UIC CODE 541-4

3rd edition, May 2007

Translation

OR

Brakes - Brakes with composite brake blocks - General conditions for certification of composite brake blocks

Frein - Freins avec semelles de frein en matériau composite - Evaluation de conformité - Conditions générales
Bremse - Bremsen mit Bremsklotzsohlen aus Verbundstoff - Allgemeine Bedingungen für die Zertifizierung von Verbundstoffbremsklotzsohlen

UNION INTERNATIONALE DES CHEMINS DE FER
INTERNATIONALER EISENBAHNVERBAND
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Leaflet to be classified in Volume:

V - Rolling Stock

Application:

With effect from 1. May 2007
All members of the International Union of Railways

Record of updates

1st edition, January 1977	First edition published under the title of: "Brakes (Brakes with composition brake blocks with high friction values for international traffic)" and 2 Amendments (this edition was only published in French and German)
2nd edition, October 1990	under the title: "Brakes - Brakes with composition brake blocks" and 3 Amendments.
3rd edition, May 2007	New requirements for K, L and LL brake blocks - certification of composite brake blocks and test methods.

The person responsible for this leaflet is named in the UIC Code

Contents

Summary

This leaflet contains the general conditions for tread brakes with composite brake blocks. It describes the required properties of the composite brake blocks, their coefficients of friction and geometry requirements, and furthermore the mechanical, physical and chemical features for both organic and sintered composite brake block linings.

The certification process for composite brake blocks including the test programs to be applied is explained. The conditions to be observed are listed. The validity duration of the certification is time-limited.

The composite brake blocks certified according to the requirements below are listed in the tables published on the UIC website.

The same applies to composite brake blocks which only meet the requirements below with restrictions.

Definitions, test methods and measurements to be performed complete the leaflet.

1 - Tread brakes with composite brake blocks

Composite brake blocks of vehicles which are brought into use after the effect of this leaflet must fulfil the conditions of this leaflet. (Please refer to point 3.5 - page 14 for the specifications of composite brake blocks on older vehicles).

1.1 - Use of tread brakes with composite brake blocks

Vehicles with tread brakes fitted with composite brake blocks are licensed in international traffic.

The permitted area of use for goods wagons is defined in point 1.2.1.

The permitted area of use for passenger coaches is defined in point 1.2.2.

The permitted area of use for motive power units is defined in point 1.2.3.

1.2 - Use of composite brake blocks

1.2.1 - Use in goods wagons

The permitted technical field of use (key values) for composite brake blocks is defined as

- V_{max} = 120 km/h,
- maximum wheelset load 22,5 t,
- brake block form to UIC standard,
- area of use: all lines in the UIC territory up to maximum 40 ‰ gradient.

The composite brake blocks to be used are certified according to the clauses of point 3 - page 11.

1.2.2 - Use in passenger coaches

reserved.

1.2.3 - Use in motive power units

reserved.

1.3 - Suitability for use

The suitability for use of the composite brake blocks to be used must be proved in operating tests. The conditions applicable to this are contained in point 3.3 - page 13.

1.4 - Braking weights

The braked weights of vehicles with composite brake blocks are determined in the method specified in *UIC Leaflet 544-1* (see Bibliography - page 77).

1.5 - Vehicle marking

Vehicles with composite brake blocks are marked K, L, or LL according to the friction coefficient. The design must correspond to *UIC Leaflet 545, Appendix F* (see Bibliography - page 77).

This marking is applied immediately after the abbreviated marking of the brake design type.

1.6 - Protection against incorrect use

Composite brake blocks with friction coefficient K must be fitted with protection against incorrect use according to point 2.4.3 - page 8.

Composite blocks with friction coefficients L and LL have no such protection.

2 - Features of composite brake blocks

2.1 - General

R **2.1.1 -** This specification defines the properties required for composite brake blocks of organic and sintered materials for the tests prescribed.

R **2.1.2 -** Composite brake blocks may be used in both bilateral or unilateral brake block arrangement with double block (2 x Bgu or 1 x Bgu) and single block (2 x Bg or 1 x Bg). The content of this specification relates exclusively to the use of composite brake blocks acting on the treads of the wheels.

O **2.1.3 -** The composition of the material and the method of production of the composite brake blocks in series production must be identical to those of the composite brake blocks used for the licensing process.

The manufacturer must present a product definition corresponding to the requirements of Appendix L - page 72.

Proof is supplied by a successful Quality Management System.

O **2.1.4 -** The use of asbestos and other fibres harmful to health is prohibited. Use of other substances of any composition which could cause a risk to health and the environment in the form of dust, fibres, particles or gas released during use of the composite brake blocks is not recommended.

R **2.1.5 -** The material composition of the composite brake blocks must be selected so as to guarantee the best compromise between:

- friction properties,
- aggressiveness against the wheel tread,
- effect on the adhesion value between wheel and rail,
- compatibility to signalling systems (track circuits),
- wear and the life of composite brake blocks, and
- the broader certification requirements.

O **2.1.6 -** The conditions in this leaflet must be observed for the entire usage thickness of the composite brake blocks.

The test and acceptance criteria are to be established.

O **2.1.7 -** During tests on the friction test bench, with the exception of the Test Program A6 "Simulation fixed brakes", page 43 on the blocks there must be no flame formation, bonding agent sweating, sustained crushing, severe odour formation, large area crumbling or detachment, or other defect which reduces the mechanical strength.

2.2 - Friction requirements

O 2.2.1 - General

2.2.1.1 - The test on friction features on a test bench comprises the following tests:

- behaviour of instantaneous and mean friction coefficients,
- behaviour under the effect of moisture,
- tendency to form metallic inclusions,
- behaviour when simulating fixed braking,
- own and counter-wear behaviour when simulating real braking load collectives,
- winter braking properties,
- compatibility with signalling systems (track circuits).

2.2.1.2 - The behaviour of the friction coefficients must, in relation to the dependency on temperature, weathering influences, and for type K also surface pressure, move within the permitted tolerances given in the chapters which follow. Depending on vehicle category, friction coefficient and block arrangement, the frictional requirements must be tested using the allocated test program and the suitability proven using certification criteria.

A product released for goods wagon use (22.5 t, wheel diameter 920 mm) must fulfil all requirements of this leaflet for the block configurations 2 x Bg and 2 x Bgu and the performance requirements S and SS.

The friction coefficients between bedded-in and non-bedded-in blocks must not deviate from each other by more than 15% under the same conditions.

2.2.2 - Friction requirements for goods wagons

O **2.2.2.1 -** To guarantee a satisfactory operating braking behaviour, the mean friction coefficients (definition, see Appendix O - page 75) of level K for dry braking with block arrangements 1 x Bg, 2 x Bg and 2 x Bgu must lie within the spread limits given in Appendix B - page 48.

To guarantee braking distance safety, the mean friction coefficients related to the highest contact force for the simulated load states, for the range of initial braking speeds 100 km/h and 120 km/h, must lie within the spread limits in Appendix C - page 50.

The spread limits to be observed for dry braking for friction levels L and LL are given in Appendix D - page 52 and Appendix E - page 53.

O **2.2.2.2 -** The instantaneous friction coefficients determined in bench tests (definition see Appendix O) must ensure that from a fully developed contact force, the resulting braking moment has a constant development rising towards the end of braking.

An example diagram of requirements is given in Appendix F - page 54 .

O **2.2.2.3 -** Under the influence of water, the mean wet friction coefficients at maximum contact force (both for empty and loaded) in the range of initial braking speeds = 100 km/h may not deviate by more than - 5% and +15% from the mean dry friction coefficients determined under the same conditions (m, v , F_{IB}).

For the range of initial braking speeds < 100 km/h and in the contact force area of the operational brake block forces, the maximum permitted deviation is ± 30 %.

O **2.2.2.4 -** The friction properties are tested under winter conditions either in a line test (for test program, see Appendix G - page 55) or on a friction test bench to Test Programme A5.

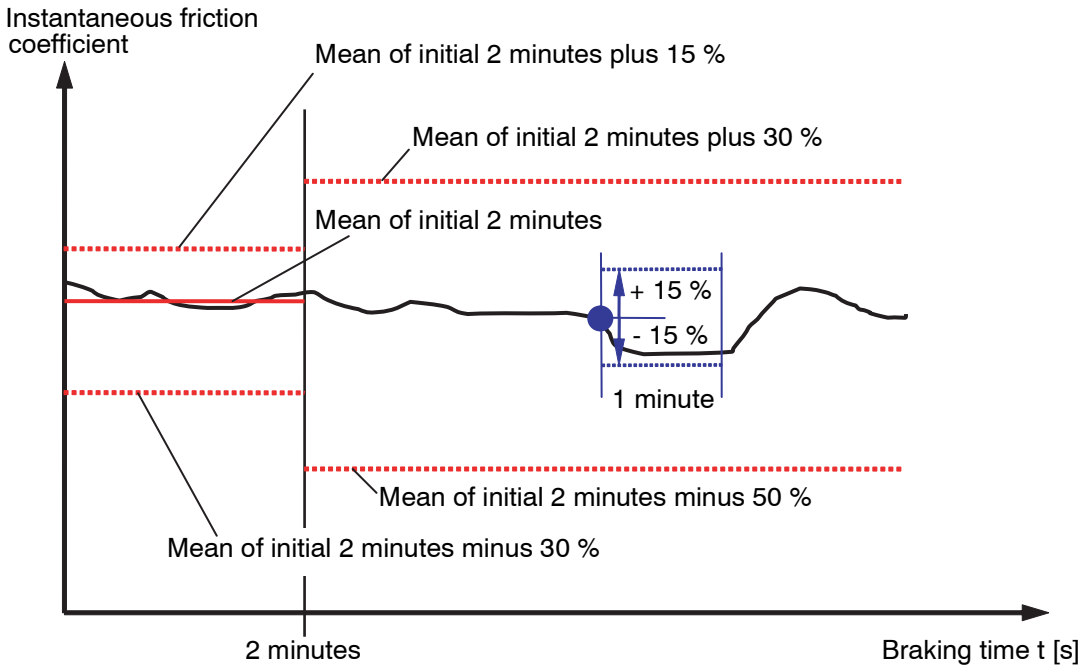
The brake distance changes determined from 100 and 120 km/h respectively may not exceed -15% to max. + 5% in relation to the braking distances (s_1) determined under reference conditions (see Line test to Appendix G) or in dry braking (see Test program A.5 - page 42).

O **2.2.2.5 -**

1. On braking to stop initiated at high starting temperatures (≥ 110 °C) (hot braking), under otherwise identical conditions, the mean friction coefficient may not deviate by more than ± 15 % from the mean value when braking from cold (≤ 60 °C) and in dry state.

2. In continuous braking (simulated downward gradient) with a maximum sustained braking power of maximum 45 kW per wheel, the instantaneous friction coefficient must fulfil the following conditions:

   - after two minutes braking, the instantaneous friction coefficient may not deviate more that - 30% / + 15% from the mean instantaneous friction coefficient of the initial two minutes,
   - throughout the rest of the braking duration, the instantaneous friction coefficient may not deviate by more than - 50% / + 30% from the mean instantaneous friction coefficient of the initial 2 minutes,
   - during the entire braking process, the variation of the instantaneous friction coefficient may not exceed +/- 15% in relation to the instantaneous friction coefficient given at the beginning of the observed period of time, for any observed section with a period of 1 minute.



O **2.2.2.6 - .**The effect of friction material under unusual thermal stresses on the wheels (e.g. fixed brakes) is tested to Test program A6 - page 43.

The following acceptance criteria apply for behaviour in accordance with conditions:

Wheel temperature [°C] [a]		
< 600	> 600	> 700
OK	not OK [b]	not OK [c]

a. measured 9 mm below the tread, the upper envelope of the 3 individual measurements applies to the assessment.
b. if the cumulative duration of excess is more than 25 min
c. if the cumulative duration of excess is more than 5 min.

These conditions apply exclusively to nominal wheel diameters 920 mm. For other wheel diameters the conditions remain to be established.

O **2.2.2.7 - .**The static friction coefficient μ_{stat} to ensure adequate holding force on down gradients is tested to Test program A12 - page 46. The following values must be achieved for μ_{stat}:

- $\mu_{stat\ K} \geq 0{,}20$
- $\mu_{stat\ LL} \geq 0{,}25$

O **2.2.2.8 - .**The tendency to form metallic inclusions when used on goods wagons is tested to test program A.4 - page 39. After the end of the bench tests, no metallic inclusions with a total area of more than 1% of the block surface may be present.

R **2.2.2.9 - .**To assess the economic feasibility of the composite block/wheel pairing, optionally the bench tests "Own and counter-wear behaviour while simulating real operational braking conditions" to test program A.11 - page 45 may be performed.

The results for the specific brake block and wheel wear must be enclosed with the certification documents.

O **2.2.3 - Friction requirements for passenger coaches**

reserved.

O **2.2.4 - Friction requirements for motive power units**

reserved.

O **2.3 - Requirements for compatibility with track circuits**

2.3.1 - The compatibility with track circuits is tested either in the line test (Test Programme see Appendix J - page 67) or on a friction test bench to test program A7 - page 45.

2.3.2 - The requirements to be observed for performance of line tests are given in Appendix J.

2.3.3 - In the case of bench tests, it must be proven that the following requirements are fulfilled.

reserved.

O **2.4 - Geometric features of composite brake blocks**

2.4.1 - Preferably composite brake blocks of standard length 320 mm should be used for brake block type Bg and 250 mm for brake block type Bgu. The preferred width for brake blocks is 80 mm and the preferred thickness 60 mm.

For design examples see Appendix H, Fig. 7 - page 60.

2.4.2 - The contour of the block surface facing the wheel tread must be designed to guarantee optimum adaptation to both the nominal wheel diameter and to the wheel diameter in worn state. The transverse profile of the block surface must be designed with a slope of 1:40.

For design examples see Appendix H, Fig. 8 - page 61.

2.4.3 - Composite brake blocks K must, on the side of the backing plate facing the brake block, be fitted with protection against incorrect use to Appendix H, Fig. 9 - page 62.

2.4.4 - The construction of the composite brake blocks must allow even wear to a block thickness of 10 mm without parts of the reinforcement or backing plate coming into contact with the wheel tread.

2.4.5 - The composite brake blocks must have 2 permanently legible wear limit marks in the area of the brake block ends of the sides facing away from the flange, where the marks have a distance of 10 mm from the rear of the backing plate.

For a possible design see Appendix H, Fig. 10 - page 63.

2.4.6 - The composite brake blocks may in no case deform under the influence of heat or moisture such that they can no longer be inserted or removed.

o 2.5 - Mechanical, physical and chemical features

2.5.1 - Proof obligations of manufacturer.

The manufacturer of composite brake blocks must present a product specification giving sufficient detail of the mechanical, physical and chemical features that during acceptance tests or in subsequent tests, it can be proved that these features have not changed and the composite brake blocks also actually correspond to the licensed composite brake blocks. In addition the manufacturer must present a safety data sheet to *EU Directive 91/155* (see Bibliography - page 77) (for example data sheet see Appendix L - page 72).

