



BSI Standards Publication

## Railway applications - Braking - Brake blocks

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## National foreword

This British Standard is the UK implementation of EN 16452:2015+A1:2019. It supersedes BS EN 16452:2015, which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by A1 A1.

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| 5                                  | 3   |
| 10                                 | 5   |
| 20                                 | 10  |
| 30                                 | 20  |
| 80                                 | 50  |
| 160                                | 100 |
| 190                                | 120 |

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English Version

## Railway applications - Braking - Brake blocks

Applications ferroviaires - Freinage - Semelles de frein

Bahnanwendungen - Bremse - Bremsklotzsohlen

This European Standard was approved by CEN on 28 February 2015 and includes Amendment 1 approved by CEN on 21 December 2018.

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## Foreword

This document (EN 16452:2015+A1:2019) has been prepared by Technical Committee CEN/TC 256 “Railway applications”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2019, and conflicting national standards shall be withdrawn at the latest by September 2019.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document includes Amendment 1 approved by CEN on 28 October 2018.

This document supersedes A1 EN 16452:2015 A1.

The start and finish of text introduced or altered by amendment is indicated in the text by tags A1 A1.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive 2008/57/EC.

For relationship with EU Directive 2008/57/EC, see informative Annex ZA, which is an integral part of this document.

Compared to the previous edition, the following changes have been made:

- a) 7.3 “Static friction coefficient” has been modified;
- b) 7.4.2 “Dynamometer test” has been modified;
- c) 7.5.1 “Generic prescriptions” has been modified;
- d) 7.4.3 “Train brake test” has been modified;
- e) Annex A “Summary of Dynamometer test programs and acceptance criteria” has been modified;
- f) Annex J “Dynamometer test program – Generic test program” has been modified;
- g) Annex M “Test run to demonstrate the extreme winter braking properties brake blocks K – LL for freight wagons” has been modified;
- h) Annex Q “Dynamometer test program – Determination of static friction coefficient” has been modified;
- i) Annex T “Brake block shear and flexural strength tests” has been modified;
- j) Annex ZA has been updated.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

## Introduction

For environmental reasons (reduction of rolling noise), this European Standard does not cover cast iron brake block requirements, although cast iron brake block technology is still widely used in Europe. Cast iron has already been replaced by composite materials for new rolling stock builds and major steps have been taken by EEC (TSI) and UIC in 2004 to accelerate the change from cast iron to composite materials.

When published this European Standard will replace the current UIC requirements for technical approval of brake blocks. The requirements of this EN are based on the state of art from UIC leaflet and a European project "Euro Rolling Silently".

## 1 Scope

This European Standard gives the requirements for the design, dimensions, performance, and testing of a brake block (otherwise known as brake shoe insert) that acts on the wheel tread as part of a tread brake system. This European Standard does not cover cast iron brake block requirements.

This European Standard is applicable to brake blocks of either “K”, “L”, or “LL” friction level designed to be fitted to tread braked rail vehicles.

This European Standard contains the requirements for interfacing the brake block with the rail vehicle, the testing procedures in order to confirm that it satisfies the basic safety and technical interchangeability requirements, the material control procedures to ensure product quality, reliability and conformity and considers health and environmental needs.

## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 13452-1, *Railway applications — Braking — Mass transit brake systems — Part 1: Performance requirements*

EN 13452-2, *Railway applications — Braking — Mass transit brake systems — Part 2: Methods of test*

EN 13715, *Railway applications — Wheelsets and bogies — Wheels — Tread profile*

EN 13979-1:2003+A2:2011, *Railway applications — Wheelsets and bogies — Monobloc wheels — Technical approval procedure — Part 1: Forged and rolled wheels*

EN 14033-1, *Railway applications — Track — Railbound construction and maintenance machines — Part 1: Technical requirements for running*

EN 14033-2:2008+A1:2011, *Railway applications — Track — Railbound construction and maintenance machines — Part 2: Technical requirements for working*

EN 14198, *Railway applications — Braking — Requirements for the brake system of trains hauled by a locomotive*

EN 14478, *Railway applications — Braking — Generic vocabulary*

EN 15179, *Railway applications — Braking — Requirements for the brake system of coaches*

EN 15313, *Railway applications — In-service wheelset operation requirements — In-service and off-vehicle wheelset maintenance*

EN 15663, *Railway applications — Definition of vehicle reference masses*

EN 15734-1, *Railway applications — Braking systems of high speed trains — Part 1: Requirements and definitions*

EN 15734-2, *Railway applications — Braking systems of high speed trains — Part 2: Test methods*

EN 16185-1, *Railway applications — Braking systems of multiple unit trains — Part 1: Requirements and definitions*

EN 16185-2, *Railway applications — Braking systems of multiple unit trains — Part 2: Test methods*

EN 50126-1, *Railway applications — The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS) — Part 1: Basic requirements and generic process*

EN ISO 4287, *Geometrical product specifications (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters (ISO 4287)*

EN ISO 4288, *Geometrical product specifications (GPS) — Surface texture: Profile method — Rules and procedures for the assessment of surface texture (ISO 4288)*

UIC 544-1, *Brakes — Braking power*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 14478 and the following apply.

#### 3.1

##### **application parameter**

configuration parameters refer to vehicle mass, operating speed, wheel diameter, braked mass, brake block configuration, brake block force

#### 3.2

##### **Bg configuration**

one brake block 320 mm per brake block holder

Note 1 to entry: Bg comes from UIC and means “Bremsklotzsohle geteilt”.

#### 3.3

##### **Bgu configuration**

two brake blocks 250 mm per brake block holder

Note 1 to entry: Bgu comes from UIC and means “Bremse geteilt mit unterteilter Sohle”.

#### 3.4

##### **brake block**

stator part of a tread brake adapted to generate a friction force when engaged with a wheel tread

#### 3.5

##### **brake block force**

force with which the brake block is made to come into contact with the wheel tread

#### 3.6

##### **friction material**

consumable portion of the brake block that acts on the wheel tread in order to provide the specified brake performance

### 3.7

#### **coefficient of friction**

#### 3.7.1

##### **mean coefficient of friction**

coefficient of friction of the friction material, integrated over distance, for any one condition of braking

#### 3.7.2

##### **instantaneous coefficient of friction**

value of coefficient of friction of the friction material at any one instant

#### 3.7.3

##### **static coefficient of friction**

coefficient of friction achieved by the friction material at standstill at the point where relative movement between the block friction surface and wheel tread takes place

### 3.8

#### **K material**

friction material with a mean coefficient of friction of 0,25 to 0,30

### 3.9

#### **L material**

friction material with a mean coefficient of friction of 0,15 to 0,25

### 3.10

#### **LL material**

friction material with a mean coefficient of friction of 0,10 to 0,15

### 3.11

#### **EU-D Rolling stock**

rolling stock governed by the requirements of the European Directive 2008/57/EC

### 3.12

#### **metal pick-up**

damage to the brake block surface as a result of the interaction between the brake block and wheel tread

### 3.13

#### **non EU-D Rolling stock**

rolling stock not governed by the requirements of the European Directive 2008/57/EC

### 3.14

#### **brake block back plate**

element onto which the friction material is fixed, acting as the interface between the brake block and brake block holder

### 3.15

#### **track circuit**

integral part of certain signalling systems, the operation of which is essential to ensure the safe operation of the signalling system

### 3.16

#### **brake type**

classification term for air brakes as specified by the UIC in accordance with their action (G = Goods = slow-acting, P = Passenger = quick-acting)

## 4 Abbreviations

|                                                           |        |                                                                                                                                                                                                                                            |
|-----------------------------------------------------------|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $m$                                                       | [t]    | Mass to be braked per wheel (inclusive of the rotational masses)                                                                                                                                                                           |
| $F_B$                                                     | [kN]   | Nominal application force per wheel                                                                                                                                                                                                        |
| $F_b$                                                     | [kN]   | Instantaneous application force per wheel                                                                                                                                                                                                  |
| $v$                                                       | [km/h] | Theoretical initial speed at the brake application initiation                                                                                                                                                                              |
| $v_i$                                                     | [km/h] | Instantaneous speed                                                                                                                                                                                                                        |
| $v_3$                                                     | [km/h] | Final speed at the end of braking                                                                                                                                                                                                          |
| $v_m$                                                     | [km/h] | Maximum service speed.                                                                                                                                                                                                                     |
| $\mu_a = \frac{F_{tR}}{F_b}$                              | [-]    | Instantaneous friction coefficient (brake block): The instantaneous friction coefficient $\mu_a$ specified at every instance of the braking time by the ratio between the total brake force $F_{tR}$ and the total application force $F_b$ |
| $\mu_m = \frac{1}{s_2} \cdot \int_0^{s_2} \mu_a \cdot ds$ | [-]    | Mean friction coefficient: the mean friction coefficient $\mu_m$ integrated over the time from where 95 % of the nominal application force $F_B$ is reached over the stopping distance $s_2$                                               |
| $\theta_0$                                                | [°C]   | Mean initial temperature at the beginning of the brake application                                                                                                                                                                         |
| $s_2$                                                     | [m]    | Stopping distance from the moment on when $F_b = 0,95 \cdot F_B$ to rest                                                                                                                                                                   |
| $R_z$                                                     | [µm]   | Surface roughness (maximum height of profile)                                                                                                                                                                                              |
| $d$                                                       | [mm]   | Diameter of wheel                                                                                                                                                                                                                          |
| $e$                                                       | [mm]   | Flange thickness                                                                                                                                                                                                                           |
| $h$                                                       | [mm]   | Flange height                                                                                                                                                                                                                              |
| $qR$                                                      | [mm]   | Distance between flange angle                                                                                                                                                                                                              |
| $a_1$                                                     | [mm]   | Back-to-back distance between wheels                                                                                                                                                                                                       |
| $P$                                                       | [-]    | Brake type – $P$ = passenger                                                                                                                                                                                                               |

## 5 Overall requirements

### 5.1 Deviations from requirements

If deviating from some points of the requirements of this standard for a particular assessment, these deviations shall be reported and explained. The influence on the assessment of the brake block in terms of the acceptance criteria shall be evaluated and recorded. The outcome of this study shall be considered as an integral part of the requirements of this standard when applied to the assessment process of the brake block.

### 5.2 Functions

The brake block is to be used as part of the friction brake of a vehicle. It shall provide the performance specified, in terms of stopping distance for instance, and in doing so shall fulfil the following requirements:

- create a braking moment or torque;

- facilitate, by frictional engagement with a wheel tread, the conversion into heat of the kinetic and potential energy involved in retarding the vehicle or vehicles which is/are attributed to the use of the tread brake;
- act as part of a holding or parking brake by frictional engagement with a wheel tread.

In achieving the above requirements, the brake block and the wheel shall not suffer damage or degradation other than normal wear and tear.

The brake block shall be considered along with the wheel tread as a friction pair.

### 5.3 Operational criteria

#### 5.3.1 Friction material performance

The design and manufacture of the brake block shall, for all intended operating conditions and vehicle rescue and recovery conditions, take into account the following criteria for friction material performance:

- all levels of stopping and slowing distances and immobilization braking specified;
- all levels of retardation specified;
- the initial speed of braking for the vehicle in question;
- the braked mass, in tare and laden conditions;
- the quantity of brake energy to be converted and its rate of conversion and dissipation;
- the range of specific pressure of the brake block friction surface on the wheel tread;
- the form and condition of the wheel tread;
- the type of material used in the manufacture of the wheel tread;
- the temperature of the wheel tread;
- the deformation of the wheel under thermal load;
- friction property variation as a function of brake block and wheel tread bedding and conditioning thereafter;
- friction property variation as a function of brake block and wheel tread according to various climatic conditions;
- signalling performance from the interaction of brake block, wheel and rail.

