Technical delivery conditions

Elastic rail pads and sandwich plates for rail fastening systems

DBS 918 235

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Content

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Foreword

This DB standard was drawn up by DB Netz AG, Technology and Facility Management, Permanent Way Technology, I.NPF 111(G) in collaboration with the DB AG Quality Assurance department on the basis of DBS 918 235 published in November 2006. It represents the interests of Deutsche Bahn AG.

The following revisions were made:

- Adjustment of the normative references
- Adjustment of the testing regulations to the stipulations of DIN EN 13146-9
- Adjustment of the requirements placed on static and dynamic stiffness
- Editorial and formal revision
- Adjustment to the current regulation structure

Annexes A and B (informative) are an integral part of this DB standard.

Introduction

The purpose of this DB standard (DBS) is to set out rules for qualification and quality assurance with respect to elastic rail pads and sandwich plates. It complements the performance requirements for rail fastening systems described in DIN EN 13481.

1 Scope

This DB Standard applies to elastic rail pads and sandwich plates with a stiffness class ≥15 kN/mm and ≤200 kN/mm under the field conditions for main-line railways encountered at DB AG. It is to be applied in connection with the qualification of new elastic rail pads and sandwich plates for the DB AG network (qualification test) and in the context of quality assurance. In the following text, elastic rail pads and sandwich plates are referred to as "products".

2 Normative references

This DB standard contains stipulations from other publications in the form of dated or undated references. These normative references are quoted in the respective positions in the text and the names of the publications are stated thereafter. In the case of dated references, subsequent amendments or revisions to these publications only belong to this standard if they have been incorporated by means of amendment or revision. In the case of undated references, the latest version of the referenced publication applies (including amendments).

DIN 45673-1	Mechanical vibration – Resilient elements used in railway tracks – Part 1: Terms and definitions, classification, test procedures
DIN EN ISO 1183-1	Plastics – Methods for determining the density of non-cellular plastics – Part 1: Immersion method, liquid pyknometer method and titration method
DIN EN ISO 1183-2	Plastics – Methods for determining the density of non-cellular plastics – Part 2: Density gradient column method
DIN EN ISO 845	Cellular plastics and rubbers; determination of apparent density

DIN ISO 815	Rubber, vulcanized or thermoplastic – Determination of compression set at ambient, elevated or low temperatures
DIN ISO 7619-1	Rubber, vulcanized or thermoplastic – Determination of indentation hardness – Part 1: Durometer method (Shore hardness)
DIN 53 504	Testing of rubber – Determination of tensile strength at break, tensile stress at yield, elongation at break and stress values in a tensile test
DIN EN ISO 527-1	Plastics – Determination of tensile properties Part 1: General principles
DIN EN ISO 527-2	Plastics – Determination of tensile properties; Part 2: Test conditions for moulding and extrusion plastics
DIN ISO 34-1	Rubber, vulcanized or thermoplastic – Determination of tear strength - Part 1: Trouser, angle and crescent test pieces
DIN 53 438-1	Testing of combustible materials; response to ignition by a small flame; general data
DIN 53 438-2	Testing of combustible materials; response to ignition by a small flame – Edge ignition
DIN 53 438-3	Testing of combustible materials; response to ignition by a small flame – Surface ignition
DIN IEC 60093	Methods of test for insulating materials; volume resistivity and surface resistivity of solid electrical insulating materials
DIN 53 508	Testing of rubber; accelerated ageing
DIN ISO 1431	Rubber, vulcanized or thermoplastic – Resistance to ozone cracking – Part 1: Static and dynamic strain testing
DIN ISO 1817	Rubber, vulcanized or thermoplastic – Determination of the effect of liquids
DIN 1451-4	Typefaces; sans-serif linear-antiqua; stenciled lettering for engraving and other processes
DIN EN 13146-9	Railway applications – Track Test methods for fastening systems Part 9: Determination of stiffness
DIN EN 13481	Railway applications – Track Performance requirements for fastening systems
DIN EN 13146-4	Railway applications – Track Test methods for fastening systems Part 4: Effect of repeated loading

