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1 Scope

This technical code applies to the heated tool butt welding of sheets according to DIN EN ISO 14632 and for the heated tool butt-, the heated tool socket- and the electro-socket welding of pipes, fittings and tapping tees made from PE-HD¹⁾ according to DIN 8074 and 8075, DIN 16 963, DIN 3543-4 and DIN 3544-1, being used for the conduction of gas, fluids and solids.

With regard to the following instructions, suitability within the melt flow rates MFR²⁾ 190/5 of 0,3 up to 1,7 g/10 min or 0,2 up to 0,7 g/10 min respective may be assumed. For the heated tool butt welding of tapping tees restrictions according to section 4.2 have to be attended.

Deviating MFR values require an additional proof by tensile creep tests according to DVS 2203-4 or supplement 1.

¹⁾ The material indication is the specification of thermoplastics group and includes the types PE 63, PE 80 and PE 100. The information complies to the current standards.

²⁾ old indication MFI = Melt Flow Index

This publication has been drawn up by a group of experienced specialists working in an honorary capacity and its consideration as an important source of information is recommended. The user should always check to what extent the contents are applicable to his particular case and whether the version on hand is still valid. No liability can be accepted by the Deutscher Verband für Schweißen und verwandte Verfahren e.V., and those participating in the drawing up of the document.

2 General requirements

The quality of welded joints depends on the qualification of the welder, the suitability of the utilized equipment and devices as well as on compliance with the welding standards. The welded joint can be tested by means of non-destructive and/or destructive methods.

The welding work must be monitored. Type and range of supervising has to be agreed between the contract partners. It is recommended to record the welding data in welding protocols (sample see appendix) or on data carriers.

Within the framework of the quality assurance it is recommended to produce and test samples of joints before and during welding.

Every welder has to be trained and has to be in possession of a valid qualification certificate. The intended application range may be decisive for the kind of qualification. For the heated tool butt welding of sheets as well as in the industrial piping system construction, the technical code DVS 2212-1 is valid. The DVGW-specification GW 330 applies analogously as qualification proof for heated tool butt and heated tool socket welding at the construction of gas and water supply systems. The welding of plastics for indoor applications is described in the technical codes DVS 1905-1 and -2.

The equipment and devices which are used for welding must comply with the requirements in DVS 2208-1.

3 Measures before welding**3.1 Requirements for welding**

The welding zone must be protected against bad weather influences (e.g. wind, moisture). If it is ensured by suitable measures (e.g. preheating, tent, heating) that the conditions are suitable for welding, work may be carried out at any outside temperature insofar as the welder is not hindered in his handling (see explanation). If necessary, an additional proof must be provided by carrying out sample welds under the mentioned conditions (section 7).

If the semi-finished product is heated up unevenly under influence of sunshine, a temperature compensation in the area of the welding joint can be reached by covering. A cooling down during the welding process by ventilation has to be avoided. During welding the pipe ends have to be closed additionally.

PE-HD-pipes from coils are oval and bent immediately after uncoiling. The pipe end must be prepared before welding, e.g. by careful heating up with a hot-air equipment and/or use of a suitable clamping res. re-rounding device.

The joining zones of the components to be welded must be undamaged and have to be free of contaminations (e.g. dirt, grease, shavings).

3.2 Cleaning

For the production of perfect welded joints it is very important that the joining areas as well as the tools and heated tools are clean and free of grease.

3.2.1 Cleaning agents

The cleaning agents or already moistened cloths in a lock-up plastic box have to consist of a 100 % vaporizing solvent, e.g. 99 parts ethanol with a purity grade of 99,8 % and 1 part MEK (methyl ethyl ketone, denaturation). Agents tested according to DVGW 603 comply with this requirement. The use of ethyl alcohol could result in a reduction of quality because of the contained water.

The paper for cleaning has to be clean, unused, absorbent, non-fuzzy and non-coloured. Exhaust the air afterwards.

3.2.2 Cleaning of heated tools

The heated tools have to be cleaned with paper before every welding process. No residues of cleaning agents or paper may remain on the heated tool.

3.2.3 Cleaning of joining areas

Before machining the joining areas it has to be ensured that the utilized tools and components are clean and free of grease even outside the welding zones, if necessary use a cleaning agent.

The treatment of the joining areas has to be done directly before the welding process starts.

Any shavings have to be removed without contacting the joining areas.

In case of contamination of the surface after machining, e.g. by contact with hands, the joining areas have to be treated with a cleaning agent if a further machining is impossible.

4 Heated tool butt welding

4.1 Heated tool butt welding of pipes, pipeline components, fittings and sheets

4.1.1 Description of the process

With the heated tool butt welding process, the joining zones of the components to be welded are aligned under pressure on the heated tool (alignment), heated up to the welding temperature with reduced pressure (heating up) and joined under pressure (joining) after removal of the heated tool (changeover). Figure 1 shows the principle of this procedure.

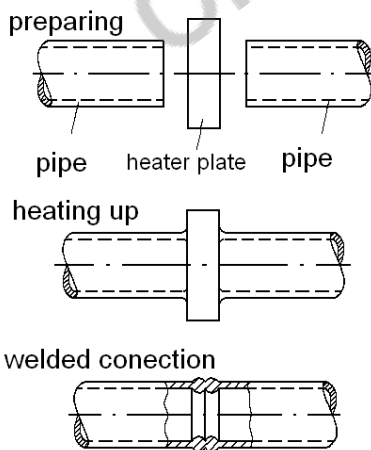


Figure 1. Principle of the heated tool butt welding of a pipe.

