



SURFACE VEHICLE RECOMMENDED PRACTICE

J2968™/1

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Measurement of Material Properties for Wet Friction Materials

RATIONALE

This SAE Recommended Practice addresses the need for a standardized test procedure to measure the material properties for wet friction materials.

1. SCOPE

This SAE Recommended Practice is intended as the definition of a standard test, which may be subject to frequent change to keep pace with experience and technical advances. This should be kept in mind when considering its use.

The specific purpose of this SAE Recommended Practice is to define a procedure to determine intrinsic properties of friction materials such as compressive modulus and rebound/recovery time at specific fatigue test pressures. Results from this test will both independently characterize the friction material and serve as input to the compression fatigue test.

NOTE: If this test is intended to determine the rebound interval for the compression fatigue test, then the maximum test pressure ($P_{\max}$) in this procedure must be selected with future fatigue testing levels in mind. It is important that the rebound time is sufficient at the maximum apply pressure to allow the material to rebound back to its original thickness.

Standard reporting processes are recommended. This procedure is intended for use by both suppliers and end users of wet friction materials.

The only variables selected by the supplier or user of the friction system are:

- Friction material.
- Fluid.
- Maximum load.
- Fatigue test cycle requirements.

These variables must be clearly identified when reporting the results of this test. Data shall not be reported as having been obtained using this procedure if any test parameters or system hardware described in this document are changed or deviated from in any way (other than the variables described above).

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2. REFERENCES

2.1 Applicable Documents

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

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 J286 SAE No. 2 Clutch Friction Test Machine Guidelines

SAE J1646 Glossary of Terms - Lubricated Friction Systems

SAE J2468 High-Preload Deflection and Compressibility Test Procedures for Friction Materials

SAE J3079/1 Validation of Compressibility Test Systems for Friction Materials

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

3. DEFINITIONS

Table 1 - Symbols and definitions

Symbol	Definition	Units
A_o	Sample disc surface area	mm ²
t_i	Friction material initial thickness (before first compression)	μm
$t_{f,n}$	Sample compacted thickness at end of cycle n	μm
W_s	Diameter of friction material sample	mm
W_r	Inner diameter of sample receptacle	mm
W_p	Diameter of plunger	mm
H_r	Inside height of receptacle	mm
H_p	Height of plunger	mm
d_c	Corrected deflection	μm
d_e	Machine deflection	μm
d_m	Measured deflection	μm
d_o	Deflection offset	μm
d_z	Zeroed deflection	μm
d_{max}	(compensated) deflection - 2 seconds after target load achieved	μm
F	Total force applied to the sample during testing	kN
P_{eq}	Equivalent hydraulic pressure	MPa
t_a	Total assembly thickness	mm
P_{max}	Pressure at maximum compression set (12 or as needed for the application)	MPa
P_{init}	Pressure at first (initial) compression set (2)	MPa
P_{step}	Pressure interval between compression sets (2)	MPa
N_{cyc}	Number of cycles to be performed at every pressure interval (50)	---
$R_{95\%}$	Rebound time (95%)	seconds

3.1 COMPRESSIBILITY

Compressibility is the transient deflection or reduction in thickness of the test sample due to compressive load. Deflection is measured in the direction of the applied load, normal to the friction surface. Deflection or reduction in thickness is measured in micrometers (μm).

3.2 CORRECTED DEFLECTION (d_c)

Corrected deflection is the measured sample deflection minus the machine deflection using Equation 1:

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

3.3 DEFLECTION OFFSET (d_o)

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

3.4 EQUIVALENT HYDRAULIC PRESSURE (p_{eq})

Equivalent hydraulic pressure is calculated by dividing the apply force by the sample disc surface area.

3.5 LOAD CYCLE

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

3.6 MEASURED DEFLECTION (d_m)

Deflection measured during the test.

3.7 MACHINE DEFLECTION (d_e)

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

3.8 SAMPLE DISC SAMPLE AREA (A_o)

Surface area of circular friction material sample disc. Calculated from disc diameter as:

$$A_o = \pi (W_s/2)^2 \quad (\text{Eq. 2})$$

The sample area is used to compute the force requirement for equivalent hydraulic pressure.

3.9 PRELOAD

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

3.10 ZEROED DEFLECTION (d_z)

Corrected deflection adjusted to 0.0 μm during the preload condition 0.5 second prior to the loading cycle. Use Equation 3.

$$d_z = d_c - d_o \quad (\text{Eq. 3})$$

4. TEST MATERIALS

4.1 Friction Material Samples

4.1.1 Three samples minimum per material should be used for testing.

4.1.2 Samples should be friction material only and 30 mm or 32 mm in diameter.

4.1.3 Samples should have no core plate and no adhesive. Testing should be performed at the bonded material density and thickness.