DIN EN ISO 7500-1	Metallic materials – Calibration and verification of static uniaxial testing machines – Part 1: Tension/compression testing machines; calibration and verification of the force-measuring system
DIN EN ISO 9513	Metallic materials – Calibration of extensometer systems used in uniaxial testing
DIN 65467	Aerospace – Testing of thermosetting resin systems with and without reinforcement – DSC method
BN 918 043	Elastomers for technical purposes; rubber and rubber-elastic polymers (Elastomere für technische Zwecke; Gummi und gummielastische Hochpolymere)
DBS 918 071-01	Ballast mats for reducing ballast stress (Unterschottermatten zur Minderung der Schotterbeanspruchung)

3 Terms and letter symbols

The following terms and letter symbols apply to the application of this DB Standard. The terms and letter symbols used are based on DIN 45673-1, DIN EN 13481-1 and DIN EN 13146-9.

3.1 Terms

- **Static stiffness**
  Ratio between a force with very slow (quasi-static) change in force and the associated deformation in the direction of the force on an elastic element. In this DBS, static stiffness only refers to vertical static stiffness.

- **Stiffness class**
  Reference value for the stiffness of a product at room temperature specified by the operator.

- **Dynamic stiffness**
  Ratio between a force with harmonic force variation and the associated deformation in the direction of the force on an elastic element. In this DBS, dynamic stiffness only refers to vertical dynamic stiffness.

- **Stiffening factor**
  Ratio between the dynamic stiffness at a specific test frequency and test temperature and product's stiffness class.

- **Upper load/lower load**
  Maximum/minimum load of a quasi-static/dynamic load acting on the rail pad/sandwich plate for the purpose of measuring stiffness.

- **Elastic rail pads**
  Elastomer that is positioned between the rail and sole plate (e.g. base plate, ribbed plate) or between the rail and sleeper.

- **Elastic sandwich plate**
  Elastomer that is positioned between sole plate (e.g. base plate, ribbed plate) and sleeper or track slab.

- **Support point force**
  Force on a support point resulting from traffic load

3.2 Letter symbols

k_{SP}	Static stiffness	[kN/mm]
k_{SPmin}	Minimum value of the static stiffness	[kN/mm]
k_{LFP}	Dynamic stiffness at a specific test frequency	[kN/mm]
f_v	Stiffening factor	[-]
F	Support point force	[kN]
F_{SPmax}	Upper load in load cycle	[kN]
F_{SP1}	Lower load in load cycle/system-related pre-loading	[kN]

4 Technical requirements

4.1 General

The economical use of these products in varying speed ranges requires differentiation among certain technical requirements. Two requirement levels have therefore been defined for dynamic stiffness in the low-frequency range. Products will be assigned to a requirement level and consequently to a field of use depending on their technical properties. The products' fields of use are defined in the guideline 820.2010 "Equipment standard concerning ballasted track for rails and points" (Ausrüstungsstandard Schotteroberbau für Gleise und Weichen) and in the "Requirements catalogue for concrete slab tracks" (Anforderungskatalog Feste Fahrbahn)

4.2 Form and dimensions

The corresponding DB AG standard drawings apply regarding the installation situation, form and dimensions of the products. The products may not display any burrs or cast seams that impair their function. The surfaces must be processed cleanly and may not display any split-offs, flaking or exfoliation. Dyed substances must be dyed consistently. Slight surface unevenness or colour deviations (e.g. smearing) resulting from the production process are permissible. Any cavities or grooves shall be designed so that they cannot clog up and that water can flow off once it has entered.

4.3 Static stiffness

The static stiffness k_{SP} of products straight from the factory shall be determined at room temperature (RT) in accordance with Section 6.2 and documented in Annex A. Depending on its stiffness class, each product must comply with a minimum value of static stiffness k_{SPmin} to be calculated on the basis of the following formula:

k_{SPmin} = stiffness class - (stiffness class x percent of the permissible deviation)

Deviation of max. -10% with a stiffness class ≥ 15 kN/mm and ≤30 kN/mm
Deviation of max. -15% with a stiffness class > 30 kN/mm and ≤200 kN/mm

