SAE International™

SURFACE VEHICLE RECOMMENDED PRACTICE

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(R) Test Procedures for Shear Strength of Automotive Brake Pads and Brake Lining Assemblies

RATIONALE

The title for this Recommended Practice has been updated to better reflect the purpose of the test, the characteristic measured (shear strength), and the specific parts where it is applicable (automotive brake pads and brake lining assemblies). The new title also facilitates internet searches, and improves the procedure description when referenced on external documents or technical specifications. Testing a drum brake shoe or a disc brake pad assembly for its shear strength is a valuable parameter during the life-cycle of a brake assembly. All friction brake assemblies have a shear loading equivalent in magnitude to the braking force that depends upon the load input perpendicular to the friction surface, the brake geometry, and the friction coefficient at the transfer layer interface. Regular braking operation also generates heat that migrates through the friction material to the backing plate or shoe rim surface. It is critical for the friction designer, the product engineer, the process manager, application engineer, or purchasing agents, to understand the shear strength and the main influencing factors that will ultimately determine the amount of shear load that the material will withstand without a mechanical failure of the assembly. This revision of the Recommended Practice increases the level of harmonization with other industry standards, allows the testing of mechanical retention systems (MRS), includes the option of testing with the movable ram at constant speed, allows the use of coupons, and improves the repeatability of the test results by introducing the application of a side load for disc brake pads.

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1. SCOPE

This SAE Recommended Practice covers equipment capabilities and the test procedure to quantify and qualify the shear strength between the friction material and backing plate or brake shoe for automotive applications. This SAE Recommended Practice is applicable to: bonded drum brake linings; integrally molded disc brake pads; disc brake pads and backing plate assemblies using mechanical retention systems (MRS); coupons from drum brake shoes or disc brake pad assemblies. The test and its results are also useful for short, semi-quantitative verification of the bonding and molding process.

This Recommended Practice is applicable during product and process development, product verification and quality control. This Recommended Practice does not replicate or predict actual vehicle performance or part durability.

1.1 Purpose

The purpose of this test is to quantify the load required to cause a shear failure at the interface of the friction material and backing plate or brake shoe. The test also provides a qualification of the failure mode on the assembly at the different layers or components. Test parts can be of different types and in different conditions: new or used from vehicle or inertia-dynamometer test, prototype or production, complete assemblies or segments, and with or without special treatment like thermal, environmental or corrosion exposure.

2. REFERENCES

2.1 Related Publications

The following publications are provided for information purposes only and are not a required part of this document.

2.1.1 ISO Publication

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

ISO 6312:2001(E) Road vehicles—Brake linings—Shear test procedure for disc brake pad and drum brake shoe assemblies

2.1.2 JIS Publication

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

JIS D4422-1990 Shear Strength Test Procedure for Drum Brake Shoe Assemblies and Pads for Automobiles (Reaffirmed: 1995)

3. DEFINITIONS

3.1 Coupon

Segment cut from a larger original drum shoe or disc pad.

3.2 Offset

Distance measured from the exposed surface of the backing plate to the shear ram edge. See Figure 4.

3.3 Mechanical Retention System (MRS)

Attachment method where mechanical protrusions on the backing plate aid the retention of the friction material or the underlayer.

3.4 Normal Load

Fixed load perpendicular to the shear load for disc brake pads or flat coupons.

3.5 Shear Failure

Shear failure is as observable movement of the friction material or complete shear from the backing plate or brake shoe.

3.6 Shear Load

Peak load observed during the test at the time of a shear failure.

3.7 Shear Strength

Ratio of the shear load divided by the sample or coupon area at the attachment layer.

4. EQUIPMENT

The equipment for performing this test shall be a compression, tensile, or similar (shear) test machine with the following minimum capabilities:

4.1 Provide a fixture that holds the disc brake pad or shoe assembly firmly

4.2 System or mechanism to provide a normal load of 0.5 ± 0.15 N/mm^2 (72.5 ± 22 psi) at right angle to the shear load on the friction material face for disc brake pads

4.3 Movable ram to apply shear load to the friction material at a constant speed rate of 10 ± 1 mm/min (0.40 ± 0.04 mm/min) or constant load rate 4500 ± 1000 N/s (1000 ± 225 lb/s); hand-operated pumps or shock loads are not allowed

4.4 Generate a constant ram speed or loading rate from zero (0) load to a load sufficient to shear the friction material from the backing plate or brake shoe

5. TEST FIXTURES AND SAMPLE PREPARATION

5.1 Sampling and Sample Preparation

Perform a visual inspection of the samples prior to testing. Remove shims, clips, or nibs to ensure proper contact and squareness on the test fixture. When testing using field-returned or tested parts, verify parts for appropriate flatness and parallelism. Perform surface grind if necessary.