4.1.2 Preparation of welding

Prior to the start of the welding process, the welding temperature of the heated tool is to be checked. This is done e.g. by means of a fast-indicating measuring device with a contact surface of 10 mm for measuring the surface temperature. The control measurement must be done within the area on the heated tool which corresponds to the semi-finished product. For adjusting a thermal balance, the heated tool may be inserted at the earliest 10 minutes after reaching the set temperature.

To ensure an optimum welding connection the heated tool has to be cleaned according to section 3.2.2 before every welding operation. The anti-adhesive coating or covering of the heated tool must be free of damages in the working zone.

The joining forces and joining pressures have to be specified for the machines to be used. These can be based on e.g. manufacturer information, calculated or measured values. Additionally, at the welding of pipes, the work piece moving force res. moving pressure is taken from the indicator of the welding machine during the slow displacement of the part to be welded and have to be added to the prior determined joining force res. joining pressure. Electronically controlled equipment is preferred, if possible with recording.

The nominal wall thickness of the parts to be welded must match in the joining area.

Pipes and fittings have to be aligned in axial direction in the welding machine before the clamping. The easy axial movement of the part to be welded-on can be ensured e.g. by means of dollies or swinging suspension.

The joining areas have to be planed with a clean and grease-free tool directly before the welding so that they are coplanar in clamped condition. Permissible gap width under alignment pressure see table 1.

Table 1. Maximum gap width between the treated welding zones.

Pipe outside diameter d mm	Gap width mm	Sheet width mm
≤ 355	0,5	
400 ... < 630	1,0	≤ 1500
630 ... < 800	1,3	> 1500 ≤ 2000
800 ... ≤ 1000	1,5	> 2000 ≤ 2300
> 1000	2,0	> 2300 ≤ 3000

Both, the gap width and the misalignment have to be controlled. The misalignment of the joining areas on the pipe outside or sheet respectively may not exceed the permissible size of 0,1 x wall thickness. A reduction of the quality arises in case of larger misalignment which limits the strength of the joint. In this case, the evaluation according to DVS 2202-1 under consideration of requirements to the joint can be done.

The treated welding areas should be neither dirtied nor touched by hand, as a retreatment would be necessary then. **An additional cleaning is not necessary and means no quality improvement.** Shavings fallen into the pipe have to be removed.

4.1.3 Welding procedure

With heated tool butt welding the joining areas are heated-up to the welding temperature by means of the heated tool and joined under pressure after removing the heated tool. The heated tool temperature is 200 to 220 °C. In principle the upper temperature limit is to be aspired for smaller wall thickness, the lower temperature limit for bigger ones (see figure 2). The upper temperature has to be chosen for PE 100 as well. The different steps of the welding process are illustrated in figure 3.

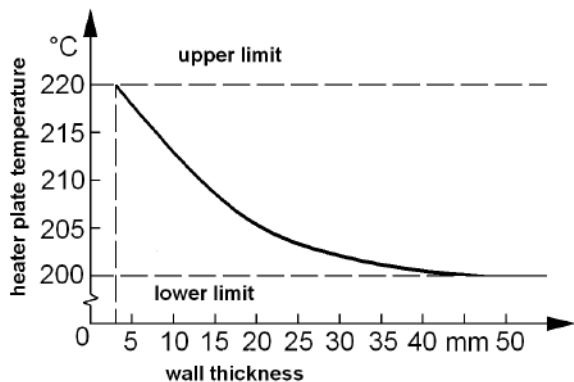


Figure 2. Recommended values for the heated tool temperatures as function of the wall thickness.

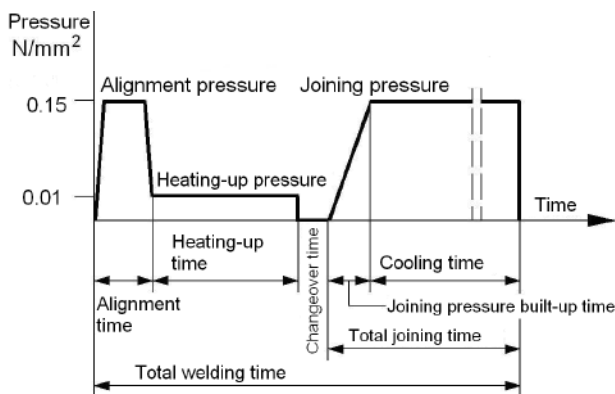


Figure 3. Process steps of heated tool butt welding.

Alignment

The joining areas of the welding components are pressed to the heated tool until all areas are coplanar on the heated tool. This fact is visible on the formation of beads. The alignment is finished

when the bead heights have reached the mentioned values in table 2, column 2 on the total pipe circumference or the total sheet surface respectively. The bead sizes are an index for a complete contact of the joining areas on the heated tool.

Heating-up

For heating-up, the joining areas must contact the heated tool with low pressure. The pressure is reduced to nearly zero ($\leq 0,01 \text{ N/mm}^2$). During heating-up, the heat penetrates the joining areas and the welding temperature is reached. Heating-up times are given in table 2, column 3.