Example 1:
Rail pads Zw 900, stiffness class 60 kN/mm
60 kN/mm x 15 % = 9 kN/mm
Minimum value of static stiffness: k_{SPmin} = 60 kN/mm − 9 kN/mm = 51 kN/mm

Example 2:
Sandwich plate Zwp 104, stiffness class 22.5 kN/mm
22.5 kN/mm x 10 % = 2.25 kN/mm
Minimum value of static stiffness: k_{SPmin} = 22.5 kN/mm − 2.25 kN/mm = 20.25 kN/mm

4.4 Dynamic stiffness, low-frequency range

The dynamic stiffness in the low-frequency range (f ≤ 20 Hz) is used to assess the products under a rolling load. The stiffening factor f_v as a quotient of the respective dynamic stiffness k_{LFP} at a specific test frequency and test temperature and of the stiffness class of the product is taken as the assessment criterion. The permissible stiffening factors for products straight from the factory are shown in Table 1.

Table 1: Permissible stiffening factors f_v in relation to the test temperature

Test temperature	Stiffness class of the product	Valid for test frequency of
	≥15 kN/mm and ≤200 kN/mm	
	Permissible stiffening factor	
50°C	$1.0 \le f_v \le 1.5$	10 Hz
23°C (RT)	$1.0 \le f_v \le 1.5$	5, 10, 20 Hz
-10°C, 0°C	$1.0 \le f_v \le 2.0$	10 Hz
-20°C	$1.0 \le f_v \le 2.5$	10 Hz

The dynamic stiffness in the low-frequency range (f ≤ 20 Hz) is to be determined in accordance with Section 6.3 and documented in Annex A.

4.5 Dynamic stiffness, mid- and high-frequency ranges

The dynamic stiffness in the mid- and high-frequency ranges (400 Hz < f < 2000 Hz) is used to assess the products in the event of additional excitation due to wheel out-of-roundness, unevenness in the tracks, wheel/rail resonances (mid-frequency excitations) or roughness and corrugations on the rail surface (high-frequency excitations) It is to be determined and documented for products in the stiffness class ≤ 60 kN/mm according to the stipulations of the unit responsible for technical aspects at DB AG.

4.6 Fatigue resistance

The fatigue resistance is used to assess a product's fitness for purpose throughout its useful life. In the envisaged rail fastening system, it is to be determined according to DIN EN 13146-4 (fastening category C or D according to DIN EN 13481-2 to -5). As a rule, it will not be necessary to determine the clamping force, the vertical static system stiffness or the longitudinal rail restraint. The products must pass the fatigue test without any recognisable destruction or cracks that affect the product's functioning (e.g. pre-assembly lip).

Following completion of the fatigue test and a rest period of 3 days, the static stiffness k_{SP} is to be determined according to Section 6.2 and the dynamic stiffness k_{LFP} is to be determined according to Section 6.3 for each product. The test frequency shall be 10 Hz, and the results are to be documented in Annex A. The tests shall be conducted at room temperature. The k_{SP} and k_{LFP} values determined after the fatigue test may not exceed the values prior to the

fatigue test by more than 15%. The lower limits for stiffening stated in Section 4.3/Section 4.4 Table 1 are to be complied with, the upper stiffening limits stated in the table may not be exceed by more than 10%.

4.7 Effect of the operating load on stiffness

Prior to field testing, the static stiffness k_{SP} is to be determined according to Section 6.2 and the dynamic stiffness k_{LFP} is to be determined according to Section 6.3 on 10 products from the delivery batch envisaged for field testing. The test frequency shall be 10 Hz (reference measurement). Upon completion of field testing, (cf. Section 5.1.2), these tests are to be repeated on the same 10 products. All tests shall be conducted at room temperature.

The k_{SP} and k_{LFP} values determined after field testing may not exceed the mean values recorded in the reference measurement prior to field testing by more than 15%. The lower limits for stiffening stated in Section 4.3/Section 4.4 Table 1 are to be complied with, the upper stiffening limits stated in the table may not be exceed by more than 10%.

4.8 Material characteristics

The following material characteristics are to be determined and documented in Annex A.

4.8.1 Density
The test shall be conducted on the basis of DIN EN ISO 1183 or DIN EN ISO 845 and the test conditions are to be documented accordingly.

