BRITISH STANDARD

BS EN
13452-2:2003

Railway applications — Braking — Mass transit brake systems —

Part 2: Methods of test

The European Standard EN 13452-2:2003 has the status of a British Standard

ICS 45.060.01

BSI
British Standards

National foreword

This British Standard is the official English language version of EN 13452-2:2003.

The UK participation in its preparation was entrusted to Technical Committee RAE/4, Braking, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

Cross-references

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 27 March 2003

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 17 and a back cover.

The BSI copyright date displayed in this document indicates when the document was last issued.

Amendments issued since publication

Amd. No.	Date	Comments

ISBN 0 580 41480 9

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 13452-2

March 2003

ICS 45.060.01

English version

Railway applications - Braking - Mass transit brake systems - Part 2: Methods of test

Applications ferroviaires - Freinage - Systèmes de freinage des transports publics urbains er suburbains - Partie 2: Méthodes d'essais

Bahnanwendungen - Bremsen - Bremssysteme des öffentlichen Nahverkehrs - Teil 2: Prüfverfahren

This European Standard was approved by CEN on 27 December 2002.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN 13452-2:2003 E

Contents

Foreword

This document (EN 13452-2:2003) 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of an identical text or by endorsement, at the latest by September 2003, and conflicting national standards shall be withdrawn at the latest by September 2003.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

CEN/TC 256/SC3/WG 23 "Braking/Urban traffic" has been assisted with the preparation of this European Standard by CEN/TC 256/SC3/WG 25 "Braking/Terminology, calculations and acceptance procedures".

This series EN 13452 *Railway applications – Braking – Mass transit brake systems* consists of two parts:

— Part 1: Performance requirements

— Part 2: Methods of test.

With regard to clause 9 of EN 13452-1, which concerns Commuter/Regional trains, it should be noted that there might be border-line cases which may also come under the scope of CEN/TC 256/SC 3/WG 22 "Braking/Mainline railways".

Annex A is informative.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

The objective of this part of the European Standard is to provide the test requirements to enable compliance with EN 13452-1 to be demonstrated.

This European Standard covers the static and dynamic brake type and routine testing of completed units or trains but it does not cover the testing of components, equipment or individual vehicles.

1 Scope

This European Standard specifies test requirements for the braking of vehicles for urban transport systems, running on steel or rubber tyred wheels and guided by steel rails or other equivalent means.

This European Standard applies to vehicles operating on:

— tramways;

— light railways;

— metros on steel wheels;

— metros on rubber tyred wheels;

— commuter/regional railways;

and is applicable to:

— all newly designed vehicles;

— all major refurbishments, if these include either redesign or extensive modifications to the brake system;

— any new builds of existing designs of vehicles.

This European Standard does not apply to special transport systems, e.g. suspended monorail, rack and pinion lines, special duty vehicles, etc.

Transport Authorities shall ensure that specifications include this European Standard as part of the brake system requirements. Suppliers shall identify, at the time of tendering, any non-compliances against this European Standard.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 13452-1:2003, *Railway applications — Braking - Mass transit brake systems — Part 1: Performance requirements.*

3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN 13452-1:2003 and the following apply.

3.1
type test
test of the brake system on a unit or a train, to show that the design, and its implementation, meets the required specifications and relevant European Standards

3.2
routine test
test of the brake system to which each unit or train is subjected, after manufacture, to ascertain whether it complies with the specified criteria

3.3
investigative test
test which may be required by the Transport Authority in order to obtain additional information

3.4
supplementary test
test which may be required by the Transport Authority if particular (or special) conditions prevail

4 Test requirements

4.1 General

The testing of new rolling stock consists of two distinct stages, namely type tests and routine tests. The content of both the type and routine tests shall be agreed with the Transport Authority.

This clause defines the requirements of both types of test which shall be performed on the braking system.

Type tests shall be performed on an early production unit or train prior to any of that fleet of vehicles entering service and forms the basis of an acceptance of the brake system design and its implementation. Type testing of refurbished rolling stock shall be undertaken if the brake system has been modified or if the train mass and/or passenger load has been significantly changed (see Section 1 of EN 13452-1:2003).

The content of the type testing for refurbished stock shall be agreed with the Transport Authority, according to the modifications implemented. Routine tests shall be performed on every production unit or train prior to that train entering service.

4.2 Type test requirements

4.2.1 Static type tests

Prior to any static testing, all necessary system integration and constructional tests shall have been successfully completed.

The principal objectives of these static type tests are to verify that the train’s braking equipment is compliant with the specification and to establish the values of all the relevant parameters as a reference for assessing the dynamic performance.

