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Welding

GLOBAL THERMOPLASTIC SOLUTIONS

Contents

1 Foreword

The term plastic welding means the permanent joining of thermoplastics by applying heat and pressure, with or without the use of a filler. The processes erroneously described as cold welding or solution welding are no longer included in this term because here the surface is dissolved and adhesively bonded with solvents.

All welding processes take place when the materials in the boundary areas of the surfaces being joined are in a ductile state. That is where the thread-like molecules of the parts being joined and pressed together link up and entwine themselves to form a homogeneous material bond.

Only plastics of the same kind, e.g. PP and PP, and within these types only ones with the same or a similar (adjacent) molecular weight and the same density, can be welded to one another, whereby colour does not have to be taken into account.

2 Hot-gas welding

(see also DVS 2207-3)

2.1 Workplace

Welding station equipment includes not only a hot-gas welding unit with nozzles (high-speed welding nozzles in diameters 3, 4 and 5 mm, fan welding nozzles, tack nozzles, profiled rod nozzles), thermometer, air flow meter, oil and water separators. Thermometers or temperature measuring stations with a needle-shaped tip have proved to be ideal because they can be pushed into the nozzle in order to measure the temperature. Accurate measurement of temperature takes place without contact 5 mm inside the nozzle (see Table 10). It is one of the preconditions for weld seams with a high weld factor (see Section 7.2).

2.2 Weld seam preparation

The most important types of seam are the DV-(X) seam, the V seam and, for sheets to be welded at right angles, the fillet. Sheets must have been properly straightened and have a chamfer of 30° – 35°. This can be performed with a plane, straightener, milling cutter, knife, saw or card scraper.

The seam used most frequently is the DV seam, in which the welding is performed from both sides alternately, in order to reduce distortion. For relatively thin sheets and structures where it is only possible to perform welding from one side it is advisable to make a V-seam. Cleaning of surfaces to be welded on sheet and rod by machining is essential.

Dirt, grease, hand sweat and oxide layers must be removed by machining in order to obtain a high weld factor. Cleaning with solvents is inadequate.

2.3 Welding process

Optimal values only arise if the base material and rod are equally ductile. At intervals the units have to be checked for temperature and air flow and readjusted if necessary.

Before the welding rod is applied, the starting point is preheated briefly until the surface is plasticised down to a depth of approx. 0.5 mm. Before every new welding pass the weld seam and the oxide layers appearing more and more quickly at high temperatures are scraped out by machining with suitable tools.

To avoid distortion it is important for each weld seam to cool down in the air before a new layer is applied. If relatively thick sheets have to be welded with DV seam preparation, the sheet must be turned over after each welding layer so that the seams are always arranged in sequence opposite to one another. When welding, it is important to ensure that there is a heated zone of equal width on both sides of the seam, the width being approx. 5 – 8 mm. To ensure a good connection of sheets to one another it is also important to obtain a double bead, whereby both sides fuse in their ductile zones. The molecular chains flow into one another and a double bead is created.

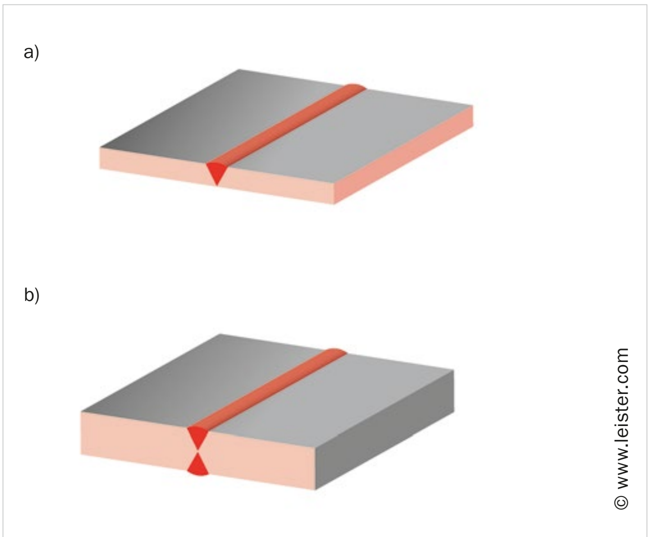


Figure 1: The most important shapes of weld seam in hot-gas welding:
a) V-seam; b) DV-seam (X-seam)

Table 1: Examples of weld seam structure

Sheet thickness	Welding rod
mm	Number x diameter (mm)
V-seam	
2	1 x 4
3	3 x 3
4	1 x 3 and 2 x 4
5	6 x 3
DV-seam (X-seam)	
4	2 (1 x 4)
5	2 (3 x 3)
6	2 (3 x 3)
8	2 (1 x 3 and 2 x 4)
10	2 (6 x 3)

Use of the circular nozzle (fan welding)

This method calls for greater manual skill and instinctive feel than working with a high-speed welding nozzle. It is chiefly used for amorphous materials such as PVC, CPVC or PETG. The rod should be held perpendicular in order to prevent transverse cracks (where the angle is too acute) and compression (where the angle is too obtuse).

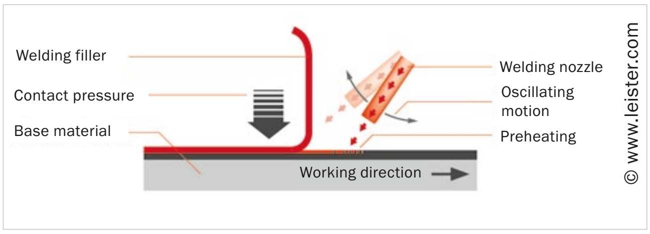


Figure 2: Principle of hot-gas fan welding (WF)

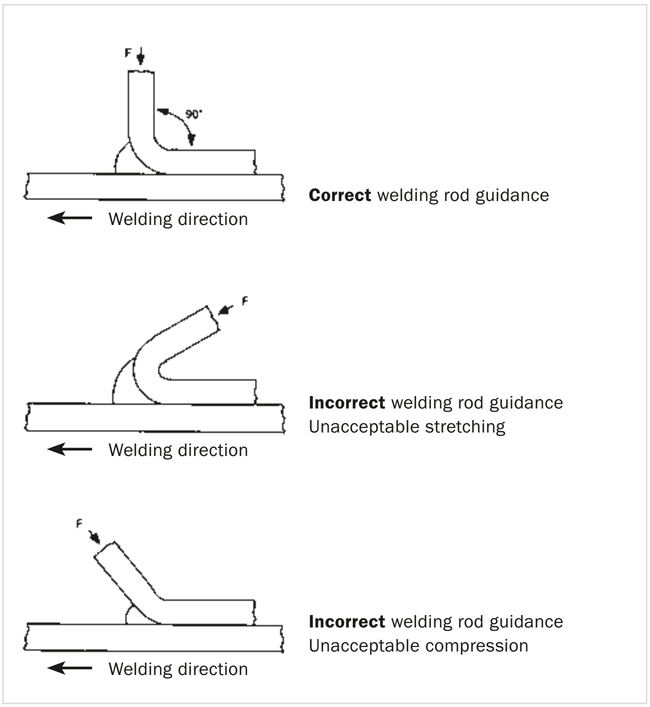


Figure 3: Welding rod guidance with the circular nozzle

Figure 4: Hot-gas fan welding with circular welding rod

Use of the high-speed welding nozzle
Welding with a high-speed welding nozzle makes it possible – compared to welding with a circular nozzle – to achieve double the welding speeds and to bring about higher levels of reliability. Special-purpose nozzles are used in which the rod is inserted and preheated. The air outlet at the nozzle foot towards the sheet is narrow and only heats a certain sheet zone required. For the various rods with regard to diameter and profile there are appropriate nozzles.

Figure 5: High-speed welding nozzle

Use of the tack nozzle
Welding with the tack nozzle serves to keep the parts in position. Fusion is performed with hot air but without any additional rod. The tack nozzle should be used for V-seams in order to ensure a perfect connection between the root zones and rule out the risk of a notch effect when bending. It is advisable to use the tack nozzle even if, for example, the external shape of a part being fabricated has to be specified with connections, etc.

2.4 Welding defects
(see DVS 2202-1)

- The sheet, or the heated zones to the left and right of the welding rod, and / or the rod itself have not been heated uniformly.
- Temperature and air flow are unsuitable.
- The sheet and the rod have not been cleaned sufficiently (oxide layer).
- The air is not devoid of water, oil or dust.
- The root of the V-seam has not been welded continuously.
- Air inclusions form inside the weld seam zone.
- The welding rod does not have sufficient volume to rule out the risk of notches in the weld seam zone.
- Welding pressure is wrong.
- The sheets have not been aligned properly.
- Welded too quickly: the welding rod has remained circular and has not been deformed sufficiently; that results in incomplete connection or no connection at all.
- If welding temperatures are too high, thermal damage occurs. The supposed benefit of faster welding this brought about by thermal damage to the molecular chains, whereby in extreme cases the original macromolecules are almost split open into the monomers. This particularly applies to polyethylene and polypropylene.

2.5 Rework on the weld seam

The weld seam is not normally subjected to machining. However, material can be removed by planing, sanding, milling or rasping, whereby care must be taken to prevent notches forming. After several sanding operations using abrasive paper with increasingly fine grit, weld seams can also be polished (e. g. in the case of PVC, PETG and PMMA).

You will find a table of approximate figures for hot-gas welding on page 31.

2.6 Weldability of various types of material

Only plastics of the same kind, e.g. PP and PP, and within these types only ones with the same or a similar (adjacent) molecular weight and the same density, can be welded to one another, whereby colour does not have to be taken into account. In practical terms this means that certain materials can only ever be welded to one another with adequate reliability if they are within one or two adjacent melt index groups. Apart from air as the temperature-carrying medium, in repair welding operations on equipment that is already in operation an inert gas atmosphere can minimise further degradation of a previously damaged material.

The melt index groups of the polyolefins can be seen by referring to the moulding compound names defined in DIN EN ISO 17855 Part 1 (PE) and DIN EN ISO 19069 Part 1 (PP). The MFR values relevant to welding can be seen from the corresponding moulding compound names.

PE

Pipework components and sheets with an MFR (190/5) of 0.2 – 1.7 g/10 min. according to DVS 2207-1 are suitable for welding to one another. This means that when the materials are heated the melt viscosity, i.e. the fusion property, is very similar. This statement has also been confirmed by the DVGW (German Gas and Water Association) in an announcement.

PP

Weldability is confirmed within the melt index group with MFR (190/5) 0.4 – 1.0 g/10 min. You can read this statement in DVS 2207 Part 11.

PVC

Even though it is not possible to derive a weldability statement for rigid PVC using the melt index, the moulding compound name defined by DIN EN ISO 11833-1 is again used as a basis. High weld seam quality is achieved for those materials that meet the following specifications/classifications:

SIMONA® Materials	Material name according to DVS	Weldability confirmed for	Hot-gas temperatures
PVC-CAW/ -MZ-COLOR/ -GLAS	PVC-U	DIN EN ISO 11833-1 Group 2 DIN 8061 & 8062	350 – 370 °C
CPVC	PVC-C	DVS 2205-1 Supplements 9 & 11 ASTM D 1784-03 Cell 23448	370 – 390 °C

PETG

Welding temperature: 320 – 340 °C
Hot-gas flow: 35 – 45 l/min.

PVDF

In the market there are two types of PVDF, manufactured by different polymerisation processes. Without going into detail it is possible to state that semi-finished products made by both processes can be welded to one another with a high quality of bond (within MFR (230/5) 1.0 – 25 g/10 min.).

DVS Guideline 2207 Part 15 deals with both heated-tool butt welding and socket welding for extruded pipes, injection-moulded fittings and sheets.

ECTFE

On account of the raw materials available, weldability is definitely confirmed for the semi-finished products used in tank and pipeline construction. In joining processes incorporating inert gas the temperature of the latter should be between 390 °C and 430 °C.

ETFE

This material can be processed in a similar way to ECTFE. Based on empirical data from tests conducted at our company, hot-gas welding and heated-tool butt welding can be used successfully.

PFA

Hot-gas temperature: 450 – 480 °C
Hot-gas flow: 50 – 60 l/min.

For the other fluoroplastics it can be assumed that the weld will be of high quality if the melt indices of the materials used are close to one another (see also DVS 2207-3, Supplement 3). In case of doubt, tests will be necessary.

3 Heated-tool welding

Warming is performed by a coated (PTFE) hot plate. Owing to the direct contact, the transmission of heat is far more intense than with hot-gas welding; the distribution of heat over the cross-section of the material is more efficient so there is no zone in the material which is subjected to a higher thermal load than what is required for welding. That means the stress to which the joints are subjected is very low. In heated-tool welding the welding process takes place when the heated surfaces of contact are brought together at a specific pressure and allowed to cool down under pressure. Modern equipment is provided with a data collection feature that makes it possible to store welding parameters and print out welding records.

Weld seam quality depends on the following criteria (see also Figure 6):

a. Weld seam preparation
The cleanliness of the parts to be joined by welding and of the heated tool is also top priority and of paramount importance in heated-tool welding. Teflon films or coatings facilitate the cleaning of heating surfaces and prevent plastics from clinging to the heated tool when warming up. This is particularly necessary for welding PVC.

b. Heated tool temperature
Semi-finished products with a large wall thickness usually call for relatively low temperatures – within tolerances (see Tables 11 to 21 and 23 to 27) – and a suitably longer exposure time.

c. Adaptation time
The properly straightened and cleaned surfaces to be welded are uniformly held against the hot tool at the pressures indicated in Tables 11 to 21 and 23 to 27 until a continuous bead of molten material appears on both sides of the heated tool.

d. Warming time
In the following phase of the total cycle time the warming pressure is linearly reduced to zero in order to obtain a heat flow in the material that is as consistent as possible. This prevents a sharply delineated temperature limit zone from developing between ductile and non-ductile material. Stresses and strains are reduced. Warming time depends on sheet thickness and the type of material.

e. Change-over time
For a weld with a high weld factor (see Section 7.2) it is crucial to join the parts being welded quickly. This particularly applies to PVC and high-temperature materials.

f. Joining pressure build-up time
In the time until full pressure has built up the pressure is linearly increased at a relatively slow rate. Sudden onset of full joining pressure would push the hot ductile material out of the welding zone. The result would be an inadequate weld factor.

g. Joining pressure and cooling time
Joining pressure and cooling time depend on the type of material and wall thickness. When the part has cooled down to room temperature at joining pressure, the full strength of the weld seam has been reached. The part can be removed from the machine. Do not cool down with water or air (stresses and strains).

