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Road vehicles — Brake lining friction materials — Friction behaviour assessment for automotive brake systems

Véhicules routiers — Matériaux de friction pour garnitures de freins — Évaluation du comportement au frottement pour les systèmes de freinage automobiles

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

ISO 26867 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 2, *Braking systems and equipment*.

Introduction

In the process of harmonizing automotive brake system applications, the modernization of friction behaviour characterization is a top priority. This International Standard is intended to replace previous friction evaluation test procedures based solely on drag brake applications, which do not take into account real-life driving conditions or vehicle specific parameters.

The varied conditions under which the friction material is evaluated ensures a wide spectrum of data, which is critical during the various phases of product life, such as product and manufacturing process development, production validation, quality control, product auditing and field issues evaluation.

This International Standard is intended to be used in conjunction with other applicable standards or test procedures (ISO, SAE, JIS/JASO, Federal Codes or Regulations, and other project or company-specific testing programmes) to fully assess the adequacy of a friction material for use in a certain application, market or vehicle platform. This International Standard does not include performance requirements related to stopping distance or braking force distribution, under different vehicle conditions of speed, temperature, tyre-to-road adhesion, loads and operating conditions of the braking system, as indicated in Federal Codes or Regulations.

This International Standard is intended as a friction evaluation inertia-dynamometer test procedure to replace previous test protocols that depend solely upon drag applications. This International Standard supports the friction assessment during the life cycle of a friction material.

Friction evaluation and characterization by performing drag applications, which were once a valid replacement for sample and scale testing, have now proven a limited approach. Drag applications do not correlate with real-world driving conditions, brake system characteristics or vehicle dynamics. The chemistry and structure of the transfer layers developed at the surface of the friction couple (friction lining and mating rotor or drum) and the resulting coefficient of friction varies as a function of changing characteristics, e.g. sliding speed, surface and bulk temperatures, braking pressure, braking energy and surface topology. During any given brake application, the braking energy varies as a result of the mass distribution and dynamic mass transfer on the vehicle. This is directly related to the vehicle's wheelbase, centre of gravity and vehicle height, which in itself can directly influence the friction material behaviour. The same brake lining or part number, when used on different vehicles, can perform differently depending upon its load, velocity, operating temperature, application force and work history. Modern testing equipment enables friction formulators, process designers, applications engineers and manufacturing personnel to obtain a wide and detailed characterization on the different levels of friction witnessed by the brake lining or pad during various brake conditions.

This International Standard is designed to evaluate the friction behaviour under a wide array of driving speeds, brake temperatures, brake pressure and deceleration levels. This new procedure provides the following benefits:

— a standard method for determining friction characteristics during early screening, benchmarking; development or production monitoring;

— the use of average by distance torque and pressure calculations;

— instantaneous friction statistics;

— an estimation of stopping distance using mean fully developed deceleration;

— controlled and recorded environmental conditions.

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1 Scope

This International Standard describes a test procedure for assessing the influence of pressure, temperature, and linear speed on the coefficient of friction of a given friction material in combination with a specific mating component (rotor or drum).

This International Standard is intended for use when comparing friction materials under the same conditions, or when controlling friction behaviour against a specification or certain performance limits. In order to take into account the different types of dynamometer cooling systems and to ensure repeatable temperature increments, the brake temperature is the control item during the fade sections. The types of brakes and discs used will vary according to individual projects.

Production verification testing can use the results from this test in conjunction with a statistical process control system as part of a quality assurance plan. The specific project or programme will detail the applicable limits and assessment criteria.

This International Standard also allows for additional sections and brake applications that can prove useful during product development testing.

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 15484, *Road vehicles — Brake lining friction materials — Product definition and quality assurance*

UNECE Regulation No.13-H, *Uniform provisions concerning the approval of passenger cars with regard to braking*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 611, ISO 15484, UNECE Regulation No.13-H and the following apply.

3.1
friction value
μ
average by distance of all instantaneous friction values for disc brakes or for drum brakes after the brake reaches 95 % of the set point value (pressure or deceleration) until it falls below 95 % of the set point level

NOTE 1 For disc brakes, the friction value is obtained using Equation (1) (see definition 3.2).

NOTE 2 For drum brakes, the friction value is obtained using Equation (2) (see definition 3.3).

NOTE 3 The average by distance friction value from each individual brake application is the value referenced as "friction value" in Table 4.

