Technical and Research Platform
SET 07, “Braking”

UIC Question 5-110 (ex 4.04.501):
Noise abatement -
Fitting freight wagons with composite brake blocks

Design rules for composite brake blocks (K)

(9th edition)

Part 1

Design and construction of freight wagons fitted with composite brake blocks with a high coefficient of friction (K)

Part 2

Brake operation, monitoring and maintenance

Applicable as of: **1 August 2013**

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Preliminary remarks and validity

In October 2003, the former UIC CTR gave full approval for the use of composite K brake blocks in international transport.

The permitted technical usage parameters (benchmark values) for composite brake blocks (K) are based on the following standard basic conditions:

- V_{max} = 120 kph
- min. axle load in accordance with UIC Leaflet 530-2
- max. axle load = 22.5 t (S-braked) or max. axle load = 20t (SS-braked); the use of **/*** as per UIC Leaflet 432 / TSI is possible
- Nominal wheel diameter 920 mm
- Brake block profile Bg or Bgu in accordance with UIC standard
- Scope of use: all lines in the UIC zone, with a maximum gradient of 40 ‰.

Chapter 3.1 of UIC Leaflet 541-4, 4th edition, describes the tests to be performed for approval of a block under these standard basic conditions. In addition to the conditions set out in chapter 3.1.1 of UIC Leaflet 541-4 for certification under standard basic conditions, it is possible to approve a brake block already certified as per chapter 3.1.1 of UIC Leaflet 541-4 for other applications. It is also possible to approve a brake block exclusively for different ranges of application. A UIC expert is to assess the conformity between the test programme conducted and the actual type of application. Appendix 1.2 describes in greater detail the procedure for this extension of approval.

This document details the provisions to be applied for the construction of wagons (Part 1), and for their operation, monitoring and maintenance (Part 2) when fitted with composite brake blocks (K).

Derogations from these provisions are only permitted if written approval is given by UIC SET 07, “Braking”[1].

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Part 1 – Design and construction of wagons fitted with composite brake blocks (K)

1.1 Technical provisions for fitting wagons with composite blocks

The following provisions and other requirements are to be observed when fitting wagons with composite brake blocks (K).

1.1.1 Requisite braking power

The braked weight percentages of the vehicles must meet the requirements of UIC Leaflet 543.

The braked weights are to be determined by line braking tests (slip tests) in accordance with UIC Leaflet 544–1, 4th edition, for the range of speeds up to the max. speed, for both whole-train and individual wagon tests.

Slip tests are not necessary if results have been obtained using a reference vehicle of the same construction type (in compliance with the following criteria), and the tests were performed by an accredited testing institute (EN 17025).

Criteria for a vehicle to be classified as a “reference vehicle of the same construction type”:

- Axle loads (tare and laden)
- Maximum speed for scheduled operations
- Brake block configuration and type of brake block
- Brake regime and braked weights
- Brake system type (automatic load-proportional braking or stepped load change)
- Nominal wheel diameter
- Drag as specified in DT 308

1.1.2 Approximate pre-calculation of brake block loads (guide only)

There are two ways of performing the approximate pre-calculation:

Option A: Pre-calculation using the time step method
As specified in UIC Leaflet 544-1, Appendix I (or EN 14531-6)

Option B: Pre-calculation using the k value method
taken from UIC-MB 544-1, section 2.2.2.1

Using the types of composite brake blocks (K) described in the present document and the brake block profiles listed in the tables, and assuming a mean dynamic efficiency value of η_{dyn}=0.83* (*using conventional brake rigging), the following formulae may be applied to calculate the brake assessment factor k_k, if using calculation method for cast-iron P10 brake blocks as described in UIC Leaflet 544-1 section 2.2.2.1.

$$k_k = a_0 + a_1 F_{dyn} + a_2 F_{dyn}^2 + a_3 F_{dyn}^3$$

where

	a_0	a_1	a_2	a_3
$k_{k\,Bg}$	4.3325	-0.3001	0.0185	-0.0004
$k_{k\,Bgu}$	4.3205	-0.1778	0.0051	0

$k_{k\,Bg}$ = Brake assessment factor for determining the braked weight on wagons fitted with composite brake blocks with the K coefficient of friction and the profile 2 x Bg

$k_{k\,Bgu}$ = Brake assessment factor for determining the braked weight on wagons fitted with composite brake blocks with the K coefficient of friction and the profile 2 x Bgu

F_{dyn} = Dynamic single block force (see also UIC Leaflet 544-1)

a_0 - a_3 = Constants

The k_k values calculated on the basis of the dynamic single block forces (F_{dyn}) and the resultant braked weight per brake block are contained in the tables in Appendix 1.1.