#### 5.3.2 Service performance

The design and manufacture of the brake block shall, for all intended operating conditions and vehicle rescue and recovery conditions, take into account the following criteria for service performance:

- the need to prevent the detachment of any part of the friction material from the brake block back plate throughout its useable thickness;

- unless specifically permitted, the friction material shall be capable of being worn down to a thickness of 10 mm at the thinnest point excluding the back plate, without mechanical degradation of the friction material or the back plate coming into contact with the wheel tread;
- the need to allow interchangeability between brake blocks of the same friction characteristics, and to avoid interchangeability between brake blocks of different friction characteristics;
- the integrity and wear rate of the brake block friction material and wheel tread;
- the need to prevent permanent deformation of the brake block back plate throughout the useable thickness of the friction material;
- the need to comply with environmental and health requirements.

### 5.3.3 Brake block characteristics

In order to comply with the above requirements the performance of the brake block shall be determined using the test methods described below.

According to proven experience, past certification of the brake block being considered, and function of the application being considered, test obligations and acceptance criteria are provided in Table 1 and Table 2 in 6.2.

The main characteristics to be assessed are as follows:

- brake block design;
- instantaneous and mean dynamic friction coefficients;
- static friction coefficient;
- wet friction behaviour;
- metal pickup formation behaviour;
- behaviour under conditions simulating a locked brake, with an applied braking force;
- brake block and wheel tread wear at different loads and service braking conditions;
- friction behaviour under severe winter conditions;
- influence on signalling systems (shuntage);
- brake block material properties.

## 6 Acceptance procedure

### 6.1 Brake block performance requirements

#### 6.1.1 General

The following tests (categories A, B and C) should be conducted and are intended to provide an evaluation of the capability of the brake block to operate under the duty level applicable to the application being considered, and are designated as follows:

Unless specifically requested, for certain applications running in non EU-D rolling stock such as metro, light rail operations, etc., it is not necessary to carry out category A tests. In this case tests according to category B and category C will be sufficient to prove the suitability of a material for use in the application concerned.

### 6.1.2 Category A

An overall assessment of the brake block performance under a range of conditions. The test schedules provided in Table 1 and Table 2 below do not include every type of application. The test conditions may be adapted to suit the application in question by agreement.

For applications running in non EU-D rolling stock, tests carried out to confirm dynamic friction performance shall follow those shown in the annexes but can be adapted where applicable to the application in question.

### 6.1.3 Category B

These are tests that are specific to the application being considered and include performance and wear.

It is recommended that these tests are conducted to ensure that the brake block material is suitable for the application in question. Annex J provides guidance on how to design brake dynamometer performance tests for a specific application and the principle for assessment and pass/fail criteria. The final choice of tests to be conducted and the detail of the test concerned will be specified based on application conditions.

### 6.1.4 Category C

Assessment of the effect of the brake block on the wheel tread and the wheel to rail interface.

Depending on the application being considered, the brake block should fulfil the requirements of Table 1 or Table 2, "category C requirements" below.

## 6.2 Approval test requirements

See Annex A for summary of dynamometer test program.

**Table 1 — Approval test requirements for materials fitted to vehicles operation in EU-D Rolling stock**

| Material                                     |                            |                            | NEW | EXISTING | EXISTING |
|----------------------------------------------|----------------------------|----------------------------|-----|----------|----------|
| Application parameter                        |                            |                            | NEW | NEW      | EXISTING |
| Requirements                                 | Specification / Test       | Acceptance criteria        |     |          |          |
| Category A requirements (EU-D Rolling stock) |                            |                            |     |          |          |
| Standard design                              | 7.1.1 and Annex S          | Annex S                    | c   | c        | c        |
| Brake block characterization test            | 7.1.2, and Annex X         | Annex X                    | a   | b        | b        |
| Dynamic friction performance                 | 7.2 and Annex C to Annex I | 7.2 and Annex C to Annex I | a   | b        | b        |

| Material                                                                                         |                         |                     | NEW | EXISTING | EXISTING |
|--------------------------------------------------------------------------------------------------|-------------------------|---------------------|-----|----------|----------|
| Application parameter                                                                            |                         |                     | NEW | NEW      | EXISTING |
| Requirements                                                                                     | Specification / Test    | Acceptance criteria |     |          |          |
| Static friction performance                                                                      | 7.3 and Annex Q         | 7.3                 | a   | b        | b        |
| Winter conditions (Freight wagons)                                                               | 7.4, Annex L or Annex M | 7.4 or Annex L      | a   | b        | b        |
| Locked brake (fusibility) freight wagon                                                          | 7.5 and Annex N         | 7.5                 | a   | b        | c        |
| Locked brake (fusibility) other vehicles                                                         | 7.5 and Annex N         | 7.5                 | c   | c        | c        |
| <b>Category B requirements (EU-D Rolling stock)</b>                                              |                         |                     |     |          |          |
| vehicle brake test                                                                               | 8.1                     | -                   | a   | b        | b        |
| dynamometer wear test (friction couple)                                                          | 8.2 and Annex R         | -                   | c   | c        | c        |
| dynamic friction performance                                                                     | 8.3 and Annex J         | -                   | c   | c        | c        |
| in service assessment                                                                            | 8.4                     | -                   | a   | b        | b        |
| <b>Category C requirements (EU-D Rolling stock)</b>                                              |                         |                     |     |          |          |
| metal pickup                                                                                     | 9.1 and Annex K         | 9.1                 | a   | b        | b        |
| influence on track circuit operation (freight wagons and coaches)                                | 9.2 Annex O or Annex P  | Annex O or Annex P  | a   | b        | b        |
| influence on track circuit operation (others)                                                    | 9.2                     | 9.2                 | c   | c        | c        |
| a = required                                                                                     |                         |                     |     |          |          |
| b = required when no previous test results are available and transposable to confirm performance |                         |                     |     |          |          |

| Material                                                                                                                                                                                                                                                                                                                                                                                                        |                      |                     | NEW | EXISTING | EXISTING |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|---------------------|-----|----------|----------|
| Application parameter                                                                                                                                                                                                                                                                                                                                                                                           |                      |                     | NEW | NEW      | EXISTING |
| Requirements                                                                                                                                                                                                                                                                                                                                                                                                    | Specification / Test | Acceptance criteria |     |          |          |
| c = only if requested<br>New material = friction material not previously used in any application<br>Existing material = friction material previously approved for other applications<br>New application parameter = a application parameter in which the friction material was not used previously.<br>Existing application parameter = a application parameter in which the friction material is already used. |                      |                     |     |          |          |

**Table 2 — Approval test requirements for materials fitted to vehicles operation in National traffic**

| Material                                                |                            |                            | NEW | EXISTING | EXISTING |
|---------------------------------------------------------|----------------------------|----------------------------|-----|----------|----------|
| Application parameter                                   |                            |                            | NEW | NEW      | EXISTING |
| Requirements                                            | Specification / Test       | Acceptance criteria        |     |          |          |
| <b>Category A requirements (Non EU-D Rolling stock)</b> |                            |                            |     |          |          |
| Standard design                                         | 7.1.1 and Annex S          | Annex S                    | c   | c        | c        |
| brake block characterization test                       | 7.1.2 and Annex X          | Annex X                    | a   | b        | b        |
| dynamic friction performance                            | 7.2 and Annex C to Annex I | 7.2 and Annex C to Annex I | a   | b        | b        |
| static friction performance                             | 7.3 and Annex Q            | 7.3                        | a   | b        | b        |
| winter conditions (freight wagons)                      | 7.4, Annex L or Annex M    | 7.4 or Annex L             | c   | c        | c        |
| Locked brake (fusibility)                               | 7.5 and Annex N            | 7.5                        | c   | c        | c        |
| <b>Category B requirements (Non EU-D Rolling stock)</b> |                            |                            |     |          |          |
| vehicle brake test                                      | 8.1                        | -                          | a   | b        | b        |
| dynamometer wear test (friction couple)                 | 8.2 and Annex R            | -                          | c   | c        | c        |
| dynamic friction performance                            | 8.3 and Annex J            | -                          | c   | c        | c        |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                        |                    |   |   |   |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|--------------------|---|---|---|
| in service assessment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 8.4                    | -                  | a | b | b |
| <b>Category C requirements (Non EU-D Rolling stock)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                        |                    |   |   |   |
| metal pickup                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 9.1 and Annex K        | 9.1                | c | c | c |
| influence on track circuit operation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 9.2 Annex O or Annex P | Annex O or Annex P | c | c | c |
| a = required<br>b = required when no previous test results are available and transposable to confirm performance<br>c = only if requested<br>New material = friction material not previously used in any application.<br>Existing material = friction material previously approved for other applications.<br>New application parameter = a application parameter in which the friction material was not used previously.<br>Existing application parameter = a application parameter in which the friction material is already used. |                        |                    |   |   |   |

### 6.3 Dynamometer specification

The dynamometer used for conducting the tests provided in the annexes should be suitable for carrying out these tests in the correct manner.

General requirements for conducting dynamometer test programmes are detailed in Annex B.

NOTE Existing documents that define the requirements of dynamometers for Railway Friction Material testing at the time of writing this standard include UIC documents: B126/RP 18, B126/DT 408 and B169/RP 37 and these could be used as reference documents.

## 7 Category A requirements

### 7.1 Brake block characteristics

#### 7.1.1 Standard design

Brake blocks used in EU-D Rolling stock should be designed according to the design dimensions and tolerances shown in Annex S.

320 mm long brake block are used in Bg configuration and 250 mm long brake block in Bgu configuration.

Pass/fail criteria: conform to dimensions and tolerances.

#### 7.1.2 Brake block characterization test

Brake blocks used during evaluation and approval testing can be type tested according to Annex X. The results of these tests can be taken into consideration during any future series production batch testing of these properties to confirm that these properties have not changed.

### 7.1.3 Brake block mechanical characteristics for service operation

#### 7.1.3.1 Shear strength

In order to test the mechanical characteristics of the assembly between back plate and friction material, the brake block is tested according to T.2. At the end of the test there shall not be any indication of detachment of the back plate from the friction material or any other visible mechanical damage.

#### 7.1.3.2 Flexural strength

The brake block material behaviour under bending stress shall be assessed according to T.3. At the end of the test, the brake block shall not show any crack initiation within the friction material or fracture of the back plate. In the case of a brake block that has a groove or slot as shown in T.3 cracking is permitted in the area where the friction material is at its thinnest where the groove meets the back plate.

#### 7.1.3.3 Limitation of permissible mechanical damage

The limitation of permissible mechanical damage of the brake block during dynamometer tests (except for test “locked brakes” in 7.5) and testing service assessment shall be assessed in accordance with Annex U. The damage shall not exceed that defined.

## 7.2 Dynamic friction performance

### 7.2.1 Generic requirements for assessment process

Experience shows that in general, the dynamic friction performance of a friction material does not comply fully with all requirements.

For this reason, for a particular application, any deviation from the specification of 7.2 shall be assessed according to EN 50126-1.

The consequences of hazard levels and frequency arising from any deviation shall be evaluated taking into consideration the levels and frequency of the potential hazard shown in Table 3.