Unless otherwise specified for the project, test five samples.

5.2 Drum Brake Shoes Fixture

Use a movable ram that contacts the edge of the lining for its full length and thickness within 1 ± 0.2 mm (0.040 ± 0.008 in) of the shoe table or rim; See Figure 1. The ram shall contact the lining on its entire width in the direction of the shear load. Apply the load in a direction perpendicular to the plane of the shoe web; support the shoe to maintain uniform loading along the length of the lining or segment; avoid distortion of the shoe table or shoe web during the test.

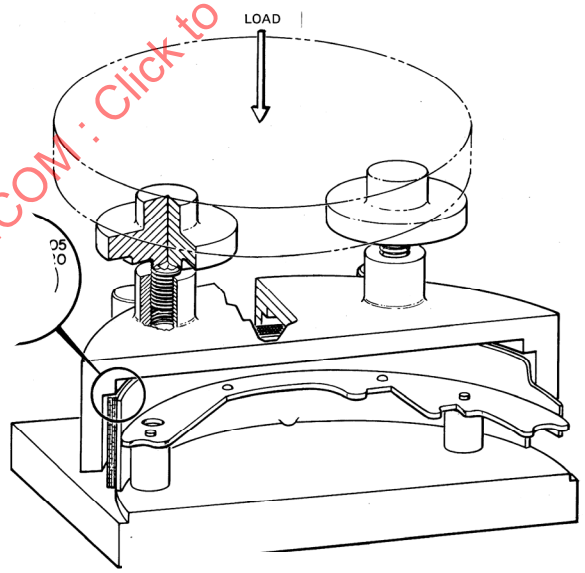

FIGURE 1 - BOND PLANE SHEAR TEST - DRUM BRAKE

5.3 Disc Brake Pads Fixture

Use a movable ram that contacts the edge of the lining for its full length and thickness within 1 ± 0.2 mm (0.040 ± 0.008 in) of the backing plate. The movable ram shall conform adequately to the lining edge contour to avoid crushing of the lining edge prior to failure. See Figures 2 to 5. The ram shall contact the lining edge along the axis perpendicular to the ram travel direction. Other offsets different from 1 ± 0.2 mm (0.040 ± 0.008 in) are acceptable to accommodate different attachment systems like MRS. Document and report the actual offset if different from the standard value.