4.8.2 Hardness
The test shall be conducted on non-cellular materials on the basis of DIN ISO 7619-1 .
Shore A or Shore D hardness is to be determined at room temperature.

4.8.3 Elongation at break
The test shall be conducted on the basis of DIN 53 504 (Sample S1 or S2) or DIN EN ISO 527 and the test conditions are to be documented accordingly.

4.8.4 Tensile strength at break
The test shall be conducted on the basis of DIN 53 504 (Sample S1 or S2) or DIN EN ISO 527 and the test conditions are to be documented accordingly.

4.8.5 Tear strength
The test shall be conducted on the basis of DIN ISO 34-1 and the test conditions are to be documented accordingly.

4.8.6 Water resistance
The test shall be conducted on the basis of DBS 918 071-01 and the test conditions are to be documented accordingly.

4.8.7 Flammability
The test shall be conducted in accordance with DIN 53 438. The products shall comply with Class K2.

4.8.8 Volume resistivity
The test shall be conducted in accordance with DIN IEC 60093 whereby the conductive silver shall have an all-round distance from the edge of 5 mm. Alternative test methods are permissible if equivalence to the reference method according to DIN IEC 60093 has been verified. The products shall comply with a volume resistivity of $\geq 10^8\ \Omega$.

4.8.9 Ageing resistance

The test shall be conducted in accordance with DIN 53 508. The specimens are to be stored at 70°C for 7 days. The products shall comply with the limits in accordance with Table 2.

Table 2: Limits for ageing resistance

Stage	N II
Ageing time	7d
Permissible reduction in elongation at break (in percent of the value upon delivery) Test temperature 70°C	20%
Permissible increase in Shore A hardness Test temperature 70°C	8
Permissible reduction in tear strength for all test temperatures	50%

4.8.10 Weather resistance/ozone resistance

Testing shall be conducted in accordance with DIN ISO 1431, Sheet 1 (Method A). The products shall be exposed to an ozone concentration of 50 pphm at room temperature and 20% elongation for a period of 48 hours. The products shall comply with crack stage 1 according to DIN ISO 1431 .

4.8.11 Resistance to the effects of oil and grease

The test shall be conducted in accordance with DIN ISO 1817 using discs with a diameter of 60 mm and the same thickness as the products. The products shall comply with the limits in accordance with Table 3.

Table 3: Limits for resistance to the effects of oil and grease

Test oil	Exposure time	Type of change	Highest value of change
ASTM oil no. 1 IRM 901	168 hours	Change in volume	+/-5%
		Change in hardness	+/-4 Shore A
ASTM oil no. 3 IRM 903	168 hours	Change in volume	+35%
		Change in hardness	-15/+2 Shore A

4.8.12 Low temperature behaviour/glass transition point

The test shall be conducted on the basis of DIN 65467 (DSC method) and the test conditions are to be documented accordingly.
The products shall comply with a temperature of $t \leq -50°C$ for the glass transition point.

4.8.13 Compression set/temperature resistance

The test shall be conducted on the basis of DIN ISO 815 and the test conditions are to be documented accordingly.
The products shall be exposed to the following conditions:

Condition a	24 hours	+70°C
Condition b	168 hours	room temperature

5 Qualification and quality assurance

5.1 Qualification of the product

5.1.1 Qualification tests

Prior to the first delivery to DB AG, every product must undergo a qualification test. Each of the requirements described in Section 4 must be verified on three products in this qualification test. (Exception: fatigue resistance test according to DIN EN 13146-4 only on one product) The test results for each single tested product must meet the requirements.

As different materials and designs are possible for the products, there are only certain properties that can be determined in advance. The unit responsible for technical aspects at DB AG (see cover sheet) may determine additional requirements and tests. Furthermore, DB AG may waive tests if, for example, product properties do not require certain tests or if material properties are already well known.

Qualification tests may only be carried out by testing organisations recognised by DB AG. The vendor shall bear the cost of qualification testing.

5.1.2 Field testing

Prior to initial serial delivery to DB AG, every new product must undergo field testing on a line specified by DB AG for a period of one year, but with a traffic load of at least 20 million metric load tons. In the event of minor product changes that do not effect ageing resistance, the unit responsible for technical aspects at DB AG may waive field testing.

