

Butt welding (butt fusion) using a heated plate is a simple and quick jointing technique performed basically by melting the pipe (fitting) end edges and holding them together under controlled temperature, time and pressure conditions. This technique is most suitable for pipe sizes of DN/OD 90 mm (DN/ID 80 mm) and above. PE pipes/fittings with fusion ends of different SDR values shall not be jointed by butt welding.

Refer to ISO 21307 for more detailed information.

The butt welding equipment usually consists of:

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

Generic butt welding guidelines

Temperature, pressure and time parameters for **single low-pressure fusion jointing procedure** are shown in the table on the next page. **Drag pressure** (minimum pressure required to overcome sliding frictional drag force of the machine and pipe) should be added to the calculated jointing pressure (drag pressure can be a positive or negative value). 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.
- **Changeover time** (time to remove heater plate and bring melted pipe ends together) 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:

- **Equipment.** Butt welding machine, preferably complying with ISO 12176-1, shall be well maintained and capable of securely and precisely aligning pipe ends. Use pipe support (rollers) to reduce drag pressure.
- **Operator.** Butt welding shall be performed by qualified and experienced operators.
- **Working environment.** Care shall be taken to keep the pipe (fitting) ends and heater plate clean from dust, sand, clay, and shielded from wind (including inside the pipes by blocking their ends) and, as possible, from sun (to avoid uneven temperature distribution). Use a shelter against adverse weather conditions. Ensure that no water or other fluid can access the fusion area neither from inside nor from outside the pipe.

Clean the pipe ends, planing tool and heater plate prior to welding removing all foreign matter with a clean lint-free material, 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.

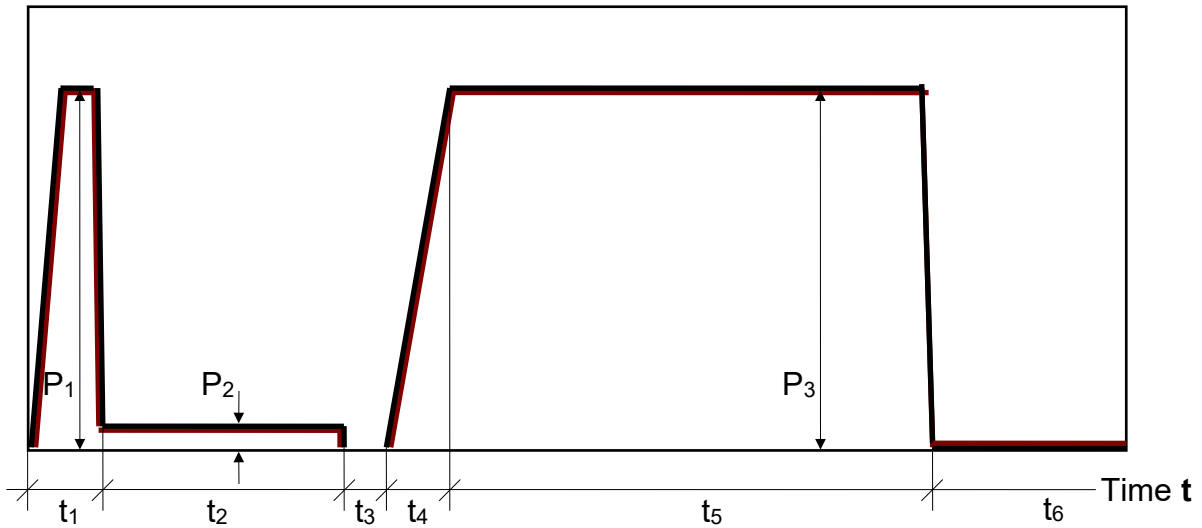
Pipes of nominal outside diameter of 315 mm and over may be welded also using **dual-pressure butt fusion cycle** according to ISO 21307.

Single high-pressure fusion jointing procedure to ISO 21307 may also be considered though it is not recommended without specialized training.

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

Butt welding parameter guidelines are as follows:

Pressure P



Butt welding parameters		Units	Value to ISO 21307:2017(E)	Comments
Heater plate temperature		°C	225 ± 10	
Heating pressure (initial bead-up pressure)	P ₁	kPa	170 ± 20	Use formula below and add drag pressure
Initial bead-up time	t ₁	sec		Varies
Minimum bead size after t ₁		mm	First indication of melt everywhere around the pipes (typically up to 1 mm)	
Minimum initial bead width (after t ₂)		mm	0.5 + 0.1×e	e = minimum wall thickness rounded to the next higher 0.1 mm, mm
Heat soak pressure	P ₂	kPa	0 to drag pressure	Use the lowest possible pressure that will allow the pipe to remain in contact with the heater plate
Minimum heat soak time	t ₂	sec	(13.5 ± 1.5)×e	
Fusion jointing pressure (interfacial pressure)	P ₃	kPa	170 ± 20	Use formula below and add drag pressure
Maximum heater plate removal time	t ₃	sec	See ISO 12176-1	
Maximum time to achieve welding pressure	t ₄	sec	3 + 0,03×OD	OD = nominal pipe outside diameter, mm
Minimum cooling time in the machine under pressure	e < 18 mm	t ₅	min	Cooling times at ambient temperature (23 ± 2)°C. Should be lengthened by approximately 1 % per 1°C at higher ambient temperatures.
	e ≥ 18 mm			
Minimum cooling time out of the machine	t ₆	min	A cooling time out of the machine and before rough handling may be recommended	

