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DVS – DEUTSCHER VERBAND FÜR SCHWEISSEN UND VERWANDTE VERFAHREN E.V.	Ultrasonic joining of mouldings and semi-finished products made of amorphous thermoplastics in series fabrication	Technical Code DVS 2216-6

Replaces June 2002 edition

Contents:

1 Scope of application

This technical code applies to the ultrasonic joining of mouldings with each other and also to combinations of mouldings and semi-finished products made of amorphous thermoplastics, homopolymers and copolymers as well as their blends including reinforced, filled, elastomer-modified, fire-protected and special settings from these plastics.

This technical code should be seen in connection with the DVS 2216-1 to DVS 2216-5 technical codes in which the general fundamentals for the ultrasonic joining of mouldings and semi-finished products made of thermoplastics are described.

2 Procedural description

In the case of ultrasonic welding and ultrasonic forming, the electrical oscillations produced by the generator in the kHz range are transformed into mechanical vibrations with the same frequency in the ultrasonic transducer (acoustic head and converter) and are supplied to the joining parts via the transformation piece (booster) and the sonotrode. In this respect, the generator, the ultrasonic transducer, the transformation piece and the sonotrode work in resonance.

The thermoplastic in the joining region is heated by means of energy transformation due to alternating compressive stresses, caused by the input mechanical vibrations, the interfacial friction of the joining faces and reflection. The locations of the maximum alternating compressive stresses are dependent on the joining part geometry.

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3 Description of the materials to be welded

3.1 Homopolymers

3.1.1 Polystyrene (PS)

Polystyrene is frequently utilised in an undyed form since the shining, crystal-clear appearance comes to bear in this case. Mouldings made of polystyrene are brittle and have very low water absorption and very good electrical insulation behaviour. Solar radiation leads to yellowing and to embrittlement which raises the sensitivity to stress cracks even further. The maximum utilisation temperature is 80°C and the processing temperature between 190°C and 260°C depending on the type.

3.1.2 Polymethyl methacrylate (PMMA)

Because of the good transparency and scratch resistance, the main area of application of polymethyl methacrylate is for components with optical requirements. Pure PMMA is brittle but has outstanding weathering resistance and only low water absorption. The heat distortion temperature is low, the maximum utilisation temperature approx. 100°C and the processing temperature 210 - 250°C. Cast PMMA is not weldable.

3.1.3 Polycarbonate (PC)

Polycarbonate is utilised in transparent and dyed forms. Mouldings made of PC possess high strength and toughness. The weathering resistance is good, as is the electrical insulation behaviour. The water absorption is low but water contact at high temperatures leads to a deterioration in the mechanical properties due to hydrolysis. The sensitivity to stress cracking caused by residual stresses can be reduced by tempering at 120°C. The maximum utilisation temperature is 135°C and the processing temperature 280 - 320°C.

3.1.4 Polysulphones (PSU and PES)

Polysulphones have high heat distortion temperatures and, even at high temperatures, very good electrical properties. The weathering resistance and the hydrolysis resistance are good but small quantities of water are absorbed quickly. The strength is good but mouldings are sensitive to notches. The maximum utilisation temperature is 200°C and the processing temperature over 320°C.

3.2 Copolymers

3.2.1 Acrylonitrile / butadiene / styrene (ABS)

ABS belongs to the polystyrene group which, due to the butadiene component, exhibits high impact and notched impact strengths, even at low temperatures. The acrylonitrile proportion increases the heat distortion temperature compared with PS. The resistances to stress cracking and to chemicals are good, as is the scratch resistance. Special ABS types are galvanisable. The maximum utilisation temperature is 100°C and the processing temperature 220 - 260°C.

3.2.2 Acrylonitrile / styrene / acrylic ester (ASA)

As far as the chemical structure is concerned, ASA is identical with ABS. In the case of the ASA, the butadiene component is replaced by acrylic ester. The properties are comparable with those of ABS but it is frequently utilised in a crystal-clear form and has better ageing and weathering resistances and very good antistatic behaviour. The maximum utilisation temperature is 90°C and the processing temperature 230 - 280°C.

3.2.3 Styrene / acrylonitrile (SAN)

SAN exhibits better behaviour than PS with regard to the strength, the toughness, the scratch resistance and the resistance to stress cracking and is therefore preferred for utilisation in the technical field. SAN is crystal-clear in the non-dyed condition but becomes yellowish as the acrylonitrile content rises. The maximum utilisation temperature is 95°C and the processing temperature 220 - 260°C.

3.2.4 Styrene / butadiene (SB)

SB is also designated as impact-resistant polystyrene. The high impact strength and flexibility are achieved by the butadiene component which gives undyed SB an opaque appearance and leads to an extreme decrease in the weathering resistance. The sensitivities to notches and stress cracking are better than those of the pure PS. The maximum utilisation temperature is 80°C, as in the case of the PS, and the processing temperature 200 - 280°C.

3.3 Blends

Blends are combinations of two or more different polymers or copolymers which are either compatible with each other and therefore form molecularly dispersed, homogeneous mixtures ("single-phase blends") or are only partially compatible ("phase-separated blends"). With these multiphase blends, one of the polymers is, as a dispersed phase, embedded in the second polymer (coherent phase) in most cases. As a rule, the coherent phase (matrix) determines the welding behaviour.

With the blends, it is possible to achieve combinations of properties which cannot be obtained with standard polymers, such as stiffness and toughness.

The blends whose coherent phases consist of a semi-crystalline thermoplastic such as PA or PBT were also included in this technical code since exact delimitation is otherwise difficult. Some of the blends are only fabricated with glass fibre reinforcement.

3.3.1 ABS+PC and ASA+PC

Both blends belong to the phase-separated blends with PC as the coherent phase; the PC proportion may be between 4[illegible] % and 85 %. These blends are characterised by a high heat distortion temperature, stiffness, toughness and weathering resistance. The resistance to stress cracking is higher than that of PC.

3.3.2 PPE+SB

The properties of this single-phase blend can be varied within wide limits due to the wide mixing range (20 - [illegible] % PPE). As the PPE proportion increases, the heat distortion temperature, the stiffness and the fire behaviour improve while the flowability and the toughness deteriorate.

3.3.3 PPE+PA

In the case of this phase-separated blend, the polyamide provides the coherent phase. This blend possesses good resistance to chemicals and dimensional stability with a high heat distortion temperature and low water absorption.

3.3.4 PC+PBT

This polymer blend with a PC proportion of 40 - 60 % offers an excellent combination of mechanical strength with resistance to chemicals and dimensional stability. The level of the resistance to chemicals is directly dependent on the crystalline proportion of the blend in question: the higher the crystallinity, the higher the resistance to chemicals.

3.3.5 PBT+A[illegible]

PBT is the coherent phase of this phase-separated blend and therefore determines the welding properties to a great extent. Moreover, the mechanical and thermal properties deviate only slightly from those of PBT. It offers advantages over PBT in the dimensional stability and the weathering resistance.

4 Material-related factors influencing the welding behaviour

In principle, all amorphous thermoplastics can be welded according to this procedure. The welding behaviour is determined by the influencing factors listed below. Further information about these is also included in Section 8.