For Comments Only

BUREAU OF INDIAN STANDARDS

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भारतीय मानक **मसौदा**

स्वचल वाहन — ब्रेक अस्तर
भाग 6 संपीड़न तनाव परीक्षण पद्धतियाँ

(पहला *पुनरीक्षण*)

Draft *Indian Standard*

Automotive Vehicles —Brake Linings
Part 6 Compressive Strain Test Methods

(*First Revision*)

ICS 43.040

Automotive Braking Systems, Vehicle Testing, Steering and performance Evaluation Sectional Committee, TED 04	**Last date for receipt of comments is 28/01/2025**

FOREWORD
(Formal Clause to be added later)

This Indian Standard was adopted by the Bureau of Indian Standards after the draft finalized by the Automotive Vehicle Testing and Performance Evaluation Sectional Committee had been approved by the Transport Engineering Division Council.

The compressive response of a brake lining or pad is an important design parameter. It is useful for the evaluation of brake fluid displacement during a brake application, brake-pedal travel and the propensity of the brake for generating judder or noise. It is also part of the brake pad characterization and a parameter for quality control.

The purpose of the test methods described in this Standard is to evaluate the compressive response or "compressibility" of friction materials or brake pads. The tests measure compressibility at ambient and elevated temperatures. During the elevated temperature portion of the test, the thermal transmission and response of brake pad are measured. The brake linings for automotive vehicles are considered as of significant importance because of their role in overall safety of the vehicle.

AIS 061 'Replacement brake lining assemblies and drum brake linings for power-driven vehicles and their trailers' is calling for inspection of lining compressive strain test as per ISO 6310. This standard (Part 6) has been made in line with ISO 6310 standard. Since thermal swell test is already covered in IS 2742 (Part 2): 1999, same were exempted.

Approval of the brake lining for application on a specific vehicle model is based on vehicle test as laid down in this standard applicable to the category to which the vehicle model belongs to. As the tests in this standard are not intended to replace the testing of the brakes on a vehicle or dynamometer, it is being accepted that a full assessment of a lining can be made only under operating conditions.

This standard is hence intended to be used for checking consistency of brake linings and disc pads manufacture. The properties shall be identified with particular brake lining or disc pad and not with the brake or vehicle on which this lining/disc pad is used.

In reporting the result of a test or analysis made in accordance with this standard, if the final value observed or calculated, is to be rounded off, it shall be done in accordance with IS 2: 1960 'Rules for rounding off numerical values' (reaffirmed, 2006).

This Indian Standard is published in seven parts. The other parts in this series are:

IS 2742: 1994 (Part 1)	Automotive vehicles — Brake linings (non-rubberized) Part 1 Specification (*first revision*)
IS 2742: 1999 (Part 2)	Automotive vehicles — Brake linings — Rubberized Part 2 Specification
IS 2742: 1994 (Part 3)	Automotive vehicles — Brake linings Part 3 Methods of test
IS 2742 : 1994 (Part 4)	Automotive vehicles — Brake linings Part 4 Co-efficient of friction —Method of test
IS 2742: 1994 (Part 5)	Automotive vehicles — Brake linings Part 5 Internal shear strength —Method of test
IS 2742: 2018 (Part 7)	Automotive vehicles — Brake linings Part 7 Shear test procedure for disc brake pad and drum brake shoe assemblies

The composition of the Committee responsible for formulating this standard is given in Annex B (Will be added later)

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated expressing the result of a test or analysis, shall be rounded off in accordance with IS 2: 2022 'Rules for rounding off numerical values (*second revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

AUTOMOTIVE VEHICLES —BRAKE LININGS PART 6 COMPRESSIVE STRAIN TEST METHODS

(First Revision)

1 SCOPE

1.1 This standard specifies a method for test and measurement of the compressive displacement of drum brake linings and disc brake pads due to loading and temperature.

1.2 This standard applies to disc brake pads or coupon samples cut from drum brake lining.

2 REFERENCES

The standard given below contains provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the edition indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below.