1.1.3 Types of composite brake blocks (K) to be used

The certified brake block types are listed in Appendix M1 of UIC Leaflet 541-4 (to be found on the UIC website).

1.1.4 Fitting wagons with composite brake blocks

- When fitting S and SS wagons, the brake rigging components must meet the requirements of UIC Leaflet 542 (5th edition, September 2010) for S running conditions (60 kN brake rigging).
  It is recommended to use the optimised 45 kN brake rigging as per Report B126 RP 39.
  Alternatively the usual brake rigging may continue to be used.

- Brake block holders and brake blocks must be fitted with protection against incorrect use in accordance with UIC Leaflet 541-1 (brake block holders) and UIC Leaflet 541-4 (brake blocks).

- The components used to control the flow of air (control valve, relay valve, load-proportional valve) must be UIC-approved.

- In the case of SS wagons, “kink” valves must be used.

- The brake blocks must not touch the wheel on either side when not applied. If the maximum permitted piston stroke is applied, then a minimum clearance of 7 mm per block must be demonstrated. This must also be demonstrated in the theoretical event of clearance potentially being reduced when travelling through a curve with R = 300m, and must be presented as part of the vehicle approval dossier.

- Further, it must be ensured that under nominal conditions for the wheel and brake block, the brake block cannot slide towards the flange area.

- Where various block types are used on a vehicle, each wheelset must be fitted with blocks of the same type as a minimum.

1.2 Wheelsets/wheels to be used

The following wheels are approved for use with composite brake blocks (K). It is recommended to use a reduced flange thickness (e.g. thickness = 30 mm):

1.2.1 Monobloc wheels as specified by EN 13979-1 / UIC Leaflet 510-5

All monobloc wheels meeting the requirements of EN 13979-1 and its application document UIC Leaflet 510-5 may be used.

1.2.2 Existing monobloc wheels

All existing types of monobloc wheels may be used, except those made of materials R2, BV2, R8 and R9.
Tyred wheels are not approved for use with composite brake blocks (K).
For use on vehicles used in SS operations, it is recommended to use wheels meeting the specifications of EN 13979-1 and its application document UIC Leaflet 510-5.

1.3 Vehicle inscriptions

Wagons fitted with composite brake blocks (K) must be marked with a “K” in a circle immediately to the right of the marking showing the type of braking system, in accordance with the requirements of EN 15877-1:2012, section 4.5.30.2.10.

Since it is currently impossible, or possible only under specific basic conditions, to guarantee that the various certified blocks are fully interchangeable, all blocks approved for the vehicle

are to be indicated next to the Ⓚ (one or several types of brake block). The type descriptions of brake blocks set out in Appendix M1 of UIC Leaflet 541-4 are to be used.

Appendix 1.1: Tables showing numerical k_k curve values for Bg and Bgu configurations (to be used only for the approximate pre-calculation)

