

Butt Welding Of Polyethylene Pipes

Butt fusion using a heated plate is a simple and quick jointing technique performed basically by melting the pipe (fitting) ends and holding them together under controlled temperature, time and pressure conditions. This technique is most suitable for pipe sizes of DN/OD 63 mm (DN/ID 50 mm) and above.

The butt welding equipment usually consists of:

- butt fusion machine (includes pump);
- planing tool;
- heating plate;
- thermometer;
- timing device;
- pipe cutter (saw);
- power source (generator);
- lint-free paper, cloth, or tissue;
- Isopropanol impregnated pipewipe or Isopropanol (Isopropyl Alcohol);
- pipe rollers;
- protective enclosures for some of the above.

Generic butt welding guidelines

Generic temperature and pressure parameters are shown in the table on the next page. **Drag pressure** (minimum frictional resistance due to the weight of the pipe and an eventual active drag pressure) should be added to the interface pressure. Avoid application of excessive pressure or abrupt pressure build-up.

Generic time parameters shown in the table include:

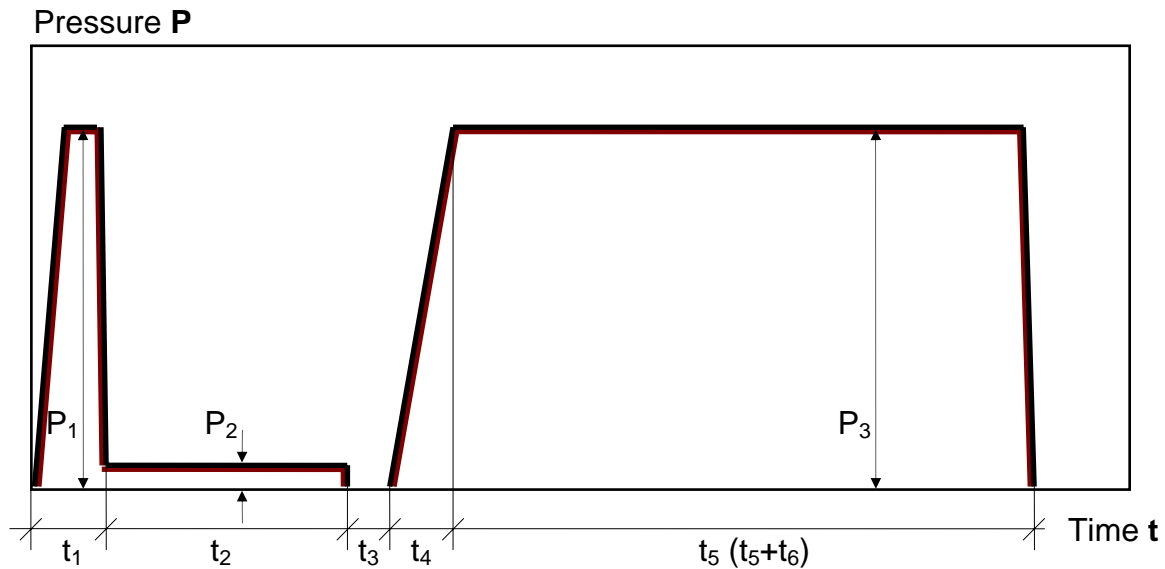
- **Heat soak time (heating time)** necessary to obtain a sufficiently large melted zone. This is the most important parameter.
- **Changeover time** should be as short as possible.
- **Pressure build-up time** necessary to gradually build up pressure.
- **Cooling time** should not be too short to avoid brittle weld due to internal stresses.

Other factors may significantly affect weld quality. The most important of these are:

- **Working environment.** Care shall be taken to keep the pipe (fitting) ends and heating plate clean from dust, sand, clay, and shielded from wind (including inside the pipes) and, as possible, from sun (to avoid uneven temperature distribution). Dirt is removed using a clean lint-free cloth or by performing a “dummy weld”.
- **Alignment.** Misalignment should be kept as small as possible and should not exceed 10% of the pipe wall thickness.

Pipes of nominal outside diameter of 315 mm and over may be welded also using **dual-pressure butt fusion cycle** according to UK Water Industry Specification WIS 4-32-08.

Schematically (not in scale), the **butt fusion cycle** is shown on the diagram below.



Butt fusion parameter guidelines are as follows:

Butt fusion parameters		Units	Value W&F recommendations	Value ISO 21307:2009(E)	Comments
Heating plate temperature		°C	210 to 225	200 to 245	
Heating pressure (interface pressure)	P ₁	kPa	130 to 170	170 ± 20	Use formula below and add drag pressure
Approximate initial bead width		mm	0.5 + 0.1×e	0.5 + 0.1×e (max. 6 mm)	e = mean wall thickness rounded up, mm
Bead up time	t ₁	sec.			Varies
Heat soak pressure	P ₂	kPa	Drag only	Drag only	
Heat soak time	t ₂	sec.	15×e	(11 ± 1) ×e	
Maximum heater plate removal time	t ₃	sec.	3 + 0.01×OD	0.1×e + 4	OD = nominal pipe outside diameter, mm
Maximum time to achieve welding pressure	t ₄	sec.	3 + 0.03×OD	0.4×e + 2	Use most of the time to gradually increase pressure
Welding and cooling pressure (interface pressure)	P ₃	kPa	130 to 170	170 ± 20	Use formula below and add drag pressure
Welding and cooling time	Under pressure	t ₅		e + 3	Time in clamps
	Without pressure	t ₆		e + 3	
	e < 15 mm	t ₅	min.	10 + 0.5×e	At temperatures over 25°C add 1 min. per °C
	e > 15 mm	t ₅	min.	1.5×e	

To calculate pressure in the hydraulic system of the butt fusion machine use the following formula:

$$\frac{\text{pipe annulus area}}{\text{hyd. cylinder area}} \times \text{interface pressure value,}$$

where $\text{pipe annulus area} = \pi \times (\text{OD} - e) \times e$.