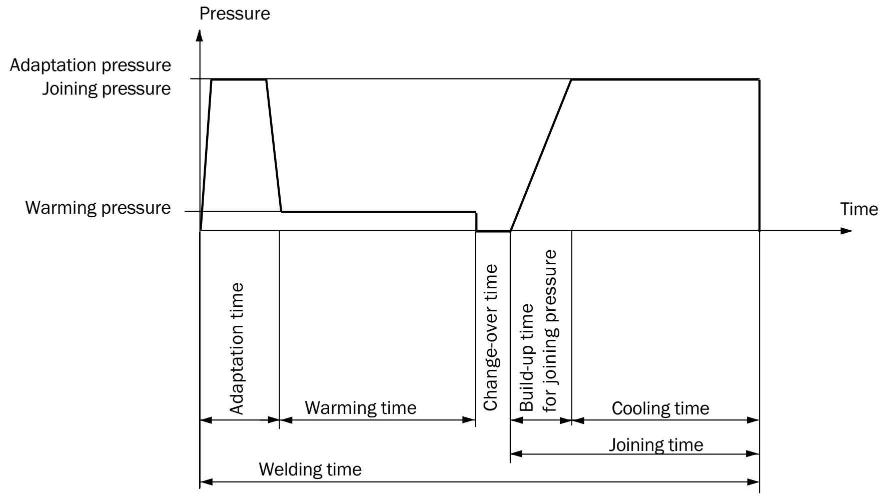


Figure 6: Pressure/time diagram; process steps in heated-tool butt welding

3.1 Fold welding

(see also DVS 2207-14)

This combined method (see Figure 7) is an adaptation of heated-tool butt welding. The cutting edge of the upper heated tool is fused into the plastic under pressure. At relatively large sheet thicknesses a small groove (approx. 0.5 x sheet thickness) can be milled in or sawn in before fusion, in order to reduce warming time and not subject the material to the heat for an excessively long period. When fusion has reached the necessary depth – 2/3 to 3/4 of sheet thickness – sufficient heat has penetrated the back of the seam from the bottom heater of the heated tool so that it undergoes a genuine hot forming process. Heated tools usually have a chamfer of 86° so flawless welding is guaranteed for 90°. For fold welding at obtuse angles it is important to use heated wedges with a flatter geometry.

On long bend-welded profiles, distinct arching is often visible when the part has cooled down. Outside the longitudinal distortion, special attention must be paid to the cooling-induced shrinkage stresses in the welding zone, which are even intensified by production-related inherent stresses in the semi-finished product. Narrow side legs lead to substantial distortion whilst legs that are wide and therefore stiffer result in less distortion. Furthermore, at relatively large sheet thicknesses from approx. 6 mm upwards it is expedient to heat the back with a second heated tool (heated tool width at least 2 x sheet thickness) or with hot air, in order to prevent undesirable stresses and strains. Bend welds perpendicular to the direction of extrusion show much less distortion and sag.

In addition – from a sheet thickness of 10 mm upwards – we recommend milling out or sawing out a V-shaped groove to approx. 50 per cent of thickness before the welding process. This groove should be provided in order to avoid excessive flash from the welding zone. Also, welding time is shortened by the reduced warming time.

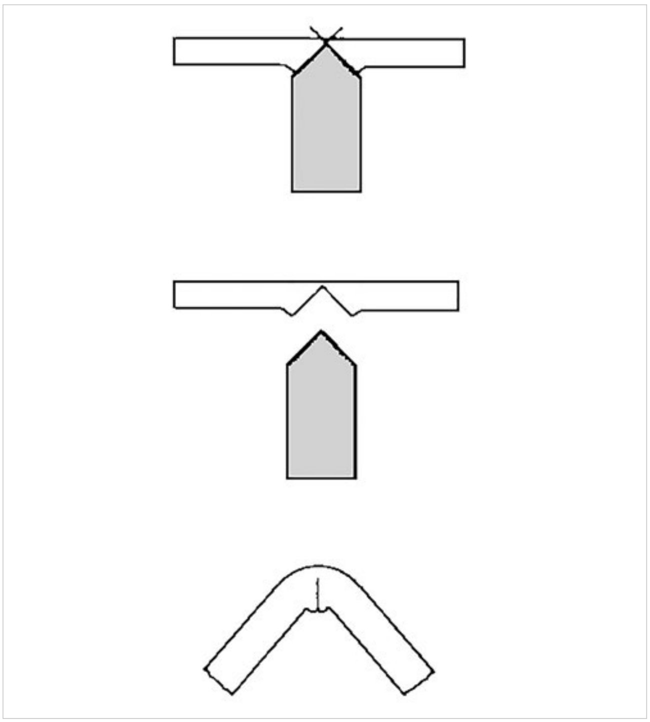


Figure 7: Fold welding

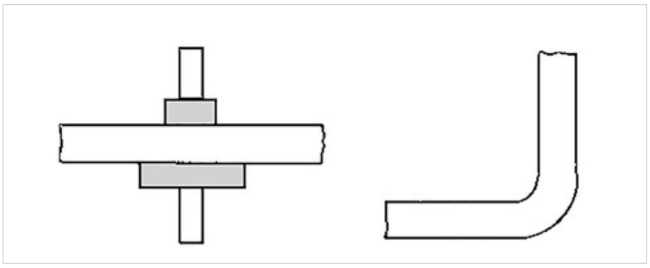


Figure 8: Bending

Table 2: Approximate figures for heated-tool fold welding on a Wegener fold welding machine, e.g. BV 300

	Set temperature °C		Time s
	Top	Bottom	per 1 mm thickness
Fold welding			
PE	220	140	~30
PP	230	150	~45
PVDF	240	160	~45
Bending			
PVC	220	170	~30

3.2 Processes for pipes and fittings

For permanent connection of SIMONA® Pipes and Fittings we recommend the processes that have proved successful in practice

- Heated-tool butt welding (see Section 3.2.1)
- Heated-tool socket welding (see Section 3.2.2)
- Electrofusion welding (see Section 4)

See also DVS Guidelines

- 2207-1 for PE
- 2207-11 for PP
- 2207-12 for PVC
- 2207-13 for CPVC
- 2207-15 for PVDF
- 2207-6 for processes, machines and parameters

Basic conditions for heated-tool butt welding, heated-tool socket welding and electrofusion welding:
The welding area must be protected against adverse weather influences (e. g. effect of moisture, wind, strong sunlight and temperatures below +5 °C). In the case of sunlight, inconsistently warmed pipes must be compensated by covering up the area of the weld in good time.

If suitable measures such as

- prewarming
- covering with a tent
- heating

ensure that a consistent pipe wall temperature adequate for welding can be maintained, work can be performed at any outdoor temperature. The dew point curve must be borne in mind. The parts to be joined must have the same temperature. If necessary, trial welds must be performed and tested.

The connecting surfaces of the parts to be welded must be devoid of soiling. Cleaning must be performed directly before welding. The same applies to the heated tool, which must be cleaned with PE cleaning agent and lint-free paper. To prevent the pipe from clinging to the heated tool and make it easier to release the pipe, the heated tools should be ones coated with Teflon. To prevent cooling by strong wind in the pipe during the welding process, the pipe ends facing away from the weld must be closed off.

3.2.1 Heated-tool butt welding
(see also DVS 2207-1, -11, -12, -13 and -15)

Basic conditions
Prior to heated-tool butt welding the faces ends of the pipes must be machined and brought up to welding temperature with the heated tool. The weld surfaces plasticised in this way are joined under pressure – after removal of the heated tool.

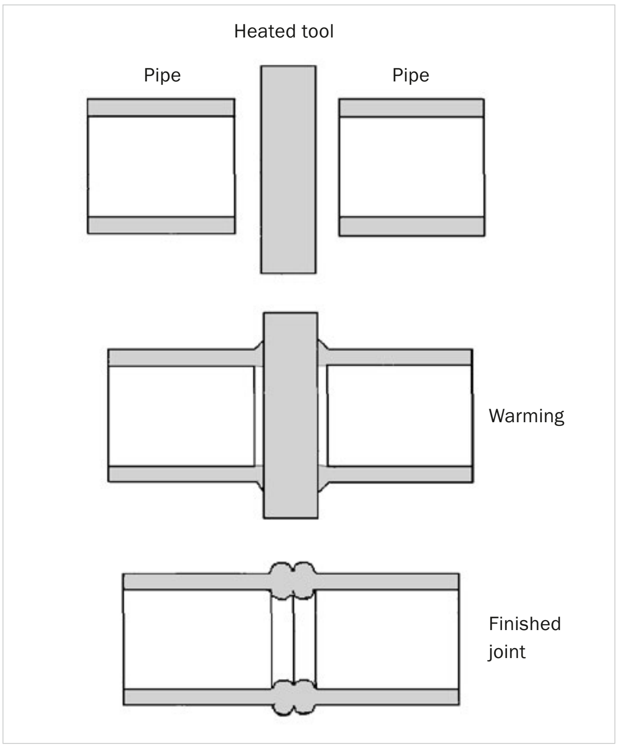


Figure 9: Principle of heated-tool butt welding

Weld seam preparation
The pipework components have to be aligned axially before they are clamped in the welding machine. Appropriate measures have to be taken to ensure that the part to be welded can move longitudinally, e. g. using adjustable pulley blocks.

The surfaces to be joined must be machined with a face cutter while clamped in position. The shaving thickness to be selected is ≤ 0.2 mm. Any shavings that fall into the pipe must be removed with the aid of a clean tool. Under no circumstances should the machined weld surfaces be touched with hands.

After machining, the pipes must be checked to make sure they are plane-parallel and firmly fixed in place. The gap remaining must not exceed the value specified in Table 3. At the same time a check must be performed to ensure that the offset of the pipe ends is less than 10 per cent of pipe wall thickness.

Table 3: Maximum gap width between the machined spigots

Pipe diameter d	Gap width a
mm	mm
≤ 355	0.5
400 – < 630	1.0
630 – < 800	1.3
800 – < 1000	1.5
> 1000	2.0

Welding process
The heated tool warmed up to welding temperature is placed between the parts to be welded and the connecting surfaces are pressed onto both sides of the heated tool at the correct adaptation pressure.

Irrespective of wall thickness, PE requires a temperature of 220 ± 10°C, PP 210 ± 10°C and PVDF 240 ± 8°C.

A temperature check is performed with a fast-indicating surface temperature measuring instrument, possibly using thermo-lubricant, or with infrared thermometers.

The force required for adaptation / joining can be calculated from the area of the weld and specific pressure. Welding machine manufacturers normally specify figures in the form of tables because most equipment uses hydraulics. Workpiece movement pressure has to be added to that specified pressure. The former is influenced by the friction of the machine parts and the weights of the parts to be welded.

Adaptation is only completed when a bead has formed around the entire perimeter of the two parts being welded, in accordance with the values specified in Tables 11 to 21 and 23 to 27. Contact pressure is reduced to near zero during the warming time that now commences.

After warming, the surfaces being joined have to be separated from the heated tool without any damage or soiling. The time required for separating the surfaces being joined, removal of the heated tool and contact between the surfaces is termed change-over time and should be kept as short as possible.

On making contact the surfaces to be welded should meet at a velocity close to zero. Then the pressure has to be increased slowly (for times see Tables 11 to 21 and 23 to 27) and maintained until the surfaces have completely cooled down. The joining pressure values specified in the tables may vary on account of the different ways in which the movement pressure of the machine is taken into account for sheets and pipes.

The weld seam area must not be allowed to cool down and the use of coolants is not permitted.

In the case of relatively large pipe wall thicknesses – roughly from 20 mm upwards – more uniform cooling can be achieved by covering up the welding area during the cooling phase so that weld seam quality benefits. After joining, there must be a uniform, continuous double bead around the entire perimeter on both sides (see Figure 10).

If the weld bead has to be machined, it should be chiefly performed before complete cooling – after approx. 1/3 of cooling time. If a cold bead has to be reworked by machining there is a risk of notches appearing. In the case of hard materials such as PVDF or PP-H it is possible that chipping occurs.

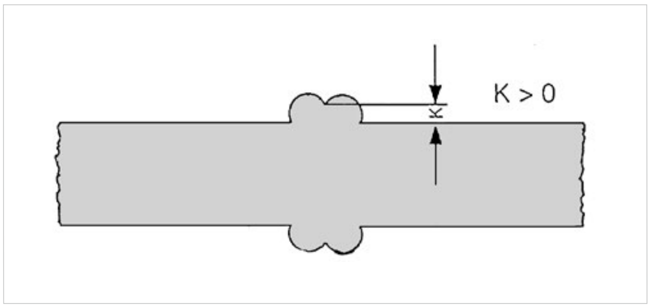


Figure 10: Bead configuration in heated-tool butt welding

3.2.2 Heated-tool socket welding

(see also DVS 2207-1, -11 and -15)

Basic conditions

Pipe and pipework components are welded with an overlap. With the aid of a socket-shaped or nozzle-shaped heated tool the two surfaces are heated to welding temperature and then joined. The pipe end, heated tool and socket are dimensionally matched to one another in such a way that joining pressure builds up during the joining procedure.

At pipe diameters

- ≥ 63 mm PE-HD and PP
- ≥ 50 mm PVDF

an appropriate welding jig must be used.

Weld seam preparation

The connecting surface of the pipe has to be machined with a peeling tool. In this context the heated tools to be used have to be taken into account in accordance with DVS Guideline 2208-1 Tables 7 and 8. The fitting must be thoroughly cleaned with a cleaning agent (e.g. Tangit Cleaner (99.9%) from Henkel; AHK PE Cleaner/Cleaning Cloths (99.9%) from SAT Kunststofftechnik GmbH) and absorbent, lint-free paper. The pipe end has to be provided with an external chamfer of approx. 15°, with a width of 2 mm for diameters up to 50 mm and with a width of 3 mm for larger diameters.

After that, in the case of all welds an insertion depth mark has to be applied to the pipe ends.

Welding process

The welding tools are heated to 260 ± 10°C. A temperature check is performed with a fast-indicating surface temperature measuring instrument or with an infrared thermometer. For warming up, the fitting is first pushed on up to the stop and then the pipe is pushed in up to the mark. The parts to be welded have to be heated according to the times specified in Tables 27 to 29.

