SAE International

SURFACE VEHICLE RECOMMENDED PRACTICE

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Wear Test Procedure on Inertia Dynamometer for Brake Friction Materials

RATIONALE

The SAE J2707 Recommended Practice is widely used or referenced by multiple companies around the globe. It is part of regular testing activities with no changes indicated or requested by the industry. Newer testing methodologies and equipment do not affect the test execution. Also, there are no issues presented to the SAE Brake Dynamometer Committee to justify a formal review process

STABILIZED NOTICE

This document has been declared "Stabilized" by the SAE Brake Dynamometer Standards Committee and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

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Foreword

The harmonization efforts by different industry groups and associations from the European Community, the United States and Japan under the ISO Working Group 2 and the Sub-Working Group 4 Friction and Wear, cover several aspects of characterization test protocols for brake friction materials used in automotive applications. Brake lining wear life, its dynamics and behavior under different temperatures and speeds are critical to the successful development and production of commercially available disc brake pads and linings, both for the Original Equipment and the Aftermarket segments. Equally important, is the evaluation of the wear characteristics of a given friction material and its mating part when subjected to a series of brake stops or snubs derived from an actual driving pattern. Different combinations of speed, temperature and deceleration, closer to what is experienced on a vehicle during regular driving, will yield different levels of wear and transfer layer phenomena. When tested under a control testing environment on an inertia dynamometer, this driving pattern replication should provide very valuable information on the wear behavior and level of a given lining and rotor or drum combination.

This Recommended Practice is intended to harmonize test procedures for simulating and evaluating wear characteristics of automotive brake lining and pads and to establish a standardized dynamometer procedure that may be related to actual condition of vehicles on the market. Therefore this committee is making two different test sequences available to the industry as an SAE Recommended Practice. The first part, or Method A, the Japanese standard JASO C 427-83, that is meant to quantify the wear sensitivity to the temperature experienced by the lining and rotor/drum combination. As a second approach, a driving pattern used by the industry, is also provided on what is called Method B. the latter is also known as Block wear testing and is more used for disc brakes.

This Recommended Practice should be used in conjunction with other applicable standards or test procedures (ISO, SAE, Federal Codes or other specific testing programs) to fully assess a friction material's adequacy for a certain application or vehicle platform.

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1. Scope

1.1 This SAE Recommended Practice specifies a dynamometer test procedure to be used for the measurement of automotive service brake linings and disc brake pads wear.

1.2 Special motor vehicles and motorcycles are excluded from the application. Trailers with nominal Gross Combination Weight Rating exceeding 40 tons are also excluded from this Recommended Practice.

2. References

There are no referenced publications specified herein.

3. Definitions

To facilitate the application of this SAE Recommended Practice, the following terms and definitions should apply.

3.1 Initial Speed

Speed at the time brake application is intiated and read using a calibrated speed sensor.

3.2 Final Speed

Speed at the time of brake release shall be 1 km/h or less.

3.3 Braking Deceleration

Braking deceleration is kept almost constant during the brake application by pedal effort or force, exept under transient conditions. In a practical test, the deceleration level shall be converted into the brake torque calculated by using equation given in 4.10.

3.4 Initial Brake Temperature

Temperature read according to the procedure at the time the brake application is initiated. When more than one brake is being tested at the same time, the initial brake temperature shall the the highest of all brakes measured on the drum(s) or disc(s). For testing using Method B-Block wear evaluation, temparatures used for drum brakes shall be defined specifically for the project.

4. Symbols and Abbreviations

The following symbols and abbreviations are used in order to perform the calculations needed during the test.

4.1 *I* — Inertia. [kgf·m·s^2], [kg·m^2]

Inertia shall be calculated according to Equation 1, and the most approximate value shall be selected for the test:

$$I = \frac{W \cdot r^2}{G} = m \cdot r^2 \qquad \text{(Eq. 1)}$$

4.2 *I'*

Inertia during the test. [kgf·m·s^2], [kg·m^2].

