April 2009

DVS – DEUTSCHER VERBAND FÜR SCHWEISSEN UND VERWANDTE VERFAHREN E.V.

Welding of thermoplastics – Welding by bending using a heated tool for panels made of PP and PE

DVS
Technical Code DVS 2207-14

Contents:

1 Scope of application

This technical code applies to welding by bending using a heated tool for panels made of polypropylene[1)] (PP-H, PP-B and PP-R) according to DIN EN ISO 15013 and for panels made of PE[1)] according to DIN EN ISO 14632.

Paying attention to the instructions in this technical code, weldability may be assumed within the melt flow rates MFR[2)] 190/5 named below:

1 0.4 – 1.0 g/10 min (PP) – approximately corresponds to the melt flow rate MFR[2)] 230/2.16 of 0.2 – 0.6 g/10 min

2 0.3 – 1.7 g/10 min or 0.2 – 0.7 g/10 min (PE)

The main areas of application for welding by bending using a heated tool are in tank and apparatus construction as well as in ventilation and air conditioning technology. DVS 2207-1 and DVS 2207-11 are technical codes which are also applicable.

2 Process description

Welding by bending using a heated tool, also called folding welding, is a mixed form of forming and heated tool butt welding and is carried out on stationary machines, predominantly in the workshop area. In the case of panel thicknesses of $s \leq 6$ mm, the panel to be folded at an angle is put on a flat, thermally insulating support and the wedge-shaped heated tool is placed on the folding position (see Fig. 1).

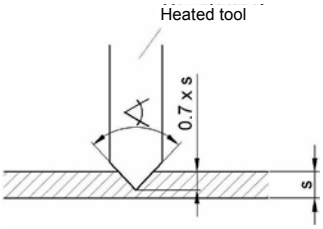

Figure 1. Welding by bending using a heated tool with heating on one side (principle).

In the case of panels with $s > 6$ mm, a flat heated tool which heats up the rear side of the panel is arranged on the underside of the machine (see Fig. 2). This serves to prevent any non-uniform stretching (tapering) in the folding zone and to achieve a reduction in the stresses.

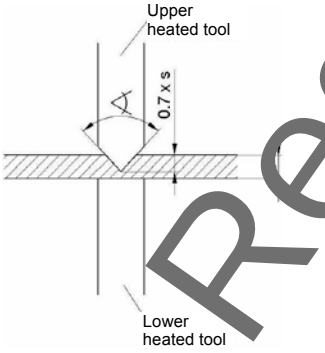

Figure 2. Welding by bending using a heated tool with heating on both sides (principle)

The wedge faces of the upper heated tool have a bevel angle adapted to the folding angle [α]. The heated tool is pressed in by approx. 75 % of the panel thickness under the effect of heat and is subsequently withdrawn. Thereafter, the panel is folded according to the bevel angle. In this respect, the plastified joining surfaces are joined with each other under joining pressure. In order

1) The material designation should be understood as a generic term for the group of thermoplastics and includes the PE 63, PE 80 and PE 100 types. The information corresponds to the current status of the standardisation.

2) MFR = melt flow rate (old designation: MFI = melt flow index)

DVS, Technical Committee, Working Group "Joining of Plastics"

Orders to: DVS Media GmbH, P.O. Box 10 19 65, 40010 Düsseldorf, Germany, Phone: +49(0)211/1591-0, Telefax: +49(0)211/1591-150

to shorten the heating-up time, panels with $s \geq 15$ mm can be provided with a groove milled in a wedge shape (depth: approx. 0.5 x wall thickness) on the top side of the panel into which the heated tool is pressed.

In order to be able to apply the joining pressure, the bevel angle of the heated tool must be smaller than the folding angle. A bevel angle of $\alpha = 87° \pm 1°$ is recommended for rectangular folds and $\alpha = 57° \pm 1°$ for folds of 60°. After the folding, the panel must be fixed for the duration of the cooling time.

The process can be applied accordingly to the PVDF material. Panels made of PVC-U and PVC-C are predominantly heated and bent without any contact

3 General requirements

The quality of the welds is influenced by the qualification of the welder, by the suitability of the utilised machines and jigs as well as by the process parameters. The quality of welds executed by bending using a heated tool can be investigated with the aid of destructive test procedures.

The welding work must be monitored. The contracting parties must reach agreement on the type and scope of the monitoring. Within the framework of the quality assurance, it is appropriate to have trial welds manufactured before the beginning and during the welding work and to test these. The process data of the welding work must be entered on welding record sheets without delay (for a specimen, see the appendix) or must be documented on data carriers.

