



Brake Component Interface Pressure Distribution Measurement

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. This standard is a laboratory or on-vehicle standard to measure interfacial pressure distributions in brake calipers, brake drums, or parking brake systems.

1.2 Applicability. This standard is applicable to all passenger car and light truck brake corners.

1.3 Remarks. This standard is used to measure the pressure distributions between brake pads and a brake rotor, between brake caliper piston(s) and the corresponding brake pad backing plate(s), between brake caliper housings and the corresponding brake pad backing plate, and/or between brake shoes and the corresponding brake drum, all over a range of caliper/cylinder pressures. This data may be used to determine the effective radius of a disc brake, the center of force on caliper pistons, the center of force on a caliper housing (and its distance from the caliper bridge), the location of friction force vectors in the brake pad to rotor interface, and the global contact area between shoes and a drum. These measurements may also be used to visualize the pressure distribution between clamped elements of interest.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

None

2.3 Additional References.

Tekscan Inc., South Boston, MA, USA (<https://www.tekscan.com/>)

3 Resources

3.1 Facilities.

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.1.3 For static measurements on a dynamometer, any dynamometer capable of mounting and supplying a prescribed hydraulic pressure to the subject brake corner may be used. For dynamic measurement of piston to backing plate or housing to backing plate pressure distributions, a dynamometer with a low speed, high torque worm drive is required. For on vehicle testing, the subject vehicle must be placed on a hoist. A power supply and a hospitable (dry) environment must be present for the equipment. It is recommended that on-vehicle measurements be static only (rotor not spinning).

3.2 Equipment. A Tekscan system consisting of a personal computer interface/data acquisition card, a personal computer with the Tekscan software, one (1) or two (2) sensor handles, and one (1) or two (2) Tekscan sensors, or equivalent, is needed. For on-vehicle measurement, a pressure transducer must be installed in the subject

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brake corner. Tekscan model 9850 sensors are recommended to test passenger car brakes, model 9851 sensors are recommended to test light truck brakes, and model 5511 sensors are recommended to test drum brakes.

For shoe to drum measurements, the drum brake backing plate or the brake drum must be machined to allow the Tekscan sensor to fit. This involves trimming the backing plate down to the radial profile of the shoes, or machining the material between the drum hat and drum friction surface around the shoes to allow the sensor to pass through the drum.

3.3 Test Vehicle/Test Piece. Brake corner hardware shall be used for testing, front or rear on vehicle or dynamometer.

3.4 Test Time.

Calendar time: 0.5 day to 1 day

Test time: 1 h to 3 h

Coordination time: 1 h to 2 h

3.5 Test Required Information. Must know (if applicable): brake rotor diameter, caliper piston(s) diameter, radial distance between caliper bridge centerline and outer edge of brake pads.

3.6 Personnel/Skills. For testing on a vehicle or an inertia dynamometer, two (2) technicians capable of performing the duties described in section 4 are required. For testing on a Rotor Thickness Variation (RTV) dynamometer, or any other dynamometer for which the hydraulic pressure controls and Tekscan computer may be placed in close proximity, only one (1) technician is required. For two (2) person operations, one (1) technician will control hydraulic pressure to the brake corner and, if applicable, control the dynamometer worm drive, and the other will operate the Tekscan equipment.

4 Procedure

4.1 Preparation.

4.1.1 The subject brake corner shall be installed on the dynamometer facility intended for use during the test, using production representative fastener torque(s) and component spacing. Alternatively, the test vehicle should be placed upon a hoist, and the tire/wheel assembly removed from the subject brake corner.

4.1.2 The brake pads/shoes shall be conditioned to the desired state for testing.

4.1.3 For a vehicle test, a pressure transducer shall be installed into the hydraulic circuit of the subject brake corner with a visible display of its reading.

4.1.4 Each specific Tekscan sensor used for measuring forces in engineering units must be equilibrated and calibrated per the procedure given in the documentation supplied with the Tekscan software. If force measurements in engineering units are not required for the test, then this step is optional.

4.1.5 Prepare the Tekscan equipment for taking measurements per the documentation supplied with the Tekscan system. See Appendix A, Figures A1 thru A4 for photographs of equipment and typical test setup.

4.1.6 Secure the Tekscan sensor handles into a position that allows them to interface with the Tekscan sensors in their installed positions without causing sharp bending, puncturing, or twisting of the sensors. The weight of the sensor handles must not bear down on the sensors themselves.