4.3 *W* — Wheel Test Load. [kgf], [N]

The test load *W* is defined according to the type of test equipment such as dual-ended dynamometer, single-ended dynamometer, etc. and shall be the value obtained by dividing the gross vehicle weight by the ratio of braking force of each wheel at the time of braking at a deceleration of 0.3 g. Another method would be to use Equations 2 and 3 when the vehicle information is available, W can be obtained by using Equation 2 for front brakes and Equation 3 for rear brakes:

$$W_{f\text{-}dyn} = \left(1 - \frac{W_{\text{r-static}}}{GVW} + \frac{h}{L} \cdot \alpha\right) \frac{GVW}{2} \qquad \text{(Eq. 2)}$$

$$W_{r\text{-}dyn} = \left(1 - \frac{W_{\text{r-static}}}{GVW} - \frac{h}{L} \cdot \alpha\right) \frac{GVW}{2} \qquad \text{(Eq. 3)}$$

4.4 $W_{r\text{-}static}$

Static axle load on the rear axle with the vehicle loaded at GVW. [kgf], [N].

4.5 *GVW*

Gross vehicle weight. Total maximum allowable weight for the vehicle indicated by the manufacturer. [kgf], [N].

4.6 *h*

Center of gravity height. Vertical distance measured from the ground to the vehicle center of gravity when loaded to its GVW. [m].

4.7 *L*

Wheel base. Horizontal distance measured between centerlines of the front and rear axles. [m].

4.8 *r*

Dynamic tire effective rolling radius. [m].

4.9 *G*

Gravitational acceleration. [9.8 m/s^2].

4.10 *T*

Braking torque obtained from the gross vehicle weight according to Equation 4. [kgf·m], [N·m]:

$$T = \frac{W \cdot r}{G} \cdot \alpha \qquad \text{(Eq. 4)}$$

4.11 *T'*

Braking torque obtained from the inertia during the actual test according to Equation 5. [kgf·m], [N·m]:

$$T' = \frac{I'}{r} \cdot \alpha \qquad \text{(Eq. 5)}$$

4.12 *α*

Braking deceleration. [m/s^2].

5. Test Conditions

5.1 Inertia for the Front Axle

According to Equation 2 if not otherwise specified.

5.2 Inertia for the Rear Axle

According to Equation 3 if not otherwise specified.

5.3 Pressure Rise Rate

25 000 + 5 000 kPa/s.

5.4 Sampling Rate

Minimum 50 ms for pressure and torque.

5.5 Temperature Measurement

Position thermocouple at the effective radius 1.0 mm ± 0.15 mm deep on the inner face for disc brakes or centerline of the lining width direction for drum brakes. Install thermocouple(s) as close as feasible to the center of the braking surface, and 1.0 mm ± 0.15 mm below the friction surface of the brake shoe or pad with the highest load. Lining thermocouple shall be reset at every wear measurement inspection.

5.6 Warm-Up Brake Applications

Warm-up applications are to be included as part of the total number of stops at each temperature step. Warm-up stops shall not exceed 50 stops per temperature step. Cooling air shall be set to 0 m/s.

5.7 Burnish

Burnish shall be continued until 90% surface contact is attained.

5.8 Cooling Air Conditions

Cooling air speed may be adjusted to keep the efficiency of the test according to the brake being tested or the dynamometer being used.

5.8.1 Cooling Air Velocity

Shall be specified in [m/s] as measured in the duct. Duct outlet shall be nominally 300 mm away from the test hardware.

5.8.2 Orientation of Brake Setup

Fixture must be mounted as close as possible to the vehicle position. In general, this helps correlation with issues like brake drag, off-brake wear, off-brake DTV, system stiffness and NVH assessment.

5.8.3 DIRECTION OF AIR WITH REGARDS TO BRAKE SETUP

Air flow inlet must be documented regarding direction (vertical or horizontal) and orientation (from forward, rear, top or bottom).

5.9 Preparation for Test

5.9.1 Make sure that no abnormalities are found on the brake before installing it on the test equipment. Make also sure that grease or any other foreign matter is not adhered onto the linings or pads.

5.9.2 A thermocouple shall be attached to the specified location of the drum (s) or disc(s), and lining. The friction surface shall be cleaned using acetone or other appropriate solution.

5.9.3 Set initial LRO shall be set to 50 µm or less when measured 10 mm from the outer diameter on the outboard side of the rotor.

6. Test Procedure

Wear test specified in following sections. Tables 1 and 2 for Method A, and Table 3 for Method B indicate the test conditions that shall be carried out in series using the same drum or disc and linings or pads.

6.1 Method A

Wear characteristics versus brake temperature.

6.1.1 GENERAL WEAR TESTS

See Table 1. (Optional temperatures are shown between parentheses).