A full functional test, including all safety devices, shall have been satisfactorily completed before beginning the dynamic tests.

Static type testing for the brake system may combine both bench tests and on-train tests. The scope of static type testing shall include, but not be limited to, the following (where applicable or equivalents depending on the type of brake equipment):

— brake cylinder pressures (or equivalent);

— load-weigh signals (e.g. pressures);

— friction pair loads (block force or pad clamping force);

— brake actuator operation and stroke;

— governor settings (e.g. pressure switches);

— brake application times;

— brake release times;

— monitoring device accuracy;

— functionality e.g. correct operation of all controls and isolation devices at train / vehicle; component level;

— interlock operation (e.g. traction inhibition in emergency braking);

— brake stored energy capacity (e.g. brake reservoir volume);

— leakage tests;

— protection devices fitted to minimise the effects of failures (e.g. chokes, check valves);

— WSP application / release times;

— sanding system operation.

In case particular parameters, e.g. brake application and release times, cannot be easily tested on certain vehicles, such tests may be undertaken as bench tests if agreed with the Transport Authority.

The exact static testing undertaken depends on the design of the particular rolling stock.

If more than one method of braking (e.g. friction brakes and track brakes) is used in any braking mode, then tests shall be conducted on each of these separately, so as to determine the functionality and response of each system.

4.2.2 Dynamic type tests

4.2.2.1 General

Prior to any dynamic testing, the static testing specified above shall have been completed. In addition any specified simulation and/or bench testing (e.g. thermal predictions, WSP evaluation) shall have been completed.

The purpose of dynamic brake testing is to demonstrate that the train performance complies as a minimum with the relevant requirements as contained in clause 6, 7, 8 or 9 of EN 13452-1:2003.

NOTE The operational performances defined in EN 13452-1 are based on theoretical values. In order to demonstrate compliance with the requirements defined in EN 13452-1 it is recommended to conduct tests and, from the results of these, to determine if the values actually achieved fall within the limits defined in EN 13452-1.

For any initial speed, in accordance with 5.5.1 of Part 1, the stopping distance for each test shall be less than or equal to the calculated value with a theoretical brake as defined with the a_e and t_e specified in 3.7.2 and 3.7.3 of EN 13452-1:2003 and in accordance with the relevant Table 3,7,11 or 15 of EN 13452-1:2003.

In addition, the comfort limits defined by the relevant Table 4, 8, 12 or 16 of EN 13452-1:2003 shall not be exceeded during any of the tests.

Additional tests shall be performed to demonstrate compliance with the brake performance specified by the Transport Authority to be achieved under defined brake failure conditions (refer to 5.6 of EN 13452-1:2003). It is recommended that the failure conditions of one brake application system being defective (e.g. equipment inactive or isolated) and the presence of unbedded components (e.g. brake blocks or pads) are considered by the Transport Authority.

Additional tests shall also be conducted to establish the performance achieved under specified degraded environmental conditions (e.g. wet track). The Transport Authority shall define these conditions and the acceptance criteria for these tests.

The Transport Authority may request investigative tests to establish the performance achieved under extreme conditions (e.g. ambient conditions, component temperature, passenger load, low adhesion, unfavourable wind).

In order to demonstrate consistent performance and ensure that the results are representative, a sufficient number of tests shall be made.

The performance obtained from different tests, done under nominally identical conditions, shall not diverge by more than a defined value from the average performance for those test conditions (e.g. same speed, load, location,..), The Transport Authority shall define this figure (tolerance or repeatability band). It is recommended that this figure does not exceed ±10 % for dry rail condition. Furthermore, the consistency of performance between tests under different conditions shall be assessed.

The tests shall be conducted so as to avoid the risk of excessive temperatures being caused by any duty, in excess of the most severe operating conditions defined by the Transport Authority. Between tests, there shall be a minimum delay time or distance covered so as to ensure comparable initial conditions.

4.2.2.2 Emergency brake - Type testing

The emergency brake testing shall be conducted at defined load and speed combinations. If more than one method of braking (e.g. friction brakes and track brakes) is used in emergency braking, then tests shall be conducted for all combinations of these, allowing for the possible failure or non-availability of any of these.

The minimum number of type tests at each of the load conditions shall be either:

— three tests each at three different speeds (total nine tests). The test speeds shall be uniformly distributed through the speed range or as otherwise defined by the Transport Authority, or

— nine tests uniformly distributed through the speed range (one test at each of nine different speeds).

The tests shall be done for a minimum of two load conditions covering the values defined in 6.3, 7.3, 8.3 or 9.3 of EN 13452-1:2003, as appropriate. If not defined by the Transport Authority, the loads shall be EL E and EL 4 (Light Rail and Regional trains) or EL 6 (all others).