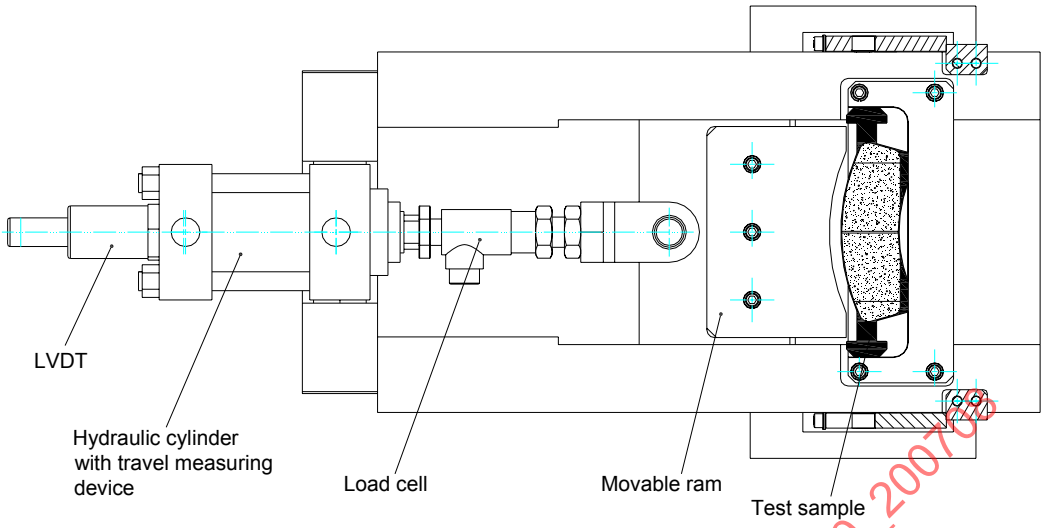

FIGURE 2 - DISC BRAKE SHEAR TEST FIXTURE

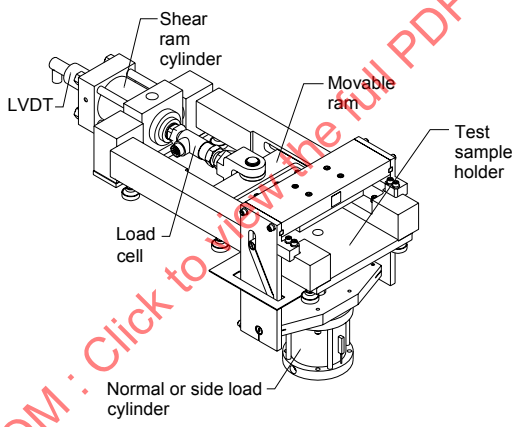

FIGURE 3 - DISC BRAKE SHEAR TEST EQUIPMENT

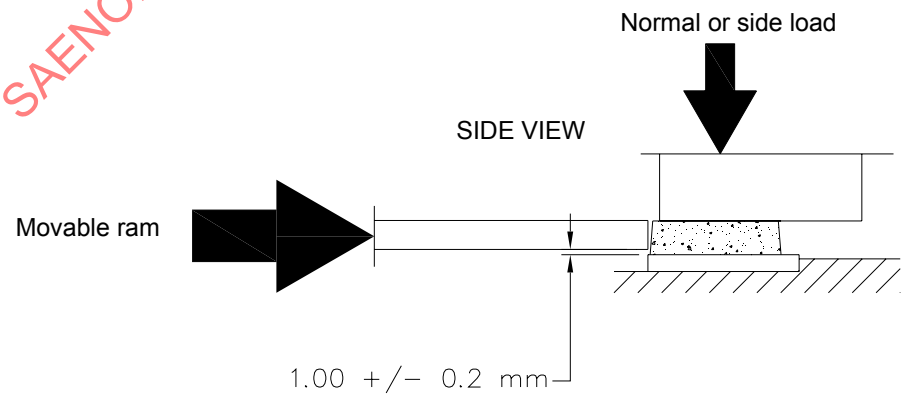

FIGURE 4 - DISC BRAKE SHEAR TEST FIXTURE OFFSET

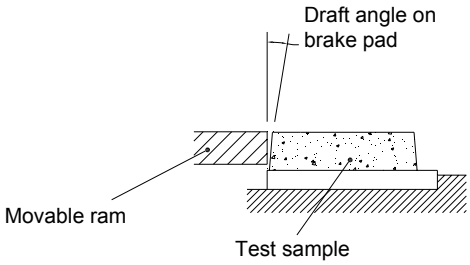

FIGURE 5 - DRAFT ANGLE (EXAGGERATED) FOR MOVABLE RAM

5.4 Test Coupons and Fixtures

Use coupons when the drum brake shoe or disc pad assembly is too large to accommodate on the machine without modifications or when the shear load exceeds the machine capability. For brake shoe assemblies make saw cuts in the loading direction to isolate the segment from the rest of the lining; be sure to cut through the friction material and into the shoe rim. For large disc brake pad assemblies or disc brake assemblies using MRS, cut a coupon as large as feasible to obtain a symmetrical shape along the loading axis. For assemblies using MRS it is acceptable to apply the load in the same direction as the pattern orientation. Document and report the actual loading direction relative to the hook formation.

6. SHEAR TEST PROCEDURE FOR DISC BRAKE PADS AND DRUM BRAKE SHOE ASSEMBLIES

6.1 Ambient Destructive Shear Test Procedure

6.1.1 Place and secure the sample on the fixture.

6.1.2 Apply the normal load 0.5 ± 0.15 N/mm^2 (72.5 ± 22 psi) at right angle to the shear load when testing disc brake pad assemblies.

6.1.3 Apply shear load at constant speed or constant load rate after the ram is in contact with the lining edge.

6.1.4 Continue applying load until shear failure occurs.

6.1.5 If partial shear occurs, check the fixture alignment and repeat the test using a new sample.

6.1.6 Record the maximum load attained in N or lbf.

6.1.7 Assess and record the percent distribution of material in the shear plane per item 7.

6.1.8 When requested, determine the approximate adhesive state-of-cure using the Cotton Tack Test (See Appendix A).

6.2 Hot Destructive Shear Test Procedure

6.2.1 Place the disc brake pad or brake shoe assembly or segment in a heating fixture or oven that will bring the sample bondline to 200 °C ± 5 °C (392 °F ± 10 °F) within 30 minutes for drum brake shoes and 300 °C ± 5 °C (572 °F ± 10 °F) within 30 minutes for disc brake pads.