5.2 Qualification of the manufacturer

Prior to the first delivery to DB AG, the manufacturer's capability to manufacture a product as specified in the contract shall be verified. This applies to every product and shall take the form of a "manufacturer-related product qualification". One component of the manufacturer-related product qualification is the qualification testing according to Section 5.1. The manufacturer-related product qualification shall be carried out by DB AG's Quality Assurance department. The manufacturer/supplier shall bear the cost of the manufacturer-related product qualification (cf. List of permanent-way products subject to quality inspection).

5.3 Quality assurance at the manufacturer's site

The manufacturer shall ensure the quality of the products on the basis of appropriate statistical process control. The tests and scope of testing listed in Table 4 are minimum requirements.The unit responsible for technical aspects at DB AG may determine additional tests.

Table 4 : Minimum requirements placed on tests and scope of testing relating to quality assurance

Test	Minimum scope of testing
Dimensions and surface quality (cf. Section 4.2)	At least 1 test specimen at the beginning and at the end of a production/material batch or at least 2 test specimens per 10,000 products,
Density (cf. Section 4.8.1)	
Hardness according to Shore A for non-cellular materials (cf. Section 4.8.2)	
Static stiffness for F = 50 kN at RT (cf. Section 4.3)	

On the one hand, new products straight from the factory must meet the requirements of this DBS and, on the other hand, they must comply with the mean values determined in the qualification test or pre-production run with a tolerance of

±10% with a stiffness class ≥15 kN/mm and ≤30 kN/mm
±15% with a stiffness class >30 kN/mm and ≤100 kN/mm.

The result may not be lower than the minimum value of the static stiffness according to Section 4.3 even after the tolerance has been deducted. In the case of products with a stiffness class >100 kN/mm, the permissible tolerance in connection with compliance with the mean values is to be determined on an individual basis between the manufacturer/supplier and the unit responsible for technical aspects at DB AG. Compliance with the requirements demanded by this DBS shall be assured by means of test schedules and test plans and presented to DB AG upon request.

In addition to the manufacturer's process control, DB AG reserves the right to check to what extent the products to be manufactured/that have been manufactured or the services to be rendered/that have been rendered fulfil contractual obligations in terms of quality and also reserves the right to intervene if necessary. Furthermore, DB AG reserves the right to review the quality assurance measures put in place by the contractor. These rights shall apply at all times and at all locations where products are produced or services rendered. The scope of these measures is based on the "List of permanent-way products subject to quality inspection" as well as on the "Supplementary contractual terms regarding quality assurance in procurement" (EVB- Qualitätssicherung Beschaffung). The scope is specified by the DB AG Quality Assurance department. The test includes the entire process workflow as well as the qualification tests.

6 Test method

6.1 General conditions for determining stiffness

The static stiffness and the dynamic stiffness in the low-frequency range ($f \leq 20$ Hz) shall be determined on the basis of DIN EN 13146-9.

A complete product must be tested in all stiffness tests. Bend-proof flat plates shall be used for applying the upper and lower loads. The outline surface of the load application plates must reproduce the intended installation situation. The lateral surfaces of the product must be able to distort freely to reflect the installation situation.

A piece of machine-made abrasive on a backing (fabric-based) – P 240 with a mean grain diameter 58 µm according to the Fepa 43-D-1984 standard – shall be inserted between the load application plates and the product being tested. The abrasive must at least cover the size of the product being tested.

6.2 Static stiffness

The static stiffness shall be determined on the basis of DIN EN 13146-9. The lower load F_{SP1} shall correspond to the system-related pre-loading of the product. Sample values are given in Annex B. The loads of the corresponding DIN EN 13481 (fastening category C or D) are to be used for the 18 kN system-related pre-loading of the product. Notwithstanding this provision, if necessary the upper load F_{SPmax} shall be determined according to the following formula:

$F_{SPmax} = (F_{SP1} + 50\ kN) \times 1.25$ [kN]

A support point force of F = 50 kN is taken as the basis for the evaluation and assessment of the product.