**Table 3 — Risk levels/frequency hazard**

| Frequency of occurrence of a hazardous event | Risk Levels                           |             |             |              |
|----------------------------------------------|---------------------------------------|-------------|-------------|--------------|
|                                              | Frequent                              | Probable    | Occasional  | Remote       |
| Frequent                                     | Intolerable                           | Intolerable | Intolerable | Intolerable  |
| Probable                                     | Intolerable                           | Intolerable | Intolerable | Intolerable  |
| Occasional                                   | Intolerable                           | Intolerable | Intolerable | Intolerable  |
| Remote                                       | Tolerable                             | Intolerable | Intolerable | Intolerable  |
| Improbable                                   | Tolerable                             | Tolerable   | Intolerable | Intolerable  |
| Incredible                                   | Tolerable                             | Tolerable   | Tolerable   | Intolerable  |
|                                              | Insignificant                         | Marginal    | Critical    | Catastrophic |
|                                              | Severity Levels of Hazard Consequence |             |             |              |

## 7.2.2 Bedded and non bedded performance

The mean friction coefficient shall not vary by more than  $\pm 15\%$  between non bedded and bedded states in the same test condition. The friction coefficient of the bedded state shall be defined as the average of measured friction coefficient of the last 5 braking stops carried out during the bedding section.

## 7.2.3 Variation in mean coefficient of friction in dry condition for a brake to rest

The mean friction coefficient ( $\mu_m$ ) in dry condition shall conform with specific range of tolerances defined in the annex applicable to the specific application.

## 7.2.4 Mean friction coefficient variation under wet conditions

### 7.2.4.1 Freight wagon

The average of mean friction coefficient in wet conditions shall be evaluated in comparison to the average of mean friction coefficient in dry conditions all other conditions being equal: initial speed ( $v$ ), total force per wheel ( $F_B$ ), initial temperature ( $\theta_0$ ) and mass to brake per wheel ( $m$ ) got from brake applications performed only before braking in high initial temperature and simulation of a downhill brake application.

The average of mean friction coefficient in wet conditions, for maximum applied brake force ( $F_B$ ) in every mass to brake per wheel ( $m$ ) and for each initial speed  $\geq 100$  km/h ( $v$ ) shall not vary by more than  $\pm 15\%$  relative to average mean friction coefficient measured in dry conditions.

For any other configurations the average of mean friction coefficient in wet conditions shall not vary by more than  $\pm 30\%$  relative to average mean friction coefficient measured in dry conditions.

### 7.2.4.2 Other vehicles

The mean friction coefficient in wet condition shall conform with specific range of tolerances defined in the annex applicable to the specific application.

## 7.2.5 Mean friction coefficient variation at high initial temperature

In the case of braking with an initial wheel tread temperature exceeding  $110^\circ\text{C}$ , the mean friction coefficient shall not vary by more than  $\pm 15\%$  compared to the average mean friction coefficient measured at a wheel temperature below  $60^\circ\text{C}$  in dry conditions, all other test conditions being equal.

## 7.2.6 Mean friction coefficient variation after simulation of a downhill brake application

The average of mean friction coefficient after simulation of a downhill brake application shall not vary by more than  $\pm 15\%$  at initial speed ( $v$ )  $\geq 100$  km/h and shall not vary by more than  $\pm 30\%$  at initial speed ( $v$ )  $< 100$  km/h compared to the average mean friction coefficient measured before simulation of a downhill brake application in dry conditions, all other test conditions being equal.

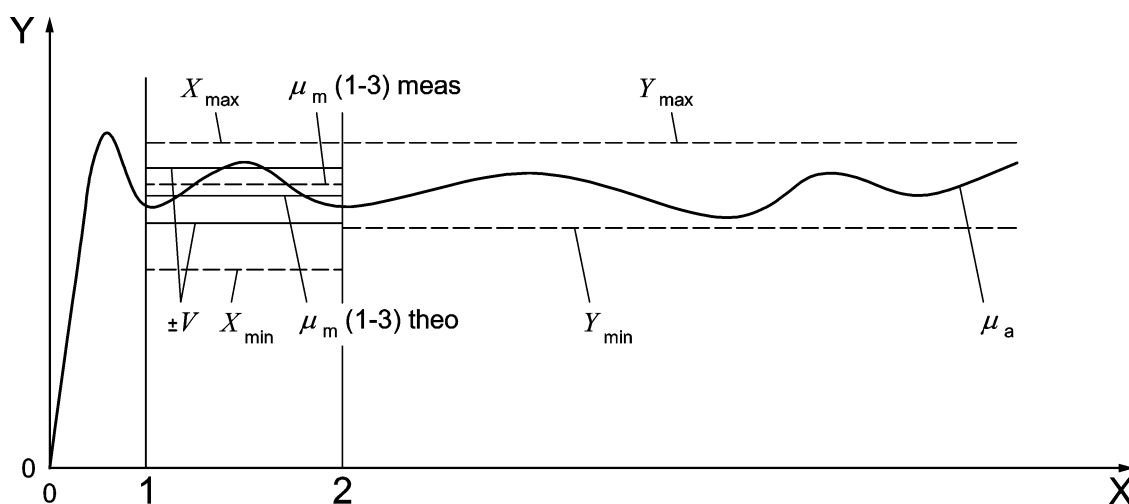
## 7.2.7 Instantaneous friction coefficient variation during simulation of a downhill brake application

### 7.2.7.1 Freight wagons

During simulation of a downhill brake application program Annex C, Annex D and Annex E, friction coefficient  $\mu_a$  recorded according to Figure 1 shall fulfil the criteria given in Table 4.

**Table 4 — General requirements for simulation of a downhill brake application**

|                            |                                                                                                                                      |                                                                                                                             |
|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|
| $\mu_m(1-3)_{\text{theo}}$ | “theo” = the mean coefficient of friction between first and third minute as defined in Table 5.                                      | See Table 5                                                                                                                 |
| $\pm V$                    | Maximum deviation range admissible for $\mu_m(1-3)_{\text{meas}}$                                                                    | $\pm 10\%$ of $\mu_m(1-3)_{\text{theo}}$                                                                                    |
| $\mu_m(1-3)_{\text{meas}}$ | “meas” = the mean coefficient of friction measured between first and third minute during simulation of a downhill brake application. | Measured value during the test                                                                                              |
| $X_{\min}$                 | Minimum permitted instantaneous coefficient of friction $\mu_a$ between first and third minute.                                      | - 30 % of $\mu_m(1-3)_{\text{meas}}$                                                                                        |
| $X_{\max}$                 | Maximum permitted instantaneous coefficient of friction $\mu_a$ between first and third minute.                                      | + 15 % of $\mu_m(1-3)_{\text{meas}}$                                                                                        |
| $Y_{\min}$                 | Minimum permitted instantaneous coefficient of friction $\mu_a$ after third minute                                                   | - 15 % of $\mu_m(1-3)_{\text{meas}}$                                                                                        |
| $Y_{\max}$                 | Maximum permitted instantaneous coefficient of friction $\mu_a$ after third minute                                                   | + 15 % of $\mu_m(1-3)_{\text{meas}}$ for brake block type K<br>+ 30 % of $\mu_m(1-3)_{\text{meas}}$ for brake block type LL |

**Key**

- X time in minutes  
 Y friction coefficient  
 1 first minute  
 2 third minute

**Figure 1 — General requirements for simulation of a downhill brake application**

**Table 5 — Value for  $\mu_m(1-3)_{theo}$** 

| Test program | Brake block | Configuration | $\mu_m(1-3)_{theo}$ |
|--------------|-------------|---------------|---------------------|
| Annex C      | K           | 2Bgu          | 0,25                |
| Annex C      | K           | 2Bg           | 0,25                |
| Annex C      | K           | 1Bgu          | 0,23                |
| Annex D      | LL          | 2Bgu          | 0,15                |
| Annex D      | LL          | 2Bg           | 0,15                |
| Annex E      | K           | 1Bg           | 0,26                |

NOTE 1 These conditions apply both to 45 kW and 40 kW under programmes Annex C and Annex D.

NOTE 2 In programmes Annex C and Annex D, the additional programme at 40 kW for 30 min only needs to be conducted if the results at 45 kW for 34 min, including comparison of the brake applications to a stop before and after the simulation of a downhill brake application, are not in compliance with the requirements.

#### 7.2.7.2 Coach

During simulation of a downhill brake application programme Annex F, the friction coefficient shall fulfil the following criteria.

After 2 min of the simulation of a downhill brake application, the instantaneous friction coefficient shall be in the range of 0,12 to 0,30.

During the whole simulation of downhill brake application duration, the instantaneous friction coefficient shall be in the range 0,10 to 0,32 and the maximum variation shall not be more than 0,15.

Within any one minute section during the simulation of a downhill brake application the instantaneous friction coefficient shall not vary by more than  $\pm 15\%$  of initial friction coefficient measured at the beginning of the one minute section.

#### 7.2.7.3 Other vehicles

During simulation of a downhill brake application, the friction coefficient shall fulfil the following criteria (assuming that the power of the specified drag brake test does not exceed 45 kW).

During the first 2 min of the simulation of a downhill brake application, the instantaneous friction coefficient shall not drop by more than 30 % of the mean friction coefficient value measured during the first two minutes of the test, and shall not increase by more than 15 % of the mean friction coefficient value measured during the first two minutes of the test.

During the whole simulation of downhill brake application duration, instantaneous friction shall not drop by more than 50 % or increase by more than 30 % of the mean friction coefficient value measured during the first two minutes of the test.

Within any one minute section during the simulation of a downhill brake application the instantaneous friction coefficient shall not vary by more than  $\pm 15\%$  of the initial friction coefficient measured at the beginning of the one minute section.

#### 7.2.8 Variation in instantaneous friction for a brake to rest

The instantaneous friction coefficient variation at the time at which the total brake force is applied during a dynamometer test, shall show that resulting brake torque is constant or at least varies within in the limits set in the annexes, and that it increases at the end of the brake application. The annexes

show the optimum variation in instantaneous friction coefficient to avoid wheel locking at brake initiation.

### 7.3 Static friction coefficient

The static friction coefficient  $\mu_{\text{stat}}$  is assessed according to Annex Q. The average of the 5 measurements of  $\mu_{\text{stat}}$  taken at each force shall be equal or higher than the level shown in Table 6.

**Table 6 — Static friction coefficient  $\mu_{\text{stat}}$**

| Material type | Program annex |      |      |
|---------------|---------------|------|------|
|               | Q.2           | Q.3  | Q.4  |
| K             | 0,20          | 0,24 | 0,24 |
| LL            | 0,20          | --   | --   |

For freight wagons, if the validation of the static coefficient of friction is conducted as per Q.2, it shall be valid for all other configurations and wheel diameters of 680 mm and above.

### 7.4 Extreme winter conditions (freight wagons)

#### 7.4.1 General

Friction behaviour under extreme winter conditions shall be assessed by a dynamometer test or by a train brake test.