6.2.2 Within 1 minute after reaching the bondline temperature, place the assembly or segment on the shear test fixture and test per item 6.1.

NOTE: The heating fixture may be part of the test equipment or external to it. The shear test fixture may be heated along with the test assembly or coupon. If heating external to the shear test fixture, the bond temperature must be no lower than 10 °C below the target test temperature at the time of shear failure. Do not hold the sample at temperature for more than 1 minute. Use a thermocouple to measure the temperature at the bond line as shown in Figure 6 for Drum Brake and Figure 7 for Disc Brake. This test is performed primarily to ensure proper cure of the adhesive.

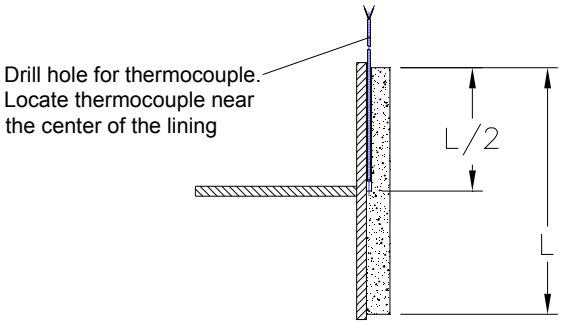

FIGURE 6 - DRAWING OF THERMOCOUPLE LOCATION - DRUM BRAKE

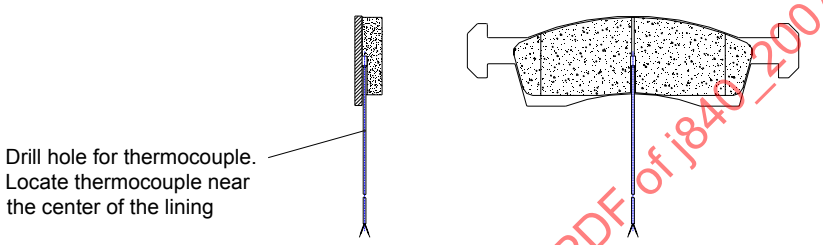

FIGURE 7 - DRAWING OF THERMOCOUPLE LOCATION - DISC BRAKE

6.3 Temperature Degradation Shear Test Procedure

6.3.1 Preheat the oven to the test temperature indicated for the project. Use temperatures from Table 1 for disc brake pad assemblies and Table 2 for drum shoe assemblies.

TABLE 1 - DISC BRAKE SOAK TEMPERATURE AND TIME

Soak Temperature	Soak Time
267 °C (500 °F)	24 h
315 °C (600 °F)	6 h
427 °C (800 °F)	2 h[1]
538 °C (1000 °F)	2 h[1]

1. Optional soak time for applications with high-operating temperatures.

TABLE 2 - DRUM BRAKE SOAK TEMPERATURE AND TIME

Soak Temperature	Soak Time
149 °C (300 °F)	24 h
204 °C (400 °F)	24 h
267 °C (500 °F)	12 h[1]
315 °C (600 °F)	2 h[1]

1. Optional soak time for applications with high-operating temperatures.

NOTE: Select the soak temperatures based on the temperatures expected at the lining/shoe interface during use for the application. Low conductivity (organic or non-asbestos organic) linings typically experience lower bond line temperatures than high conductivity linings (semi-metallics).

6.3.2 After completion of the soak time, remove the disc brake pad or brake shoe assembly or segment and let it cool down to room temperature.

6.3.3 Place the assembly or segment on the shear test fixture and test per item 6.1.

7. SHEAR FAILURE ASSESSMENT

Report the percentage of retention at each of the layers applicable to the assembly. On the test report indicate the layer followed by the corresponding percent retention. See Figure 8.