Health effects of substances released

The manufacturer must assess the substances released during proper use and their effects on health. The test and acceptance criteria to be applied remain to be defined.

2.5.2 - Mechanical requirements.

2.5.2.1 - Shear strength.

The backs of the brake blocks and the method of connection between the backing plate and friction material must be designed so that any stresses occurring can be safely resisted. The method of connecting the friction material with the backing plate is free. The connection is tested using the test device shown in Appendix I, Fig. 12 - page 65 with a test force of 15 kN.

After the end of the test, no damage may have occurred to the friction material/ backing plate connection.

2.5.2.2 - Bending strength.

The bending strength is tested in the method shown in Appendix I, Fig. 13 - page 66. After the end of the test there may be no visible surface or through cracks and no detachment from the backing plate except for surface and through cracks at the nominal break point.

2.5.3 - Thermal requirements.

1. The friction material must not cause heat damage to the wheel treads.

   Also it must not damage the friction surface or have a tendency to form metallic inclusions.

2. Composite brake blocks must resist the maximum heat stresses occurring within the limits of the certification program, without burning, melting, forming severe deposits on the wheel treads or wearing to an unusually great extent.

These requirements do not apply to the test program A6 (Simulation "Fixed brakes") - page 43.

o 2.6 - Marking of certified composite brake blocks

Certified composite brake blocks must bear the following marking on the backing plate:

- type designation of brake block type,
- name or symbol of manufacturer,
- production date (week and year), etc...
- batch number,
- UIC and friction level (K, L, LL),
- customer item number or customer-specific marking (e.g. colour marking) - optional.

These markings are embossed, engraved or punched, and must be applied so that each composite brake block can still be identified in operation after complete wear.

For design example see Appendix H, Fig. 11 - page 64.

3 - Certification of composite brake blocks

3.1 - Certification process

3.1.1 - General

The certification process includes performance of the bench tests prescribed in this leaflet, proof of braking performance according to conditions, and an operational test. The product certification process of the UIC applies.

3.1.1.1 - Overview of all tests to be performed for certification

Vehicle category	max RSL (t)	Block arrangement Bg 1x	Bg 2x	Bgu 1x	Bgu 2x	Test program/ appendix necessary for certification
Goods wagon V-BKS (K)	18,0	X				A3, A4, A5/App. G, A6, A7/App. J, App. I, A11 (optional), A12
	22,5		X	X	X	A1,
Goods wagon V-BKS (LL)	22,5	--	X	--		A2, A4, A5/App. G, A6, A7/App. J, App. I, A11 (optional), A12
		--		--	X	
Passenger coach V-BKS (L)	reserved					
Goods wagon (extra block brake)	reserved					
Locomotives	reserved					

Note: The test programmes

A4, Establishment of metallic inclusions

A5 (or App. G), Proof of winter braking properties

A6, Simulation "Fixed brakes"

A7 (or App. J), Compatibility with track circuits

need only be performed in one of the prescribed block configurations, and a positive test result is then valid also for the other block configurations.

3.1.2 - Bench tests

The type and scope of bench tests to be performed are described in point 2.1 - page 4 to 2.3 - page 8.

3.1.3 - Dependency tests to determine braking power

The type and scope of dependency tests to be performed are based on *UIC Leaflet 544-1*. Proof of observation of the specified braking performance level (k-factor as ratio of brake weight to block force) and maximum permitted spread of braking distances must be given.

3.1.4 - Operational test

Satisfactory behaviour relating to:

- Development of brake block-wear,
- Tendency to form metallic inclusions,
- Occurrence of surface and through cracks, detachments and crumbling,
- Frequency of occurrence of wheel damage,
- Aggressiveness towards the wheel treads, and,
- Checking of acoustically-relevant surface conditions of the wheels

must be tested in operation on a UIC RU.

A detailed report of this operational trial must be produced.

3.1.5 - Certification

The certification application must be submitted to the UIC with the various test reports and a summary report in 25 copies in two of the three UIC languages.

The composite blocks certified to these regulations are listed in Appendix M - page 73 which is published on the UIC website.

Composite blocks which are licensed before the effect of these regulations by the UIC are contained in Appendix N - page 74.

3.2 - Conditions for bench certification tests

O **3.2.1 - Test benches**

The test benches used for the certification tests must be accepted by the UIC and the test sequences accredited to *ISO EN 17025* (see Bibliography - page 77).

O **3.2.2 - Test blocks**

The brake blocks used for the tests must be those of original size which correspond to series production. Each test program must be performed with new blocks from the same delivery batch.

R **3.2.3 - Terms**

Appendix O - page 75 defines the abbreviations and formulae used in the text and appendices.

O 3.3 - Conditions for line certification tests

3.3.1 - Test wagons

The wagons to be used for the braking performance and operational tests must correspond to the latest state of the art in terms of running and braking systems.

3.3.2 - Braking performance

Only products which have proved compliance with the braking weight to *UIC Leaflet 544-1* may be used for the operational test.

3.3.3 - Operating test

This test must be performed on at least

- 5 wagons per brake block configuration requested,
- under various weather conditions, for 12 months without interruption,
- for a distance of at least 60,000 km in an individual vehicle.

These operating tests must provide proof that the composite block types correspond to the conditions of use given in the certification application, no damage has been caused to the wheels and blocks, and there has been no deterioration in operation.

3.4 - Validity of certification

Composite blocks for tread brakes are in principle licensed for 10 years unless major changes in the requirements of this leaflet raise doubts about their suitability earlier.

If a manufacturer wishes to renew the certification of a brake block, a corresponding application must be submitted to the UIC at least one year before expiry of this period.

The application for renewal of certification must be accompanied by a test report according to point 3.1.1 - page 11 (Brake blocks from current production).

The brake block must meet the requirements of the leaflet applicable at the time of application.

Where there is sufficient experience, a repeat operational test may be omitted from the renewal application.

Otherwise, recertification must be requested in the following cases:

- greatly modified production methods or constituents of brake blocks,
- modified requirements.

The validity of the blocks licensed under the conditions of this leaflet is given in Appendix M - page 73.

3.5 - Continued use

Vehicles which were in use before the date of effect of the current issue of this leaflet and which are fitted with composite blocks may still be used provided they are listed in Appendix N - page 74 of the leaflet and for technical reasons cannot be replaced by types in Appendix M - page 73.

In the case of changes to the brake systems of these vehicles, these must be converted to brake block types of Appendix M.

4 - Quality control process

4.1 - Manufacturer's quality control

Brake blocks may only be produced by manufacturers who are regarded as suitably qualified by the customer and the end user RU in a method established by them.

4.2 - Securing and monitoring of production quality

The manufacturer must have an organisation, resources and methods to guarantee the production quality and monitoring of the deliveries intended for the customer and end user RU.

Subject to an agreement between the customer, end user RU and manufacturer, the former may propose application of *ISO Standard 9001* (see Bibliography - page 77).

The customer and end user RU shall in this case ensure, by testing, monitoring and control activities in the manufacturer's works, that the measures introduced are also efficient.

The selected monitoring method must be given in the order.

Appendix A - Test programs A1 to A12

Test program A1: **V-BKS (K) - Proof of friction properties:**

Program A1_a: Performance program

Program A1_b: Simulation "Braking evaluation"

2 x Bg (2 x 320) or
2 x Bgu (4 x 250) or
1 x Bgu (2 x 250)

Test program A2: **V-BKS (LL) - Proof of friction properties:**

Program A2_a: Performance program

Program A2_b: Simulation "Braking evaluation"

2 x Bg (2 x 320) or
2 x Bgu (4 x 250)

Test program A3: **V-BKS (K) - Proof of friction properties:**

Program A3_a: Performance program

Program A3_b: Simulation "Braking evaluation"

1 x Bg (1 x 320)

Test program A4: **Formation of metallic inclusions:**

1 x Bg (1 x 320) or
2 x Bg (2 x 320) or
2 x Bgu (4 x 250)

Test program A5: **Proof of winter braking properties**

(reserved)

Test program A6: **Simulation "Fixed brakes"**

2 x Bg (2 x 320) or
2 x Bgu (4 x 250)

Test program A7: **Proof of compatibility with track circuits**

(reserved)

Test program A8: **V-BKS (L) - Extra block brake passenger wagons**

(reserved)

Test program A9: **V-BKS (L) - Extra block brake goods wagon**

(reserved)

Test program A10: **V-BKS (K) for locomotives**

(reserved)

Test program A11: **Simulation of real usage conditions**

(reserved)

Test program A12: **Definition of static friction coefficients**

2 x Bg (2 Blocks 320 x 80 $\binom{+1}{-2}$ mm) or

2 x Bgu (4 Blocks 250 x 80 $\binom{+1}{-2}$ mm) or

1 x Bgu (2 Blocks 250 x 80 $\binom{+1}{-2}$ mm) per wheel

A.1 - Test program A1 for V-BKS (K) - Proof of friction properties for S and SS (S/SS) approved goods wagon (v_{max} = 120 km/h)

A.1.1 - Test program A1_a: Performance program

V-BKS-Material	organic or sintered
Type of brake block per wheel	2 x Bg (2 Blocks x 320 x 80 $\binom{+1}{-2}$ mm) or 2 x Bgu (4 Blocks x 250 x 80 $\binom{+1}{-2}$ mm) or 1 x Bgu (2 Blocks x 250 x 80 $\binom{+1}{-2}$ mm)
Wheel type	Conforms to *UIC Leaflet 510-5* (see Bibliography - page 77) (wheel rim internal diameter 820 mm)
Wheel diameter	870 $\binom{+5}{-0}$ mm - The precise diameter must be given in the test report.
Mass per wheel (Wheelset load)	2,5 t 9,0 t 11,25 t (5,0 t 18,0 t 22,50 t)

Braking No.	V	F_B	θ_0	M	Weigh after	Comments
	[km/h]	[kN]	[°C]	[t]	Nr.	
1.1 to 1.X	100	24	20 - 100	9,0	1.X [a]	Braking to stop, dry, to bed in blocks to min. 85 % contact; running-in edges must support
1 3 5	100	38	50 - 60	9,0		Braking to stop, dry after cooling-down phase
2 4 6	120	38	50 - 60	9,0	6 [a]	
7 to 26	100	7	20 - 100	2,5	26 [a]	Braking to stop to condition the blocks
27 39	100	7	50 - 60	2,5		Braking to stop, dry, after cooling down phase
28 40	30					
29 41	120					
30 42	60					
31 43	100	5				
32 44	30					
33 45	120					
34 46	60					
35 47	100	9				
36 48	30					
37 49	120					
38 50	60					
51	70	-	50 - 60	-	51 [a]	Continuous braking, dry 10 kW for 15 min to eliminate wheel stresses

Braking No.			V	F_B	θ_0	M	Weigh after	Comments
			[km/h]	[kN]	[°C]	[t]	Nr.	
52	64	76	100	7	20 - 30	2,5		Braking to stop, wet, after cooling down phase
53	65	77	30					
54	66	78	120					
55	67	79	60					
56	68	80	100	5				
57	69	81	30					
58	70	82	120					
59	71	83	60					
60	72	84	100	9				
61	73	85	30					
62	74	86	120					
63	75	87	60					
88	92		100	38	20 - 30	11,25		Braking to stop, wet, after cooling down phase
89	93		30					
90	94		120					
91	95		60					
	96		70	-	50 - 60	-		Continuous braking, dry, with a power of 10 kW for 15 min, to dry the blocks
							96	
97	109		100	24	50 - 60	11,25		Braking to stop, dry, after cooling down phase
98	110		30					
99	111		120					
100	112		60					
101	113		100	9				
102	114		30					
103	115		120					
104	116		60					
105	117		100	38				
106	118		30					
107	119		120					
108	120		60					
	121		100	38	110 - 120 [b]	11,25		Braking to stop, dry, after cooling down phase
	122		30		110 - 120			
	123		120		110 - 120			
	124		60		110 - 120		124 [a]	
	125		100	24	50 - 60	11,25		Braking to stop, dry, after cooling down phase
	126		30					
	127		120					
	128		60				128	
	129		70	-	20 - 60	11,25		Continuous braking, dry, with a power of 45 kW for 34 min.
	130		70	38	-	11,25		Braking to stop, dry, immediately after continuous braking, without cooling-down phase

Braking No.	V	F_B	θ_0	M	Weigh after	Comments
	[km/h]	[kN]	[°C]	[t]	Nr.	
131	70	-	-	-	131	Continuous braking, dry with a power of 10 kW for 15 min, immediately after braking to stop, without cooling-down phase
132	100	38	50-60	11,25		Braking to stop, dry, after cooling down phase
133	30					
134	120					
135	60					
136	70	-	50-60	-	136	Continuous braking, dry 10 kW for 15 min to eliminate wheel stresses

a. This weighing, which is performed in empty tests and under wet conditions, is optional..
b. If the temperature after brake stops Nos 120 and 122 is less than 110 °C, brake stops Nos 121 and 123 should follow at this achieved temperature.

A.1.2 - Conditions for performance of the test program A1_a

Ventilation conditions

		Test bench speed (km/h)		Cooling air speed (km/h)	
	v	dry	wet	dry	wet
During braking with	≤ 80 km/h	v	v	v/2	10
	> 80 km/h	v	v	40	10
Between brake stops		100	50	40	10

The cooling air speed must be adjusted while complying with the conditions of *ERRI Report B 126/DT 408* (see Bibliography - page 77).

Wear

The individual wear of the blocks must be determined as follows:

- by optional measurements after brake stops Nos 1.X, 6, 26, 51, and 124;
- by compulsory measurements after brake stops Nos 96, 128, 131, 136.

The permitted individual wear of the blocks in brake stops Nos 97 to 128 may not exceed XXX cm^3/MJ (value to be determined).

Roughness index of wheel tread

The wheel roughness is measured after brake stops Nos 1.X, 128 and 136 (see recommended method in *ERRI Report B 126/RP 18* - see Bibliographie - page 77).

Interruptions

During the tests, interruptions of maximum 3 days are permitted only before tests Nos 1, 7, 27, 97, 125 and 132.

In the case of interruption before test No 52, to maintain the wetting conditions a braking identical to test No 50 must be performed outside the program.

Temperatures

After the brake stops, the temperature must always be reduced to the initial value again.

The braking to stop (test No 130) which immediately follows the continuous braking, must be performed without cooling-down phase at the temperature developed at the end of this continuous braking.

The continuous braking (test No 131), which immediately follows the braking to stop, which in turn follows a continuous braking, must be performed without a cooling-down phase at the temperature developed at the end of this braking to stop.

For brake stops Nos 1, 27, 96, 97, 125 and 132, an initial temperature of 20 °C to 60 °C is permitted.

Wetting conditions

The brake stops under wet conditions must be performed with a total water quantity of 14 litres per wheel per hour.

