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Road vehicles — Brake linings — Compressive strain test methods

Véhicules routiers — Garnitures de freins — Méthode d'essai de la compressibilité

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Foreword

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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 6310 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 2, *Braking systems and equipment*.

This third edition cancels and replaces the second edition (ISO 6310:2001), which has been technically revised.

Introduction

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 International Standard is to evaluate the compressive response or “compressibility” of friction materials or brake pad assemblies. The tests measure compressibility at ambient and elevated temperatures. During the elevated temperature portion of the test, the thermal transmission and response of the brake pad assembly are measured.

Road vehicles — Brake linings — Compressive strain test methods

1 Scope

This International Standard specifies a method for test and measurement of the compressive displacement of brake linings or brake pad assemblies due to loading and temperature. It also provides a test method to assess lining thermal swell and growth.

This International Standard applies to disc brake pad assemblies or coupon samples cut from the friction material.

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*

3 Terms and definitions

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

3.1
compressibility
C
change in pad 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 the brake lining, 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

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

where

D_{tot} is the total deflection measured by the apparatus;

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

3.6
temperature transfer
T_T
temperature rise at the backing plate of a brake pad assembly 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;

T_2 is the initial temperature of the backing plate for the hot test

3.7
pad thermal growth
d_G
permanent change in thickness of the sample after the friction surface has been in contact with the heating plate at (400 ± 10) °C for a given period at a given pressure and then cooled down to room temperature

3.8
pad thermal swell
d_S
change in thickness of the sample after the friction surface has been in contact with the heating plate at (400 ± 10) °C for a given period at a given pressure

4 Symbols and units

Table 1 lists the symbols and corresponding units used in this International Standard.

Table 1 — Symbols and units

Symbol	Definition	Unit	Accuracy
A_0	friction material contact area	cm^2	0,5 cm^2
C	compressibility [a]	µm	1 µm
C_{400}	hot compressibility	µm	1 µm
d	average thickness of coupon sample [b]	mm	0,1 mm
d_G	pad growth or thermal expansion back at ambient temperature	µm	1 µm
d_S	pad swell or thermal expansion	µm	1 µm
D	net deflection of test sample [c]	µm	1 µm
D_{app}	deflection of the test apparatus itself at p_A [d]	µm	1 µm
D_{tot}	total deflection measured by the test apparatus at the maximum test pressure	µm	1 µm
F_B	pre-load	MPa [e]	1 % [f]
F_P	test load	MPa [e]	1 % [f]
p_A	test pressure at sample contact area or unit area pressure [g]	MPa [e]	1 % [f]
p_D	simulated hydraulic line pressure [h]	MPa [e]	1 % [f]
T_1	test temperature of the heating plate for hot test	°C	± 2 °C
T_2	initial temperature of the backing plate for hot test	°C	± 2 °C
T_3	final temperature of the backing plate during hot test	°C	± 2 °C
T_T	temperature transfer	°C	2 %
ε_{pA}	compressive strain at p_A [i]	—	0,000 2

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.

i D/d. Used in test method A.

5 Principles

5.1 General

The test measures either:

— the compressive strain of a friction material coupon (test method A), or

— the compressive deflection of a brake pad assembly (test method B).

Depending upon the type of sample, one of two alternative test methods is followed for applying the test load.

Test results from test method A and test method B should not be directly compared.

5.2 Test method A — Coupon sample and/or airbrake 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 pad materials for drum brake assemblies, commercial vehicle disc or drum brakes 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, ε_{pA}.

5.3 Test method B — Hydraulic disc brake pad assembly

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 B is typically used for passenger car and light truck hydraulic disc brake pad assemblies.

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 calliper piston configuration for test method 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 specifications

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.

Table 2 — Maximum contact face pressure and ramp rates for test method A

Type of brake assembly	Maximum pressure at contact interface MPa	Apply pressure ramp rate MPa/s	Apply rate in crosshead speed control mm/min
Commercial vehicle disc	8 [a]	4,0 ± 0,5	15
Commercial vehicle drum	5	2,5 ± 0,5	10
Drum brake linings	3	1,5 ± 0,5	6

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

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.