When the warming time has elapsed, the fitting and pipe are removed from the heated tool with a jerk and pushed together up to the mark and up to the stop, respectively, without twisting or tilting. The parts joined must be fixed in position and cooled down according to the specifications in Tables 27 to 29.

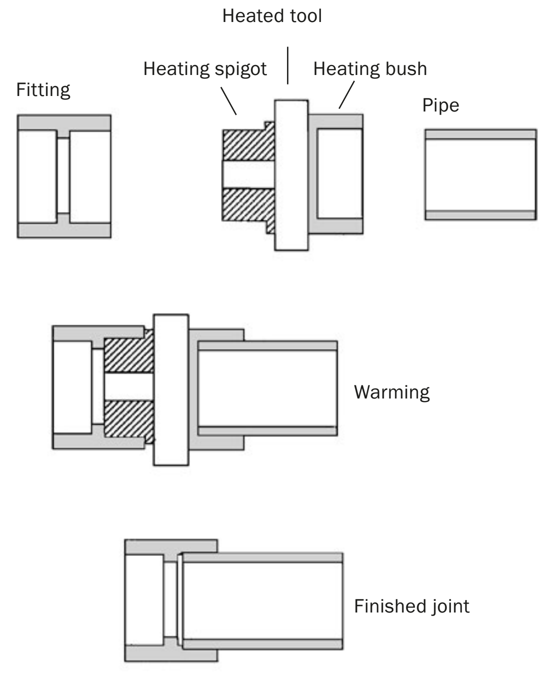


Figure 11: Principle of heated-tool socket welding

4 Electrofusion welding

(see also DVS 2207-1 and -11)

4.1 Basic conditions

The connecting surfaces, i.e. the pipe surface and the inside of the socket, are heated to welding temperature by electricity with the aid of resistance wires embedded in the socket (heating coil) and then they are welded. At present this process can be used for PE, PP and PVDF.

4.2 Weld seam preparation

To ensure flawless electrofusion welding it is essential to have clean surfaces. The surface of the pipes must be prepared in the welding zone using a card scraper or a rotary scraper. The inside edge has to be deflashed and the outside edge has to be rounded as shown in Figure 13.

The fitting must be thoroughly cleaned with a special-purpose cleaning agent (e.g. Tangit Cleaner (99.9%) from Henkel; AHK PE Cleaner/ Cleaning Cloths (99.9%) from SAT Kunststofftechnik GmbH) and absorbent, lint-free paper.

The out-of-roundness of the pipe must not exceed 1.5 per cent of the outside diameter, or a maximum of 3 mm. Otherwise appropriate re-rounding clamps should be used.

When pushing on the fitting care must be taken to ensure that the parts are inserted neither at an angle nor forcefully or else the heating coil might be displaced or damaged.

4.3 Welding process

Only a welding unit that is matched to the particular fitting may be used. Before welding the values are set on the welding unit either manually (voltage and welding time) according to the diameter and nominal pressure of the pipe or read in with a scanner wand. The unit and the fitting are connected by means of a welding cable. The welding process itself takes place automatically; modern units generate welding records. The pipe joint can only be moved when it has cooled down.

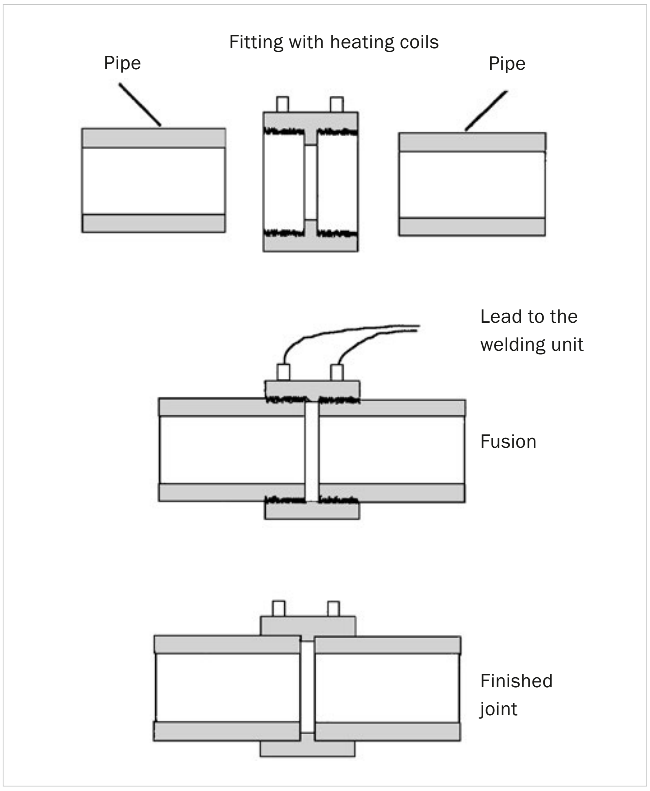


Figure 12: Principle of electrofusion welding

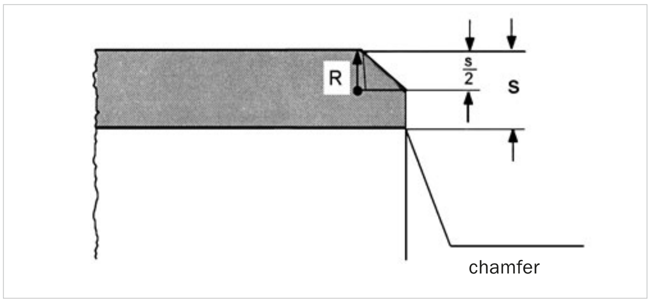


Figure 13: Preparation of the pipe ends

5 Friction welding

(see also DVS 2218-1/2/3)

5.1 Process

In friction welding the plasticization necessary for welding is brought about without applying thermal energy and preferably without using a filler by rubbing the two parts being welded against one another at the connecting surface in the material bead and then welded under pressure.

A workpiece is usually moved against a stationary one in a rotary motion, whereby the axially symmetrical connecting surfaces can be either end faces or peripheral faces.

5.2 Weld seam preparation

The connecting surfaces of the parts to be welded must be devoid of soiling. Cleaning agents that have a dissolving or swelling effect on the plastic must not be used.

For the success of a welding process the geometric configuration of the connecting surfaces is important. In the case of a butt joint between parts up to a diameter of about 40 mm the connecting surfaces must be turned (butt seam) whilst in the case of parts with a diameter above 40 mm one or both connecting surfaces have to be shaped slightly convex by machining (fillet) (see Figure 14).

Thin-walled parts (pipes) must be supported near the connecting surfaces in a suitable manner.

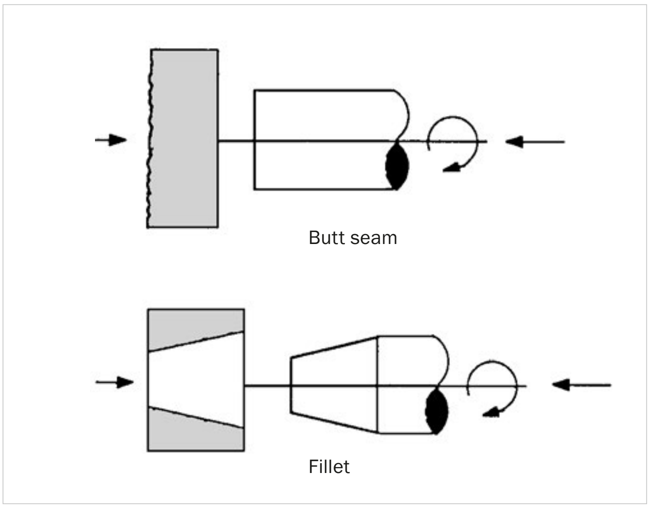


Figure 14: Welding the seam

5.3 Welding process

The workpieces to be welded are clamped into a jig (see Figure 15); then one of the workpieces is rotated against the other one, which is usually stationary. When the welding temperature has been reached – the correct time is evident from the fact that plasticised material oozes out all round the perimeter – the fixture of the stationary workpiece is released and consequently the rotary motion of the two workpieces against one another is terminated as quickly as possible. The joining pressure is maintained until adequate cooling has taken place.

The main influencing variables in friction welding are:

Warming pressure: Pressure at which the connecting surfaces are pressed against one another during rotary motion

Warming time: Time during which warming pressure is active

Joining pressure: Pressure for joining the parts to be welded

Joining time: Time during which joining pressure is active

Depending on the diameter of the weld area the peripheral speeds used in practice are about 1 – 4 m/s. Material conditions, workpiece conditions and interdependent welding conditions (e. g. rubbing speed, warming pressure and joining pressure) must be determined by the welder in preliminary tests for the particular application.

For polyolefins and PVC-U the warming pressure (rubbing pressure) and joining pressure (welding pressure) are approx. 0.5 – 1.5 N/mm^2. It is important to keep rubbing pressure as low as possible so that as the plastic becomes ductile it cannot be thrown out of the butt joint.

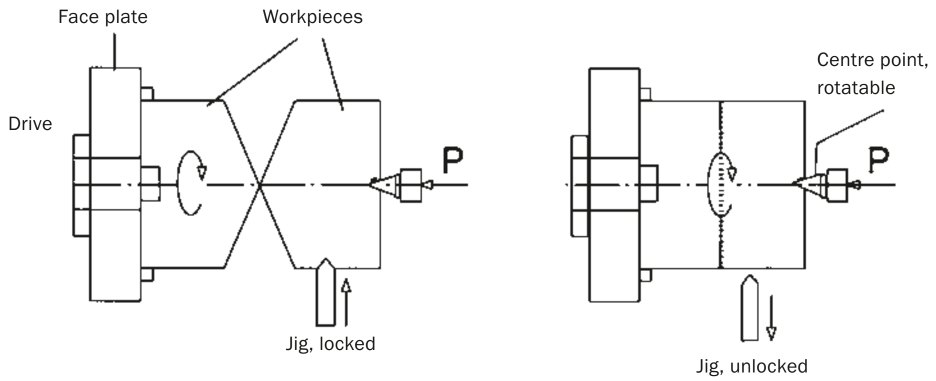


Figure 15: Principle of friction welding; left: prepared for welding; right: welding completed

6 Extrusion welding

(see also DVS 2207-4)

Extrusion welding is used, inter alia, for connecting thin-walled parts. Welding is performed using a homogeneous welding filler. For PVC-U / CPVC this process can only be used with limitations (in such cases please consult the manufacturer of the extruder). Special-purpose screws have to be used with units suitable for PVDF, possibly after consultation with the manufacturer of the extruder.

6.1 Weld seam preparation

Directly before welding the surfaces to be connected, the adjacent areas and any damaged surfaces (especially if there are weather or chemical influences) must be machined down to intact zones. Cleaning agents (e.g. ethanol 99.9%) that attack or alter the surface of the plastic must not be used.

Example:
Material PP, sheet thickness 10 mm, vee butt joint 60°, suitable extruders, PP rod Ø 4 mm.

Settings:
60° opening angle, air gap 1 mm (see Figure 16), TM = 225 – 230 °C, TL = 275 – 295°C, distance between the pre-heating nozzle and the base material 10 – 15 mm, output capacity of the extruder approx. 1.5 kg/h results in a welding speed of ≈ 150 – 175 mm/min. Welding speed: < 30 cm/min for PE / PP with a wall thickness of 10 mm.

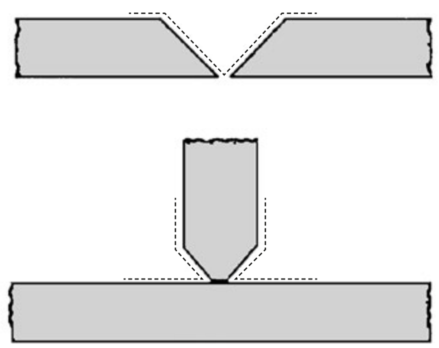


Figure 16: Cleaning of the welding zones

6.2 Temperature

Table 4: Temperature

SIMONA® materials	Material names according to DVS	Temperature of extrudate measured at the nozzle outlet (TM)	Air temperature measured in the hot air nozzle (TL)	Air flow (cold air intake)
		°C	°C	l/min
PE-HD	PE-HD	210 – 230	250 – 300	≥ 300
PE 100	PE-HD	210 – 230	250 – 300	≥ 300
PE FOAM		210 – 230	250 – 300	≥ 300
PP-H AlphaPlus®/PP-H/PP-C/PP-R	PP-H/PP-B/PP-R	210 – 240	250 – 300	≥ 300
PP FOAM		210 – 240	250 – 300	≥ 300
PVC-CAW	PVC-U	170 – 180	300 – 360	≥ 300
CPVC	PVC-C	195 – 205	300 – 360	≥ 300
PVDF	PVDF	240 – 260	280 – 350	≥ 300
ECTFE	ECTFE	270 – 300	340 – 380	≥ 300

6.3 Influence of moisture

Plastics, including welding fillers made of polyolefins, can absorb moisture at the surface under certain conditions. For example, tests conducted on PE-EL/PP-EL at a well-known manufacturer of raw materials and at SIMONA both resulted in the following assessment:

Welding filler absorbs moisture at the surface depending on material conditions and ambient conditions. In extrusion welding this accumulated moisture can take the form of bubbles in the weld seam or in a rough surface of the seam. This phenomenon occurs to a greater extent as weld seam thickness increases (a-dimension).

In order to eliminate the "moisture" issue in welding we recommend observing the following points:
- Install a water/oil separator in the air system
- Avoid differences in temperature between the parts being welded (condensation)
- Store welding filler as dry as possible (e.g. boiler rooms)
- Pre-dry welding filler if necessary (air expulsion oven: PE 80 °C / PP 100 °C / PVC 60 °C, for at least 12 h)
- Weld large a-dimensions (≥ 18 mm) in more than one pass

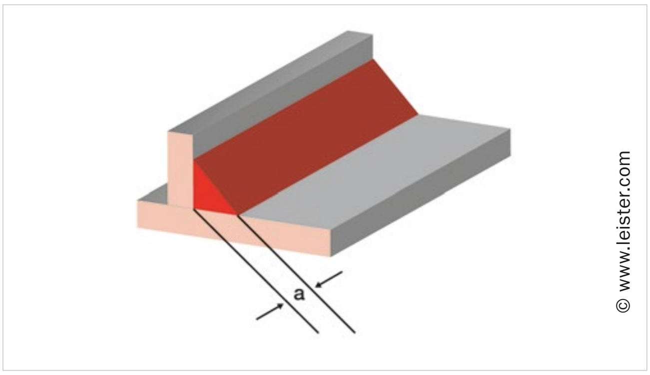


Figure 17: Fillet, a-dimension

Relative humidity
Formula:

$$\text{Rel. humidity [\%]} = \frac{\text{Prevailing level of moisture x 100}}{\text{Max. level of moisture}}$$

If the moisture content of the air is the same:
- relative humidity decreases during warming and
- relative humidity rises when cooling down.

