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

*Véhicules routiers — Matériaux de friction pour garnitures de freins — Évaluation du comportement en friction pour les systèmes de freinage automatiques*

ICS 43.040.40

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# Foreword

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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.

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

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# Introduction

The efforts of harmonization among different countries and technical groups have the modernization of friction behaviour characterization of automotive brake systems applications as a top priority. This International Standard is intended to replace previous friction evaluation testing based solely on drag brake applications, which do not take into account real-life driving conditions, or vehicle specific parameters.

The varied condition under which the friction material is evaluated ensures a wide spectrum of data that 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.

Use this International Standard in conjunction with other applicable standards or test procedures (ISO, SAE, JASO, Federal Codes or regulations, and other project or company-specific testing programs) to fully assess a friction material's adequacy 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, tire-to-road adhesion, loads, and operating conditions of the braking system as indicated on 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 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. Lining transfer layer properties, hence friction level is heavily dependant upon the type of brake application. During any given brake application the braking energy varies as a result from the weight distribution and dynamic weight transfer on the vehicle. This is directly related to the vehicle's wheelbase, centre of gravity, and vehicle height, which in itself can influence directly 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 provides friction formulators, process designers, applications engineers, and manufacturing personnel the ability 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. Some benefits of this new procedure are:

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

— use of average by distance torque and pressure calculations;

— instantaneous friction statistics;

— estimation of stopping distance using mean fully developed deceleration;

— controlled and recorded environmental conditions.

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

## 1 Scope and field of application

This inertia-dynamometer standard describes 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). Use this standard when you need to compare friction materials under the same conditions or to control the friction behaviour against a specification or certain performance limits. To take into account the different types of dynamometer cooling systems and 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 program will detail the applicable limits and assessment criteria. This standard allows as well additional sections and brake applications very useful during product development testing. The additional brake applications added for the development testing are indicated in **bold**.

## 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.

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*ISO 15484—*[1] *Road vehicles - Brake Linings – Friction Materials – Product definition and assurance*

*ISO 611:2003* *Road vehicles - Braking of automotive vehicles and their trailers – Vocabulary*

*ECE Regulation 13-H* *Uniform Provisions Concerning the Approval of: Passenger Cars with Regard to Braking.*

## 3 Symbols and abbreviated terms

| Symbol | Unit | Description |
|---|---|---|
| $\alpha$ | m/s² | Deceleration |
| $A_p$ | mm² | Piston area |
| $C^*$ | - | instantaneous effectiveness value for drum brakes |
| *GVW* | kgf | Gross vehicle weight |
| *H* | m | Centre of gravity height |
| *I* | kg·m² | Inertia reflected at the brake |

1) To be published.


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| Symbol | Unit | Description |
|---|---|---|
| $L$ | m | Vehicle wheel base |
| LRO | µm | Lateral Ron-out |
| Md | N·m | Brake torque at 1.0 g |
| $Md_{Brake}$ | N·m | Measured torque |
| *mfdd* | $m/s^2$ | Mean fully developed deceleration when release speed > 0.5· $v_p$ per ECE Reg. 13-H |
| $N$ | - | Snub number during the fade section |
| P | kPa | Applied pressure |
| $p_{max}$ | kPa | Maximum hydraulic pressure |
| $p_{Threshold}$ | kPa | Threshold pressure or minimum pressure required to develop braking torque |
| $P_{500no\text{-}p}$ | kPa | Pressure at 500 N pedal force with no power assist for FMVSS 135 vehicles |
| $P_{667no\text{-}p}$ | kPa | Pressure at 667 N pedal force with no power assist for FMVSS 105 vehicles |
| $r_{eff}$ | mm | Brake effective radius |
| $R$ | m | Dynamic tire effective rolling radius |
| $s_b$ | m | Calculated distance travelled between $v_p$ and $v_b$ |
| $s_e$ | m | Calculated distance travelled between $v_p$ and $v_e$ |
| $S_{norm}$ | m | Normalized stopping distance using FMVSS 135 and ECE Regulation 13-H nominal values |
| $T_{AN}$ | °C | Initial brake temperature for snub number N during the fade section |
| $T_{A1}$ | °C | Initial brake temperature for snub number 1 during the fade section |
| $T_{A15}$ | °C | Initial brake temperature for snub number 15 during the fade section |
| $T_{max}$ | °C | Maximum temperature for fade sections |
| $v_b$ | km/h | Linear speed at $0.8{\cdot}v_p$ |
| $v_e$ | km/h | Linear speed at $0.1{\cdot}v_p$ for stops or release speed for brake snubs |
| $v_{max}$ | km/h | Vehicle maximum rated speed |
| $v_p$ | km/h | Prescribed or braking speed for the brake application |
| $W$ | kgf | Test wheel load |
| $W_{r\text{-}static}$ | kgf | Static axle load on the rear axle at GVW |
| µ* | - | Instantaneous friction value for disc brakes |
| µ | - | Average by distance friction value for disc brakes |
| η | - | Efficiency taken as 1 |

