DVS – DEUTSCHER VERBAND FÜR SCHWEISSEN UND VERWANDTE VERFAHREN E.V.	**Hot plate welding of mouldings made from amorphous thermoplastics in volume production**	**Direction DVS 2215-3** (April 1999)

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1 Scope

See Specification DVS 2215-1, section 1.

2 Description of process

See Specification DVS 2215-1, section 2.

3 Short description of the materials to be welded

3.1 Homopolymers

3.1.1 Polystyrene (PS)

Polystyrene is often used unpigmented, as this brings out its brilliant, crystal-clear appearance. Mouldings made from polystyrene are brittle, have very low water absorption and very good electrical insulating behaviour. Exposure to the sun results in yellowing and embrittlement which further increases its sensitivity to stress cracks. The maximum application temperature is 80 °C, and the processing temperature between 190 and 260 °C depending on type.

3.1.2 Polymethylmethacrylate (PMMA)

Because of its good transparency and resistance to scratches, the main field of use of polymethylmethacrylates are components with optical requirements. Pure PMMA is brittle, but outstandingly weathering-resistant and with low water absorption. The heat distortion temperature is low and the maximum application temperature is about 100 °C, the processing temperature 210 to 250 °C. Cast PMMA cannot be welded.

3.1.3 Polycarbonate (PC)

Polycarbonate is used in both transparent and pigmented forms. Mouldings made from PC have high strength and toughness. Both the weathering resistance and the electrical insulating properties are good. Water absorption is low, but water contact at high temperatures leads to a degradation of the mechanical properties through hydrolysis. Sensitivity to residual stress cracks can be reduced by tempering at 120 °C. The maximum application temperature is 135 °C, and the processing temperature 280 to 320 °C.

3.1.4 Polysulphones (PSU, PES)

Polysulphones are highly resistant to heat and have very good electrical properties even at high temperatures. Weathering resistance and hydrolysis resistance are good, but water is

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absorbed quickly in low quantities. Strength is good, but mouldings are notch-sensitive.

The maximum application temperature is 200 °C, the processing temperatures above 320 °C.

3.2 Copolymers

3.2.1 Acrylonitrile / butadiene / styrene (ABS)

ABS belongs to the polystyrene group which, because of the butadiene components, is characterised by high impact and notch resistance, even at low temperatures. The acrylonitrile proportion increases the thermoforming resistance compared with PS. Resistance to stress cracks and chemicals and resistance to scratches are good. Special ABS types can be galvanised. The maximum application temperature is 100 °C, the processing temperature 220 to 260 °C.

3.2.2 Acrylonitrile / styrene / acrylate (ASA)

ASA has the same chemical composition as ABS, but with the butadiene components replaced by acrylate. The properties are similar to those of ABS but it is often used crystal-clear and has better ageing and weathering resistance and very good antistatic behaviour.

The maximum application temperature is 90 °C and the processing temperature 230 to 280 °C.

3.2.3 Styrene / acrylonitrile (SAN)

SAN has better properties than PS in strength, toughness, scratch resistance and stress crack resistance and is therefore preferred in industrial applications. When unpigmented SAN is crystal-clear, but yellowy as the acrylonitrile content increases. The maximum application temperature is 95 °C, the processing temperature 220 to 260 °C.

3.2.4 Styrene / butadiene (SB)

SB is also called shock-resistant polystyrene. The high impact strength and flexibility is provided by the butadiene components. These give unpigmented SB an opaque appearance and considerably reduce the weathering resistance. The notch and stress crack sensitivity is better than with pure PS. The maximum application temperature is 80 °C as with PS, and the application temperature 200 to 280 °C.

3.3 Blends

Blends are combinations of two or more different polymers or copolymers which are either compatible with each other and thus form molecular disperse, homogenous mixtures ("single-phase blends") or only partially compatible ("phase-separated blends"). In these multi-phase blends one of the polymers is stored as a disperse phase in the second (coherent) phase. The coherent phase (matrix) generally determines the welding behaviour.

The blends allow combinations of properties which cannot be obtained with standard polymers, such as stiffness and toughness.

This specification also covers those blends whose coherent phase consists of a partially crystalline thermoplastic such as PA or PBT, as otherwise exact delimitation is very difficult. Apart from the usual commercial blends, blends which are only created during processing, e. g. from recycled components, are also used (ABS + PMMA). Some of the blends are manufactured with a preferably glass fibre reinforcement.

3.3.1 PC + ABS, PC + ASA

Both blends are generally phase-separated blends with PC as the coherent phase; the PC proportion can be between 4[illegible] and 85 %. These blends are characterised by high thermoforming resistance, stiffness, toughness and weathering resistance. Stress crack resistance is greater than with PC.

3.3.2 PPE + SB

The properties of this single-phase blend can be varied significantly through the great mixture range (20 to 95 % PPE). As the PPE proportion rises, thermoforming resistance and stiffness increase and flowability and toughness decrease. The impact strength can be increased by rubber additives.

3.3.3 PPE + PA

In these phase-separated blends the polyamide is the coherent phase. A PA 6, PA 66 or other polyamide can be used. These blends have good resistance to chemicals with dimensional stability at high thermoforming resistance and low water absorption.

3.3.4 PC + PBT

Blends of this combination have two phases and are characterised by high resistance, good dimensional stability and resistance to chemicals. Chemical resistance increases as the PBT content rises.

3.3.5 PBT + ASA

PBT is the coherent phase of these phase-separated blends and thus largely determines the welding characteristics. The mechanical and thermal properties also deviate only slightly from those of PBT. The principal advantage over PBT lies in the dimensional stability. These blends are preferably used with glass fibre reinforcement.

3.3.6 ABS + PMMA

Mixtures of ABS and PMMA are produced in the recycling of rear lights on motor vehicles and are used in the manufacture of rear lamp housings. The recycled component offers greater scratch resistance, UV resistance and thermoforming resistance than ABS. Impact strength increases as the PMMA proportion rises.

3.4 Amorphous thermoplastics with additives

Additives such as

- fillers and reinforcements
- colouring agents
- flame retardants
- stabilisers
- antistatic agents
- elasticizers
- processing aids (ejection aids)
- additives for electrical conductivity, among others

can influence the welding behaviour. Additives can place certain requirements on safety (see also section 11).

4 Material-related influences on the welding behaviour

4.1 Flow behaviour

The flow behaviour of thermoplastic melts is roughly characterised by the melt volume rate (MVR) or the melt mass flow rate according to ISO 1133 (single point measured value at variable shear speed). The standard defines the combination of mass and temperature at which the flow rate has to be determined. It is only possible to compare those values with each other which were measured under the same test conditions (mass temperature and load weight).

The plasticizing behaviour of the joining zone is decisively influenced by the material to be welded. In general, it is the case that easy-flowing types with high MVR plasticize more quickly than viscous types with low MVR and tend more easily towards adhesion of the melt on the hot plate. This is particularly true for hot plate temperatures over 270 °C, at which no PTFE anti-adhesion coating can be used. This is why high-temperature welding takes place with hot plate temperatures at which no strings form. In the standard heat-contact process adhesion can be reduced by lowering the hot plate temperature.