- 4.1.3.1 If necessary, friction material shall be subjected to a temperature and loading cycle like that experienced when the material is bonded to a production intent core plate. This step ensures the material is in a condition as similar as possible to that intended when installed in the final wet clutch system.
- 4.1.3.2 Note that samples such as woven materials may require bonding to the core plate to maintain material integrity.
- 4.1.4 Samples should have no grooves or segments.
- 4.1.5 Special Sample Notes
 - 4.1.5.1 Friction material samples bonded to core plates may demonstrate significantly different deflection response and/or rebound times.
 - 4.1.5.2 If the core plate is not flat, the “spring” effect of the core plate will increase the measured deflection to more than that of the friction material alone. Rebound time will appear much shorter than true the friction material properties.
 - 4.1.5.3 Adhesive bonding layer between the friction material and core plate may also influence deflection response.
 - 4.1.5.4 Increased variability among samples of bonded materials can be expected and consequently a larger sample set may be required.

4.1.6 Clearly identify, store, and ship samples in plastic bags.

4.2 Test Fluid

- 4.2.1 Use a fluid type typical for the intended application. Note the fluid used in the test report.
- 4.2.2 If the specific fluid type is not available, the alternative is standard DEX VI ATF as it has standard viscosity.

4.3 Sample Preparation

- 4.3.1 Label the test samples with unique identifiers. Ensure the sample labelling does not influence the deflection measurement.
- 4.3.2 Samples should be stored at $23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ and $50\% \pm 10\%$ relative humidity (RH) for 24 hours minimum before test. Note conditions in report.
- 4.3.3 Thickness Measurements
 - 4.3.3.1 Friction material sample thickness measurements are to be made after pre-test soaking of test samples in the intended fluid for 30 minutes. Lightly blot excess fluid from sample with a lint free cloth.
 - 4.3.3.2 Thickness of the test samples should be measured while placed vertically between a precision-matched pair of 1-2-3 machinist blocks covering the entire sample area. Calculate the mean value of the thickness of the parts.

5. TEST EQUIPMENT

- 5.1 The test equipment required to properly conduct this test must demonstrate the performance qualifications of the current version of SAE J3079/1. The test stand should be regularly qualified in accordance with accepted laboratory calibration and maintenance intervals.

5.2 Facilities

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

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 applications allows for 50 MPa equivalent hydraulic pressure for 32 mm diameter sample; larger applications will need a larger actuator	40 kN minimum
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 preload	±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
Temperature control accuracy of heating platen	±2 °C
Sampling rate for force and deflection measurement	1 to 1000 Hz
Sampling rate for temperature measurement	1 to 50 Hz minimum
Max time to stabilize at low preload (0.04 MPa, 30 N) upon down ramp from apply load	1.0 second
Maximum overshoot to apply load (12 MPa)	1%
Maximum undershoot to preload upon down ramp from apply load	20%
Slope of pressure during release from apply load to preload	Must remain to within 10% of specified decay rate down to 100 N threshold

5.3 Test Stand

A compressibility test stand with uniaxial load frame and loading device that provides loading to upper plate of sample fixture.

5.4 Deflection Measurement Device

Use a device for measuring piston simulator deflection with a resolution of ±0.1 μm. Deflection measurement device shall exert less than 1.0 N of force during measurement.

NOTE: Accuracy in a range of 0.1 μm requires attention to cleanliness and verification that the test fixture, plates, adaptors, and test pieces do not contain burrs, platen surface irregularities, or other contaminants.

5.5 Wet Friction Test Fixture

5.5.1 The sample fixture consists of an upper plunger and a lower steel receptacle. The receptacle allows the sample to be immersed in the test fluid and the plunger carries load from the upper test stand platen to the sample. Deflection is measured from the top of the plunger.

5.5.2 See Figure 1 for fixture requirements. Horizontal surfaces shall be parallel to within 2 μm.

5.5.3 The plunger must have adequate clearance with the receptacle such that the plunger does not come in contact with the receptacle sides and to allow room for fluid expansion. While the diameters of the plunger (W_p) and receptacle (W_r) are not specified, the maximum difference between these diameters is not to exceed 1 mm ($W_r - W_p < 1$ mm). This will ensure that the sample does not float from under the fixture plunger and remains in proper position throughout the test.

5.5.3.1 Note that the plunger diameter must be of sufficient diameter to completely cover the test sample diameter.

- 5.5.4 The plunger height (H_p) and receptacle depth (H_r) are also not specified. However, it is recommended the minimum receptacle depth be 15 mm and minimum plunger height be 20 mm to ensure that test fluid does not escape from the receptacle during testing.
- 5.5.5 At base of the receptacle should be a hole with groove or recess directly adjacent to the fixture side. This recess will allow for placement of thermocouple probe such that fluid temperature can be measured throughout test. It is critical that thermocouple probe not interfere with sample contact with bottom receptacle surface.
- 5.5.6 The fluid thermocouple through-port should be mounted on the receptacle such that the thermocouple probe can be stably positioned directly in the test fluid at interface of the receptacle base.