IS No.	*Title*
IS 11852: 2013	Automotive vehicles — Uniform provisions concerning the approval of vehicles of categories M, N and T with regard to braking (*second revision*)

3 TERMS AND DEFINITIONS

3.1 Compressibility (C) — Change in friction material thickness or deflection, caused by a uniaxial compression load during the final loading cycle, to the maximum test pressure, which is measured in the same direction as the compression force, perpendicular to the friction surface.

3.2 Compressive Strain (ε) — Ratio of the reduction in thickness of friction material, due to the compression load, to its initial thickness, which is measured in the direction of the application force, perpendicular to the friction surface.

3.3 Deflection (D) — Net deflection of the sample as a result of the subtraction of the deflection of the apparatus itself from the total deflection measured by the apparatus.

$$D = D_{tot} - D_{app}$$

where,

D_{tot} is the total deflection measured by the apparatus; and
D_{app} is the deflection of the apparatus itself.

3.4 Friction Material Contact Area (A_0) — Measure of the area of friction material that carries the test load

NOTE: It is advisable that slots, chamfers and any other features be accounted for in determining A_0

3.5 Hot Compressibility - (C_{400}): —Compressibility with a heated platen temperature of 400°C (for disc brake pads). C_{200}: Compressibility with a heated platen temperature of 200°C (for drum brake linings).

3.6 Temperature Transfer (T_T) — Temperature rise at the backing plate of a brake pad after the friction surface has been in contact with the heating plate at (400 ± 10)°C for a given period at a given pressure.

$$T_T = T_3 - T_2$$

where,

T_3 is the final temperature of the backing plate during the hot test; and
T_2 is the initial temperature of the backing plate for the hot test.

4 SYMBOLS AND UNITS

lists the symbols and corresponding units used in this standard (*see* Table 1).

5 PRINCIPLES

5.1 General

The test measures either:

a) The compressive strain of a friction material coupon (test method A), or
b) The compressive deflection of a brake pad (test method B).

Depending upon the type of sample, either method A or method B is followed for applying the test load. Test results from test method A and test method B shall not be directly compared.

Table 1 Symbols and Units
(*Clause* **4**)

Sl. No	Symbol	Definition	Unit	Accuracy
(1)	(2)	(3)	(4)	(5)
i)	A_0	Friction material contact area	cm^2	$0.5 cm^2$
ii)	C	Compressibility[a)]	μm	$1 \mu m$
iii)	C_{200}, C_{400}	Hot compressibility	μm	$1 \mu m$
iv)	d	Average thickness of coupon sample[b)]	mm	0.1 mm
v)	D	Net deflection of test sample[c)]	μm	$1 \mu m$
vi)	D_{app}	Deflection of the test apparatus itself at p_A[d)]	μm	$1 \mu m$
vii)	D_{tot}	Total deflection measured by the test apparatus at the maximum test pressure	μm	$1 \mu m$
viii)	F_B	Pre-load	MPa[e)]	1%[f)]
ix)	F_P	Test load	MPa[e)]	1%[f)]
x)	p_A	Test pressure at sample contact area or unit area pressure[g)]	MPa[e)]	1%[f)]
xi)	p_D	Simulated hydraulic line pressure[h)]	MPa[e)]	1%[f)]
xii)	T_1	Test temperature of the heating plate for hot test	°C	2°C
xiii)	T_2	Initial temperature of the backing plate for hot test	°C	2°C
xiv)	T_3	Final temperature of the backing plate during hot test	°C	2°C
xv)	T_T	Temperature transfer	°C	2%
xvi)	εP_A	Compressive strain at p_A[i)]	—	0.0

a) D at p_D. Used in test method B.
b) Average of five measurements.
c) $D_{tot} - D_{app}$
d) No sample installed.
e) 1 bar = 0.1 MPa.
f) 1% full-span accuracy.
g) Test method A.
h) Test method B.
j) *D/d*. Used in test method A.