TABLE 1—GENERAL WEAR TESTS

Section	Initial Speed (km/h)	Initial Drum Brake Temperature (°C)	Initial Disc Brake Temperature (°C)	Braking Deceleration (g)	Number of Stops (N)
Burnish	50	100	100	0.3	200
Wear test 100 °C	50	100	100	0.3	1000
Wear test 200 °C	50	200	200	0.3	1000
Wear test 250 °C	50	250	250	0.3	1000
Wear test 300 °C	50	300	300	0.3	500
Wear test 350 °C	50	(350)	350	0.3	500
Wear test 400 °C	50	-	400	0.3	200
Wear test 450 °C	50	-	(450)	0.3	200
Wear test 500 °C	50	-	(500)	0.3	200
Second wear test 100 °C	50	100	100	0.3	500
Second wear test 200 °C	50	200	200	0.3	500
Second wear test 250 °C	50	(250)	(250)	0.3	500
Second wear test 300 °C	50	(300)	(300)	0.3	250
Second wear test 400 °C	50		(400)	0.3	100

6.1.2 HIGH SPEED WEAR TESTS

See Table 2. (Optional test items).

TABLE 2—HIGH SPEED WEAR TEST

Section	Initial Speed (km/h)	Initial Drum Brake Temperature (°C)	Initial Disc Brake Temperature (°C)	Braking Deceleration (g)	Number of Stops (N)
Burnish	50	100	100	0.3	200
High speed wear test	100	100	100	0.3	100

6.2 Method B—Block Wear Evaluation

See Table 3 for disc brakes. This series can be repeated as many times as indicated by the project.

TABLE 3—BLOCK WEAR TESTS

Section	Initial Speed (km/h)	Final Speed (km/h)	Initial Disc Brake Temperature (°C)	Braking Deceleration (g)	Number of Stops (N)
Burnish	50	4	100	0.25	100
Town block #1	50	4	150	0.25	200
Highway block #1	150	80	150	0.40	100
Country road block #1	80	4	200	0.35	200
Country road block #2	100	4	125	0.40	200
Highway cycle #2	180	80	100	0.50	50
Town block #2	50	4	150	0.25	200
Country road block #3	100	4	125	0.40	200
Hill descent block	80	4	350	0.35	50

7. Measuring Procedure

7.1 Measurement of Wear Thickness

Measurement of the thickness of the lining or pads wear shall be done as follows:

7.1.1 MEASURING INSTRUMENT

Micrometer or equivalent instrument shall be used in measurement with accuracy up to 0.001 mm.

7.1.2 MEASURING LOCATIONS

In order to ensure accurate measurement of the brake lining or pad wear, 8 points on each side shall be measured when feasible. Measurement locations shall be numbered starting at the outer leading edge and move clockwise on the surface of the lining or pad. Last measurement location then shall be on the inner leading edge of the lining or pad.

7.1.3 MEASUREMENT

Thickness of the brake lining or pad shall be measured at the start of test and after each test temperature (Method A) or after each complete Table 3 series (Method B) with an accuracy of 0.01 mm or better under the room temperature conditions.

7.2 Wear by Mass Measurement

Measurement of the mass of brake lining or pad wear shall be done as follows:

7.2.1 An appropriate measuring instrument such as a balance or other equivalent instrument with an accuracy of 0.01 g or better shall be used.

7.2.2 The mass of the brake linings or pads shall be measured for each specified test temperature with an accuracy of 0.01 g or better under the room temperature conditions.

7.2.3 DRUM OR DISC MEASUREMENT

Measurement of drum or disc wear thickness is optional. Measurement locations shall be defined for the project.

8. Recording

Recording procedure shall be as follows:

8.1 Thickness wear rate shall be expressed as the mean value by averaging all values of 1000 brake applications. It is also desirable to record the maximum and minimum values for reference.

8.2 It is desirable to express the wear mass by the mean value by averaging all the values of 1000 brake applications.

8.3 It is also desirable to express the wear rate as calculated by Equations 6 and 7:

$$V = \frac{t \cdot A}{E_k} \qquad \text{(Eq. 6)}$$

$$E_k = \frac{I \cdot \omega^2 \cdot N}{2} \qquad \text{(Eq. 7)}$$

8.3.1 *V*

Wear rate. [10^{-7}cm^3/kgf·m], [10^{-7}cm^3/N·m]

8.3.2 E_K

Total mechanical work. ([kgf·m], [N·m]