In wet brake stops, the wheel wetting in the cooling phases must not be interrupted between tests Nos 52 to 95.

After braking No 51 spraying begins only when the wheel temperature has reached 80 °C.

Accuracy of braking parameters

The accuracy required for the individual braking parameters is given in the *ERRI Report B 126/RP 18* "*Requirements for brake test benches for international licensing of friction materials*".

Other conditions

The brake stops must be performed chronologically in the sequence given.

The number of bedding-in brake applications required to achieve a contact patch of at least 85% of the block friction surface must be given in the test report.

Test wheels

Both wheels from operational use and new wheels can be used.

Before fitting on the test bench, the wheel diameter must be brought to the value shown in the Test Programme.

A.1.3 - Test program A1_b: Simulation brake assessment

V-BKS-Material	organic or sintered
Type of Brake block per wheel	2 x Bg (2 blocks x 320 x 80 $\binom{+1}{-2}$ mm) or 2 x Bgu (4 Blocks x 250 x 80 $\binom{+1}{-2}$ mm) or 1 x Bgu (2 Blocks x 250 x 80 $\binom{+1}{-2}$ mm)
Wheel type	Conforms to *UIC Leaflet 510-5* (wheel rim internal diameter 820 mm)
Wheel diameter	870 $\binom{+5}{-0}$ mm - The precise diameter must be given in the test report.
Mass per wheel (Wheelset load)	2,5 t 11,25 t (5,0 t 22,50 t)

Braking No.	V	F_B	θ_0	M	Comments
	[km/h]	[kN]	[°C]	[t]	
1.1 to 1.X	Continuous braking for bedding in at 60 km/h, 20 kW				
1 to 19	100	9	20 - 100	2,5	Braking to stop to condition the blocks
20 to 24	100	9	50 - 60	2,5	Wagon S + SS Braking to stop, dry, after cooling-down phase
25 to 29	120	9	50 - 60	2,5	
30 to 34	100	9	50 - 60	2,5	
35 to 39	100	9	20 - 30	2,5	S + SS wagon Braking to stop, wet, after cooling-down phase [a]
40 to 44	120	9	20 - 30	2,5	
45 to 49	100	9	20 - 30	2,5	
50	70	-		-	Continuous braking with 10 kW for 15 min to dry the blocks
51 to 55	100	24	50 - 60	11,25	S wagon Braking to stop, dry, after cooling-down phase
56 to 60	120	24	50 - 60	11,25	
61 to 65	100	24	50 - 60	11,25	
66 to 70	100	38	50 - 60	11,25	SS wagon Braking to stop, dry, after cooling-down phase
71 to 75	120	38	50 - 60	11,25	

a. This test is performed for information.

A.1.4 - Conditions for performance of the test program A1_b

Rotation and ventilation conditions

		Test bench speed (km/h)		Cooling air speed (km/h)	
	v	dry	wet	dry	wet
During braking at	≤ 80 km/h	v	v	v/2	10
	> 80 km/h	v	v	40	10
Between brake stops		100	50	40	10

The cooling air speed must be adjusted while complying with the conditions of *ERRI Report B 126/ DT 408*.

Bedding in

Bedding in takes place by continuous braking at 20 KW at 60 Km/h (maximum temperature between 60 °C and 250 °C) to at least 85% contact pattern.

Roughness index of wheel tread

The wheel roughness is measured before braking 1.1 and after brake stops Nos 1.X and 75 (see recommended method from *ERRI Report B 126/RP 18*).

Interruptions

During the tests, interruptions of maximum 3 days are permitted only before brake stops Nos 1, 20, 35, 51 and 66.

In the case of interruption before tests Nos 1, 20, 35, 45 and 66, identical brake stops as before, Nos 1X, 19, 34, 50 and 65, must be repeated.

Temperatures

After the brake stops the temperature must always be reduced to the initial value again.

Wetting conditions

The brake stops under wet conditions must be performed with a total water quantity of 14 litres per wheel per hour.

After brake stop no. 34 spraying begins only when the wheel temperature has reached 80 °C.

Accuracy of braking parameters

The accuracy required for the individual braking parameters is given in *ERRI Report B 126/RP 18*.

Test wheels

Both wheels from operational use and new wheels can be used. Before fitting on the test bench, the wheel diameter must be brought to the value shown in the Test Programme.

Other conditions

The brake stops must be performed chronologically in the sequence given.

Appearance, form, surface and position of any inclusions in the friction side of the block must be recorded on each block test. The inclusions are left in place during the various observation phases. A photo is to be taken on each dismantling.

On each change of friction material, the wheel is regenerated with a "cleaning block" so that the condition of the tread at the start is always the same.

A.2 - Test program A2 for V-BKS (LL) - Proof of friction properties for S- and SS (S/SS) approved goods wagon (v_{max} = 120 km/h)

A.2.1 - Test program A2_a: Performance program

V-BKS-Material	organic or sintered
Type of brake block per wheel	2 x Bg (2 Blocks x 320 x 80 $\binom{+1}{-2}$ mm) or 2 x Bgu (4 Blocks x 250 x 80 $\binom{+1}{-2}$ mm)
Wheel type	Conform to *UIC Leaflet 510-5* (wheel rim internal diameter 820 mm)
Wheel diameter	870 $\binom{+5}{-0}$ mm - The precise diameter must be given in the test report.
Mass per wheel (Wheelset load)	2,5 t 9,0 t 11,25 t (5,0 t 18,0 t 22,50 t)

Braking No	V	F_B	θ_0	M	Weigh after	Comments
	[km/h]	[kN]	[°C]	[t]	No	
1.1 to 1.X	100	60	20 - 100	9,0		Bedding-in brake stops to at least 85% contact on the friction face, running-in edges must support.
					1.X [a]	
1 3 5	100	100	50 - 60	9,0		Braking to stop, dry, after cooling-down phase
2 4 6	120	100	50 - 60	9,0	6 [a]	
7 to 26	100	16	20 - 100	2,5		Braking to stop to condition the blocks
					26 [a]	
27 39	100	16	50 - 60	2,5		Braking to stop, dry after cooling-down phase
28 40	30					
29 41	120					
30 42	60					
31 43	100	12				
32 44	30					
33 45	120					
34 46	60					
35 47	100	20				
36 48	30					
37 49	120					
38 50	60					
51	70	-	50 - 60	-	51 [a]	Continuous braking with 10KW for 15 min [b]

Braking No			V	F_B	θ_0	M	Weigh after	Comments
			[km/h]	[kN]	[°C]	[t]	No	
52	64	76	100					
53	65	77	30	16				
54	66	78	120					
55	67	79	60					
56	68	80	100					
57	69	81	30	12	20 - 30	2,5		Braking to stop, wet after cooling-down phase
58	70	82	120					
59	71	83	60					
60	72	84	100					
61	73	85	30	20				
62	74	86	120					
63	75	87	60					
88	92		100					
89	93		30	100	20 - 30	11,25		Braking to stop, wet after cooling-down phase
90	94		120					
91	95		60					
	96		70	-	50 - 60	-		Continuous braking 10 kW for 15 min [b]
						-	96	
97	109		100					
98	110		30	60				
99	111		120					
100	112		60					
101	113		100					
102	114		30	20	50 - 60	11,25		Braking to stop, dry after cooling-down phase
103	115		120					
104	116		60					
105	117		100					
106	118		30	100				
107	119		120					
108	120		60					
	121		100		110 - 120 [c]			
	122		30	100	110 - 120	11,25		Braking to stop, dry after cooling-down phase
	123		120		110 - 120			
	124		60		110 - 120		124 [a]	
	125		100					
	126		30	60	50 - 60	11,25		Braking to stop, dry after cooling-down phase
	127		120					
	128		60				128	
	129		70	-	20 - 60	-		Continuous braking (St Gotthard) with 45 kW for 34 min.
	130		70	100	-	11,25		Braking to stop, dry, immediately after continuous braking, without cooling-down phase.

Braking No	V	F_B	θ_0	M	Weigh after	Comments
	[km/h]	[kN]	[°C]	[t]	No	
131	70	-	-	-		Continuous braking, with 10 kW for 15 min, immediately after braking to stop, without cooling-down phase
					131	
132	100	100	50-60	11,25		Braking to stop, dry after cooling-down phase
133	30					
134	120					
135	60					
136	70	-	50-60	-	136	Continuous braking with 10KW for 15 min [b]

Brake development time 4 s ± 0,2 s

a. This weighing, which is performed in empty tests and under wet conditions, is optional.
b. Continuous braking to eliminate inherent stresses in the wheel and prevent crack formation.
c. If the temperature after brake stops Nos 120 and 122 is less than 110°C, brake stops Nos 121 and 123 are performed at this achieved temperature.

A.2.2 - Conditions for performance of the test program A2_a

Rotation and ventilation conditions

		Test bench speed (km/h)		Cooling air speed (km/h)	
	v	**dry**	**wet**	**dry**	**wet**
During braking at	≤ 80 km/h	v	v	v/2	10
	> 80 km/h	v	v	40	10
Between brake stops		100	50	40	10

The cooling air speed must be adjusted while complying with the conditions of *ERRI Report B 126/DT 408*.

Wear

The individual wear of the blocks must be determined as follows:

- by optional measurements after brake stops Nos 1.X to 6, 26, 50, 95 and 124.
- by compulsory measurements after brake stops Nos 96,128, 131 and 136.

The permitted individual wear of the blocks in brake stops Nos XX to YY may not exceed XXX cm^3/MJ (value to be determined).

Roughness index of wheel tread

The wheel roughness is measured after brake stops Nos 1.X, 128 and 136, (see recommended method from *ERRI Report B 126/RP 18*).

Interruptions

During the tests, interruptions of maximum 3 days are permitted only before brake stops Nos 1, 7, 27, 96, 97, 125 and 132.

In the case of an interruption before test No. 52, to maintain the wetting conditions a braking identical to test No 50 must be performed outside the program.

Temperatures

After the brake stops the temperature must always be reduced to the initial value again.

The braking to stop No 130, after the continuous braking, is performed without cooling-down phase at the temperature achieved at the end of the braking.

For brake stops Nos 1, 27, 97, 125, 129 and 132, initial temperatures of 20 to 60°C are permitted.

Wetting conditions

The brake stops under wet conditions must be performed with a total water quantity of 14 litres per wheel per hour.

In wet brake stops, the wheel wetting in the cooling phases must not be interrupted between tests Nos 52 and 95.

After braking No 51 spraying begins only when the wheel temperature has reached 80 °C.

Accuracy of braking parameters

The accuracy required for the individual braking parameters is given in the *ERRI Report B 126/RP 18*.

Test wheels

Both wheels from operational use and new wheels can be used. Before fitting on the test bench, the wheel diameter must be brought to the value shown in the Test Programme.

Other conditions

The brake stops must be performed chronologically in the sequence given.

The number of bedding-in brake applications required to achieve a contact patch of at least 85% of the block friction surface must be given in the test report.

A.2.3 - Test programs A2_b - Simulation brake assessment

V-BKS-Material	organic or sintered
Type of brake block per wheel	2 x Bg (2 Blocks x 320 x 80 $\binom{+1}{-2}$ mm) or 2 x Bgu (4 Blocks x 250 x 80 $\binom{+1}{-2}$ mm)
Wheel type	Conforms to *UIC Leaflet 510-5* (wheel rim internal diameter 820 mm)
Wheel diameter	870 $\binom{+5}{-0}$ mm - The precise diameter must be given in the test report
Mass per wheel (Wheelset load)	2,5 t 11,25 t (5,0 t 22,50 t)

Braking No.	V [km/h]	F_B [kN]	θ_0 [°C]	M [t]	Comments
1.1 to 1.X	Continuous braking for bedding in at 60Km/h, 20 KW				
1 to 19	100	16	20 - 100	2,5	Braking to stop to condition the blocks
20 to 24	100	16	50 - 60	2,5	Wagon S + SS Braking to stop, dry, after cooling-down phase
25 to 29	120	16	50 - 60	2,5	
30 to 34	100	16	50 - 60	2,5	
35 to 39	100	16	20 - 30	2,5	S + SS wagon Braking to stop, wet, after cooling-down phase [a]
40 to 44	120	16	20 - 30	2,5	
45 to 49	100	16	20 - 30	2,5	
50	70	-		-	Continuous braking with 10 kW for 15 min to dry the blocks
51 to 55	100	60	50 - 60	11,25	S Wagon Braking to stop, dry, after cooling-down phase
56 to 60	120	60	50 - 60	11,25	
61 to 65	100	60	50 - 60	11,25	
66 to 70	100	100	50 - 60	11,25	SS Wagon Braking to stop, dry, after cooling-down phase
71 to 75	120	100	50 - 60	11,25	

a. This test is performed for information.

A.2.4 - Conditions for performance of the test program A2_b

Rotation and ventilation conditions

		Test bench speed (km/h)		Cooling air speed (km/h)	
	v	**dry**	**wet**	**dry**	**wet**
During braking at	≤ 80 km/h	v	v	v/2	10
	> 80 km/h	v	v	40	10
Between brake stops		100	50	40	10

The cooling air speed must be adjusted while complying with the conditions of *ERRI Report B 126/ DT 408*.

Bedding in

Bedding in is performed by continuous braking at 20 KW at 60 Km/h (maximum temperature between 60 °C and 250 °C) to at least 85% contact on the friction face.

Roughness index of wheel tread

The roughness is measured before braking 1.1 and after brake stops Nos 1.X and 75 (see recommended method from *ERRI Report B 126/RP 18*).

Interruptions

During the tests, interruptions of 3 days maximum are permitted only before brake stops Nos 1, 20, 35, 51 and 66.

In the case of an interruption before tests Nos 1, 20, 35, 51 and 66, identical brake stops to those before, Nos 1.X, 19, 34, 50 and 65, must be repeated.

Temperatures

After the brake stops the temperature must always be reduced to the initial value again.

Wetting conditions

The brake stops under wet conditions must be performed with a total water quantity of 14 litres per wheel per hour.

After braking no. 34 spraying begins only when the wheel temperature has reached 80 °C.

Accuracy of braking parameters

The accuracy required for the individual braking parameters is given in the *ERRI report B 126/RP 18*.

Test wheels

Both wheels from operational use and new wheels can be used. Before fitting on the test bench, the wheel diameter must be brought to the value shown in the Test Programme.

Other conditions

The brake stops must be performed chronologically in the sequence given.

Appearance, form, surface and position of any inclusions in the friction side of the block must be recorded on each block test. The inclusions are left in place during the various observation phases. A photo is to be taken on each dismantling.

On each change of friction material, the wheel is regenerated with a "cleaning block" so that the condition of the tread at the start is always the same.