Changeover

After heating-up, the joining areas are to be detached from the heated tool. The heated tool should be withdrawn without damage or contamination of the heated joining zones. The joining areas should be joined together quickly until they almost have contact. The changeover time should be as short as possible (see table 2, column 4), as otherwise the plasticized areas will cool down. The welding joint quality would be influenced negatively.

Joining

The areas to be welded should meet with a speed of nearly zero. The demanded joining pressure is built possibly linear. The required times are shown in table 2, column 5. The joining pressure is $0,15 \pm 0,01 \text{ N/mm}^2$.

Raised mechanical loads during or directly after the declamping are allowed only after finished cooling. The joining pressure has to be kept completely during the cooling time at ambient temperature (see table 2, column 5).

The reduction of the cooling time up to 50 %, that means joining pressure release and removal of the welded part from the welding equipment, is allowed under the following requirements:

- the welding is done under workshop conditions
- the removal from the welding equipment and the temporary storage are causing only slight loads to the joint
- it concerns components with a wall thickness of $\geq 15 \text{ mm}$.

A further treatment with full mechanic load of the joint is allowed only after complete cooling down according to table 2, column 5.

Table 2. Recommended values for the heated tool butt welding of pipes, fittings and sheets made of PE-HD at an outside temperature of approx. 20 °C and moderate air flow (interim values have to be interpolated).

1 Nominal wall thickness s mm	2 Alignment Heated tool temperature see figure 2 Bead height on heated tool on the end of the alignment time (alignment p = 0,15 N/mm ²) mm	3 Heating-up Heating-up time = 10 x wall thickness p = $\leq 0,01 \text{ N/mm}^2$ s	4 Changeover Changeover time (Maximum time) s	5 Joining	
				Joining pressure build-up time s	Cooling time under joining pressure (minimum values) p = $0,15 \text{ N/mm}^2 \pm 0,01$ min
up to 4,5	0,5	up to 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	16 ... 20	19 ... 25	45 ... 60
50 ... 70	4,0	500 ... 700	20 ... 25	25 ... 35	60 ... 80

After the joining, a uniform double-bead must appear. The bead size shows the regularity of the welds. Different beads could be caused by different melt flow behaviour of the joined materials. Based on the experience with commercial semi-finished products made from PE 80 and PE 100 with the mentioned MFR-range the weldability can be assumed, even if it results in asymmetric welding beads. K has to be always > 0 (see figure 4).

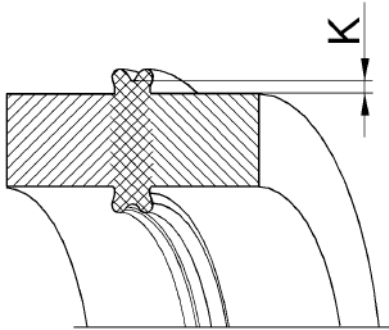


Figure 4. Bead formation at heated tool butt welding (principle) of a pipe.

Short version of processing instructions see appendix.

4.2 Heated tool butt welding of tapping tees

The heated tool butt welding of tapping tees is applicable with PE-HD pipes according to DIN 8075 of melt-flow index values of 0,7 up to 1,3 g/10 min. For piping system components made of PE-HD with MFI values of 0,2 up to 0,7 g/10 min the welding process is applicable only in conjunction with a reinforcement embracing the pipe. The last-mentioned condition is also valid if, especially in the case of fittings attached at a subsequent stage, an attribution within the scope of this standard is not possible.

Heated tool butt welds of tapping tees have to be carried out by means of welding devices.

4.2.1 Description of the process

The connection zones of pipe and tapping tee are aligned and heated up by means of a shaped heated tool under alignment pressure. After removal of the shaped heated tool the joining faces are joined under joining pressure.

4.2.2 Preparation of welding

Prior to the start of the welding process, the welding temperature set on the heated tool is to be checked according to section 4.1.2.

To ensure an optimum welding connection the heated tool has to be cleaned according to section 3.2.2 before every welding operation. The anti-adhesive coating of the heated tool must be free of damages in the working zone.

Prior to clamping into the welding equipment the joining surface of the pipe has to be scraped with a trimming blade or another suitable tool. Shavings have to be removed without contacting the joining area. The treated welding areas should be neither dirtied nor touched by hand, otherwise cleaning of the joining areas according to section 3.2.2 is necessary. The tapping tee always has to be cleaned according to section 3.2.3.

The roundness of the pipe is to be ensured by the clamps of the welding equipment or special re-rounding devices. The fit of the tapping tee face is to be controlled.

Prior to welding the required forces for alignment and joining have to be determined from the table provided with the equipment.

4.2.3 Welding procedure

The shaped heated tool, heated to the welding temperature (200 up to 220 °C) is introduced between the welding components. The alignment pressure is 0,15 N/mm². After beads have formed according to table 3, column 1, the specific set pressure for

heating-up is reduced to $\leq 0,01$ N/mm² during the now starting heating-up time. The heating time depends on data provided by the manufacturer of the fitting. When the heating time has elapsed the shaped heating tool is to be withdrawn without damaging and contamination of the joining area. The changeover time should be as short as possible (maximum value see table 3, line 3). The joining areas should be joined together promptly afterwards.

After complete cooling the welding device may be removed.

