DVS – DEUTSCHER VERBAND FÜR SCHWEISSEN UND VERWANDTE VERFAHREN E.V.	**Welding of thermoplastics** **Machines and devices for the heated tool welding of pipes, pipeline components and sheets**	**Directive DVS 2208-1** (December 1997)

Contents:

1 Scope

By means of this directive the processors of semi-finished products and the manufacturers of machines shall obtain a general idea of the requirements which are to be made on devices and machines for heated tool and electrofusion welding of thermoplastics. On the basis of the indicated characteristics, the processor is able to check with which devices or machines he can realize his weld jobs safely and appropriately for the material involved.

The directive refers to the methods and the different types of welding with heated tools where the joining areas are heated up through direct contact with the heated tool, as described e. g. in DVS 2207-1, -11 and -15.

Subject of the directive refers especially to machines for the welding of polyolefines (PE, PP and PB) as well as PVDF and PVC-U.

If operating with welding machines for other thermoplastics, it should be checked in the single case if there are requirements to be followed depending on the material involved and on the methods which are different to those prescribed in this directive.

Special machines, the complete field of welding foils and lining membranes, the infrared welding technology as well as machines for high frequency, vibration and friction welding etc. are not subject to this directive.

2 General requirements on the machines

The requirements on the machines and devices for heated tool welding are complex and bound up with the appropriate weld job. For that purpose the production of universal machines convertible for all weld jobs is not recommended. Therefore at first the general requirements and then the characteristics of the respective machine groups are described below.

The manufacturer is obliged to certify in the right form that his product is fulfilling the requirements of this directive.

2.1 Clamping devices

The clamping devices have to be constructed in a way that the parts to be welded can be clamped quickly and safely, and that the forces necessary for welding can be transferred without a change in position of the working pieces. The clamping devices must not have a detrimental effect on the surface of the working pieces. For pipes and pipeline components they must be constructed in a way that smoothness in the weld area is attained.

DVS, Technical Committee, Working Group W 4 "Plastics, Welding and Adhesive Bonding"
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2.2 Guide elements

The guide elements must be able to bear the appearing forces and make sure that the forces necessary for welding are transferred safely and exactly onto the working pieces. The guides must easily function in all working orders. This is achieved e. g. by a good permanent lubrication.

In case of manual lubrication the lubricating points must be labeled, easily visible and handy. Appropriated remarks should appear in the working instructions.

2.3 Device for the preparation of the weld seam

For weldings which demand working on the joining areas in clamped condition, a cutting device has to be provided. This device must not impede other working phases of the machine.

2.4 Controlling and regulating devices

As a protection of consistent results, pressure and/or time as well as the other welding conditions have to be adjustable. Requirements on the thermoregulation are handled in section 3.6. Record the actual and the desired values in the right form.

The pressure should be easily adjustable, readable and accessible. The manometer of hydraulic machines must have a dial graduation of ≤ 1% of the final value. The precision of indication is ± 0.5 bar (quality grade 0.5).

On machines with spring power the indicator must have a dial graduation of

10 N range ≤ 100 N
20 N range > 100 ... ≤ 500 N
50 N range > 500 N

indicated values. The necessary working pressure of the machine should be pre-selectable. The difference between desired and actual joining force must not exceed ± 10%. In case of higher deviations prepare a correction table.

2.4.1 Force control

For heated tool socket welding and electrofusion welding, the force cannot be measured by the machines. Concerning the heated tool butt-welding, please see section 4.1.5.1.

2.4.2 Time control

For a safe welding joint, an exact control of the time is necessary. It should be possible to observe the times.

2.4.3 Print out of logs

On machines with logging function and on controlled machines, logs must be printed out with at least the following contents:

Devices for heated tool butt-welding:

- machine type, machine no.
- date, clock
- log no., welder no.
- site or order no., seam no.
- dimension of semi-finished product, material
- outside temperature
- desired and actual temperature of the heated tool
- heat up time, change over time, pressure build up time
- moving pressure, desired pressure, actual pressure, cooling time
- all disturbances during the welding process must be logged.

Devices for electrofusion welding:

- device no., mode of operation (if several are provided)
- date, clock
- site or order no.
- welder no. or name
- continuous logging or seam no.
- manufacturer, type, diameter, dimension of semi-finished product
- ambient temperature
- desired time, actual time
- voltage, electric resistance, if possible heat energy
- all disturbances during the welding process must be logged.

2.5 Arrangement of the heated tool

For heated tool butt and socket welding the suspension and the guide of the heated tool has to be constructed in a way that the heated tool is matching to the joining surfaces or is self centering, and that it can be moved within certain limits without resistance (floating). After expiration of the heating up time, separating and removing of the heated tool should be quickly possible without exceeding the change over time. If necessary, special devices for separating the heated tool from the work piece are to be provided.

2.6 Construction and identification of the machines

Design and construction of the welding machine must be in accordance with the operative conditions and the ambient influences of the weld jobs.

The working instructions have to contain

- the characteristic values of the machine
- description of function
- instructions for maintenance.

On each machine, information about

- manufacturer
- type
- year of construction
- rating (according to DIN) which are indispensable for the safe operation

must be permanently affixed and easily readable.

2.7 Working safety

The requirements for the prevention of accidents are to be followed and, the safety rules according to VDE and UVV are to be observed, especially at operation with more than 42 V.

The "Law about technical working substances" (law for the safety of machines) of April 27th, 1993 prescribes that technical working substances may only be issued if they are in accordance with the accepted rules of technology as well as with the prescriptions for the prevention of accidents and the industrial safety prescriptions.

At machines which are manufactured as from January 1st, 1996 the CE-mark of conformity must be present.