A.3 - Test program A3 for V-BKS (K) - Proof of friction properties for S-and SS (S/SS) approved Goods wagon (v_{max} = 120 km/h)

A.3.1 - Test program A3_a - Performance program

V-BKS-Material	organic or sintered
Type of brake block per wheel	1 x Bg (1 block x (320 x 80 $\binom{+1}{-2}$ mm))
Wheel type	Conforms to *UIC Leaflet 510-5* (wheel rim internal diameter..... mm)
Wheel diameter	790 $\binom{+5}{-0}$ mm - The precise diameter must be given in the test report
Mass per wheel (Wheelset load)	2,5 t 5,8 t 9,00 t (5,0 t 11,6 t 18,00 t)

Braking No.	V	F_B	θ_0	M	Weigh after	Comments
	[km/h]	[kN]	[°C]	[t]	Nr.	
1.1 to 1.X	100	20	20 - 100	5,8		Braking to stop, dry, to bed in the block to min. 85 % contact pattern; running-in edges must support
					1.X [a]	
1 to 20	100	8	20 - 100	2,5		Braking to stop to condition the block
					20 [a]	
21 36	100	8	50-60	2,5		Braking to stop dry, after cooling-down phase
22 37	30					
23 38	120					
24 39	60					
25 40	140					
26 41	100	5				
27 42	30					
28 43	120					
29 44	60					
30 45	140					
31 46	100	12				
32 47	30					
33 48	120					
34 49	60					
35 50	140					
51	70	-	50 - 60	-	51 [a]	Continuous braking, dry 10 kW for 15 min to eliminate wheel stresses

Braking No.			V	F_B	θ_0	M	Weigh after	Comments
			[km/h]	[kN]	[°C]	[t]	Nr.	
52	67	82	100					
53	68	83	30					
54	69	84	120	8				
55	70	85	60					
56	71	86	140					
57	72	87	100					
58	73	88	30					
59	74	89	120	5	20 - 30	2,5		Braking to stop wet, after cooling-down phase
60	75	90	60					
61	76	91	140					
62	77	92	100					
63	78	93	30					
64	79	94	120	12				
65	80	95	60					
66	81	96	140					
97		101	100					
98		102	30	30	20 - 30	9		Braking to stop wet, after cooling-down phase
99		103	120					
100		104	60					
	105		70		50 - 60	-		Continuous braking, dry, with a power of 10 kW for 15 min., to dry the blocks
							105	
106		118	100					
107		119	30	20				
108		120	120					
109		121	60					
110		122	100					
111		123	30	8	50 - 60	9	-	Braking to stop dry, after cooling-down phase
112		124	120					
113		125	60					
114		126	100					
115		127	30	30				
116		128	120					
117		129	60					
	130		100		110 - 120 [b]			
	131		30	30	110 - 120	9		Braking to stop dry, after cooling-down phase
	132		120		110 - 120			
	133		60		110 - 120		133 [a]	
	134		100					
	135		30	20	50 - 60	9		Braking to stop dry, after cooling-down phase
	136		120					
	137		60				137	
	138		70	-	50-60	9		Continuous braking, dry, with a power of 36 kW for 34 min

Braking No.	V	F_B	θ_0	M	Weigh after	Comments
	[km/h]	[kN]	[°C]	[t]	Nr.	
139	70	30	-	9	-	Braking to stop, dry, immediately after the continuous braking, without cooling-down phase
140	70	-	-	-	140	Continuous braking, dry, with a power of 10 kW for 15 min., immediately after the braking to stop, without cooling-down phase
141 142 143 144	100 30 120 60	30	50-60	9		Braking to stop dry, after cooling-down phase
145	70	-	50-60	-	145	Continuous braking, dry 10 kW for 15 min to eliminate wheel stresses

Brake development time 4 s ± 0,2 s.

a. This weighing, which is performed in empty tests and under wet conditions, is optional.
b. If the temperature after brake stops Nos 129 and 131 is less than 110°C, brake stops Nos 130 and 132 are performed at this achieved temperature.

A.3.2 - Conditions for performance of test program A3_a

Ventilation conditions

		Test bench speed (km/h)		Cooling air speed (km/h)	
	v	**Dry**	**wet**	**dry**	**wet**
During braking	≤ 80 km/h	v	v	v/2	10
	> 80 km/h	v	v	40	10
Between brake stops		100	50	40	10

The cooling air speed must be adjusted while complying with the conditions of *ERRI Report B 126/DT 408*.

Wear

The individual wear of the blocks must be determined as follows:

- by optional measurements after brake stops Nos 1.X, 20, 51 and 133,
- by compulsory measurements after brake stops Nos 105, 137, 140 and 144.

The permitted individual wear of the blocks in brake stops Nos 106 to 137 may not exceed XXX cm^3/MJ (value to be determined).

Roughness index of wheel tread

The wheel roughness is measured after brake stops Nos 1.X, 129 and 145. (see recommended method from *ERRI Report B 126/RP 18*).

Interruptions

During the tests, interruptions of 3 days maximum are permitted before Tests No 1, 21, 51, 106, 134 and 141 only.

In the case of an interruption before test No 51, an extra identical braking No 50 must be performed outside the program to observe the conditions for wetting.

Temperatures

After the brake stops the temperature must always be reduced to the initial value again.

The braking to stop (test No 139) that immediately follows the continuous braking, is performed without a cooling-down phase at the temperature achieved at the end of continuous braking.

The continuous braking (test No 140) that immediately follows the braking to stop, which in turn follows a continuous braking, is performed without a cooling-down phase at the temperature achieved at the end of the braking to stop.

For brake stops Nos 21, 106, 134 and 141, an initial temperature between 20 °C and 60 °C is permitted.

Wetting conditions

The brake stops under wet conditions must be performed with a total water quantity of 12 litres per wheel per hour. In wet brake stops, the wheel wetting in the cooling phases must not be interrupted between tests Nos 52 to 104.

After braking No 51 spraying begins only when the wheel temperature has reached 80 °C.

Accuracy of braking parameters

The accuracy required for the individual braking parameters is given in the *ERRI report B 126/RP 18*.

Other conditions

- The brake stops must be performed chronologically in the sequence given.

- The number of bedding-in brake stops required to achieve contact of at least 85 % on the friction face must be given in the test report.

Test wheels

Both wheels from operational use and new wheels can be used.

Before fitting on the test bench, the wheel diameter must be brought to the value shown in the Test Programme.

A.3.3 - Test program A3_b - Simulation brake assessment 1 x Bg

Reserved.

A.4 - Test program A4 - Formation of metallic inclusions

A.4.1 - Test program A4 - Formation of metallic inclusions

V-BKS-Material	organic or sintered
Type of brake block per wheel	1 x Bg (1 Block x (320 x 80 $\binom{+1}{-2}$ mm)) or 2 x Bg (2 Blocks x (320 x 80 $\binom{+1}{-2}$ mm)) or 2 x Bgu (4 Blocks x (250 x 80 $\binom{+1}{-2}$ mm))
Wheel type	Conforms to *UIC Leaflet 510-5* (wheel rim internal diameter 820 mm for wheel - ∅ 870) (wheel rim internal diameter . .... mm for wheel - ∅ 790)
wheel diameter	∅ 790 or 870 mm (semi-worn)
Mass per wheel (wheelset load)	2,5 t 9,0 t or 11,25 t (5,0 t 18,0 t or 22,50 t)

Braking No.	V	F_B (kN)			θ_0	Comments
	[km/h]	2 Bgu 2 Bg (K)	2 Bgu 2 Bg (LL)	1 Bg (K)	[°C]	
R1 to Rx	100	25	25	25	20 - 100	X brake stops to stop, dry, with 9 t/wheel to bed in the block to min. 85% contact pattern
Rx + 1 to Rx + 10	100	7	16	8	20 - 100	10 brake stops to stop to condition the block with 2,5 t/wheel
1 7 13 19	100	7	16	8	20 - 30	Braking to stop, wet, after cooling-down phase Test block(s)
2 8 14 20	30	"	"	"		
3 9 15 21	60	"	"	"		
4 10 16 22	100	5	12	5		
5 11 17 23	30	"	"	"		
6 12 18 24	60	"	"	"		
25 27 29	60	5	12	5	50 - 60	Braking to stop, dry after cooling-down phase Test block(s)
26 28 30	100					
31 to 40	60	5	12	5	20 - 30	Braking to stop, wet, after cooling-down phase Test block(s)
41 to 50	100	"	"	"		
51 to 60	60	7	16	8		
61 to 70	100	"	"	"		
71 73 75	30	7	16	8	50 - 60	Braking to stop, dry, after cooling-down phase Test block(s)
72 74 76	60					

Braking No.	V	F_B (kN)			θ_0	Comments
	[km/h]	2 Bgu 2 Bg (K)	2 Bgu 2 Bg (LL)	1 Bg (K)	[°C]	
77	70	-	-	-	20 - 30	Continuous braking, wet, with a braking power of 15 kW for 10 min
78	70	5	12	5	-	Braking to stop, dry, immediately after continuous braking, without cooling-down phase Test block(s)
79	70	-	-	-	20 - 30	Continuous braking, wet, with a braking power of 15 kW for 20 min
80	70	5	12	5	-	Braking to stop, dry, immediately after continuous braking, without cooling-down phase Test block(s)
		11,25 t wheel	11,25 t wheel	9 t wheel		Perform extra test loaded only if after Br.No 80 the total area of metallic inclusions exceeds 1% of the total area of the brake blocks
81 85 89	100	38	100	30	50 - 60	Braking to stop dry, after cooling-down phase Test block(s)
82 86 90	30					
83 87 91	120					
84 88 92	60					

Braking time: 4 s ± 0,2 s.

A.4.2 - Conditions for performance of test program A4

		Test bench speed (km/h)		Cooling air speed (km/h)	
	v	dry	wet	dry	wet
During braking	≤ 80 km/h	v	v	v/2	10
	> 80 km/h	v	v	40	10
Between brake stops		100	50	40	10

The cooling air speed must be adjusted while complying with the conditions of *ERRI Report B 126/ DT 408*.

Interruptions

During the tests, interruptions of 3 days maximum are permitted only before Nos 1, 25, 31, 71, 77, 79 and 81.

Temperatures

The initial temperature must be achieved during the brake stops by lowering the temperature.

An initial temperature of 20 °C to 60 °C is permitted for brake stops Nos 25, 71 and 81.

Wetting conditions

The brake stops under wet conditions are performed with a water quantity of 12 litres (wheel diameter 790 mm) or 14 litres (wheel diameter 870 mm) per wheel per hour.

In wet brake stops, the wheel wetting in the cooling phases must not be interrupted between tests Nos 1 to 24 and 31 to 70, nor during the entire continuous braking time.

After brake stops nos. RX+10, 30, 76 and 78, wetting begins again only when the wheel temperature has reached 80 °C.

Other conditions

The brake stops are performed chronologically in the sequence given.

On each test of the block, the appearance of the block friction surface, the form, surface composition and position of any inclusions are recorded. The inclusions are left in place during the various observation phases. A photo is to be taken before removal.

A.5 - Test program A5 - Proof of winter braking properties

Reserved.

A.6 - Test program A6 - Simulation "Fixed Brakes"

NB : Readers are advised that test program A6 is still being optimised; imminent changes are possible.

A.6.1 - Test program A6

V-BKS-Material	organic or sintered
Type of brake block per wheel	2 x Bg (2 Blocks x (320 x 80 $\binom{+1}{-2}$ mm)) or 2 x Bgu (4 Blocks x (250 x 80 $\binom{+1}{-2}$ mm))
Wheel type	Conforms to *UIC Leaflet 510-5* (wheel rim internal diameter 820 mm)
Wheel diameter	870 $\binom{+5}{-0}$ mm - The precise diameter must be given in the test report

Braking No.	V	F_B	θ_0	Comments
	[km/h]	[kN]	[°C]	
ES (bedding in)	70	-	20-80	Continuous braking with a power of 25 kW to bed in the block to min. 80 % friction surface contact (in cycles with 45 min per cycle)
BS (brake fault)	100	9 kN (K) 24 kN (LL)	20-60	Continuous braking with constant contact force for max 60 min.

A.6.2 - Conditions for performance of test program A6

Ventilation conditions

The cooling air speed is 35 km/h, it is set observing the conditions of *ERRI Report B 126/DT 408* .

Wear

The blocks are weighed and measured before and after the tests.

During the tests, the block wear is monitored continuously.

Interruptions

Interruptions are not permitted.

Stoppage criteria

The tests are stopped before expiry of the prescribed braking time if the following stoppage criteria are achieved:

Block wear > 16 mm

Temperatures

The temperature is measured using 3 thermocouples arranged in the running circle plane 9 mm below the tread and offset by 120° to each other.

Accuracy of braking parameters

The accuracy required for the individual braking parameters is given in the *ERRI report B 126/RP 18*.

Other conditions

The tests are performed with new blocks.

Test wheels

Both wheels from operational use and new wheels can be used. Before fitting on the test bench, the wheel diameter must be brought to the value shown in the Test Programme. The hollowness of the wheel tread may not exceed 1 mm, if necessary re-profile before testing.

A.7 - Test program A7 - Proof of compatibility with track circuits

Reserved.

A.8 - Test program A8 for V-BKS (L) - Extra block brake passenger coach

Reserved.

A.9 - Test program A9 for V-BKS (L) - Extra block brake goods wagon

Reserved.

A.10 - Test program A10 for V-BKS (K) - Locomotives

Reserved.

A.11 - Test program A11 - Simulation of real usage conditions

Reserved.

A.12 - Test program A12 - Draft - Definition of static friction coefficients

A.12.1 - Test program

V-BKS-Material	organic or sintered
Type of brake block per wheel	2 x Bg (2 Blocks 320 x 80 $\binom{+1}{-2}$ mm) or 2 x Bgu (4 Blocks 250 x 80 $\binom{+1}{-2}$ mm) or 1 x Bgu (2 Blocks 250 x 80 $\binom{+1}{-2}$ mm) per wheel
Wheel type	Conforms to *UIC Leaflet 510-5* (wheel rim internal diameter 820 mm)
Wheel diameter	870 $\binom{+5}{-0}$ mm - The precise diameter must be given in the test report.

Braking	V	F_B	θ_0	Comments
	[km/h]	[kN]	[°C]	
Bedding in	100	24 (K) 60 (LL)	20-80	Braking to stop, dry, to bed in the block to min. 85% contact pattern; running-in edges must support
1 - 5 6 - 10 11 - 15 16 - 20	-	5 14 30 40	< 30	

A.12.2 - Conditions for performance of the test program A12

Measurement values

During the tests, the following measurements must be made and recorded continuously for each test via a recorder:

- time,
- torque,
- rotation angle of test wheel in relation to brake block,
- contact force,
- instantaneous friction coefficient (calculated).

Ventilation conditions

The normal cooling air speed for bedding in is 40 km/h, this must be set with observation of the conditions of *ERRI Report B 126/DT 408*.

Interruptions

Interruptions are not permitted.

Temperatures

The temperature is measured by thermocouples under the wheel tread or "thermo-sliders" on the wheel tread.

Accuracy of braking parameters

The accuracy required for the individual braking parameters is given in the *ERRI report B 126/RP 18*.

