

**Content:**

- 1 Scope
  - 2 General description of methods
  - 3 Requirements on welding equipment
    - 3.1 General
    - 3.2 Special requirements for distance control
  - 4 Radiant heated tools
    - 4.1 Radiators
      - 4.1.1 Types of radiators
      - 4.1.2 Temperature exactness
    - 5 Welding, procedure and parameters
      - 5.1 General requirements
      - 5.2 Measures before welding
        - 5.2.1 Welding requirements
        - 5.2.2 Cleaning
      - 5.3 Preparation of the components to be welded
      - 5.4 Welding procedure
        - 5.4.1 Start-up
        - 5.4.2 Heating up
        - 5.4.3 Changeover
        - 5.4.4 Joining
        - 5.4.5 Cooling
      - 5.5 Safety indications
    - 6 Testing of welded joints
      - 7 Standards and Technical Codes
        - 7.1 Standards
        - 7.2 Technical Codes
      - 8 Explanations
- Appendix: Indications and protocol for testing of equipment  
Welding protocols

**1 Scope**

In this Technical Code the non-contact heated tool butt welding and the requirements for devices and machines are described. With the mentioned features the processor can check which devices or machines are most suitable for the safety realizable performance of his welding works appropriate to the materials involved.

This Technical Code relates to methods and the different types of processes of heated tool butt welding where the heating up of the joining areas is done without any contact. Machines, devices and their parameters for the welding of pipeline components, sheets and other components out of PP (PP-H/PP-B/PP-R) and PVDF are described. Occasionally the system dependency according to the manufacturer's instructions with material combinations of PP and PVDF have to be considered. Concerning the welding suitability of materials PP and PVDF see the topic "scope" in DVS 2207-11 and DVS 2207-15.

With the welding of other plastics e.g. PFA, E-CTFE the parameters have to be checked and possibly adjusted. The welding joint quality must be proved depending on the system (machine, parameters, component).

**2 General description of methods**

With the non-contact heated tool butt welding the joining areas of the parts to be welded have to be shaved in order to reach a plan

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.

parallelism of the surfaces to be joined. The joining areas have to be heated up without contacting the heating tool yet maintaining a defined distance in order to achieve a thermoplastic condition (heating up). After reaching a plasticised state the radiant heated tool butt is removed (adjusting) and the components are joined under pressure (joining). The welding joint has to be cooled down whilst retaining the joining pressure in the finished joining position.

The following joining methods are distinguished at heated tool butt welding machines with radiant heating:

- Welding with joining pressure control: the joining pressure is adjusted and kept constant by the machine.
- Welding with joining distance limitation: the joining distance is limited with adjustable distance bolts.
- Welding with combined joining pressure control and joining distance limitation: the joining distance is limited by machine control and adjusted to the joining force control by a thermal reduction after falling below a certain joining force.

**3 Requirements on welding equipment****3.1 General**

The requirements on welding machines for the non-contact heated tool butt welding method are mentioned in the Technical Code DVS 2208-1. Further detailed requirements are listed in section 3.2.

**3.2 Special requirements for distance control**

Welding machines with an automatic joining process demand the adjustment for an exact distance control. With manual controlled machines the position of the guiding devices must be exactly adjustable by distance bolts.

With the application of mechanical distance limits (distance bolts) these have to be suitably protected so that dirt or falling in of shavings is absolutely avoided. The reproducible position exactness must be  $\pm 0,05 \text{ mm}$ .

**4 Radiant heated tools**

Heated tool and machine are a unit. Therefore the machine has to be re-calibrated after the change of the heated tool.

The construction of the heated tool must guarantee a perfect heating up of the joining areas to the welding temperature under working conditions. The handling of the heated tool must enable keeping the adjustment time according to table 2.

The voltage supply in the heated tool area has to be protected against thermal damages, just as the active surface of the heated tool against mechanical damages.

The mounting and guidance of the heated tool must enable a plane parallel position of heated tool to the joining areas.

The heated tool must be plane parallel within its active surface and the maximum deviation must be lower than 0,2 mm. The measurement is done at  $23 \pm 2 \text{ }^\circ\text{C}$ .

#### 4.1 Radiators

The heated tools for non-contact welding are radiant heated tools which are classified depending on wave ranges.

