Butt welding instructions

Butt welding with contact heating elements is the process of jointing two elements (pipes and/or fittings) of the same diameter and thickness, the joining surfaces of which are heated until fusion by contact with a heating element and then, after the heating element has been removed, are pressed together to form the weld. The following instructions are provided for reference purposes only. Installers must be properly trained and have an in-depth knowledge of the procedures to be followed according to the type of welding equipment being used.

Preliminary checks before welding

To ensure the joint is made properly:

- Ambient temperatures must be within the range from +5 °C to +40 °C.
- When inspecting the elements to be welded together, check the dimensions (check for excess ovality).
- Check the working temperature of the heating element with a calibrated contact thermometer. This measurement must be made 10 minutes after the rated temperature has been reached, thus allowing the element to heat up over its entire surface area and depth. Fusion temperature must be between 200° C and 220° C.
- Check the surface of the heating element (integrity of the non-stick coating) and clean with a lint-free cloth or soft paper wipe.
- Check that the welding unit is functioning correctly.
- Check the efficiency of the welding unit jaw clamps; ensure they are able to guarantee the correct alignment between the two sides of the joint and that the contact surfaces are perfectly parallel.
- Check the pulling force of the carriage, both in terms of friction and in relation to the load to be moved (pipes or fittings).
- Check the efficiency of the measuring instruments (pressure gauge and timer).
- Check that the pipes and/or fittings to be welded together are of the same diameter and thickness (same SDR).

Preparing for welding

- **Cleaning the surfaces:** Before positioning the parts to be welded, remove all traces of dirt, grease, oil, dust, etc., from the external and internal surfaces of the ends, using a clean, lint-free cloth soaked in a suitable detergent. When choosing the type of liquid detergent, use recommended products supplied by specialist producers: trichloroethane, chlorothene, ethyl alcohol and isopropyl alcohol are all suitable.
- **Clamping the ends**: The ends of the two parts to be welded must be clamped in such a way that axial misalignment does not exceed 10% of the thickness (fig. 1).
- **Planing the edges to be welded:** to guarantee proper parallelism and flatness, and, equally important, to eliminate the film of oxide that forms, the ends of the two parts to be joined must be planed. When this procedure is concluded, bring the two ends into contact and ensure that any clearances between them do not exceed 0.5 mm. The shavings must form continuously on both the edges to be welded (fig. 2). It is good practice, after the planing stage, to inspect the resulting shavings to verify the absence of manufacturing defects.
Shavings must be removed from the internal surface of the components to be welded using a brush or a clean cloth. In any event, after planing, the two surfaces must not be touched or contaminated in any other way; for this reason the welding operations must be performed immediately after preparation.
If any traces of dust have settled on the planed surfaces, before they can be welded they should be cleaned with a cloth soaked in specific detergent.

Fig. 1

Fig.2

Butt welding procedure

The butt fusion welding of pipes and/or fittings using contact heating elements must be performed by carrying out all the steps in the welding cycle, and picture at the end of this chapter.

• **Equalizing:** As shown in the welding cycle, equalizing is the first step, where the twoedges to be welded are located against the heating element at a pressureequal to p1+pt, for the necessary time, with the purpose of creating a uniform internal and external bead (fig. 3).
This equalizing step is finished when the bead heights around the entire pipecircumference have reached the values specified in the next table.The equalizing pressure value must be such that, when in contact with theheating element, the surfaces to be welded are subjected to the pressure described in the table.; to achieve this condition, p1 pressure values must be taken from the tables supplied by manufacturer of the fusion jointing machine, because, apart from the diameter and thickness of the elements to be welded, these values also depend on the cross section of the thrust cylinder in the welder circuit and can therefore alter in accordance with the specific model of welding unit you are using.
The symbol pt indicates the pulling pressure required to overcome the friction offered by the welding unit and the weight of the pipe locked in the mobile guide, combining to impede the free movement of the guide. This reading is taken on the pressure gauge supplied with the machine, while moving the mobile guide (fig. 4). In any event, it must never be higher than the pressure value p1, otherwise it may prove necessary to use carriages or suspension systems to facilitate movement of the pipe.

• **Pre-heating:** after the lip has formed, the pressure is lowered (10% of the contact and preheating value), thus allowing the material to heat up uniformly through its entire depth.

• **Changeover (Removing the heating element):** this phase must be performed as rapidly as possible, detaching the pipe edges to be welded from the heating element, extracting the element without damaging the softened surfaces and then immediately bringing the two edges to be welded into contact with each other. This procedure must be performed quickly to avoid the risk of excessive cooling of the edges (surface temperature falls by 17 °C in just 3 seconds)

• **Jointing build-up period:** the two edges are brought into contact and the relative pressure is increased progressively to the value (p5+pt), where p5=p1 and pt is the pulling pressure (fig. 5).