Other conditions

- The surface state of the wheel treads must be detected and documented in the test report.
- The application of break-away torque must rise continuously. Slipping must occur within 0,5 and 2,0 s from the start of the torque rise.
- It must be ensured that the play in the system is limited to a minimum, and existing play must be taken into account in analysis.

Test wheels

Both wheels from operational use and new wheels can be used. Before fitting on the test bench, the wheel diameter must be brought to the value shown in the test program. The hollowness of the wheel tread may not exceed 1 mm, if necessary re-profile before testing.

Appendix B - Spread of mean friction coefficients, friction level K (2xBg, 2xBgu, 1xBg)

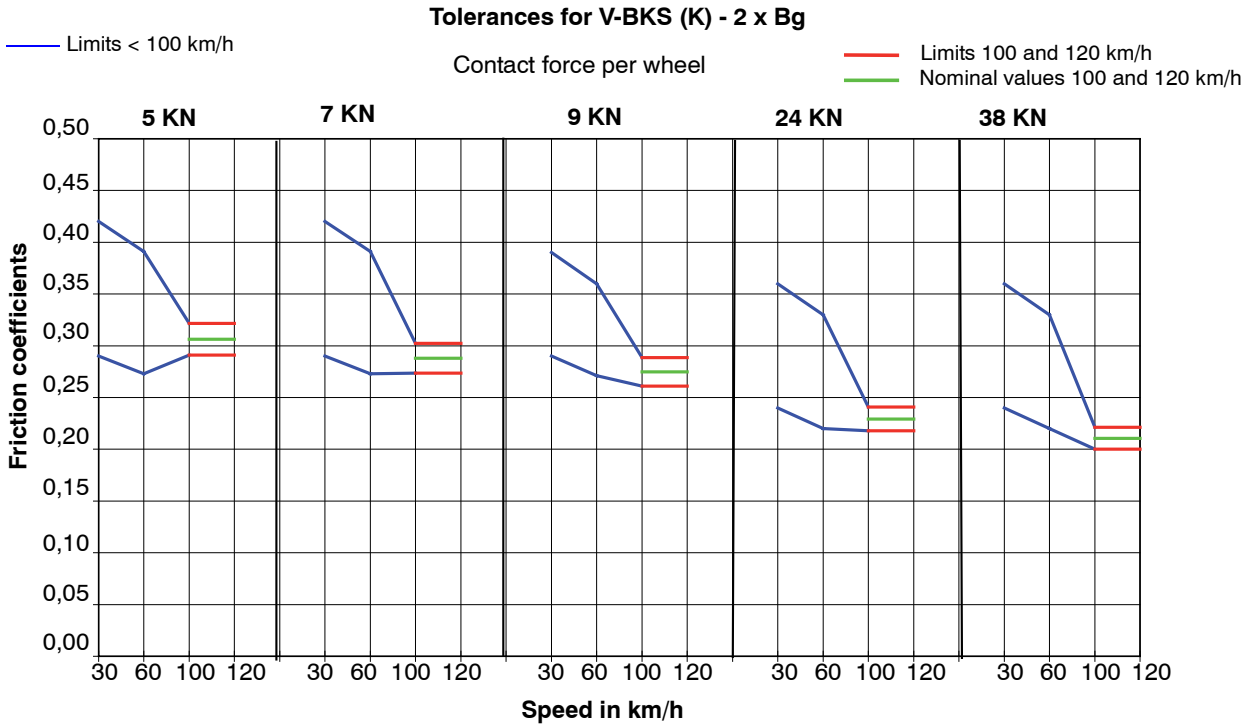


Fig. 1 - Block configuration 2 x Bg

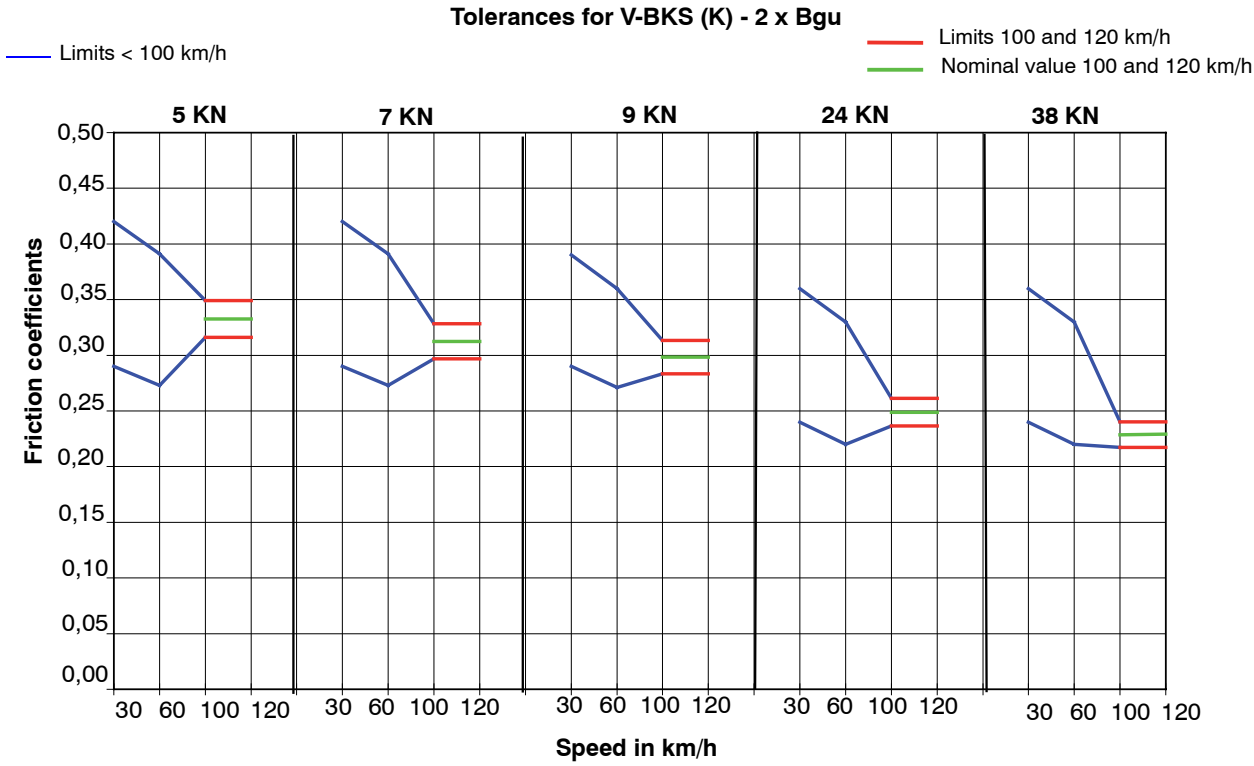


Fig. 2 - Block configuration 2 x Bgu

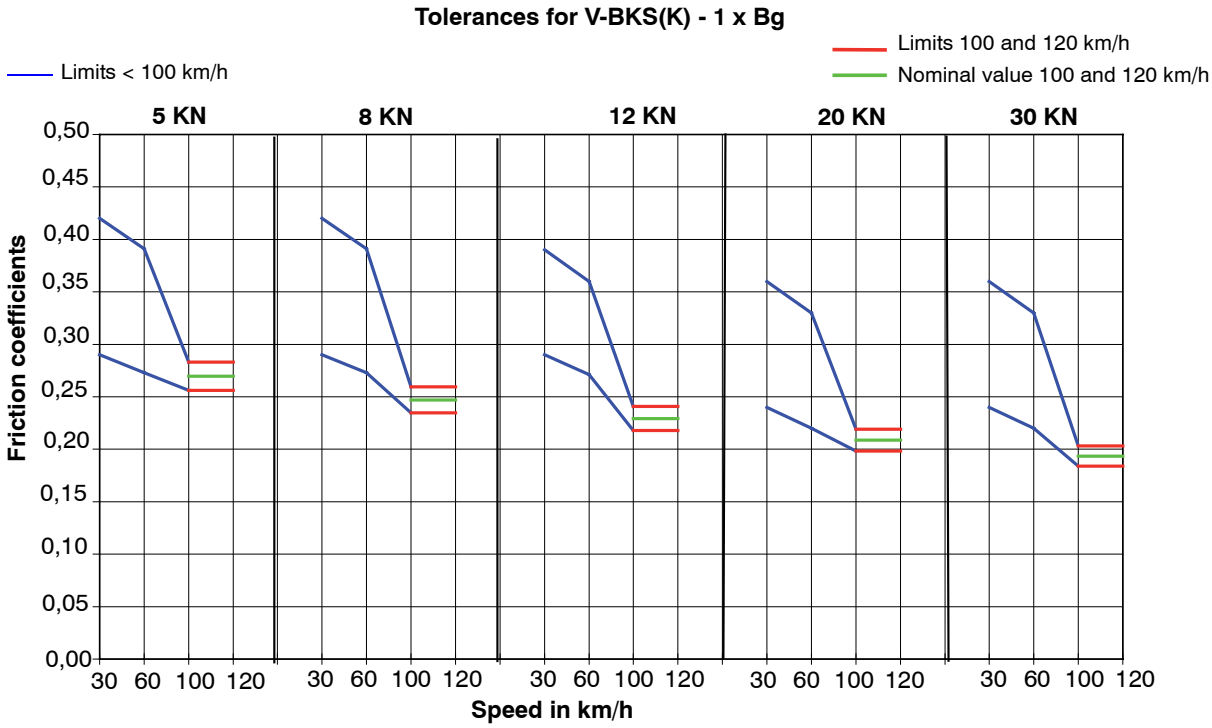


Fig. 3 - Block configuration 1 x Bg

Reserved

Fig. 4 - Block configuration 1 x Bgu

Appendix C - Spread of mean friction coefficients, friction level K

for brake assessment speeds 100 km/h and 120 km/h

Table 1 :

1 x Bg				
Contact force	**V (km/h)**	**μ_{Min}**	**μ_{Norm}**	**μ_{Max}**
Empty 12 kN	100	0,22	0,23	0,24
	120	0,22	0,23	0,24
Loaded 20 kN	100	0,20	0,21	0,22
	120	0,20	0,21	0,22
Loaded 30 kN	100	0,18	0,19	0,20
	120	0,18	0,19	0,20

Table 2 :

2 x Bg				
Contact force	**V (km/h)**	**μ_{Min}**	**μ_{Norm}**	**μ_{Max}**
Empty 9 kN	100	0,26	0,27	0,29
	120	0,26	0,27	0,29
Loaded 24 kN	100	0,22	0,23	0,24
	120	0,22	0,23	0,24
Loaded 38 kN	100	0,20	0,21	0,22
	120	0,20	0,21	0,22

Table 3 :

2 x Bgu				
Contact force	**V (km/h)**	**μ_{Min}**	**μ_{Norm}**	**μ_{Max}**
Empty 9 kN	100	0,28	0,30	0,31
	120	0,28	0,30	0,31
Loaded 24 kN	100	0,24	0,25	0,26
	120	0,24	0,25	0,26
Loaded 38 kN	100	0,22	0,23	0,24
	120	0,22	0,23	0,24

Table 4 :

1 x Bgu				
Contact force	**V (km/h)**	**μ_{Min}**	**μ_{Norm}**	**μ_{Max}**
	Reserved			

Appendix D - Spread of mean friction coefficients, friction level L

Reserved.

Appendix E - Spread of mean friction coefficients, friction level LL

Reserved.

Appendix F - Example diagram of requirements for instantaneous friction development

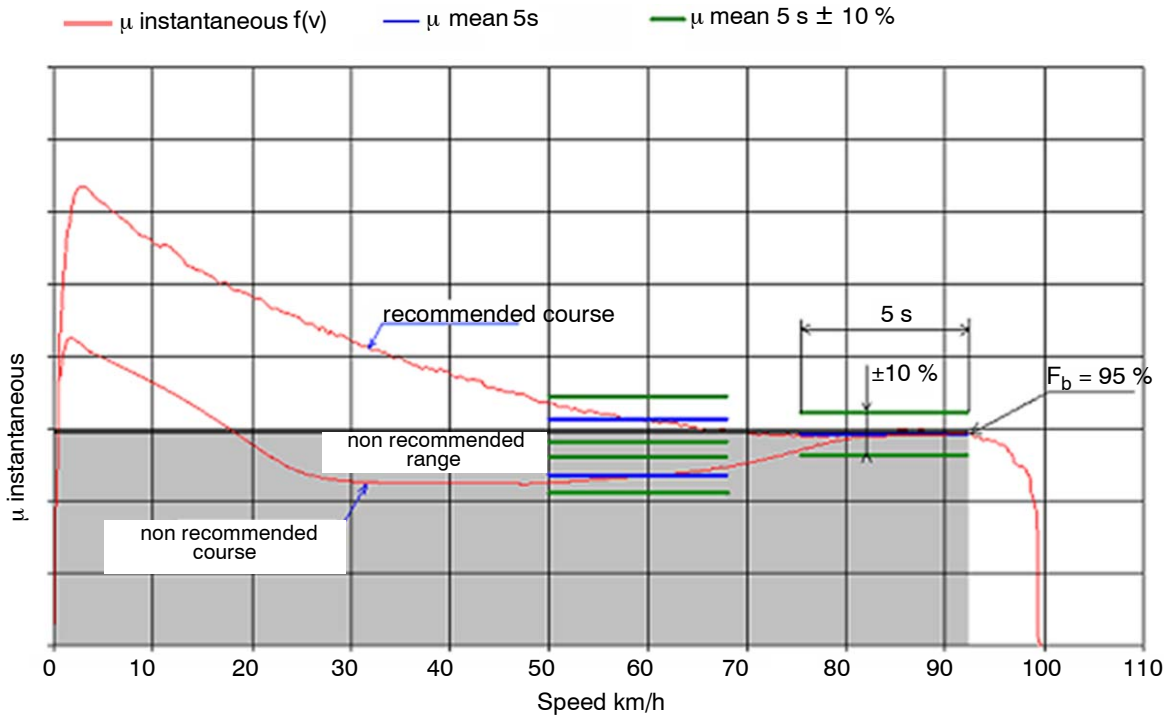


Fig. 5 -

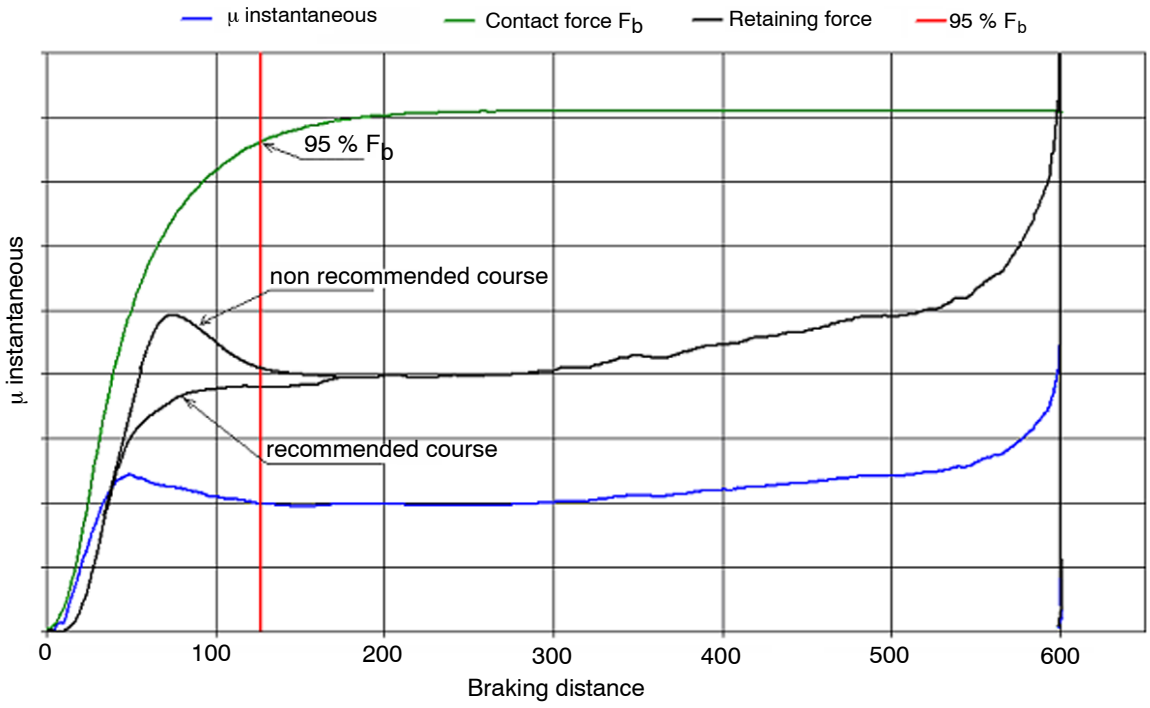


Fig. 6 -

Appendix G - Proof of winter braking suitability; line test

G.1 - General

This is performed with a train configuration comprising 5 wagons and one motive power unit as comparison tests between line brake tests without flying snow ("reference tests") and those with flying snow ("winter tests").