2.8 Inspection and maintenance

The operator is obliged to perform at least one inspection on the welding machine per year by a competent person. For machines and devices with especially high usage this testing cycle should be shortened. The working instructions should indicate times and extension of maintenance.

The appendix contains a pattern for inspection sheets.

3 General requirements on the heated tools

Heat is transferred from the inlayed electric heaters or heat transfer mediums (oil, gas etc.) to the surface of the heated tool by means of a heat conducting material.

The heated tool must be constructed in a way that under working conditions, a perfect heating up of the joining areas to welding temperature be guaranteed. Handling of the heated tool may not have a negative effect on the change over time. During adjusting and heat up time the operator must be able to observe the performance of the bead on the heated tool.

The heated tool has to be movable into a position in which it can be cleaned safely and without problems. The desired temperatures which can be set on the machine must not lead to a destruction or a changing of the surface coating.

The characteristic features of electrofusion welding are described in section 6.

3.1 Formation

The welding area of the work piece has to lie completely within the effective area of the heated tool. The effective area here is defined as the area in which temperature and heat to be transferred are adjustable within the demanded tolerance zone. The dimensions of the effective area have to be marked firmly on the heated tool.

3.2 Material

The heated tools are made out of a suitable material being sufficiently conducting, corrosion-resistant and without bubbles.

3.3 Condition of surface

The surface of the heated tool has to be within the effective area in a condition that the remaining of residue of the plastic material is avoided as much as possible. Cleaning of the surface must be possible without damage. Coatings (e.g. PTFE) are recommended in order to keep the surface more easily clean and to loosen the adhesive forces during the separation of the joining pieces.

PTFE-spray acts as a separating agent and must not be used. When the joining pieces are separated from the heated tool, the spray would also be taken into the weld seam.

For a quality check of the surface, new PTFE-coated heated tools have to be heated up to the working temperature of 260 °C for at least one hour before initial operation. Temperatures of more than 270 °C will destroy the PTFE-coating, and the heated tools have to be re-coated.

Notice as well:

- roughness class at PTFE-coating acc. to DIN/ISO 1302 N9 $R_a \leq 6{,}3$ µm, $R_t \leq 16$ µm. Usual thickness of coating is 30 up to 50 µm. The PTFE-coating should be colored in a way that enables detection of damage and residue of the welding process.
- For galvanized coatings, no pre-copper plating and no galvanized coatings containing copper may be used.

3.4 Minimum efficiency of the heated tool

At the end of the adjusting time, the fall of temperature in the area where the work piece is close-lying must be adjusted to a value < 5 °C, independent of the sort of temperature control, the thus resulting control behavior and the temperature profile on the effective heated tool area. For that purpose a sufficient heat capacity of the heated tool and a sufficient heating efficiency are necessary.

3.5 Minimum range of temperature

The heated tool has to be continuously adjustable in the necessary temperature range on the whole effective area

- while heated tool butt welding from 180 up to 260 °C
- while heated tool socket welding from 230 up to 270 °C

measured at the working position of the heated tool, after at least 30 min. operation, at a low blast, and at 23 ± 2 °C ambient temperature.

3.6 Precision of temperature

The variations of temperature on a heated tool result from technically-determined inaccuracy (variation of control and distribution of temperature in the effective area), from the position of the heated tool (e.g. natural convection, screening effects) and from ambient influences (e.g. draught).

Variation of control means the difference between the highest and the lowest temperature at any part of the effective area of the heated tool. Distribution of temperature results from the difference between the highest and the lowest average temperature in the effective area.

For the calculation of the technically determined variation in temperature, optimum test conditions are necessary, excluding ambient influences, such as natural convection. Disturbances, such as draught, influence the measuring results under field conditions so seriously that variations in temperature which are higher than the values of the complete technically-determined variations shown in table 1 do not necessarily indicate an insufficient heated tool.

If in the working position of a heated tool (vertical position) a deviation in temperature is measured which is higher than the allowed one according to table 1, line 3, the measurement has to be repeated in horizontal position. In case of repeated deviations, further steps should be taken in order to optimize the test conditions (e.g. lab-examinations).

Measurements are taken at 4 points of the outer effective area limit on heated tools for pipes, in intervals of 90°. On tools for welding sheets, the tool is moved into cleaning position, and the measurements are taken after expiration of 8 minutes in a medium without draught. They are taken at the center beginning at a distance of 50 cm, and at/under the fixing points. The time should be long enough that the values are indicated permanently, at least 60 seconds per check point. For the difference, select the smallest and the highest measured value.

The measurements are taken at 23 ± 2 °C ambient temperature and a heated tool temperature of 210 °C, respectively 260 °C (heated tool socket welding). For that purpose, high-speed thermometers with a surface strip sensor are suggested which enable a good contact to the surface and quick reaction times.

The temperature control should be integrated in the machine control in order to indicate higher variations from desired temperature on the heated tool or to block the welding process.

4 Machines for heated tool butt welding

The problem definitions in the various ranges of application for heated tool butt-welding make diverse requirements for the respective welding machines.

4.1 Welding machines for pipes

Welding machines for pipes can be designed mainly for operation on site or in the workshop. Workshop machines normally enable a higher grade of mechanization due to the fixed installation.

4.1.1 Clamping devices

In order to avoid high local stress in the pipe and deformations, the clamping devices have to enclose the pipe surface for at least 80 %, parallel to the welding area. They have to be solid enough to keep the geometric circular form of the pipes. Even under highest working pressures they have to maintain their position to the guides.

Table 1. Maximum allowed technically determined variations in temperature.

