surface alignment is achieved.
- Bring the parts together and check that the surfaces to be joined are parallel to each other. The maximum deviation from parallel between the parts is as follows:-

Diameter (mm)	Permitted Deviation (mm)
< 40	≤ 0.5
≤ 400	≤ 1.0

Make a note of the drag pressure that is required to move the pipe at the welding machine. This value will be required later.

At the same time, check that the alignment (offset) of the pipe wall does not exceed a value of 10% of the wall thickness of the pipe. If this limit is exceeded, the two parts must be re-aligned in the clamps and the planning process carried out again.

Note: Planning should only take place immediately before welding.
The planed surfaces must not be touched by hand before welding takes place, otherwise they will need to be cleaned or re-planed.

Butt fusion welding of polyethylene

Making a butt fusion joint

- Before commencing the welding process, check and note the welding parameters required for the pipe that is being welded: bead height, pre-heating time, adjusting time, build-up pressure time and cooling time.

- Insert the heating element and draw the parts against the heater plate at the combined alignment pressure of the drag pressure + 0.15 N/mm^2. A bead will develop around the circumference of the fusion faces. When the bead reaches the height required, reduce the heating pressure to 0.02N/mm^2 and allow the joint to heat for the time designated in the table.

- Working quickly, remove the heating element from the fusion area, and join the surfaces to be welded, keeping the adjusting time as short as possible.

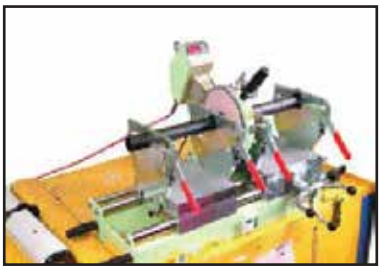
- Steadily and continuously, increase the joining pressure until the combined alignment pressure of the drag pressure + 0.15 N/mm^2 is reached. The welded parts must stay in the machine until the cooling time is completed. During this time, regularly check the joining pressure and adjust if necessary. Do not use any method to assist cooling.

- When cooling is completed, relieve the pressure from the joint, loosen and remove the clamps, then take out the completed fusion joint.

- Inspect the joint for any visible signs of defects or contamination. A correctly made joint will have two parallel beads around its circumference. They should be almost equally sized, with smooth bead surfaces. Possible differences in the formation of the beads may be attributed to the different flow behavior of the parts being joined (e.g. pipe to fitting). If there is the requirement to remove the weld bead for special reasons, this should be done without leaving notches in the parent parts. Special tools are available and must be used if bead removal is required.

Do not pressurize the joint for a minimum period of one hour.

The heating element is brought into place



Heating of the pipes

The heating element is removed and the pipes brought together