



Park Brake Durability, Deformation, Efficiency and Function Tests for Manual and Electric Systems

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 defines testing for the park brake system.

1.1.1 Durability Test of assembly for hand, foot and electrically operated park brake. Assemble positioning according to vehicle installation.

1.1.2 Functional Robustness Test (drop-down) of hand operated park brake.

1.1.3 Handle Grip/Pedal Pad Attachment Test.

1.1.4 Elastic and Plastic Deformation Test for hand and foot operated park brake lever/pedal.

1.1.5 Efficiency Measurement Test of the park brake lever/pedal assembly (hand lever or foot pedal).

1.1.6 Efficiency Measurement Test of the complete hand and foot park brake system (only GM internal testing).

1.1.7 Efficiency Measurement Test of the individual parking brake cables with pressure hose in the 270 degree principle test (GM internal testing only).

1.1.8 Efficiency Measurement Test (force and stroke) of the park brake cable assembly in vehicle routing with spring packs.

1.2 Applicability. This test procedure is applicable to all manual and electrical operated park brake systems (see Table 1).

Table 1: Applicability of Test per Type of Park Brake System

Type of Test	Manual Park Brake; Hand Apply	Manual Park Brake; Foot Apply	Electric Apply Park Brake
1.1.1 Durability Test	X	X	X
1.1.2 Functional Robustness Test	X		
1.1.3 Grip/Pad Attachment Test	X	X	
1.1.4 Elastic/Plastic Deformation Test	X	X	
1.1.5, 1.1.6, 1.1.7, 1.1.8 Efficiency Measurement Tests	X	X	X ^{Note}

Note: Efficiency measurement tests 1.1.5 and 1.1.6 not applicable.

1.3 Remarks. It is important to test all possible customer usages of the park brake system. To that end, in addition to the durability test, the manual hand operated park brake should be tested for robustness of the pawl slipping over the ratchet after an actuation.

2 References

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

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2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW15395

2.3 Additional References.

- CG4638
- Component Technical Specifications (CTS)
- Global Document Management (GDM) System (ID) (<https://documents.gm.com/gdm3/component/main>)
- Subsystem Technical Specifications (SSTS)

(ID) = This reference is limited to internal distribution within General Motors and shall not be distributed outside this company. Contact the GM Lead Engineer for further instructions.

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.

3.2 Equipment.

3.2.1 Durability Test of Assembly for Hand, Foot and Electrically Operated Park Brake.

3.2.1.1 Durability Test for Manual Hand Operated Park Brake. Equipment includes:

3.2.1.1.1 A park brake lever actuating unit with force control measurement elements and documentation/recording equipment.

3.2.1.1.2 A park brake lever and cable assembly with a complete rear axle, including wheel hub and brake drum or brake disc.

3.2.1.1.3 All necessary retaining and guide elements for cable routing and fastening according to vehicle installation.

3.2.1.1.4 An actuation unit for service stops that applies the brake caliper. The service stops are required to minimize any caliper misalignment during repeated number of park brake actuations. The rig should be designed so that the actuating force is directed in a 15 degree angle (durability only) from the plane of the lever arc in the outboard (toward the driver's side) direction. See Appendix A, Figures A15 and A16.

3.2.1.1.5 A climate chamber to simulate the environmental conditions for the component described in the specification.

3.2.1.2 Durability Test for Manual Foot Operated Park Brake. Equipment includes:

3.2.1.2.1 A park brake pedal actuating unit with force control and travel-sensing measurement elements with documentation/recording equipment. The test is focusing on durability.

3.2.1.2.2 The rig should be designed so that the actuating force is directed in a 15 degree angle (durability only) from the plane of the lever arc in the outboard (toward the driver's side) direction, with load centered on the pad. See Appendix A, Figure A10.

3.2.1.2.3 A climate chamber to simulate the environmental conditions for the component described in the specification.

3.2.1.3 Durability Test for Electric Park Brake (EPB) Equipment includes:

3.2.1.3.1 A computer which simulates the necessary car Controller Area Network (CAN) signals (or other applicable/required system signals) needs to be connected to the system during the test. The system should be activated either by the CAN system or by a separate system (pneumatic or electric) activating the control push/pull switch.

3.2.1.3.2 The EPB has to be cooled by an air blower. If required, equipment to apply dyed water to the cable end fittings during the test should be available.

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3.2.1.3.3 A climate chamber to simulate the environmental conditions for the component described in the specification.