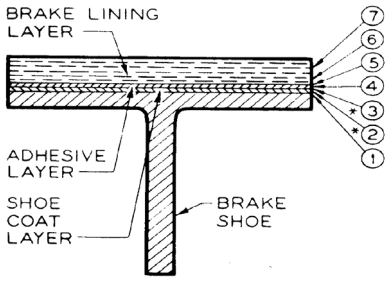

FIGURE 8 - STANDARD LAYERS TO ASSESS BOND FRACTURE
SEE ITEM 8.12 FOR DESCRIPTION

8. TEST REPORT

Include the following information unless otherwise specified by the test requestor:

8.1 Test part identification and batch number.

8.2 Number of samples tested.

8.3 Sample type (complete assembly or coupons).

8.4 Constant speed rate or constant load rate and value.

8.5 Normal load applied (yes/no).

8.6 Sample area at shear plane.

8.7 Load orientation relative to the MRS pattern orientation (optional).

8.8 Special sample treatment prior to shear test and description (vehicle test, inertia-dynamometer test, thermal soak, environmental, corrosion, or other).

8.9 Temperature and soak time for hot destructive test or temperature degradation shear test procedure.

8.10 Minimum, average, and maximum shear load for multiple samples.

8.11 Minimum, average, and maximum shear strength for multiple samples.

8.12 Description of shear failure and assessment of material retention in percentage per item 7:

8.12.1 Layer 1: adhesion failure (bare metal) between brake shoe metal and shoe coat or between brake shoe metal and adhesive, when there is no shoe coat.

8.12.2 Layer 2: cohesion failure within the shoe coat; eliminate when there is no shoe coat.

8.12.3 Layer 3: adhesion failure between adhesive and shoe coat; eliminate when there is no shoe coat.

8.12.4 Layer 4: cohesion failure within the adhesive layer.

8.12.5 Layer 5: adhesion failure between the lining and adhesive.

8.12.6 Layer 6: shallow failure within lining with less than 0.50 mm (0.002 in) of lining remaining.

8.12.7 Layer 7: deep failure within the lining material.

8.13 Digital picture of the backing plate or shoe rim at the shear plane.

8.14 Deviations from procedure and comments if needed.

9. NOTES

9.1 Marginal Indicia

The change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. An (R) symbol to the left of the document title indicates a complete revision of the report.

PREPARED BY THE SAE BRAKE LININGS STANDARDS COMMITTEE
OF THE SAE BRAKE FORUM COMMITTEE

APPENDIX A - COTTON TACK TEST

A.1 PURPOSE

This test determines the approximate state-of-cure of some adhesives on a fractured disc brake pad or drum brake shoe assemblies. Obtain from the adhesive vendor information on the specific solvent to use in this test. Due to the subjective nature of this test, use it only for process control purposes, not for product qualification.

A.2 EQUIPMENT AND MATERIAL

Long fiber absorbent cotton, an eye dropper, a suitable solvent, a chisel 12.7 mm (0.5 in) wide, a hammer, a vise, a rough cut file, a stiff wire brush, and fine emery paper.

A.3 SAMPLE PREPARATION

Hold the assembly on a vise; remove a lateral strip of material approximately 25.4 mm (1 in) wide using the chisel. Use a file and wire brush to remove all traces of debris or lining material from the test area; leave the adhesive bonded to the shoe. Use of fine emery paper is allowed to produce a smooth surface of adhesive for testing. A rough adhesive surface may cause mechanical sticking of the cotton to the adhesive which will invalidate the test.

NOTE: As an alternative, perform a standard shear test per item 6.1 to remove the lining material from the shoe.

A.4 TEST PROCEDURE

A.4.1 Expose the adhesive layer per item 3.

A.4.2 With the eye dropper, apply 2 or 3 drops of solvent.

A.4.3 While the solvent is evaporating, use a small wad of cotton to dab (not wipe) the moistened surface repeatedly at a rate of approximately 2 dabs per second, until the surface is completely dry.

A.4.4 Blow lightly on the surface to remove any stray cotton fibers left the surface.

A.4.5 Determine whether any cotton remains stuck to the surface. Take care to determine if any cotton fibers remaining are stuck to the surface due to mechanical locking rather than tacky adhesive.

A.5 TEST REPORT

A.5.1 If there are no cotton fibers stuck to the surface, report "no tack".

A.5.2 If there are cotton fibers adhered to the surface and it has been determined that this is not due to a rough surface, report "tack".

A.6 INTERPRETATION OF RESULTS

Tack may be an indication that the adhesive cure is not complete. Perform the State-of-Cure Test (Appendix B) for confirmation purposes.

NOTE: This test may not properly reflect the state-of-cure on all types of adhesive. Contact the adhesive vendor to determine the suitability of this test.