

Submitted for recognition as an American National Standard

**Road Vehicles—Brake Linings—Compressibility Test Procedure**

**Foreword**—The compressive nature 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. The purpose of this test procedure is to evaluate the compressibility of friction materials and disc 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.

**2.1.1 ISO PUBLICATIONS**—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8006.

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

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

**3. Definitions**

**3.1 Compressibility of brake friction materials** can be described in three ways.

**3.1.1 REDUCTION IN THICKNESS**—The absolute deflection,  $D$ , or reduction in thickness of the brake lining due to the compressive forces and temperatures given in this document. 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 ( $\mu\text{m}$ ). Sample deflection or reduction in thickness is the recommended description of lining compressibility.

**3.1.2 COMPRESSIVE STRAIN**—The relative change in thickness of the brake lining sample due to the compressive forces and temperatures given in this document. Compressive strain is simply the deflection of the sample divided by the initial sample thickness. Compressive strain is measured in the direction of the application force, perpendicular to the friction surface. Strain is unit-less. Compressive strain can also be described as a percent change in thickness.

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be reaffirmed, revised, or cancelled. SAE invites your written comments and suggestions.

**QUESTIONS REGARDING THIS DOCUMENT: (724) 772-8512 FAX: (724) 776-0243**  
**TO PLACE A DOCUMENT ORDER: (724) 776-4970 FAX: (724) 776-0790**  
**SAE WEB ADDRESS <http://www.sae.org>**

3.1.3 COMPLIANCE—Rate of change of the deflection of the brake lining with change in compressive force, measured at a particular force value. 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  $\mu\text{m}/\text{N}$ .

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

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

3.3.1 SAMPLE TYPE I—Disc brake pad assembly (friction material and backing plate.)

3.3.2 SAMPLE TYPE II—Friction material coupon.

A friction material coupon may be sectioned from an assembly, and the friction material may be removed from the backing plate if desired. It is recommended that a material coupon sample be circular and large enough 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                         | $d$                  |                                                        | $\mu\text{m}$          |
| Deflection of the test machine (without sample)  | $d^e$                |                                                        | $\mu\text{m}$          |
| Deflection of sample (or reduction of thickness) | $D$                  | $= d - d^e$                                            | $\mu\text{m}$          |
| Compressive strain of assembly                   | $e_a^{\text{comp}}$  | $= D / a_0$                                            |                        |
| Percent reduction in thickness                   | $\% e^{\text{comp}}$ | $= 100 (D/a_0)$                                        | %                      |
| Compliance at load $x$ , (where $L$ is load)     | $K_x$                | $= \left( \frac{\partial D}{\partial L} \right)_{L=x}$ | $\mu\text{m}/\text{N}$ |

5. **Equipment**—The test equipment should include:

- A loading device that provides uniform loading over the surface of the test specimen.
- A loading cylinder to simulate a caliper piston configuration.
- A compression platen.
- A device to measure applied compression force to an accuracy of 1% full scale load of test machine.
- A gauge for measuring the deflection of the sample to an accuracy of 0.001 mm. This gauge should be positioned either on the sample or the platen and in contact with the ram as near to its center line as possible.
- A recording device or computer to log the measured load and/or pressures, displacements, and temperatures.
- A heating device to raise the temperature of the platen to a specified temperature and a thermocouple to monitor that temperature.
- A thermocouple or device to measure the temperature of the test sample.
- A micrometer.

## 6. Test Rig Specification

**6.1 Loading**—The maximum force required is that which corresponds to the service maximum vehicle system line pressure, e.g., 160 bar. The recommended loading rate is that which achieves 80 bar/s simulated line pressure. The testing machine must have self-aligning capability or parallelism between the platen and ram loading face must be maintained.