3.2.2 Functional Robustness Test (Drop-Down) of a Hand Operated Park Brake. Equipment includes:

3.2.2.1 Additional or different equipment described in 3.2.1.1.1, 3.2.1.1.2, 3.2.1.1.3 and 3.2.1.1.4 might be required to ensure, that the park brake lever has the possibility to be tested multiple times over a specified range (e.g., a tooth in the ratchet) with small changes in displacement during a specified time.

3.2.2.2 A small pendulum ($90\text{ g} \pm 5\text{ g}$) should be incorporated to the test system to automatically hit the lever in the field of pawl (to simulate, e.g., slamming door) if the pawl is positioned on top of a tooth. In this test, the force should not be applied in the 15 degree angle, as this makes the test less robust.

3.2.3 Handle Grip/Pedal Pad Attachment Test. Equipment includes:

3.2.3.1 Handle Grip: Detaching fork for detaching the grip from the park brake lever without applying any clamping forces (to the grip).

3.2.3.2 Pedal Pad: Detaching device that pulls around the perimeter of the pad without adding any retaining force to the pad/lever-arm interface.

3.2.4 Elastic and Plastic Deformation Test for Hand and Foot Operated Park Brake Lever/Pedal. Equipment includes:

3.2.4.1 Force and travel sensors with documenting/recording equipment are required.

3.2.4.2 A park brake lever/pedal assembly and a suitable device for mounting the lever in the test position.

3.2.5 Efficiency Measurement Test of Park Brake Lever/Pedal Assembly. Equipment includes:

3.2.5.1 Park brake lever/pedal assembly and a suitable device for mounting the lever/pedal in the test position.

3.2.5.2 An actuating unit.

3.2.5.3 Two (2) force sensors.

3.2.5.4 An angle deflection transducer.

3.2.6 Efficiency Measurement Test of the Complete Hand and Foot Park Brake System. (Includes hand or foot lever/pedal, cable, brackets/guides for routing, etc., and disc brake assembly or drum brake assembly.) Equipment includes:

3.2.6.1 A park brake lever actuating unit with force control measurement elements and documentation/recording equipment.

3.2.6.2 A park brake lever and cable assembly with a complete rear axle, including wheel hub and brake drum or brake disc.

3.2.6.3 All necessary retaining and guide elements for cable routing and fastening according to vehicle installation.

3.2.6.4 An actuation unit for service stops that applies the brake caliper with a pressure of $3000\text{ kPa} \pm 500\text{ kPa}$ prior to the efficiency measurement. The service stops are required to minimize any caliper misalignment during repeated park brake actuations. The rig should be designed so that the actuating force is aligned with the lever grip/pedal pad.

3.2.6.5 One (1) angle deflection transducer, three (3) force sensors and three (3) travel sensors located in 3.2.6.5.1 through 3.2.6.5.8 are required:

3.2.6.5.1 Angle Deflection Transducer 1: Measuring the angle of the park brake lever actuation.

3.2.6.5.2 Force Sensor 1: Measuring force input to grip at G-point. Position of G-point see Appendix A, Figure A4.

3.2.6.5.3 Force Sensor 1A: Measuring force output of lever to secondary cables. (Not required at supplier.)

3.2.6.5.4 Force Sensor 2: Measuring left hand side cable force output at rear caliper/drum brake.

3.2.6.5.5 Force Sensor 3: Measuring right hand side cable force output at rear caliper/drum brake.

3.2.6.5.6 Travel Sensor 4: Measuring travel input to cable assembly.

3.2.6.5.7 Travel Sensor 5: Measuring left hand side cable travel output at rear caliper/drum brake.

3.2.6.5.8 Travel Sensor 6: Measuring right hand side cable travel output at rear caliper/drum brake.

Note: Actuating speed (v) = $5\text{ degrees/s} \pm 1\text{ degree/s}$. See Appendix A, Figure A12 and Figure A13.

3.2.7 Efficiency Measurement Test for Cable in 270 Degree Principle Test. Equipment includes:

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3.2.7.1 Force and travel sensors with recording equipment.

3.2.7.2 A tensile testing machine, suitable for the required forces and test speeds.

3.2.8 Efficiency Measurement Test of the Park Brake Cable Assembly in Vehicle Routing. Rig table for setup assembly equipment includes:

3.2.8.1 A cable assembly with the correct vehicle routing, but mounted to rigid fixation points and abutments is required.

3.2.8.2 Spring packs, according to the vehicle program Component Technical Specification (CTS)/Subsystem Technical Specification (SSTS) and in agreement with project engineer, must be used to simulate force and travel of the rear brakes.