5.2 Test Method A — Coupon Sample (for Brake Lining) and/or Air Disc Brake Pad

Test method A loads a sample coupon to the force required to achieve a unit-area pressure at the contact interface. Test method A can be used to assess friction materials for commercial vehicle drum brake assemblies and commercial vehicle disc brake assemblies, and material coupons for research and development purposes.

For large pads used on a commercial vehicle, measure the compressive strain at the left and the right halves separately or use a segment cut in the radial direction. In other cases, sample sizes should be large enough to account for material not being homogeneous. Surfaces of coupon samples should be flat and parallel.

Unless otherwise specified, report the compressive strain value, εP_A.

5.3 Test Method B — Hydraulic Disc Brake Pad
Test method B loads the brake lining assembly to simulate a hydraulic line pressure of 10 MPa (100 bar) or 16 MPa (160 bar).

NOTE — In common practice, the line pressure is expressed in bar in order to differentiate it from the face pressure at the contact area. Test method A is typically used for drum brake linings and heavy truck air disc brake pads. Test method B is typically used for passenger car and light truck hydraulic disc brake pad.

Unless otherwise specified, report the compressive deflection or compressibility value, *C*, in μm**.**

6 TEST APPARATUS

The test apparatus shall consist of the following.

6.1 Compressibility Test-Stand or Uniaxial Material-Testing Load Frame

To provide a uniform load over the surface of the test sample.

6.2 Loading Cylinder

To simulate**:**

a) A caliper piston configuration for test method B; and
b) A loading ram surface larger than the sample contact area for test method A.

6.3 Compression Platen

6.4 Device

To measure the applied compression force to an accuracy of 1% of full-scale of the test apparatus.

6.5 Gauge

To measure the time-based deflection of the sample with an accuracy of 0.001 mm. Position the gauge on the loading cylinder or on the platen and in contact with the loading ram as near to its centre line as possible.

6.6 Recording Device or Computer

To log load, pressure, displacements and temperatures as function of time.

6.7 Heating Device

To raise the temperature of the platen to a specified temperature.

6.8 Thermocouple (1.5 mm diameter recommended)

To measure the temperature of the platen. The position of the thermocouple should be as close as possible to the centre line of the loading ram and embedded 3 mm below the test surface of the platen.

6.9 Thermocouple or Device

To measure the temperature of the test sample.

6.10 Micrometer

To measure sample thickness.

7 TEST STAND SPECIFICATION

7.1 Loading

7.1.1 *Test Method A*

Recommended maximum pressure and pressure ramp rates are listed in Table 2. When determining actual sample contact area and contact face pressure, remove the areas of any slots, chamfers and holes.

7.1.2 *Test Method B*

Apply a force corresponding to a simulated hydraulic line pressure of 10 MPa (100 bar) or 16 MPa (160 bar). The pressure used shall be clearly identified on the test report. The recommended loading rate is 8 MPa/s (80 bar/s) simulated line pressure when testing in constant loading rate control, or 15 mm/min when testing in crosshead speed control.

Table 2 Maximum Contact Face Pressure and Ramp Rates for Test Method A
(*Clause* **7.1.1**)

S.No	Type of friction material	Maximum Pressure at Contact Interface MPa	Apply Pressure Ramp Rate MPa/s	Apply Rate in Cross Head Speed Control mm/min
(1)	(2)	(3)	(4)	(5)
i)	Commercial vehicle disc pad	8[1)]	4.0 ± 0.5	15
ii)	Commercial vehicle drum brake linings	3	1.5 ± 0.5	6

a) For large pads, 5 MPa is an alternative pressure used.

7.2 Heated Platen

For the hot test, test temperature of the heating plate, T_1, on the surface shall be (200 ± 10)°C for drum brake linings and (400 ± 10)°C for disc pads.

