SAE International™

SURFACE VEHICLE STANDARD

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(R) Road Vehicles—Brake Linings—Compressibility Test Procedure

RATIONALE

Adjusted test pressures to be consistent with US usage and practice. Allowed use of constant crosshead speed control equipment and constant loading rate equipment.

FOREWORD

The compressive response of a brake lining is an important design parameter when evaluating brake fluid volume displacement, brake pedal travel, or the propensity of a brake system to generate roughness or noise. Brake lining compressibility is also useful for lining characterization and quality control. The purpose of this test procedure is to evaluate the compressibility of disc brake friction materials and brake pad assemblies.

1. SCOPE

This SAE Standard specifies a method for testing and measuring the compressibility of friction materials and disc brake pad assemblies to be used in road vehicles. This SAE test method is consistent in intent with ISO 6310.

2. REFERENCES

2.1 Applicable Publications

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest version of SAE publications shall apply.

2.1.1 ISO Publications

Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ISO 611:1994 Road vehicles—Braking of automotive vehicles and their trailers—Vocabulary

ISO 6310:1998 Road vehicles—Brake linings—Compressibility test procedure

2.1.2 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. DEFINITIONS

3.1 Compressibility

Compressibility is the absolute deflection, C, or reduction in thickness of the brake lining due to the compressive forces and temperatures given in this document. Compressibility is a measure of the brake lining assembly and is dependent upon assembly geometry. Deflection is measured in the direction of the application force, perpendicular to the friction surface. Sample deflection or reduction in thickness is measured in microns (μm). Sample deflection or reduction in thickness is the recommended description of lining compressibility.

3.2 Compliance

Rate of change of the deflection of the brake lining with change in compressive force, measured at a particular force value is known as compliance, k_x. Compliance is the instantaneous slope of the deflection-load curve measured during application of compressive force perpendicular to the friction surface. The units of compliance as defined here are μm/N.

3.3 For other definitions relating to brake system components and design, see ISO 611.

3.4 This document allows for lining compressibility testing of two configurations; the sample types are described here:

3.4.1 Sample Type I

Disc brake pad assembly (friction material and backing plate.) Sample Type I is commonly used for passenger car and light truck applications.

3.4.2 Sample Type II

Lining assembly coupon.

A coupon may be sectioned from a large disc assembly, and the friction material may be removed from the backing plate if desired. It is recommended that coupon sample should be as large as possible to account for material inhomogeneity. Surfaces of specimen should be flat and parallel.

4. SYMBOLS AND UNITS

See Table 1.

TABLE 1 - SYMBOLS AND UNITS

Parameter	Symbol	Equation	Unit
Initial thickness of friction material	t_0		mm
Initial thickness of assembly	a_0		mm
Displacement measurement	d		μm
Deflection of the test machine (without sample)	d_e		μm
Sample contact area of friction material	Ao		cm^2 or μm^2
Compressibility (or reduction of thickness under load)	C	$= d - d_e$	μm
Compliance at load x, (where L is load)	K_x	$=\left(\frac{\partial C}{\partial L}\right)_{L=x}$	μm/N

5. EQUIPMENT

The test equipment should include:

a. A compressibility test stand, uniaxial material testing load frame or a loading device that provides uniform loading over the surface of the test specimen.

b. A loading cylinder to simulate a caliper piston configuration or other brake application mechanism.

c. A compression platen.

d. A device to measure applied compression force to an accuracy of 1% full scale load of test machine.

e. A gauge for measuring the deflection of the sample to an accuracy of 0.001 mm. This gauge should be positioned either on the loading cylinder or the platen and in contact with the ram as near to its center line as possible.

f. A recording device or computer to log the measured load and/or pressures, displacements, temperatures as function of time.

g. A heating device to raise the temperature of the platen to a specified temperature and a thermocouple to monitor that temperature.

h. A thermocouple or device to measure the temperature of the test sample.

i. A micrometer.