3.2.8.3 All necessary retaining and guide elements that are the responsibility of the cable supplier must be used for cable routing and fastening to the rigid fixation points, according to vehicle installation.

3.2.8.4 The rig should be designed so that the actuating force is initiated in line with the primary cable/coupler. Three (3) force sensors and three (3) travel sensors located in 3.2.8.4.1 through 3.2.8.4.6.

3.2.8.4.1 Force Sensor 1: Measuring force input to cable assembly.

3.2.8.4.2 Force Sensor 2: Measuring left hand side cable force output at rear caliper/drum brake.

3.2.8.4.3 Force Sensor 3: Measuring right hand side cable force output at rear caliper/drum brake.

3.2.8.4.4 Travel Sensor 4: Measuring travel input to cable assembly.

3.2.8.4.5 Travel Sensor 5: Measuring left hand side cable travel output at rear caliper/drum brake.

3.2.8.4.6 Travel Sensor 6: Measuring right hand side cable travel output at rear caliper/drum brake.

Note: Actuating speed (v) = 4 mm/s $\pm$ 1 mm/s. See Appendix A, Figure A14.

3.3 Test Vehicle/Test Piece.

3.3.1 Durability Test of Assembly for Hand, Foot and Electrically Operated Park Brake. At least three (3) park brake levers (or a quantity specified in the validation plan) with brake cable assembly and brakes shall be tested.

3.3.2 Functional Robustness Test (Drop-Down) of a Hand Operated Park Brake. At least three (3) park brake levers (or a quantity specified in the validation plan) with brake cable assembly and brakes shall be tested.

3.3.3 Handle Grip/Pedal Pad Attachment Test. At least three (3) park brake levers or pedals (or a quantity specified in the validation plan) shall be tested.

3.3.4 Elastic and Plastic Deformation Test for Hand and Foot Operated Park Brake Lever/Pedal. At least 12 (three (3) per test according to Table 2) park brake lever assemblies (or a quantity specified in the validation plan) shall be subjected to the elastic and plastic deformation test in the various loading directions.

3.3.5 Efficiency Measurement Test of Park Brake Lever/Pedal Assembly. At least three (3) park brake lever/pedal assemblies (or a quantity specified in the validation plan) shall be tested for efficiency.

3.3.6 Efficiency Measurement Test of the Complete Hand and Foot Park Brake System. At least three (3) park brake complete assemblies (or a quantity specified in the validation plan) shall be tested for efficiency.

3.3.7 Efficiency Measurement Test for Cable in 270 Degree Principle Test. At least three (3) individual parking brake cables with pressure hoses (or a quantity specified in the validation plan) shall be tested for efficiency.

3.3.8 Efficiency Measurement Test of the Park Brake Cable Assembly in Vehicle Routing. At least three (3) park brake cable complete assemblies (or a quantity specified in the validation plan) shall be tested for efficiency.

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Table 2: Deformation Test Parameters

Test Force (N)	Permissible Elastic per Test Force Direction (mm)	Permissible Plastic per Test Force Direction (mm)	Testing Direction
F1 Hand = 660	8	2.5	Tensile against fixed cable connector at last notch with 15 degree angle toward driver (Appendix A, Figure 2)
F1 Hand = 850	No Failure	No Failure	Tensile against stop at full apply position with 15 degree angle toward driver, 500 N of the 850 N must be driven into the cable (Appendix A, Figure A1)
F2 Hand = 500	4	2	Compressive against stop at release position with 15 degree angle away from driver in Y-Z section (Appendix A, Figure A2)
F2 Foot = 1112	No Failure	No Failure	Compressive against stop at full apply position with 15 degree angle away from driver, 800 N of the 1112 N must be driven into the cable (Appendix A, Figure A10)
F3 Hand/Foot = 4.5 F3 Hand/Foot = 10 F3 Hand/Foot = 222	1 ^{Note 1} 2 ^{Note 1} 14	0 0 1	Full return/released position and at 66% of maximum apply angle. (Appendix A, Figures A3 and A10)
F7/F8 Hand = 500 F7/F8 Hand = 850 ^{Note 2}	20 No Failure	4 No Failure	Compressive against position of first notch with 45 degree angle towards driver and towards co-driver (Appendix A, Figures A17 and A18)

Note 1: As sum of lateral play/deformation in both directions.

Note 2: If 850 N cannot be reached due to plastic deformation, a minimum total deformation (elastic + plastic) of 60 mm must be reached without collapse. The force is not allowed to be lower than 650 N at 60 mm total deformation.