If the air cools down to the extent that the relative humidity reaches a figure of 100 % and there is further cooling, water vapour must separate from the air in the form of a mist. The temperature at which this takes place is termed the dew point. Consequently, condensation always occurs if air is cooled down to below the dew point.

With the aid of Table 5 you can determine the dew point. At a given temperature of 20 °C and a relative humidity of 60 %, for example, the resulting dew point is 12 °C.

Table 5: Dew point of air in relation to temperature and relative humidity of air

Air temperature	Dew point [1] in °C at a relative humidity of													
°C	**30 %**	**35 %**	**40 %**	**45 %**	**50 %**	**55 %**	**60 %**	**65 %**	**70 %**	**75 %**	**80 %**	**85 %**	**90 %**	**95 %**
30	10.5	12.9	14.9	16.8	18.4	20.0	21.4	22.7	23.9	25.1	26.2	27.2	28.2	29.1
29	9.7	12.0	14.0	15.9	17.5	19.0	20.4	21.7	23.0	24.1	25.2	26.2	27.2	28.1
28	8.8	11.1	13.1	15.0	16.6	18.1	19.5	20.8	22.0	23.2	24.2	25.2	26.2	27.1
27	8.0	10.2	12.2	14.1	15.7	17.2	18.6	19.9	21.1	22.2	23.3	24.3	25.2	26.1
26	7.1	9.4	11.4	13.2	14.8	16.3	17.6	18.9	20.1	21.2	22.3	23.3	24.2	25.1
25	6.2	8.5	10.5	12.2	13.9	15.3	16.7	18.0	19.1	20.3	21.3	22.3	23.3	24.1
24	5.4	7.6	9.6	11.3	12.9	14.4	15.8	17.0	18.2	19.3	20.3	21.3	22.3	23.1
23	4.5	6.7	8.7	10.4	12.0	13.5	14.8	16.1	17.2	18.3	19.4	20.3	21.3	22.2
22	3.6	5.9	7.8	9.5	11.1	12.5	13.9	15.1	16.3	17.4	18.4	19.4	20.3	21.2
21	2.8	5.0	6.9	8.6	10.2	11.6	12.9	14.2	15.3	16.4	17.4	18.4	19.3	20.2
20	1.9	4.1	6.0	7.7	9.3	10.7	12.0	13.2	14.4	15.4	16.4	17.4	18.3	19.2
19	1.0	3.2	5.1	6.8	8.3	9.8	11.1	12.3	13.4	14.5	15.5	16.4	17.3	18.2
18	0.2	2.3	4.2	5.9	7.4	8.8	10.1	11.3	12.5	13.5	14.5	15.4	16.3	17.2
17	–0.6	1.4	3.3	5.0	6.5	7.9	9.2	10.4	11.5	12.5	13.5	14.5	15.3	16.2
16	–1.4	0.5	2.4	4.1	5.6	7.0	8.2	9.4	10.5	11.6	12.6	13.5	14.4	15.2
15	–2.2	–0.3	1.5	3.2	4.7	6.1	7.3	8.5	9.6	10.6	11.6	12.5	13.4	14.2
14	–2.9	–1.0	0.6	2.3	3.7	5.1	6.4	7.5	8.6	9.6	10.6	11.5	12.4	13.2
13	–3.7	–1.9	–0.1	1.3	2.8	4.2	5.5	6.6	7.7	8.7	9.6	10.5	11.4	12.2
12	–4.5	–2.6	–1.0	0.4	1.9	3.2	4.5	5.7	6.7	7.7	8.7	9.6	10.4	11.2
11	–5.2	–3.4	–1.8	–0.4	1.0	2.3	3.5	4.7	5.8	6.7	7.7	8.6	9.4	10.2
10	–6.0	–4.2	–2.6	–1.2	0.1	1.4	2.6	3.7	4.8	5.8	6.7	7.6	8.4	9.2

[1] Approximation is possible by means of linear interpolation

6.4 Equipment

The portable extrusion welding unit consists of a compact extruder as a plasticizing unit, which is driven by an electric motor, for example.

For preheating the weld joint a blower or commercial hot-air gun with a connection point for air supply is already integrated.

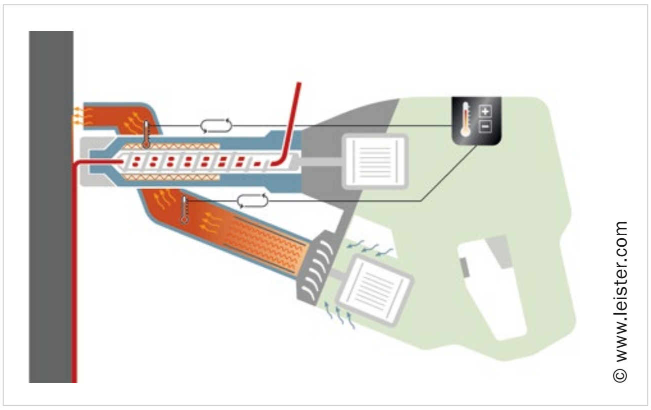


Figure 18: Extruder

Extrusion welding features the following characteristics:

- Welding is performed using a homogeneous welding filler with the same moulding compound.
- The welding filler is plasticized homogeneously and completely.
- The surfaces being joined are heated to welding temperature with hot air.
- Plasticization depth is 0.5 – 1.0 mm.
- The extruded compound is brought into form with a welding shoe and pressed into place.
- Compared to hot-gas welding, shorter working times and higher levels of strength are achieved whilst seam quality is high and inherent stresses are low.

Design of welding shoes

The extruded welding filler is brought into form with a welding shoe, e. g. made of PTFE, and pressed into place. The following factors depend on the shape of this welding shoe:

- Shot capacity
- Injection speed
- Material flow
- Seam seal / type
- Uniform pressure

Welding shoes must be adapted to the particular type of seam. General rules: The wider the weld seam, the longer the shoe should be (see also DVS 2207-4).

The only materials that can be used for the welding shoe are plastics with high thermal resistance, and PTFE has proved successful. Apart from the required high thermal resistance this plastic has good slip properties and is anti-adhesive.

Figure 19: Welding shoe

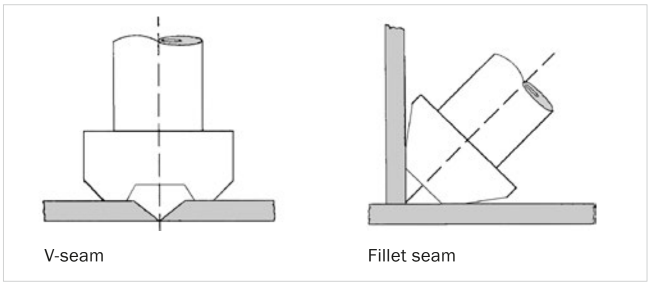


Figure 20: Design of a welding shoe

6.5 Rework on the weld seam

Weld seams should always be made so that no subsequent machining is necessary. Extrusion weld seams should have a uniform smooth surface and flawless welded edge zones.

To avoid notches in the seam root a root sealing run or seam securement can be hot-gas welded.

The extrudate that occasionally oozes out at the edge of the welding shoe must – especially in the case of joints exposed to high loads – be removed manually without notches using an appropriately shaped card scraper or triangular scraper.

6.6 Avoidance of void formation in the welded seam

Voids develop only after the welding process proper. They can be reduced by altering the level of moisture, the cooling rate and welding shoe geometry, and, to a minimal extent, by varying the welding parameters.

Voids occur especially when walls are thick. They arise because after solidification of the seam surface a stable outer skin forms which counteracts volume contraction. Voids are the inevitable result.

Slow and hence low-bubble cooling of the weld seam is achieved by using a covering fabric, e.g. glass wool with aluminium foil or textile cloth.

This also reduces stresses and strains in the seam area.

6.7 Types of seam

The various types of seam are as follows:

- T-joint
- HV-seam (half V-seam) with fillet
- DV-seam (X-seam)

The projection g serves to support and guide the welding shoe (see Figures 21 and 22).

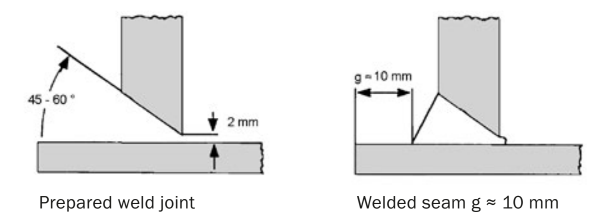


Figure 21: T-joint, HV-seam with fillet

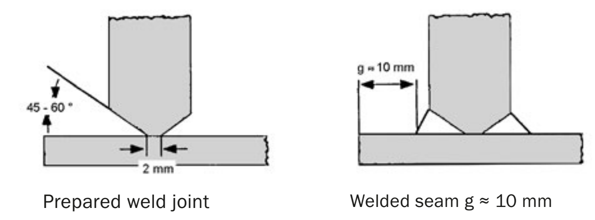


Figure 22: T-joint with double HV-seam

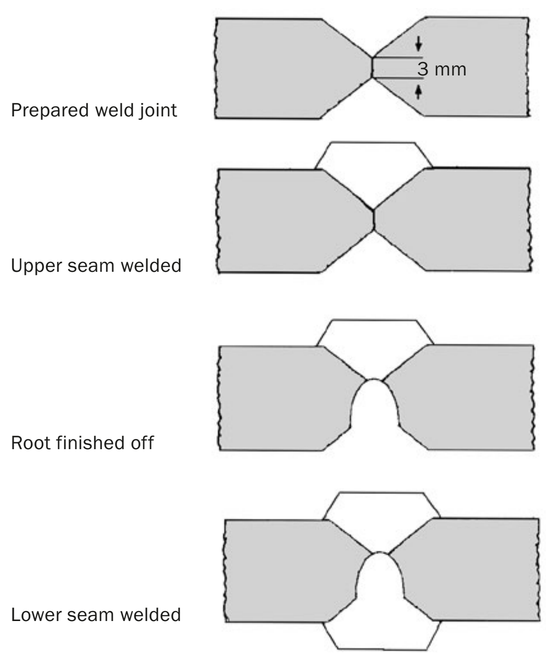
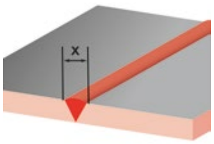
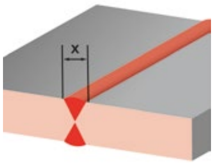
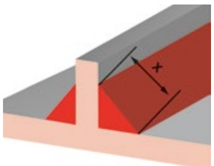
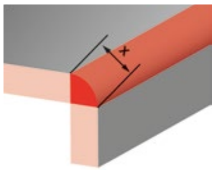
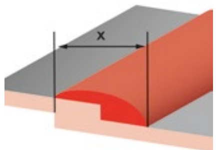
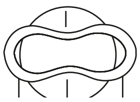
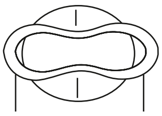
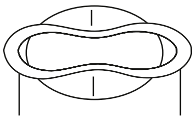
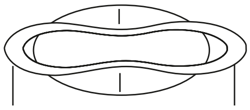


Figure 23: Butt joint weld with DV-seam – weld seam without gap

6.8 Variables enabling flawless weld seams

- Cleanliness of base material, filler material, prewarming air
- Melting point of the welding filler
- Melting point of the base material
- Hot-gas temperature
- Compound discharge of the welding extrudate
- Hot-gas flow
- Welding rate (forward feed)
- Welding pressure (contact pressure)

Table 6: Examples of the dimensional design of a welding nozzle and the cross-section of the air outlet aperture for welding operations up to 40 mm (DIN EN 13705, 2004)

Weld seam profile	V-profile	X-profile	T-profile	Angle profile	Overlap
					
X (mm) nozzle	up to 16	from 17 to 21	from 21 to 30	from 25 to 40	
					

Figures: © www.leister.com

7 Testing weld seam strength

7.1 Manual testing

DVS Guideline 2203-5: "This version of the technological bending test is a simple, orientational workshop test. On account of force required this method is limited to test specimen thicknesses of ≤ 10 mm. The test specimen is bent with the machined weld seam over a rounded web 6 mm thick with rapid application of force (see Figure 24) until fracture or to such an extent that the free ends of the specimen are making contact with the web."

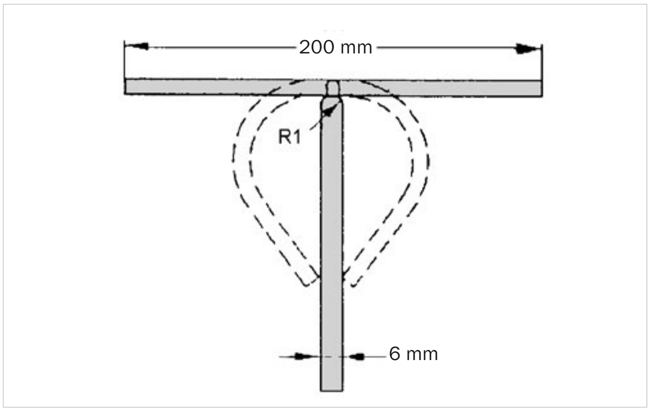


Figure 24: Illustration of mechanical testing

7.2 Weld factor (tensile test)
(DVS 2205-1 BB 6)

The weld factors determined in the tensile test provide information about the quality of a weld seam. The short-time factors apply to loading times of up to one hour. Consequently, only the long-time factors have to be used for component calculation.