#### 7.4.2 Dynamometer test

##### 7.4.2.1 Test program to demonstrate the braking properties under severe snowy conditions

The dynamometer test program to demonstrate the extreme winter braking properties is set out in L.1 and L.2 and is only applicable if the friction element

- a) is intended to be used in subsystems which fall under the following scope:
  - 1) nominal wheel diameters of 680 mm to 920 mm;
  - 2) friction element configuration;
    - i) 1Bg (if the test was performed in configuration 1Bg or 2Bgu);
    - ii) 1Bgu (if the test was performed in configuration 1Bgu or 2Bgu);
    - iii) 2Bg (if the test was performed in configuration 2Bg or 2Bgu);
    - iv) 2Bgu (if the test was performed in configuration 2Bgu);
  - 3) mass per wheel  $\geq 1,8$  t;
- b) complies with one of the following cases of the mean dynamic friction coefficient, given in Table 7, as determined in accordance with J.4.

Table 7 — Cases of the mean dynamic friction coefficient

| Case | Mean dynamic friction coefficient | Total $F_B$ per wheel | Initial speed |
|------|-----------------------------------|-----------------------|---------------|
|      |                                   | $F_B$<br>kN           | $v$<br>km/h   |
| 1    | $0,28 < \mu_m < 0,32$             | 9                     | 100           |
| 2    | $0,27 < \mu_m < 0,31$             | 9                     | 120           |
| 3    | $0,17 < \mu_m < 0,19$             | 16                    | 100           |
| 4    | $0,16 < \mu_m < 0,18$             | 16                    | 120           |

To demonstrate the extreme winter braking properties of friction elements complying with cases 1 and 2 of Table 7, the test program of L.1 shall be applied; for friction elements complying with cases 3 and 4 of Table 7, the test program of L.2 shall be applied.

#### 7.4.2.2 Values to be determined in order to define the area of use

The test program shall be carried out three times and the establishment of the suitability shall be done for the maximum test speeds of 100 km/h and 120 km/h as follows:

- For a maximum speed of 100 km/h the deviation of the average value of the measured stopping distances  $s_1$  under snow (brake application No 29, 33, 37, 42 and 46 of L.1 or L.2) from the average value of the measured stopping distances  $s_1$  under dry conditions (brake application No 16, 18, 20, 22 and 24 of L.1 or L.2) shall be determined;
- For a maximum speed of 120 km/h the deviation of the average value of the measured stopping distances  $s_1$  under snow (brake application No 31, 35, 39, 44 and 48 of L.1 or L.2) from the average value of the measured stopping distances  $s_1$  under dry conditions (brake application No 17, 19, 21, 23 and 25 of L.1 or L.2) shall be determined.

#### 7.4.2.3 Pass/fail criteria

The results shall conform to the pass/fail criteria defined in L.4.

For the brake blocks design for area of use corresponding at S and/or SS wagons if the dynamometer test is performed in brake block configuration 2Bgu, a positive assessment also applies to the other brake block configurations.  $\square_{A1}$

#### 7.4.3 Train brake test

$\square_{A1}$  The winter friction properties shall be assessed in conformity with prescriptions of Annex M. The results shall conform to the pass/fail criteria defined in M.3.

M.1 Test program to demonstrate the braking properties under severe snowy conditions.

M.2 Values to be determined in order to define the area of use.

M.3 Assessment of measurement data and pass/fail criteria.

For the brake blocks design for area of use corresponding at S and/or SS wagons if the test run is performed in brake block configuration 2Bgu, a positive assessment also applies to the other brake block configurations.  $\square_{A1}$

## 7.5 Locked brake (fusibility)

### 7.5.1 Generic prescriptions

The behaviour of the brake block under conditions that simulate a locked brake with a given applied braking force is assessed according to test conditions such as wheel diameter, applied braking force and initial stopping speed. Annex N provides test programmes.

- N.1 Test program for freight wagons with brake blocks type K and LL
- N.2 Test program for locomotives with brake blocks type K
- N.3 Test program for EMU – DMU at speed from 100 km/h to 160 km/h with brake blocks type K
- N.4 Test program for High speed train with brake blocks type K

The wheel tread temperature values for acceptance are given in **Table 8**.

**Table 8 — Wheel tread temperature values for acceptance**

| Wheel temperature <sup>a</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                               |                          |                           |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|---------------------------|
| < 600 [°C]                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | > 600 [°C]               | > 700 [°C] and < 850 [°C] |
| conform                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | not conform <sup>b</sup> | not conform <sup>c</sup>  |
| <sup>a</sup> Measured 9 mm under wheel tread surface. It is advised to take into account the maximum temperature value given by any of the 3 thermocouples at any time. Thermocouples to be positioned at 120° to each other.<br><sup>b</sup> If the cumulative time over the temperature limit exceeds 25 min.<br><sup>c</sup> If the cumulative time over the temperature limit exceeds 5 min in the range 700 °C to 850 °C, or if the maximum temperature exceeds 850 °C. |                          |                           |

The above test criteria apply for the acceptance of applications with brake block configuration 2Bgu, 2Bg 1Bgu and 1Bg and wheels with a nominal diameter between 680 mm and 920 mm.

### 7.5.2 Specific prescriptions for freight wagons

The result of a test carried out with 2Bg or 2Bgu configuration and wheel with nominal diameter of 920 mm is valid for all configurations with wheel diameter between 680 mm and 920 mm.

Tests carried out in either 1Bg or 1Bgu configuration shall be conducted following the basis of N.1 using the following parameters:

- bedding according to programme N.1;
- $F_B = \frac{1}{4}$  of the maximum force during an emergency braking of the vehicle concerned;
- speed =  $\frac{3}{4}$  of the maximum service speed of the vehicle;
- test time = maximum 1 h following the same principle as N.1.

## 8 Category B requirements

### 8.1 Vehicle brake test

The vehicle brake tests shall be conducted according to the requirements of the European Standards below. If specific prescriptions are not included in these ENs, tests shall be conducted according to UIC 544-1.

EN 13452-1, *Railway applications — Braking — Mass transit brake systems — Part 1: Performance requirements*

EN 13452-2, *Railway applications — Braking — Mass transit brake systems — Part 2: Methods of test*

EN 14033-1, *Railway applications — Track — Railbound construction and maintenance machines — Part 1: Technical requirements for running*

EN 14033-2:2008+A1:2011, *Railway applications — Track — Railbound construction and maintenance machines — Part 2: Technical requirements for working*

EN 14198, *Railway applications — Braking — Requirements for the brake system of trains hauled by a locomotive*

EN 15179, *Railway applications — Braking — Requirements for the brake system of coaches*

EN 15734-1, *Railway applications — Braking systems of high speed trains — Part 1: Requirements and definitions*

EN 15734-2, *Railway applications — Braking systems of high speed trains — Part 2: Test methods*

EN 16185-1, *Railway applications — Braking systems of multiple unit trains — Part 1: Requirements and definitions*

EN 16185-2, *Railway applications — Braking systems of multiple unit trains — Part 2: Test methods*

#### **Pass/fail criteria:**

Conformity with requirements of the relevant ENs and UIC 544-1.

### 8.2 Dynamometer wear test (friction couple)

In order to assess the brake block/wheel tread friction couple wear, a test that simulates actual service conditions for the application in question is recommended. Brake block and wheel tread wear are measured. An example of brake block/wheel tread friction couple wear test program for freight wagons is given in Annex R.

### 8.3 Dynamic friction performance

It is recommended that a test is conducted to ensure that the brake block material is suitable for the application in question, Annex J provides a format to design brake dynamometer performance tests for a given application.

### 8.4 In service assessment

In order to prove the suitability of the material for use in service, the brake block that has successfully met the performance criteria required during dynamometer tests and the associated brake performance tests of the vehicle shall be subject to an in service assessment.

It is recommended that the in service test assessment covers all climate conditions that the brake block would be exposed to during its use.

This assessment should confirm that the brake block under consideration does not cause damage to the wheel or cause any adverse effect to the mechanical integrity of the brake block assembly or introduce

any unforeseen operational problems. Brake block and wheel tread wear should also be monitored during this assessment. For new materials the duration of this service assessment should be a minimum of 12 months.

Annex V provides the relevant test programmes and pass/fail criteria.

For freight wagons, if the in service assessment is performed in regime SS it is not necessary to repeat the evaluation in regime S if the SS freight wagons were used in part in heterogeneous train with vehicle in regime S and SS.

NOTE "S and SS come from UIC".

## 9 Category C requirements

### 9.1 Metal pick up

The tests provided in Annex K can be used to assess metal pick up tendency in various applications. Any resulting metal pick up should not exceed more than 5 % of total brake block rubbing surface.

For freight wagons:

If the test is conducted in the 2xBgu configuration, its results shall also apply to the ether configurations in combination with all wheel diameters of 680 mm and above.

If the test is conducted in a different configuration, its results shall only apply to the configuration tested in combination with all wheel diameters of 680 mm and above.

### 9.2 Influence on track circuit operation (shuntage)

Composite brake blocks can influence the correct operation of the track circuit system. It is important to verify that the brake block friction material does not influence the operation of the track circuit system.

There are two methods available:

#### **Method 1:**

Dynamometer test and pass/fail criteria applicable for assessment of brake block for freight wagon (see Annex O). For freight wagons, a positive result at dynamometer test shall be applied for all configurations and all nominal wheel diameters of 680 mm and above.

#### **Method 2:**

Track test and pass/fail criteria applicable for assessment of brake block type L. For coach see Annex P. A positive result at test run shall be applied for all configurations and all nominal wheel diameters of 680 mm and above peer vehicle type (coach).

## 10 Environmental issues

### 10.1 General

All materials used in the manufacture of the friction material and the resulting wear products shall comply with the relevant environmental health regulations applicable at the time of use.

### 10.2 Noise

It is recommended to take into consideration the noise level found during braking and take steps in the development of the product to minimize this.

### 10.3 Odour

The formulation of the friction material should be such that any odour produced by the brake block in normal use is kept to a minimum.

### 10.4 Smoke, fumes and sparkling

The formulation of the friction material should take into account the need to keep the level of smoke, fumes and sparks produced by the brake block in normal use to a minimum.

### 10.5 Recycling and disposal

Consideration should be given to the need to recycle as much of the brake block as possible after use. Where re-cycling is not possible, the entire brake block should be capable of being disposed of without the need for special precautions.

## 11 Marking

As a minimum, the back of each brake block shall be permanently marked with the following:

- manufacturers name or logo;
- date of manufacture (week and year);
- material designation;
- part number.

## Annex A (normative)

### Summary of Dynamometer test programs and acceptance criteria

Table A.1 covers friction performance test programs.

**Table A.1 — Friction performance test programs**

| Rolling stock type                           | Brake block type | Brake block configuration |         |        |         | Friction test program | Acceptance criteria |
|----------------------------------------------|------------------|---------------------------|---------|--------|---------|-----------------------|---------------------|
|                                              |                  | 1 × Bg                    | 1 × Bgu | 2 × Bg | 2 × Bgu |                       |                     |
| Freight wagon                                | K                | X                         |         |        |         | Annex E               | Annex E             |
|                                              |                  |                           | X       | X      | X       | Annex C               | Annex C             |
|                                              |                  |                           |         |        |         |                       |                     |
|                                              |                  |                           |         |        |         |                       |                     |
|                                              | LL               |                           |         | X      | X       | Annex D               | Annex D             |
| Coach (brake block combined with disc brake) | L                | X                         |         |        |         | Annex F               | Annex F             |
| Locomotive                                   | K                |                           | X       |        |         | Annex G               | Annex G             |
| EMU/DMU                                      | K                |                           | X       |        |         | Annex H               | Annex H             |
| High speed train                             | K                | X                         |         |        |         | Annex I               | Annex I             |
| Other applications                           | All              | X                         | X       | X      | X       | Annex J               | Annex J             |

Table A.2 below covers other dynamometer test programs.