##### 4.1.1 Types of radiators

The following types of radiators are usual:

- Short-wave or bright radiators (wave range up to 1,6  $\mu\text{m}$ )
- Medium-wave radiators (wave range > 1,6 up to 3,5  $\mu\text{m}$ )
- Long-wave or dark radiator (wave range > 3,5  $\mu\text{m}$ )

The general structure of radiators is that a filament is embedded in a metallic or ceramic mass which can be heated up to a temperature of 1000 °C with the wire. An infrared radiation (IR) is created.

##### 4.1.2 Temperature exactness

The temperature deviations measured on the heated tool opposite to the temperature adjustment result from technically limited inexactness (regulator deviation and temperature distribution on the active surface), installation position of the tool (e. g. natural convection, shielding effects) and environmental influences (e. g. draught).

**Table 1. Maximum allowed technically limited temperature deviations.**

	Heated tools for pipes and fittings		Heated tools for sheets
	< 250	$\geq 250 \dots \leq 2000$	independent
Active surface [cm <sup>2</sup> ]			
Regulator deviation [°C]	3	3	3
Temperature distribution on active surface [°C]	5	7	8
Technically limited total deviation [°C]	8	10	11

Since each heated tool has its own radiation characteristic the tool and machine must be adjusted (calibrated) to each other. This results in different heated tool surface temperatures with the same input temperature adjusted on the machine. This has to be considered during the measurement of the heated tool temperature.

The measurements are done at an ambient temperature of  $23 \pm 2$  °C and a reference temperature which is within the operating range of the machine.

Since the heated tools could have high temperatures, the measurement has to be done with an adequate measuring device. With the use of non-contact measuring devices (dark radiators), a measuring spot diameter of maximum 20 mm has to be kept.

#### 5 Welding, procedure and parameters

With the heated tool butt welding method with radiator heating, the welding parameters depend on the system. In the following the method parameters and method indications for the welding with joining pressure and joining distance limitation are given.

##### 5.1 General requirements

The quality of welding joints depends on the qualification of the welders, suitability of the used machines, devices and components as well as the compliance of welding guidelines. The welding joint can be tested and inspected by destructive and/or visual methods.

The welding works must be supervised. The type and scope of supervision has to be agreed. It is recommended to record the procedure data in welding protocols (example see appendix) or data carriers.

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

Every welder has to be trained. The intended application range may be decisive for the kind of qualification. The welding exam certificate according to DVS 2212-1 in the groups I-4 res. I-8 in conjunction with the complementing training certificate on non-contact heated tool butt welding issued by an authorized training institute or by the particular machine manufacturer is valid as qualification proof.

#### 5.2 Measures before welding

##### 5.2.1 Welding requirements

The welding zone must be protected against bad weather influences (e. g. moisture and temperatures below + 5 °C res. higher than + 40 °C). If it is ensured by suitable measures (e. g. preheating, tent, heating) that a component temperature sufficient for welding can be kept – as far as the welder is not hindered in his handling – work may be carried out at any outside temperature. If necessary, an additional proof must be provided by carrying out sample welds under the mentioned conditions, see section 6.

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 dow during the welding process by uncontrolled draught has to be avoided. During the welding of pipes the pipe ends have to be closed.

The joining areas of the parts to be welded may not be damaged and have to be free of contaminations (e. g. dirt, oil, shavings).

The welding process may only be started when the heated tool temperature according to manufacturer's instructions. This has to be guaranteed by adequate measures, e.g. timed lock, lock of menu prompt, etc. In order to guarantee an exact temperature distribution on the heated tool surface the heated tool in neutral position should be stored in a suitable protection device.

##### 5.2.2 Cleaning

The surfaces to be joined should be clean and free of grease and only similarly clean tools and heated tools are to be utilised if a perfect welding joint is to result.

##### 5.2.2.1 Cleaning agents

The use of cleaning agents is mentioned in the manufacturer's instructions.

The paper for cleaning must be clean, unused, absorbent, non-fraying and non-coloured.

##### 5.2.2.2 Cleaning of the heated tool

The heated tool may not be cleaned in heated up condition because of the high heated tool temperatures. Contaminations have to be removed from the cold heated tool whereby the manufacturer's instructions have to be considered.

##### 5.2.2.3 Cleaning of joining areas

Before shaving the joining areas it has to be ensured that the used tools and components are clean and free of grease in the welding zone, if necessary cleaning agents should be used.

#### 5.3 Preparation of components to be welded

The nominal wall thicknesses of the parts to be welded must correspond in the joining area.

During clamping the components to be welded must be aligned in