



SURFACE VEHICLE STANDARD

J2468™**NOV2018**Issued 1999-04
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Superseding J2468 DEC2006

(R) High-Preload Deflection and Compressibility Test Procedures for Friction Materials

RATIONALE

The compressive response of a brake lining is an important design parameter when evaluating brake fluid volume consumption, brake pedal travel, or the propensity of a brake system to generate roughness (low-frequency vibration) or noise. Brake lining compressibility is also useful for lining characterization and quality control as part of the product specification and as part of regulatory requirements for certain markets. The purpose of this series of test procedures is to evaluate the compressibility of disc and drum brake friction materials and its assemblies.

This revision includes the following changes:

- a. Integration with the SAE J3079 series of recommended practices for deflection and compressibility measurements.
- b. Harmonization of sample types with other international standards.
- c. Improved layout to facilitate the execution of specific methods for different types of friction materials.

The SAE J3079 series of recommended practices include:

- Part 1 – Validation of Compressibility Test Systems for Brake Friction Materials
- Part 2 – Low-Preload Deflection Measurement for Brake Pads, Noise Shims, and Brake Pad Assemblies

1. SCOPE

This standard specifies a method for testing and measuring the deflection of friction materials assemblies and compressibility of friction materials. This standard applies to disc brake pad assemblies and its coupons or segments, brake shoe lining and its coupons or segments, and brake blocks segments used in road vehicles. This SAE test method is consistent in intent with the ISO 6310 and the JIS 4413.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless a specific revision is indicated, the latest issue of SAE publications shall apply.

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2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J3079-2 Low-Preload Deflection Measurement for Brake Pads, Noise Shims, and Brake Pad Assemblies

2.1.2 ISO Publications

Copies of these documents are available online at <http://website.ansi.org/>.

ISO 611 Road Vehicles - Braking of Automotive Vehicles and Their Trailers - Vocabulary

ISO 6310 Road Vehicles - Brake Linings - Compressibility Test Procedure

2.1.3 JIS Publications

Available from JSA, 4-1-24 Akasaka Minato-ku, Tokyo 107-8440, Japan, Tel: +81-3-3583-8005, www.jsa.or.jp.

JIS D 4413 Automotive Parts - Brake Linings and Disc Brake Pads - Compressibility Test Procedure

3. SYMBOLS AND DEFINITIONS

Table 1 - Symbols and definitions

Symbol	Definition	Units
A_o	Brake pad contact area with the rotor	mm ²
A_p	Piston(s) hydraulic area	mm ²
A_s	Sample or coupon contact area with heating platen	mm ²
c_i	Inner chamfer of piston adaptor	mm
c_o	Outer chamfer of piston adaptor	mm
d_c	Corrected deflection	μm
$d_{c,\%}$	Corrected deflection as a percent of total sample thickness	%
$d_{c,400}$	Corrected deflection at elevated temperature (400 °C)	μm
$d_{c,400,\%}$	Corrected deflection at elevated temperature (400 °C) as a percent of total sample thickness	%
d_e	Machine deflection	μm
$d_{e,400}$	Machine deflection at elevated temperature (400 °C)	μm
d_m	Measured deflection	μm
$d_{m,400}$	Measured deflection at elevated temperature (400 °C)	μm
d_o	Deflection offset	μm
$d_{o,400}$	Deflection offset at elevated temperature (400 °C)	μm
d_z	Zeroed deflection	μm
$d_{z,400}$	Zeroed deflection at elevated temperature (400 °C)	μm
h_{cycle}	Hysteresis for the entire cycle	%
h_{load}	Hysteresis at a specific step (equivalent hydraulic pressure or force) within the cycle	%
h_o	External height of the piston simulator without the interface feature with the upper platen	mm
h_i	Internal depth of the piston simulator	mm
F	Total force applied to the sample during testing	N

Symbol	Definition	Units
P_{eq}	Equivalent hydraulic pressure	kPa
t_a	Total assembly thickness	mm
t_b	Backing plate (or shoe table) thickness	mm
t_f	Friction material thickness	mm
r_i	Inner radii of piston adaptor	mm
r_o	Outer radii of piston adaptor	mm

3.1 COMPRESSIBILITY

Compressibility is the transient deflection or reduction in thickness of the brake friction material or brake pad assembly, due to compressive load. The actual dimensions (thickness, flatness, parallelism, etc.) and shape of the friction material under testing will also influence the compressibility characteristics and behavior. For brake pad assemblies, compressibility can also include the deflection of the noise shims (μm).