See 5.3.2 of EN 13452-1:2003.

4.2.2.3 Security brake - Type testing

The security brake testing shall be conducted to demonstrate the stopping performance at specified load and speed combinations. If not defined by the Transport Authority, the load conditions shall be EL E and EL 4. The security brake testing shall be conducted at the speeds defined previously for the emergency brake testing.

4.2.2.4 Service brake - Type testing

The service brake testing shall be conducted at the load and speed combinations defined below. If more than one method of braking (e.g. friction and electro-dynamic brakes) is used in service braking, then tests shall be conducted for all combinations of these, allowing for the possible failure or non-availability of any of these.

The performance during the blending of these systems shall also be assessed during these tests to check that the transition occurs without significant jerk, underbraking or overbraking. During blending the instantaneous deceleration shall not vary by more than ± 10 % from that demanded.

It is recommended that at least three tests should be made. As a minimum, subject to the agreement of the Transport Authority, two tests at each load and speed condition shall be undertaken. This level of testing shall be applied to each of the service braking methods (e.g. friction and electro-dynamic brakes).

The speeds shall be evenly distributed through the speed range. If not defined by the Transport Authority, the selected speeds shall be 1/3, 2/3 and 3/3 of the maximum speed.

The tests shall be done for a minimum of two load conditions covering the values defined in the relevant 6.3, 7.3, 8.3 or 9.3 of EN 13452-1:2003. If not defined by the Transport Authority, the selected loads shall be EL E and EL 4 (Light Rail and Regional trains) or EL 6 (all others).

The response of the service brake system to changes in demand shall be assessed during these tests in respect of the change of deceleration, jerk, and response time.

Service brake testing may include testing representative of typical service operating conditions e.g. thermal evaluation of the friction brake components. The details of such tests shall be defined by the Transport Authority. (e.g. route, load, speed profile, number of brake applications, acceptance criteria).

Tests may be conducted, if required by the Transport Authority, so as to determine the effects of significant initial conditions (e.g. variations in disc temperature) on the performance.

4.2.2.5 Type testing under degraded adhesion conditions

These tests may form part of either the emergency brake and/or the service brake testing. The tests conducted under degraded environmental conditions are those in which the WSP and/or sanding performance will be demonstrated. If sanding equipment is fitted, tests should be conducted with it (the sanding equipment) both operative and inoperative.

The Transport Authority shall define the test conditions to be used. Guidance is provided in A.4 on possible methods to induce low or poor adhesion conditions.

4.2.2.6 Data measurements - Type testing

The wheel diameters on the train undergoing type testing shall be recorded so that the effect of this on the results can be assessed.

During dynamic testing, the following parameters shall be recorded in order to demonstrate compliance with EN 13452-1:

— speed - initial;

— speed - continuous;

— deceleration;

— time;

— stopping distance;

— brake demand.

In addition, the following may be recorded to assist in determining more precisely the performance of the train under various conditions;

— wheelset or wheel speeds to determine if wheelslide occurs;

— pressures or equivalent to monitor the friction brake response;

— temperature (equipment) to check maximum temperature achieved;

— line voltage if electro dynamic brake is used in regenerative mode;

— interface signals (e.g. blending signals) if electro dynamic brake is used;

— battery voltage if track brake is used.

4.2.3 Holding brake - Type testing

Where fitted, a type test shall be conducted to determine the ability of the holding brake to hold the train, at the required load, on the defined gradient for the specified time under defined conditions (see clause 6, 7, 8 or 9 of EN 13452-1:2003, as appropriate).

4.2.4 Parking brake - Type testing

4.2.4.1 Holding test

A test shall be conducted to determine the ability of the parking brake to hold the train, at the required load, on the defined gradient under defined conditions (see 6, 7, 8 or 9 of EN 13452-1:2003, as appropriate).

4.2.4.2 Push-through test

Where specified, a type test shall be conducted to prove that, if an EL E train has to be moved with the parking brake applied, the wheels will still rotate rather than slide.

4.3 Routine test requirements

4.3.1 General

All routine tests shall be completed successfully prior to the introduction of that train into service.

4.3.2 Static routine tests

Prior to any static testing, all necessary system integration and constructional tests shall have been completed successfully. The principal objective of the static routine tests is to verify that each train's braking equipment is consistent with that of the type tested train.

A full functional test, including all safety devices**,** shall have been satisfactorily completed before beginning the dynamic tests.