Table 3. Recommended values for the heated tool butt welding of tapping tees made of PE-HD at outside temperature of 20 °C and moderate air flow.

1	Alignment under $p = 0,15$ N/mm ² Bead heights on heated tool at the end of the alignment time Min. value [mm]	1,0
2	Heating-up under $p \leq 0,01$ N/mm ² Heating-up time [s]	acc. to manufacturer data
3	Changeover Max. time [s]	10
4	Joining pressure build-up time	5
5	Joining Cooling time under joining pressure $p = 0,15$ N/mm ² Min. value [min]	15

Short version of processing instructions see appendix.

5 Electro-socket welding

5.1 Description of the process

The joining areas (pipe surface and inside of the fitting) are overlapped and welded by resistance wires inside the fitting (heating coils) which are heated up by electrical energy (see figure 5).

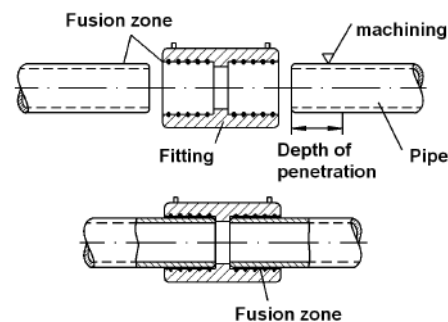


Figure 5. Electro-socket welding (principle).

5.2 Welding equipment

Only welding equipment adjusted to the parts to be welded may be used. Automatic welding equipment is preferred – possibly with recording. The welding equipment must supply the required welding parameters for the fitting to be welded such as welding time, current and voltage. The device must switch off as soon as the necessary quantity of heat has been fed to the welding zone.

5.3 Preparation of welding

Clean surfaces and a stress free installation are very important for the fabrication of perfect welded joints. With the choice of pipes with limited diameter tolerance according to DIN 8074 the installation of fittings is easier.

For axial pipe connections the pipes have to be cut rectangular by means of a suitable device. In case of a bevelled shrinkage of the pipe cut edge the un-treated pipe has to show the nominal diameter d (figure 6) at the designated insert depth minimum in the area of the heated socket. If necessary the pipe end should be shortened immediately before welding.

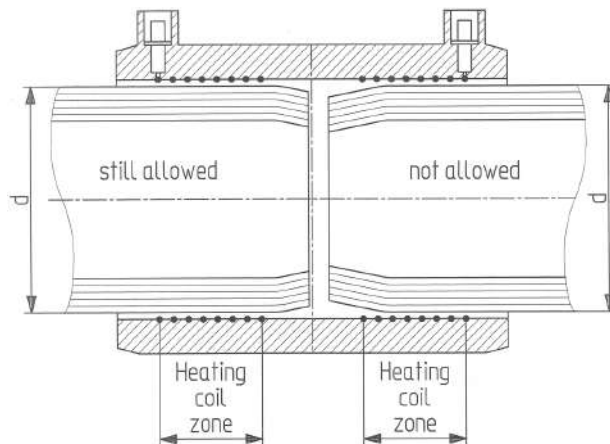


Figure 6. Bevelled shrink of the pipe end.

The ovality of the pipe may not exceed 1,5 % of the outside diameter, max. 3 mm. If necessary, re-rounding devices can be used.

The surface of the pipe or fitting in the welding zone has to be completely machined. A scraping tool with a constant wall thickness removal of approx. 0,2 mm should be used. **Take care for a small annular gap!**

The pipe end has to be deburred inside and outside, shavings have to be removed without contacting the joining areas.

The fitting may only be removed from the protective package immediately before the installation.

In case of contamination of the pipe surface after machining it must be cleaned according to section 3.2.3. It has to be considered that no contamination is rubbed into to the welding zone. The joining area of the fitting or tapping tee respectively has to be cleaned according to section 3.2.3.

The insert depth of the pipe has to be controllable by an added mark or suitable device. The fitting may neither be tilted nor pushed onto the pipe end with force (low stress installation). The tapping fitting has to be clamped on the pipe by means of a suitable device under consideration of the manufacturer's instructions.

The contact socket for the connection of the welding cable must be easy reachable.

Fitting and pipe have to show the same temperature level before the welding process. Concerning welding equipment with automatic temperature compensation, take care that the measured environmental temperature corresponds to the conditions of the welding location. If necessary the welding equipment as well as the pipe and fitting have to be protected e.g. against direct sun radiation.

5.4 Welding procedure

The correct insert depth has to be controlled by means of the mark. The components to be welded should be secured against dislocation.

The welding equipment is connected by a cable with the part to be welded. The welding cable has to be placed without weight loaded. The contact areas must be clean. The required data of the fitting or tapping tee for the welding process are taken automatically from the welding equipment by scanning the specific component barcode. The shown data (e.g. dimension) have to comply with the component data. After starting the

welding process it runs automatically. The welding time is usually shown on the welding equipment. It has to be transferred to the welding protocol as well as other data from the welding machine, if no data recording is done.

Consider error message! If there should be any interruption to the power supply in the early part of the welding process, the welding may be repeated as long as no visible defects on the fitting or error messages with the welding equipment have appeared, and the fitting manufacturer has given his permission for re-welding to take place.

The joining area (pipe and fitting) must be cooled down completely before the welding process is started again.