The objective of the tests is to establish the winter braking behaviour of composite materials under real conditions of use.

G.1.1 - Test wagon

5 wagons of the same design with the same equipment for:

- bogie type,
- brake design,
- block arrangement and design,
- type of brake blocks.

G.1.2 - Motive power unit

Any MPU, maximum speed ≥ 120 km/h with indirect braking disconnected.

G.1.3 - Documentation

The following documentation must be present:

- wagon data/wagon data sheet,
- brake design/brake calculation,
- detailed data on brake design/brake equipment,
- complete data on block type used,
- results of tests performed with this block type and application.

G.2 - Test conditions

The following test conditions are required for the brake tests:

Period of performance:	Winter half year with flying snow
Test line:	max. gradient conditions +/- 2 ‰
Initial braking speeds:	60, 100 and 120 km/h
Brake type:	P
Climatic conditions:	Minus temperatures with snow on track
Test configuration:	Train combination of 5 wagons + MPU (unbraked)
Features:	To ensure a good comparability of the test conditions, it must be ensured that: - the brake stops usually take place at the same points, - for each test day, preferably two wagon groups are tested, - the tests are performed and the weather conditions are assessed by the same test team.

G.2.1 - Assessment principles

G.2.1.1 - Parameters

- speed,
- braking distance,
- time,
- main air line pressure,
- external temperature.

The required parameters can alternatively be recorded with a train monitoring system installed in the MPU.

G.2.1.2 - Calculation of braking hundredths of individual wagons

The calculation of the brake hundredths resulting for the individual wagons is performed in simplified form as follows:

for v_0 = 100 km/h:

$$\lambda_{\text{Test wagon}} = \frac{m_{\text{meas·part}} \left(\frac{52840}{S_{\text{Bvers}}} - 10 \right)}{m_{\text{Test wagon}}}$$

for v_0 = 120 km/h:

$$\lambda_{\text{Test wagon}} = \frac{m_{\text{meas·part}} \left(\frac{83634}{S_{\text{Bvers}}} - 19 \right)}{m_{\text{Test wagon}}}$$

$\lambda_{\text{Test wagon}}$	Braking hundredths of a test wagon
$m_{\text{Meas. part}}$	Weight of test configuration
$m_{\text{Test wagon group}}$	Weight of test wagon group
S_{Bvers}	Corrected braking distance of test configuration in tests

G.2.1.3 - Allocation criteria "Reference" or "Winter" Test

The following allocation criteria apply to the line test:

Reference test "R"	➔	Snow behaviour 0 to 1 no or little flying snow (all wagons visible)
Winter test "W"	➔	Snow behaviour 2 to 5 moderate to severe flying snow (at "5" - no wagon visible)

G.3 - Evaluation of Measurement Data

G.3.1 - Table Presentation

The results are compiled in table form. The following data must be included:

Brake test with type xxx empty													*UIC Leaflet 544-1*	C	D
Block: XXX						Gradient: max. ± 2 ‰							100 km/h	52840	10
Test No.	Place km	Brake type	Time HH:MM	V_0 (km/h)	V_{corr} (km/h)	Brake time (s)	Fully developed deceleration $m/s^2*0,01$	Braking distance measured (m)	Braking distance corr. (m)	λ corr. per wgn	Snow behaviour	External temperature	120 km/h Date	83634 R/W	19 Comment

G.3.2 - Statistical Processing

For each test series, the following data must be given:

- test number,
- place and date,
- brake type,
- time,
- external temperature,
- V_0,
- V_{corr},
- braking time,
- braking distance measured,
- braking distance corrected,
- λ,
- snow behaviour,
- reference test/Winter test,

- number of tests,
- mean of corrected braking distances,
- standard deviation of corrected braking distances,
- λ mean,
- λ standard deviation.

G.3.3 - Classification of measurement data

The measurement values are classed into the following groups for each wagon combination and speed:

- Measurement values for **reference test "R"** Snow behaviour 0 to 1
- Measurement values for **winter test "W"** Snow behaviour 2 to 5

The number of reference and winter tests must be at least 10 for each wagon combination and speed.

For the reference tests, the quotient between standard deviation (Stw) and mean (Mw) must be < 5%.

There is no requirement for this in the winter test.

Appendix H - Drawing examples V-BKS - 5 diagrams

For information on the standard contact surface and form of brake block wedges see *UIC Leaflet 541-1* (see Bibliography - page 77).

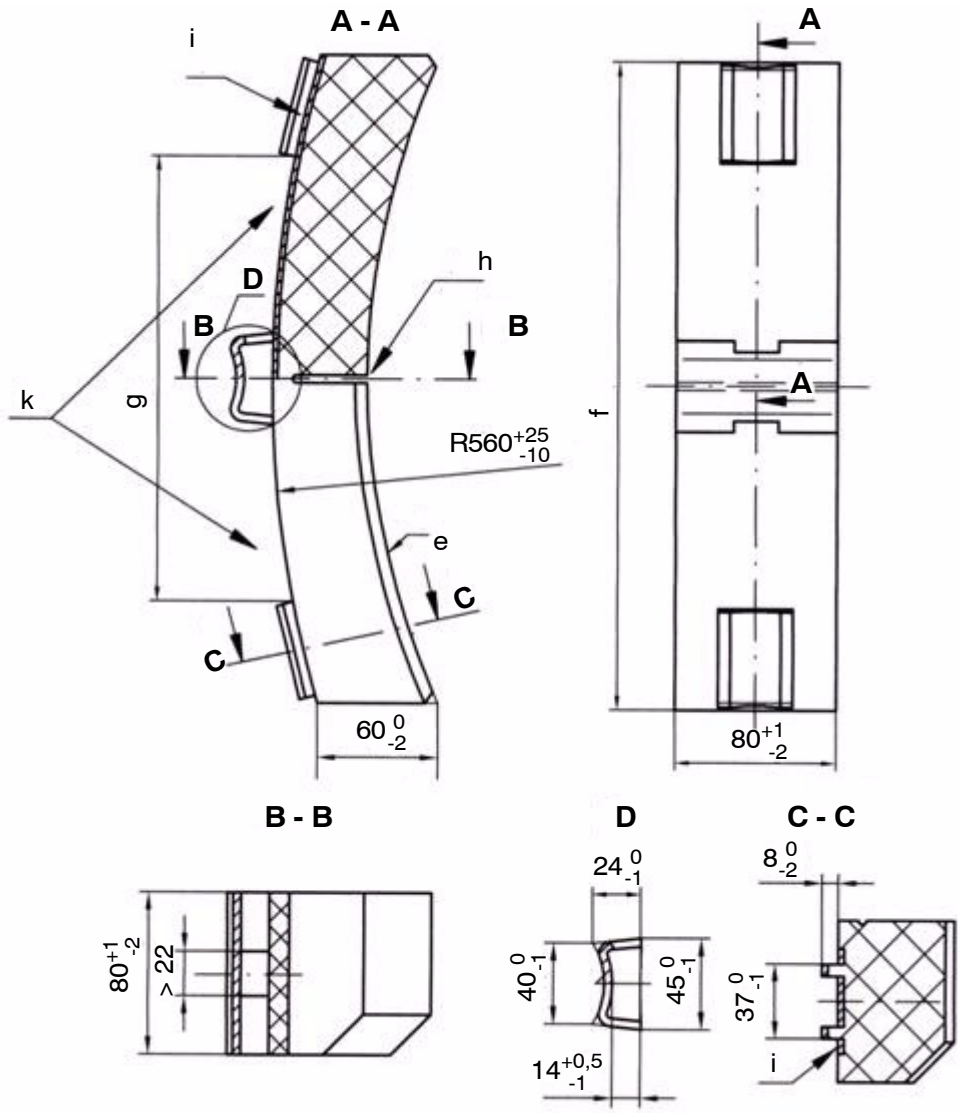


Fig. 7 - Design examples for standard brake blocks length 250 mm and 320 mm

General tolerances according to the applicable standard (e.g. *ISO 2768-m*).

e	The cross profile of the friction surface must be compatible with that of the wheel profile (e.g.: 1:40). The longitudinal profile of the friction surface must match the rim diameter, optionally with double the radius.		
f	For brake blocks	Bgu :	f = 250 mm
		Bg :	f = 320 mm
g	For brake blocks	Bgu :	g = 182 mm
		Bg :	g = 220 mm
h	With or without expansion joint, as per manufacturer's preference.		
i	Type and design of parent panel, as per manufacturer's preference.		
k	Protection against in correct use is to be considered for V-BKS (K) - see fig. 9 - page 62		

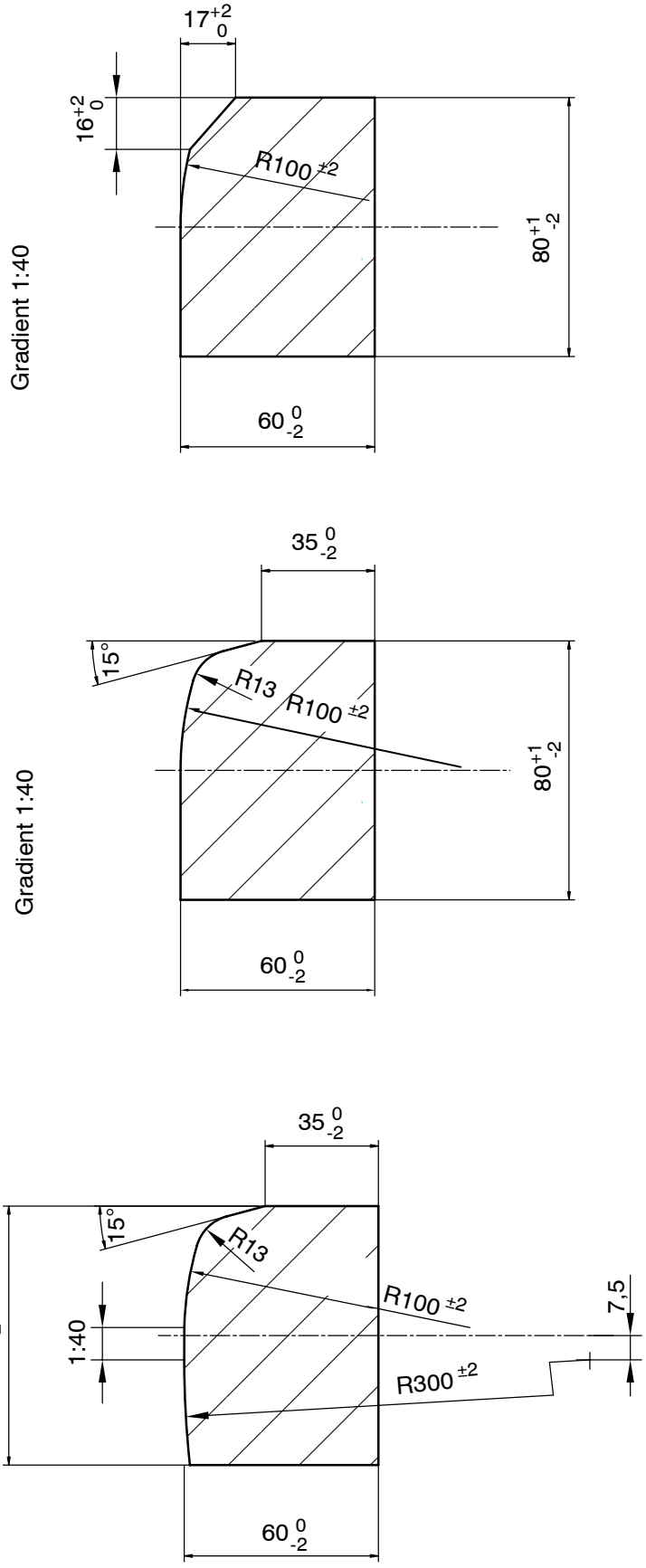


Fig. 8 - Design examples for contour of friction surface

General tolerances according to the applicable standard (e.g. *ISO-2768-m*).