3.2
instantaneous friction value
*μ**
⟨disc brake⟩ ratio of instantaneous output torque to instantaneous input torque at any specific point in time, calculated as follows:

$$\mu^* = \frac{10^5 \times M_{\text{d,brake}}}{2 \times \left(p - p_{\text{threshold}}\right) \times A_\text{p} \times r_{\text{eff}} \times \eta} \quad (1)$$

where

$M_{\text{d,brake}}$ is the measured torque;

p is the applied pressure;

$p_{\text{threshold}}$ is the threshold pressure or minimum pressure required to develop braking torque;

A_p is the piston area;

r_{eff} is the brake effective radius;

η is the efficiency

3.3
instantaneous effectiveness value
*C**
⟨drum brake⟩ ratio instantaneous output torque to instantaneous input torque at any specific point in time, calculated as follows:

$$C^* = \frac{10^5 \times M_{\text{d,brake}}}{\left(p - p_{\text{threshold}}\right) \times A_\text{p} \times r_{\text{eff}} \times \eta} \quad (2)$$

where

$M_{\text{d,brake}}$ is the measured torque;

p is the applied pressure;

$p_{\text{threshold}}$ is the threshold pressure or minimum pressure required to develop braking torque;

A_p is the piston area;

r_{eff} is the brake effective radius;

η is the efficiency

3.4
mean fully developed deceleration
d_{mfd}
deceleration calculated as follows:

$$d_{\text{mfd}} = \frac{v_\text{b}^2 - v_\text{e}^2}{25{,}92 \times \left(s_\text{e} - s_\text{b}\right)} \quad (3)$$

where

v_e is the release speed;

v_b is the linear speed at $0{,}8v_p$;

v_p is the prescribed or braking speed for the brake application;

s_e is the calculated distance travelled between v_p and v_e;

s_b is the calculated distance travelled between v_p and v_b

NOTE Equation (3) applies only when the release speed v_e is lower than $0{,}5v_p$. The d_{mfd} calculation for brake applications with v_e higher than $0{,}5v_p$ provides a very short range of data to perform a useful calculation. For certain brake applications, $0{,}8v_p$ can be lower than the release speed.

3.5
step
sequence number to label the different **sections** (3.6) during the test and ensure the test is conducted in the prescribed order

3.6
section
group of similar brake applications under similar conditions or following a specific logic

NOTE 1 The brake applications can be **stops** (3.7) or **snubs** (3.8).

NOTE 2 The specific logic can be increasing brake pressure, increasing initial speed, or increasing brake temperature.

3.7
stop
brake stop
brake application where the brake slows down the test inertia until the equivalent linear speed is 0,5 km/h or less

3.8
snub
brake snub
brake application where the brake slows down the test inertia to an equivalent linear speed above 5 km/h

3.9
characteristic section
series of **brake snubs** (3.8) at moderate speed, brake pressure and temperature, in order to assess how the friction level changes as the test progresses

NOTE This involves green or new characteristic, stability checks after each burnish cycle, and immediately before or after **low speed/low pressure sections (3.6)**.

3.10
burnish section
series of **brake snubs** (3.8) at varying braking power in order to condition the friction couple and develop a steady coefficient of friction

NOTE Varying braking power involves changing deceleration at constant kinetic energy dissipation.

3.11
ramp application section
series of **brake stops** (3.7) where the brake pressure increases steadily and slowly, in order to assess the friction change with increasing input force

NOTE This is especially useful for drum brake systems.

3.12
low speed/low pressure section
series of **brake stops** (3.7) at low energy and low brake pressure

EXAMPLE In stop-and-go traffic or low speed manoeuvring.

3.13
pressure line section
series of **brake snubs** (3.8) at moderate energy in order to assess the effect on friction level as a function of increasing input brake pressure

3.14
speed line section
series of **brake snubs** (3.8) at constant input brake pressure and increasing speeds, and hence kinetic energy

3.15
failed booster section
series of **brake stops** (3.7) in order to assess the torque output while simulating a failed condition when the vacuum or hydraulic assist unit is fully depleted, and when only the driver input load at the brake pedal, brake pedal amplification and master cylinder multiplication factors are used to generate input pressure to the brake corner

3.16
motorway applications section
series of **brake snubs** (3.8) in order to assess the ability of the brake to develop torque at or near highway speeds

3.17
fade section
series of **brake stops** (3.7) intended to heat the brake and assess the coefficient of friction sensitivity to the increasing elevated temperatures on the surface of the mating couple

3.18
hot performance section
series of **brake snubs** (3.8) similar to the pressure line but at elevated temperatures, in order to simulate heavy braking or overloaded conditions