The cables can be removed after switching off the equipment. Check the welding indicators if available on the fitting. The connection may be moved only after cooling down. The fitting or mounting manufacturer supplies corresponding information. The drilling of tapping tees may be done only after finished cooling time.

Details from the manufacturer about additional cooling times, e.g. till the pressure test, have to be considered.

Short version of handling instructions see appendix.

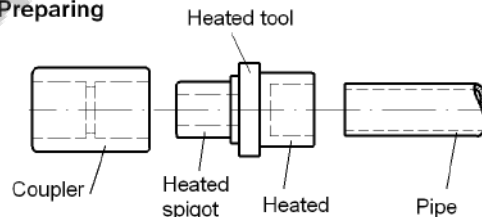
6 Heated tool socket welding

6.1 Description of the process

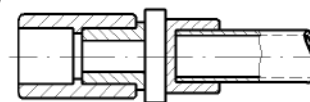
At heated tool socket welding (see figure 7), pipe and pipeline components are welded in overlapped condition. Pipe end and fitting are heated up to welding temperature by a socket or spigot-shaped heated tool and subsequently joined together.

Heated tools and fittings are dimensionally adapted so that on joining a joining pressure will be built-up. Heated tool socket welding can be performed manually up to 50 mm pipe diameter. At diameters as from 63 mm, a welding device is required because of the higher joining force.

Preparing



Heating up



Welded connection

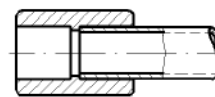


Figure 7. Heated tool socket welding (principle).

6.2 Welding device

The heated tools are heated electrically and are coated anti-adhesively.

6.3 Preparation of welding

The fitting has to be cleaned inside and outside according to section 3.2.3. The treatment of the joining areas of the welding components should take place immediately before welding is started. The pipe end has to be bevelled according to figure 8 and table 4. The joining area of the pipe is to be treated according to the manufacturers guidelines. Concerning manual welds the insert depth is to be marked on the pipe with distance l according to table 4.

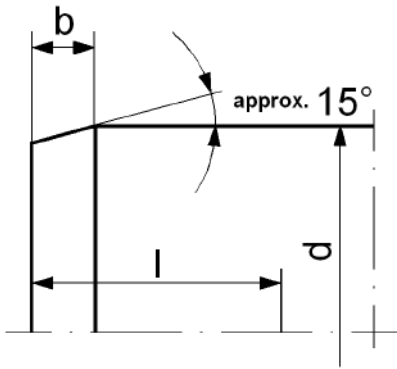


Figure 8. Beveling of the pipe end.

Table 4. Values for pipe chamfer and insert depth.

Pipe outside diameter d [mm]	Pipe chamfer b [mm]	Insert depth l [mm]
16	2	13
20		14
25		16
32		18
40		20
50	3	23
63		27
75		31
90		35
110		41
125		46

Before welding starts the welding temperature (250 to 270 °C) set on the heated tool has to be controlled according to section 4.1.2.

Heating socket and heating spigot must be free of contaminations and should be cleaned before welding according to section 3.2.2. The anti-adhesive coating of the heating spigot and heating socket must be free of damages in the welding area.

6.4 Welding procedure

For the purpose of heating, fitting and pipe are pushed swiftly and axially onto the devices fitted on the heated tool and held until the stop at machine welding or until the mark at manual welding. **It has to be absolutely avoided that the pipe is pushed onto the end of the heating socket.** Afterwards the heating-up time starts according to the time values in table 5, column 2.

After the heating time has elapsed, the fitting and pipe should be withdrawn sharply from the heated tool and pushed together immediately without any twisting until the stop or mark (maximum adjusting time see table 5, column 3).

At manual welding the joined components have to be kept fixed according to the time mentioned in table 5, column 4. The connection may be loaded by further installation works only after cooling time is over (table 5, column 5).

Short version of handling instructions see appendix.

7 Testing of welded joints

Various tests can be used to test the quality of individual welding processes. Differentiation is made between destructive and non-destructive tests. For details see table 6. Tests and sampling can be carried out prior to or during welding work according to agreement.

Table 5. Recommended values for the heated tool socket welding of pipes and pipeline components made of PE-HD at outside temperature of 20 °C and moderate air flow.

1 Pipe outside diameter d mm	2 Heating-up Heated tool temperature 250 up to 270 °C		3 Changeover Changeover time (Maximum time) s	4 Cooling		
	Heating up time for SDR ²⁾ 11, SDR 7,4, SDR 6 s	Heating up time for SDR ²⁾ 17, SDR 17,6 s		fixed s	total min	
	16	5		1)	4	6
20	10					
25	7		6		20	4
32					8	
40					12	
50	18		8		30	6
63		24				
75	30	18	10	40	8	
90	40	26		50		
110	50	36		60		
125	60	42				

1) Due to the low wall thickness this welding method is not recommended.
 2) Standard Dimension Ratio ~ d/s (ratio outside diameter / wall thickness).

Table 6. Test methods for weld joints.