3.2 CORRECTED DEFLECTION (d_c) AND CORRECTED DEFLECTION AT ELEVATED TEMPERATURE ($d_{c,400}$)

Measured deflection minus the machine deflection using Equation 1:

$$d_c = d_m - d_e \quad \text{Eq. 1A}$$

$$d_{c,400} = d_{m,400} - d_{e,400} \quad \text{Eq. 1B}$$

3.3 CORRECTED DEFLECTION AS A PERCENT OF TOTAL SAMPLE THICKNESS ($d_{c,\%}$) AND CORRECTED DEFLECTION AT ELEVATED TEMPERATURE AS A PERCENT OF TOTAL SAMPLE THICKNESS ($d_{c,400,\%}$)

Measured deflection minus the machine deflection using Equation 2 to express it as a percent of the total sample thickness:

$$d_{c,\%} = (d_m - d_e)/t_a \quad \text{Eq. 2A}$$

$$d_{c,400,\%} = (d_{m,400} - d_{e,400})/t_a \quad \text{Eq. 2B}$$

Alternatively, use t_f instead of t_a when there is no backing plate on the sample under testing.

3.4 DEFLECTION OFFSET (d_o)

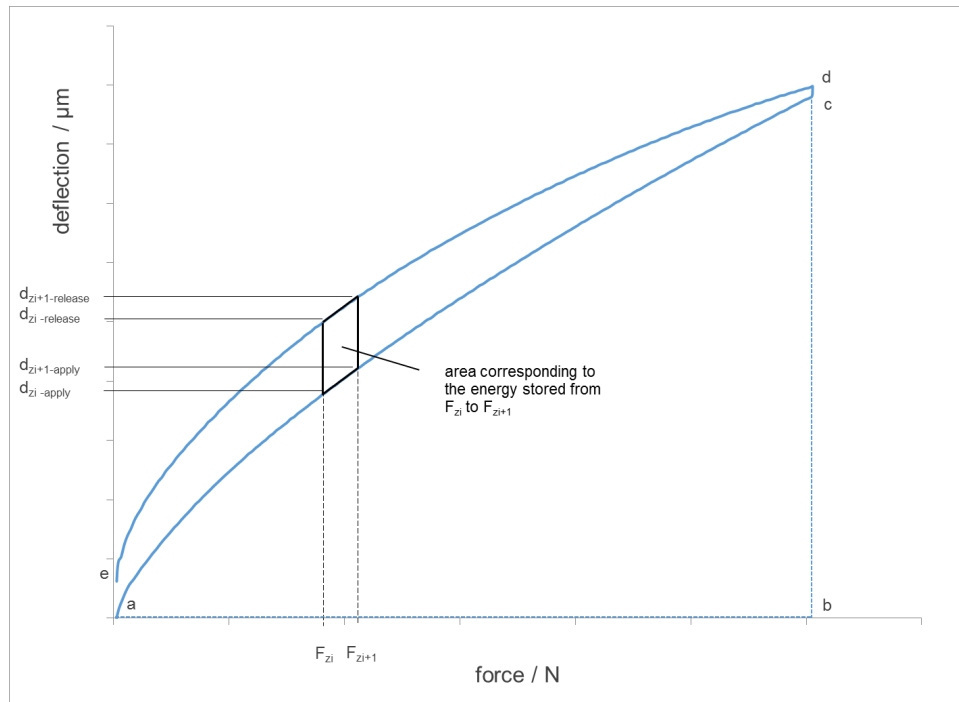
Deflection offset is the corrected deflection value 0.5 seconds prior to the loading cycle.

3.5 EQUIVALENT HYDRAULIC PRESSURE (p_{eq})

Pressure calculated by dividing the apply force by the total piston hydraulic area.

3.6 HYSTERESIS PER CYCLE (h_{cycle}) AND CYCLE HYSTERESIS

Hysteresis is the lag in deflection that occurs with brake pads and shims during the unloading condition compared to the loading condition. Hysteresis creates a loop in the deflection versus load curve and depends, among other parameters, on the load application rate, the dwell times, and the material under testing. Calculate hysteresis as the ratio (or percent) of the stored energy over the total input energy during the apply cycle. See Figure 1; use Equations 3 through 5.