Table 7: Weld factor

SIMONA® materials	Material names according to DVS	Hot-gas welding		Heated-tool butt welding		Extrusion welding	
		Short-time factor	Long-time factor	Short-time factor	Long-time factor	Short-time factor	Long-time factor
PE-HD/PE 100	PE-HD	0.8	0.4	0.9	0.8	0.8	0.6
PP-H AlphaPlus®/ PP-H	PP-H	0.8	0.4	0.9	0.8	0.8	0.6
PVC-CAW/ -MZ-COLOR/-GLAS	PVC-U	0.8	0.4	0.9	0.6	0.8	0.6
CPVC	PVC-C	0.7	0.4	0.8	0.6	–	–
PVDF	PVDF	0.8	0.4	0.9	0.6	–	–

The weld factor indicates the ratio of weld seam tensile strength to the tensile strength of the base material:

$$\frac{\text{Tensile strength of the weld seam}}{\text{Tensile strength of the base material}}$$

7.3 Technological bending test

(DVS 2203-5)

The technological bending test serves – in conjunction with other tests – to assess the quality of welding work. The bending angle and fracture micrograph indicate the deformability of the joint and hence the quality of the weld seam as executed. The creep of a welded joint can only be determined to a limited extent by the results of a bending test.

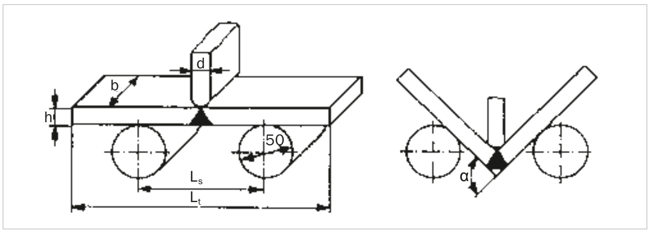


Figure 25: Illustration of the test conducted on a machine

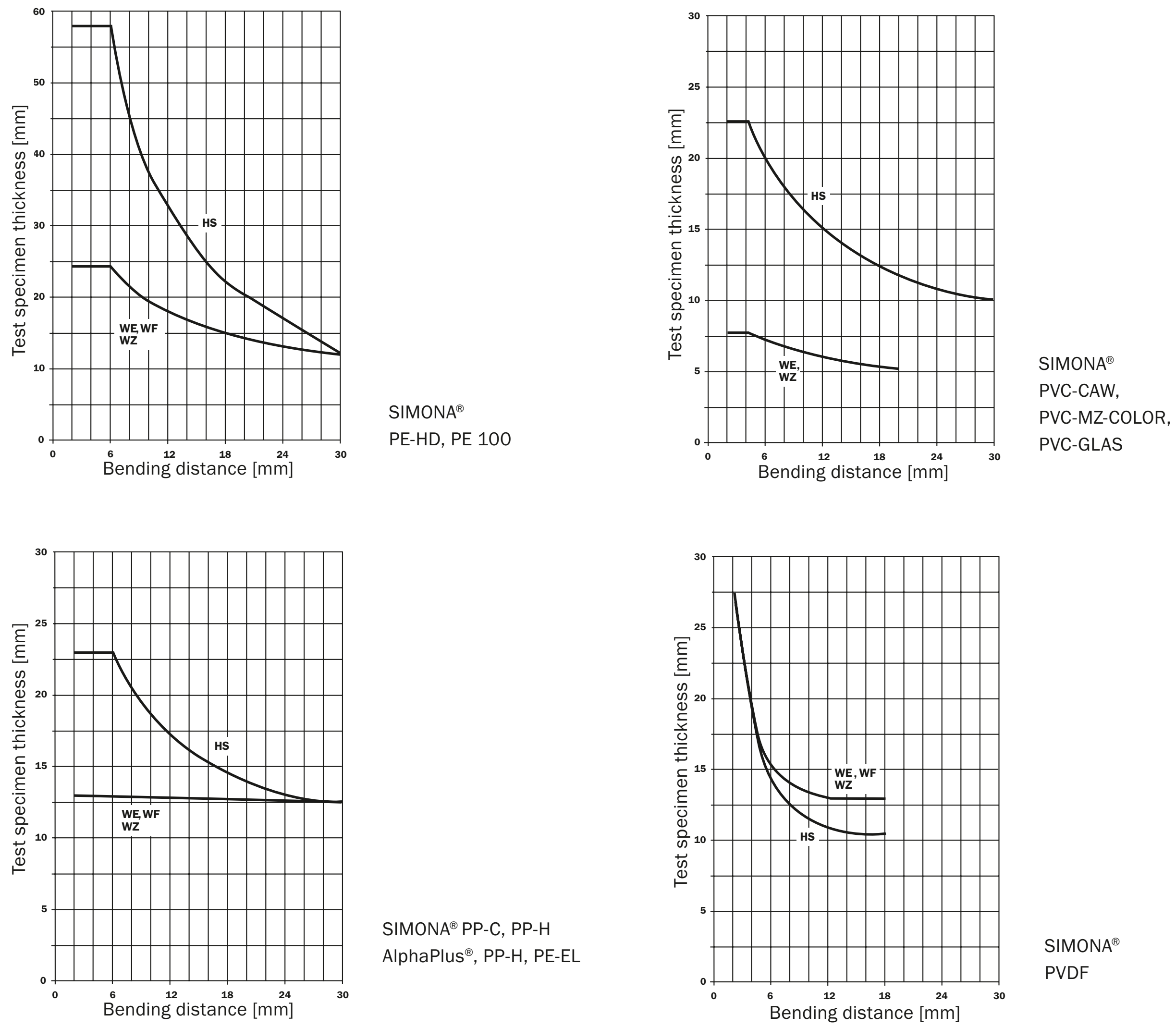
Table 8: Dimensions of the test specimens and the experimental setup (DVS 2203-5)

Test specimen				Experimental setup	
Thickness h Nominal dimension	**Width b**		**Minimum length L_t**	**Effective span L_s**	**Bending die thickness d**
	Pipe	Sheet			
mm	mm	mm	mm	mm	mm
3 < s ≤ 5	0.1 x d[①] Min.: 6 Max.: 30	20	150	80	4
5 < s ≤ 10		20	200	90	8
10 < s ≤ 15		20	200	100	12.5
15 < s ≤ 20		30	250	120	16
20 < s ≤ 30		30	300	160	25

[①] Nominal diameter

Table 9: Test velocity

Material	Test velocity
	mm/min
PE-HD	50
PP-H, -B	20
PP-R	50
PVC-U	10
PVDF	20
ECTFE	20



HS: Heated-tool butt welding
WF: Hot-gas fan welding
WZ: Hot-gas welding
WE: Hot-gas extrusion welding

Figure 26: Dependence of minimum bending distances for SIMONA® Semi-Finished Products on test specimen thickness

8 Welded joints

8.1 Structural strength of welded joints

Inner and outer notches and unfavourable wall thickness transitions result in a structural strength that under certain circumstances can be well below material strength. Welded joints always constitute an inhomogeneity. Since in most cases weld seams are not machined, there are also irregularities at the surface which reduce structural strength.

Figure 27 shows four different corner connections with different configurations. If the corner connections are subjected to a bending load, it is evident that right-angled corner connections are generally much less favourable than rounded corners with joins outside the fillet. Fillets always allow much more favourable flow of force and result in structural strength that is up to 10 times higher than that of conventional right-angled corner connections.

If a seam is welded on one side only, T-shaped connections have much less favourable behaviour than if a weld is provided on both sides (see Figure 28). Here too it is important that there are no notches on the tensile side of the part being subjected to the load. One favourable effect on the structural strength is that concave flits provide a certain amount of curvature and consequently have a positive influence on the flow of force.

Figure 29 shows connections that are being exposed to a tensile load. Tensile stresses and shear stresses development in the seam zone. A machined V-seam provides high structural strength because the flow of force is not hindered and the notch effect is minimised. In the case of simple butt strap joints there are not only thrust forces and tensile forces but also bending moments in the weld seam. Structural strength is very low because the flow of force is considerably hindered. By contrast, a double butt strap joint enables a favourable deflection of forces. The type of connection has a high level of structural strength. The same applies to cross connections.

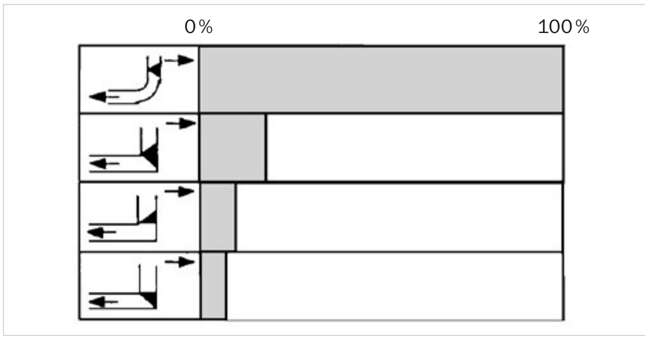


Figure 27: Angled welded joints

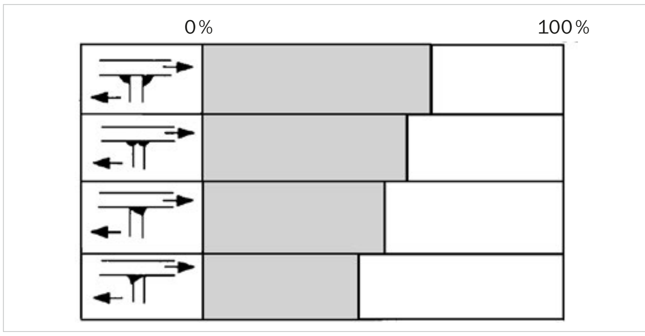


Figure 28: T-shaped welded joints

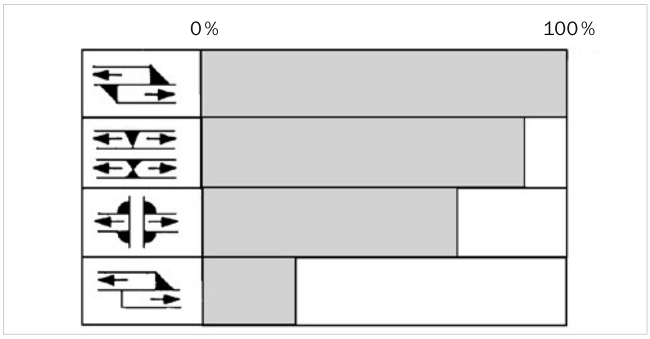


Figure 29: Flat welded joints

8.2 Position of weld seams

The following design examples must be seen in context and in addition to DVS 2205 Sheet 3.

In the case of load-bearing seams or fillet welds the weld seams must be sized in such a way that the required cross-sections are adequate to transmit forces. Butt joints are preferable. V-seams must be backed at the root.

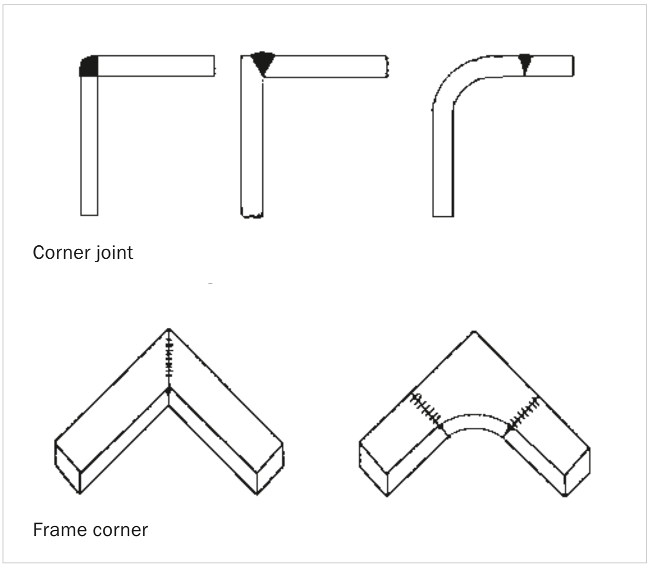


Figure 30: Examples of corner design

Transitions in the force characteristic are desirable in butt joints with different wall thicknesses.

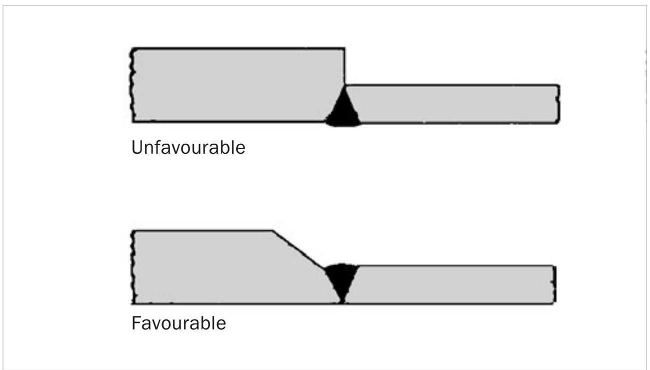


Figure 31: Examples of cross-section changes

Accumulations of weld seams should be avoided. Intersecting seams are not allowed.