Test method	Heated tool butt welding		Electro socket welding		Heated tool socket welding
	Sheets, pipes, fittings	Tapping tees	Fittings	Tapping tees	Pipes, fittings
Visual test	DVS 2202-1 Table 1	Smooth welding joint on the complete circumference Mechanical treatment of pipe surface has to be visible also outside of the welding area.	DVS 2202-1 Table 3	DVS 2202-1 Table 3	DVS 2202-1 Table 2
Radiographic and X-ray test	applicable. Statement about e.g. voids is possible, but not about the quality.				
Tensile test	DVS 2203-2; Short-term welding factor DVS 2203-1, Suppl. 1	non applicable			
Tensile creep test	DVS 2203-4; tensile creep welding factor DVS 2203-1, Suppl. 2	DVS 2203-4, Suppl. 1			
Technological bending test	DVS 2203-5. Minimum bending angle acc. to DVS 2203-1, Suppl. 3, Figures 1 and 2 Minimum bending distance acc. to DVS 2203-1, Suppl. 3, Figures 7 and 8	non applicable			
Internal pressure creep rupture test	DIN 16963-5, section 5.4.3.1, Length of each pipe piece acc. to table 6. Non meaningful for long-term welding factor > 0,5	DIN 3544-1, sections 2.3 and 3.2 at 80 °C	DIN 16963-5, section 5.4.3.1	DIN 3544-1, sections 2.3 and 3.2 at 80 °C	DIN 16963-5, section 5.4.3.1
Torsion shear test	non applicable	see appendix. Also applicable as site test for pipe wall thickness ≥ 4 mm.			
Radial peeling test	non applicable	see appendix. Also applicable as site test for pipe wall thickness ≥ 4 mm.			
Compression test	non applicable		DIN EN 12814-4, section 8. Also applicable as site test.		
Peeling test	non applicable		DIN EN 12814-4, section 7		non applicable

8 Standards and technical codes

DIN 3543-4	Tapping tee fittings made from rigid PE for pipes made from rigid PE; dimensions	DIN EN ISO 15494	Thermoplastic piping systems for industrial applications; Polybutene (PB), Polyethylene (PE), Polypropylene (PP); Requirements to pipeline components and to the piping system; Metric sizes
DIN 3544-1	Fittings made from rigid PE, type 1 and 2, requirements and testing of tapping tee fittings	DIN 16 963	Pipe joints and pipeline components for pressure pipelines made from polyethylene high density (PE-HD)
DIN 8074	Pipes made from polyethylene (PE); PE 63, PE 80, PE 100, PE-HD; dimensions	DIN 19537	Pipes and fittings made from polyethylene high density (PE-HD) for sewage channels and pipelines ;
DIN 8075	Pipes made from polyethylene (PE); PE 63, PE 80, PE 100, PE-HD; General quality requirements, testing	-1	-, dimensions
DIN EN ISO 1872-1	Thermoplastics; Polyethylene (PE)-moulding materials; designation systems and basics for specifications	-2	-, technical delivery conditions
DIN EN 12814-4	Testing of welding joints made from thermoplastics; Part 4: Peeling test	DVGW GW 330	Welding of pipes and pipeline components made from polyethylene (PE80, PE 100 and PE-Xa) for gas- and water system welders; Training and testing scheme
DIN EN ISO 14632	Extruded sheets made from polyethylene (PE-HD); Requirements and test methods	DVGW GW 331	Supervisor for welding of pipelines made from PE-HD for gas and water supply; Training and testing scheme

DVGW VP 603	Preliminary test basis for cleaning agents and their tanks for the preparation of welding joints on polyethylene pipes	6. Take off the planing tool at the pipe welding machine.
DVS 2202-1	Failures on welded joints of thermoplastics; features, description, evaluation	7. Remove shavings from the welding area without touching the joining zones.
DVS 2203-1	Testing of welded joints on sheets and pipes of thermoplastics; testing methods – requirements	8. Check the coplanarity by moving the joining areas together (maximum gap width according table 1).
Suppl. 1	Requirements for tensile test	9. Check the misalignment (maximum 0,1 x wall thickness).
Suppl. 2	Requirements for tensile creep test	10. Check the heated tool temperature subject to the wall thickness (see figure 2).
Suppl. 3	Requirements for technological bending test, bending angle/bending distance	11. Clean the heated tool with a cleaning agent according sections 3.2.1 and 3.2.2 with unused, absorbent, non-fuzzy and non-coloured paper and exhaust it.
-2	–, tensile test	12. Determine the moving pressure res. moving force before each welding and record it in the welding protocol.
-4	–, tensile creep test	13. Determine the values for aligning, heating-up and joining pressure.
-4 Suppl. 1	–, tensile creep test; testing of socket welding connections on pipes	14. Set the reference values according to table 2.
-5	Technological bending test	15. Bring the heated tool to the welding position.
DVS 2208-1	Welding of thermoplastics; Machines and equipment for the heated tool welding of pipes, pipeline components and sheets	16. Align the welding areas to the heated tool until a bead is formed (according to table 2, column 2).
DVS 2212-1	Testing of plastic welders; Test group I and II	17. Heating-up with reduced pressure $\leq 0,01 \text{ N/mm}^2$, heating-up time according to table 2, column 3.
Betr.Sich.V	Regulation of industrial safety	18. After heating-up is finished, withdraw the joining areas from the heated tool and remove it from the welding position.

9 Explanation

This technical code has been adjusted according to the state-of-the-art with regard to improved cleaning agents and the development of larger pipeline components. The non-contact heated tool welding is explained in DVS 2207-6.