	Heated tools for pipes and fittings					Heated tools for sheets
Effective area [cm²]	< 250	≥ 250 ... ≤ 2000	> 2000 ... ≤ 5000	> 5000 ... ≤ 12000	> 12000	
Variation of control [°C]	3	3	3	3	3	3
Distribution of temperature within the effective area [°C]	5	7	11	13	14	8
Total technically determined variation [°C]	8	10	14	16	17	11

The clamping devices have to be constructed in a way that no sharp-edged damages may occur on the pipe surface. It is recommended to put not more than 2 clamping shells into one another. If more shells are inserted, the manufacturer has to take this into consideration during construction.

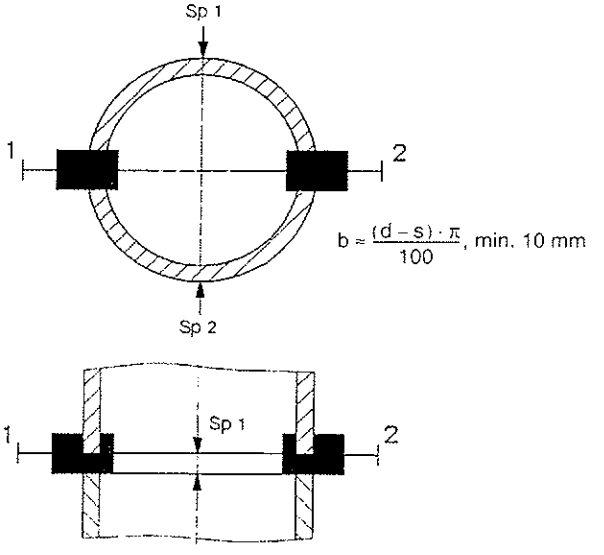
For fittings, special clamping devices may be provided. If necessary, they have to be horizontally and vertically adjustable.

4.1.2 Guide elements and clamping devices

Guide elements and clamping devices together have to guarantee in the test according to figure 1 in the respective working area of the machine, even with maximum working pressure and larger pipe diameter, that the values of table 2 (measured at cold joining areas) not be exceeded in case of bending or movement of the pipe at the most sensitive point.

Table 2. Difference of the gap dimensions at joining pressure depending on the pipe diameter (intermediate values have to be interpolated).

Pipe diameter d [mm]	Difference of the gap dimensions ≈ 0.8‰ x d, min. 0.25 [mm]
≤ 315	0.25
315 ... 630	0.25 ... 0.50
630 ... 800	0.50 ... 0.65
800 ... 1000	0.65 ... 0.80
1000 ... 1200	0.80 ... 0.95
1200 ... 1600	0.95 ... 1.30



1/2 turned by 90° to the guide elements, e.g. horizontally arranged clamping pieces with lower guide
b breadth of the clamping pieces
Sp 1 upper check point
Sp 2 lower check point
d pipe outside diameter
s pipe wall thickness

Figure 1. Measurement of the gap dimension.

Measurement is taken when the pipes are clamped and planed in the machine. Adjusting of the pipes and planing has to be done carefully since there should be no (or only a small) gap between the pipe ends. The machine is opened and two facing clamp pieces are put on the pipe ends, turned by 90 degrees to the guide elements. The clamp pieces have to be produced with a precision in measuring thickness of ± 0.025 mm. Then the pipe ends are driven to each other until they are in contact. The difference of the gap dimension at Sp 1 and Sp 2 means inaccuracy of planing. After that, the pressure on the joining pressure of 0.15 N/mm² necessary for the clamped pipe is increased. The thus resulting difference of the gap dimensions on Sp 1 and Sp 2 must not exceed the value according to table 2 plus the formerly determined inaccuracy resulting from the planing process. A measuring block should be inserted for the determination of the gap dimensions according to figure 1.

Guide elements must be protected against corrosion at the sliding surface, e.g. by means of hard chrome plating.

4.1.3 Heated tools

The used heated tool should be plane-parallel within the effective area. For allowed variations see table 3.

Table 3. Allowed variation from plane-parallelism.

Diameter or length of edge [mm]	Allowed variation from plane-parallelism [mm]
≤ 250	≤ 0.2
250 ... 500	≤ 0.4
500 ... 800	≤ 0.8
800 ... 1200	≤ 1.2
1200 ... 1600	≤ 2.0

Measurement is taken at 23 ± 2 °C and at a singular short-timed heat up of the heated tool up to maximum operation temperature of 260 °C. For operation in the workshop, the heated tool is in general firmly mounted on the machine (floating suspension). In case the heated tool is not fixed, the respective devices for driving in and fixation must be provided (e. g. grips, hooks, loops).

In case the heated tool needs to be separated mechanically from the joining surfaces due to the dimension and quality, the respective devices are to be provided.

The current supply in the area of the heated tool should be protected against thermal damages, and the effective area of the heated tool against mechanical damage. Heated tools which are not fixed to the machine should be put into a protective device during non-use.

4.1.4 Device for the preparation of the weld seam

For the plane-parallel cutting of the joining surfaces of the clamped pipes, a respective cutting device has to be provided. The cutting device must bring the chips to the outside diameter of the pipe. The operator must be able to see the resulting chips and to finish the planning process when plane-parallelism is reached. The maximum allowed variation from the plane-parallelism of the joining surfaces can be seen in table 4.

Table 4. Allowed variation from plane-parallelism.

Pipe diameter [mm]	Allowed variation from plane-parallelism [mm]
≤ 355	≤ 0.5
400... < 630	≤ 1.0
630... < 800	≤ 1.3
800...< 1000	≤ 1.5
>1000	≤ 2.0

4.1.5 Controlling and regulating devices for force, time, temperature and path

Controls and regulations have to be adjustable and guarantee a consistent welding.