7.2 Heated platen

For the hot test, the test temperature of the heating plate, T_1, on the surface shall be (400 ± 10) °C.

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 Figure 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 (e.g. solid or annular piston) and location as the actual contact surface of the calliper piston in which the pad will be used in service, or alternatively an agreed position that provides reproducible measurements (see Figure 2). If the intended brake system has a calliper 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 the case of passenger car disc brake linings (test method B), measure the thickness of the sample at five points (see Figure 4) using a micrometer. Calculate the average value of the thickness, d.

If the pad sample contains slots, take the measurements as shown in Figure 4 b).

9.1.3 In the 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.

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.

Figure 5 illustrates the test cycle.

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 Figure 5 for the measurements to be taken and recorded).

9.3 Temperature transfer and thermal expansion measurements

9.3.1 Install a thermocouple in the pad backing plate, as shown in Figure 3. It shall be positioned in the centre of the piston area, but outside of holes or similar in the backing plate.

9.3.2 Remove the sample and loading ram adapter (piston) from the compression platen. Preheat the platen to a stabilized surface temperature of (400 ± 10) °C. Wait at least 30 min to stabilize the temperature.

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

9.3.4 Immediately after step 9.3.3, place the sample (which should be at ambient temperature) on the heated platen. Record the initial temperature, T_2, of the backing plate. Apply the pre-load of 0,5 MPa (5 bar).

9.3.5 Set the displacement gauge to zero.

9.3.6 Record the final temperature at the backing plate, T_3, after 10 min ± 10 s for passenger car brake pads, or after 15 min ± 10 s for commercial vehicle brake pads, at the test pressure.

9.3.7 Record the change in sample pad thickness after 10 min ± 10 s for passenger car brake pads or 15 min ± 10 s for commercial vehicle brake pads at the test pressure.

9.4 Hot compressibility test

9.4.1 If steps 9.3.2 to 9.3.7 have been followed, proceed directly to 9.4.2; if not, first follow 9.3.2 to 9.3.7 above.

9.4.2 Reset the displacement gauge to zero.

9.4.3 Perform two compression cycles, using the same loading parameters as for room temperature cycles.

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

9.4.5 Measure the pad thickness at the locations in Figure 4, and report sample growth, d_G, if required.

10 Test device deflection compensation

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 in Equation (1):

$$D = D_{tot} - D_{app} \quad (1)$$

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:

— F_B = 1,6 kN;

— F_P = 50 kN; 60 kN;

— F/t = 25 kN/s;

— 2 cycles.

EXAMPLE 2 Test conditions for LINK machines:

— F_B = 3,0 kN;

— F_P = 59,5 kN;

— F/t = 35 kN/s;

— 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 brake lining including batch reference;

b) type of sample, reference to any additional coatings, shims, etc.;

c) size of the sample pad area;

d) number of samples tested;

e) assembly 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;

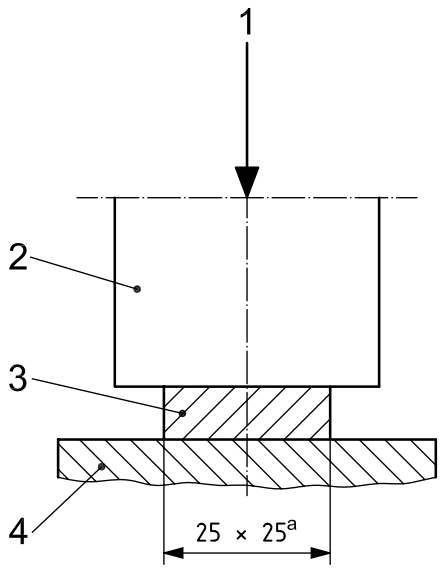
h) test method used (A or B);

i) average value for ambient compressibility or compressive strain for all samples tested;

j) average value for hot compressibility or compressive strain for all samples tested;

k) ambient temperature and humidity (if required).