The welding of thermoplastics at environmental temperatures below 5 °C is generally problematic. This concerns less the material specific properties of the thermoplastics but the limited manual skill of the welder. Welding outside at any temperature requires an environment which enables the welding staff to perform the individual work steps without quality reducing influences. The parts to be welded must have the same temperature level. Test welds have to be performed and tested.

Regarding the pipe end condition it has to be considered that the welding preparations include also the remove of frost, ice and moisture from the joining area ($\geq 0,5 \times$ fitting length) by means of heat (e.g. hot gas device). Fittings and tapping tees must be stored in closed, frost-free rooms and provided / used for welding only in the required quantity.

The quality evaluation of socket welding joints by the internal pressure creep test is only insufficiently possible. In combination with the tensile creep test a first sign is contained in DVS 2207-1, suppl. 1 (draft), table 1.

Appendix: Processing instructions (short versions)

Ad 4.1 Heated tool butt welding of pipes, pipeline components, fittings and sheets

Processing instruction (short version)

1. Establish acceptable working conditions, e.g. welding tent
2. Connect the welding equipment to the mains or alternating current generator and control the function.
3. Adjust and clamp the parts to be welded, e.g. by dollies.
4. Close the pipe ends against air movement.
5. Clean the joining areas even outside of the welding zone by means of cleaning agents according to sections 3.2.1 and 3.2.3 with unused, absorbent, non-fuzzy and non-coloured paper.
Machine the joining zones, at pipes e.g. with planing tool.

Ad 4.2 Heated tool butt welding of tapping tees

Processing instruction (short version)

1. Establish acceptable working conditions, e.g. welding tent
2. Control the function of the welding equipment.
3. Ensure the roundness of the pipe by the clamps of the welding equipment or corresponding re-rounding devices.
4. Adjust and clamp the parts to be welded, e.g. by dollies.
5. Clean the joining areas even outside of the welding zone by means of cleaning agents according to sections 3.2.1 and 3.2.3 with unused, absorbent, non-fuzzy and non-coloured paper. Machine the pipe surface.
6. Remove shavings from the welding area without touching the joining zones.
7. Control the surface fit of the tapping tee.
8. Fix the welding equipment onto the pipe.
9. Clamp and adjust the tapping tee.
10. Choose the correctly shaped heated tool.
11. Clean the connection surfaces –if contaminated – and the heated tool according to sections 3.2.1, 3.2.2 and 3.2.3 by means of unused and absorbent, non-fuzzy and non-coloured paper and exhaust it.

12. Determine forces for alignment and joining (table of manufacturer).
13. Check the welding temperature (200 up to 220 °C).
14. Set the heated tool to the welding position.
15. Align the welding areas to the heated tool until a bead of 1 mm arises.
16. Heating-up with reduced pressure $\leq 0,01 \text{ N/mm}^2$, heating-up time according to manufacturers data.
17. Withdraw the connection areas to be welded from the heated tool after heating-up time is finished and bring them into welding position.
18. The joining areas should be joined together within the changeover time of maximum 10 seconds.
19. Build-up joining pressure speedy and smooth within 5 seconds.
20. Cooling down under joining pressure, minimum 15 minutes.
21. Declamping of the welded parts after cooling time.
22. Complete the welding protocol.

Ad 5.3 Electro-socket welding of fittings and tapping tees

Processing instruction (short version)

1. Establish acceptable working conditions, e.g. welding tent.
2. Connect the welding unit to the mains or the alternating current generator and check function.
3. Deburr the outside of the rectangular cut pipe end. Shorten the pipe in case of too much pipe end shrinkage. See figure 6.
4. Ensure that pipe ends are round using re-rounding clamps, permitted ovality up to $\leq 1,5 \%$, max. 3 mm.
5. Clean the joining areas even outside of the welding zone by means of cleaning agents according to sections 3.2.1 and 3.2.3 with unused, absorbent, non-fuzzy and non-coloured paper. Machine the pipe surface in the welding area if possible with a scraping tool and wall thickness removal of approx. 0,2 mm. Remove the shavings without touching the pipe surface.
6. Clean the treated pipe surface – if contaminated and if necessary, according to manufacturers instructions, also the inside of the fitting – with a cleaning agent according to sections 3.2.1 and 3.2.3 with unused, absorbent, non-fuzzy and non-coloured paper and exhaust it.
7. Insert the pipes into the fitting and control the insert depth by means of the mark or suitable device. Fix the tapping tee on the pipe. Take care for low stress installation. Secure the pipe against dislocation.
8. Connect cable to fitting. Cable must be free of weight load.
9. Enter welding data e.g. by means of barcode scanner, check the displayed data on the equipment and start the welding process.
10. Control the correct welding procedure on the welding equipment e.g. by control of the display information and if available with the welding indicators. Consider error messages.
11. Disconnect cable from fitting.
12. Declamping of the welded parts after cooling time. Remove fixing device.
13. Complete the welding protocol form if no automatic protocol is made.