Bg - Bremsklotz Sabot de frein Bg					
Fdyn [kN]	k_k [-]	B [t]	Fdyn [kN]	k_k [-]	B [t]
3,2	3,549	1,158	10,6	2,754	2,975
3,4	3,510	1,217	10,8	2,745	3,022
3,6	3,473	1,275	11,0	2,738	3,070
3,8	3,437	1,331	11,2	2,730	3,117
4,0	3,403	1,387	11,4	2,723	3,164
4,2	3,369	1,442	11,6	2,716	3,212
4,4	3,336	1,496	11,8	2,710	3,260
4,6	3,305	1,550	12,0	2,704	3,308
4,8	3,274	1,602	12,2	2,698	3,356
5,0	3,245	1,654	12,4	2,693	3,404
5,2	3,216	1,705	12,6	2,688	3,453
5,4	3,188	1,755	12,8	2,683	3,501
5,6	3,162	1,805	13,0	2,679	3,550
5,8	3,136	1,854	13,2	2,675	3,599
6,0	3,112	1,903	13,4	2,671	3,648
6,2	3,088	1,951	13,6	2,667	3,697
6,4	3,065	1,999	13,8	2,663	3,746
6,6	3,043	2,047	14,0	2,660	3,795
6,8	3,021	2,094	14,2	2,656	3,845
7,0	3,001	2,141	14,4	2,653	3,894
7,2	2,982	2,188	14,6	2,650	3,943
7,4	2,963	2,235	14,8	2,647	3,993
7,6	2,945	2,281	15,0	2,644	4,042
7,8	2,927	2,328	15,2	2,640	4,091
8,0	2,911	2,374	15,4	2,638	4,140
8,2	2,895	2,420	15,6	2,635	4,189
8,4	2,880	2,466	15,8	2,632	4,238
8,6	2,865	2,512	16,0	2,629	4,287
8,8	2,852	2,558	16,2	2,625	4,336
9,0	2,839	2,604	16,4	2,622	4,384
9,2	2,826	2,650	16,6	2,619	4,432
9,4	2,814	2,696	16,8	2,616	4,479
9,6	2,803	2,743	17,0	2,612	4,527
9,8	2,792	2,789	17,2	2,608	4,573
10,0	2,782	2,835	17,4	2,605	4,620
10,2	2,772	2,882	17,6	2,601	4,666
10,4	2,762	2,929	17,8	2,596	4,711

Bgu - Bremsklotz Sabot de frein Bgu					
Fdyn [kN]	k_k [-]	B [t]	Fdyn [kN]	k_k [-]	B [t]
3,2	3,804	1,241	10,6	3,009	3,251
3,4	3,775	1,308	10,8	2,995	3,297
3,6	3,747	1,375	11,0	2,982	3,344
3,8	3,719	1,440	11,2	2,969	3,390
4,0	3,691	1,505	11,4	2,956	3,436
4,2	3,664	1,569	11,6	2,944	3,482
4,4	3,637	1,631	11,8	2,933	3,527
4,6	3,611	1,693	12,0	2,921	3,573
4,8	3,585	1,754	12,2	2,910	3,619
5,0	3,559	1,814	12,4	2,900	3,666
5,2	3,534	1,873	12,6	2,890	3,712
5,4	3,509	1,932	12,8	2,880	3,758
5,6	3,485	1,989	13,0	2,871	3,805
5,8	3,461	2,046	13,2	2,862	3,851
6,0	3,437	2,102	13,4	2,854	3,898
6,2	3,414	2,158	13,6	2,846	3,945
6,4	3,391	2,213	13,8	2,838	3,992
6,6	3,369	2,267	14,0	2,831	4,040
6,8	3,347	2,320	14,2	2,824	4,088
7,0	3,326	2,373	14,4	2,818	4,136
7,2	3,305	2,425	14,6	2,812	4,185
7,4	3,284	2,477	14,8	2,806	4,234
7,6	3,264	2,529	15,0	2,801	4,283
7,8	3,244	2,579	15,2	2,796	4,333
8,0	3,225	2,630	15,4	2,792	4,383
8,2	3,205	2,679	15,6	2,788	4,433
8,4	3,187	2,729	15,8	2,784	4,485
8,6	3,169	2,778	16,0	2,781	4,536
8,8	3,151	2,826	16,2	2,779	4,588
9,0	3,133	2,875	16,4	2,776	4,641
9,2	3,116	2,923	16,6	2,774	4,695
9,4	3,100	2,970	16,8	2,773	4,749
9,6	3,084	3,018	17,0	2,772	4,803
9,8	3,068	3,065	17,2	2,771	4,859
10,0	3,053	3,112	17,4	2,771	4,915
10,2	3,038	3,158	17,6	2,771	4,971
10,4	3,023	3,205	17,8	2,772	5,029

Appendix 1.2: Certifying a friction material for other applications

Above and beyond the conditions for a certification under standard conditions described in point 3.1.1. of the UIC leaflet, it is possible to approve a block already certified against point 3.1.1 for other applications. It is also possible to approve a block exclusively for these alternative uses. A UIC expert is to assess the conformity between the test programme conducted and the actual type of application.

