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.

Refer to ISO 21307 for more detailed information.

The butt welding equipment usually consists of:
- butt fusion machine (includes pump);
- planing tool;
- heating 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 and pressure parameters for single low-pressure fusion jointing procedure are shown in the table on the next page. Drag pressure (minimum pressure required to overcome frictional drag force of the machine and pipe) should be added to the calculated jointing 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.
- 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:
- Equipment. Butt welding machine 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 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). 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, planning tool and heating 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 fusion cycle** is shown on the diagram below. **Butt fusion parameter guidelines are as follows:**

<table>
<thead>
<tr>
<th>Butt fusion parameters</th>
<th>Units</th>
<th>Value to ISO 21307:2011(E)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating plate temperature</td>
<td>°C</td>
<td>200 to 245</td>
<td></td>
</tr>
<tr>
<td>Heating pressure (initial bead-up pressure)</td>
<td>P₁</td>
<td>kPa 170 ± 20</td>
<td>Use formula below and add drag pressure</td>
</tr>
<tr>
<td>Initial bead-up time</td>
<td>t₁</td>
<td>sec.</td>
<td>Varies</td>
</tr>
<tr>
<td>Minimum bead size after t₁</td>
<td>mm</td>
<td>First indication of melt everywhere around the pipes (typically up to 1 mm)</td>
<td></td>
</tr>
<tr>
<td>Minimum initial bead width (after t₂)</td>
<td>mm 0.5 + 0.1×e (max. 6 mm)</td>
<td>e = mean wall thickness rounded up, mm</td>
<td></td>
</tr>
<tr>
<td>Heat soak pressure</td>
<td>P₂</td>
<td>kPa 0 to drag pressure</td>
<td></td>
</tr>
<tr>
<td>Heat soak time</td>
<td>t₂</td>
<td>sec. (11 ± 1) × e</td>
<td></td>
</tr>
<tr>
<td>Fusion jointing pressure (interfacial pressure)</td>
<td>P₃</td>
<td>kPa 170 ± 20</td>
<td>Use formula below and add drag pressure</td>
</tr>
<tr>
<td>Maximum heater plate removal time</td>
<td>t₃</td>
<td>sec. 0.1×e + 4</td>
<td>OD = nominal pipe outside diameter, mm</td>
</tr>
<tr>
<td>Maximum time to achieve welding pressure</td>
<td>t₄</td>
<td>sec. 0.4×e + 2</td>
<td>Use most of the time to gradually increase pressure</td>
</tr>
<tr>
<td>Minimum cooling time</td>
<td>Under pressure t₅</td>
<td>min. e + 3</td>
<td>In the machine</td>
</tr>
<tr>
<td></td>
<td>Without pressure t₆</td>
<td>min. e + 3</td>
<td>Out the machine</td>
</tr>
</tbody>
</table>

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

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

where  

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

These parameters should be suitable for both PE 80 and PE 100 pipes.
**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 (e.g. using pipe rollers, etc.).
- Clean the pipe ends and the spigot ends of fittings, the planning tool and heating plate of the welding machine, 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. Inspect the pipe for incomplete planning, voids or other imperfections.
- 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. Typically, 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 Isopropanol impregnated pipewipes (use as many as required), and allow it to dry naturally.
- 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.
- Place the heating plate between the planed pipe (fitting) ends.
- Bring both pipe (fitting) ends into full contact with the heating plate simultaneously increasing pressure to \( P_1 \) value (with added drag pressure) till first indication of melt is everywhere around both pipes.
- Reduce pressure to a level at which contact is just maintained between the pipe (fitting) ends and the heating 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 heating plate, a slightly longer heat soak time is required).
- 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 \( t_3 \).** 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, if possible, \( t_6 \)).

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 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 (for at least time \( t_6 \); 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 destructive testing 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.