**6.2 Elevated Temperature Capability**—400 °C

### 6.3 Loading Configurations

**6.3.1 SAMPLE TYPE I, DISC BRAKE PAD ASSEMBLY**—See Figure 1.

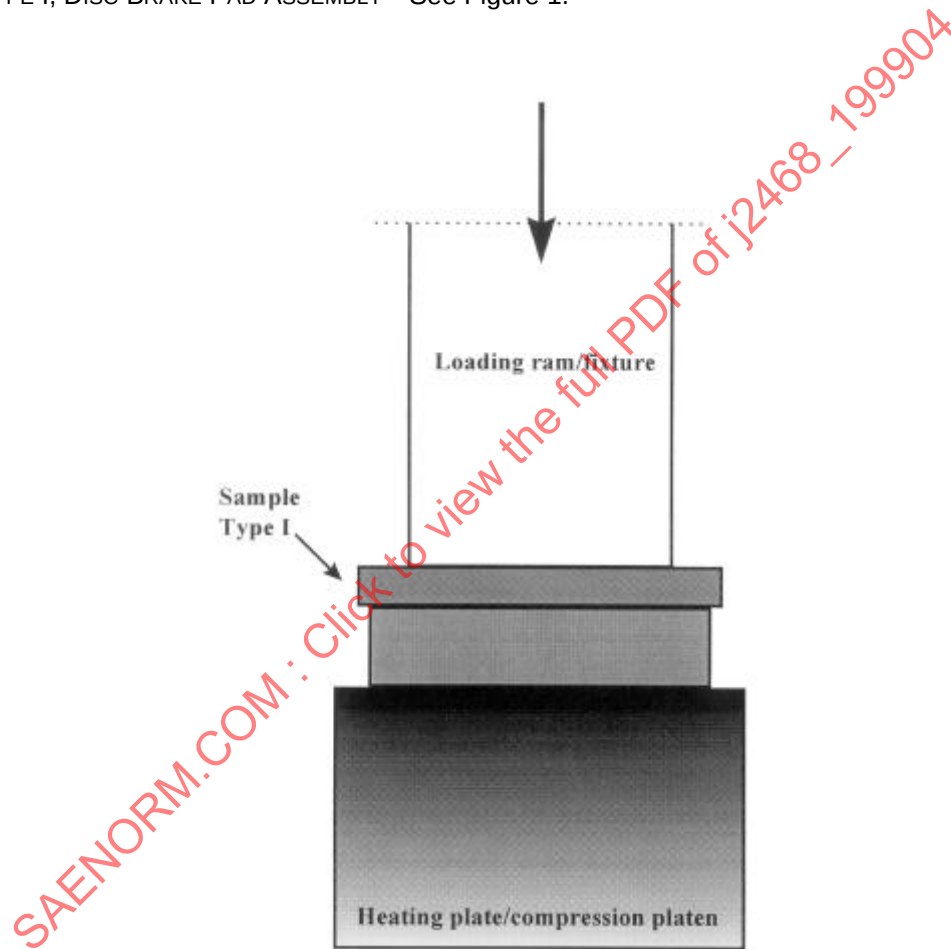


FIGURE 1—SAMPLE TYPE 1: BRAKE LINING ASSEMBLY

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 or caliper in which the pad will be used in service. If the intended brake system has a dual piston caliper, it is recommended to use a single piston simulator cylinder of contact area equivalent to the total piston contact area in the caliper.

6.3.2 SAMPLE TYPE II, FRICTION MATERIAL COUPON SAMPLE—See Figure 2.

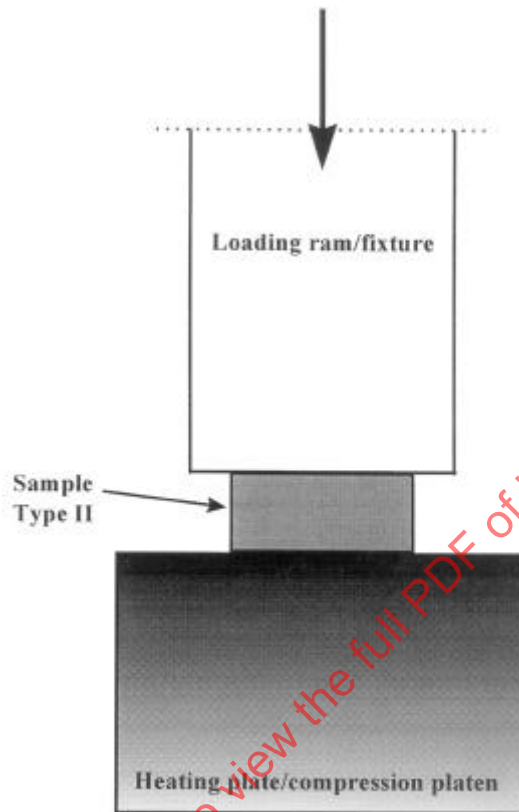


FIGURE 2—SAMPLE TYPE II: FRICTION MATERIAL COUPON

Use a flat loading fixture of area equal to or larger than the sample area so that the entire face of the sample is uniformly loaded. (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.

**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.

## 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.)

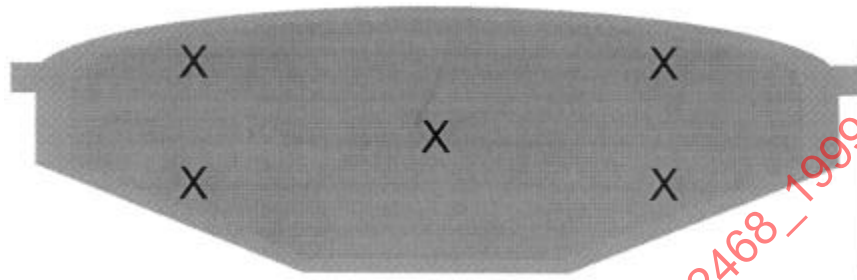


FIGURE 3—RECOMMENDED THICKNESS MEASUREMENT POSITIONS FOR SAMPLE TYPE I  
(IF LINING HAS A CENTER SLOT, SHIFT CENTER POSITION MEASUREMENT TO  
APPROXIMATELY 3 MM FROM THE SLOT.)

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.

8.4 Place the sample on the platen at room temperature ( $23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ ) with its friction surface against the surface of the platen with the ram and piston fixture correctly located.

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 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 a rate of 80 bar/s then unloading at the same rate to the pre-load value. The recommended maximum force is that which yields a system hydraulic pressure of 160 bar (16 MPa). An alternative maximum pressure can be used for specific applications.

For testing sample Type II, the maximum load should be the 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  $10\text{ cm}^2$  small sample is cut from a  $60\text{ cm}^2$  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.)

### Room Temperature Compressibility Test Loading Pattern

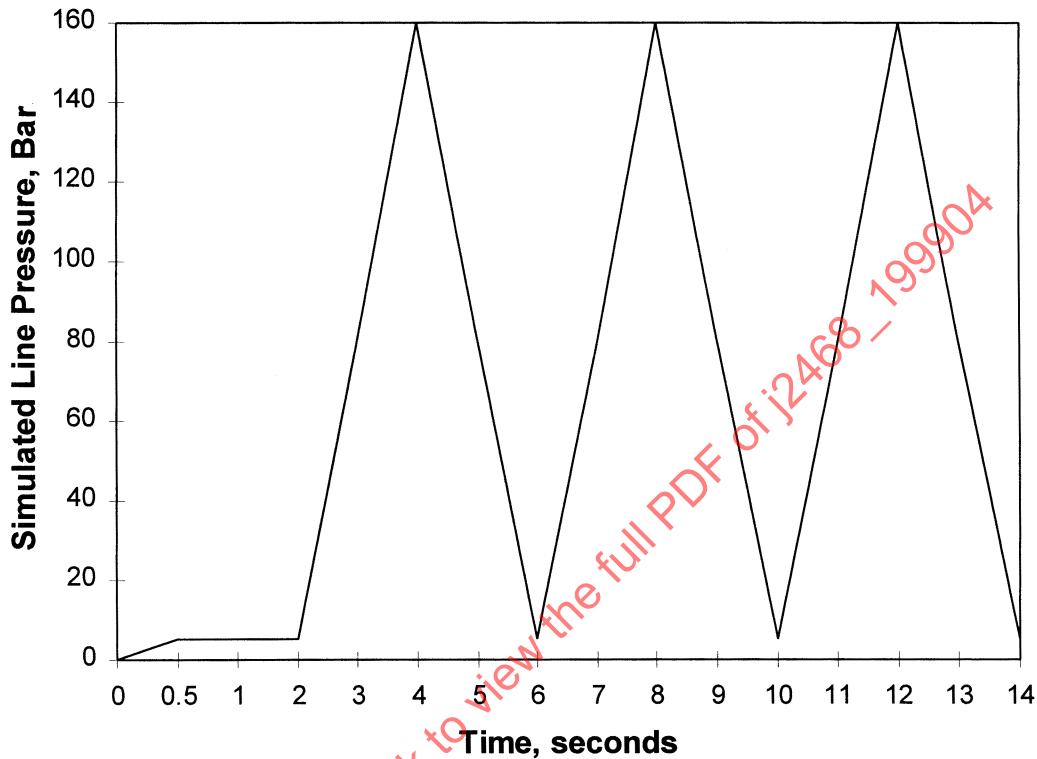


FIGURE 4—ROOM TEMPERATURE COMPRESSIBILITY TEST SEQUENCE

- 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 a pre-load of 5 bar (0.5 MPa).
- 8.5.2.3 Zero the displacement gage.
- 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 gage.
- 8.5.2.6 Perform two loading-unloading cycles. Use same loading parameters as used for room temperature cycles described in 8.5.1. Following hot test, cool equipment to ambient temperature.