Table A.2 — Other dynamometer test programs

| Test Program                               | Annex   | Brake block type | Brake block configuration |         |        |         |                                      |
|--------------------------------------------|---------|------------------|---------------------------|---------|--------|---------|--------------------------------------|
|                                            |         |                  | 1 × Bg                    | 1 × Bgu | 2 × Bg | 2 × Bgu |                                      |
| Metal Pick-up                              | K.1     | K                | X                         |         | X      | X       | Freight wagon                        |
|                                            |         | LL               |                           |         | X      | X       | Freight wagon                        |
|                                            | K.2     | K                |                           | X       |        |         | Locomotive                           |
|                                            | K.3     | K                |                           | X       |        |         | DMU/EMU,                             |
|                                            | K.4     | K                | X                         |         |        |         | High speed train                     |
| Extreme winter braking properties          | L.1     | K                |                           |         |        | X       | Freight wagon                        |
|                                            | L.2     | LL               |                           |         |        | X       | Freight wagon                        |
| Simulation of “Locked brake”               | N.1     | K, LL            |                           |         | X      | X       | Freight wagon                        |
|                                            | N.2     | K                |                           | X       |        |         | Locomotive                           |
|                                            | N.3     | K                |                           | X       |        |         | DMU/EMU                              |
|                                            | N.4     | K                | X                         |         |        |         | High speed train                     |
| Compatibility with track circuits          | Annex O | K                | Small scale dynamometer   |         |        |         | Freight wagon                        |
|                                            |         | LL               |                           |         |        |         |                                      |
| A <sub>1</sub> Static friction coefficient | Q.1     | K, LL            | X                         | X       | X      | X       | Freight wagon (generic test program) |
|                                            | Q.2     | K, LL            |                           | X       | X      | X       | Freight wagon (S or SS)              |
|                                            | Q.3     | K                |                           | X       |        |         | Locomotive and DMU/EMU               |
|                                            | Q.4     | K                | X                         |         |        |         | High speed train A <sub>1</sub>      |
| Simulation of service conditions           | R.1     | K                |                           |         |        | X       | Freight wagon                        |
|                                            | R.2     | LL               |                           |         |        | X       |                                      |

## Annex B (normative)

### General requirements for conducting dynamometer test programmes

#### B.1 General

The following general requirements apply to all dynamometer tests unless other more specific requirements are quoted in a specific test, in which case this specific requirement takes priority.

#### B.2 Rotation and ventilation conditions

**Table B.1 — Speed and ventilation conditions**

|                                | Speed of the test bench<br>km/h |                         | Speed of the cooling air<br>km/h |                         |
|--------------------------------|---------------------------------|-------------------------|----------------------------------|-------------------------|
|                                | Under dry<br>conditions         | Under wet<br>conditions | Under dry<br>conditions          | Under wet<br>conditions |
| During braking at;             | $v$                             | $v$                     | $v / 2$                          | 10                      |
| $v \leq 80$ km/h               | $v$                             | $v$                     | 40                               | 10                      |
| $v > 80$ km/h                  |                                 |                         |                                  |                         |
| Between the brake applications | 100                             | 50                      | 40                               | 10                      |

#### B.3 Brake application timing $t_s$

The time to reach 95 % of the demanded  $F_B$  should be  $4 \text{ s} \pm 0,2 \text{ s}$ .

#### B.4 Bedding

If bedding is done using brake stops to rest then a minimum number of bedding brake stops is to be carried out once to ensure wheel conditioning is as below:

- 40 for organic blocks;
- 80 for sinter blocks.

#### B.5 Wear

The wear of the brake block will be measured prior to the specific braking stops as indicated in each type of dynamometer program. Wear for each individual section of the test and for the overall wear of the material, shall be calculated in  $\text{cm}^3/\text{MJ}$ .

There are no acceptance criteria for wear values.

## B.6 Roughness index of the wheel tread

The roughness of the wheel is to be measured prior to the specific braking stops as indicated in each type of dynamometer program. Measurement of Rz and Ra shall be done following EN ISO 4287 and EN ISO 4288.

NOTE It is authorized to do the test using a resin sample.

## B.7 Interruption of the tests

Should there be an interruption to any of the testing programmes before recommencing the program it is necessary to repeat the previous 5 stops carried out before the interruption (drag brakes excluded).

In the case of an interruption prior to the first wet stop, one brake application identical to the last brake application in dry (not including any drag brake application) is required outside of the program in order to conform to the wet conditions.

## B.8 Temperatures

Temperatures should be measured on the surface by 3 rubbing thermocouples spaced equally across the wheel tread or by embedded temperature sensors typically 5 mm below the wheel tread surface. The value is established on an average of three individual values. Alternative temperature measurements have to achieve at least an equivalent accuracy.

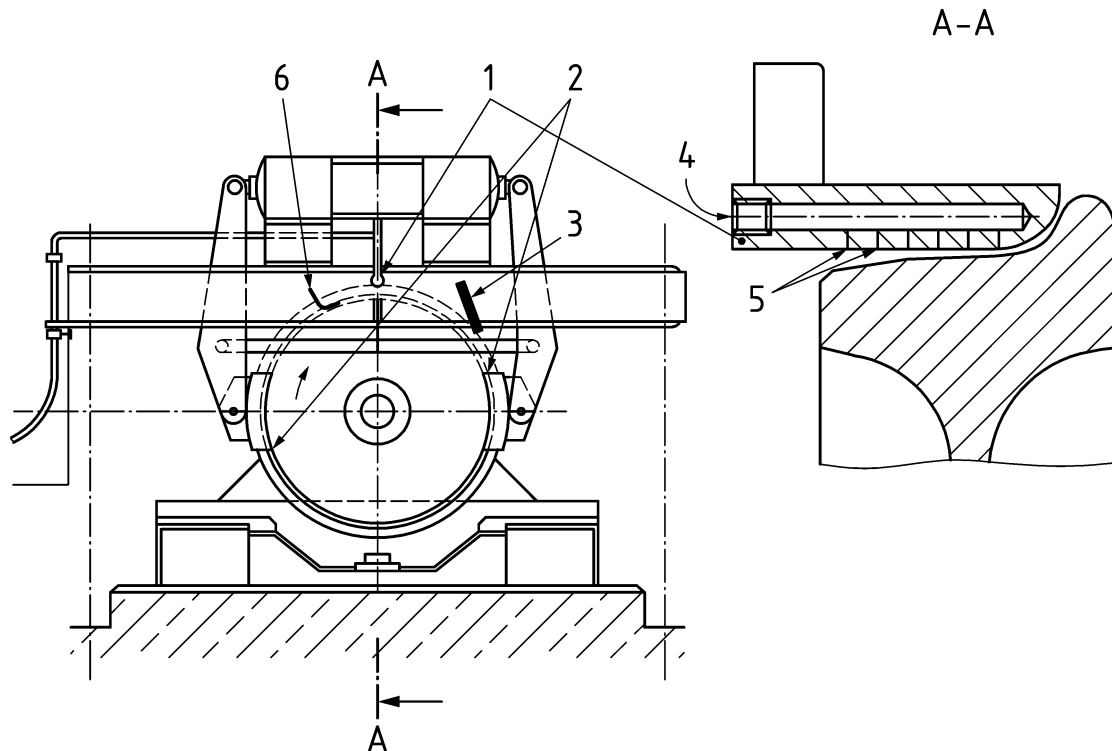
During subsequent brake applications, the initial temperature shall always be achieved by reducing the temperature to this value, prior to the brake application.

If the tests are interrupted according to the point "Interruption of the test" above, then initial temperature for the first stop shall be in the range 20 °C to 60 °C.

## B.9 Wet conditions

Concerning the brake applications under wet conditions, the wheel wetting shall not interrupted during each complete set of wet stops (including cooling period). For the first stop of any wet test section after a dry section, the start of the wheel tread wetting takes place only when the temperature of the wheel is below 80 °C.

The wet testing shall be conducted with 6 holes for water spray spaced 15 mm apart with a diameter of 0,5 mm. The spray head should be positioned approximately 5 mm above the wheel tread. During the cooling between wet stop, a gap of at least 2 mm should be maintained between wheel tread and the brake block surface. An example of the wet testing configuration is shown in Figure B.1:



#### Key

- 1 spray head
- 2 leading edge of brake block in the direction of rotation shall be fully bedded
- 3 water deflection shield
- 4 water inlet example
- 5 spray holes
- 6 position sliding thermocouples

**Figure B.1 — Dynamometer wet test configuration**

### B.10 Test of simulation of downhill

When the requirements for simulation of a downhill are specified in power [kW] in program test, the test shall be performed at constant power and speed.

### B.11 Test wheels

It is possible to use either wheels taken from service or new wheels. Before the assembly on the test bench, their diameter shall be adapted to the value indicated in the test program.

During the test the appearance, the surface condition and the position of any metal pick up on the friction face of the brake block shall be registered. A photograph shall be taken during every disassembly.

After every exchange of the friction material, the wheel tread shall be regenerated so that the tread surface condition is consistent for all tests.

## Annex C (normative)

### Composite brake blocks (K) (2Bg – 2Bgu)– Demonstration of friction properties for S and SS (S/SS) – braked freight wagons ( $v_{\max} = 120$ km/h)

#### C.1 Program for performance tests

Conditions for Table C.1

|                                  |                                                                                                                                                     |
|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
|                                  | 2 × Bgu [4 brake blocks of $250 \times 80 \left( \begin{smallmatrix} +1 \\ -2 \end{smallmatrix} \right)$ mm] per wheel.                             |
| Brake shoe Insert configuration: | 2 × Bg [2 brake blocks of $320 \times 80 \left( \begin{smallmatrix} +1 \\ -2 \end{smallmatrix} \right)$ mm] per wheel.                              |
|                                  | 1 × Bgu [2 brake blocks of $250 \times 80 \left( \begin{smallmatrix} +1 \\ -2 \end{smallmatrix} \right)$ mm] per wheel.                             |
| Wheel type:                      | In conformity with EN 13979–1                                                                                                                       |
| Wheel diameter:                  | $870 \left( \begin{smallmatrix} +5 \\ -0 \end{smallmatrix} \right)$ mm (new wheel 920 mm). The accurate diameter shall be given in the test report. |
| To be braked mass per wheel:     | 1,8 t, 9,0 t and 11,25 t                                                                                                                            |
| Water flow rate:                 | 14 l/h                                                                                                                                              |