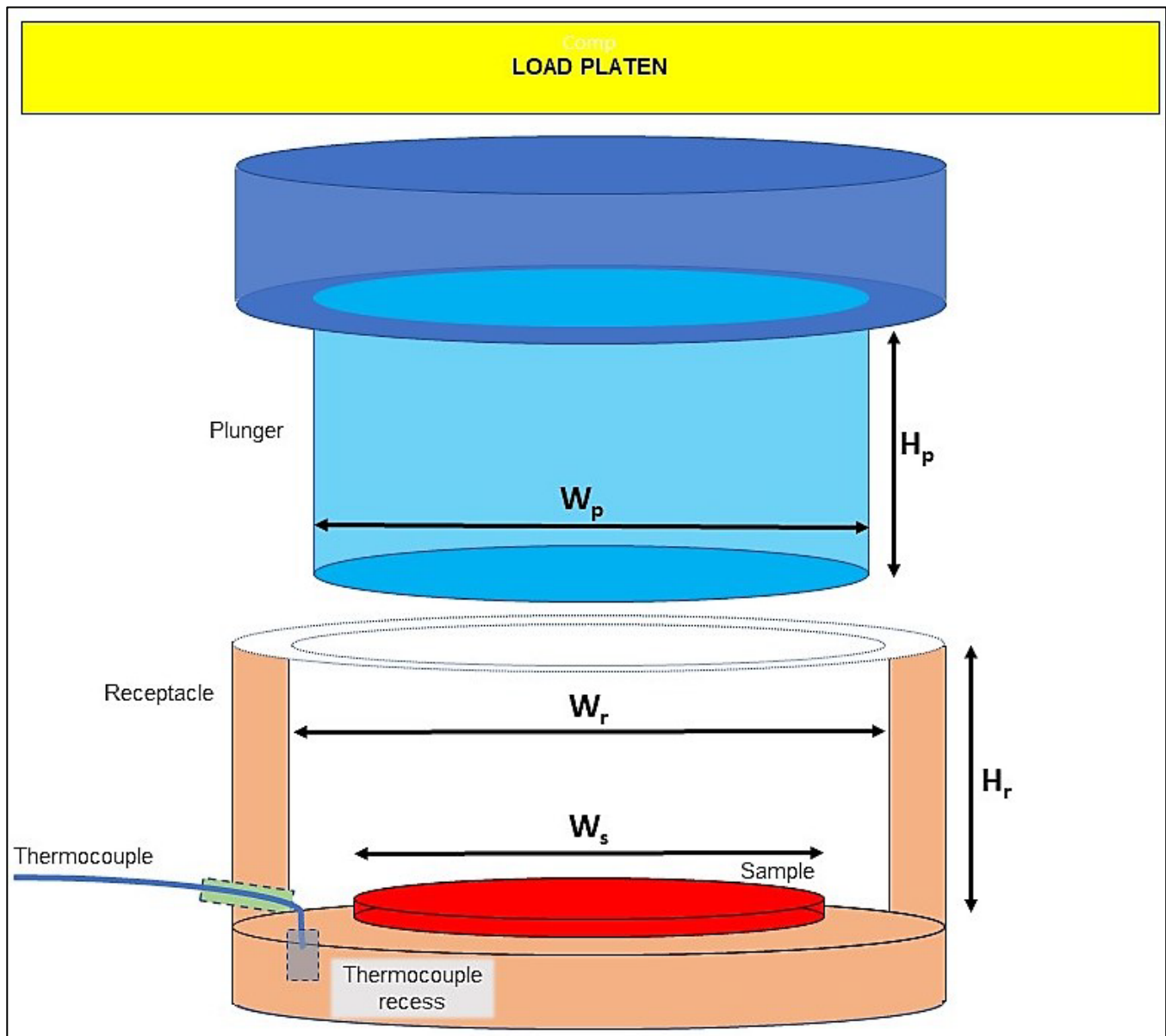


Figure 1 - Friction material disc sample fixture

- 5.5.7 The friction material test sample fixture is a precision device. It must be protected during storage to avoid contact with other parts and it must be stored in an environmentally controlled location. Conduct a visual inspection before and after testing. Verify the surface topography at least annually using optical or laser holography methods. Verify flatness and parallelism to be within specification. If any part of the plunger or receptacle shows surface damage (nicks, corrosion, or excessive material deposits), it should be reworked, re-qualified, or replaced.