4 Symbols and abbreviated terms

4.1 Symbols

Symbol	Definition	Unit
A_p	Total piston area	mm^2
C^*	Instantaneous effectiveness value for drum brakes	—
d_{mfd}	Mean fully developed deceleration when $v_e > 0{,}5v_p$ [a]	m/s^2
F	Test wheel load	N [b]
$F_{f,dyn}$	Test wheel load for front brakes at m_{GV}	N [b]
$F_{r,dyn}$	Test wheel load for rear brakes at m_{GV}	N [b]
$F_{r,static}$	Static axle load on the rear axle at m_{GV}	N [b]
H	Centre of gravity height	m
I	Test inertia reflected at the brake	kg·m^2

L	Vehicle wheel base	m
m_{GV}	Gross vehicle mass	kg
M_{d}	Brake torque at 1,0 g deceleration	N·m
$M_{d,brake}$	Measured torque	N·m
N	Brake application number during the fade section	—
p	Applied pressure	kPa
p_{max}	Maximum hydraulic pressure	kPa
$p_{threshold}$	Threshold pressure or minimum pressure required to develop braking torque	kPa
$p_{500,nopower}$	Pressure at 500 N pedal force with no power assist for FMVSS 135 vehicles	kPa
$p_{667,nopower}$	Pressure at 667 N pedal force with no power assist for FMVSS 105 vehicles	kPa
r_{eff}	Brake effective radius	mm
R	Dynamic tyre effective rolling radius	m
s_{b}	Calculated distance travelled between v_{p} and v_{b}	m
s_{e}	Calculated distance travelled between v_{p} and v_{e}	m
s_{norm}	Normalized stopping distance [c]	m
T_{max}	Maximum temperature for fade sections [d]	°C
$T_{start,N}$	Starting temperature for the *N*th brake application during the fade section	°C
$T_{start,1}$	Starting temperature for the first brake application during the fade section	°C
$T_{start,15}$	Starting temperature for the fifteenth brake application during the fade section	°C
v_{b}	Linear speed at 0,8v_{p}	km/h
v_{e}	Linear speed at 0,1v_{p} for stops or release speed for brake snubs	km/h
v_{max}	Vehicle maximum rated speed	km/h
v_{p}	Prescribed or braking speed for the brake application	km/h
z	Deceleration	m/s^{2}
μ	Average by distance friction value for disc brakes	—
μ^{*}	Instantaneous friction value for disc brakes	—
η	Brake efficiency	%

a In accordance with UNECE Regulation No.13-H.

b 9,806 65 = 1 kgf. The use of the unit kgf is deprecated.

c Using FMVSS 135 and UNECE Regulation No.13-H nominal values.

d If different from nominal.

4.2 Abbreviated terms

ABS	antilock braking system
DTV	disc thickness variation
ESP	electronic stability programme
FMVSS	Federal Motor Vehicle Safety Standard
LRO	lateral run-out
NVH	noise, vibration and harshness
OE	original equipment
UNECE	United Nations Economic Commission for Europe
VSC	vehicle stability control

5 Test conditions and preparation

5.1 Inertia for the front axle

The inertia for the front axle shall be calculated using 75 % of half the gross vehicle mass, unless otherwise specified for the project and the tyre rolling radius.

5.2 Inertia for the rear axle

The inertia for the rear axle shall be calculated using 25 % of half the gross vehicle mass, unless otherwise specified for the project and the tyre rolling radius.

5.3 Test wheel load

When vehicle parameters are available for the project, the test wheel load can also be calculated according to Equation (4) for front brakes or Equation (5) for rear brakes. Wheel load shall take into account static loading and dynamic mass transfer at a vehicle deceleration of 0,3 g.

$$F_{\text{f,dyn}} = \left(1 - \frac{F_{\text{r,static}}}{m_{\text{GV}}} + \frac{H}{L} z\right) \times \frac{m_{\text{GV}}}{2} \qquad (4)$$

$$F_{\text{r,dyn}} = \left(1 - \frac{F_{\text{r,static}}}{m_{\text{GV}}} - \frac{H}{L} z\right) \times \frac{m_{\text{GV}}}{2} \qquad (5)$$

5.4 Pressure ramp rate

The pressure ramp rate shall be (25 000 ± 5 000) kPa/s for all brake applications.

5.5 Maximum pressure

The maximum pressure applied to the brake can be lower than that specified in this International Standard in order to accommodate specific brake configurations or brake system design parameters.