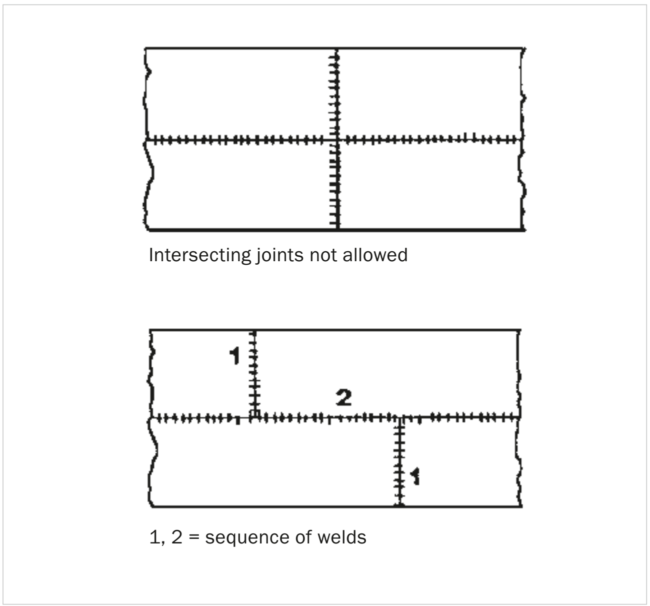


Figure 32: Examples of weld seam accumulations

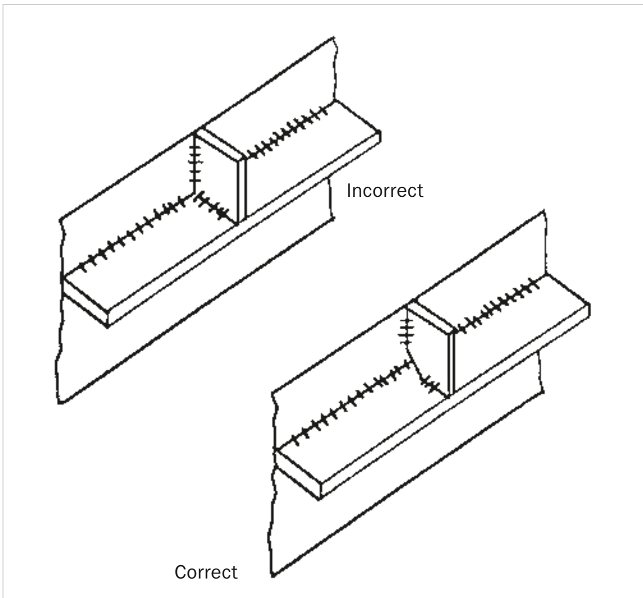


Figure 33: Connection of reinforcements

9 Standards and references

9.1 DVS Information sheets

2201	**–2**	07/1985	Testing semi-finished products made of thermoplastics – Suitability for welding – Test methods – Requirements
2202		08/2016	Evaluation of plastic joints connecting to pipework components and sheets – Characteristics, description, evaluation
2203			Testing of welded joints in sheets and pipes made of thermoplastics
	–1	01/2003	Test methods – Requirements
	–2	08/2010	Tensile test
	–3	04/2011	Tensile impact test
	–4	12/2021	Tensile creep test
	–5	08/1999	Technological bending test
2204	**–1**	01/2011	Gluing of thermoplastics
2205			Calculation of tanks and equipment made of thermoplastics
	–1	12/2021	Specifications
	–2	12/2021	Vertical, circular, pressureless tanks
	–3	04/1975	Welded joints
	–4	01/2020	Flange assemblies
	–5	07/1987	Rectangular tanks, design details
	–5 Supplement	10/1984	Rectangular tanks, design details
2206			Non-destructive testing of tanks, equipment and pipelines made of thermoplastics
	–1	09/2011	Dimensional and visual inspection
	–2	09/2015	Leak test
	–4	09/2011	Testing at high electrical voltage
	–5	09/2011	Angle measurement on electrofusion (HM) welded joints and heated-tool socket (HD) welded joints
2207			Welding of thermoplastics
	–1	08/2015	Heated-tool welding of pipes, pipework components and sheets made of PE-HD
	–3	12/2019	Hot-gas welding and hot-gas fan welding of pipes, pipework components and sheets – Methods, requirements
	–4	12/2019	Extrusion welding of pipes, pipework components and sheets – Methods, requirements
	–6	09/2003	Contactless heated-tool butt welding of pipes, pipework components and sheets – Methods, machines, parameters
	–11	05/2020	Electrofusion welding of pipes, pipework components and sheets made of PP
	–12	12/2006	Electrofusion welding of pipes, pipework components and sheets made of PVC-U
	–14	04/2009	Heated-tool fold welding of sheets made of PP and PE
	–15	12/2005	Electrofusion welding of pipes, pipework components and sheets made of PVDF
2208	**–1**	09/2019	Welding of thermoplastics – Machines and equipment for the heated-tool welding of pipes, pipework components and sheets
2210	**–1**	04/1997	Industrial piping made of thermoplastics – Design and execution – Above-ground pipe systems
2211		05/2021	Welding of thermoplastics – Welding fillers – Marking, requirements, tests
2212	**–1**	12/2015	Testing of plastic welders – Test groups I and II

DVS Information sheets can be obtained from: DVS Media GmbH, Aachener Str. 172, 40233 Düsseldorf, Germany

9.2 DIN Standards

DIN 1910 – 100	02/2008	Welding and allied processes
DIN EN 13705	09/2004	Welding of thermoplastics – Machines and equipment for hot gas welding (including hot gas extrusion welding)

DIN Standards can be obtained from: Beuth Verlag GmbH, Am DIN-Platz, Burggrafenstraße 6, 10787 Berlin, Germany

9.3 VDI Guidelines

VDI 2003	01/1976	Chip-forming machining of plastics

VDI Guidelines can be obtained from: Beuth Verlag GmbH, Am DIN-Platz, Burggrafenstraße 6, 10787 Berlin, Germany

9.4 KRV Guidelines

Gluing instructions for PVC pressure pipes

KRV Guidelines can be obtained from: Kunststoffrohrverband e.V., Gütegemeinschaft Kunststoffrohre e.V., Dyroffstr. 2, 53113 Bonn, Germany

9.5 References

References:

- Above standards and guidelines
- Hoechst brochure: „Umformen, Bearbeiten, Fügen“
- Hadick: Schweißen von Kunststoffen
- Taschenbuch DVS-Merkblätter und -Richtlinien, Fügen von Kunststoffen, Band 68/IV, 16. Auflage, 2016
- Figures 1, 2, 4, 5, 17, 18, 19 and figures in table 6:
- Leister Technologies AG
  Galileo-Strasse 10
  6056 Kägiswil
  Switzerland
  www.leister.com

10 Appendix

Depending on the machine and working conditions it may be necessary to vary the recommended figures indicated in the following tables, especially the warming times. It is always necessary to make and test work specimens.

Hot-gas string bead welding based on DVS 2207-3

Table 10: Recommended figures for hot-gas string bead welding of SIMONA® Sheets and Pipes

SIMONA® Materials	Material names according to DVS	**Air**	**Temperature**①	**Speed**②	**Welding force**	
				cm/min	N	
				with high-speed welding nozzle Ø	**with welding rod Ø**	
		l/min	°C	3 - 4 mm	3 mm	4 mm
PE						
PE-HD, PE 100, PE-EL	PE-HD	45 – 60	300 – 340	25 – 35	15 – 20	25 – 35
PE FOAM		40 – 60	320 – 340	< 50	–	–
PE 500	PE 500	40 – 60	270 – 300	< 25	–	–
PP						
PP-H AlphaPlus®, PP-H, PP-C, PP-EL	PP-H/PP-B	45 – 60	300 – 340	25 – 35	15 – 20	25 – 35
PP FOAM		50 – 60	300 – 340	< 50	–	–
PPs		50 – 60	300 – 320	< 50	–	–
PVC						
PVC-MZ-COLOR	PVC-U	45 – 55	350 – 370	< 50	15 – 20	25 – 35
PVC-GLAS	PVC-U	45 – 55	350 – 370	< 60	15 – 20	25 – 35
PVC-CAW	PVC-U	45 – 60	350 – 370	25 – 35	15 – 20	25 – 35
CPVC	PVC-C	45 – 60	370 – 390	18 – 22	20 – 25	30 – 35
COPLAST-AS		45 – 50	340 – 360	< 100	15 – 20	25 – 35
SIMOPOR		45 – 50	340 – 360	< 100	15 – 20	25 – 35
PETG						
SIMOLUX	PET-G	45 – 50	300 – 320	< 50	15 – 20	25 – 35
Fluoroplastics						
PVDF	PVDF	45 – 60	365 – 385	20 – 25	20 – 25	30 – 35
ECTFE	ECTFE	50 – 60	380 – 420	22 – 25	10 – 15	15 – 25
ETFE	ETFE	50 – 60	420 – 460	–	–	–
FEP	FEP	50 – 60	400 – 460	7 – 9	10 – 15	15 – 25
PFA	PFA	50 – 60	420 – 480	6 – 8	10 – 15	15 – 25

① Measured 5 mm inside the nozzle, at the centre of the nozzle outlet aperture.
② Depending on welding filler diameter, welding temperature and weld joint geometry.

Heated-tool butt welding based on DVS 2207-1

Table 11: Recommended figures for heated-tool butt welding of sheets made of SIMONA® PE-HD / PE 100 / PE-EL

Sheet thickness	Temperature[1]	Adaptation[2] p ≈ 0.15 MPa	Warming p ≈ 0.01 MPa	Change-over	Joining p ≈ 0.15 MPa	
		Bead height	Time	Max. time[3]	Time to full pressure build-up	Cooling time at joining pressure
mm	°C	mm	s	s	s	min
3	220	0.5	30	< 3	3.0	6.0
4	220	0.5	40	< 3	4.0	6.0
5	215	1.0	50	< 3	5.0	7.0
6	215	1.0	60	< 3	5.5	8.5
8	215	1.5	80	< 3	6.5	11.0
10	215	1.5	100	< 3	7.0	12.5
12	210	2.0	120	< 3	8.0	16.0
15	210	2.0	150	< 3	8.5	19.5
20	205	2.0	200	< 3	10.5	25.0
25	205	2.5	250	< 3	11.5	31.0
30	200	2.5	300	< 3	13.5	36.5
35	200	3.0	350	< 3	15.5	42.5
40	200	3.5	400	< 3	17.0	48.5
50	200	3.5	500	< 3	25.0	60.0
60	200	4.0	600	< 3	30.0	70.0
70	200	4.0	700	< 3	35.0	80.0

[1] In the case of PE 100 a constant heated tool temperature of 220 °C is recommended for all wall thicknesses.
[2] Bead height on the heated tool at the end of adaptation time (adaptation at 0.15 MPa)
[3] Change-over time must be kept as short as possible or else the plasticised surfaces will become cold.

Heated-tool butt welding based on DVS 2207-1

Table 12: Recommended figures for heated-tool butt welding of sheets made of SIMONA® PE 500

Sheet thickness	Temperature	Adaptation[1] p ≈ 0.15 – 0.30 MPa	Warming p ≈ 0.01 MPa	Change-over	Joining p ≈ 10.00 MPa	
		Bead height	Time	Max. time[2]	Time to full pressure build-up	Cooling time at joining pressure
mm	°C	mm	s	s	s	min
3	210	0.5	60	< 3	< 10	4.5
4	210	0.5	80	< 3	< 10	6
5	210	1.0	100	< 3	< 10	7.5
6	210	1.0	120	< 3	< 10	9
8	210	1.5	160	< 3	< 10	12
10	210	1.5	200	< 3	< 10	15
12	205	2.0	240	< 3	< 10	18
15	205	2.0	300	< 3	< 10	22.5
20	205	2.0	400	< 3	< 10	30
25	205	2.5	625	< 3	< 10	37.5
30	205	2.5	750	< 3	< 10	45

[1] Bead height on the heated tool at the end of adaptation time (adaptation at p = 0.15 – 0.30 MPa)
[2] Change-over time must be kept as short as possible or else the plasticised surfaces will become cold.

There is no guideline concerning the welding of high-molecular weight materials. However, good results are achieved with the figures indicated above.

Table 13: Recommended figures for heated-tool butt welding of sheets made of SIMONA® PE FOAM

Sheet thickness	Temperature	Adaptation[1] p ≈ 0.30 MPa	Warming p ≈ 0.01 MPa	Change-over	Joining p ≈ 0.30 MPa	
		Bead height	Time	Max. time[2]	Time to full pressure build-up	Cooling time at joining pressure
mm	°C	mm	s	s	s	min
6	215	1.0	60	< 3	5.5	8.5
8	215	1.5	80	< 3	6.5	11.0
10	215	1.5	100	< 3	7.0	12.5
12	210	2.0	120	< 3	8.0	16.0
15	210	2.0	150	< 3	8.5	19.5
20	205	2.0	200	< 3	10.5	25.0

[1] Bead height on the heated tool at the end of adaptation time (adaptation at 0.30 MPa)
[2] Change-over time must be kept as short as possible or else the plasticised surfaces will become cold.

Heated-tool butt welding based on DVS 2207-11

Table 14: Recommended figures for heated-tool butt welding of sheets made of SIMONA® PP-H AlphaPlus®/ PP-H /PP-C / PP-EL / PPs

Sheet thickness	Temperature	Adaptation[1] p ≈ 0.10 MPa	Warming p ≤ 0.01 MPa	Change-over	Joining p ≈ 0.10 ± 0.01 MPa	
		Bead height	Time	Max. time[2]	Time to full pressure build-up	Cooling time at joining pressure
mm	°C	mm	s	s	s	min
3	200 – 220	0.5	105	< 3	5	6
4	200 – 220	0.5	130	< 3	5	6
5	200 – 220	0.5	145	< 3	5 – 6	6 – 12
6	200 – 220	0.5	160	< 3	5 – 6	6 – 12
8	200 – 220	1.0	190	< 3	6 – 8	12 – 20
10	200 – 220	1.0	215	< 3	6 – 8	12 – 20
12	200 – 220	1.0	245	< 3	8 – 11	20 – 30
15	200 – 220	1.0	280	< 3	8 – 11	20 – 30
20	200 – 220	1.5	340	< 3	11 – 14	30 – 40
25	200 – 220	1.5	390	< 3	11 – 14	30 – 40
30	200 – 220	1.5	430	< 3	14 – 19	40 – 55
35	200 – 220	2.0	470	< 3	14 – 19	40 – 55
40	200 – 220	2.0	505	< 3	19 – 25	55 – 70
50	200 – 220	2.5	560	< 3	25 – 32	55 – 70

[1] Bead height on the heated tool at the end of adaptation time (adaptation at 0.10 MPa)
[2] Change-over time must be kept as short as possible or else the plasticised surfaces will become cold.

Table 15: Recommended figures for heated-tool butt welding of sheets made of SIMONA® PP FOAM

Sheet thickness	Temperature	Adaptation[1] p ≈ 0.20 MPa	Warming p ≈ 0.01 MPa	Change-over	Joining p ≈ 0.20 ± 0.01 MPa	
		Bead height	Time	Max. time[2]	Time to full pressure build-up	Cooling time at joining pressure
mm	°C	mm	s	s	s	min
6	215	0.5	160	< 3	5 – 6	6 – 12
8	215	1.0	190	< 3	6 – 8	12 – 20
10	215	1.0	215	< 3	6 – 8	12 – 20
12	210	1.0	245	< 3	8 – 11	20 – 30
15	210	1.0	280	< 3	8 – 11	20 – 30
20	205	1.5	340	< 3	11 – 14	30 – 40

[1] Bead height on the heated tool at the end of adaptation time (adaptation at 0.20 MPa)
[2] Change-over time must be kept as short as possible or else the plasticised surfaces will become cold.