The welders must be trained and must possess a valid qualification certificate. The type and scope of the qualification are determined by the area of application in which the welder is active. Welding by bending using a heated tool is assigned to the heated tool butt welding of panels to which the plastics welder qualification test according to DVS 2212-1 applies.

The machines and jigs used for the welding must comply with the requirements in DVS 2208-1. Requirements extending beyond these are described in this technical code.

4 Measures before the welding

4.1 Prerequisites for the welding

The folding area must be undamaged and must be protected from unfavourable ambient influences such as cold, draughts, the action of moisture and similar influences. If suitable measures (e.g. protected workplace and drying of the folding zone) ensure conditions permissible for the welding, the work may be carried out at any ambient temperature – provided that the dexterity of the welder is not hindered. If necessary, additional evidence must be provided by manufacturing trial welds under the ambient influences to be expected (see Section 8).

If the panel to be folded was heated non-uniformly due to solar radiation, the temperatures must be equalised in the area of the folding zone in good time before the welding. It is necessary to avoid any abrupt cooling during the welding operation, e.g. due to draughts.

4.2 Cleaning

For the manufacture of flawless welded joints, it is essentially important that not only the folding zone but also the tools and the heated tools are clean and free from grease. Wherever necessary, the zones affected by soiling must be cleaned using a suitable cleaning agent.

4.2.1 Cleaning agents

The cleaning agent, a cleaning fluid is most suitable, must consist of a solvent with 100 % vaporisation, e.g. of 99 parts ethanol with a degree of purity of 99.8 % and one part MEK (methyl ethyl ketone, denaturation). Cleaning agents tested according to DVGW 603 comply with this stipulation.

The cleaning fluid may be used in the form of cloths which have been moistened in the factory and must be kept in a lockable receptacle (e.g. plastic box). In so far as paper is utilised for the cleaning, this must be clean, unused, absorbent, non-fraying and undyed. Ensure subsequent extraction.

The use of spirit may lead to a quality reduction in the welded joint because of the water contained in it.

4.2.2 Cleaning of the heated tool

For optimum fold welds, it is necessary to clean the heated tool according to Section 4.2.1 before every welding operation, particularly if the material is changed. No residues of cleaning agents or paper may remain on the heated tool. The anti-adhesive coating or covering of the heated tool must be undamaged in the working area.

4.2.3 Cleaning of the folding zone

The folding zone must be cleaned immediately before the welding. The cleaning must be carried out beyond the welding area with a cleaning agent according to Section 4.2.1. If the folding zone is soiled once again (e.g. because of contact with the welder's hands), the area concerned must be recleaned.

4.3 Checking of the heated tool temperature

The heated tool temperature necessary for the welding must be checked before the beginning of the welding work. This is carried out, for example, with a quick-display temperature gauge for surface measurements whose sensor exhibits a contact area > 10 mm. The control measurement must be taken at the levels in the case of the upper heated tool and on the front face of the lower heated tool. So that a thermal equilibrium can occur, the heated tool may be used, at the earliest, ten minutes after the nominal temperature has been reached.

Table 1. Heated tool temperature.

	PE-HD	PP
Upper heated tool[1)]	210 ± 10 °C	
Lower heated tool[2)]	~ 230 °C	~ 140 °C

1) In the case of low wall thicknesses (s ≤ 4.5 mm), choose the higher temperature.
2) Dependent on the design of the machine. Preliminary tests are advisable. It must be possible to bend the panel without any great resistance.

5 Execution of the welding

5.1 Alignment

At the beginning of the welding operation, the folding zone is heated up to the welding temperature using the upper heated tool in the case of heating on one side or using two heated tools in the case of heating on both sides. Pressure or the dead weight of the upper heated tool results in a wedge-shaped recess in the panel. This is designated as alignment. The alignment operation is concluded when the heated tool has penetrated into the panel by 0.7 x wall thickness (see Fig. 1 and Fig. 2).

5.2 Heating-up

When the penetration depth has been reached, the joining zone is heated up on both sides of the heated tool in order to plastify the joining faces. Guide values for the heating-up times, depending on the nominal wall thickness of the panel, are included in DVS 2207-1, Table 2, Column 3 for PE and in DVS 2207-11, Table 2, Column 3 for PP. Optimum results are obtained when these heating-up times are shortened by 20 %.