The tests required for such an approval are given in the following table.

Material			**3.1.1 approval**	**New**	**3.1.1.1 approval**	**New**
Configuration			**New**	**New**	**New**	**New**
Traffic (international/domestic)			Intern.	Intern.	Dom.	Dom.
Requirement	**Test**	**Acceptance**				
Product specification	2.5.1		**	*	***	*
Strength test	App. I		**	*	***	*
Performance programme	A13		**	*	**	*
Metallic inclusions	A4		**	*	***	*
Winter	A5, App G		**	*	***	***
Braking incident	A6		**	*	***	***
Track circuits	A7		**	*	***	***
Real usage conditions	A11		***	***	***	***
Static coefficient of friction	A12		**	*	***	***
Slip tests			**	*	***	***
Service tests			**	*	***	***

The following test categories exist:

*** mandatory**
Those tests in the table marked with an asterisk are to be executed in every instance.

**** to be executed if there are no test results transferable to the usage scenario in question, or the validity limits (for Programmes A4, A5, A6, A7, A12) given in the UIC leaflet are exceeded**
In this category, the principle is that only those aspects are to be tested which are not already covered by the existing scope of testing, provided the block has already been certified for use under standard conditions. The tests for metallic inclusions, winter conditions, braking incidents, track circuits and the static coefficient of friction are overarching in nature, and are valid for the usage scenarios described in UIC Leaflet 541-4. In general, therefore, only those friction tests which are to be conducted under the generic test programme (see below) need to be tested for the specific usage scenario.

The generic test programme (see below) is only to be executed for blocks already approved against point 3.1.1.1 if at least one of the following conditions is not met:

- Nominal wheel diameter D between 680 mm and 920 mm
- Speed at initiation of braking max. 120 km/h
- Contact forces between 5 and 38 kN (K blocks) or 12 kN and 100 kN (LL blocks)
- Braked weight per wheel between 2.5 and 11.25 t

In order to ensure that the temperature broadly corresponds to that under standard conditions, the relevant observations are to be conducted (ratio of wheel rim volume to brake force to be applied). [3]

To assess the friction level, the tolerances indicated in the UIC leaflet may be applied.

If the new application falls within the aforementioned general conditions, no testing of the product is required for its approval.

***** only to be executed if the customer or the approval authority requires it**

[3] In so doing, the performance limits of the wheel used are to be observed, as defined in the relevant standards (UIC Leaflet 510-5 / EN 13979-1).

Generic test programme

Brake block configuration	
Type of wheel	
Wheel diameter	∅ XXX ± 5 mm (last machining diameter before wheel is fully worn to scrapping size as per standard EN 13979-1)
Mass per wheel	M1 t and M2 t

Brake application no.	**Initial speed**	**Total F_B per wheel**	**Initial tempe-rature θ_0**	**Braked weight per wheel**	**Weighing after**	**Remarks**
	[km/h]	[kN]	[°C]	[t]	No	
1-1 to 1-x	Sm	2/3 Fb2	20-100	0,8 * M2	1.x [a]	Brake applications to a stop under dry conditions to allow the blocks to bed-in to at least 85% of the friction material surface
1 3 5 2 4 6	¾ Sm Sm	Fb2 Fb2	50-60 50-60	0,8 * M2 0,8 * M2	6 [a]	Brake applications to a stop under dry conditions, after a period of cooling.
7 to 26	Sm	2/3 Fb1	20-100	M1	26 [a]	Conditioning stops
27 39 28 40 29 41 30 42	¾ Sm ¼ Sm Sm 2/4 Sm	2/3 Fb1	50-60	M1		Brake applications to a stop under dry conditions, after a period of cooling.
31 43 32 44 33 45 34 46	¾ Sm ¼ Sm Sm 2/4 Sm	1/3 Fb1				
35 47 36 48 37 49 38 50	¾ Sm ¼ Sm Sm 2/4 Sm	Fb1				
51	¾ Sm	–	–	–	51 [a]	10KW drag brake application for a period of 15 minutes, immediately after the above brake application, without any period of cooling
52 64 76 53 65 77 54 66 78 55 67 79	¾ Sm ¼ Sm Sm 2/4 Sm	2/3 Fb1	20-30	M1		Brake applications to a stop under wet conditions, after a period of cooling.
56 68 80 57 69 81 58 70 82 59 71 83	¾ Sm ¼ Sm Sm 2/4 Sm	1/3 Fb1				