Heated-tool butt welding based on DVS 2207-12 (as at 2023)

Table 16: Recommended figures for heated-tool butt welding of sheets made of SIMONA® PVC-CAW / PVC-MZ-COLOR / PVC-GLAS at an outside temperature of 20 °C and with moderate air movement

Sheet thickness	Temperature	Adaptation[1] p = 0.50 MPa	Warming p ≈ 0.01 MPa	Change-over	Joining p ≈ 0.50 MPa	
		Bead height	Time	Max. time[2]	Time to full pressure build-up	Cooling time at joining pressure
mm	°C	mm	s	s	s	min
1.9	222 – 238	0.5	28.5	≤ 2	2	4
3	222 – 238	0.5	45	≤ 2	3	6
4	222 – 238	0.5	60	≤ 2	3	8
6	222 – 238	1.0	90	≤ 2	4	12
8	222 – 238	1.0	120	≤ 2	5	16
10	222 – 238	1.0	150	≤ 2	6	20
12	222 – 238	1.5	180	≤ 2	7	24
15	222 – 238	1.5	225	≤ 2	9	30
20	222 – 238	1.5	300	≤ 2	11	40
25	222 – 238	1.5	375	≤ 2	14	50

[1] Bead height on the heated tool at the end of adaptation time (adaptation at 0.60 MPa)
[2] Change-over time must be kept as short as possible or else the plasticised surfaces will become cold.

Heated-tool butt welding to DVS 2207-13

Table 17: Recommended figures for heated-tool butt welding of sheets made of SIMONA® CPVC

Sheet thickness	Temperature	Adaptation[1] p = 0.50 ± 0.01 MPa	Warming p = 0.01 MPa	Change-over	Joining p = 0.50 ± 0.01 MPa	
		Bead height	Time	Max. time[2]	Time to full pressure build-up	Cooling time at joining pressure
mm	°C	mm	s	s	s	min
2	see Fig. 34	0.5	28	≤ 2	4	4
3	see Fig. 34	0.5	42	≤ 2	4	6
4	see Fig. 34	0.5	56	≤ 2	4	8
6	see Fig. 34	1.0	86	≤ 2	4	12
8	see Fig. 34	1.0	122	≤ 2	4	16
10	see Fig. 34	1.0	168	≤ 2	4	20
12	see Fig. 34	1.5	222	≤ 2	4	24
15	see Fig. 34	1.5	294	≤ 2	4	30
20	see Fig. 34	1.5	392	≤ 2	4	40
25	see Fig. 34	1.5	490	≤ 2	4	50

[1] Bead height on the heated tool at the end of adaptation time (adaptation at p = 0.50 ± 0.01 MPa)
[2] Change-over time must be kept as short as possible or else the plasticised surfaces will become cold.

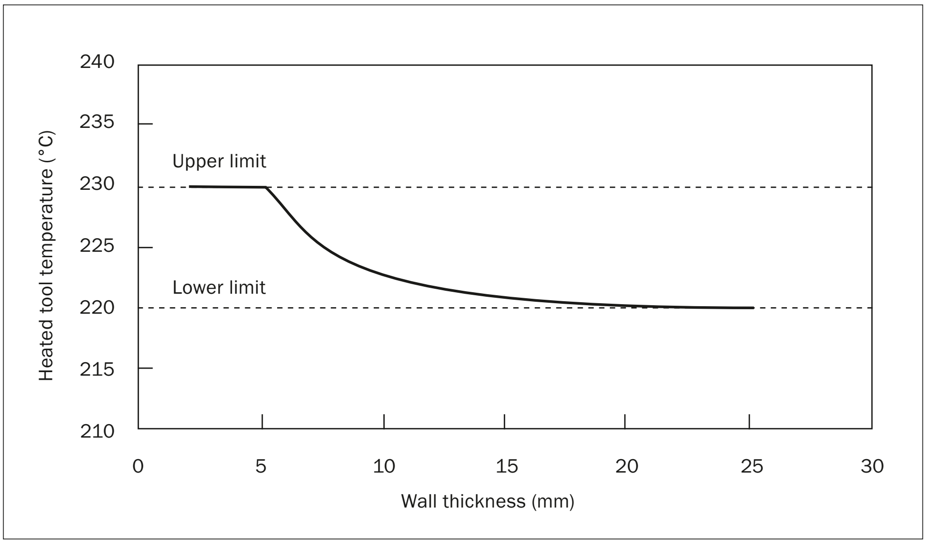


Figure 34: Heated tool temperatures as a function of wall thickness

Heated-tool butt welding

Table 18: Recommended figures for heated-tool butt welding of sheets made of SIMOLUX

Sheet thickness	Temperature	Adaptation① p ≈ 0.10 ± 0.01 MPa	Warming p ≈ 0.01 MPa	Change-over	Joining p ≈ 0.10 ± 0.01 MPa	
		Bead height	Time	Max. time②	Time to full pressure build-up	Cooling time at joining pressure
mm	°C	mm	s	s	s	min
2	210	0.5	30	< 2	4	3
3	210	0.5	40	< 2	4	4.5

SIMOLUX sheets do not normally have to be predried.

① Bead height on the heated tool at the end of adaptation time (adaptation at p = 0.10 ± 0.01 MPa)
② Change-over time must be kept as short as possible or else the plasticised surfaces will become cold.

Table 19: Recommended figures for heated-tool butt welding of sheets made of SIMONA® ECTFE

Sheet thickness	Temperature	Adaptation① p ≈ 0.30 MPa	Warming p ≤ 0.01 MPa	Change-over	Joining p ≈ 0.15 MPa	
		Bead height	Time	Max. time②	Time to full pressure build-up	Cooling time at joining pressure
mm	°C	mm	s	s	s	min
2.3	260 – 270	> 0.5	35	< 3	3	~ 5
3	260 – 270	> 0.5	45	< 3	4	~ 6
4	260 – 270	> 0.5	60	< 3	5	~ 8
5	260 – 270	> 0.5	75	< 3	6	~ 10

① Bead height on the heated tool at the end of adaptation time (adaptation at 0.30 MPa)
② Change-over time must be kept as short as possible or else the plasticised surfaces will become cold.

Important! The heated tools of the familiar butt welding machines have a temperature limit of 250 °C. Please contact the manufacturers of the machines.

Table 20: Recommended figures for heated-tool butt welding of sheets made of SIMONA® PFA

Sheet thickness	Temperature	Adaptation① p ≈ 0.10 ± 0.01 MPa	Warming p ≈ 0.01 MPa	Change-over	Joining p ≈ 0.10 ± 0.01 MPa	
		Bead height	Time	Max. time②	Time to full pressure build-up	Cooling time at joining pressure
mm	°C	mm	s	s	s	min
2.8	500	0.5	245	< 2	4	6

① Bead height on the heated tool at the end of adaptation time (adaptation at 0.10 MPa)
② Change-over time must be kept as short as possible or else the plasticised surfaces will become cold.

Heated-tool butt welding to DVS 2207-15

Table 21: Recommended figures for heated-tool butt welding of sheets made of SIMONA® PVDF

Sheet thickness	Temperature	Adaptation[1] p = 0.10 MPa	Warming p ≤ 0.01 MPa	Change-over	Joining p = 0.10 MPa	
		Bead height	Time	Max. time[2]	Time to full pressure build-up	Cooling time at joining pressure
mm	°C	mm	s	s	s	min
3	245	0.5	70	< 3	3.5	5.5
4	245	0.5	80	< 3	4.0	7.0
5	245	0.5	90	< 3	4.5	8.0
6	240	0.5	100	< 3	5.0	9.0
8	240	1.0	120	< 3	5.5	11.5
10	240	1.0	140	< 3	6.5	14.0
12	235	1.0	160	< 3	7.5	16.5
15	235	1.3	190	< 3	8.5	20.0
20	235	1.7	240	< 3	10.5	26.0
25	235	2.0	290	< 3	13.0	32.0
30	235	2.0	340	< 3	13.0	40.0
40	235	2.0	440	< 3	13.0	50.0
50	235	2.0	540	< 3	13.0	60.0

[1] Bead height on the heated tool at the end of adaptation time (adaptation at 0.10 MPa)
[2] Change-over time must be kept as short as possible or else the plasticised surfaces will become cold.

Contactless heated-tool butt welding of PVDF is subject to DVS Guideline 2207-6: Welding of thermoplastics – Contactless heated-tool butt welding of pipes, pipework components and sheets – Processes, machines, parameters.

Extrusion welding to DVS 2207-4

Table 22: Recommended figures for extrusion welding of SIMONA® Sheets

SIMONA® Materials	Material names according to DVS	Temperature of extrudate measured at the nozzle outlet	Air temperature measured in the hot air nozzle	Air flow (cold air intake)
		°C	°C	l/min
PE-HD	PE-HD	210 – 230	250 – 300	150 – 400
PE 100	PE-HD	210 – 230	250 – 300	150 – 400
PE FOAM		210 – 230	250 – 300	150 – 400
PP-H AlphaPlus®/ P-H / PP-C / PP-R	PP-H / PP-B / PP-R	210 – 240	250 – 300	150 – 400
PP FOAM		210 – 240	250 – 300	150 – 400
PVC-CAW	PVC-U	190 – 200	330 – 360	150 – 400
CPVC	PVC-C	195 – 210	300 – 360	150 – 400
PVDF	PVDF	240 – 260	280 – 350	150 – 400
ECTFE	ECTFE	270 – 300	340 – 380	150 – 400

Heated-tool butt welding to DVS 2207-1 (as at 2023)

Table 23: Recommended figures for heated-tool butt welding of pipes made of SIMONA® PE 80 / PE 100 / PE 100 RC

Wall thickness	Adaptation① p = 0.15 MPa	Warming p = 0.01 MPa	Change-over	Joining p = 0.15 MPa	
	Bead height	Time	Max. time②	Time to full pressure build-up	Cooling time at joining pressure (minimum figure③)
mm	mm	s	s	s	min
to 4.5	0.5	45	5	5	6
4.5 – 7	1.0	45 – 70	5 – 6	5 – 6	6 – 10
7 – 12	1.5	70 – 120	6 – 8	6 – 8	10 – 16
12 – 19	2.0	120 – 190	8 – 10	8 – 11	16 – 24
19 – 26	2.5	190 – 260	10 – 12	11 – 14	24 – 32
26 – 37	3.0	260 – 370	12 – 16	14 – 19	32 – 45
37 – 50	3.5	370 – 500	370 – 500	19 – 25	23 – 31
50 – 70	4.0	500 – 700	500 – 700	25 – 35	31 – 43
70 – 90	4.5	700 – 900	700 – 900	35	43 – 55
90 – 110	5.0	900 – 1100	900 – 1100	35	55 – 67
110 – 130	5.5	1100 – 1300	1100 – 1300	35	67 – 79

Heated tool temperature is 200 – 220 °C.
In the case of PE 100 a constant heated tool temperature of 220 °C is recommended for all wall thicknesses.

① Bead height on the heated tool at the end of adaptation time (adaptation at 0.15 MPa)
② Change-over time must be kept as short as possible or else the plasticised surfaces will become cold.
③ Depending on ambient temperature (e.g. in the workshop) different cooling times may apply (see DVS Guideline).

Cooling time of pipes and pipework components

Table 24: Cooling times of pipes and pipework components made of SIMONA® PE 80 / PE 100 / PE 100 RC depending on ambient temperature or under special conditions

Pipe wall thickness	Cooling times in relation to ambient temperature (minimum figures)			Cooling times under special conditions①
mm	min			min
	bis 15 °C	15 °C – 25 °C	25 °C – 40 °C	
bis 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
70 – 90	50 – 64	64 – 82	85 – 109	43 – 55
90 – 110	64 – 78	82 – 100	109 – 133	55 – 67
110 – 130	78 – 92	100 – 118	133 – 157	67 – 79

① Cooling times apply under the following conditions:
- the joint is made in a workshop and
- removal from the welding machine and temporary storage up to the end of cooling time as per table only subject the joint to minimal strain

Heated-tool butt welding to DVS 2207-11 (as at 2023)

Table 25: Recommended figures for heated-tool butt welding of pipes and sheets made of SIMONA® PP-H AlphaPlus® / PP-H / PP-C / PP-R up to 40 °C and with moderate air movement

Wall thickness	Adaptation[1] p = 0.10 MPa	Warming p ≤ 0.01 MPa	Change-over	Joining p = 0.10 ± 0.01 MPa	
	Bead height	Time	Max. time[2]	Time to full pressure build-up	Cooling time at joining pressure (minimum figure[3])
mm	mm	s	s	s	min
to 4.5	0.5	to 53	5	6	6
4.5 – 7	0.5	53 – 81	5 – 6	6 – 7	6.5 – 9.5
7 – 12	1.0	81 – 135	6 – 7	7 – 11	9.5 – 15.5
12 – 19	1.0	135 – 206	7 – 9	11 – 17	15.5 – 24
19 – 26	1.5	206 – 271	9 – 11	17 – 22	24 – 32
26 – 37	2.0	271 – 362	11 – 14	22 – 32	32 – 45
37 – 50	2.5	362 – 450	14 – 17	32 – 43	45 – 61
50 – 70	3	450 – 546	17 – 22	43	61 – 85

Heated tool temperature is 210 ± 10 °C.

[1] Bead height on the heated tool at the end of adaptation time (adaptation at 0.10 MPa)
[2] Change-over time must be kept as short as possible or else the plasticised surfaces will become cold.
[3] Cooling times apply under the following conditions:
- the joint is made in a workshop and
- removal from the welding machine and temporary storage up to the end of cooling time as per table only subject the joint to minimal strain

Table 26: Cooling times of pipes and pipework components made of SIMONA® PP-H AlphaPlus® / PP-H / PP-C / PP-R depending on ambient temperature or under special conditions

Pipe wall thickness	Cooling times in relation to ambient temperature (minimum figures)			Cooling times under special conditions[1]
mm	min			min
	to 15 °C	15 °C – 25 °C	25 °C – 40 °C	
bis 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

[1] Cooling times apply under the following conditions:
- the joint is made in a workshop and
- removal from the welding machine and temporary storage up to the end of cooling time as per table only subject the joint to minimal strain

Heated-tool butt welding to DVS 2207-15 (as at 2023)

Table 27: Recommended figures for heated-tool butt welding of pipes and sheets made of SIMONA® PVDF at an outside temperature of approx. 20 °C and with moderate air movement

Wall thickness	Adaptation① p = 0.10 MPa	Warming p ≤ 0.01 MPa	Change-over	Joining p = 0.10 MPa	
	Bead height	Time	Max. time②	Time to full pressure build-up	Cooling time at joining pressure (minimum figure③)
mm	mm	s	s	s	min
1.9 – 3.5	0.5	59 – 75	3	3 – 4	5 – 6
3.5 – 5.5	0.5	75 – 95	3	4 – 5	6 – 8.5
5.5 – 10.0	0.5 – 1.0	95 – 140	4	5 – 7	8.5 – 14
10.0 – 15.0	1.0 – 1.3	140 – 190	4	7 – 9	14 – 19
15.0 – 20.0	1.3 – 1.7	190 – 240	5	9 – 11	19 – 25
20.0 – 25.0	1.7 – 2.0	240 – 290	5	11 – 13	25 – 32

Heated tool temperature is 240 ± 8 °C.