Dimensions in millimetres

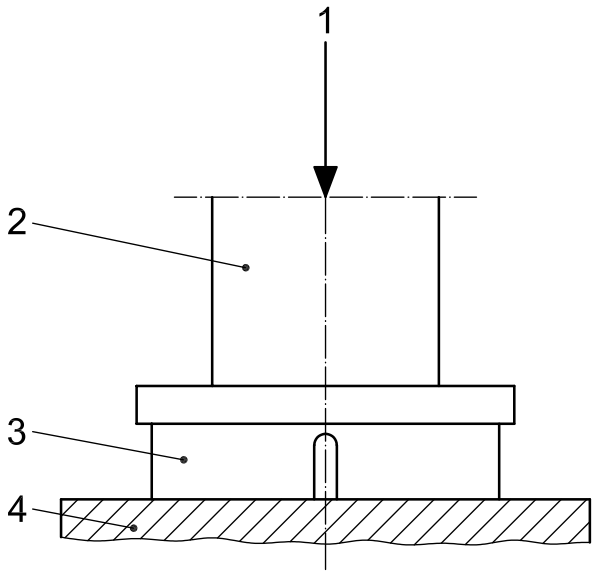


Key

1 load
2 ram
3 test sample with maximum thickness possible
4 heating plate

[a] A larger sample is allowed for friction materials for commercial vehicle disc-brake pads.