Area a-b-c: total input energy during the apply cycle

Area a-c-d-e: total energy stored within the hysteresis loop

Figure 1 - Deflections and forces to calculate cycle hysteresis

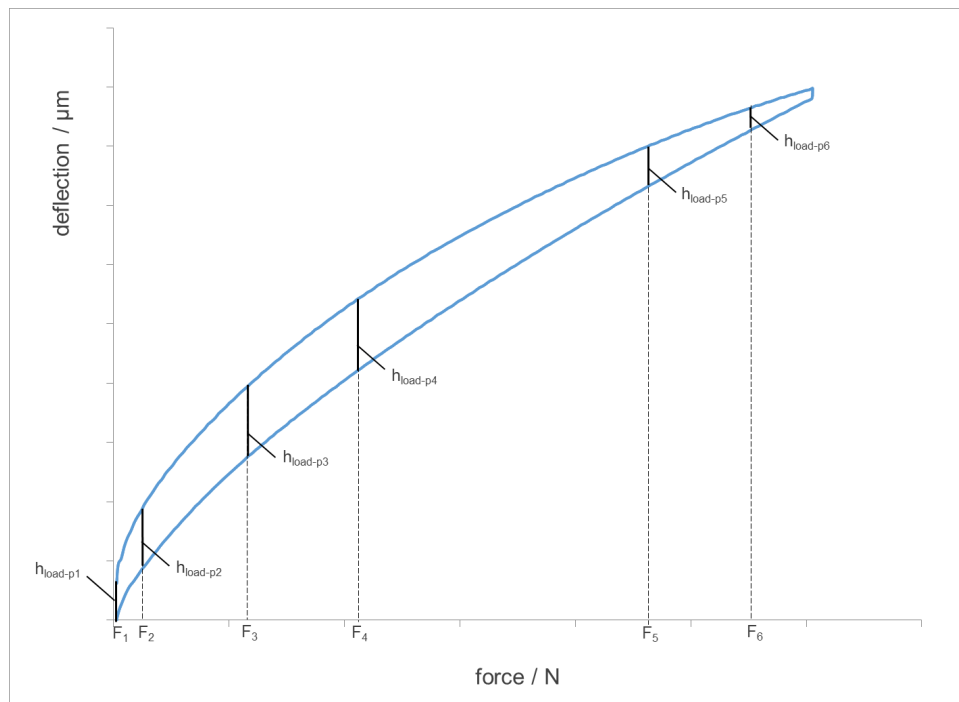
$$h_{load} = \frac{E_{release} - E_{apply}}{E_{apply}} \quad \text{Eq. 3}$$

$$E_{apply} = \sum_{z=1}^n (F_{zi+1} - F_{zi})(d_{zi+1\ apply} + d_{zi\ apply})/2 \quad \text{Eq. 4}$$

$$E_{release} = \sum_{z=1}^n (F_{zi+1} - F_{zi})(d_{zi+1\ release} + d_{zi\ release})/2 \quad \text{Eq. 5}$$

3.7 HYSTERESIS AT LOAD (h_{load})

Hysteresis for a given load is defined as the difference between the deflection during the release step minus the deflection during the apply step. Use only the zeroed deflection d_z for this calculation. Alternatively, express h_{load} as a percent of the deflection during the apply step. See Figure 2; use Equation 6.



$F_1, F_2, \dots, F_6$: specific load steps or loads equivalent to specific hydraulic pressure levels

$h_{load-p1}, h_{load-p2}, \dots, h_{load-p6}$: hysteresis for load steps one to six

Figure 2 - Deflections and forces to calculate hysteresis

$$h_{load-i} = d_{zi\ release} - d_{zi\ apply}$$

Eq. 6

3.8 LOAD CYCLE

Load cycle is the loading of the test sample that occurs after the preload. For this test procedure, the load cycle uses a constant rate to apply load during the apply and release conditions, with a constant load dwell time at the maximum and at the minimum loads.

3.9 MEASURED DEFLECTION (d_m)

Deflection measured during the test.

3.10 MACHINE DEFLECTION (d_e)

Deflection measured during the third cycle of the machine deflection test.

3.11 PISTON HYDRAULIC AREA (A_p)

Area of the caliper bore used to convert the test system's actuator load to equivalent hydraulic pressure. This area is generally larger than the area calculated using the outside diameter of the piston simulator.

3.12 PISTON SIMULATOR

The piston simulator is a device used to apply the load to the test sample, replicating the interface with the caliper piston(s) from the caliper assembly.

NOTE 1: When the actual dimensions of the piston(s) is(are) not available, use a standard piston simulator with dimensions agreed upon with the test requestor.

NOTE 2: In order to ensure the correct loading, use the diameter(s) equivalent to the equivalent hydraulic area(s) from the caliper assembly.

3.13 PRELOAD

Preload is the steady state load applied to the test sample prior to the load cycle.