① Bead height on the heated tool at the end of adaptation time (adaptation at 0.10 MPa)
② Change-over time must be kept as short as possible or else the plasticised surfaces will become cold.
③ Cooling times apply under the following conditions:

- the joint is made in a workshop and
- removal from the welding machine and temporary storage up to the end of cooling time as per table only subject the joint to minimal strain

Heated-tool socket welding to DVS 2207-1 (as at 2023)

Table 28: Recommended figures for heated-tool socket welding of pipes and fittings made of SIMONA® PE-HD / PE 100 / PE 100 RC at an outside temperature of 20 °C and with moderate air movement

Pipe diameter	Warming		Change-over	Cooling①	
d	Time		Max. time	Min. time	
	SDR 11	SDR 17			
				Fixed	Total
mm	s	s	s	s	min
16	5	②	4	6	2
20	5	②	4	6	2
25	7	②	4	10	2
32	8	②	6	10	4
40	12	②	6	20	4
50	18	②	6	20	4
63	24	②	8	30	6
75	30	18	8	30	6
90	40	26	8	40	6
110	50	36	10	50	8
125	60	46	10	60	8

Heated tool temperature is 260 ± 10 °C.

① In manual welding the joined parts must be held tightly / fixed in accordance with the time indicated in the „Fixed“ column. The joint may be subjected to loading by the other laying operations only when the cooling time has elapsed (see „Total“ column).
② Not to be recommended because wall thickness is inadequate.

Heated-tool socket welding to DVS 2207-11 (as at 2023)

Table 29: Recommended figures for heated-tool socket welding of pipes and fittings made of SIMONA® PP-H AlphaPlus® / PP-H / PP-R at an outside temperature of 20 °C and with moderate air movement

Pipe diameter	Warming		Change-over	Cooling[1]	
d	Time		Max. time	Min. time	
	SDR 11	SDR 17			
				Fixed	Total
mm	s	s	s	s	min
16	5	[2]	4	6	2
20	5	[2]	4	6	2
25	7	[2]	4	10	2
32	8	[2]	6	10	4
40	12	[2]	6	20	4
50	18	[2]	6	20	4
63	24	10	8	30	6
75	30	15	8	30	6
90	40	22	8	40	6
110	50	30	10	50	8
125	60	35	10	60	8

Heated tool temperature is 260 ± 10 °C.

[1] In manual welding the joined parts must be held tightly / fixed in accordance with the time indicated in the „Fixed“ column. The joint may be subjected to loading by the other laying operations only when the cooling time has elapsed (see „Total“ column).
[2] Not to be recommended because wall thickness is inadequate.

Heated-tool socket welding to DVS 2207-15 (as at 2023)

Table 30: Recommended figures for heated-tool socket welding of pipes and sheets made of SIMONA® PVDF at an outside temperature of 20 °C and with moderate air movement

Pipe diameter	Pipe wall thickness	Warming	Change-over	Cooling[1]	
d		Time	Max. time	Min. time	
				Fixed	Total
mm	mm	s	s	s	min
16	1.5	4	4	6	2
20	1.9	6	4	6	2
25	1.9	8	4	6	2
32	2.4	10	4	12	4
40	2.4	12	4	12	4
50	3.0	18	4	12	4
63	3.0	20	6	18	6
75	3.0	22	6	18	6
90	3.0	25	6	18	6
110	3.0	30	6	24	8

Heated tool temperature is 260 ± 10 °C.

[1] In manual welding the joined parts must be held tightly / fixed in accordance with the time indicated in the „Fixed“ column. The joint may be subjected to loading by the other laying operations only when the cooling time has elapsed (see „Total“ column).

Welding record – Hot-gas welding and hot-gas fan welding of sheets and pipes to DVS 2207-3

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Project designation:

Project no.:

Drawing no.:

Welder:

Welding supervisor[1]**:**

Welding certificate no. (valid until, issued by):

Base material (manufacturer, type, batch, date):

Welding filler (manufacturer, batch, date):

Welding machines, make, type:

Nozzle(s):

Date	**Design detail**	**Weld seam no.**	**Joined part thickness** mm	**Weld seam type** (symbol)	**Method** WF/WZ	**Air flow** l/min

Hot gas temperature[2] °C	**Welding speed** cm/min	**Ambient temperature** °C	**Semi-finished product temperature** °C	**Weather** (code no.)	**Protective measures** (code no.)	**Visual assessment**

[1] Plastics welding specialist to DVS 2213
[2] Measured at the centre of the nozzle outlet aperture, 5 mm inside the nozzle

Weather
1 = sunny, 2 = dry, 3 = precipitation, 4 = wind

Protective measures
1 = none, 2 = umbrella, 3 = tent, 4 = heater

Remarks, e.g. difficult conditions:

Date / welder's signature

Date / welding supervisor's signature

SIMONA

Welding record – Heated-tool butt welding of sheets to DVS 2207-1

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www.simona.de

Title of the order: 　　**No. of the order:**

Owner: 　　**Contractor:**

Welder: 　　**ID:**

Welding supervisor's name and company:

Material:

Welding machine (make, type, serial no., year of manufacture):

Seam no.	Date	Sheet thickness mm	Measured heated tool temperature[1)] °C		Set points[2)]		
			Minimum	Maximum	Adaptation[3)] bar / kp	Warming[3)] bar / kp	Joining[3)] bar / kp

Warming time[4)] s	Change-over time[4)] s	Joining pressure build-up time[4)] s	Cooling time at joining pressure[3)] min	Ambient temperature °C

[1)] From control interval, frequency as per 4.1.2
[2)] According to the welding machine manufacturer's specifications or from a machine test plus movement pressure or force
[3)] Delete what is inapplicable
[4)] The measured values have to be entered

Remarks, e. g. difficult conditions:

Date / welder's signature

Date / welding supervisor's signature

SIMONA

Welding record – Heated-tool butt welding of pipes and pipework components to DVS 2207

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Title of the order: ______ **No. of the order:** ______

Owner: ______ **Contractor:** ______

Welder: ______ **ID:** ______

Welding supervisor's name and company: ______

Material: ______

Welding machine (make, type, serial no., year of manufacture): ______

☐ **Laid above ground** ☐ **Buried**

Seam no.	**Date**	**Pipe size** Ø d x s	**Measured heated tool temperature**[1] °C		**Movement pressure**	**Joining pressure** (machine table)	**Setpoints**[2]		
		mm	Minimum	Maximum	bar	bar	Adaptation bar	Warming bar	Joining bar

Warming time[3] s	**Joining pressure build-up time**[3] s	**Change-over time**[3] s	**Cooling time at joining pressure**[3] s	**Ambient temperature** °C	**Weather** (code no.)	**Protective measures** (code no.)

[1] From control interval, frequency as per 4.1.2
[2] According to the welding machine manufacturer's specifications or from a machine test plus movement pressure or force
[3] The measured values have to be entered

Weather
1 = sunny, 2 = dry, 3 = precipitation, 4 = wind

Protective measures
1 = none, 2 = umbrella, 3 = tent, 4 = heater

Remarks, e. g. difficult conditions:

______

Date / welder's signature

Date / welding supervisor's signature

SIMONA

Welding record – Extrusion welding of sheets and pipes to DVS 2207-4

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Project designation:

Project no.: **Drawing no.:**

Welder: **Welding supervisor[1]:**

Welding certificate no. (valid until, issued by):

Base material (manufacturer, type, batch, date):

Welding filler (manufacturer, batch, date):

Welding machine (make, type):

Year of manufacture / last machine inspection: **Method variant acc. to DVS 2207-4:**

Date	**Weld seam no.**	**Joined part thickness** mm	**Weld seam type** (symbol)	**Welding shoe no.**	**Air flow** l/min	**Mass temperature[2]** °C

Hot gas temperature[3] °C	**Welding speed** cm/min	**Ambient temperature** °C	**Semi-finished product temperature** °C	**Weather** (code no.)	**Protective measures** (code no.)

[1] Plastics welding specialist to DVS 2213
[2] Measured with an insertion thermometer at the extrudate outlet of the welding machine / of the welding unit
[3] Measured at the centre of the nozzle outlet aperture, 5 mm inside the nozzle

Weather
1 = sunny, 2 = dry, 3 = precipitation, 4 = wind

Protective measures
1 = none, 2 = umbrella, 3 = tent, 4 = heater

Remarks, e.g. difficult conditions:

Date / welder's signature

Date / welding supervisor's signature

SIMONA

Welding record – Electrofusion welding of pipework components to DVS 2207-1

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Title of the order: **No. of the order:**

Owner: **Contractor:**

Welder: **ID:**

Welding supervisor's name and company:

Material:

Welding machine (make, type, serial no., year of manufacture):

☐ **Laid above ground** ☐ **Buried**

Seam no.	**Date**	**Pipe size** Ø d x s mm	**Fitting data**			**Device setting**	
			A[1]	B[2]	Serial no.	manual	automatic

Fitting resistance[3] Ohm	**Secondary voltage**[3] Volt	**Welding times**		**Ambient temperature** °C	**Weather** (code no.)	**Protective measures** (code no.)	**Operating mode**	
		Heating s	Cooling min				Mains	Generator

[1] A = manufacturer's abbreviation (e. g. Friatec = F, Plasson = PL, Georg Fischer = GF)
[2] B = fitting code (1 = socket, 2 = angle, 3 = tee, 4 = reducer, 5 = saddle, 6 = cap, 7 = transition fitting)
[3] Entry as required depending on the system used
[4] The measured values have to be entered

Weather
1 = sunny, 2 = dry, 3 = precipitation, 4 = wind

Protective measures
1 = none, 2 = umbrella, 3 = tent, 4 = heater

Date / welder's signature

Date / welding supervisor's signature

Overview of welding equipment manufacturers

Manufacturer	Hot-gas string bead welding (WZ)	Hot-gas extrusion welding (WE)	Hot-air blowers and heated tools	Heated-tool butt welding of sheets	
Dohle Extrusionstechnik GmbH Eitorferstr. 1 D-53809 Ruppichteroth Phone +49 (0) 2295 902960 info@dohle-extruder.de www.dohle-extruder.de	X	X	X		
Forsthoff GmbH Freiheitstr. 24 D-42719 Solingen Phone +49 (0) 212 336052 info@forsthoffwelding.com www.forsthoffwelding.com	X		X		
Haubold Technik Wehrstraße 44 D-69509 Mörlenbach Phone +49 (0) 6209 8819 email@haubold-technik.de www.haubold-technik.de					
HERZ GmbH Kunststoff- und Wärmetechnologie Biberweg 1 D-56566 Neuwied Phone +49 (0) 2622 88550 info@herz-gmbh.com www.herz-gmbh.com	X	X	X	X	
HSK Kunststoff Schweißtechnik GmbH Zilzkreuz 1 D-53604 Bad Honnef Phone +49 (0) 2224 9017501 info@hsk-kunststoff.de www.hsk-kunststoff.de	X	X	X	X	
HÜRNER Schweisstechnik GmbH Nieder-Ohmener Str. 26 D-35325 Mücke (Atzenhain) Phone +49 (0) 6401 91270 info@huerner.de www.huerner.de					
Ingenia GmbH Hauptstraße 72 D-56858 Altlay Phone +49 (0) 6543 50490 info@ingenia-gmbh.de ingenia-gmbh.gmbh				X	
Leister Technologies AG Galileo-Strasse 10 CH-6056 Kägiswil Phone +41 (0) 41 6627474 salessupport@leister.com www.leister.com	X	X	X		

Fold swing-bend welding	Hot bending	Heated-tool butt welding of pipes	Heated-tool socket welding (HD)	Electrofusion welding (HM)	Pipe machining tools
	X	X	X		
	X				
	X	X	X		
	X	X	X	X	X
		X	X	X	X
X	X				

Manufacturer	Hot-gas string bead welding (WZ)	Hot-gas extrusion welding (WE)	Hot-air blowers and heated tools	Heated-tool butt welding of sheets	
MUNSCH Kunststoff-Schweißtechnik GmbH Im Staudchen D-56235 Ransbach-Baumbach Phone +49 (0) 2623 8980 info-kst@munsch.de www.munsch-kunststoff-schweisstechnik.de		X			
Reichel GmbH – Bubenheimer Maschinen Am Giener 26 D-55268 Nieder-Olm Phone +49 (0) 6132 714571 info@reibu.de www.reibu.de					
Eugen Riexinger GmbH & Co. KG Egartenring 2 D-75378 Bad Liebenzell Phone +49 (0) 7052 930900 info@riex.de www.riex.de				X	
RITMO SPA Via Volta, 35/37 – Z.I. Selve IT-35037 Bresseo di Teolo (PD) Phone +39 (0) 49 9901888 info@ritmo.it www.ritmo.it		X		X	
ROTHENBERGER Werkzeuge GmbH Industriestraße 7 D-65779 Kelkheim Phone +49 (0) 6195 8001 info@rothenberger.com www.rothenberger.com					
Tecnodue I.T.S. – Ital Trade Services S.r.l. Via Scarsellini, 77 IT-16149 Genova (GE) Phone +39 (0) 10 6423396 info@its-tecnodue.com www.tecnodue.eu		X		X	
VULKAN AG Trischlistrasse 23 CH-9400 Rorschach Phone +41 (0) 71 8447888 info@vulkanag.ch www.vulkanag.ch	X		X		
WEGENER International GmbH Ernst-Abbe Straße 30 D-52249 Eschweiler Phone +49 (0) 2403 704840 info@wegenerwelding.de www.wegenerwelding.de	X	X		X	
WIDOS – Wilhelm Dommer Söhne GmbH Einsteinstraße 5 D-71254 Ditzingen Phone +49 (0) 7152 99390 info@widos.de www.widos.de				X	

As at March 2023. Please note that this equipment is also available from other manufacturers.

Fold swing-bend welding	Hot bending	Heated-tool butt welding of pipes	Heated-tool socket welding (HD)	Electrofusion welding (HM)	Pipe machining tools
	X				
		X			
		X			
		X	X	X	X
		X			
X					
		X	X	X	X

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11 Legal note and advice

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