4.1.5.1 Control of force

During heated tool butt welding, the forces for adjusting, heating up and joining from the smallest up to the largest welding diameter must be continuously adjustable, with respect to the different specific forces for the weldable plastics. Friction losses in drive or guide elements have to be detected in the right way,

e.g. by means of load cells. The operation forces must be increased by this moving force. The respective actual force at the joining surfaces has to be indicated on an instrument which is large enough to be easily readable. The manufacturer has to indicate the adjustable minimum and maximum force of the machine. The force range of the machine must be adjusted with a pressure reserve of ≥ 20%, which is necessary for a maximum welding diameter and for the surmounting of the frictional forces.

The heating up pressure has to be controllable to zero after adjusting. Test e.g. by means of a pressure pickup. Beginning with zero, the joining force is increased by degrees (lineally) regularly up to the final value as soon as the joining surfaces have touched each other. This final value has to be kept during cool-down time.

4.1.5.2 Control of time

An exact time control is the guarantee for a correctly combined affect on the machine functions and forces, especially clear with the linear increase of the adjusting and the joining force.

The adjusting time begins when the joining surfaces touch the heated tool and ends when full contact is made.

The heating up time begins after the adjusting, when the heated tool is lying completely on the joining surfaces and ends with the separation of the heated tool.

The change-over time begins with the separation of the heated tool from the joining surfaces and ends with the contact of these surfaces. It results from the sum of various machine functions and should be as short as possible.

The joining time begins with the contact of the joining surfaces and ends when the welding joint has cooled down. This includes the build-up time for the joining pressure, increasing from zero linear to the final value.

4.1.5.3 Control of path

The machine control should detect and work with the position of the guide elements and thus of the work pieces to each other. Thus time-optimized movements are started. The construction of the machine has to realize the required change-over times.

4.1.6 Construction of the machine and safety in operation

Workshop machines have to fulfill the following requirements:

- solid design
- universal basic construction (assistant tools and clamping devices swivelling or moving)
- quick clamping device
- grade of mechanization as high as possible
- indication of the pressure intensification (hydraulic pressure / welding force)

Besides a light construction, machines for the site should fulfill the following requirements:

- solid design
- devices for transport, bringing into and out of pipe ditches (e.g. grips)
- in case of larger machines, a running gear with locking device is recommendable
- indication of the pressure intensification (hydraulic pressure / welding force)

For the construction and operation of the machines, the respective safety rules have to be observed. See also section 7.

4.2 Welding machines for sheets

The welding machines are mainly designed for stationary use for the welding of sheets or work pieces formed out of sheets with a straight-lined seam. For the production of consistent weld seams of high quality a high grade of automation is necessary.

4.2.1 Clamping devices

The clamping force applied to the work piece by means of the clamping device is the product of machine force and friction loss between clamping shells and surface of the work piece. The necessary clamping force may be applied either only by means of the clamping device or by means of a combination of clamping device and additional clamping device. The clamped work pieces may not make any relative movements towards the clamping elements, i.e. slide through.

Normally, clamping devices consist of supporting tables and clamping beams. They have to enable an exact clamping of the work pieces. The mismatch of the table supports one to the other must not exceed 0.2 mm at the plate support. Take special care that the supporting tables are guided exactly and that a bending or tipping is avoided by means of right strengthenings and bearings.

The selected form of the section for the clamping devices is in direct relation to the smallest hollow section in round or rectangular type which can be produced, and of which the dimensions have to be indicated by the manufacturer of the machine.

4.2.2 Guide elements

The guide elements have to guarantee that the clamped parts are in alignment and that they will not change their position under maximum working force. When welding short pieces, they must lay in the center of the table. The working instructions must indicate this necessity.

4.2.3 Heated tools

The used heated tool must be plane-parallel within its effective area over the height and the length. Allowed variations are shown in table 5, without any distinction of length.

Table 5. Allowed variation of plane-parallelity.

Height of effective area [mm]	Allowed variation of plane-parallelity [mm]
≤ 30	≤ 0.3
> 30	≤ 0.5

4.2.4 Controlling and regulating devices

The automation of the welding process through control or regulation of force, time, path and temperature is advantageous. The controls must be adjustable and guarantee a consistent welding. The adjustable minimum and maximum forces must be indicated by the manufacturer of the machine.

During the total welding process, the measured process data of heated tool temperature, table force and table path have to be registered and observed as far as possible. The control has to be constructed in a way that operating errors are avoided or indicated to the operator.

4.2.5 Construction of the machine and safety in operation

The machines have to fulfill the following requirements:

- solid construction
- frame and table construction resistant to torsion
- clamping forces must be worked into the frame of the machine
- avoid bending of the tables by means of several rolling bearings
- table movement with less friction.

For a better transport of the work pieces, solid table extensions should be provided which also enable a later attaching of work piece holders.

Quick unlocking of the clamping beams will make the safe and unproblematic discharging of welded hollow sections much easier.

The heated tool should be thermic insulated during the joining process so that neither radiant nor convective heat can influence the lower side of the work piece thus causing different speeds of cooling. The thermic insulation of the heated tool is always advantageous for the period when the heated tool is not in working position. Both measures are energy saving.

For the quality assurance of the welding process, the permanent print out diagrammatically of important data of heated tool temperature, table force and table stroke should be possible. The time for change-over and the force ramps of adjusting and joining should be lengthened. Complete the weld log by the name of the welder, seam number, site or order number etc. as well as by serial number of the machine and date including time.

In case the power supply is interrupted, no uncontrolled movements may be initiated.

5 Machines for heated tool socket welding

5.1 Designs

A distinction is to be made between socket welding devices with manual application of the force and socket welding machines with mechanical, pneumatic or hydraulic application.

The manual welding devices have been developed for welding diameters ≤ 50 mm. For welding, devices or machines with restricted guidance should be chosen.