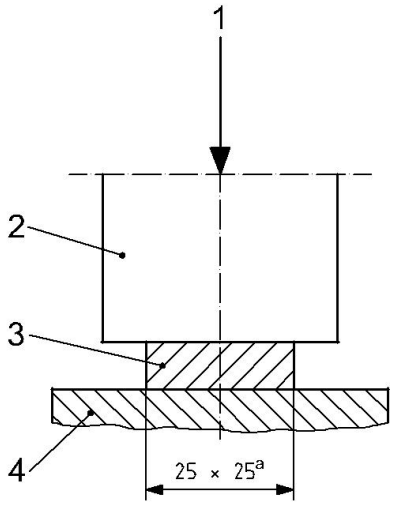
7.3 Loading Ram

7. 3.1 *Test Method A — Coupon Sample*

The face of the loading ram shall be flat and the periphery shall at least circumscribe the periphery of the sample in order to distribute the load uniformly over the surface (*see* Fig. 1). To calculate the unit-area pressure, use the actual friction material area in contact with the mating face. For commercial vehicle (CV) pads, the standard loading ram is an annular piston shape with a 60 mm outer diameter and a 50 mm inner ring diameter.

7. 3.2 *Test Method B — Disc Brake Pad Assembly*

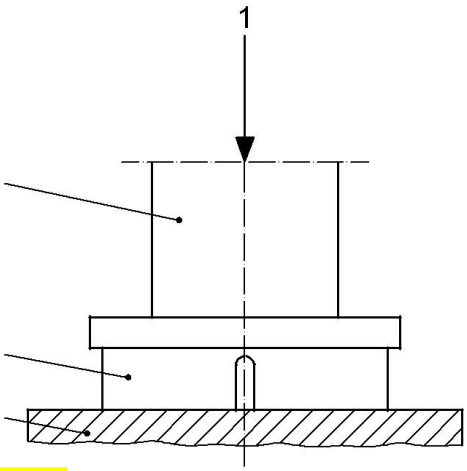
A fixture representing a piston is introduced between the ram and the friction material pad, such that the loading surface has the same form (for example, solid or annular piston) and location as the actual contact surface of the caliper piston in which the pad will be used in service, or alternatively an agreed position that provides reproducible measurements (*see* Fig. 2).



Key

1 = Load
2 = Ram
3 = Test sample with maximum thickness possible
4 = Heating plate
a = A larger sample is allowed for commercial vehicle disc-brake pads.

FIG. 1 COUPON SAMPLE



Index numbers 2-4 missing in this figure

Key
1 Load
2 Ram
3 Test sample
4 Heating plate

FIG. 2 DISC BRAKE PAD

If the intended brake system has a caliper with more than one piston, use an adequate piston- shaped loading fixture. Alternatively, an agreed piston adaptor different from the brake design can be used in order to provide reproducible measurements.

8 SAMPLING

8.1 It is recommended that a minimum of five samples be measured at room temperature, and three samples at elevated temperature.

8.2 To avoid influencing the test results, the flatness and surface roughness of the sample should be the same as that of normal production.

8.3 When testing to measure friction material properties, it is recommended that backing materials, such as anti-noise shims or rubber coatings, be removed prior to testing, and this information should be reported.

8.4 For accurate measurements, parts should be stabilized at (23 ± 5)°C and (50 ± 10)% relative humidity before testing. Record and report environmental test conditions.

9 TEST METHOD

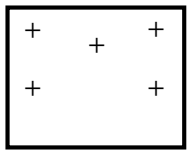
9.1 General Set-up

9.1.1 Ensure that the test stand is properly calibrated.

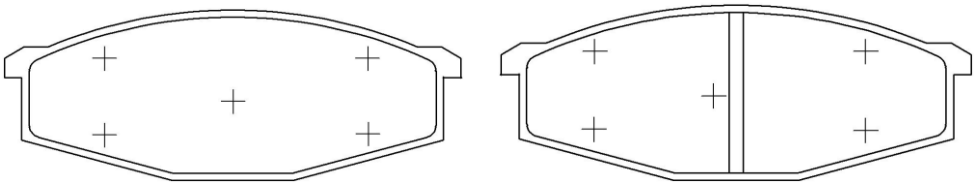
9.1.2 In case of drum brake linings (test method A), measure the thickness of coupon sample at five points [*see* Fig. 3 a)], and in case of passenger car disc pads (test method B), measure the thickness of the sample at five points [*see* Fig. 3 b)] using a micrometer. Calculate the average value of the thickness, *d*.