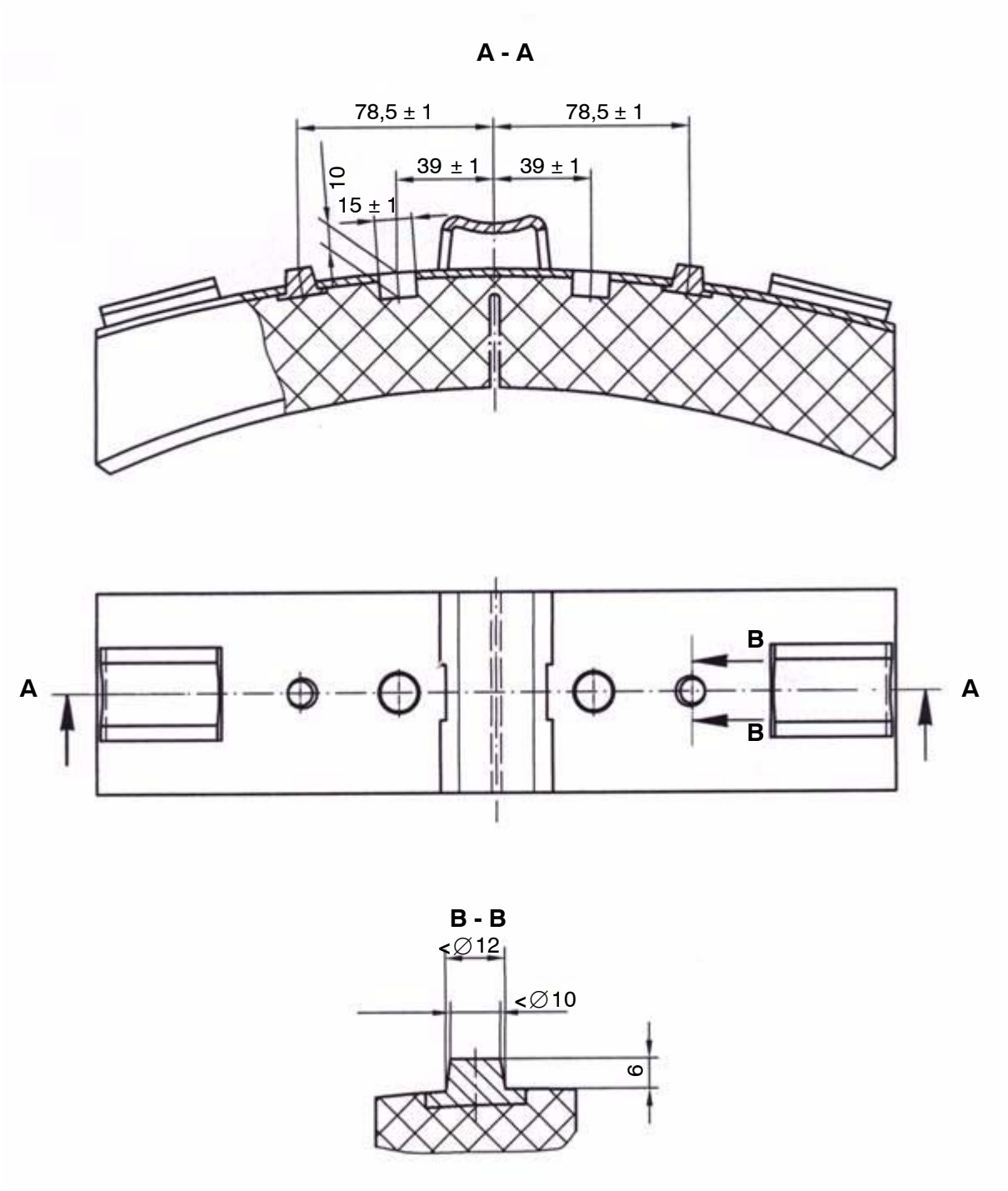


Fig. 9 - Proof against incorrect use for brake blocks friction type K

General tolerances according to the applicable standard (e.g. *ISO-2768-m*).

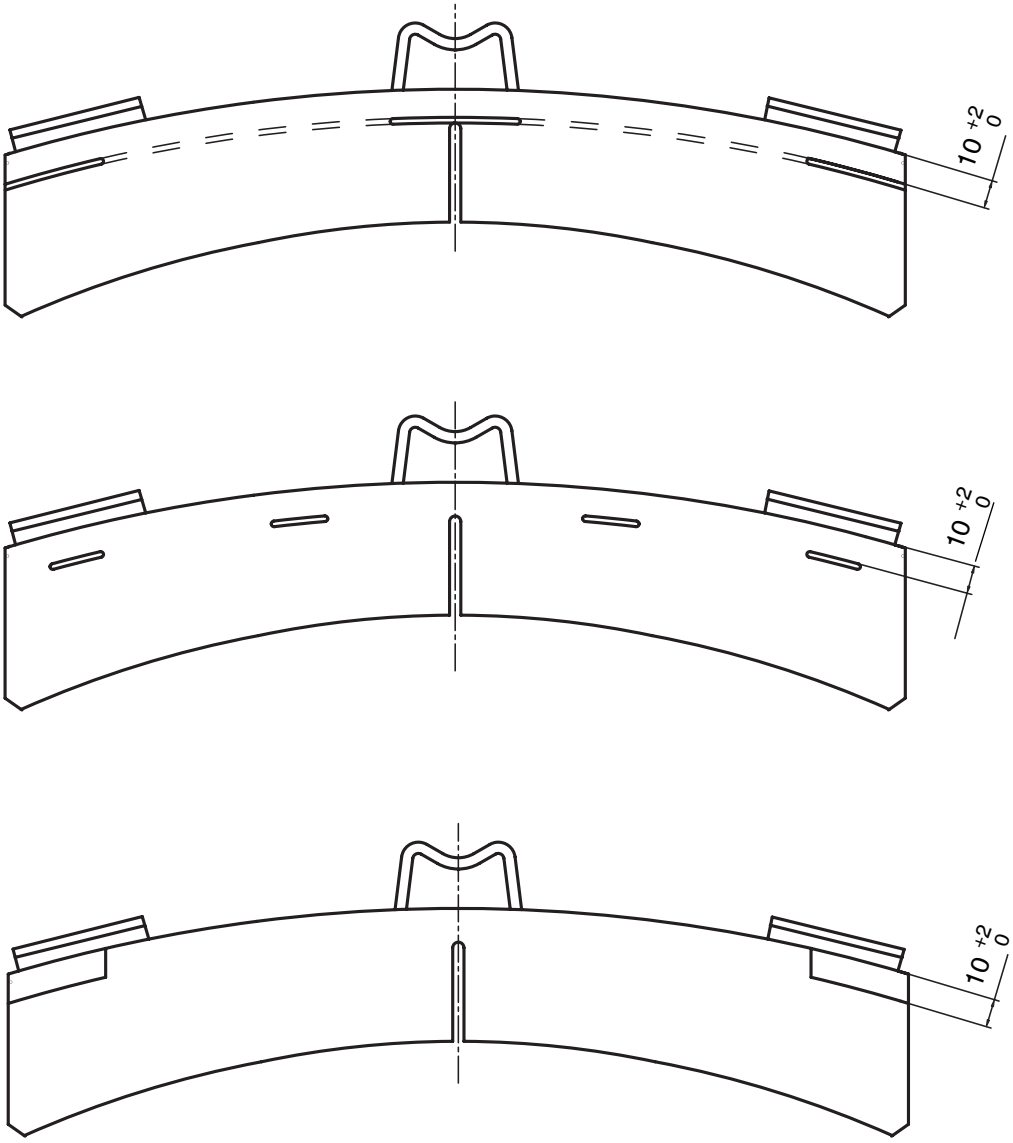


Fig. 10 - Design example for wear limit marking

- All wear markings are to be positioned on the side not facing the wheel flange.
- Other designs, deviating from the examples shown above are permitted.
- The positioning of the wear markings must ensure that the brake blocks can be worn up to the markings, without parts of the reinforcement or the parent panel being scraped. This also applies to the application of the smallest wheel diameters.

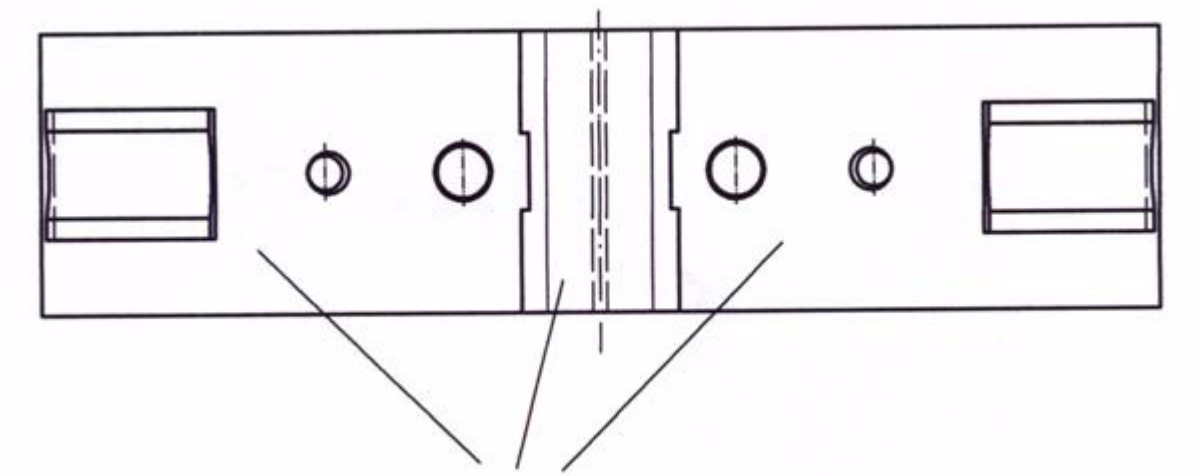


Fig. 11 - Design example for marking

Design example for marking the brake block:

- The type of positioning is left up to the manufacturer,

- Font size minimum 4 mm,

- The following markings are obligatory

  - Type designation of the brake block type,
  - Name or designating symbol of the manufacturer,
  - Date of manufacture (week and year),
  - Batch number,
  - UIC + friction coefficient level (e.g. UIC-K or UIC-L or UIC-LL)

- The following markings are optional

  - Customer item number or customer-specific designation (depending on customer requirements, e.g. colour coding).

Appendix I - Strength tests

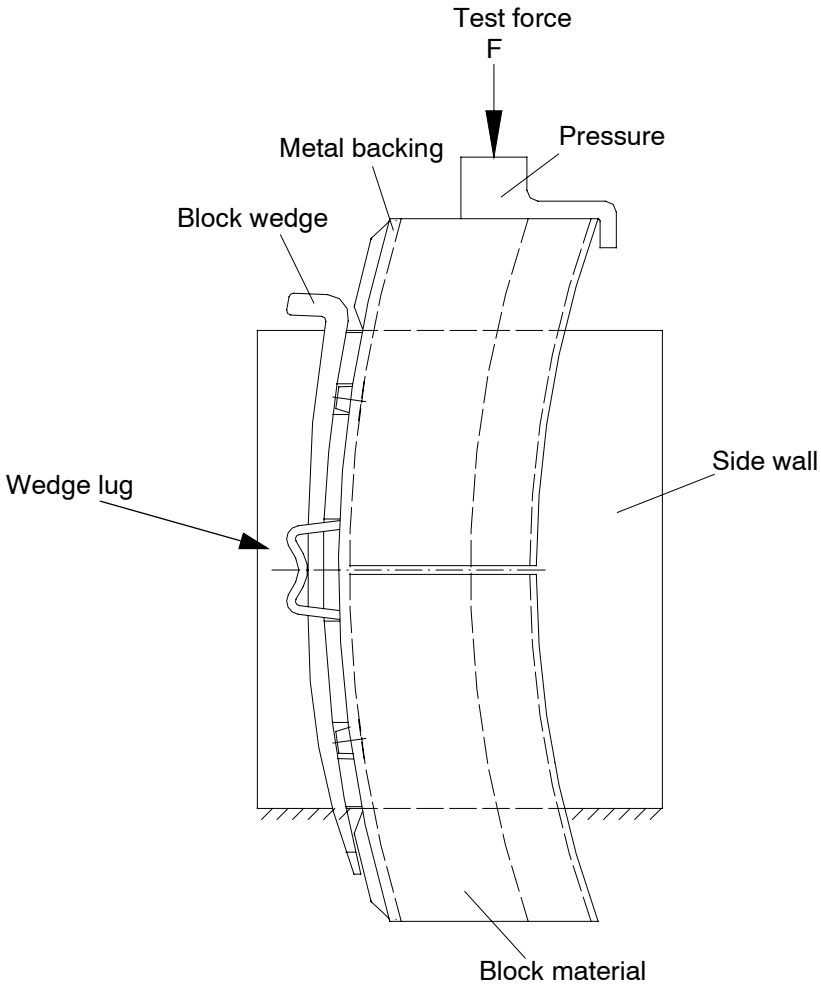


Fig. 12 - Device for testing the strength of the metal backing plate - block material connection

Test conditions:

Test load F

F = 15 kN (K -, L - or LL - block, 250 mm or 320 mm).

Performance

The test is to be carried out as shown in fig. 12. A new block is to be used for the test. This is determined by means of the wedge lug. A lug is to be introduced for two-part blocks or single blocks with a centre groove, to ensure the complete load transfer between the block parts.

Test load F is to be applied evenly in the direction of the circumferential load when braking and increased to the maximum load of 15 kN within 4 s and maintained constantly for 2 minutes.

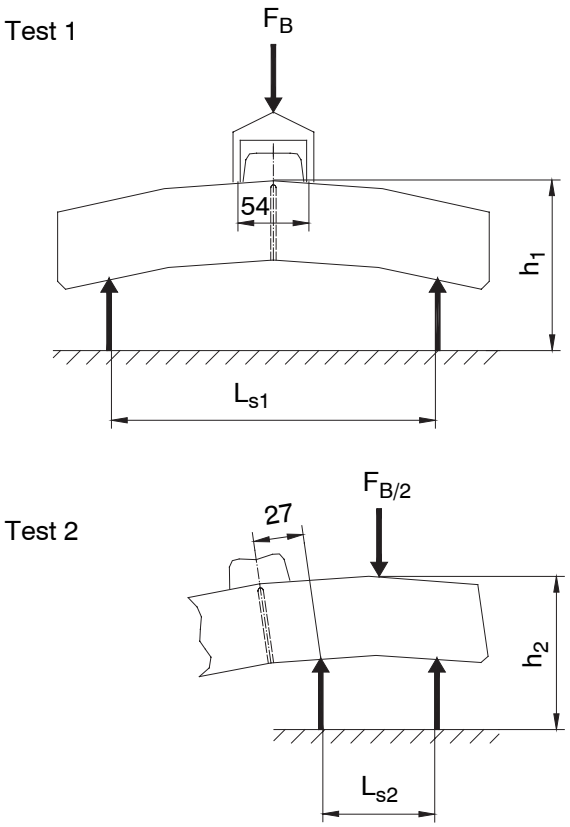


Fig. 13 - Test of bending strength

Test conditions

Test force F_B
$F_{B\ K}$ = 19 kN (K-Block, 250 and 320 mm)
$F_{B\ LL}$ = 28 kN (LL-Block 250 mm)
$F_{B\ LL}$ = 33 kN (LL-Block 320 mm)

Support width L_s
L_{s1} = 200 mm (Block 250 mm)
L_{s1} = 270 mm (Block 320 mm)

L_{s2} = 75 mm (Block 250 mm)
L_{s2} = 110 mm (Block 320 mm)

Flexion Δh
Δh_1 = 2 mm
Δh_2 = 1 mm

Performance
For both tests, new brake blocks are used.

The test force is applied evenly at a speed of 30 mm/min to the given max. value of the test force **or** to the given max. value of the flexion Δh, and held constant for 2 min.