All sorts of devices and machines are suitable for welding on site and in the workshop.

5.2 Technological variants

Heated tool socket welding can be done as described as follows:

The one technological variant of socket welding is without mechanical treatment of the surface in the area of the weld seam (process A).

The other technological variant is characterized by a mechanical treatment of the pipe surface in the area of the weld seam before starting the welding (process B). This may be done by means of calibration tools with dimensions according to table 6.

Table 6. Calibration diameters and lengths for cutting the pipe ends (process B).

Pipe diameter d [mm]	Calibration diameter d_1 [mm]	Calibration length l [mm] (minimum)
16	15.90 ± 0.05	13
20	19.90 ± 0.05	14
25	24.90 ± 0.05	16
32	31.90 ± 0.05	18
40	39.85 ± 0.10	20
50	49.85 ± 0.10	23
63	62.80 ± 0.15	27
75	74.80 ± 0.15	31
90	89.80 ± 0.15	35
110	109.75 ± 0.20	41
125	124.75 ± 0.20	44

Table 7. Dimensions of the heated tools for process A without mechanical treatment of the pipes.

Pipe diameter d [mm]	D_1 [1] [mm]	D_2 [1] [mm]	D_3 [1] [mm]	D_4 [1] [mm]	L_1 [mm]	L_2 [mm]	L_3 [mm]	R [mm]
16	16.15	15.92	15.43	15.65	11.0	4	13.0	2.5
20	20.15	19.94	19.40	19.65	12.0	4	14.0	2.5
25	25.15	24.92	24.37	24.65	13.0	4	15.0	2.5
32	32.15	31.90	31.34	31.65	14.5	5	16.5	3.0
40	40.15	39.88	39.31	39.65	16.0	5	18.0	3.0
50	50.20	49.84	49.27	49.65	18.0	5	20.0	3.0
63	63.20	62.78	62.22	62.70	24.0	6	24.0	4.0
75	75.25	74.57	73.67	74.98	26.0	6	26.0	4.0
90	90.30	89.54	88.61	90.05	29.0	6	29.0	4.0
110	110.30	109.45	108.48	110.10	32.5	6	32.5	4.0
125	125.30	124.38	123.36	125.10	35.0	6	35.0	4.0

1) Dimensions are valid at 260 + 10°C
Tolerances for diameter ≤ 40 mm ± 0.04 mm
≥ 50 mm ± 0.06 mm

Table 8. Dimensions of the heated tools for process B with mechanical treatment of the pipes.

Pipe diameter d [mm]	D_1 [1] [mm]	D_2 [1] [mm]	D_3 [1] [mm]	D_4 [1] [mm]	L_1 [mm]	L_2 [mm]	L_3 [mm]	R [mm]
16	15,90	15,76	15,37	15,50	14,0	4	13	2,5
20	19,85	19,70	19,31	19,45	15,0	4	14	2,5
25	24,85	24,68	24,24	24,40	17,0	4	16	2,5
32	31,85	31,65	31,17	31,35	19,5	5	18	3,0
40	39,80	39,58	39,10	39,30	21,5	5	20	3,0
50	49,80	49,55	49,07	49,30	24,5	5	23	3,0
63	62,75	62,46	61,93	62,20	29,0	6	27	4,0
75	74,75	74,42	73,84	74,15	33,0	6	31	4,0
90	89,75	89,38	88,75	89,10	37,0	6	35	4,0
110	109,70	109,27	108,59	109,00	43,0	6	41	4,0
125	124,70	124,22	123,49	123,95	48,0	6	46	4,0

1) Dimensions are valid at 260 + 10°C
Tolerances for diameter ≤ 40 mm ± 0.04 mm
≥ 50 mm ± 0.06 mm

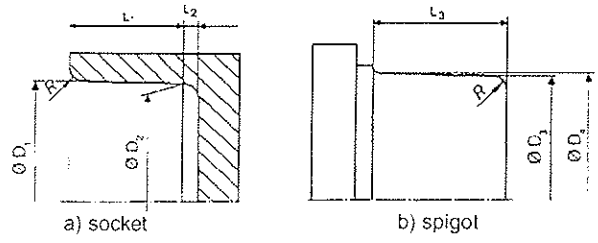


Figure 2. Heated tools for socket welding.

The requirements for the dimensions of the fittings for heated tool socket welding are determined in the respective standards, see section 7.1.

5.3 Welding machines and devices

5.3.1 Heated tools

For the best possible transmission of the heat from the heated surfaces onto the heated tools a totally plain layer is necessary. The heated tools (sockets and spigots) are described in figure 2, the dimensions are shown in table 7 and table 8.

5.3.2 Clamping devices

The clamping devices have to guarantee that pipes and fittings will be held safely without deformation, and that they will come together in centered position.

5.3.3 Guide elements

The guide elements have to guarantee that the joining pieces are moved centrically towards the heated tools during heating up and welding process.

If necessary, adjusting devices for centering must be provided.

5.3.4 Controlling and regulating devices for force and path

The strength of the machines has to be rated in a way that joining may be executed evenly and without shock.

A distance limitation for the heating up as well as for the welding process has to be provided according to the depth of the socket.

6 Electrofusion welding devices

The devices are mainly used in mobile building site operations. Considerations for this fact must be made in the design. Operation with different generators has to be possible (take note of the manufacturer's information).

6.1 Construction

6.1.1 In general

The calibration and the maintenance of the welding device should be easy. The manufacturer has to indicate the power for the connection to a generator.

The weight has to be reduced to a minimum for the easy transport of the device by a singular person. It should not weigh more than 35 kg including frame and connection cable.

Under all usual site conditions, the operation has to be possible without dangers. Device and accessories have to be designed in a way that the working safety and the efficiency may not be affected either by corrosion or by mechanical influences during transport or handling.