These parameters should be suitable for both PE 80 and PE 100.

Generic butt fusion procedure may be basically divided into the following steps.

- Cut straight the pipe(s) to be welded.
- Reduce the drag resistance as much as possible (eg. using pipe rollers, etc.).
- Clean the pipe ends and the spigot ends of fittings by wiping them with a clean, untreated, lint-free cloth. Remove all foreign matter.
- Clamp the pipe (fitting) in the butt fusion machine. The pipes should be properly aligned.
- Check that the butt fusion machine is compatible with the pipe outside diameter and butt fusion cycle to be applied.
- Plane the pipe (fitting) ends by closing the butt fusion machine around the planing tool. Closing pressure shall be sufficient to produce a steady flow of polyethylene slivers on both sides of the rotating planing tool. The operation is complete when the pipe (fitting) ends are parallel to each other (or when a minimal distance exists between the fixed and movable jaws of the butt fusion machine).
- Lower the pressure while keeping the tool rotating. Move the clamp backwards, stop and remove the planing tool. Remove all pipe chips from the planing operation and any foreign matter with a clean, untreated, lint-free cloth. Do not touch the newly faced surfaces with hands.
- Close the butt fusion machine, and check that the pipes are aligned (the pipe profiles must be rounded and aligned with each other to minimise mismatch of the pipe walls). The jaws of the butt fusion machine must not be loosened at any time or the pipe may slip during fusion. If any adjustment at all is made on one or both inside clamps, then the planing operation should be repeated.
- Gap between the pipe (fitting) ends shall be as small as possible. In whatever case, it shall not exceed:
 - 0.3 mm for OD < 225 mm;
 - 0.5 mm for 225 mm ≤ OD ≤ 400 mm;
 - 1 mm for OD > 400 mm.
- Measure the drag pressure (usually defined as the minimum pressure needed for very slow movement of pipe or for holding pipes together during the above alignment).
- Check that the heating plate is at the correct temperature. Check that the surface coating of the heating plate is intact and without scratches.
- Clean the plate with an Isopropanol impregnated pipewipe (or clean, untreated, lint-free cloth moistened in Isopropanol), and allow it to dry.
- Clean the pipe ends (planed surfaces and at least 30 mm along the pipe from the ends) with an Isopropanol impregnated pipewipe, and allow them to dry.
- Place the heating plate between the pipe (fitting) ends.
- Close the butt fusion machine around the heating plate with the pressure P_1 (including the drag pressure) till the specified bead width has been reached.
- Reduce pressure to a level at which contact is just maintained between the pipe (fitting) ends and the heating plate (P_2). Maintain the contact (without separation of the pipe ends and the plate) for the heat soak time t_2 duration (note, that the lower temperature of the heating plates requires a slightly longer heat soak time).

- When the heat soak time t_2 has elapsed, quickly open the butt fusion machine, remove the heating plate and having quickly checked the pipe ends for possible damage, close the butt fusion machine again (this operation shall be done quickly within the specified time t_3). If melted plastic surface sticks to the heating plate, or is damaged, discontinue the fusion operation, let the pipe ends cool, and start over from the beginning. Use minimum pressure needed to bring the pipes together when closing the machine.
- Gradually increase pressure to the specified pressure P_3 . **Use practically all of the time t_4 .** Note, that excessive pressure or too quick pressure application will squeeze too much melt out of the fusion area resulting in a weakened (brittle) joint. The force applied will cause each bead to roll back onto the pipe. The degree of bead roll-over may differ between different pipe materials.
- Store the heating plate in the protective enclosure between fusion cycles.
- The butt fusion machine shall remain closed during the whole butt fusion time t_4 and t_5 (and t_6).
- When the cooling period has elapsed (or when the surface of the bead is cool to the touch), release the pressure in the butt fusion machine. Open the clamps.
- When removed from clamps, the pipe shall be handled with care (including when removing the pipe). The pulling, installation or rough handling of the pipe should be avoided till the weld has completely cooled (for at least an additional 30 minutes; this does not prevent careful moving the butt-welding machine to the next weld).
- Examine the joint. Remove the bead, if required, using a purpose made tool (the bead may be used to assess weld quality), and examine the joint again. If upon examination the joint appears faulty, cup open and start over from the beginning.

We recommend testing a butt weld joint made from the pipe to be used and under the intended welding conditions prior to installation.

Consider using **dual-pressure butt fusion cycle** according to ISO 21307:2009(E) for pipes of wall thickness over 25 mm.