3.14 ZEROED DEFLECTION (d_z)

Corrected deflection adjusted to 0.0 μm during the pre-load condition 0.5 seconds prior to the loading cycle. Use Equation 7.

$$d_z = d_c - d_o$$

Eq. 7

4. EQUIPMENT

The test equipment needs to be capable of meeting the specifications indicated on Table 2. In addition, reference any specific requirements for deflection and compressibility cycles.

Table 2 - Minimum test system capabilities and specifications

Parameter	Minimum requirement or capability
The test facilities and equipment shall be in good working order and shall have a valid calibration label	Calibration records
Load capacity for hydraulic brake applications – approximately to allow a twin 60 mm piston simulator at 10000 kPa of equivalent system pressure	60 kN
Load capacity for air disc brake applications – approximately to allow a 200 cm^2 pad at 8 MPa of equivalent contact pressure	160 kN
Analog-to-digital converter for force measurement	16-bit minimum
Rate to apply the equivalent system pressure	1000 to 10000 kPa/s
Control of equivalent pressure at pre-load	± 5 kPa
Control of equivalent pressure at target load	± 10 kPa
Rated accuracy for instrumentation controlling equivalent system pressure	± 5 kPa
Signal noise for instrumentation controlling equivalent system pressure	≤ 5 kPa
Resolution of deflection measuring device	± 0.1 μm
Force exerted on piston simulator by the deflection measuring device	< 1 N
Flatness and parallelism of steel plate	< 2 μm
Temperature control accuracy of heating platen	± 2 $^{\circ}\text{C}$
Sampling rate for force and deflection measurement	1000 Hz
Sampling rate for temperature measurement	50 Hz

4.1 Facilities

Test facility capable of maintaining test equipment and test hardware at $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$ and $50\% \pm 10\%$ RH.

4.2 Test Stand

A compressibility test stand with uniaxial load frame and loading device that provides loading of the test specimen, similar to how it is loaded by the piston and rotor in a brake caliper assembly.

4.3 Alignment System

The test stand must have self-alignment capability to allow the piston simulator to align its contact surface to the specimen under test. The alignment system cannot cause extra compliance in the deflection measurement of the test specimen.

4.4 Deflection Measurement Device

Use a device for measuring piston simulator deflection with a resolution of $\pm 0.1 \mu\text{m}$. Deflection measurement device shall exert less than 1.0 N of force during measurement.

NOTE: Accuracy in a range of one-tenth of a micron requires attention to cleanliness and verification that plates, adaptors, and test pieces do not contain burrs and other contaminants.

4.5 Test Stand Verification

Verify the measurement capability of the test stand using with the following items:

- a. Appropriate checklists to verify features, functionality, and specifications (full scales, accuracies, sampling rates, etc.).
- b. Verification of apply rate and deflection measurement using the standard and (optional) soft judge devices.
- c. Gage repeatability and reproducibility study with at least 10 preselected brake pads and at least three operators, with three repeats each.

4.6 Test Stand Condition

All test equipment, fixtures, and samples shall be inspected prior to use. Nicks, burrs, corrosion, or contamination on any contacting surfaces can cause variation in the test equipment that can exceed the intended measurement capability of the test procedure.

4.7 Steel Plate

A 15 mm thick steel plate made of the same material as the heating platen is required. Length, width, surface finish, and flatness of steel plate shall allow full surface contact between the steel plate and piston simulator, and between the steel plate and heating platen. The steel plate is intended to reduce the potential for damaging the heating platen during piston simulator baseline deflection measurements. Maintain and verify the flatness and parallelism to be within $2 \mu\text{m}$.

NOTE 1: The steel plate is a precision device. It must be protected during storage to avoid contact with other parts, and they must be stored in an environmentally controlled location. Conduct a visual inspection prior to testing. The surface topography should be verified annually, using optical or laser holography. Verify flatness and parallelism to be within specification. If any part of these devices show surface damage (nicks, corrosion, or excessive material deposits), they should be reworked and re-qualified, or replaced.

NOTE 2: A poor-quality steel block (high surface roughness or lack of flatness) can cause extra deflection during the machine baseline measurement. This additional deflection can lower the compensated results in 2 to $5 \mu\text{m}$.

4.8 Sample Locator; Pad Locator

A fixture shall be used to locate the brake pads relative to the piston simulator to duplicate the alignment of the brake pad with the caliper piston (see Figure 2). The pad-locating device shall have 0.5 to 1.0 mm clearance from the friction material edges, to avoid constraining the test specimen during the load application. Ensure the sample locator does not interfere with either the pad or the noise shim.

NOTE: Common pad-locator dimensions do not assure common pad alignment from machine to machine, even from the same supplier. Verify for each machine the alignment of the sample and the piston simulator. Include in the test report a picture of the sample (pad) locator used for the test.