It must not be possible to start the welding process if the input parameters and/or the connected load are beyond the specific operation range.

6.1.2 Electrical safety

The welding device has to be in accordance with the protective system IP 54 according to DIN VDE 0721-911. All electric parts must be protected against condensation. In the buttons and keys at the outside of the device, no water may accumulate.

The device has to resist an insulation check with 3750 V during one minute according to DIN EN 60742. The testing voltage is laid on all elements which are separated from the supply voltage by insulation.

The output circuit must be galvanized and separate from the input, and so constructed that the safety of the operator be guaranteed.

The safety requirements of the national regulations must be fulfilled by machines as well as accessories.

A firmly mounted connection cable has to be at least 4 m long. The flexibility must be adapted to the operating and storing conditions.

The plugs have to meet the safety requirements for outdoor use.

The following operation controls must be easily visible:

- START-key in green color
- EMERGENCY-OFF-key in red color

The EMERGENCY-OFF-key has to guarantee a safe separation from the power supply even under the most unfavorable conditions.

A short circuit overload protection has to be provided in the input circuit.

6.1.3 Direction of operator

All the optical and/or acoustic signals have to be well perceptible under normal site conditions.

6.1.4 Identification systems

The welding device has to be provided with a device for reading and decoding of the welding parameters. Indications may be made by manual keyboard entry, but preferably by automatic input by means of a data medium such as bar code or magnetic card. The change of data after the start of the welding process must not be possible.

6.1.5 Thermometry for compensation of the welding energy

The welding device may be equipped by an element for thermometry of the ambient temperature. The definition of the measurement should be 1 °C. The device may be fixed at the welding device or be movable for measurement by the operator. The influence of the heating of the machine itself may not be larger than the accuracy of temperature.

6.1.6 Transformers

All transformers have to be security transformers according to DIN EN 60742, including an internal overload protection.

6.2 Courses of operation

Extent and frequency of the input voltage have to be observed. If the measured values are beyond the guaranteed limits this has to be indicated acoustically and/or optically.

The entered data may be checked for conformity with the connected fitting by the operator or by the welding device. In case of automatic input, all data are checked by the device. Should a non-conform data for the welding process be discovered, the start of the welding process must be blocked, and the cause indicated.

The operator must confirm the indicated information by pressing the START-key or another key. See also the working instructions of the manufacturer.

After the primary or the secondary circuit of the welding device has been interrupted, a complete restart of the welding process has to be performed. If the welding is interrupted by an external or internal incident, the reason for the interruption has to be indicated.

Important information about the welding process (time, voltage, current, resistance, power) should be indicated.

6.3 Requirements on the devices

6.3.1 Range of operation

Operation of the welding device has to be possible between −10 °C and +40 °C without restriction.

6.3.2 Power supply

Operation on the line as well as on a generator has to be possible. The device has to be designed for a tolerance in frequency and in voltage of at least ± 15%. Any damage by exceeding the indicated range of voltage or frequency must be excluded.

6.3.3 Resistance measuring of the fitting

Devices with resistance measuring may show a maximum measuring inaccuracy of ± 5%. Before starting the welding process, the fitting is checked for ease of passage. The testing voltage may not heat the filament of the fitting.

The open-circuit voltage of the measuring device may not exceed 24 V.

6.3.4 Energy output

The control is to register either voltage or current within the welding time or the welding energy.

The maximum output power has to be declared for the continuous duty at 23 °C. An overload of 10% for at least one minute has to be possible. The cycle time (ratio time switched-on to time switched-off) for calculating the duty cycle (ED) has to be at least 10 for devices with output power ≤ 2 kW, and at least 15 for devices ≥ 2 kW.

6.3.4.1 Control of voltage

The output voltage is stabilized within a range of ± 2% of the desired welding voltage. The measurement of the voltage is taken at the fitting or at the adapter. Voltage controlled devices must be able to transfer 110 A. The desired voltage or current has to be reached in at least 3 steps (see table 9).

Table 9. Rise time in dependence on the nominal power.

Nominal power of the fitting kW	Maximum rise time s
≤ 1.5	1.0
> 1.5...≤ 2.5	3.0
> 2.5	5.0

6.3.4.2 Control of current

The output current is stabilized in a range of ± 2% of the working conditions. The prescribed desired current has to be reached within maximum 3 seconds.

6.3.4.3 Regulation of power

The power which is transferred into the fitting is to be controlled with an accuracy of ± 5% within the working conditions, including the correction of the ambient temperature.

6.3.5 Welding time

The welding time has to be kept with an accuracy of ± 1% under working conditions.

6.3.6 Safety devices

The welding device must be provided with safety devices which interrupt the welding process. Tripping has to be indicated and logged if a log recorder is present.

The obligatory safety devices consist of:

– Checking of voltage and current
If for more than 5% of the welding time (max. 3 seconds), the value of voltage or current is beyond ± 2% of the prescribed value, the welding process has to be interrupted.

– Interruption
The device does not start welding if a resistance > 200 Ω at the fitting is measured. Tests for interruptions are performed during the complete welding process. If an interruption occurs, the welding has to be aborted within a maximum of 1 second.

The optional safety devices consist of:

– Input voltage and frequency
If the input voltage is beyond the working range for more than 5 seconds, welding has to be interrupted.

– Short circuit
If the current in the fitting is increasing due to an unintended short circuit, welding has to be interrupted.

6.3.7 Stress detection

The welding device is stored during 24 hours at an ambient temperature of 40 °C ± 3%. Thereafter, the output power prescribed by the manufacturer should be reached with an ED of 60% for the duration of one hour (under consideration of the cycle time of the device according to section 6.3.4). After this check, the welding readiness must be listed according to these regulations.

