Integral Parking Brake Caliper Adjuster Function Test

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 used to assess the over adjustment and related drag of an integral parking brake caliper through a wide operating temperature range, and with moderate taper wear. This test will not predict the effects of severe taper wear on adjuster function.

1.2 Applicability. This standard is applicable to all integral park brake calipers with automatic mechanical adjuster.

1.3 Remarks. This test compares the change in brake fluid displacement for a brake corner during the fade schedule, with and without the adjuster mechanism functioning. This data is used to calculate the apparent over adjustment of the caliper in these conditions. In addition, apparent friction, apparent piston travel, and torque hysteresis are evaluated. Tapered lining wear is also evaluated as part of this test.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW14974 GMW14986

2.3 Additional References.

CCD-FRM-HQR01, Test Information Sheet, only required for testing at Milford Proving Ground (MPG).

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 MPG Brake Component Development (BCD) inertia brake dynamometer or equivalent test facility shall be used.

3.2 Equipment.

3.2.1 An inertia brake dynamometer capable of performing torque control, pressure control, corrected pressure control, ramp, and modulated brake applies.

3.2.2 The following measurements shall be made and digitally recorded at 500 Hz:

3.2.2.1 Dynamometer speed.

3.2.2.2 Brake apply pressure.

3.2.2.3 Brake torque.

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3.2.2.4 Brake rotor temperature.

3.2.2.5 Fluid displacement.

3.2.3 The following measurements shall be recorded at 5 Hz continuously from the start to the end of the test, including during the off-brake time.

3.2.3.1 Dynamometer speed.

3.2.3.2 Brake apply pressure.

3.2.3.3 Brake torque.

3.2.3.4 Brake rotor temperature.

3.2.3.5 Fluid displacement.

3.3 Test Vehicle/Test Piece. Production representative brake corner hardware shall be used to produce the tailstock assembly.

3.4 Test Time.

Calendar time:	1 day
Parts preparation time:	2 h
Setup time:	2 h
Test time:	(6 to 8) h

3.5 Test Required Information. For testing at MPG, the Test Information Sheet CCD-FRM-HQR01 needs to be completed by the test requester and submitted to the test engineer. Form will be supplied by the test engineer. Contact other test sites for any required forms for testing.

3.6 Personnel/Skills. One (1) technician trained for the operation of an inertia brake dynamometer and to perform the duties described in paragraph 4 is required.

4 Procedure

4.1 Preparation.

4.1.1 Rotor thermocouple shall be installed per GMW14974.

4.1.2 The assembled corner lateral run out (LRO) shall not exceed 50 µm. The assembled corner LRO shall be measured on the inboard face of the rotor at a radius 10 mm inside of the rotor outer diameter using a dial indicator.

4.2 Conditions.

4.2.1 Environmental Conditions. Cooling air is provided to the brake. Cooling air temperature shall be between +10 °C and +30 °C. Cooling air humidity control is not required.

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 dynamometer inertia is adjusted to the gross vehicle mass, maximum tire static loaded radius, and 80 % of vehicle energy transferred into the brakes. For front brakes, dynamic loading is set at 0.9G deceleration, and for rear brakes the dynamic loading is set at 0.6G deceleration.

4.3 Instructions.

4.3.1 Run with Adjuster Functioning. Perform the test sequence described in Table 1.

4.3.2 Run with Adjuster Disabled. Starting with a new set of pads (the rotor may be re-used), perform the test sequence described in Table 1, using the same caliper with the adjuster mechanism disabled. A common method of disabling the adjuster is to drill out the adjuster threads (when applicable).

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Table 1: Test Sequence and Instructions

Test Section Name	Braking Speed (km/h)	Cooling Speed (km/h)	Number of Stops/ Snubs	Control and Level	Condition
Start-of-Test Brake Lining Measurements	N/A	N/A	N/A	N/A	Record the pre-test brake lining thickness and mass. (Per GMW14986)
Retract caliper piston and pads and zero the dynamometer main torque sensor.					
Pre-test Equipment Check					
- Ramp applies	100	70	5	5000 kPa/s, 13 000 kPa or 1.1G maximum deceleration limit.	Initial brake temperature +90 °C
- Modulated applies	100	30	3	0.5 Hz sinusoidal or ramp apply and release at 6200 kPa/s maximum. If less than or equal to two modulations achieved, reduce the maximum pressure to generate two to three modulations.	Initial brake temperature +90 °C
Green					
- Cold ramp applies	100	70	3	5000 kPa/s; 13 000 kPa or 1.1G maximum deceleration limit.	Initial brake temperature ≤ +40 °C
- Warm ramp applies	100	70	5	5000 kPa/s; 13 000 kPa or 1.1G maximum deceleration limit.	Initial brake temperature +90 °C
- Modulated applies	100	30	3	0.5 Hz sinusoidal or ramp apply and release at 6200 kPa/s maximum. If less than or equal to two modulations achieved, reduce the maximum pressure to generate two to three modulations.	Initial brake temperature +90 °C
Burnish	80	40	200	Corrected pressure control stop, 3500 kPa/s apply rate to a 0.31G deceleration rate.	Initial brake temperature +100 °C
Cool Down	10	70	N/A	Allow the brake rotor to cool to +50 °C.	
Burnished					
- Cold ramp applies	100	70	3	5000 kPa/s; 13 000 kPa or 1.1G maximum deceleration limit.	Initial brake temperature ≤ 40°C
- Warm ramp applies	100	70	5	5000 kPa/s; 13 000 kPa or 1.1G maximum deceleration limit.	Initial brake temperature +90 °C
- Modulated applies	100	30	3	0.5 Hz sinusoidal or ramp apply and release at 6200 kPa/s maximum. If ≤ two modulations achieved, reduce the maximum pressure to generate two to three modulations.	Initial brake temperature +90 °C
Apparent Piston Travel with Preconditioning					
- Preconditioning	50	30	10	Torque control stops are made at 3500 kPa/s apply rate to 0.20G average deceleration.	Initial brake temperature +90 °C
- Apparent piston travel	100	30	2	Ramp applies are made at 5000 kPa/s apply rate to 13 000 kPa maximum pressure or a 1.1G deceleration limit (whichever occurs first).	Initial brake temperature +90 °C

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Test Section Name	Braking Speed (km/h)	Cooling Speed (km/h)	Number of Stops/ Snubs	Control and Level	Condition
STOP TEST – Retract caliper piston and pads and zero the dynamometer main torque sensor.					
1st Fade Section	100	20 ± 5	10	Constant torque stops are made at 7500 kPa/s apply rate; 1.0G deceleration.	Initial brake temperature ≤ +100 °C (1st stop) and ≤ +600 °C (all other stops) with a cycle time of ≥ 15 s.
Post 1st Fade					
- Ramp applies	100	70	5	5000 kPa/s; 13 000 kPa or 1.1G maximum deceleration limit.	Initial brake temperature +90 °C
- Modulated applies	100	30	3	0.5 Hz sinusoidal or ramp apply and release at 6200 kPa/s maximum. If less than or equal to two modulations achieved, reduce the maximum pressure to generate two to three modulations.	Initial brake temperature +90 °C to +600 °C maximum
Apparent Piston Travel with Preconditioning					
- Preconditioning	50	30	10	Torque control stops are made at 3500 kPa/s apply rate to 0.20G average deceleration.	For disc brakes, the caliper piston is physically retracted to create clearance between the piston and the inboard pad. Initial brake temperature +90 °C
- Apparent piston travel	100	30	2	Ramp applies are made at 5000 kPa/s apply rate to 13 000 kPa maximum pressure.	Initial brake temperature +90 °C
2nd Fade Section	100	20 ± 5	20	Constant torque stops are made at 7500 kPa/s apply rate; 1.0G deceleration.	Initial brake temperature ≤ +100 °C (1st stop) and ≤ +600 °C (all other stops) with a cycle time of ≥ 15 s.
Post 2nd Fade					
- Ramp applies	100	70	5	5000 kPa/s; 13 000 kPa or 1.1G maximum deceleration limit.	Initial brake temperature +90 °C
- Modulated applies	100	30	3	0.5 Hz sinusoidal or ramp apply and release at 6200 kPa/s maximum. If less than or equal to two modulations achieved, reduce the maximum pressure to generate two to three modulations.	Initial brake temperature +90 °C to +600 °C maximum
Apparent Piston Travel with Preconditioning					
- Preconditioning	50	30	10	Torque control stops are made at 3500 kPa/s apply rate to 0.20G average deceleration.	Initial brake temperature +90 °C
- Apparent piston travel	100	30	2	Ramp applies are made at 5000 kPa/s apply rate to 13 000 kPa maximum pressure or a 1.1G deceleration limit (whichever occurs first).	Initial brake temperature +90 °C
AFTER COOLDOWN: Retract caliper piston and pads and record the dynamometer main torque sensor zero reading.					
Brake Lining Measurements	N/A	N/A	N/A	N/A	Allow brake to cool to room temperature. Record the post test brake lining thickness and mass (per GMW14986).

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5 Data

5.1 Calculations.

5.1.1 Digital Signal Processing Rate. All test data representing brake applies are processed at 200 Hz.

5.1.2 Digital Signal Zeroing. Brake pressure and torque channels are digitally zeroed based on 0.5 s of digitally recorded data prior to each brake apply.

5.1.3 Residual Brake Drag Torque. Residual brake drag torque is calculated from the low speed (5 Hz) continuously recorded torque signal by filtering the data set to include data points that meet the following criteria:

a. Hydraulic pressure < 100 kPa or < hold-off pressure, whichever is lower.

b. Rotational speed > 160 min^{-1} (rpm).

If it is found, in the course of the test, that the zero reading of the main dynamometer torque sensor has changed, then the test engineer should be consulted on whether the drag data should be corrected (if possible, usually by adding or subtracting the offset from zero) or discarded.

5.1.4 Apparent Over Adjustment. Apparent over adjustment is computed by the following steps:

5.1.4.1 Compute the Apparent Piston Travel (APT) for both test conditions (adjuster functioning and adjuster disabled) for a pressure level selected to be at or close to the adjuster lock-up pressure. A lock-up pressure of (2500 to 3000 kPa is typical.

5.1.4.2 Compute the increase in APT at the adjuster lockout pressure of each braking event relative to the 2nd stop in the 1st fade sequence for both test conditions (adjuster functioning and adjuster disabled). Events that show a decrease in APT are shown as zero increase. The rationale for choosing the 2nd event is that the 1st event helps to set the caliper into a consistent APT condition.

5.1.4.3 Apparent over adjustment is the difference between APT increase during the test without the adjuster and the APT increase recorded during the test with the adjuster. Apparent over adjustment is reported as a positive value only; negative values are reported as zero.

5.2 Interpretation of Results.

Note: Results may be compared to applicable technical specifications or to the results from tests on other brake components.

5.2.1 Graphical Summaries.

5.2.1.1 Ramp Applies. Plot apparent friction (output) versus hydraulic apply pressure between 0 kPa and 12 000 kPa for each ramp apply. Plot green, burnished, and post 1st and 2nd fade applies in the cold and warm conditions on the same graph. Separately, plot average apparent friction (output), initial brake temperature (IBT), and maximum brake temperature versus stop number for each brake apply. Example plots are displayed in Appendix A, Figures A1 and A2.

5.2.1.2 Burnish Schedule. Plot average apparent friction (output), IBT, and maximum brake temperature for every 10th brake apply during the burnish schedule. An example plot is displayed in Appendix A, Figure A2.

5.2.1.3 Apparent Piston Travel with Preconditioning. Plot the apparent piston travel versus hydraulic pressure between 0 kPa and 12 000 kPa for each Apparent Piston Travel with Preconditioning ramp apply. Plot burnished warm, and post 1st and post 2nd fade warm ramp applies on the same graph. An example plot is displayed in Appendix A, Figure A3.

5.2.1.4 Hysteresis. Plot braking torque versus apply pressure for the second cycle of each modulated apply. Plot green, burnished, post 1st and post 2nd fade applies on separate graphs. An example plot is displayed in Appendix A, Figure A4.

5.2.1.5 Apparent Friction. Plot the average apparent friction (output), IBT, and maximum brake temperature for each of the 10 and 20 stops during the fade sections. An example plot is displayed in Appendix A, Figure A2.

5.2.1.6 Apparent Piston Travel During the Fade Sections. Plot the apparent piston travel versus stop number, 1 thru 10 for the first fade and 1 thru 20 for the second fade. Plot apparent piston travel at 500 kPa, 2500 kPa, 5000 kPa, and maximum pressure. Also plot the maximum pressure values using a secondary axis. An example plot is displayed in Appendix A, Figure A5.

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