**Table C.1 – Program for performance tests**

| No. of brake application |   |   | Initial speed | Total $F_B$ per wheel | Initial temperature | Mass to brake per wheel | weighing after | Remarks                                                                                                                                                                                    |
|--------------------------|---|---|---------------|-----------------------|---------------------|-------------------------|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                          |   |   | $v$           | $F_B$                 | $\theta_0$          | $m$                     |                |                                                                                                                                                                                            |
|                          |   |   | km/h          | kN                    | °C                  | t                       | No.            |                                                                                                                                                                                            |
| 1.1 – 1.X                |   |   | 100           | 24                    | 20 – 100            | 9,0                     | 1.X            | Brake applications to rest under dry conditions to allow bedding of the brake blocks up to at least 85 % of the friction material surface. Measure wheel roughness at end of this section. |
| 1                        | 3 | 5 | 100           | 38                    | 50 – 60             | 9,0                     |                | Brake applications to rest under dry conditions, after a period of cooling                                                                                                                 |
| 2                        | 4 | 6 | 120           |                       |                     |                         |                |                                                                                                                                                                                            |

| No. of brake application |    |    | Initial speed | Total $F_B$ per wheel | Initial temperature | Mass to brake per wheel | weighing after | Remarks                                                                                                                                                                          |
|--------------------------|----|----|---------------|-----------------------|---------------------|-------------------------|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                          |    |    | $v$           | $F_B$                 | $\theta_0$          | $m$                     |                |                                                                                                                                                                                  |
|                          |    |    | km/h          | kN                    | °C                  | t                       | No.            |                                                                                                                                                                                  |
| 7 to 26                  |    |    | 100           | 7                     | 20 – 100            | 1,8                     |                | Conditioning stops                                                                                                                                                               |
| 27                       | 39 |    | 100           | 7                     | 50 – 60             | 1,8                     |                | Brake applications to rest under dry conditions, after a period of cooling                                                                                                       |
| 28                       | 40 |    | 30            |                       |                     |                         |                |                                                                                                                                                                                  |
| 29                       | 41 |    | 120           |                       |                     |                         |                |                                                                                                                                                                                  |
| 30                       | 42 |    | 60            |                       |                     |                         |                |                                                                                                                                                                                  |
| 31                       | 43 |    | 100           | 5                     | 50 – 60             | 1,8                     |                | Brake applications to rest under dry conditions, after a period of cooling                                                                                                       |
| 32                       | 44 |    | 30            |                       |                     |                         |                |                                                                                                                                                                                  |
| 33                       | 45 |    | 120           |                       |                     |                         |                |                                                                                                                                                                                  |
| 34                       | 46 |    | 60            |                       |                     |                         |                |                                                                                                                                                                                  |
| 35                       | 47 |    | 100           | 9                     | 50 – 60             | 1,8                     |                | Brake applications to rest under dry conditions, after a period of cooling                                                                                                       |
| 36                       | 48 |    | 30            |                       |                     |                         |                |                                                                                                                                                                                  |
| 37                       | 49 |    | 120           |                       |                     |                         |                |                                                                                                                                                                                  |
| 38                       | 50 |    | 60            |                       |                     |                         |                |                                                                                                                                                                                  |
| 51                       |    |    | 70            | -                     | -                   | -                       |                | 10 kW drag brake application for a period of 15 min done immediately after brake n° 50, without interruption. This is to evenly distribute the residual stress within the wheel. |
| 52                       | 64 | 76 | 100           | 7                     | 20 – 30             | 1,8                     |                | Brake applications to rest under wet conditions, after a period of cooling                                                                                                       |
| 53                       | 65 | 77 | 30            |                       |                     |                         |                |                                                                                                                                                                                  |
| 54                       | 66 | 78 | 120           |                       |                     |                         |                |                                                                                                                                                                                  |
| 55                       | 67 | 79 | 60            |                       |                     |                         |                |                                                                                                                                                                                  |
| 56                       | 68 | 80 | 100           | 5                     | 20 – 30             | 1,8                     |                | Brake applications to rest under wet conditions, after a period of cooling                                                                                                       |
| 57                       | 69 | 81 | 30            |                       |                     |                         |                |                                                                                                                                                                                  |
| 58                       | 70 | 82 | 120           |                       |                     |                         |                |                                                                                                                                                                                  |
| 59                       | 71 | 83 | 60            |                       |                     |                         |                |                                                                                                                                                                                  |

| No. of brake application |     |    | Initial speed | Total $F_B$ per wheel | Initial temperature    | Mass to brake per wheel | weighing after | Remarks                                                                                                                                                      |
|--------------------------|-----|----|---------------|-----------------------|------------------------|-------------------------|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                          |     |    | $v$           | $F_B$                 | $\theta_0$             | $m$                     |                |                                                                                                                                                              |
|                          |     |    | km/h          | kN                    | °C                     | t                       | No.            |                                                                                                                                                              |
| 60                       | 72  | 84 | 100           | 9                     | 20 – 30                | 1,8                     |                | Brake applications to rest under wet conditions, after a period of cooling                                                                                   |
| 61                       | 73  | 85 | 30            |                       |                        |                         |                |                                                                                                                                                              |
| 62                       | 74  | 86 | 120           |                       |                        |                         |                |                                                                                                                                                              |
| 63                       | 75  | 87 | 60            |                       |                        |                         |                |                                                                                                                                                              |
| 88                       | 92  |    | 100           | 38                    | 20 – 30                | 11,25                   |                | Brake applications to rest under wet conditions, after a period of cooling                                                                                   |
| 89                       | 93  |    | 30            |                       |                        |                         |                |                                                                                                                                                              |
| 90                       | 94  |    | 120           |                       |                        |                         |                |                                                                                                                                                              |
| 91                       | 95  |    | 60            |                       |                        |                         |                |                                                                                                                                                              |
| 96                       |     |    | 70            | -                     | -                      | -                       | 96             | 10 kW drag brake application for a period of 15 min in dry condition done immediately after brake n° 95 without interruption to rest to dry the brake block. |
| 97                       | 109 |    | 100           | 24                    | 50 – 60                | 11,25                   |                | Brake applications to rest under dry conditions, after a period of cooling                                                                                   |
| 98                       | 110 |    | 30            |                       |                        |                         |                |                                                                                                                                                              |
| 99                       | 111 |    | 120           |                       |                        |                         |                |                                                                                                                                                              |
| 100                      | 112 |    | 60            |                       |                        |                         |                |                                                                                                                                                              |
| 101                      | 113 |    | 100           | 9                     | 50 – 60                | 11,25                   |                | Brake applications to rest under dry conditions, after a period of cooling                                                                                   |
| 102                      | 114 |    | 30            |                       |                        |                         |                |                                                                                                                                                              |
| 103                      | 115 |    | 120           |                       |                        |                         |                |                                                                                                                                                              |
| 104                      | 116 |    | 60            |                       |                        |                         |                |                                                                                                                                                              |
| 105                      | 117 |    | 100           | 38                    | 50 – 60                | 11,25                   |                | Brake applications to rest under dry conditions, after a period of cooling                                                                                   |
| 106                      | 118 |    | 30            |                       |                        |                         |                |                                                                                                                                                              |
| 107                      | 119 |    | 120           |                       |                        |                         |                |                                                                                                                                                              |
| 108                      | 120 |    | 60            |                       |                        |                         |                |                                                                                                                                                              |
| 121                      |     |    | 100           | 38                    | 110 – 120 <sup>a</sup> | 11,25                   |                | Brake applications to rest under dry conditions with high initial temperature, after a period of cooling                                                     |
| 122                      |     |    | 30            |                       |                        |                         |                |                                                                                                                                                              |
| 123                      |     |    | 120           |                       |                        |                         |                |                                                                                                                                                              |
| 124                      |     |    | 60            |                       |                        |                         |                |                                                                                                                                                              |

| No. of brake application                                                                                                                                                                                                |     | Initial speed | Total $F_B$ per wheel | Initial temperature | Mass to brake per wheel | weighing after | Remarks                                                                                                                                                                                                                           |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|---------------|-----------------------|---------------------|-------------------------|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                         |     | $v$           | $F_B$                 | $\theta_0$          | $m$                     |                |                                                                                                                                                                                                                                   |
|                                                                                                                                                                                                                         |     | km/h          | kN                    | °C                  | t                       | No.            |                                                                                                                                                                                                                                   |
| 125                                                                                                                                                                                                                     |     | 100           | 24                    | 50 – 60             | 11,25                   | 128            | Brake applications to rest under dry conditions, after a period of cooling                                                                                                                                                        |
| 126                                                                                                                                                                                                                     |     | 30            |                       |                     |                         |                |                                                                                                                                                                                                                                   |
| 127                                                                                                                                                                                                                     |     | 120           |                       |                     |                         |                |                                                                                                                                                                                                                                   |
| 128                                                                                                                                                                                                                     |     | 60            |                       |                     |                         |                |                                                                                                                                                                                                                                   |
| 129                                                                                                                                                                                                                     |     | 70            | -                     | 20 – 60             | -                       |                | Simulation of a downhill brake application with a power of 45 kW for a period of 34 min                                                                                                                                           |
| 130                                                                                                                                                                                                                     |     | 70            | 38                    | -                   | 11,25                   | 130            | Brake application to rest under dry conditions immediately after the simulation of a downhill brake application, without any cooling break                                                                                        |
| 131 to 140                                                                                                                                                                                                              |     | 120           | 24                    | 50 – 60             | 11,25                   |                | Conditioning stops                                                                                                                                                                                                                |
| 141                                                                                                                                                                                                                     | 145 | 100           | 38                    | 50 – 60             | 11,25                   |                | Brake applications to rest under dry conditions, after a period of cooling                                                                                                                                                        |
| 142                                                                                                                                                                                                                     | 146 | 30            |                       |                     |                         |                |                                                                                                                                                                                                                                   |
| 143                                                                                                                                                                                                                     | 147 | 120           |                       |                     |                         |                |                                                                                                                                                                                                                                   |
| 144                                                                                                                                                                                                                     | 148 | 60            |                       |                     |                         |                |                                                                                                                                                                                                                                   |
| 149                                                                                                                                                                                                                     |     | 70            | -                     | -                   | -                       | 149            | 10 kW drag brake application for a period of 15 min done immediately after brake n° 148, without interruption. This is to evenly distribute the residual stress within the wheel. Measure wheel roughness at end of this section. |
| <sup>a</sup> Should the temperature obtained during the brake applications nos. 120 and 122 be under 110 °C, then the brake applications no. 121 and 123 shall be performed with the temperature achieved at that time. |     |               |                       |                     |                         |                |                                                                                                                                                                                                                                   |

Conditions for Table C.2

|                              |                                                                                                                                                     |
|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
|                              | $2 \times \text{Bgu}$ [4 brake blocks of $250 \times 80 \left( \begin{smallmatrix} +1 \\ -2 \end{smallmatrix} \right)$ mm] per wheel.               |
| Brake block configuration:   | $2 \times \text{Bg}$ [2 brake blocks of $320 \times 80 \left( \begin{smallmatrix} +1 \\ -2 \end{smallmatrix} \right)$ mm] per wheel.                |
|                              | $1 \times \text{Bgu}$ [2 brake blocks of $250 \times 80 \left( \begin{smallmatrix} +1 \\ -2 \end{smallmatrix} \right)$ mm] per wheel.               |
| Wheel type:                  | In conformity with EN 13979-1                                                                                                                       |
| Wheel diameter:              | $870 \left( \begin{smallmatrix} +5 \\ -0 \end{smallmatrix} \right)$ mm (new wheel 920 mm). The accurate diameter shall be given in the test report. |
| To be braked mass per wheel: | 9,0 t and 11,25 t                                                                                                                                   |

See Note 2 in 7.2.7.1.