If the pad sample contains slots, take measurements as shown in Fig. 3 b) ii).

9.1.3 In case of disc brake pads, measure the backing plate thickness and subtract it from the average sample thickness. Record only the friction material thickness, *d*.



a) Drum brake linings (coupon sample)



i) Unslotted pad ii) Slotted pad

b) Disc pads

FIG. 3 SPOTS FOR MEASURING THICKNESS OF TEST SAMPLES

9.1.4 Measure and record nominal sample contact area, A_0

9.1.5 Place the sample on the platen at room temperature [(23 ± 5) °C] with its friction surface against the surface of the platen with the ram and piston fixture correctly located. Ensure that the location of the piston fixture is consistent with the location on the actual application in order to ensure repeatability of test results.

9.2 Room Temperature Compressibility Test

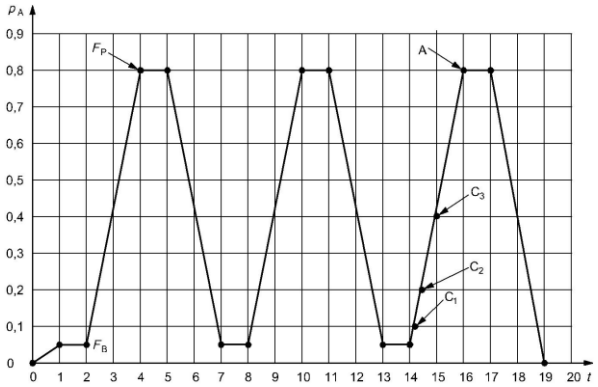
9.2.1 Pre-load to the force value that corresponds to 0.5 MPa (5 bar) hydraulic system pressure, or 0.5 MPa contact face pressure, and hold for no more than 5 s.

9.2.2 Set the displacement gauge to zero while the sample is held at pre-load.

9.2.3 Perform three loading and unloading cycles starting from the pre-load.

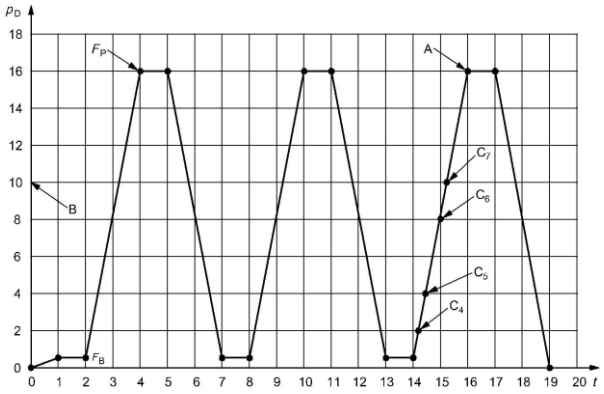
NOTE — A cycle consists of increasing to the maximum pressure at the rate required, then unloading at the same rate to the pre-load value.

9.2.4 Measure displacement and load (or pressure) during the loading cycles. If computer data acquisition is available, it is recommended that continuous displacement versus pressure (and load) be recorded. Record and report displacement at the maximum pressure on the first cycle and last cycle. In addition, on the last cycle, readings should be recorded at several points while the pressure increases (*see* Fig. 4 for the measurements to be taken and recorded).



t = Time, in s
p_A = Pressure, in MPa (1 bar = 0.1 MPa)
F_B = Pre-load, in MPa
F_P = Test load, in MPa
A = Point at which reading is taken
C_1, C_2, C_3 = Additional measurement points (indicated for disc pads only)

