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Testing of welded joints of thermoplastics plates and tubes: Technological bend test

Direction DVS 2203-5

(August 1999)

Contents:

1 Scope

The bend test may be used in conjunction with other tests to assess the performance of butt welded assemblies made from thermoplastics materials.

Welded parts with comparable seam geometries, e.g. on profiles, can also be tested with reference to this guideline.

The bend angle, the ram displacement while bending and the fracture appearance when the test is terminated provide a guide to the ductility of a welded joint and hence the weld quality.

The ductility properties of the material, the applied weld methods and the geometry of the test specimens influence the achievable bend angle resp. ram displacement and they have to be taken in consideration while evaluating.

The results derived from the bend tests can only partly be used to assess the long term behaviour of welded joints.

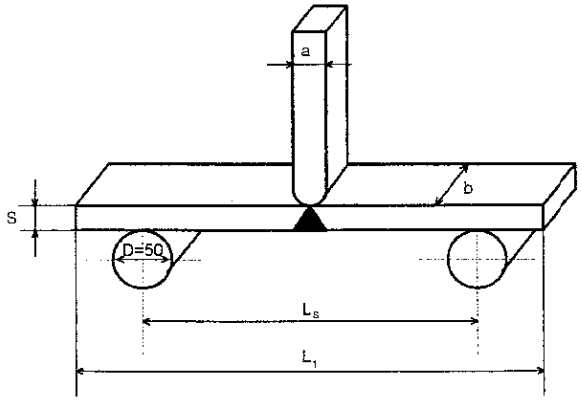
The bend tests can also be used to optimize welding parameters. In this case it is helpful to use none standard test conditions (e.g. to decrease the test temperature or to increase the speed of bending).

2 Method and design

The technological bend test is performed with reference to DIN 50 121.

The tests shall be carried out at least eight hours after welding. No heat treatment operations are allowed to be carried out on the test specimen.

Fig. 1 shows the test arrangement.



s thickness of test specimen
b width of test specimen
L_1 total length of specimen
L_S distance between axes of rollers
f ram displacement
α bend angle
a diameter of ram
D Diameter of the rollers in mm

Figure 1. Sketch of the test arrangement.

Table 1 gives the dimensions of the test arrangement and the test specimens. The dimensions of the specimens mentioned are related to the nominal dimensions of the semi-finished products.

For a thickness > 30 mm it is recommended to reduce the thicknesses of the test specimens to less than 30 mm by machining from the sides in contact with the ram end (pipes: from the outside). In case of pipes the maximum thicknesses at the

Table 1. Dimensions of the test arrangement and the test specimens.

test specimen				distance between axes of rollers L_s [mm]	diameter of ram a [mm]
thickness s [mm] nominal value	width b [mm]		minimum length L_1 [mm]		
	pipe	plate			
3 < s ≤ 5	0.1 × d[1)]	20	150	80	4
5 < s ≤ 10	min.: 6	20	200	90	8
10 < s ≤ 15	max.: 30	20	200	100	12.5
15 < s ≤ 20		30	250	120	16
20 < s ≤ 30		30	300	160	25

[1)] Nominal diameter

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

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edges of the specimens have to be taken into account before applying the chamfers. The distance between the rollers for test specimens with thickness > 30 mm which will be tested without reduction of thickness is calculated with the formula:

$L_S = D + a + 3\ s.$
(D = 50 mm; a = 25 mm; s = thickness of test specimen).

The width of ram and the width of supports have to be larger than the width of specimen. The ram has to be positioned in the middle of the weld. The tendency of the specimens to slip during testing can be reduced by using a corrugated ram or grinding paper at the tip of the ram.

In case of welded pipes the test specimens have to be cut uniformly distributed around the circumference of the pipe. The test specimens shall be cut either radially or with parallel sides. The width of the specimens cut radially is given by the mean value of the largest and the smallest width.

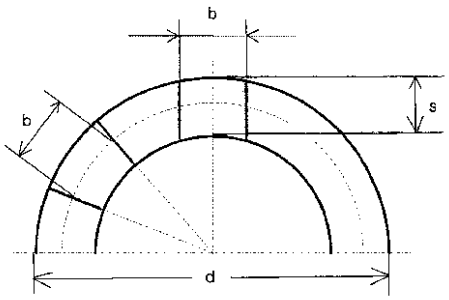

Figure 2. Cross sections of specimens cut from pipes.

The beads have to be removed where the ram is in contact with the specimen during testing. A maximum of 1 mm of the longitudinal edges of the test specimen to be subjected to extension shall be removed at an angle of approximately 45°. These chamfers shall be continuous through the bead.

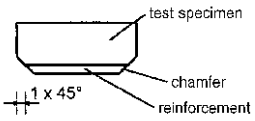

Figure 3. Geometry of the chamfers.

2.1 Requirements on test equipment

The moment when the tip of the ram is in contact with the specimen has to be recorded reproducibly. The test procedure has to be stopped automatically or manually when the specimen breaks or a crack occurs. The result has to be recorded.

2.1.1 Measurement of bend angle

The accuracy of the measuring device and the display shall be at least ±1°. For this reason the equipment shall have an electronical or mechanical measuring device with sufficient precision.