• **Welding:** Welding pressure must be maintained for the time described in the cooling time for joining pressure column. (fig. 6).

• **Cooling:** once the joint has been welded, contact pressure is removed and the joined parts can be removed from the fusion jointing machine, although it must not be subjected to mechanical stress until it has cooled completely. Time requested to get a complete cooling is the same described in the table in "Cooling time" column.

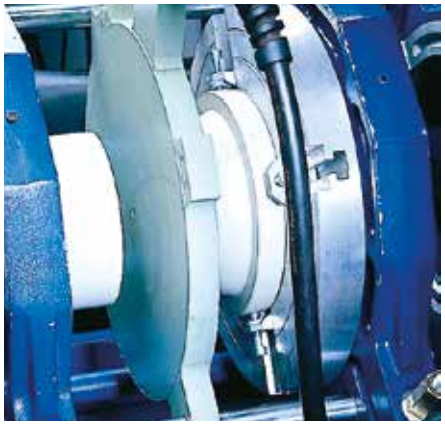


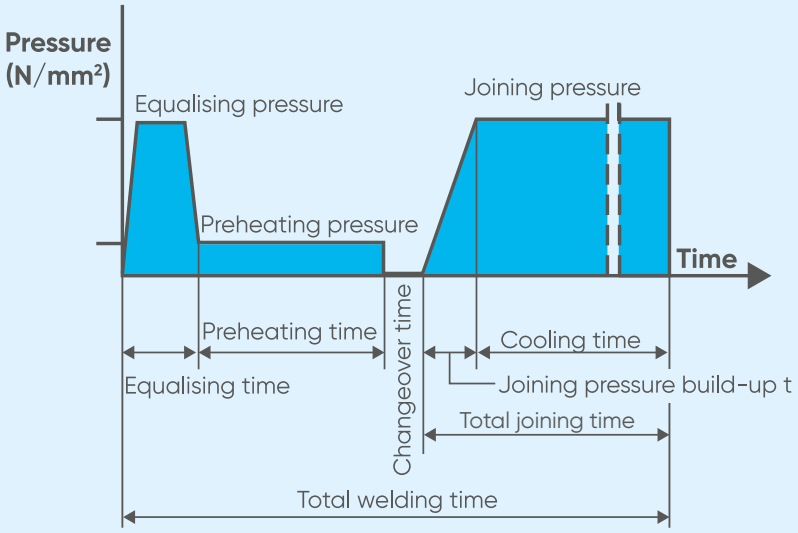
Fig. 3

Fig. 4

Fig. 5

Fig. 6

Welding cycle



Nominal wall thickness (mm)	Equalizing Bead height on heating element at end of equalizing time (minimum values) (equalizing p=0.15±0.01 N/mm²) (mm)	Preheating Preheating time=10x nominal wall thickness (preheating p≤0.01 N/mm²) (sec)	Changeover Changeover time (maximum) (sec)	Jointing pressure build-up time (Maximum time, may be undercut by up to 50%) (sec)	Cooling time (minimum values) at joining pressure p=0.15±0.01 N/mm² (min)
up to 4.5	0.5	up to 53	5	6	table below
4.5 - 7	0.5	53 – 81	5 - 6	6 – 7	
7 - 12	1	81 – 135	6 – 7	7 - 11	
12 - 19	1	135 – 206	7 – 9	11 – 17	
19 - 26	1.5	206 – 271	9 - 11	17 - 22	
26 - 37	2	271 – 362	11 – 14	22 – 32	
37 - 50	2.5	362 - 450	14 - 17	32 – 43	
50 - 70	3	450 - 546	17 - 22	43	

Nominal wall thickness (mm)	Cooling time (minimum values) at joining pressure p=0.10÷0.01 N/mm² as a function of ambient temperature			
	Up to 15°C (min)	15°C - 25°C (min)	25°C - 40°C Cooling time (min)	Cooling time (minimum values) at pressure welding p= 0.10±0.01 N/mm² in special conditions* (min)
up to 4.5	4	5	6.5	3.5
4.5 - 7	4 - 6	5 - 7.5	6.5 - 9.5	3.5 – 5
7 - 12	6 - 9.5	7.5 - 12	9.5 - 15.5	5 - 8
12 - 19	9.5 - 14	12 - 18	15.5 - 24	8 – 12
19 - 26	14 - 19	18 - 24	24 - 32	12 – 16
26 - 37	19 - 27	24 - 34	32 - 45	16 – 23
37 - 50	27 - 36	34 - 46	45 - 61	23 - 31
50 - 70	36 - 50	46 - 64	61 - 85	31 - 43

* These cooling times apply only under the following conditions:

- welding done in the laboratory/workshop;

- the removal of the part from the welding machine and its temporary storage until it has completely cooled down for the defined time in accordance with the fifth column above causes negligible loading of the joint connection.