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

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

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

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

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

- Cut straight the pipe(s) to be welded.
- Reduce the drag resistance (or pipe movement on slopes) as much as possible (e.g. using pipe rollers, etc.).
- Clean the inside and outside of the pipe ends or fitting spigots, the planing tool and heater plate of the welding machine, by wiping them with a clean, untreated, lint-free cloth. Remove all foreign matter. Clean the pipe ends (planed surfaces and at least 30 mm along the pipe from the ends) with different Isopropanol impregnated pipewipes and allow them to dry naturally.
- Check that the butt welding machine is compatible with the pipe outside diameter and with the butt welding cycle to be applied.
- Clamp the pipe (fitting) in the butt welding machine. It is good practice to ensure that the pipe details printed along the two pipes are aligned and placed at the top of the machine when possible. The pipes (pipe and fitting spigot) shall be properly aligned.
- Plane the pipe (fitting) ends by closing the butt welding 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 clean and parallel to each other (or when a minimal distance exists between the fixed and movable jaws of the butt welding 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. Inspect the pipe for incomplete planing, voids or other imperfections.
- Close the butt welding 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 welding machine must not be loosened at any time or the pipe may slip during fusion. If any adjustments are made on one or both inside clamps, then the planing operation should be repeated.
- Gap between the pipe (fitting) ends shall be absent or as small as possible. Typically, it shall not exceed:
 - ◆ 0.3 mm for $OD < 225$ mm;
 - ◆ 0.5 mm for $225 \text{ mm} \leq OD \leq 400$ 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 heater plate is at the correct temperature where the pipe or fitting wall cross-section makes contact. Check that the surface coating of the heater plate is intact and without scratches.
- Place the heater plate between the planed pipe (fitting) ends.
- Bring both pipe (fitting) ends into full contact with the heater plate simultaneously under initial bead-up pressure P_1 (with added drag pressure) till first indication of melt is everywhere around both pipe ends.
- Reduce pressure to a level at which contact is just maintained between the pipe (fitting) ends and the heater plate (P_2) without separation of the pipe ends and the plate at any time. Maintain the contact for the heat soak time t_2 duration (note, that the lower is the temperature of the heater plate, a slightly longer heat soak time is required).
- When the heat soak time t_2 has elapsed, quickly open the butt welding machine, remove the heater plate and having quickly checked the pipe ends for absence of any damage, close the butt welding machine again (this operation shall be done in a controlled manner as quickly as possible and within the specified time t_3). If melted plastic from the pipe end surface sticks to the heater plate, or is damaged, discontinue the fusion operation, let the pipe ends cool, and start over from the beginning.
- Examples of the maximum heater plate removal time, t_3 , from ISO 21307:2017(E), informative Annex A:
 - ◆ $e = 3.0$ mm: maximum $t_3 = 5$ sec;
 - ◆ $e = 5.8$ mm: maximum $t_3 = 6$ sec;
 - ◆ $e = 10.0$ mm: maximum $t_3 = 7$ sec;
 - ◆ $e = 18.2$ mm: maximum $t_3 = 10$ sec;
 - ◆ $e = 28.6$ mm: maximum $t_3 = 13$ sec;
 - ◆ $e = 36.4$ mm: maximum $t_3 = 16$ sec;

- ◆ e = 45.5 mm: maximum t_3 = 18 sec;
 - ◆ e = 57.3 mm: maximum t_3 = 22 sec;
 - ◆ e = 90.9 mm: maximum t_3 = 30 sec.
- 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 heater plate in the protective enclosure between fusion cycles.
 - The joint shall be held immobile in the butt welding machine during the whole welding time t_5 (and, if possible, t_6 after releasing pressure in the butt welding machine, particularly if working at higher temperatures than $(23 \pm 2) ^\circ\text{C}$ or when the joint may be subjected to rough handling).
 - When the cooling period has elapsed, release the pressure in the butt welding machine. Open the clamps.
 - When removed from the machine, the pipes shall be handled with care (including when removing the pipes). The pulling, installation or rough handling of the pipe should be avoided till the weld has completely cooled (this does not prevent careful moving the butt welding machine to the next weld).
 - Examine the joint. If required, remove the bead 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 destructive testing of a butt weld joint made from the pipe to be used and under the intended welding conditions prior to installation as well as random testing during construction.