4.2 Conditions.

4.2.1 Environmental Conditions. Not applicable.

4.2.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

4.2.2.1 The stability of the Tekscan force readings change with temperature. The Tekscan sensors cannot withstand high temperatures and high shear loads. The brake pads and rotors shall be at or near ambient (room) temperature for this test, and only static tests, or tests transmitting a small level of shear load between sliding components, may be performed.

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4.3 Instructions.

4.3.1 Pad to Rotor Pressure Distribution Measurement.

4.3.1.1 Retract the caliper piston(s) into the bore enough to allow the Tekscan sensor to slide easily between the pad(s) and rotor.

4.3.1.2 Position the Tekscan sensor(s) between the pad(s) and rotor. The sensor shall be placed such that it is centered under the pad in the brake rotor tangential direction, and the outer edge of the pad is within the outer edge of the sensing area of the sensor. For some caliper designs it may be necessary to separate the caliper housing from the bracket to place the sensor. The sensor may be gently bent to fit, but care must be taken not to sharply bend or crease the sensor.

4.3.1.3 Apply pressure to the brake corner to seat the pads against the Tekscan sensor and rotor, to hold the sensors in place. Release the pressure after the pads are seated if the housing was removed to place the sensor, and then squeeze the pads against the sensor and rotor by hand to set the pads in the bracket and hold the sensor in place. In some cases, it may be necessary to tape the sensor in place until the caliper can be assembled. Tape must not be present in the pad to rotor interface when measurements commence.

4.3.1.4 Apply 10 MPa to 12 MPa of hydraulic pressure to the subject brake corner. Observe the graphical pressure distribution on the computer to verify that the sensor(s) has been properly placed. If the sensor does not completely cover the pad to rotor interface, or if it is visibly off center, then release the pressure and repeat 4.3.1.1 thru 4.3.1.4 until the sensor(s) is adequately positioned. Release hydraulic pressure after this check.

4.3.1.5 Start a movie recording with the Tekscan equipment.

4.3.1.6 Apply the specified level of hydraulic pressure to the brake corner. When pressure has stabilized at the specified level, stop the movie recording. Release the hydraulic pressure.

4.3.1.7 Repeat 4.3.1.5 and 4.3.1.6 for each specified pressure level. A typical range of pressure levels to test is 500 kPa, 2000 kPa, 5000 kPa, and 12 000 kPa. More data points are generally measured in the lower pressure range to capture the non-linear behavior of the pressure distributions in this range.

4.3.2 Piston to Pad Backing Plate Pressure Distribution Measurement (Static–Rotor Not Spinning).

4.3.2.1 Retract the caliper piston(s) into the bore enough to allow the Tekscan sensor to slide easily between the piston(s) and the corresponding pad backing plate(s).

4.3.2.2 Position the Tekscan sensor(s) between the piston(s) and pad backing plate(s). Each sensor shall be placed such that it completely covers the area of contact between the piston and pad backing plate. The sensor shall be placed such that the tangential axis of the sensor is parallel to the tangential axis of the brake corner. For some caliper designs it may be necessary to separate the caliper housing from the bracket to place the sensor. The sensor may be gently bent to fit, but care must be taken not to sharply bend, crease, or puncture the sensor.

4.3.2.3 Apply pressure to the brake corner to seat the piston against the Tekscan sensor and pad backing plate, to hold the sensor in place. Release the pressure after the piston is seated. In some cases, it may be necessary to tape the sensor in place until the caliper can be assembled. Tape must not be present in the piston to pad backing plate interface when measurements commence.

4.3.2.4 Apply 10 MPa to 12 MPa of hydraulic pressure to the subject brake corner. Observe the graphical pressure distribution on the computer to verify that the sensor(s) has been properly placed. If the sensor does not completely cover the piston to pad backing plate interface, or if it is visibly off center, then release the pressure and repeat 4.3.2.1 thru 4.3.2.4 until the sensor(s) is adequately positioned. Release hydraulic pressure after this check.

4.3.2.5 Start a movie recording with the Tekscan equipment.

4.3.2.6 Apply the specified level of hydraulic pressure to the brake corner. When pressure has stabilized at the specified level, stop the movie recording. Release the hydraulic pressure.

4.3.2.7 Repeat 4.3.2.5 and 4.3.2.6 for each specified pressure level. A typical range of pressure levels to test is 500 kPa, 2000 kPa, 5000 kPa, and 12 000 kPa. More data points are generally measured in the lower pressure range to capture the non-linear behavior of the pressure distributions in this range.

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4.3.3 Caliper Housing (Fingers) to Pad Backing Plate Pressure Distribution Measurement (Static – Rotor Not Spinning).

4.3.3.1 Retract the caliper piston(s) into the bore enough to allow the Tekscan sensor to slide easily between the caliper housing (fingers) and the corresponding pad backing plate.

4.3.3.2 Position the Tekscan sensor between the housing and pad backing plate. Each sensor shall be placed such that it completely covers the area of contact between the housing (fingers) and pad backing plate. The sensor shall be placed such that the tangential axis of the sensor is parallel to the tangential axis of the brake corner. For some caliper designs it may be necessary to separate the caliper housing from the bracket to place the sensor. The sensor may be gently bent to fit, but care must be taken not to sharply bend, crease, or puncture the sensor.

4.3.3.3 Apply pressure to the brake corner to seat the housing against the Tekscan sensor and pad backing plate to hold the sensor in place. Release the pressure after the housing is seated. In some cases, it may be necessary to tape the sensor in place until the caliper can be assembled. Tape must not be present in the piston to pad backing plate interface when measurements commence.

4.3.3.4 Apply 10 MPa to 12 MPa of hydraulic pressure to the subject brake corner. Observe the graphical pressure distribution on the computer to verify that the sensor(s) has been properly placed. If the sensor does not completely cover the piston to pad backing plate interface, or if it is visibly off center, then release the pressure and repeat 4.3.3.1 thru 4.3.3.4 until the sensor(s) is adequately positioned. Release hydraulic pressure after this check.

4.3.3.5 Start a movie recording with the Tekscan equipment.

4.3.3.6 Apply the specified level of hydraulic pressure to the brake corner. When pressure has stabilized at the specified level, stop the movie recording. Release the hydraulic pressure.

4.3.3.7 Repeat 4.3.3.5 and 4.3.3.6 for each specified pressure level. A typical range of pressure levels to test is 500 kPa, 2000 kPa, 5000 kPa, and 12 000 kPa. More data points are generally measured in the lower pressure range to capture the non-linear behavior of the pressure distributions in this range.

4.3.4 Piston to Pad Backing Plate Pressure Distribution Measurement (Dynamic–Rotor Spinning).

Note: It is recommended that dynamic measurements be made on an inertia dynamometer with a worm gear drive, and not on a vehicle. This allows the precise control over the rotational speed and hydraulic pressure required for a successful test.

4.3.4.1 Retract the caliper piston(s) into the bore enough to allow the Tekscan sensor to slide easily between the piston(s) and the corresponding pad backing plate(s).

4.3.4.2 Position the Tekscan sensor(s) between the piston(s) and pad backing plate(s). Each sensor shall be placed such that it completely covers the area of contact between the piston and pad backing plate. The sensor shall be placed such that the tangential axis of the sensor is parallel to the tangential axis of the brake corner. For some caliper designs it may be necessary to separate the caliper housing from the bracket to place the sensor. The sensor may be gently bent to fit, but care must be taken not to sharply bend, crease, or puncture the sensor.

4.3.4.3 Apply pressure to the brake corner in order to seat the piston against the Tekscan sensor and pad backing plate, to hold the sensor in place. Release the pressure after the piston is seated. In some cases, it may be necessary to tape the sensor in place until the caliper can be assembled. Tape must not be present in the piston to pad backing plate interface when measurements commence.

4.3.4.4 Apply 10 MPa to 12 MPa of hydraulic pressure to the subject brake corner. Observe the graphical pressure distribution on the computer to verify that the sensor(s) has been properly placed. If the sensor does not completely cover the piston to pad backing plate interface, or if it is visibly off center, then release the pressure and repeat 4.3.4.1 thru 4.3.4.4 until the sensor(s) is adequately positioned. Release hydraulic pressure after this check.

4.3.4.5 Start Dynamometer Worm Drive and stabilize brake rotational speed to an equivalent of 2 to 3 km/h. The dynamometer controls should be set to maintain this speed even when hydraulic pressure is applied.

4.3.4.6 Start a movie recording with the Tekscan equipment.

4.3.4.7 Apply the specified level of hydraulic pressure to the brake corner. Use a rapid ramp rate; pressure should be applied and stabilized within 1 s. The sensor may need to be vented per the instructions provided with

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the Tekscan equipment to avoid air entrapment with the rapid apply rate. When pressure has stabilized at the specified level, stop the movie recording. Release the hydraulic pressure.

4.3.4.8 Repeat 4.3.4.6 and 4.3.4.7 for each specified pressure level. A typical range of pressure levels to test is 500 kPa, 2000 kPa, 5000 kPa, and 12 000 kPa. More data points are generally measured in the lower pressure range to capture the non-linear behavior of the pressure distributions in this range.

4.3.5 Caliper Housing (Fingers) to Pad Backing Plate Pressure Distribution Measurement (Dynamic-Rotor Spinning).

Note: It is recommended that dynamic measurements be made on an inertia dynamometer with a worm gear drive, and not on a vehicle. This allows the precise control over the rotational speed and hydraulic pressure required for a successful test.

4.3.5.1 Retract the caliper piston(s) into the bore enough to allow the Tekscan sensor to slide easily between the caliper fingers and the corresponding pad backing plate(s).

4.3.5.2 Position the Tekscan sensor between the caliper fingers and pad backing plate. Each sensor shall be placed such that it completely covers the area of contact between the fingers and pad backing plate. The sensor shall be placed such that the tangential axis of the sensor is parallel to the tangential axis of the brake corner. For some caliper designs, it may be necessary to separate the caliper housing from the bracket to place the sensor. The sensor may be gently bent to fit, but care must be taken not to sharply bend, crease, or puncture the sensor.

4.3.5.3 Apply pressure to the brake corner to seat the fingers against the Tekscan sensor and pad backing plate, to hold the sensor in place. Release the pressure after the piston is seated. In some cases, it may be necessary to tape the sensor in place until the caliper can be assembled. Tape must not be present in the piston to pad backing plate interface when measurements commence.

4.3.5.4 Apply 10 MPa to 12 MPa of hydraulic pressure to the subject brake corner. Observe the graphical pressure distribution on the computer to verify that the sensor(s) has been properly placed. If the sensor does not completely cover the piston to pad backing plate interface, or if it is visibly off center, then release the pressure and repeat 4.3.5.1 thru 4.3.5.4 until the sensor(s) is adequately positioned. Release hydraulic pressure after this check.

4.3.5.5 Start Dynamometer Worm Drive and stabilize brake rotational speed to an equivalent of 2 km/h to 3 km/h. The dynamometer controls should be set to maintain this speed even when hydraulic pressure is applied.

4.3.5.6 Start a movie recording with the Tekscan equipment.

4.3.5.7 Apply the specified level of hydraulic pressure to the brake corner. Use a rapid ramp rate; pressure should be applied and stabilized within 1 s. The sensor may need to be vented per the instructions provided with the Tekscan equipment to avoid air entrapment with the rapid apply rate. When pressure has stabilized at the specified level, stop the movie recording. Release the hydraulic pressure.

4.3.5.8 Repeat 4.3.5.6 and 4.3.5.7 for each specified pressure level. A typical range of pressure levels to test is 500 kPa, 2000 kPa, 5000 kPa, and 12 000 kPa. More data points are generally measured in the lower pressure range to capture the non-linear behavior of the pressure distributions in this range.

4.3.6 Shoe to Drum Pressure Distribution Measurement.

4.3.6.1 Back off the adjuster just enough so that the Tekscan sensor may be easily inserted between the shoes and the drum friction surface.

4.3.6.2 Insert the Tekscan sensors between the primary and secondary shoes and the brake drum. Position them so the sensor completely covers the friction interface.

4.3.6.3 Apply 10 MPa to 12 MPa of hydraulic pressure to the subject brake drum. Observe the graphical pressure distribution on the computer to verify that the sensor(s) has been properly placed. Repeat 4.3.6.2 and 4.3.6.3 as necessary until the sensors are properly placed. Release the hydraulic pressure.

4.3.6.4 Start Tekscan movie recording.

4.3.6.5 Increase pressure to the specified test level. When pressure has stabilized at the specified level, apply the specified level of torque to the brake drum around its axis of rotation using a handheld "clicker"-style torque wrench. The Tekscan sensors are not designed to withstand significant shear motion, so torque levels must be kept below the threshold that causes the brake to slip around the sensor. A suitably conservative threshold is

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