60	72	84	¾ Sm	Fb1				
61	73	85	¼ Sm					
62	74	86	Sm					
63	75	87	2/4 Sm					
Brake application no.			**Initial speed**	**Total F_B per wheel**	**Initial tempe-rature θ_0**	**Braked weight per wheel**	**Weighing after**	**Remarks**
			[km/h]	[kN]	[°C]	[t]	No	
88		92	¾ Sm	Sm	20-30	M2		Brake applications to a stop under wet conditions, after a period of cooling.
89		93	¼ Sm					
90		94	Sm					
91		95	2/4 Sm				95 [a]	
96			70	-		-	96	10KW drag brake application for a period of 15 minutes, immediately after the above brake application, without any period of cooling
97		109	¾ Sm	2/3 Fb2	50-60	M2		Brake applications to a stop under dry conditions, after a period of cooling.
98		110	¼ Sm					
99		111	Sm					
100		112	2/4 Sm					
101		113	¾ Sm	1/3 Fb2				
102		114	¼ Sm					
103		115	Sm					
104		116	2/4 Sm					
105		117	¾ Sm	Fb2				
106		118	¼ Sm					
107		119	Sm					
108		120	2/4 Sm					
121			¾ Sm	Fb2	110-120 [b]	M2		Brake applications to a stop under dry conditions, after a period of cooling. (Fade test)
122			¼ Sm		110-120			
123			Sm		110-120			
124			2/4 Sm		110-120		124 [a]	
125			¾ Sm	2/3 * Fb2	50-60	M2		Brake applications to a stop under dry conditions, after a period of cooling (to verify μ after Fade test.) Measurement of wheel roughness
126			¼ Sm					
127			Sm					
128			2/4 Sm				128	

129		70	-	50-60	-		Simulation of a downhill brake application [c] with a power of 45 kW for 34 min; these conditions (speed, power and time) may be adjusted to the conditions of the individual scope extension
130		XXX	Fb2	-	M2	130	Braking to a stop, dry, without any period of cooling, directly after brake application n°129
131	to 140	Sm	2/3 * Fb2	50 -60	M2		Brake applications for reconditioning
141	145	¾ Sm	Fb2	50 - 60	M2		Braking to a stop, dry, after period of cooling
142	146	¼ Sm	Fb2	50 – 60			
143	147	Sm	Fb2	50 – 60			
144	148	2/4 Sm	Fb2	50 - 60			
149		70					Drag brake application releasing 10 kW over 15 min, performed immediately after brake application n°148 without any period of cooling, to reduce residual wheel stresses Measure wheel roughness

a This weighing, conducted during empty tests and under wet conditions, is optional.

b If the temperature obtained during stop numbers 120 and 122 is below 110 °C, stop numbers 121 and 123 must be performed with the temperature achieved at the time.

c Simulation of a downhill run is performed at constant power and speed.

Definitions

M1 Tare braked mass per wheel (including rotating mass)

M2 Laden braked mass per wheel (including rotating mass)

Fb1 Total brake block application force per wheel, tare

Fb2 Total brake block application force per wheel, laden

Sm Maximum service speed

Part 2 – Brake operation, monitoring and maintenance

2.1. Recommendations for brake operation

The driver must know how many K-braked wagons are in the train (see UIC Leaflet 472, International Train Journal and Braking Sheet).
Since composite brake blocks (K) have a different coefficient of friction to cast-iron blocks, particularly at low speeds, and in view of the specificities of winter conditions, the following guidelines should be observed in brake operation:

2.1.1 Brake operation at speeds of below 50 kph

In trains of which more than half the wagons are fitted with composite brake blocks (K), the service braking performance at speeds of under 50 kph is different to that for a train fitted with cast-iron blocks only. This should be taken into account either by braking earlier or by a greater drop in pressure in the main brake pipe.