Table C.2 – Additional program for performance tests

| No. of brake application                        |    |   |     | Initial speed | Total $F_B$ per wheel | Initial temperature | Mass to brake per wheel | weighing after | Remarks                                                                                                                                    |
|-------------------------------------------------|----|---|-----|---------------|-----------------------|---------------------|-------------------------|----------------|--------------------------------------------------------------------------------------------------------------------------------------------|
|                                                 |    |   |     | $v$           | $F_B$                 | $\theta_0$          | $m$                     |                |                                                                                                                                            |
|                                                 |    |   |     | km/h          | kN                    | °C                  | t                       | No.            |                                                                                                                                            |
| Tests to be conducted using a set of new blocks |    |   |     |               |                       |                     |                         |                |                                                                                                                                            |
| 1.1 – 1.X                                       |    |   |     | 100           | 24                    | 20 – 100            | 9,0                     | 1.X            | Brake applications to rest under dry conditions to allow bedding of the brake blocks up to at least 85 % of the friction material surface. |
| 1                                               | 3  | 5 | 100 | 38            | 50 – 60               | 9,0                 |                         |                | Brake applications to rest under dry conditions, after a period of cooling                                                                 |
| 2                                               | 4  | 6 | 120 |               |                       |                     |                         |                |                                                                                                                                            |
| 7                                               | 11 |   | 100 | 38            | 50 – 60               | 11,25               |                         |                | Brake applications to rest under dry conditions, after a period of cooling                                                                 |
| 8                                               | 12 |   | 30  |               |                       |                     |                         |                |                                                                                                                                            |
| 9                                               | 13 |   | 120 |               |                       |                     |                         |                |                                                                                                                                            |
| 10                                              | 14 |   | 60  |               |                       |                     |                         |                |                                                                                                                                            |
| 15                                              | 19 |   | 100 | 9             | 50 – 60               | 11,25               |                         |                | Brake applications to rest under dry conditions, after a period of cooling                                                                 |
| 16                                              | 20 |   | 30  |               |                       |                     |                         |                |                                                                                                                                            |
| 17                                              | 21 |   | 120 |               |                       |                     |                         |                |                                                                                                                                            |
| 18                                              | 22 |   | 60  |               |                       |                     |                         |                |                                                                                                                                            |
| 23                                              |    |   |     | 70            | -                     | 50 – 60             | -                       |                | Simulation of a downhill brake application with a power of 40 kW for a period of 30 min                                                    |
| 24                                              |    |   |     | 70            | 38                    | -                   | 11,25                   |                | Brake application to rest under dry conditions immediately after the simulation of a downhill brake application, without any cooling break |
| 25 to 34                                        |    |   |     | 100           | 24                    | 50 – 60             | 11,25                   |                | Conditioning stops                                                                                                                         |
| 25                                              | 29 |   | 100 | 38            | 50 – 60               | 11,25               | 32                      |                | Brake applications to rest under dry conditions, after a period of cooling                                                                 |
| 26                                              | 30 |   | 30  |               |                       |                     |                         |                |                                                                                                                                            |
| 27                                              | 31 |   | 120 |               |                       |                     |                         |                |                                                                                                                                            |
| 28                                              | 32 |   | 60  |               |                       |                     |                         |                |                                                                                                                                            |

## C.2 Program for simulation brake assessment

Conditions for Table C.3

|                              |                                                                                                                                                     |
|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| Brake block configuration:   | $2 \times \text{Bgu}$ [4 brake blocks of $250 \times 80 \left( \begin{smallmatrix} +1 \\ -2 \end{smallmatrix} \right)$ mm] per wheel.               |
|                              | $2 \times \text{Bg}$ [2 brake blocks of $320 \times 80 \left( \begin{smallmatrix} +1 \\ -2 \end{smallmatrix} \right)$ mm] per wheel.                |
|                              | $1 \times \text{Bgu}$ [2 brake blocks of $250 \times 80 \left( \begin{smallmatrix} +1 \\ -2 \end{smallmatrix} \right)$ mm] per wheel.               |
| Wheel type:                  | In conformity with EN 13979-1                                                                                                                       |
| Wheel diameter:              | $870 \left( \begin{smallmatrix} +5 \\ -0 \end{smallmatrix} \right)$ mm (new wheel 920 mm). The accurate diameter shall be given in the test report. |
| To be braked mass per wheel: | 1,8 t, 9,0 t and 11,25 t                                                                                                                            |
| Water flow rate:             | 14 l/h                                                                                                                                              |

**Table C.3 – Program for simulation brake assessment**

| No. of brake application                       | Initial speed | Total $F_B$ per wheel | Initial temperature | Mass to brake per wheel | weighing after | Remarks                                                                                                                                                       |
|------------------------------------------------|---------------|-----------------------|---------------------|-------------------------|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                | $v$           | $F_B$                 | $\theta_0$          | $m$                     |                |                                                                                                                                                               |
|                                                | km/h          | kN                    | °C                  | t                       | No.            |                                                                                                                                                               |
| 1.1 – 1.X                                      | 100           | 24                    | 20 – 100            | 9,0                     | 1.X            | Brake applications to rest under dry conditions to allow bedding of the brake blocks up to at least 85 % of the friction material surface.                    |
| 1 to 19                                        | 100           | 24                    | 20 – 100            | 1,8                     |                | Conditioning stops                                                                                                                                            |
| 20 to 24                                       | 100           | 9                     | 50 – 60             | 1,8                     |                | Brake applications to rest under dry conditions, after a period of cooling                                                                                    |
| 25 to 29                                       | 120           |                       |                     |                         |                |                                                                                                                                                               |
| 30 to 34                                       | 100           |                       |                     |                         |                |                                                                                                                                                               |
| 35 to 39                                       | 100           | 9                     | 20 – 30             | 1,8                     |                | Brake applications to rest under wet conditions, after a period of cooling                                                                                    |
| 40 to 44                                       | 120           |                       |                     |                         |                |                                                                                                                                                               |
| 45 to 49                                       | 100           |                       |                     |                         |                |                                                                                                                                                               |
| 50                                             | 70            | -                     | -                   | -                       |                | 10 kW drag brake application for a period of 15 min in dry condition done immediately after brake n° 49 without interruption to rest to dry the brake blocks. |
| 51 to 55                                       | 100           | 24                    | 50 – 60             | 11,25                   |                | Brake applications to rest under dry conditions, after a period of cooling                                                                                    |
| 56 to 60                                       | 120           |                       |                     |                         |                |                                                                                                                                                               |
| 61 to 65                                       | 100           |                       |                     |                         |                |                                                                                                                                                               |
| 66 to 70                                       | 100           | 38                    | 50 – 60             | 11,25                   | 75             | Brake applications to rest under dry conditions, after a period of cooling                                                                                    |
| 71 to 75                                       | 120           |                       |                     |                         |                |                                                                                                                                                               |
| NOTE Tests 35 to 49 performed for information. |               |                       |                     |                         |                |                                                                                                                                                               |

C.3 Dispersion range of mean friction coefficients

C.3.1 General

Dispersion range of mean friction coefficients in dry condition applicable for test programs C.1 and C.2.

C.3.2 2Bgu configuration

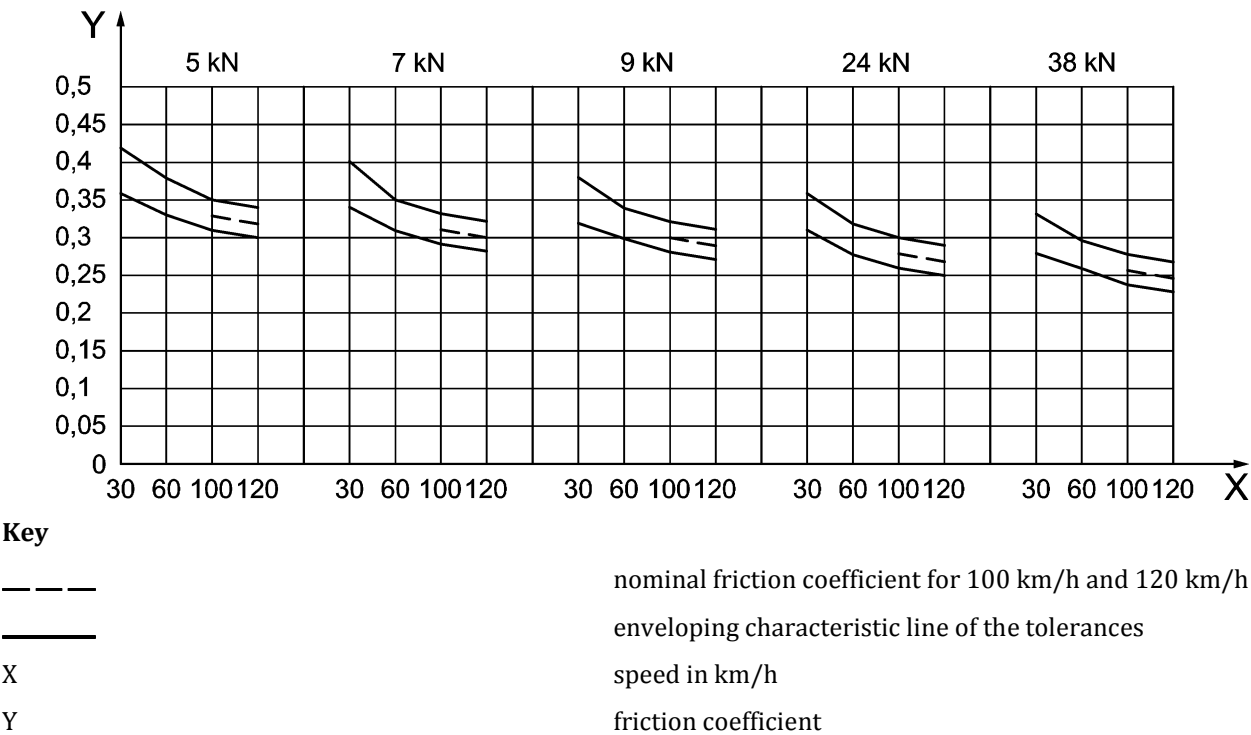


Figure C.1 —Dispersion range of means friction coefficient in dry condition, 2Bgu configuration

**Table C.4 —Dispersion range of mean friction coefficient in dry condition, 2Bgu configuration**

| $F_B$<br>kN | Initial speed<br>$v$ (km/h) $\geq$ | 30    | 60    | 100   | 120   |
|-------------|------------------------------------|-------|-------|-------|-------|
| 5           | Maximum                            | 0,420 | 0,380 | 0,350 | 0,340 |
|             | Nominal                            |       |       | 0,330 | 0,320 |
|             | Minimum                            | 0,360 | 0,330 | 0,310 | 0,300 |
| 7           | Maximum                            | 0,400 | 0,350 | 0,330 | 0,320 |
|             | Nominal                            |       |       | 0,310 | 0,300 |
|             | Minimum                            | 0,340 | 0,310 | 0,290 | 0,280 |
| 9           | Maximum                            | 0,380 | 0,340 | 0,320 | 0,310 |
|             | Nominal                            |       |       | 0,300 | 0,290 |
|             | Minimum                            | 0,320 | 0,300 | 0,280 | 0,270 |
| 24          | Maximum                            | 0,360 | 0,320 | 0,300 | 0,290 |
|             | Nominal                            |       |       | 0,280 | 0,270 |
|             | Minimum                            | 0,310 | 0,280 | 0,260 | 0,250 |
| 38          | Maximum                            | 0,330 | 0,300 | 0,280 | 0,270 |
|             | Nominal                            |       |       | 0,260 | 0,250 |
|             | Minimum                            | 0,280 | 0,260 | 0,240 | 0,230 |