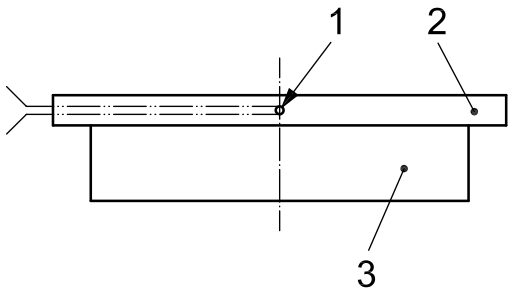
Figure 1 — Coupon sample



Key

1 load
2 ram
3 test sample
4 heating plate

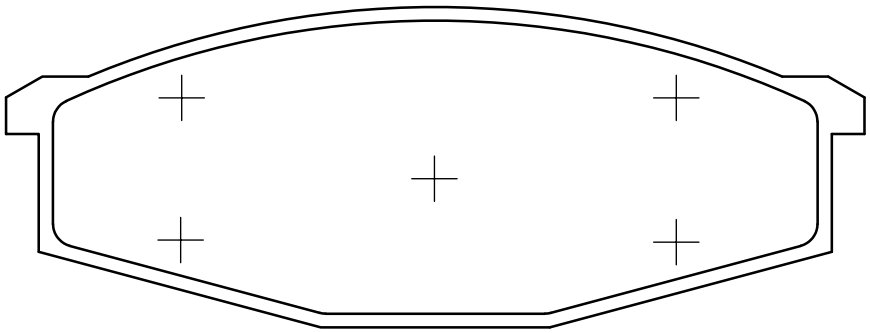
Figure 2 — Disc brake pad assembly



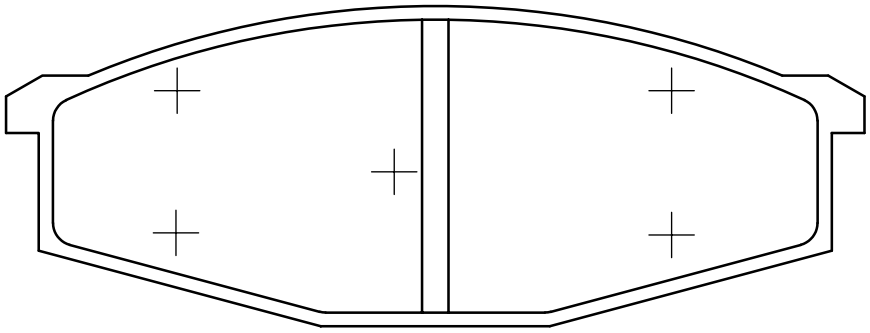
Key

1 thermocouple tip
2 backing plate
3 friction material

Figure 3 — Thermocouple location for heat transfer management

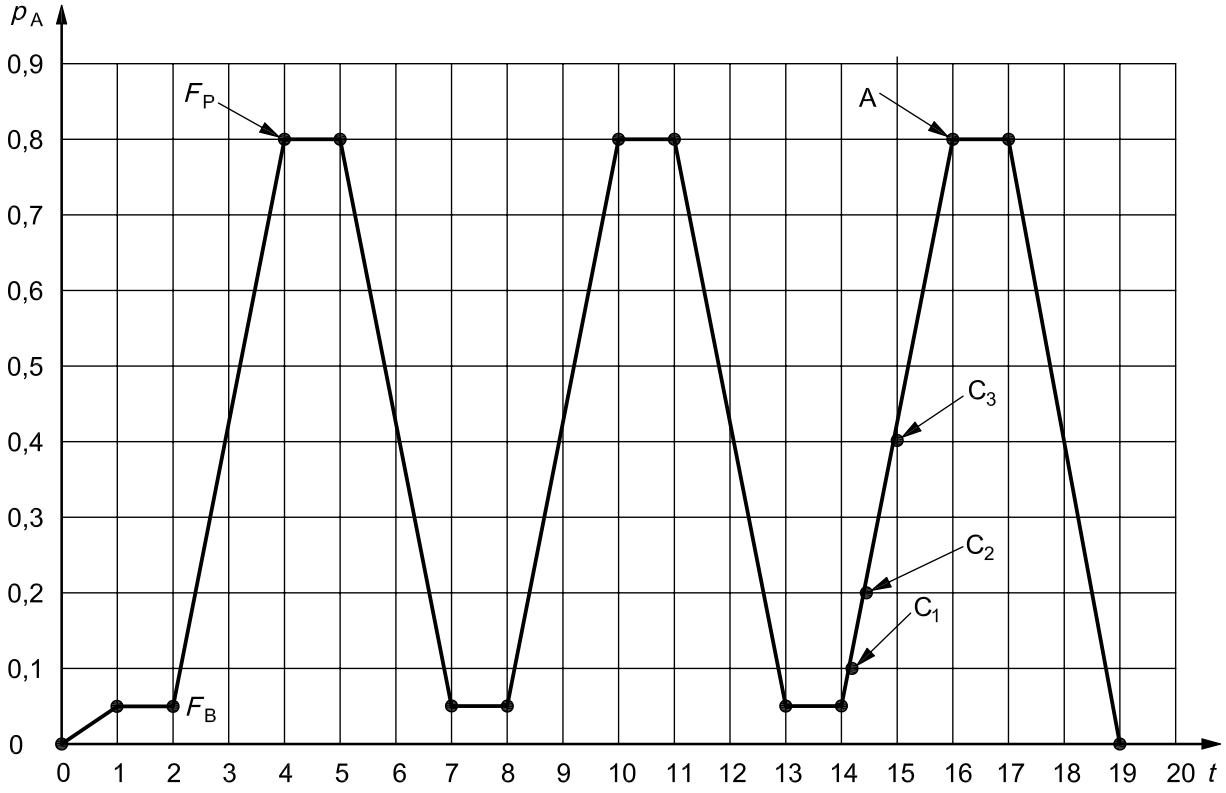


a) Without slot



b) Slotted pad

Figure 4 — Sample measurement guidelines

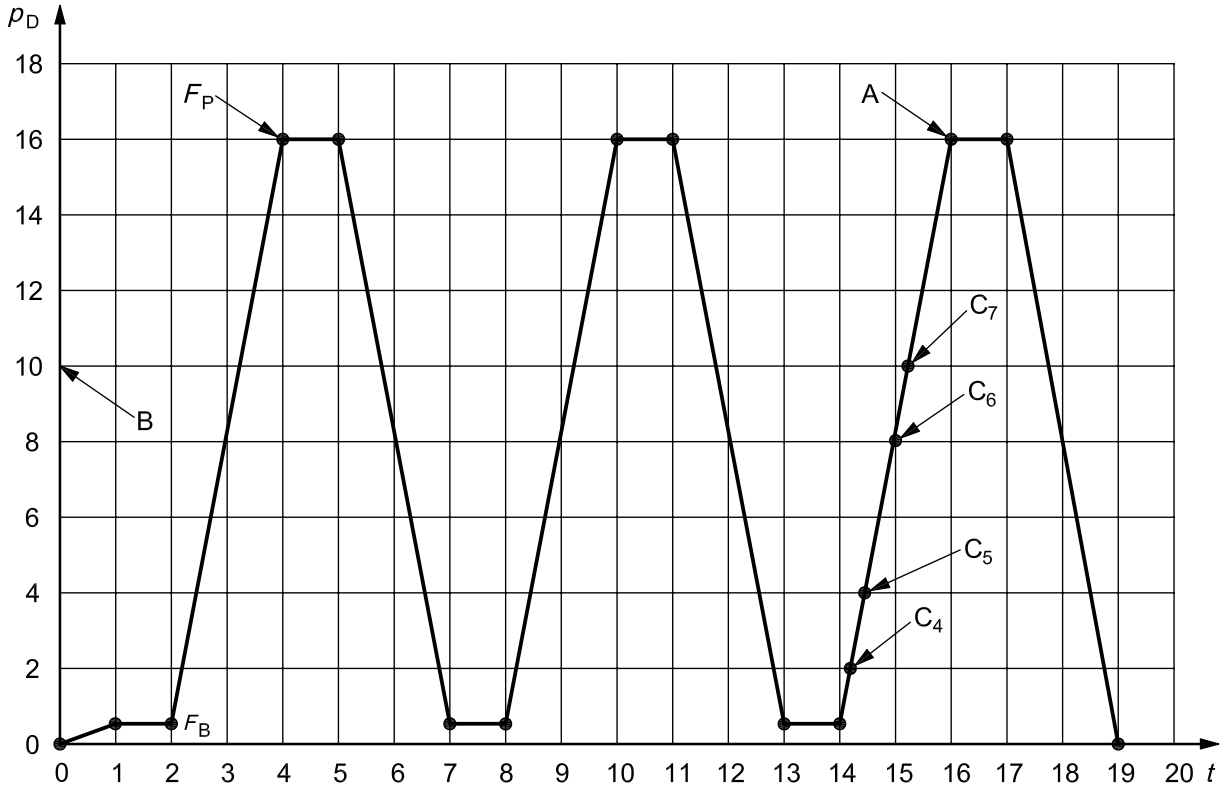


Key

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 pad assemblies only)

a) Test method A

Figure 5 (*continued*)



Key

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 pad assemblies only)

b) Test method B

Figure 5 — Compressive strain RT test cycle for 16 MPa (160 bar)

Annex A
(informative)

Example test report

Parameter		Test method A	Test method B
		Unit area pressure MPa (unless otherwise specified)	Line pressure MPa (unless otherwise specified)
Pre-load		0,5	0,5
Load rate		4 MPa/s	8 MPa/s
Maximum load (expressed in pressure)	Pad	8	16 or 10
	Lining	3	6
Measurement stages	Pad	1 2 4 8	2 4 8 16
	Lining	1,5 3	3 6
No. of cycles	Room temperature test	3	3
	Hot test	2	2
Sample size	Pad		
	Lining		
Ram type:	Flat surface:	Actual piston:	
Test date:			
Name of tester:			
Reference number:			
Lining manufacturer:			
Lining reference:			
Batch identification:			
Sample type:			
Special coatings, shims, etc.:			
Sample size:			
Assembly thickness $\overline{d_i}$ (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 MPa	$\overline{\varepsilon_{pA}}$	p_A MPa	C 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 —	
Heat transfer maximum temperature: **Thermal expansion: max. …… min. …… end ……** (µm)				
Characteristic curves attached? (Yes/No):				

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