2.1.2 Brake operation under winter conditions

The following instructions are based on the provisions of UIC Leaflet 421 and are of a recommendatory nature.

1. Definition of winter conditions from a braking perspective

- temperature below 0 ºC and
- loose snow on track and/or
- rails covered in snow or iced over and/or
- wagons used with heavy snow/ice deposits

2. Measures to ensure correct braking performance

- Before moving parked trains or partial consists, a full brake application is to be performed (pressure in main brake pipe to be reduced to ~ 1.5 bar).
- The “brakes released” position must be verified on both sides of the train during the full brake test before departure from the station of origin.
- The wheels must be observed to turn freely as the train departs.
- Following departure from the station of origin, the driver is to perform a service braking before reaching the maximum scheduled speed, without dynamic braking of the motive power unit if possible, in order to check whether the braking performance is satisfactory.

If the train deceleration is normal, the brakes are to be released immediately. If the brake performance is less effective than anticipated, and this is attributable to the winter conditions, the brakes are to be released, following which an additional braking should be performed in order to try and warm up the friction components.

If the braking performance is significantly less effective than anticipated, the train is to be stopped by means of a rapid brake application, and the friction components are to be kept warm by subsequent sporadic braking during the journey.

A braking should thus be performed
- every 10 – 15 minutes or
- every 20 – 30 km.

If the driver still considers the deceleration insufficient in spite of these measures, then the train may henceforth proceed only at reduced speed. The driver must inform the traffic controller of his decision by radio.

The test brake applications described above are to be performed before reaching:
- a terminus,
- a long downhill section with a steep gradient.

3. Other measures to be taken under winter conditions

- It is of vital importance to check the air-tightness of the train when performing the brake tests.
- During maintenance and repair, the air pressure chambers are to be carefully drained.

2.2 Monitoring measures

In addition to existing national rules, the damage catalogue is to be used to correctly identify and assess damage to composite brake blocks and wheels braked with composite blocks and the necessary corrective measures.

2.2.1 Monitoring of brake blocks

For the in-service monitoring of composite brake blocks (K), the provisions of the GCU (General Contract for the Use of wagons, Appendix 10, Point 3.8, formerly RIV 2000 § 28.14) are to be applied, according to which blocks must be replaced if:

- They are broken radially from the friction surface to the edge of the plate except at the level of the expansion joint)
- There is visible spalling of the block material along more than ¼ of the length of the block
- There are metal inclusions
- The thickness of the block is less than 10 mm

Further information on brake block assessment may be found in the damage catalogue.

Maintenance of vehicles fitted with composite brake blocks is performed identically to maintenance of those fitted with cast-iron blocks.

2.2.2 Monitoring of wheels

The following rules are to be observed for wheels:

In-service monitoring of wheels is undertaken in accordance with the provisions of the GCU.

Monobloc wheels (particularly the tread) are to be inspected by eye during technical inspections. Assessment of their condition is performed in accordance with the GCU or UIC Leaflet 510-2. Particular attention is to be paid to visual signs of excessive thermal stresses (e.g. obvious, clearly delineated coloured patches under the wheel rim, blue wheel rims, material deposits), heavy or uneven wear, damage to wheel tread and thermal cracks. In assessing the wheel profile, particular attention is to be paid to maintaining the minimum and maximum permitted values for the flange thickness and flange height.

Contrary to the rules in force for wagons with cast-iron brakes, for K-braked wagons fitted with the **Becorit 929-1 or Becorit 929-1SG** blocks (or if the type of block cannot be unambiguously identified), wheelsets whose wheels are able to withstand high thermal stresses as specified in UIC Leaflet 510-5 are to be treated identically to wheelsets with wheels not meeting the requirements of Leaflet 510-5 if evidence of excessive thermal stresses appears, until otherwise stated.

For wagons fitted with the Becorit 929-1 or Becorit 929-1SG blocks, wheelsets whose wheels meet the requirements of UIC Leaflet 510-5 may not bear the white marking on the axle boxes, in order to better enable wagon inspectors to apply the GCU.

Further information on wheel assessment may be found in the damage catalogue.

2.3 Other points

Used blocks are to be disposed of in accordance with national rules.