Due to the fact that the point of contact between the specimen and the rollers is moving continuously during the test the result shall to be corrected by an non-linear scale, a correction factor or an appropriate measuring equipment which is able to guide the centre.

2.1.2 Measurement of ram displacement

The accuracy of the measuring device and the display shall be 0.1 mm at least.

3 Performance

Unless otherwise specified or fixed by technical specifications the test shall be carried out according to DIN 50014-23/50-2.

At least 6 test specimens shall be tested for each welded test piece. In the case of welded plates, 3 test specimens shall be tested for each face of the weld. In case of welded pipes the inside shall be subjected to extension.

The ram speed is given in table 2.

Table 2. Ram speed for some thermoplastics.

material	test speed mm/min
PE-HD	50
PP-R	50
PP-H, -B	20
PVDF	20
PVC-U	10

3.1 Evaluation

The technological bending test does not provide values for the design of thermoplastic constructions. Nevertheless a specialist is able to assess generally the welded joints by the results of the deformation behaviour.

The results of technological bending tests can be evaluated in two ways, as bend angle or as ram displacement. Bend angle and ram displacement cannot be transferred into each other mathematically.

3.1.1 Determination of the bend angle

The bend angle is determined as the difference between the final angle when either fracture occurs or a crack is visible and the initial angle. The angles at both ends of the specimen outside of the rollers are measured. The bend angle is calculated by addition of both values. Possibly existing angle-deviations from the horizontal are to be determined and considered (Fig. 4).

The full bending of the specimen in the described test equipment is considered as "no failure" and the bend angle is defined with a value of 160° for the calculation of the mean value.

3.1.2 Determination of the ram displacement

The ram displacement is determined as the difference between the final ram displacement when either fracture occurs or a crack is visible and the initial position of the ram. The full bending of the specimen in the described test equipment is considered as "no failure" and the ram displacement taken from table 3 for the calculation of the mean value.

Table 3. Ram displacements corresponding to the bend angle of 160° in case of no failure for the calculation of the mean value.

thickness of test specimen s [mm]	bend angle [°]	ram displacement f [mm]
3 < s ≤ 5	160	60
5 < s ≤ 15		70
16 < s ≤ 20		85
21 < s ≤ 25		170
26 < s ≤ 30		150

3.1.3 Good/ bad evaluation

For a good/bad evaluation the single values shall be taken into consideration. Each value shall be equal or larger to the minimum bend angles or the minimum ram displacements given in guideline DVS 2203-1. If up to two test specimens do not achieve the minimum bend angle or ram displacement as specified in the requirements, two further test specimens from the same welded test piece cut in the same direction can be tested.

No more than two additional test specimens shall be tested. The additional test specimens shall meet the requirements.

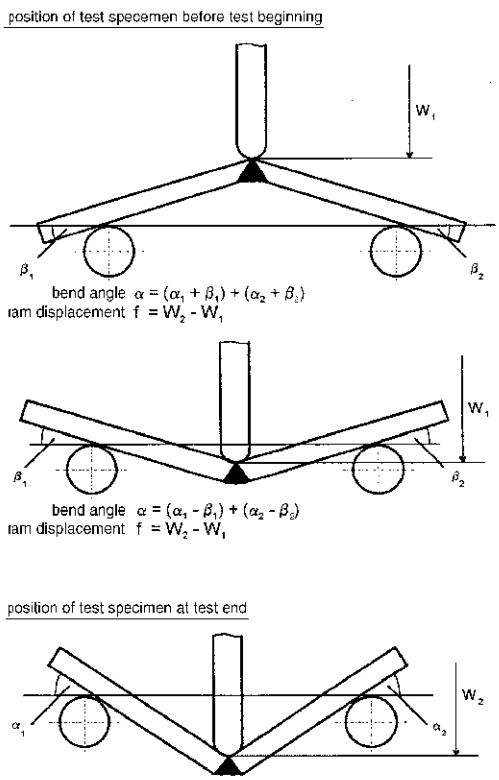

Figure 4. Schematic graph of the determination of bend angle and ram displacement.

3.1.4 Study of parameters/Comparison of methods

The calculation of arithmetic mean values without additional specimens is recommended in the case of comparative investigations like optimizing welding parameters or optimizing welding procedures.

3.2 Criteria of failure

The test specimen can fail by a spontaneous break or by starting a crack and continuous crack growth.

When either a crack occurs or a starting crack becomes visible with the naked eye, the measured value is determined. A starting crack has a depth of ca. 0.5 mm. Condition for the sure recognition is a sufficient illumination of the critical areas of the test specimen and a sufficient observation e.g. by a mirror.

4 Test report

The test report shall refer to this guideline and it shall include at least the following information:

- material, kind of delivery and designation of the product
- date and method of the welded joint
- position of the test specimen in the product
- shape of the test specimen (either radial or parallel sides)
- thickness of the test specimens in mm (nominal value)
- width of the test specimens in mm
- number of the test specimens
- conditioning while testing
- test speed in mm/min
- bend angle or ram displacement
- kind of failure, crack progress if necessary
- test date

5 Normative references

DIN 50014 Atmospheres and their technical application, standard atmosphere