6. TEST RIG SPECIFICATION

6.1 Loading

6.1.1 For hydraulic disc brakes, the maximum force required is that which corresponds to the service maximum vehicle system line pressure or 100 bar simulated line pressure. The recommended loading rate is that which achieves 15 mm/min when testing in crosshead speed control, or 80 bar/s (4 MPa/s) simulated line pressure if testing in constant loading rate control. The testing machine must have self-aligning capability or parallelism between the platen and ram loading face must be maintained.

6.1.2 For air operated disc brakes, the maximum force required shall correspond to 80 bars (8 Mpa) unit pressure on the friction surface, also called as face pressure.

6.2 Elevated Temperature Capability

400 °C.

6.3 Loading Configurations

6.3.1 Sample Type I, Disc Brake Pad Assembly

See Figure 1.

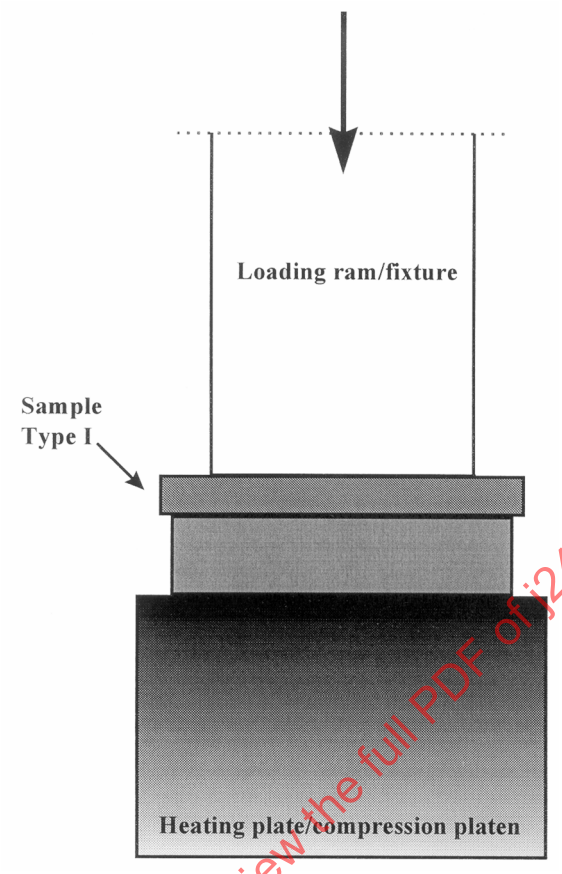

FIGURE 1 - SAMPLE TYPE 1: BRAKE LINING ASSEMBLY

A fixture representing a piston is introduced between the ram and the friction material pad such that the loading surface has the same form and location as the actual contact surface of the piston in which the pad will be used in service. If the intended brake system has a dual piston caliper, a dual piston-shaped loading fixture should be used.

6.3.2 Sample Type II, Friction material Coupon Sample

See Figure 2.

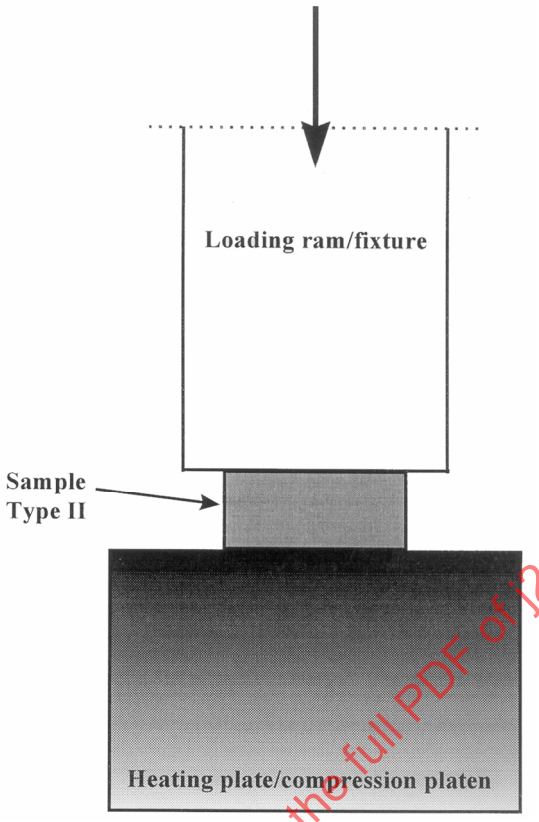

FIGURE 2 - SAMPLE TYPE II FRICTION MATERIAL COUPON

Coupons should be tested with a parallel metal adapter plate, of larger dimensions than the coupon, to uniformally distribute the load over the coupon surface. (A fixture simulating a piston is not recommended for this sample type.)