WARNINGS

During the butt welding, take care of the following recommendations:

- Always wear appropriate personal protective equipment (for example, gloves and safety glasses to protect hands and eyes).
- Follow all the safety instructions specified by welding equipment manufacturer.
- It is a good practice, after the planing stage, to inspect the resulting shavings to verify the absence of manufacturing defects. Shavings must be removed from the internal surface of the components to be welded using a brush or a clean cloth.
- In any event, after planing, the two surfaces must not be touched or contaminated in any other way; for this reason, the welding operations must be performed immediately after preparation.
- If any traces of dust have settled on the planed surfaces, before they can be welded, they should be cleaned with a cloth soaked in specific detergent.

Checking the quality of the welded joint

Joints can be checked using two alternative techniques: non-destructive tests and destructive tests. While these latter tests call for the use of special equipment, the quality of the joint can also be checked with a simple visual inspection.

Visual inspections should assess the following points:

a) The weld bead must be uniform around the entire circumference of the joint;

b) The notch in the centre of the bead must remain above the outside diameter of the welded parts;

c) The external surface of the bead must not show any signs of porosity or inclusions of dust or other contaminants;

d) There should be no visible signs of surface breakup;

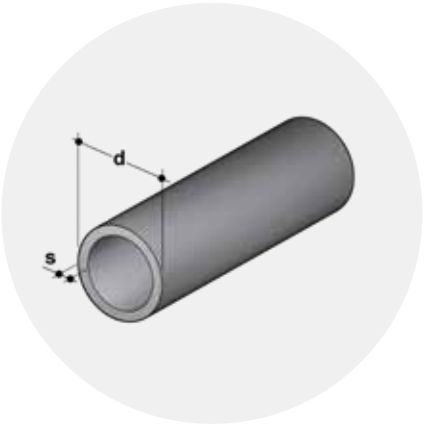
e) The surface of the weld bead should not have a very highly reflective finish, as this is a sign of overheating;

f) Axial misalignment of the welded parts must be no greater than 10% of their thickness.

Most common defects

The table reports the most common types of defect encountered if the correct welding procedure is not followed.

Irregular path of the weld bead around the circumference of the pipe	
Possible causes	Insufficiently meticulous preparation of ends to be welded with consequent uneven heat distribution
Reduced size of weld bead	
Possible causes	Incorrect adjustment of welding parameters (temperature, pressure and time)
Notch in centre of bead is too deep	
Possible causes	Temperature or pressure values are too low
Inclusions in the surface of the weld bead	
Possible causes	Insufficient cleaning of the ends to be welded
Porosity of weld bead	
Possible causes	Welding performed in excessively humid ambient conditions
Surface of weld bead presents an excessively smooth shiny finish	
Possible causes	Overheating during welding
Misalignment exceeds 10% of the thickness of the pipe and the fitting	
Possible causes	Incorrectly executed centring or excessive ovality of pipe



Compatibility and safety factors

PP-H components can be welded to compatible components in PPR and PPB without problems, once that the compatibility of the MFI value according to the DVS standard is verified. Because of the difference between PP-H and PPR in terms of MRS (MRS10 for PP-H, MRS8 for PPR, where MRS or Minimum Required Strength is the minimum guaranteed breaking strength of the material, subjected to tangential tension using hydrostatic pressure, at a temperature of 20 °C and for a lifetime of 50 years) and the consequent safety factors to be adopted, exact correspondence of the wall thickness / outside diameter ratio is of the maximum importance.

For this purpose, both the SDR (Standard Dimension Ratio) and the Series of thicknesses S have been introduced. In accordance with standard EN ISO 15494, the safety factor to be adopted and the SDR/Series determine the reference nominal pressure value PN (PN: max. working pressure in bar at 20 °C, for a duration of 50 years, in water).

$$SDR = \frac{d}{s} \qquad \sigma = \frac{MRS}{c} \qquad S = \frac{(SDR - 1)}{2} \qquad PN = \frac{\sigma}{S}$$

SDR	S
11	5
17.6	8.3

Wall thickness

d	Wall thickness S (mm)	
	SDR 11 - ISO S 5	SDR 17.6 - ISO S 8.3
12	1.8	-
16	1.8	-
20	1.9	1.8
25	2.3	1.8
32	2.9	1.9
40	3.7	2.3
50	4.6	2.9
63	5.8	3.6
75	6.8	4.3
90	8.2	5.1
110	10	6.3
125	11.4	7.1
140	12.7	8.0
160	14.6	9.1
180	16.4	10.2
200	18.2	11.4
225	20.5	12.8
250	22.7	14.2
280	25.4	15.9
315	28.6	17.9
355	32.2	20.1
400	36.3	22.7
450	40.9	25.5
500	45.4	28.3
560	50.8	31.7
630	-	35.7
710	-	40.2
800	-	45.3