Ad 6 Heated tool socket welding

Processing instruction (short version)

1. Establish acceptable working conditions, e.g. welding tent.
2. Connect the welding equipment to the mains or alternating current generator and control the function.
3. Clean the heating tools by means of a cleaning agent according to sections 3.2.1 and 3.2.2 with unused, absorbent, non-fuzzy and non-coloured paper.
4. Check the welding temperature (250 up to 270 °C).
5. Clean all non-treated joining areas with a cleaning agent according to sections 3.2.1 and 3.2.3 with unused, absorbent, non-fuzzy and non-coloured paper and exhaust it.
6. Machine the rectangular cut pipe end according to figure 8 and table 4 or according to the fitting manufacturer instruction. If necessary mark the insert depth.
7. Insert the fitting and pipe simultaneously into the heating spigot / the heating socket till the stop / mark. The pipe end may not contact the end of the heating socket.
8. Observe the heating-up time according to table 5, column 2.
9. Pull off the fitting and pipe and push them swiftly and axially together to the stop / mark (maximum changeover time see table 5, column 3) and fix this position (see table 5, column 4).
10. Cool down the connection. Mechanical load of the connection only after finished cooling time according to table 5, column 5.
11. Complete the welding protocol.

Ad 7 Testing of welded joints

The torsion shear test and radial peeling test are applicable for a quick check of the welding quality of PE-HD pipe connections. The wall thickness of the pipe should be $\geq 4 \text{ mm}$.

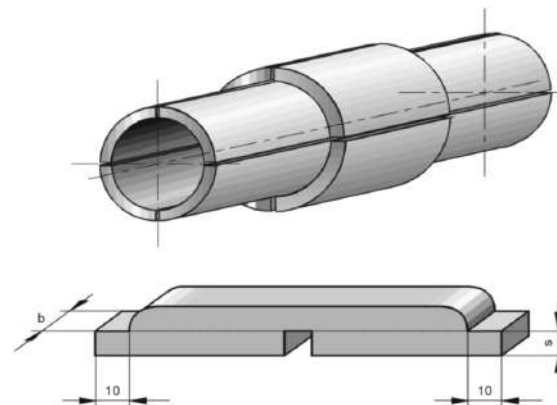


Figure 9. Test sample from electro-socket or heated socket welding joint.

Four test specimen are evenly removed from the whole circumference by longitudinal spacing. The contact sockets have to be omitted at electro-socket welding. The dimensions are:

- Test specimen length = socket length + 2 x 200 mm pipe length
 Test sample length = socket length + 2 x $\approx 10 \text{ mm}$ pipe length
 Test sample width b = 3 up to 6 mm at pipe wall thickness $\leq 10 \text{ mm}$
 b = 5 up to 6 mm at pipe wall thickness $> 10 \text{ mm}$

Torsion shear test: The torsion shear test is used for the evaluation of the fracture behaviour and the fracture appearance

of the welding joint. For this purpose the test sample (see figure 9) is fixed completely in a bench vice with one part e.g. socket cross section. The other part e.g. pipe cross section, is caught with a suitable tool and twisted for 90° in the welding section (see figure 10). The pitch rate is very low in order to widely exclude the fracture behaviour of the test sample. The clamping areas should be slightly undercut in order to insert the twisting moment directed to the welding joint section.

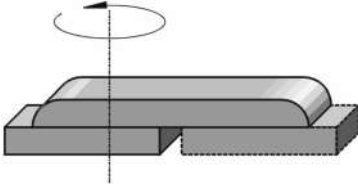


Figure 10. Application of force during torsion shear test.

Evaluation is done according to table 7.

Radial peeling test: For this test the pipe cross section of the test sample (see figure 9) which is fixed by the socket cross section in the winch vice by means of a suitable pliers or another clamping device is radially peeled at possibly low speed (see figure 11).

Evaluation is done according to table 7.



Figure 11. Application of force during radial peeling test.

Table 7. Evaluation criteria for torsion shear and radial peeling test.

Fracture behaviour	Type, characteristic	Evaluation
High release forces, ductile fracture, > 80 % of the welding zone	Very structured fracture appearance with plastic and ductile yield	No resp. minor faults
Welding zone is partly or completely melt, but only spot-welded	Isolated delaminations, contaminations, insufficient surface peeling	Unacceptable faults
Brittle fracture	Release zone is large-pored, fine structured, interspersed with a lot of voids, partly burnt, overheated welding joint	
	Pipe surface is not melt, welding joint too cold, too large welding gap	

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Protocol form for the Electrofusion welding of pipes and pipeline components

o laid overground
o laid underground

Material

Sheet

of

Customer

Executive company

Welding equipment:

Weather

Preventive measures

Name of order

Name of welder

Identification No.

Label:

1 = sonny

1 = none

2 = dry

2 = umbrella

Type:

3 = rain or snow

3 = tent

No. of order

Name and company of the welding supervisor

Machine No.:

4 = windy

4 = heating

Year of construction:

Order as above in case of multiple nominations (e. g. 34 = rain and wind)

Weld No.	Date	pipe dimension ø d x s mm	A	Fitting data		Unit setting		Resistance of the fitting ¹⁾ Ohm	Secondary voltage ¹⁾ Volt	Welding times ²⁾		Environmental temperature °C	Code-No.		Operating mode	
				B	Serial No.	manual	automatic			joining s	Cooling s		Weather	Preventive measures	Mains	Generator

Welding signature:

Date and signature of welding supervisor:

¹⁾ Enter where applicable according to system used.
²⁾ Enter measured values.

- A = Manufacturer's code
- B = Fitting code
- 1 = Coupler
- 2 = Angle
- 3 = T-piece
- 4 = Reduction
- 5 = Saddle
- 6 = Cap
- 7 = Connecting piece
- 8 = Fitting