5 tests must be performed per series.

The base for the supports must have a radius of R = 5 mm.

Appendix J - Proof of compatibility with track circuits

Test program for composite blocks type K, L or LL to prove compatibility with the track circuits

J.1 - Object

This document describes the test method and proof of compatibility with the track circuits of the European rail networks for composite brake blocks used on goods wagons.

J.2 - Area of application

This specification applies to all composite blocks for which a licence is requested for international goods transport. It also applies for composite blocks already licensed, for which the composition has been changed.

J.3 - Reference standards

PrEN 50238: compatibility between rolling stock and train location systems (see Bibliography - page 77).

J.4 - Specialist terms

UM 71 Classic: track circuit with electrical separation joint.

J.5 - Safety, availability and reliability requirements

Proof of compatibility of a composite brake block with the track circuits must show that a goods wagon braked with composite brake blocks is always guaranteed to be located by track circuits, irrespective of their type.

J.6 - Functional and technical requirements

The proof of compatibility of a composite block type is determined by the residual voltage which is determined on passage of a goods wagon braked with this type of block. This value is measured in the area of the track circuit UM 71 Classic at the secondary winding of the input transformer on the receiver side (measurement of U_{R1R2} voltage).

J.7 - Test report and proof of shunt tolerance (compatibility with track circuits)

- The tests must be performed by a test institute which is accredited by a body with UIC mandate. The test instrumentation is at their discretion.

- After the tests the test institute produces a report for the results obtained and their correlation. From these results, the body appointed by the UIC to point J.7.2 - page 69 issues a report for the "shunt tolerance" (or "compatibility with track circuits") of the composite block types tested.

J.7.1 - Test conditions

K-blocks must be tested on a goods wagon type S40, LL-blocks on an R10.

This goods wagon must be fitted with the composite brake block to be tested (bedded in to at least 80% contact on the friction surface of the block). The test goods wagon must be empty and ready for operation.

The tests take place on the Paris-Brest line between the stations Plouaret and Plounérin on a level, stabilised section with welded longitudinal rails and low traffic (< 20 scheduled trains per day, except test trains).

The tests are performed with a motive power unit with insulated wheelsets.

The measurements are performed on sections at least 650 m long with GSK type UM 71 Classic (432E, 432F, 432G) and a U_{R1R2} voltage of around 250 mV.

The measurements are performed as follows:

- Stopped in last quarter of a GSK on receiver side,

- Travel at 30 and 60 km/h and at top speed,

- Operating braking and fast braking.

Only the measurements performed according to conditions are taken into account, i.e.:

- Dry rail surface,

- Relative humidity between 70 and 95 %.

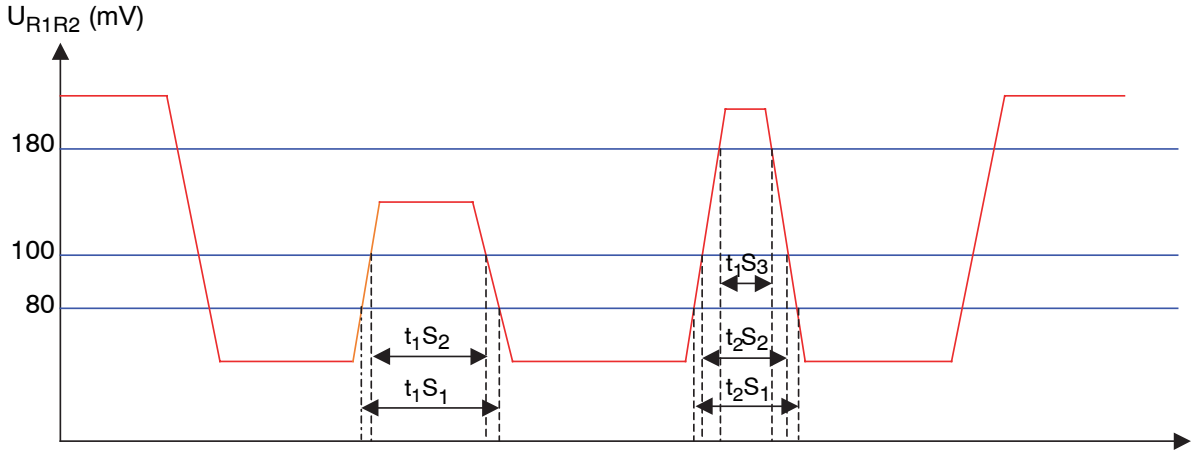
As the acceptance conditions are based on calculations of the mean times of exceeding the individual limit values to obtain a representative test, 40-45 measurements must be present with at least 3 test drives for each configuration above.

J.7.2 - Results analysis

J.7.2.1 - Preliminary evaluation

A special computer program calculates, for each measurement, the maximum value of the residual voltage and the three cumulative times of exceeding each of the three predefined limit values:

- S_1: 80 mV,
- S_2: 100 mV,
- S_3: 180 mV.



Cumulative exceeding time S_1: $t_iS_1 = t_1S_1 + t_2S_1$,

Cumulative exceeding time S_2: $t_iS_2 = t_1S_2 + t_2S_2$,

Cumulative exceeding time S_3: $t_iS_3 = t_1S_3$.

J.7.2.2 - Analysis method

The analysis method is as follows:

1. Determination of maximum value of residual voltage when stopped,
2. Determination of absolute maximum of residual voltage,
3. Calculation of cumulative time of exceeding each limit value, for all measurements:
   - Total time for exceeding limit value S_1: $t_{total}S_1 = \Sigma t_1S_1$
   - Total time for exceeding limit value S_2: $t_{total}S_2 = \Sigma t_1S_2$
   - Total time for exceeding limit value S_3: $t_{total}S_3 = \Sigma t_1S_3$

4. Calculation of mean of cumulative time of exceeding each limit value, per measurement:

   - mean time for exceeding limit value S_1: $t_{mean}S_1 = t_{total}S_1/N$
   - mean time for exceeding limit value S_2: $t_{mean}S_2 = t_{total}S_2/N$
   - mean time for exceeding limit value S_3: $t_{mean}S_3 = t_{total}S_3/N$

   N (total number of measurements) = 3 n, where n corresponds to the number of runs and 3 is the number of monitored TC for the run.

J.7.3 - Acceptance conditions

In use of a goods wagon, a composite brake block is considered shunt-compatible with TC if the following conditions are observed:

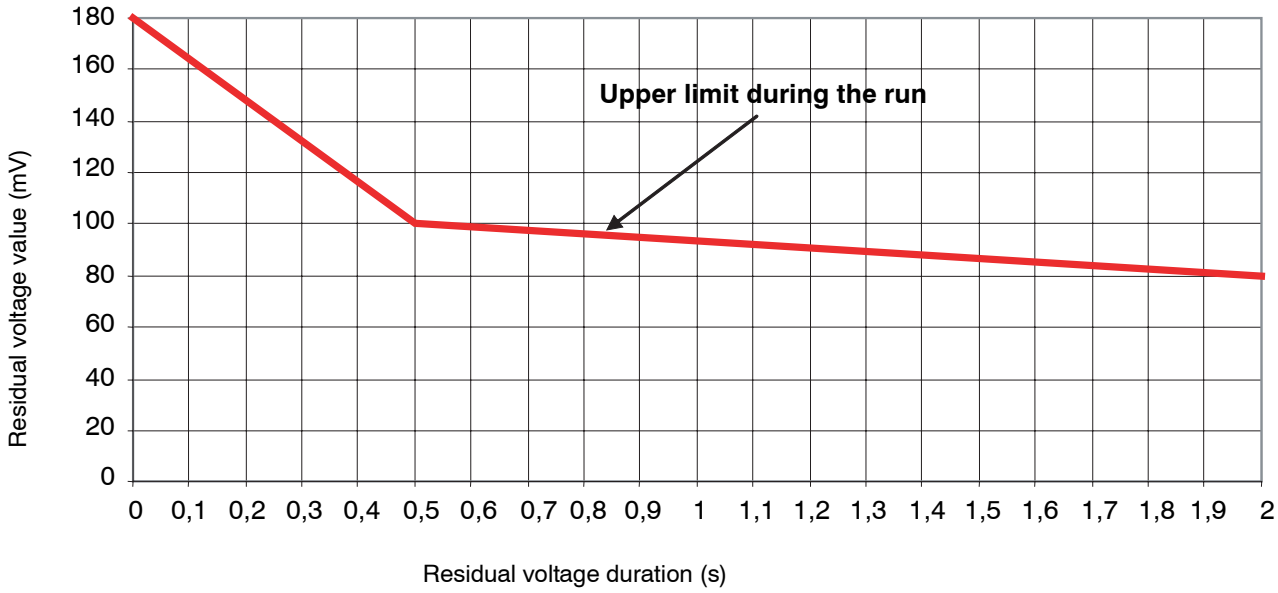
- maximum residual voltage when stopped ≤ 30 mV,
- all measured residual voltage values ≤ 180 mV,
- the mean of cumulative times with residual voltage values for 100 mV < 0,5 seconds,
- the mean of cumulative times with residual voltage values for 80 mV < 2 seconds,

These conditions are depicted graphically in the following diagram.

The limit curve for acceptance is defined by the following points:

- Ordinates with origin 180 mV,
- Mean of time of exceeding limit value 100 mV: 0,5s,
- Mean of time of exceeding limit value 80 mV: 2s,

The limit curve for acceptance when stopped is defined by the equation y = 30 mV.



Appendix K - Reserved

Appendix L - Requirements for data sheets

Reserved.

Appendix M - Composite brake blocks for international traffic

M.1 - Composite brake blocks with high friction level (K)

The list of composite brake blocks licensed for international traffic is shown on the UIC website: http://www.uic.asso.fr/ Activities/Technology and Research/Products.

M.2 - Composite brake blocks with medium friction level (L)

The list of composite brake blocks licensed for international traffic is shown on the UIC website: http://www.uic.asso.fr/ Activities/Technology and Research/Products.

M.3 - Composite brake blocks with low friction level (LL)

The list of composite brake blocks licensed for international traffic is shown on the UIC website: http://www.uic.asso.fr/ Activities/Technology and Research/Products.

Appendix N - Composite brake blocks licensed before 01.01.1996 - Stock protection

Licensed on the basis of the clauses in *UIC Leaflet 541-4, 2nd edition (1.10.1990)* (see Bibliography - page 77) (quality control by user RU).

The list of composite brake blocks licensed for international traffic is shown on the UIC website: http://www.uic.asso.fr/ Activities/Technology and Research/Products.

Appendix O - Definitions

In data on the friction coefficient tolerance, we distinguish between:

- the **instantaneous friction coefficient** μ_a , which is determined in any moment of braking by the ratio of total braking force F_t to total contact force F_b:

$$\mu_a = \frac{F_t}{F_b}$$

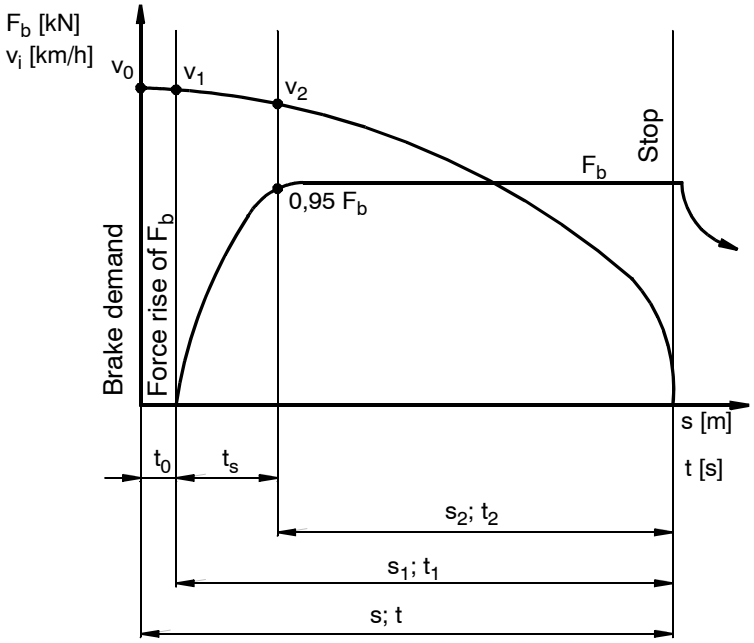
- the **mean friction coefficient** μ_m , determined from reaching 95 % of the nominal contact force F_B of the friction coefficient μ_m for the braking distance s_2:

$$\mu_m = \frac{1}{s_2} \times \int_0^{s_2} \mu_a \times ds$$

- **static friction coefficient**: friction coefficient at start of slipping of mean value from measurement records for intersection of the linearised curve of the rotary angle with the time axis

Definitions and abbreviations

-	Proportional mass to be braked by a wheel (including rotation part)	m [t]
-	Total nominal contact force per wheel	F_B [kN]
-	Total instantaneous contact force per wheel	F_b [kN]
-	Mean contact force (integrated for s_2)	F_{bm} [kN]
-	Pressure in brake cylinder	p_c [bar]
-	Instantaneous tangential force per brake related to the wheel radius	F_{tR} [kN]
-	Mean tangential force (integrated for s_2) related to the wheel	F_{umR} [kN]
-	Total nominal braking power per wheel for continuous braking (v and F_{tR} = const. regulated)	P [kW]
-	Mean braking power (integrated for s_2)	P_m [kW]
-	Nominal speed on braking	v [km/h]
-	Instantaneous speed	v_i [km/h]
-	Actual speed on braking	v_0 [km/h]
-	Correction factor for speed	K [-]
-	Speed at start of force rise from F_b	v_1 [km/h]
-	Speed at time at which F_b = 0,95 x F_B	v_2 [km/h]
-	Free-run time between brake demand and start of brake force rise from F_b	t_0 [s]
-	Brake build-up time from 0-95 % of F_B	t_s [s]



-	Total braking distance from brake demand to stop	s [m]
-	Total braking time	t [s]
-	Braking distance from start of force rise from F_b to stop	s_1 [m]
-	s_1 corresponding braking time	t_1 [s]
-	Braking distance from time at which F_b = 0,95 x F_B to stop	s_2 [m]
-	s_2 corresponding braking time	t_2 [s]
-	Instantaneous retardation	a [m/s^2]
-	Mean retardation (starting from v_0 and s calculated)	$a_m = \frac{v_0^2}{2s}$ [m/s^2]
-	Instantaneous friction coefficient (brake block)	$\mu_a = \frac{F_{tR}}{F_b}$
-	Mean friction coefficient	$\mu_m = \frac{1}{s_2} \times \int_0^{s_2} \mu_a \times ds$
-	Mean initial temperature at start of braking process	θ_0 [°C]
-	Maximum temperature achieved by mean of instantaneous temperatures	θ_m [°C]
-	Instantaneous single temperature	θ_I [°C]
-	Maximum single temperature	θ_{max} [°C]
-	Maximum temperature difference between 2 temperature measurement points	$\Delta\theta_{max}$ [°C]

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Warning

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