Static routine testing for the brake system shall include, but not be limited to, the following:

— brake cylinder pressures (or equivalent);

— load-weigh signals (e.g. pressures);

— governor settings (e.g. pressure switches);

— brake application times;

— brake release times;

— monitoring device functionality;

— functionality e.g. correct operation of all controls at train / vehicle component level;

— sanding system operation.

The exact static testing undertaken will depend on the design of the particular rolling stock.

If more than one method of braking (e.g. friction brakes and track brakes) is used in any braking mode, then tests shall be conducted so as to check the functionality of each system.

4.3.3 Dynamic routine tests

4.3.3.1 General

Prior to any dynamic testing, the static testing specified above shall have been completed.

The purpose of dynamic routine brake testing is to confirm that each train's performance is in accordance with that established and accepted during the type testing. Supplementary tests may be performed as required to confirm the correct operation of particular sub-systems.

4.3.3.2 Emergency brake - Routine testing

A minimum of two stops shall be made from two different speeds at EL E load level.

4.3.3.3 Security brake - Routine testing

A minimum of two stops shall be made from two different speeds at EL E load level.

4.3.3.4 Service brake – Routine testing

A minimum of two stops shall be made from two different speeds at EL E load level. During these tests or supplementary tests, the correct operation of each method of braking shall be confirmed.

4.3.3.5 Routine testing under degraded adhesion conditions

No dynamic testing is required in addition to functional static testing.

4.3.3.6 Data measurements - Routine testing

During dynamic testing, the following parameters shall be recorded in order to demonstrate compliance with EN 13452-1:

— speed - initial;

— stopping distance;

— brake demand.

4.3.4 Holding brake - Routine testing

No more testing is required in addition to the functional and integrity testing performed in the static condition.

4.3.5 Parking brake - Routine testing

4.3.5.1 Holding test

No more testing is required in addition to the functional and integrity testing performed in the static condition unless the parking brake uses dedicated equipment (e.g. separate parking brake actuator). In such cases, a test shall be conducted at EL E condition.

4.3.5.2 Push-through test

No testing is required.

4.4 Documentation

4.4.1 General

The verification of the brake performance against the specified requirements shall be fully documented.

The documentation for each test shall consist of:

— test procedure;

— test report.

4.4.2 Test procedure

The test procedure shall define the method of undertaking the test including the acceptance criteria and the information to be recorded in the associated test report.

The structure of the procedure shall be as follows:

— purpose of the testing;

— reference and issue of the associated performance calculation;

— type and routine testing to be performed upon the vehicle prior to these tests;

— reference to any associated test procedures;

NOTE There can be several procedures to cover the total level of testing required:

— train configuration, i.e. the arrangement and vehicle types in the test formation;

— loading condition(s) under which the tests are to be performed;

— environmental conditions under which the test shall be performed;

— site conditions under which the test shall be performed, e.g. the track (minimum curve radius and maximum gradient), tunnel or open air;

— testing equipment. The test equipment required to perform the test shall be defined, e.g. the measurement devices, brake triggering. The instrument setting parameters, e.g. response time, filtering, scales shall be defined;

— test personnel skills. The skills of personnel required to perform the test shall be defined;

— test description. The test process shall be fully detailed including those parameters which shall be recorded as defined in 4.2 and 4.3;

— acceptance criteria, expressed as minimum or maximum acceptable values in accordance with EN 13452-1 shall be defined;

— test procedure document identity, i.e. number, revision, date, approved by..... .

4.4.3 Test report

The test report shall include all of the information required by the test procedure together with the results of the tests. Any deviations from the test procedure shall be identified. The report shall include a clear statement as to whether the tests were passed successfully.

The structure of the test report shall reflect that of the test procedure stated in 4.4.2. Sufficient information shall be included in the report to avoid the need to continually refer to the test procedure.

In addition the report shall include specific reference to the vehicles used in the test and the status of components and software which influence the braking performance of the train, e.g. software issue, component modification level.

The test report document identity shall be stated, i.e. number, revision, date, approved by..... .

For each test or series of tests, the report shall record the following as a minimum:

— vehicle number;

— reference to EN 13452-1 and EN13452-2;

— date (of test);

— location (test site);

— weather conditions;

— results;

— all related graphics required to demonstrate compliance with EN 13452-1;

— acceptance criteria;

— names and functions of personnel present during the test.

5 Guidance on testing methods

Refer to annex A.

Annex A
(informative)

Brake testing

A.1 Emergency/security/service brake testing

The preferred method of dynamic testing is to conduct such tests on dry, straight, notionally constant gradient (ideally level) track. If testing cannot be done over level track, the effect of the prevailing gradient (at each test site) should be evaluated. As directed by the Transport Authority, this can be done either:

— by calculating the effect of the gradient on the required performance; or

— by testing in both directions and calculating the mean value of the stopping distances (from the same speed).

It is recommended that the maximum gradient permitted at such test sites is no more than 5 ‰ (1 in 200).

The initial speed, measured at the application of braking, should not differ from the target speed by more than ± 3 km/h.

When the initial speed (v_o) differs from the target speed (v_r) and/or the track is not level, the formula below can be used to correct the measured stopping distance. This formula may be used for gradients up to 10 ‰ (1 in 100).

$$s_r = \frac{v_r^2\left(s_0 - v_0 \times t_e\right)}{v_0^2 - 2\times\left(\frac{M_s}{M_d}\right)\times g \times i \times \left(s_0 - v_0 \times t_e\right)} + v_r \times t_e$$

— s_r corrected distance, in m;

— s_o measured distance, in m;

— v_r target speed, in m/s;

— v_o speed measured at application of braking, in m/s;

— t_e equivalent response time measured during static testing, in s;

— M_s static mass, in t;

— M_d dynamic mass, in t;

— g gravity, in m/s²;

— i Gradient, in m/m: rising gradient is positive (e.g. for a gradient of 5 ‰= 0,005 m/m)

Before starting the brake testing, the test engineer should check that the relevant brake equipment is operating correctly and that adequate wheel to rail adhesion is present.

NOTE This can be done by making brake applications over the test site and checking for:

– wheelslide activity;

– consistency of the stopping distance.

When loading the vehicles to simulate laden conditions, the weights should be distributed within the vehicles in accordance with a defined loading plan for the test weights.

If there are particular weather conditions (particularly prevailing winds) which may affect the braking performance, then tests should be conducted in both directions to determine the effect.

It is recommended that the emergency brake is initiated by an automatic device. If this is not done, then the effect of the tolerances in the initiation method on the results should be assessed.

To evaluate the performance of the service brake, similar testing method to that used for the emergency brake testing should be used.

During the assessment of different types of service brake, it is recommended that particular attention is taken to ensure consistent performance is achieved to avoid operational difficulties.

If significant parts of the network consist of steep gradients, then the brake performance should be checked under these conditions.

A.2 Parking brake testing

A.2.1 Holding test

This can be done by either:

— placing a train or unit with a defined load on a defined gradient;

— placing a train or unit with a defined load on a defined gradient with a number of the parking brakes isolated to simulate the required condition;

— measuring the force required to move a train or unit (of defined load) against the parking brakes on level tangent track (e.g. by winching or traction source).

A.2.2 Push-through test

This test can be done by moving an empty vehicle, unit or train with the parking brakes fully applied over a defined distance and observing whether the affected wheels rotate. This can be achieved by causing one, or more, of the parking brake application systems to apply.

The parking brake should retain its holding capability immediately after this test movement has been completed.

NOTE It should then be tested to show that the parking brake still holds the vehicle.

A.3 Holding brake testing

This can be done using the same methods defined for the parking brake with the appropriate defined load.

A.4 Track testing under degraded adhesion conditions

If it is required to undertake testing under degraded adhesion conditions, the following methods can be used to induce low or poor adhesion conditions.

— For assessing the performances with adhesion between 0,13 and 0,06, spray methodology techniques, such as water sprays or similar to that described in UIC 541-05 can be used. The particular technique will depend on the target level of adhesion. (The aqueous solution concentration will be adjusted in order to obtain the levels of adhesion required by the Transport Authority).

— For assessing the performances with very low adhesion below 0,06, three possible methods are:

1) liquid soap solution applied to wheel/rail interface whilst braking;

2) kraft paper tape is fixed on rail over the full brake distance, lightly wetted by spraying water from the train;

3) colza oil is applied on the rail on the full brake distance;

NOTE 1 The use of oil in quantity can cause harm to the environment and should only be used under controlled conditions

NOTE 2 The use of any of these techniques can influence the friction characteristic of the brake blocks/pads. These should therefore be replaced (or treated if practical) on completion of such tests.

For trains which are fitted with an adhesion enhancing system – such as automatic sanding – that is normally operational, the effect of this system being isolated should be determined. Tests should be conducted with the system operational, and than repeated with the system isolated, so as to enable the change in performance to be assessed.

A.5 Simulation testing under degraded adhesion conditions

As an alternative to conducting track tests on a UIC approved WSP, simulator rig tests can be used to validate WSP changes and performance over a wide range of vehicle and operating conditions. Simulator rig tests are particularly valuable when changes are required to adjust the WSP parameters to suit a variation in the vehicle design.

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