A) Test method A



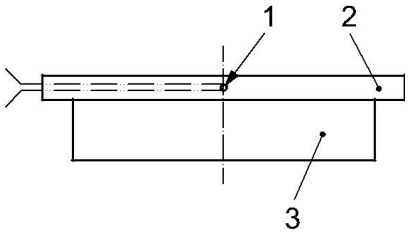
t = Time, in s
p_D = Simulated hydraulic pressure, in MPa (1 bar = 0.1 MPa)
F_B = Pre-Load, In MPa
F_p = Test Load, In MPa
A = Point at which reading is taken
B = Alternative Test Pressure of 10 MPa (100 bar) (*See* 5.3)
C_4, C_5, C_6, C_7 = Additional measurement points (indicated for disc pads only)

B) Test method B

FIG. 4 COMPRESSIVE STRAIN RT TEST CYCLE FOR 16 MPA (160 BAR)

9.3 Hot Compressibility Test

9.3.1 Install a thermocouple in the pad backing plate, as shown in Fig. 5. It shall be positioned in the centre of the piston area, but outside of holes or similar, in the backing plate.



Key
1. Thermocouple tip
2. Backing plate
3. Friction material

FIG. 5 THERMOCOUPLE LOCATION FOR HEAT TRANSFER

9.3.2 Remove the sample and loading ram adaptor (piston) from the compression platen. Pre-heat the platen to a stabilized surface temperature of (400 ± 10)°C in case of disc brake pads and (200 ± 10)°C in case of drum brake linings. Wait for at least 30 min to stabilize the temperature.

9.3.3 Install the loading ram adaptor, which shall be at ambient temperature.

9.3.4 Immediately after step 9.3.3, place a fresh sample (which shall be at ambient temperature) on the heated platen. Apply the pre-load of 0.5 MPa (5 bar). The sample shall be a fresh coupon sample in case of drum brake lining or a fresh disc pad.

9.3.5 Set the displacement gauge to zero.

9.3.6 Record the final temperature at the backing plat, T_3, after 10 min ± 10 s for drum brake linings and passenger car brake pads or 15 min ± 10 s for commercial vehicle brake pads at the test pressure (as per Table 2). Report the temperature transfer, T_T, if required.

9.3.7 Reset the displacement gauge to zero.

9.3.8 Perform two loading and unloading cycles, using the same loading parameters followed for room temperature test.

9.3.9 Remove the test sample from the test stand and allow it to cool to ambient temperature.

9.3.10 Measure the sample thickness at the locations indicated in Fig. 4 a) for drum brake linings and Fig. 4 b) for disc pads, and report sample growth, d_G, if required.

10 TEST DEVICE DEFLECTION

It is known that during compressive testing of friction material, the test device itself will also deflect. This displacement of the test apparatus under load, D_{app} shall therefore be subtracted from the total measured displacement during the test, D_{tot} in order to determine the net displacement of the friction material sample, D, as shown below:

$$D = D_{tot} - D_{app}$$

This compensation can be done automatically or manually. Measure D_{app} as a function of pressure by loading the ram with the piston in place against the base platen without a sample installed.

NOTE — Alternatively, a stiff, hardened steel plate with known force-deflection can be used as a dummy sample to protect the base platen.

Automatic displacement compensation can then be performed as a function of pressure. Alternatively, a manual subtraction of the machine deflection can be performed on the maximum pressure deflection reading for each test.

11 VERIFICATION OF THE TEST STAND USING REFERENCE SAMPLES

A regular test should be done with a reference sample such as a Hottinger force gauge housing C2/50 kN (Jurid) or a Verification Standard Spring (LINK) with a suitable positioning tool and reasonable test parameters.

EXAMPLE 1 Test conditions for Jurid machines:

a) F_B = 1.6 kN;
b) F_P = 50 kN; 60 kN;
c) F/t = 25 kN/s; and
d) 2 cycles.

EXAMPLE 2 Test conditions for LINK machines:

a) F_B = 3.0 kN;
b) F_P = 59.5kN;
c) F/t = 35 kN/s; and
d) 3 cycles.