The tests shall be conducted at room temperature. The static stiffness is to be additionally determined at the test temperatures –20°C, –10°C, 0°C and +50°C for the support point force F = 50 kN. The products are to be acclimatised in such a way that the required test temperature is kept constant for at least 16 hours before commencing the test.

6.3 Dynamic stiffness, low-frequency range

The dynamic stiffness shall be determined on the basis of DIN EN 13146-9.

The test frequencies shall be 5, 10, and 20 (tolerance: +/-1 Hz) in sequence. The load shall be removed from the product and there shall be a rest period of approximately 3 minutes between the individual test frequencies.

The setting on the test machine shall be adjusted in a preliminary test. The test object or another product from the test series can be used for this purpose. Following an appropriate rest period for the test object (approx. 10 minutes with the load removed) or after placing the test object in the test machine, the machine shall be restarted. The target values for the upper and lower load must have settled within a maximum of 3 s.

The tests shall be conducted at room temperature. The dynamic stiffness is to be additionally determined at the test temperatures –20°C, –10°C, 0°C and +50°C for the test frequency of 10 Hz. The products are to be acclimatised in such a way that the required test temperature is kept constant for at least 16 hours before commencing the test.

Marking

A mark in bold font H8 according to DIN 1451-4 shall be imprinted during manufacturing of the product. Alternatively, the mark can be printed on the product if it is verified that the mark is indelible.

The mark shall consist of:

- The abbreviated product designations (e.g. Zw 900, Zwp 104)

- The stiffness class of the product (in kN/mm)
- The manufacturer's mark and
- The last two figures of the year of manufacture.

Example of marking:
Zw 900 – (60) [manufacturer's mark] 15

Attachment A (informative) - Results of the qualification test

Table A1: Dynamic stiffness in the low-frequency range (f ≤ 20 Hz)

Test temperature	Test specimen no.:	Test frequency					
		5 Hz		10 Hz		20 Hz	
		k_{LFP}	f_d	k_{LFP}	f_d	k_{LFP}	f_d
New products straight from the factory							
Stiffness class: _____							
(+50 ±3) °C							
	Mean value						
(+23 ±5) °C							
	Mean value						
(±0 ±3) °C							
	Mean value						
(-10 ±3) °C							
	Mean value						
(-20 ±3) °C							
	Mean value						
Products after the fatigue test							
(+23 ±5) °C							
	Mean value						

Table A2: Static stiffness

Test temperature	Test specimen no.:	Support point force Δ F
		50 kN
		k_{SP}
New products straight from the factory		
Stiffness class: _____		
Minimum static stiffness k_{SPmin}: _____		
(+50 ±3) °C		
	Mean value	
(+23 ±5) °C		
	Mean value	
(±0 ±3) °C		
	Mean value	
(-10 ±3) °C		
	Mean value	
(-20 ±3) °C		
	Mean value	
Products after the fatigue test		
(+23 ±5) °C		
	Mean value	

Table A3: Material characteristics

Material characteristic	Sample	Measured value	Limit value
Density (DIN EN ISO 1183, DIN EN ISO 845)			
Hardness (DIN ISO 7619-1)			
Elongation at break (DIN 53 504, DIN EN ISO 527)			
Tensile strength at break (DIN 53 504, DIN EN ISO 527)			
Tear strength (DIN ISO 34-1)			
Water resistance (BN 918 071-1)			
Flammability (DIN 53 438)			Class K2
Volume resistivity (DIN IEC 60093)			$\geq 10^8$ Ω cm
Ageing resistance (DIN 53 508)			Stage NII (DBS 918 043)
Weather resistance (DIN ISO 1431)			Crack stage 1
Resistance to the effects of oil and grease (DIN ISO 1817)			Section 4.8.11
Low temperature behaviour (DIN 65467)			≤ −50 °C
Compression set (DIN ISO 815)			

Attachment B (informative) - System-related pre-loading

Rail fastening	System-related pre-loading
W 14K 900	18 kN
W 14K 700	18 kN
W 21 1000	18 kN
System 300-1 (Skl 15)	18 kN
System 336	15 kN
System ECF	12 kN
Pandrol P 1 1100	20 kN