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1 Range of Application

This guideline applies for testing of fusions produced according to DVS 2225-1 and -4 through welding, gluing and vulcanization with liners of polymer materials for ground and water construction, landfill coatings and other groundwater protection measures.

DVS 2203 applies for fusions in apparatus and pipeline construction.

This guideline allows, as extension of DVS 2225-2 "Construction Site Tests" a quality and quantity specific valuation of fusions in short and long term tests.

The guideline is to be understood as instruction for processing staff, users and testers of polymer liners to execute the tests and to value the quality of fusions. This part #1 states the requirements mentioned in detail in part 2 and 4 of this guideline.

The selection of the appropriate test procedures has to be made with reference to the respective execution and application. Prescriptions in admissions or application specific regulations have to be considered.

Furthermore, it has to be made sure that test results depend on the manufacturing conditions for test pieces and testing conditions.

2 Materials, Characteristics and Seam Shapes

Liners are made from thermoplastics or elastomer and are fused by welding, vulcanization or gluing to sealing systems for ground and water construction.

The qualities of the liners are described in the respective DIN standards. Thickness of the liners is 2 to 5 mm. They can be built-up homogeneously or as multi-layer; the surface can be even or structured.

Overlap joints with overlap seams or coated seams are used as joint shapes (see DVS 2225-1).

We emphasize to DVS 2211 and additional advices in DVS 2207-4 concerning the welding additives for coated seams of PE liners.

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DVS, Technical Committee, Working Group W 4 "Plastics, Welding and Adhesive Bonding"

3 Tests

To value the quality of fusions several testing procedures are required under consideration of requirements resp. the required results.

3.1 Nondestructive Tests

Execution, evaluation and limits of the nondestructive tests are described in the following sections of DVS 2225-2:

- Outer texture section 4.2
- Dimensions section 4.3
- Density test section 4.5

3.2 Destructive Tests

Execution, evaluation and limits of the nondestructive tests are described in the following sections of DVS 2226:

- Lap shear test part 2
- Peeling test part 3¹⁾
- Dynamic mechanical analysis part 4

4 Requirements

The liners used for fusions have to meet the requirements and guidelines being valid for the respective application (see also section 5).

The fusions have to meet the requirements mentioned below.

4.1 Nondestructive Tests

The requirements for the nondestructive tests are described in DVS 2225-2 sections 4.2, 4.3 and 4.5.

4.2 Destructive Tests

4.2.1 Lap shear test

The requirements mentioned in table 1 apply for the lap shear test.

Table 1. Material specific requirements for lap shear test.

Characteristic	PE	CB, PIB /C-P, PE-C	Elastomer
Type of failure		Draft and fracture in the transient area or the basic material outside the seam area	
End-termion Factor	0.9	≥ 0.6	≥ 0.7

¹⁾ Simplification site analysis can be executed according to part 4 of DVS 2226

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In case a layer separation below the required values occurs on multi-layer liners the quality of the seam can only be assessed qualified as the separation resistance of the liner determines the result. The suitability of the liner has eventually to be tested.

4.2.2 Peeling test

The requirements mentioned in table 2 apply for the peeling test.

Table 2. Material specific requirements for peel test.

Characteristic	PE	ECB, PIB, PVC-P, PE-C	Elastomer
Kind of failure	Draft and fracture in the transient area or the basic material outside the seam area in addition for coated seams: draft and fracture in welding filler.	Peeling is admitted if the peel resistance R_s is achieved.	
Peeling resistance R_s (N/mm)	look table 2a ²⁾	≥ 0.5 ³⁾	≥ 0.5 ³⁾

Table 2a. Reducing factors in peel test for PE.

$R_s \geq \sigma_s \times d \times Z$ with σ_s = yield stress in short term tensile test in N/mm² and
Z = thickness and seam dependent reducing factor

Type of seam	Reducing factor Z		
	thickness of liner 2.0 mm	thickness of liner 2.5 mm	thickness of liner 3.0 mm
Overlap seam with test channel ÜP	0.8	0.7	0.6
Coated seam AN	0.60	0.55	0.50

4.2.3 Tensile creep test

The requirements mentioned in table 3 apply for the tensile creep test

Table 3. Material specific requirements for the creep rupture test.

Characteristic	PE	ECB, PIB PVC-P, PE-C	Elastomer
Long term fusion factor f_s	Coated seam: ≥ 0.4 ⁴⁾ Overlap seam: ≥ 0.5 ⁴⁾	Requirements are currently elaborated.	

²⁾ For PE R_s is to be understood as draft and fracture value. The requirement value is based on experiences made with the usual landfill liners with a thickness of 2.0 to 3.0 mm. For a liner thickness of 2.5 mm R_s is calculated with $15 \times 2.5 = 37.5$ N/mm.

³⁾ These values are based on current experiences.

⁴⁾ Higher values can be reached under ideal production conditions and seam geometry.

⁵⁾ (Hoechst AG) Extensive analysis experiences are available concerning this additive, allowing result comparisons and determination of requirements. When using other products of the same composition compare number of ethylene oxide molecules within the poly glycol ether chain. (Hessel, J. and Mauer, E.: Dynamic Mechanical Analysis in aqueous wetting agent solution. Material Analysis 3 (1994) 6, pages 240/43).

The requirement for application of the creep rupture welding cycles determined this way is the achievement of a minimum life cycle of the basic material (table 4).

Table 4. Minimum life cycle of the basic material validating the long-term fusion factors (Test additive: 2% wetting agent dissolution Arkopal N 100⁵⁾).

Material	Test stress N/mm ²	Test temperature °C	Minimum duration h
PE	4	95	30
	3	95	250
	4	80	500

No requirements can be currently stated for structured liners.

5 Standards, Guidelines and Regulations

- DIN 7864-1 Elastomer liners for seals – requirements, tests
- DIN 16726 Plastic roof liners and seal liners – tests
- DIN 16729 ECB plastic roof and seal liners – requirements
- DIN 16736 PE-C plastic roof and seal liners, laminated on one side, requirements, tests
- DIN 16937 PVC-P plastic seal liners, bitumen resistant – requirements
- DIN 16938 PVC-P plastic seal liners, not bitumen resistant test procedures, requirements
- DVS 2203-2 Testing of thermoplastic fusions – tensile test
- DVS 2203-3 Testing of thermoplastic fusions – impact test
- DVS 2203-4 Testing of thermoplastic fusions – dynamic mechanical analysis
- DVS 2203-5 Testing of thermoplastic fusions – technological bending test
- DVS 2211 Welding additives for the thermoplastic – range of application, designation, requirement – test
- DVS 2225-1 Fusion of liners of polymer material for ground and water construction, fusion, vulcanization, gluing
- DVS 2225-2 Fusion of liners of polymer material for ground and water construction on site test
- DVS 2225-3 Fusion of liners of polymer material for ground and water construction – requirements for welding machines and tools
- DVS 2225-4 Welding of PE liners for landfill sealing and securing of problem sites