If there is a difference of more than 5 µm between the reference sample and its expected value, check the accuracy of the force measuring device, accuracy of the displacement gauge, and flatness of the test platen.

12 TEST REPORT

Annex A presents a sample test report. Other formats are acceptable provided they include at least the following information:

a) Manufacturer and reference name/number of friction material including batch reference;
b) Type of sample, reference to any additional coatings, shims, etc.;
c) Size of the sample (area);
d) Number of samples tested;
e) Disc pad thickness mm to an accuracy of 0.1 mm and thickness of friction material;
f) Piston size, inner and outer ring diameter (in the case of a disc pad);
g) Piston position relative to the pad if deviating from the centre-line position;
h) Test method used (A or B);
j) Average value for ambient compressibility or compressive strain for all samples tested;
k) Average value for hot compressibility or compressive strain for all samples tested; and
m) Ambient temperature and humidity (if required).

ANNEX A
(*Informative*)

EXAMPLE TEST REPORT

<table>
<tr><td colspan="2" rowspan="2">PARAMETER</td><td colspan="4">Test Method A</td><td colspan="4">Test Method B</td></tr>
<tr><td colspan="4">Unit area pressure
MPa
(unless otherwise specified)</td><td colspan="4">Line pressure
MPa
(unless otherwisespecified)</td></tr>
<tr><td colspan="2">Pre-load</td><td colspan="4">0.5</td><td colspan="4"></td></tr>
<tr><td colspan="2">Load rate</td><td colspan="4">4 MPa/s</td><td colspan="4"></td></tr>
<tr><td rowspan="2">Maximum load (expressed in pressure), MPa</td><td>Pad</td><td colspan="4">8</td><td colspan="4"></td></tr>
<tr><td>Lining</td><td colspan="4">3</td><td colspan="4"></td></tr>
<tr><td rowspan="2">Measurement stages, MPa</td><td>Pad</td><td>1</td><td>2</td><td>4</td><td>8</td><td>2</td><td>4</td><td>8</td><td>16</td></tr>
<tr><td>Lining</td><td colspan="2">1.5</td><td colspan="2">3</td><td colspan="2">3</td><td colspan="2">6</td></tr>
<tr><td rowspan="2">No. of cycles</td><td>Room temperature test</td><td colspan="4">3</td><td colspan="4">3</td></tr>
<tr><td>Hot test</td><td colspan="4">2</td><td colspan="4">2</td></tr>
<tr><td rowspan="2">Sample size, mm:</td><td>Pad</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Lining</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Ram type:</td><td colspan="9">Flat Surface: Actual piston:</td></tr>
<tr><td colspan="10">Test date:</td></tr>
<tr><td colspan="10">Name of tester:</td></tr>
<tr><td colspan="10">Reference number:</td></tr>
<tr><td colspan="10">Friction material manufacturer:</td></tr>
<tr><td colspan="10">Friction material reference:</td></tr>
<tr><td colspan="10">Batch identification:</td></tr>
<tr><td colspan="10">Sample type:</td></tr>
<tr><td colspan="10">Special coatings, shims, etc.:</td></tr>
<tr><td colspan="10">Sample size:</td></tr>
</table>

Pad thickness *di* (mm)**:**
Lining thickness (mm)**:**
Number of samples:
Piston size:
Test method adopted (A or B):

Compressive Strain	Test Method A		Test Method B	
	p_A	ε_{pA}	p_A	C
	MPa		MPa	µm
Ambient Pad (lining) First and third cycles	8(3) 1 (1.5) 2 4 8 (3)		10 16 10 16 —	
Hot Pad (lining) First and second cycles	8(3) 1 (1.5) 2 4 8 (3)		10 16 10 16 —	
Temperature transfer, T_T (for disc pads): Sample growth, d_G:				
Characteristic curves attached? (Yes/No):				

ANNEX A
(*Foreword*)

COMMITTEE COMPOSITION

Automotive Braking Systems, Vehicle Testing, Steering and performance Evaluation Sectional Committee, TED 04

Will be added later