## 4 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 15484, ECE Regulation 13-H, ISO 611:2003 and the following apply.

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**4.1**
**friction value**
**µ**
average by distance of all instantaneous friction values obtained using equation1 for disc brakes or equation 2 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 This average by distance friction value from each individual brake application is the value referenced as "friction value" for definitions 4.4 through 4.25.

**4.2**
**instantaneous friction value**
**µ***

ratio of instantaneous output torque to instantaneous input torque for a disc brake at any specific point in time according to Equation 1

$$\mu * = \frac{10^5 \times Md_{Brake}}{2 \times \left(p - p_{Threshold}\right) \times A_P \times r_{eff} \times \eta} \qquad (1)$$

**4.3**
**C* value**
Ratio of instantaneous output torque to instantaneous input torque for a drum brake at any specific point in time according to Equation 2

$$C * = \frac{10^5 \times Md_{Brake}}{\left(p - p_{Threshold}\right) \times A_P \times r_{eff} \times \eta} \qquad (2)$$

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**4.4**
**test average µ value**
average friction value from all brake applications from steps 3, 5 (last 5 stops), 7, 8, 12, 16, 17, and 20 without optional brake applications

**4.5**
**test minimum µ value**
lowest friction values from steps 3, 5 (last 5 stops), 7, 8, 12, 16, 17, and 20 without including optional brake applications

**4.6**
**test maximum µ value**
highest friction values from steps 3, 5 (last 5 stops), 7, 8, 12, 16, 17, and 20 without including optional brake applications

**4.7**
**characteristic/stability check µ value**
average and minimum friction values from last 3 brake applications from step 3

**4.8**
**ramp applications µ value**
average and minimum friction values from the two brake applications from step 4

**4.9**
**cold characteristic µ value**
friction value from first brake application from step 5

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**4.10**
**stability during cold characteristic μ values**
average and minimum friction values from last 3 brake applications from step 5

**4.11**
**low speed/low pressure (1) μ values**
average and minimum friction values from all brake applications from step 6

**4.12**
**pressure line (1) μ value at 6000 kPa**
friction values from brake application at 6000 kPa from step 7

**4.13**
**high speed μ value**
friction values from last brake application from step 8 without including optional brake applications

**4.14**
**normalized stopping distance during FMVSS 135 failed booster**
normalized stopping distance from stops 1 and 6 from step 9

**4.15**
**0,9$v_{max}$ motorway μ value**
friction value from last brake application from step 10

**4.16**
**low speed/low pressure (2) μ values**
average and minimum friction values from all brake applications from step 11

**4.17**
**characteristic/recovery (1) μ values**
average and minimum friction values from last 3 brake applications from step 12

**4.18**
**fade 1 minimum μ value**
minimum friction value from step 13

**4.19**
**hot performance μ value**
minimum friction value from last 5 brake applications from step 14

**4.20**
**low speed/low pressure (3) μ values**
average and minimum friction values from all brake applications from step 15

**4.21**
**characteristic/recovery (2) μ values**
average and minimum friction values from last 3 brake applications from step 16

**4.22**
**pressure line (2) μ value at 6000 kPa**
friction values from brake application at 6,000 kPa from step 17

**4.23**
**fade 2 minimum μ value**
minimum friction value from step 18

**4.24**
**low speed/low pressure (4) μ values**
average and minimum friction values from all brake applications from step 19

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