6.4 Compensation of Deflection of the Test Machine

During compression testing, a test machine will also deflect. This deflection has to be compensated for (manually or automatically) in the determination of the net displacement of the friction material sample. The deflection of the test device, d_e, is measured by loading the ram with the piston fixture in place on the base platen without a sample installed and then recording displacement at the test pressures. Compressibility or deflection of the sample is then $C = d - d_e$.

7. SAMPLING AND PREPARATION OF SAMPLES

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

7.2 The flatness and surface roughness of the samples should be that of normal production.

7.3 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. When testing to evaluate the full disc brake pad assembly, backing materials may be left on.

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

8. TEST PROCEDURE

8.1 Ensure that test stand is properly calibrated.

8.2 Measure the thickness of Sample Type I at 5 points as in Figure 3 with a micrometer. Calculate the mean value a_0, of the assembly thickness. (If the pad sample contains a slot, then take the center measurement just adjacent to the slot.) Measure the thickness of Sample Type II at 5 points similarly distributed.

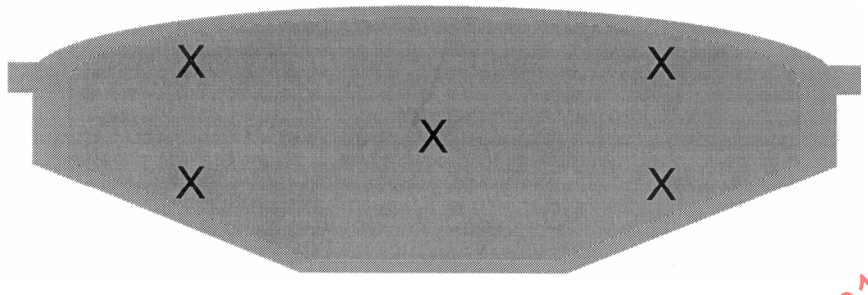

FIGURE 3 - RECOMMENDED THICKNESS MEASUREMENT POSITIONS FOR SAMPLE TYPE I (IF LINING HAS A CENTER SLOT, SHIFT CENTER POSITION MEASUREMENT TO APPROXIMATELY 3 mm FROM THE SLOT.)

8.2.1 If the compressive strain of the friction material is required, then the friction material thickness, t_0, independent of the backing plate, must be determined.

8.3 Measure and record nominal sample contact area, A_o.

8.4 Place the sample on the platen at room temperature (23 °C ± 5 °C) with its friction surface against the surface of the platen with the ram and piston fixture correctly located. Careful centering of the sample beneath the loading (piston) fixture is important for repeatability of results.

8.5 Test Sequence

The room temperature test sequence is illustrated in Figure 4 and is described as follows:

8.5.1 Room Temperature Test

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

8.5.1.2 Zero the displacement gage while the sample is held at pre-load.

8.5.1.3 Perform three loading and unloading cycles starting from the pre-load. A cycle consists of increasing to the maximum pressure at the rate specified in Table 2, then unloading at the same rate to the pre-load value. The recommended maximum force is that which yields a system pressure as stated in Table 2 for the listed time period. An alternative maximum pressure or time can be used for specific applications. If deviating from the specified values, note maximum pressure and hold time on test report.

TABLE 2 - TEST CYCLE CONDITIONS

Brake Input Mechanism	Application Rate	Maximum Pressure	Maximum Pressure Hold Time
Hydraulic	15 mm/min or 80 bar/s	100 bar (10 MPa) simulated input pressure	1 second
Air	3.0 ± 0.5 MPa/s	8.0 MPa unit face pressure	1 second

For testing sample Type II, the maximum load should be the same fraction of the system maximum that corresponds to the fraction of the sample area with respect to the full pad contact area. (For example, if a 10 cm^2 small sample is cut from a 60 cm^2 pad, then to achieve the same pressure at the contact area, the maximum load value should be 1/6th that of the full pad test.) If deviating from this prescribed maximum condition, note conditions on test report.

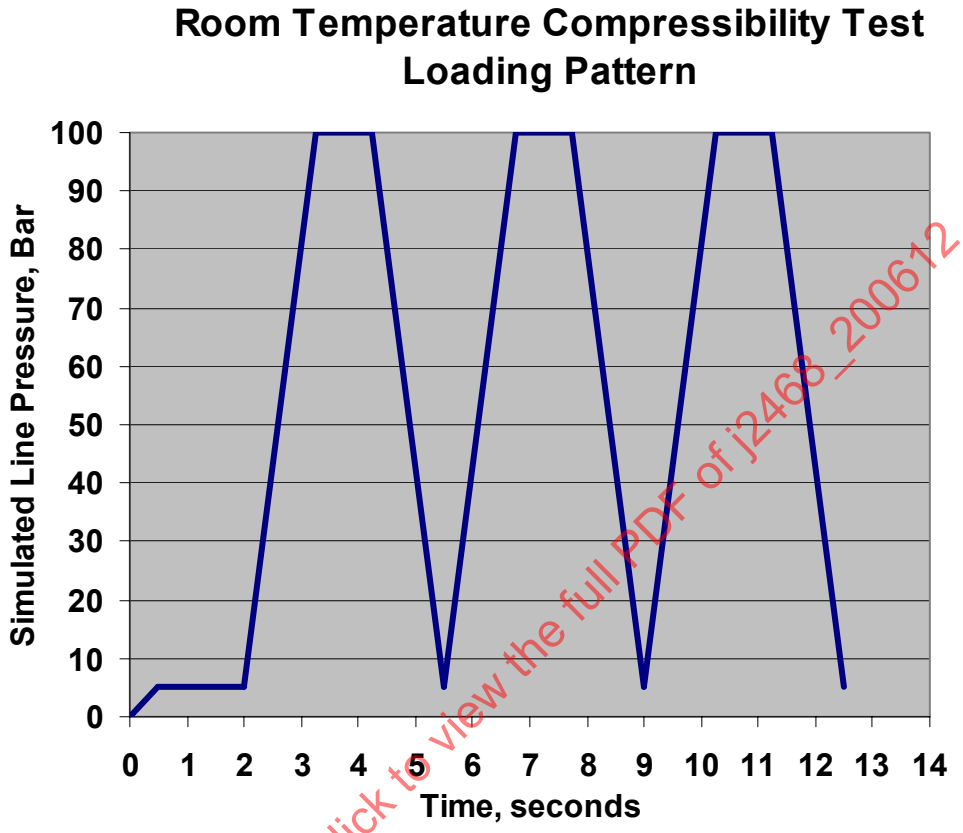

FIGURE 4 - ROOM TEMPERATURE COMPRESSIBILITY TEST SEQUENCE

8.5.1.4 Measure displacement and load during the loading cycles. If computer data acquisition is available, it is recommended that continuous displacement versus pressure (and load) be recorded. Displacement should be recorded and reported at the maximum pressure on the first cycle and last cycle, and in addition on the last cycle, readings should be recorded at several points while the pressure increases.

8.5.2 Hot Test

The hot test is conducted at 400 °C or the maximum anticipated operating temperature.

8.5.2.1 Remove sample from the heating plate. Preheat the heating plate to a stabilized surface temperature of 400 °C ± 10 °C.

8.5.2.2 Place the same sample on the heating plate and apply pre-load of 5 bar (0.5 MPa).

8.5.2.3 Zero the displacement gauge.

8.5.2.4 Maintain the pre-load for 10 min ± 30 s. Record changes in displacement during this preheat, pre-load period.

8.5.2.5 Re-zero the displacement gauge.