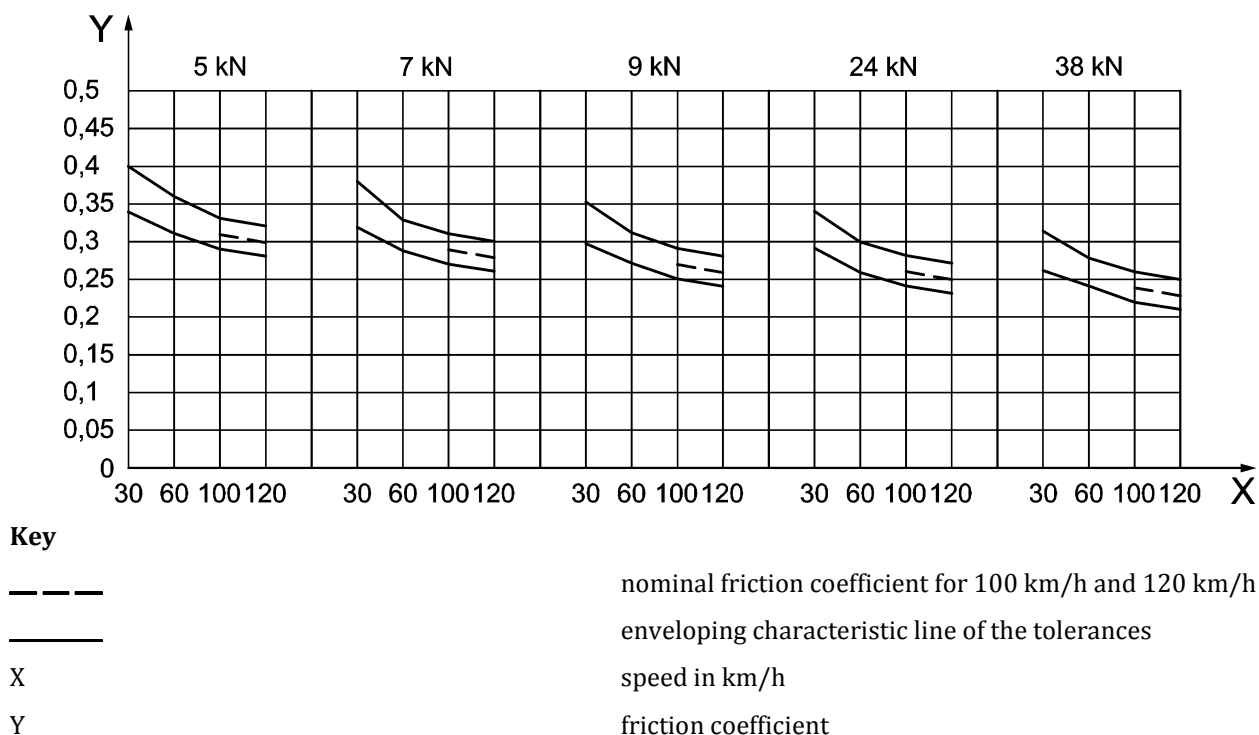
**C.3.3 2Bg configuration****Figure C.2 —Dispersion range of mean friction coefficient in dry condition, 2Bg configuration**

**Table C.5 —Dispersion range of mean friction coefficient in dry condition, 2Bg configuration**

| $F_B$<br>kN | Initial speed<br>$v$ (km/h) $\geq$ | 30    | 60    | 100   | 120   |
|-------------|------------------------------------|-------|-------|-------|-------|
| 5           | Maximum                            | 0,403 | 0,357 | 0,330 | 0,320 |
|             | Nominal                            |       |       | 0,310 | 0,300 |
|             | Minimum                            | 0,341 | 0,310 | 0,290 | 0,280 |
| 7           | Maximum                            | 0,377 | 0,334 | 0,310 | 0,300 |
|             | Nominal                            |       |       | 0,290 | 0,280 |
|             | Minimum                            | 0,319 | 0,290 | 0,270 | 0,260 |
| 9           | Maximum                            | 0,351 | 0,311 | 0,290 | 0,280 |
|             | Nominal                            |       |       | 0,270 | 0,260 |
|             | Minimum                            | 0,297 | 0,270 | 0,250 | 0,240 |
| 24          | Maximum                            | 0,338 | 0,299 | 0,280 | 0,270 |
|             | Nominal                            |       |       | 0,260 | 0,250 |
|             | Minimum                            | 0,286 | 0,260 | 0,240 | 0,230 |
| 38          | Maximum                            | 0,312 | 0,276 | 0,260 | 0,250 |
|             | Nominal                            |       |       | 0,240 | 0,230 |
|             | Minimum                            | 0,264 | 0,240 | 0,220 | 0,210 |

## C.3.4 1Bgu configuration

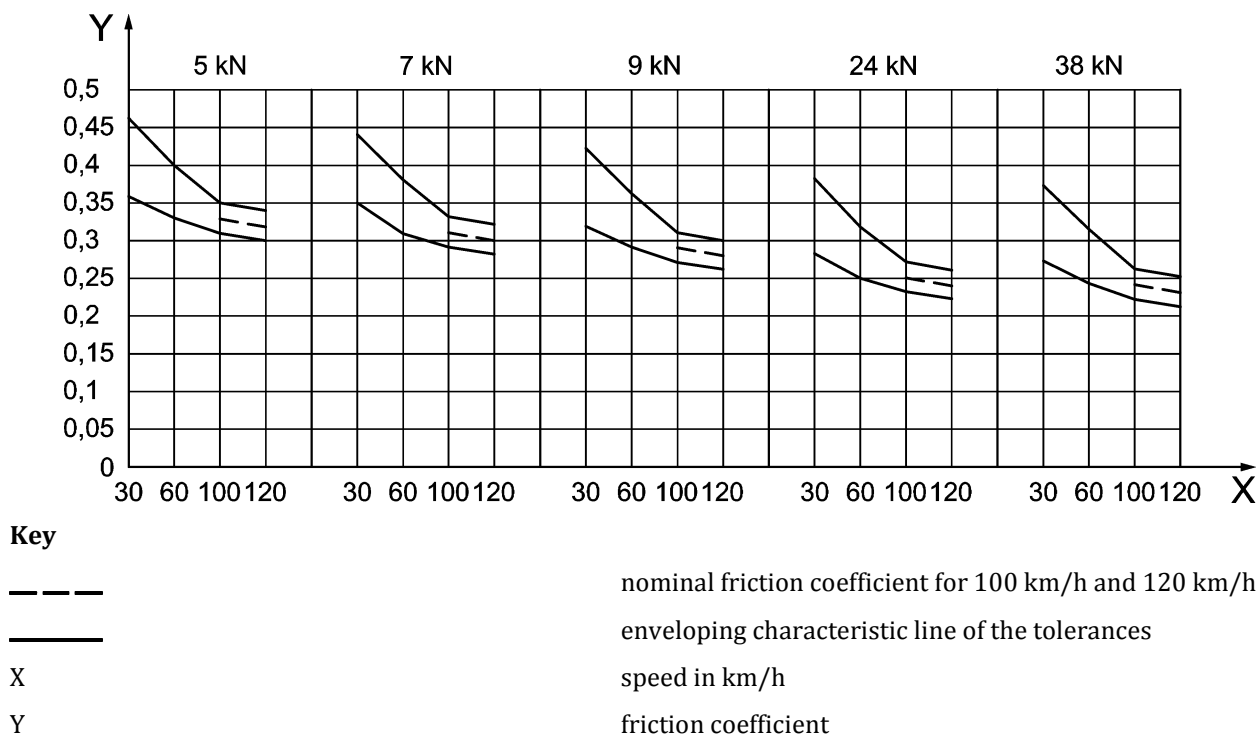


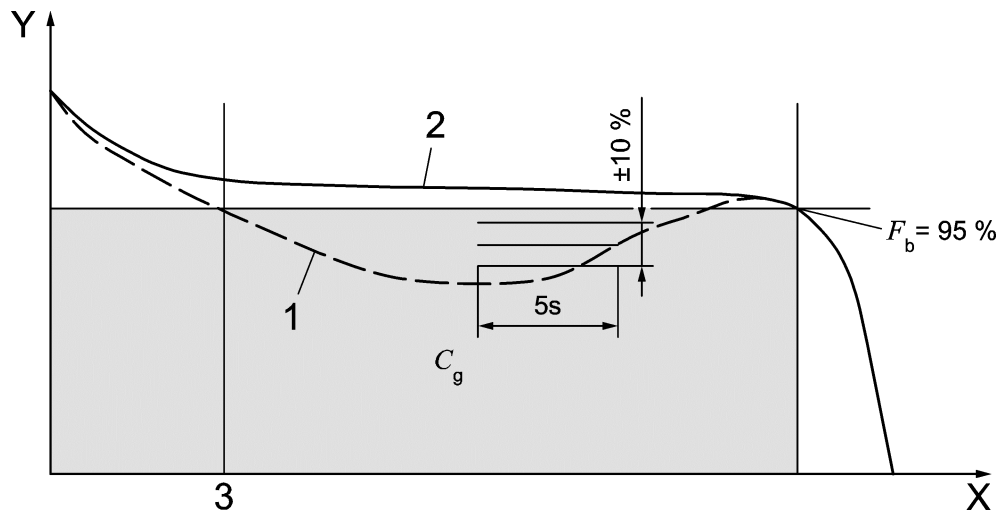
Figure C.3 —Dispersion range of mean friction coefficient in dry condition, 1Bgu configuration

Table C.6 —Dispersion range of mean friction coefficient in dry condition, 1Bgu configuration

| $F_B$<br>kN | Initial speed<br>$v$ (km/h) $\geq$ | 30    | 60    | 100   | 120   |
|-------------|------------------------------------|-------|-------|-------|-------|
| 5           | Maximum                            | 0,460 | 0,400 | 0,350 | 0,340 |
|             | Nominal                            |       |       | 0,330 | 0,320 |
|             | Minimum                            | 0,360 | 0,330 | 0,310 | 0,300 |
| 7           | Maximum                            | 0,440 | 0,380 | 0,330 | 0,320 |
|             | Nominal                            |       |       | 0,310 | 0,300 |
|             | Minimum                            | 0,350 | 0,310 | 0,290 | 0,280 |
| 9           | Maximum                            | 0,420 | 0,360 | 0,310 | 0,300 |
|             | Nominal                            |       |       | 0,290 | 0,280 |
|             | Minimum                            | 0,320 | 0,290 | 0,270 | 0,260 |
| 24          | Maximum                            | 0,380 | 0,320 | 0,270 | 0,260 |
|             | Nominal                            |       |       | 0,250 | 0,240 |
|             | Minimum                            | 0,280 | 0,250 | 0,230 | 0,220 |
| 38          | Maximum                            | 0,370 | 0,310 | 0,260 | 0,250 |
|             | Nominal                            |       |       | 0,240 | 0,230 |
|             | Minimum                            | 0,270 | 0,240 | 0,220 | 0,210 |

## C.4 Dispersion range of instantaneous friction coefficients

Dispersion range of instantaneous friction coefficients applicable for test programs C.1 and C.2.



### Key

- 1 example of instantaneous coefficient friction ( $\mu_a$ ), poor profile
- 2 example of instantaneous coefficient friction ( $\mu_a$ ), good profile
- 3 30 km/h
- Cg grey area, not recommended area for instantaneous friction profile
- X instantaneous speed (km/h)
- Y friction coefficient ( $\mu$ )

**Figure C.4 — Maximum variation in instantaneous friction values**

### Specification

From the moment  $F_b = 95\%$  to speed of 30 km/h, instantaneous friction shall not vary more than  $\pm 10\%$  for a period of 5 s.