6.4 Mechanical requirements

After a crash onto a concrete area from a height of 1 m, the welding device still has to be able to fulfill the requirements of these regulations.

6.5 Identification

The type plate on the welding device should contain the data prescribed in section 2.6. In addition, the technical data sheet should contain the data prescribed in table 10.

Table 10. Manufacturer's data sheet.

Power transfer [kW]	ED [%]	Duty cycle [s]	Turn-off cycle [s]
x[1)]	100	x[1)]	x[1)]
x[1)]	60	x[1)]	x[1)]
x[1)]	35	x[1)]	x[1)]
[1)] Manufacturer's information			

7 Standards and guidelines

7.1 Standards

DIN 16962	Pipe joints and pipeline components for pressure pipelines made of polypropylene (PP)
DIN 16963	Pipe joints and pipeline components for pressure pipelines made of high density polyethylene (PE-HD)
DIN 16831	Pipe joints and pipeline components for pressure pipelines made of polybutene (PB)

For PVDF no DIN standard is existing. The dimensions of the pipeline components for heated tool socket welding are corresponding to DIN 16962.

ISO 10931	Plastic piping systems for industrial applications – Poly(vinylidenefluoride) (PVDF)
DIN EN 292-1	Safety of machinery – Basic concepts, general principles for design – Part 1: Basic terminology, methodology
DIN EN 292-2	Safety of machinery – Basic concepts, general principles for design – Part 2: Technical principles and specifications
DIN EN 60204-1	Safety of machinery – Electric equipments of machinery – Part 1: General requirements
DIN EN 294	Safety of machinery – Safety distances to prevent danger zones being reached by the upper limbs

DIN EN 418	Safety of machinery – EMERGENCY-OFF-device, functional aspects; principles for design
DIN EN 60742	Isolating transformers and safety transformers; requirements
DIN ISO 1302	Engineering drawings; statement of the surface quality
DIN VDE 0100	Regulations for the erection of power plants with nominal voltages up to 1000 Volt
DIN VDE 0105-1	Operation of power plants; general definitions
DIN VDE 0281-1	Polyvinyl chloride-isolated transmissions with nominal voltages up to 450/750 V – Part 1: General requirements
DIN VDE 0551	Regulations for safety transformers (German version of EN 60742)
DIN EN 60335-1	Safety of electric appliances for use in the home and similar purposes – Part 1: General requirements
DIN EN 60335-2	Safety of electric appliances for use in the home and similar purposes – Part 2: Special requirements for portable electric heating apparatus
DIN VDE 0721-911	Industrial electric heating installations – General safety regulations
DIN VDE 0470-1	Types of protection by housings (IP Code)

7.2 Directives

DVS 2207-1	Welding of thermoplastics; Part 1: Heated tool welding of pipes, pipeline components and sheets made of PE-HD
DVS 2207-11	Welding of thermoplastics; Part 11: Pipelines made of PP
DVS 2207-15	Welding of thermoplastics; Part 15: Heated tool welding of pipes, pipeline components and sheets made of PVDF
89/293/EWG	Guideline of the Council of June 14th, 1989 for the adaptation of the legal regulations of the member states for machinery
VBG 4	Electric installations and operating material
VBG 5	Power operated working substances
VBG 22	Machines for the chemical industry, rubber and plastic industry

8 Explanation

The directive edition 7.83 was updated according to the latest developments in technology. Statements to the devices for electrofusion welding were enlarged.

In the opinion of the Committee, heated tool socket weldings are performed today with tools according to process B (table 8) only. In the next revision, the tools of process A (table 7) will no longer be listed.

The observance of the regulations for working safety and the prevention of accidents should be assessed by a neutral building inspection. In addition, maintenance instructions were described.

Devices for contact-less heated tool welding are being explored at present by another working committee.

Appendix: Patterns for test certificates

Test certificate for heated tool butt welding machines (components pipeline)

Product/manufacturer _____ Type _____

Machine/device no. _____ Range of dimension* _____

Heated tool no. _____ *(also valid for the necessary heated tools)

Date of last inspection _____

	Test result	Assessment
• Safety of persons and operation		
Connection cable incl. plug		
Tools and operating elements		
Condition and tightness of the hydraulic system		
Optic and acoustic checking devices		
EMERGENCY-OFF-function		
• Clamping device and guide elements		
Measurement of gap	Gap difference ____ mm	
Condition of clamping elements and surface		
Condition of guide elements		
Condition of sliding surfaces		
• Cutting tools		
Condition of the cutting elements		
Assessment of chip	Thickness of chip ____ mm	
Plane-parallelity of joining areas after treatment		
Condition of joining areas after treatment		
• Heated tool	Adjusted temperature ____ °C	
Plane-parallelity	Variation * ____ mm	
Distribution of temperature	Variation * ____ °C	
Accuracy of temperature acc. to set-point	Variation * ____ °C	
Condition of surface		
Performance test (for the dimension range)		
Joining force control	Variation * ____ %	
Accuracy of reading joining force (gauge pressure)	Variation * ____ %	
Build up time joining force	Variation * ____ %	
Active time joining	Variation * ____ %	
* (variation from reference quantity)		
	Reference quantity according to DVS	
• Working instructions (in case of missing, enter 0)		
Assessment general condition (for remarks regarding the general condition please use a separate sheet)		

Key of assessment tests and condition
1 = without claim
2 = small claim
3 = claim restricting the use
4 = further use not allowed

Key of assessment measurements
1 = within allowed tolerances
2 = variation with small influence
3 = variation restricting the use
4 = not allowed variation

Date of test: Testing dept. with stamp and signature:

Tester:

Test certicate for heated tool butt welding machines (sheets)

Product/manufacturer _____ Type _____

Machine/device no. _____ Range of dimension* _____

Heated tool no. _____ *(also valid for the necessary heated tools)

Date of last inspection _____

	Test result	Assessment
• Safety of persons and operation		
Connection cable incl. plug		☐
Tools and operating elements		☐
Condition and tightness of the hydraulic / pneumatic system		☐
Condition of maintenance unit		☐
Optic and acoustic checking devices		☐
EMERGENCY-OFF-function		☐
• Clamping device and guide elements		
Condition of clamping elements and surface		☐
Condition of guide elements		☐
Condition of sliding surfaces		☐
Table mismatch	☐ mm	☐
• Flattener		
Plane-parallelity		☐
Straightness and alignment		☐
Elevation adjustment		☐
• Heated tool	Adjusted temperature ☐ °C	
Plane-parallelity	Variation * ☐ mm	☐
Elevation adjustment in working position		
Distribution of temperature	Variation * ☐ °C	☐
Accuracy of temperature acc. to set-point	Variation * ☐ °C	☐
Condition of surface		☐
Performance test (for the dimension range)		
Joining force control	Variation * ☐ %	☐
Accuracy of reading joining force (gauge pressure)	Variation * ☐ %	☐
Build up time joining force	Variation * ☐ %	☐
Active time joining	Variation * ☐ %	☐
* (variation from reference quantity)		
	Reference quantity according to ☐ DVS	☐
• Working instructions (in case of missing, enter 0)		☐

Assessment general condition (for remarks regarding the general condition please use a separate sheet) ☐

Key of assessment tests and condition
1 = without complaint
2 = small complaint
3 = complaint restricting the use
4 = further use not allowed

Key of assessment measurements
1 = within allowed tolerances
2 = variation with small influence
3 = variation restricting the use
4 = variation not allowed

Date of test:

Testing dept. with stamp and signature:

Tester:

Test certificate for heated tool socket welding machines

Product/manufacturer _____ Type _____

Machine/device no. _____ Range of dimension* _____

Heated tool no. _____ *(also valid for the necessary heated tools)

Date of last inspection _____

	Test result	Assessment
• **Safety of persons and operation**		
Connection cable incl. plug		☐
Tools and operating elements		☐
Optic checking devices		☐
• **Clamping device and guide elements**		
Condition of clamping elements and surface		☐
Condition of guide elements		☐
Condition of sliding surfaces		☐
Condition of rack		☐
• **Cutting tools (process B)**		
Condition of peeling tool		☐
Condition of peeling elements		☐
Condition of joining areas after treatment		☐
• **Heated tool (socket and spigot)**	Adjusted temperature ☐ °C	
Accuracy to size (after adjested temperature has been reached)	Variation * ☐ mm	☐
Distribution of temperature	Variation * ☐ °C	☐
Accuracy of temperature acc. to set-point	Variation * ☐ °C	☐
Condition of surface		
* (variation from reference quantity)	Reference quantity according to DVS	
Performance test		
Movement control		☐
Locking device		☐
Efficacy of limit stop		☐
• **Working instructions** (in case of missing, enter 0)		☐
Assessment general condition (for remarks regarding the general condition please use a separate sheet)		☐

Key of assessment tests and condition
1 = without complaint
2 = small complaint
3 = complaint restricting the use
4 = further use not allowed

Key of assessment measurements
1 = within allowed tolerances
2 = variation with small influence
3 = variation restricting the use
4 = not allowed variation

Date of test:

Testing dept. with stamp and signature:

Tester:

Test certificate for electrofusion welding devices

Product/manufacturer _____ Type _____

Device no. _____ Date of last inspection _____

	Test result	Assessment
• **Safety of persons and operation**		
Connection cable incl. plug		☐
Optic and acoustic checking devices		☐
Short circuit and overload protection		☐
EMERGENCY-OFF-function		☐
Insulating resistances		☐
• **Welding device, visual check**		
Housing		☐
Measuring pin, probe		☐
Display		☐
Adapter		☐
Welding cable		☐
• **Welding device, performance test line-powered**		
Start, stop		☐
Keyboard/reading pen/scanner		☐
Input of welding data		☐
Logging		☐
• **Check of the welding voltage** (by means of digital measuring unit with Crest-factor > 3.0)	Actual value / Variation	
Load: 0.3 Ω / Test voltage 20 V (± 2 V)	☐ V ☐ %	☐
Load: 15 Ω / Test voltage 40 V (± 2 V)	☐ V ☐ %	☐
• **Check of temperature coverage** (by means of testing thermometer with allowed variation ± 3°C)	Value at 40°C / Value at 40°C	
Actual value	☐ °C ☐ °C	☐
Variation from limit	☐ % ☐ %	☐
• **Check of resistance and welding time** (by means of digital measuring unit and stop watch)	Variation at 0.3 W / Variation at 15 Ω	
Comparison of resistance with reference value (allowed var. = ± 5%)	☐ % ☐ %	☐
Comparison of welding time with reference value (allowed var. at > 100 s = ± 1%)	☐ % ☐ %	☐
• **Working instructions** (in case of missing, enter 0)		☐
• **Date of maintenance exceeded**	☐ yes ☐ no	☐
Tip: the herewith documented test does **not** substitute the inspection by the manufacturer		
Assessment general condition (for remarks regarding the general condition please use a separate sheet)		☐

Key of assessment tests and condition
1 = without complaint
2 = small complaint
3 = complaint restricting the use
4 = further use not allowed

Key of assessment measurements
1 = within allowed tolerances
2 = variation with small influence
3 = variation restricting the use
4 = not allowed variation

Date of test:

Testing dept. with stamp and signature:

Tester: