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Road vehicles — Test of braking systems on vehicles with a maximum authorized total mass of over 3,5 t using a roller brake tester

Part 1: Pneumatic braking systems

Véhicules routiers — Essai des systèmes de freinage des véhicules ayant une masse totale maximale autorisée supérieure à 3,5 t effectué sur banc d'essai de freinage à rouleaux

Partie 1: Systèmes de freinage pneumatique

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Foreword

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ISO 21069-1 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 2, *Braking systems and equipment*.

ISO 21069 consists of the following parts, under the general title *Road vehicles — Test of braking systems on vehicles with a maximum authorized total mass of over 3,5 t using a roller brake tester*:

— *Part 1: Pneumatic braking systems*

Air-over-hydraulic braking systems and hydraulic braking systems are to form the subjects of future parts 2 and 3.

Introduction

The present ECE Regulation No. 13 covers only some aspects of the periodic technical inspection of vehicles in use. In order to fulfil the requirements of section 5.1.4 of Regulation 13, ISO 21069 has been conceived to cover the periodic measurement of braking performance of vehicles in service.

Road vehicles — Test of braking systems on vehicles with a maximum authorized total mass of over 3,5 t using a roller brake tester

Part 1: Pneumatic braking systems

1 Scope

This part ISO 21069 specifies a roller brake test for determining the braking efficiency of road vehicles having a maximum authorized total mass (Code ISO-MO8) as defined in ISO 1176 of more than 3,5 t, being of categories M2, M3, N2, N3, O3 and O4 as defined in UNECE R.E.3 and equipped with full power air (pneumatic) braking systems. Also applicable to electronic braking systems (EBS), its purpose is to ensure comparable measurement results from different testers, leading to reliable assessment of the efficiency of service braking systems wherever roller brake tests are performed.

2 Normative references

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

ISO 611, *Road vehicles — Braking of automotive vehicles and their trailers — Vocabulary*

ISO 1176, *Road vehicles — Masses — Vocabulary and codes*

ISO 3833, *Road vehicles — Types — Terms and definitions*

ECE Regulation No. 13:1996, *Uniform Provisions Concerning the Approval of Vehicles of Categories M, N and O with regard to braking*, incorporating supplements 1 to 5 to the 09 series of amendments

UNECE [1)] R.E.3:1997, *Consolidated Resolution on the Construction of Vehicles*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 611, ISO 1176, ISO 3833 and the following apply.

3.1
braking force
force between the tyre and the rotating roller, produced at the circumference of the tyre during braking, which opposes the force generated at that interface by the roller brake tester in order to cause a rotation of the wheel

1) United Nations Economic Commission for Europe.

3.2
reference braking force
braking force of one axle generated at the circumference of the tyre on a roller brake tester, relative to brake actuator pressure

NOTE 1 Reference braking forces are stated by the manufacturer covering the performance of vehicle brakes for the purpose of technical inspection and declared at the time of type approval.

NOTE 2 This information is provided in tabular or graphical form, beginning at a brake actuator pressure of 100 kPa (1 bar) and increasing in increments of no more than 100 kPa up to the pressure generated to meet Type O laden conditions for each axle.

3.3
braking force imbalance
difference in the braking forces, measured with running wheels, between brakes on an axle

NOTE It is expressed as a percentage of the higher force.

3.4
braking force variation
difference between the maximum and minimum values of the braking force, measured over a single wheel revolution with a constant actuation force

NOTE It is expressed as a percentage of the mean braking force.

3.5
roller brake tester
measuring machine consisting of two pairs of powered rollers used for the assessment of a vehicle's braking performance

NOTE The assessment is made by measuring the braking forces between the tyres and the drive rollers for each wheel/twin wheel, either simultaneously or independently, while the wheels of the vehicle axle are being driven and supported by rollers.

4 Symbols

Symbol	Meaning	Unit
F_{Bi}	Extrapolated braking forces at brake actuator pressure $p_{Alad\ i}$	N
ΣF_{Bi}	Sum of all F_{Bi} on all axles	N
F_{Hi}	Braking force at the circumference of tyres on axle i at brake actuator pressure p_{Ahi}	N
F_i	Braking force at the circumference of tyres on axle i	N
F_{Li}	Braking force at the circumference of tyres on axle i at brake actuator pressure p_{Ali}	N
F_M	Total normal static reaction of road surface on all wheels of the individual motor vehicle or F_M corresponding to F_i	N
$F_{M\ max}$	Maximum permissible F_M	N
F_R	Total normal static reaction of road surface on all wheels of the individual trailer vehicle	N
$F_{R\ max}$	Maximum permissible normal static reaction of fully laden trailer vehicle	N
p_{Ai}	Brake actuator pressure on axle i	kPa [a]
p_{AHi}	High applicable brake actuator pressure on axle i	kPa [a]
$p_{A\ lad\ i}$	Minimum design brake actuator pressure of laden vehicle on axle i (for extrapolation purposes)	kPa [a]
$p_{AL\ i}$	Low brake actuator pressure on axle i	kPa [a]
z	Braking rate	—
$z_{M\ lad}$	Braking rate of laden motor vehicle	—
$z_{R\ lad}$	Braking rate of laden trailer vehicle	—

NOTE 1 All measurements are made with the vehicle stationary.
NOTE 2 Subscript i indicates axle Nos. 1, 2, 3, ... n.

[a] 1 kPa = 0,01 bar; 1 bar = 0,1 MPa = 10^5 Pa; 1 MPa = 1 N/mm^2.

5 Test conditions and evaluations

5.1 General

The characteristics of roller brake testers are specified in Annex A.

The efficiency test for braking systems shall be carried out with reference to

— legal requirements,

— the vehicle manufacturer's data, and

— the instruction manual of the roller brake tester.

5.2 Preparation of vehicle and roller brake tester

5.2.1 Rollers and tyres shall be clean.

5.2.2 Tyre pressure shall be adjusted in accordance with the vehicle manufacturer's recommendations.

5.2.3 Additional instrumentation may be used to measure the static axle loading without the rollers running.

5.2.4 Braking testing, for the purposes of official vehicle inspection, shall be carried out on a roller brake tester certified by the technical services. Vehicle data and the measured values shall be recorded with the wheels rotating in the forward direction.

5.2.5 Permanent multiple-axle drive systems shall be assessed on special roller brake testers which have the features for the testing axles of such systems.

5.3 Calculation and evaluation of test data

5.3.1 Braking efficiency calculation

The recorded measurements of braking forces are used to calculate the vehicle braking rate, taking into account the parameters of the vehicle and the maximum load at which it is permitted to operate.

The braking test may be made in the fully laden state or in a lightly laden condition at lower actuation pressures on the assumption that braking forces increase predictably with increasing pressure.

The actuator pressure and brake force shall be determined simultaneously and in real time.

Extrapolation of brake output forces may be used to predict the laden braking rate. This may be achieved by following one of the extrapolation methods given in 5.3.3.

The most reliable means of measuring the braking forces is with the vehicle in the fully laden condition. Where this is not practical, a prediction of the laden performance may be made using the multi-point, two-point or one-point measurement method. In such cases, the following important prerequisites shall be taken into consideration.

— A minimum of 30 % of the design brake actuator pressure shall be achieved by suitable loading, dead weight of the axle or by load simulation.

— The measurement points (first point at beginning and the cut off point) should be as far as possible away from each other (multi-point and two point method) to ensure the right gradient of the function of the graph (pressure vs. force).

— If one of these methods is not applicable, the use of the one-point method is permitted with the following additional prerequisite: the starting point, fixed at 40 kPa, shall not deviate in the direction of higher values, because this would assume an increase in error source; this starting point shall be checked in advance of the measuring.

If it is prescribed in the relevant national requirements, the rolling resistance may be treated accordingly.

5.3.2 Determination of braking force or braking rate

The braking force or, alternatively, the braking rate (maximum braking force/vertical wheel load) shall be determined for

— each wheel individually, or

— each axle individually.

5.3.3 Methods of determination

5.3.3.1 Reference braking forces method

The measured braking forces and corresponding actuator pressures shall be compared with the reference braking forces for evaluation purposes.

5.3.3.2 Laden measurement method

The braking rate shall be determined directly by measuring the braking forces for the vehicle in the laden condition. The laden braking rate calculation requires no extrapolation, being simply given by the following equations:

$$z_{\mathrm{M\,lad}} = \frac{\sum F_i}{F_{\mathrm{M\,max}}}$$

in the case of a motor vehicle;

$$z_{\mathrm{R\,lad}} = \frac{\sum F_i}{F_{\mathrm{R\,max}}}$$

in the case of a towed vehicle.

5.3.3.3 One-point measurement method

This is an extrapolation method requiring only a single braking force measurement for each wheel/axle. The test shall be carried out with the highest achievable braking forces and with the corresponding brake actuator pressure beneath the locking limit of the wheels.

This generates the highest braking forces without too-high wheel slip on the rollers and without tyre damage.

During the test of each axle, at least 30 % of the design brake actuator pressure shall be achieved by the normal axle load or suitable loading of vehicle or a simulation of load. This is important for the reliability of the calculated braking force. Some national requirements may call for a higher percentage to be achieved. The one-point measurement is possible, since the starting point is standardized at 40 kPa and this assumes a fixed value for all brake threshold pressures. The measured braking forces at each axle shall then be extrapolated to the minimum design pressure $p_{\mathrm{Alad}\,i}$. The braking rate of the vehicle is given laden by the following equations:

$$z_{\mathrm{M\,lad}} = \frac{\sum F_{\mathrm{B}i}}{F_{\mathrm{M\,max}}}$$

in the case of a motor vehicle;

$$z_{\text{R lad}} = \frac{\sum F_{\text{B}i}}{F_{\text{R max}}}$$

in the case of a towed vehicle.

In these equations

$$F_{\text{B}i} = F_i R_{\text{p}i}$$

where

$$R_{\text{p}i} = \frac{P_{\text{A lad}\,i} - 40}{P_{\text{A}i} - 40}$$

5.3.3.4 Two-point measurement method

The starting point is not standardized. The braking force shall be measured at a low brake actuator pressure, a little above the threshold point where braking force can be measured. The second (main) measurement shall be performed using the highest applicable braking forces, with the corresponding brake actuator pressure beneath the locking limit of the wheels. See 5.4 b).

Again, the measured braking forces at each axle shall be extrapolated to the minimum design pressure. For a correct calculation, at least 30 % of the design brake actuator pressure is achieved by suitable loading of the axle or simulation of load.

The laden braking rate is given from $z_{\text{M lad}}$ or $z_{\text{R lad}}$ using the equations in 5.3.3.3, where

$$F_{\text{B}i} = F_{\text{H}i} + R_{\text{F}i}\left(P_{\text{A lad}\,i} - P_{\text{AH}i}\right)$$

where

$$R_{\text{F}i} = \frac{F_{\text{H}i} - F_{\text{L}i}}{P_{\text{AH}i} - P_{\text{AL}i}}$$

5.3.3.5 Alternative multi-point measuring methods and calculations

The laden braking rate may also be achieved by extrapolating multiple measurements of braking forces and actuator pressures using least-square numerical methods.

5.4 Presentation of results

The test report shall contain the following data:

a) general information:

1) manufacturer or trade mark of the vehicle;

2) vehicle category;

3) vehicle model and tyre;

4) vehicle identification number (VIN);

5) number of axles;

6) axle configuration (multi-axle assembly, bogie);

7) maximum authorized total mass;

8) maximum static axle load;

9) service braking system.

b) test results:

1) measured braking force total;

2) reference braking forces or braking rate;

3) brake actuator pressure for each wheel/axle;

4) control line pressure;

5) braking forces imbalance across each axle;

6) braking force variation on each wheel/axle;

7) outline of the roller brake tester;

8) make of the roller brake tester;

9) model;

10) software version;

11) serial number.

Test results shall be rated “successful” if the minimum prescribed service braking performance, as laid down in ECE Regulation No. 13:1996, annex 4, paragraph 2.1.1 for motor vehicles, or 3.1.2.1 for trailers, can be justifiably predicted for the laden vehicle with the minimum design pressure (see ECE Regulation No. 13:1996, paragraph 5.1.4.5.2.). For roller brake testing, a much lower speed is acceptable.

Annex A
(normative)

Technical requirements of roller brake tester

A.1 Technical features

A.1.1 Based on the maximum axle load rating which can be accommodated, roller brake testers may be built in several sizes, the largest being rated for axles with a mass of up to 13 000 kg. The maximum axle load rating sets the requirement for the maximum braking force measurement, given the capability of testing in the fully laden condition. The maximum braking force (F_{roll}), expressed in newtons, on each roller is given by Equation (A.1):

$$F_{\text{roll}} = \frac{1}{2} m \times g \times \mu \qquad \text{(A.1)}$$

where

m is the maximum axle load, expressed in kilograms;

g $= 10\ \text{m}\cdot\text{s}^{-2}$;

μ is the coefficient of dry adhesion between tyre and roller.

A.1.2 The diameter of the rollers shall not be less than 200 mm, excepting in the case of an on-ground roller brake tester, for which the diameter of the rollers shall not be less than 150 mm.

A.1.3 The length of each roller shall not be less than 900 mm.

A.1.4 The distance between the rollers shall be such that vehicles with tyre diameters of between 530 mm and 1 300 mm can be tested.

A.1.5 To achieve a locking point at a higher brake force/actuator pressure on the tested axle, the height of the rear roller upper surface may be increased to 40 mm, but not to more than 100 mm above the front roller.

In order to test a multi-axle assembly (bogie), some rollers may be raised. The upper surface of the rear rollers and, preferably, also that of the front roller may be raised 40 mm, but not to more than 100 mm above the surface of the test ground.

A.1.6 The surface of the drive roller shall have a coefficient of adhesion of at least 0,7 in the dry and 0,5 if wet, when testing with normal commercial vehicle tyres in used condition.

The effective adhesion may be reduced below these values due to the separation of two rollers.

A.1.7 The testing equipment shall be capable of operation at ambient temperatures in the range from at least + 5 °C to + 40 °C (optionally below + 5 °C).

A.1.8 Should it be necessary to operate at a temperature outside this range, the local ambient temperature shall be controlled or else a tester designed for more extreme conditions shall be used.

A.1.9 The installation and use of roller brake testing equipment shall comply with national safety-in-the-work-place standards. In the absence of such standards, the following applies as a minimum.

a) If the test machine is equipped with an automatic roller starting function, the rollers should start only after a time delay of 3 s or more has elapsed once the axle has been placed on the roller tester.

b) An automatic cut-off function should be provided to avoid tyre damage.

c) The test shall be stopped automatically if a slip of more than 27 % ± 3 % between tyre and roller is detected.

d) The roller drive shall stop automatically once the vehicle axle leaves the roller tester.

e) A safety function shall be provided to ensure that both pairs of rollers can start only when they are both loaded simultaneously by the wheels of the vehicle under test.

f) Working pits where roller brake testers are installed shall be equipped with a pit safety system.

g) If installed over a pit, the roller brake tester shall have an automatic stop function which shall stop the roller drive whenever a person enters the dangerous area of the pit (the whole pit length or at least 2,5 m from the rollers in any direction).

h) An emergency stop function is mandatory with stay-down stop buttons located in strategic positions.

i) Protection of the electric/electronic controls and transmissions against electromagnetic interference and any disturbing influences shall be provided.

j) Provisions shall be made to prevent unintended starting of the roller drive motors.

A.2 Measurement systems, ranges and resolutions

The braking force measurement range per wheel shall be as set in accordance with Equation A.1. Examples are given in Table A.1.

Table A.1 — Example braking forces

Loads in metric tonnes

Axle load t	**Design max. braking force** N
3	10 500
5	17 500
7	24 500
10	35 000
13	45 500

The display shall resolve to 100 N or better in the range up to 5 000 N, and to 500 N or better above that limit. The display shall be easily readable from a normal testing position. If equipped with an analog scale, the diameter shall not be less than 280 mm.

The braking force display shall be set to zero without a vehicle on the rollers. The rolling resistance of vehicle wheel and roller measured with a test vehicle in place on the rollers should be indicated as force related to the real mechanical zero and should not be the basis for a new setting of the zero point.

It shall be possible to calibrate the braking force measuring systems over the full measurement range, including the zero reading. Instructions and the means for doing this shall be provided.

The operating wheel speed should be in the range 2 km/h to 6 km/h peripheral tyre speed. Throughout the braking force measurement range, the speed of the roller shall not fall to less than 75 % of the free running speed.

A.3 Accuracy of measuring devices

A.3.1 Braking force

At below 5 000 N, the accuracy of the braking force measurement shall be within ± 100 N; at above 5 000 N, it shall be ± 2 % of the measured value.

Imbalance between right and left braking force measurements shall not exceed 2,5 %, if the same braking force is applied to both sides.

A.3.2 Vertical load

At below 10 000 N, the vertical force shall be measured with a tolerance ± 300 N; at above 10 000 N, it shall be ± 3 % of the measured value.

A.3.3 Compressed air pressure

The brake actuator and supply air pressures shall be measured using calibrated instruments.

At below 500 kPa, the tolerance shall be ± 10 kPa; at above 500 kPa, it shall be ± 2 % of the measured value.

A.4 Data collection

The following parameters shall be measured/recorded:

a) braking force of each wheel;

b) rolling resistance of each wheel plus roller;

c) braking force variation during each wheel revolution;

d) braking forces imbalance across each axle;

e) pressure(s) in brake actuator(s);

f) control line pressure in trailers.

NOTE For a procedure for the periodic inspection of the equipment and the associated documentation, see Annex B. Alternatively, the procedure for inspection and documentation as prescribed by appropriate national or international regulations can be used.

Annex B
(informative)

Periodic inspection of equipment and its documentation

B.1 General

Check tests are required to be carried out at the time when the roller brake tester is first commissioned and thereafter at least every 2 years.

B.2 Visual inspection

B.2.1 Surface condition of the roller

Check the roller surface for irregularities (flat spots, roughness, wear) that would reduce the coefficient of adhesion in accordance with A.1.6.

B.2.2 Roller diameter

Check that roller diameter remains within tolerances specified by the manufacturer of the machine.

B.2.3 Condition of indicators

Check the condition of analog and digital indicators, displays, lamps, bells and audible warning devices.

B.2.4 Pressure line wiring and connections

Ensure that these are all in good condition and present no safety hazard.

B.2.5 Foundations of the roller brake test bench

Inspect the pit for the anchoring and foundations of the roller brake test machine and the state of cleanliness.

B.2.6 Moving parts inspection

B.2.6.1 Check clearance of moving parts.

B.2.6.2 Inspect for wear and tear (chains, bearing etc.).

B.3 Inspection of all safety facilities

B.3.1 Check that the measuring rollers are functioning correctly.

B.3.2 Check the operation of the automatic slip cut-off function.

B.3.3 Check the operation of the emergency stop function.

B.3.4 Inspect the pit safety system for correct operation.

B.4 Measuring accuracy

B.4.1 General

Carry out the calibration to the accuracy levels specified in A.3.

B.4.2 Braking force

Recalibrate the braking force measuring system.

B.4.3 Vertical load

Recalibrate the vertical force measuring system.

B.4.4 Compressed air device(s)

Recalibrate the air pressure measuring system.

B.5 Documentation

A test report shall be issued containing the results of the test and the inspection, signed by the person conducting the test.

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