3.4 Test Time.

Estimated for each assembly.

Calendar time: 25 days to 30 days per park brake

Test hours: 450 h to 600 h per park brake

Coordination hours: 50 h to 60 h per park brake

3.5 Test Required Information.

Not applicable.

3.6 Personnel/Skills.

The test stand personnel shall be suitably trained for the requirements of the individual tests.

4 Procedure

4.1 Preparation.

4.1.1 Durability Test of Assembly for Hand, Foot and Electrically Operated Park Brake.

4.1.1.1 Durability Test for Manual Hand Operated Park Brake. Install the axle assembly in an evenly loaded position. Route the cable assembly, including all guide and retaining elements, according to vehicle installation and positioning of the park brake lever assembly. Connect the park brake lever to the actuating unit at the apply point G, as shown in Appendix A, Figure A5. The rig should be designed so that the actuating force is directed in a 15 degree angle (durability only) from the plane of the lever arc in the outboard (toward the driver's side) direction. See Appendix A, Figures A15 and A16.

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4.1.1.2 Durability Test for Manual Foot Operated Park Brake. Install the axle assembly in evenly loaded position. Route the cable assembly, including all guide and retaining elements, according to vehicle installation and positioning of the park brake lever/pedal assembly. Connect the park brake pedal to the actuating unit at the center of pad for foot pedal apply point. The rig should be designed so that the actuating force is directed in a 15 degree angle (durability only) from the plane of the lever arc in the outboard (away from driver) direction, with load centered on the pad. See Appendix A, Figure A10.

4.1.1.3 Durability Test for Electric Park Brake. Install the axle assembly in an evenly loaded position. Route the cable assembly, including all guide and retaining elements, according to vehicle installation and positioning of the park brake assembly. Set up the car CAN, or other applicable/required system, hardware and software to actuate the EPB. An alternate actuation method is a pneumatic actuator to push/pull the maneuver switch.

4.1.2 Functional Robustness Test (Drop-Down) of a Hand Operated Park Brake. Install assembly per 4.1.1.1. Additionally, install a transducer for detection of lever position and a pendulum for excitation of the lever basement.

Note: Do not use the 15 degree angled application.

4.1.3 Handle Grip/Pedal Pad Attachment Test. Mount the park brake lever assembly in the testing device so that the grip/pad can be detached in the longitudinal direction without clamping on the grip/pedal.

4.1.4 Elastic and Plastic Deformation Test for Hand and Foot Operated Park Brake Lever/Pedal. Set up the park brake lever, as described in Table 2 for the performed test (e.g. tensile, compressive, etc.), and the foot operated pedal (55% of total apply for quiet apply). See Appendix A, Figures A1, A2, A3 and A10 for force application.

4.1.5 Efficiency Measurement of Park Brake Lever/Pedal Assembly. Install the park brake lever/pedal assembly in the testing device. Connect the actuating unit to the lever grip/pedal pad at the apply point G for hand lever and at center of pad for pedal. Fasten a cable to the cable/park brake connector assembly which applies the input force by means of a deflection pulley and a suspended weight.

4.1.6 Efficiency Measurement Test of the Complete Hand and Foot Park Brake System. Install the axle assembly in evenly loaded position. Route the cable assembly, including all guide and retaining elements, according to vehicle installation and positioning of the park brake lever assembly. Connect the park brake lever to the actuating unit at the apply point G, as shown in Appendix A, Figure A5. The rig should be designed so that the actuating force is aligned with the lever grip/pedal pad.

4.1.7 Efficiency Measurement Test for Cable in 270 Degree Principle Test. Use the 270 degree, S-shaped routing of the individual cables with pressure hose according to Appendix A, Figure A11. Connect the cable ends to the tensile testing machine and the force-application weight.

4.1.8 Efficiency Measurement Test of the Park Brake Cable Assembly in Vehicle Routing. Route the cable assembly, including all guide and retaining elements, according to vehicle installation at rigid fixation points and rigid abutment. Connect the park brake cable assembly to the brake force and stroke simulating spring packs and to the actuating unit. The rig should be designed so that the actuating force is initiated in line with the primary cable/coupler.

4.2 Conditions.

4.2.1 Environmental Conditions. The tests shall be performed under laboratory conditions at $+23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ without additional environmental influences, unless otherwise defined. A climate chamber shall generate the specified conditions for the component.

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.

4.3 Instructions.

Note: See example data sheets in Appendix A, Figures A6 through A8.

4.3.1 Durability Test of Assembly for Hand, Foot and Electrical Operated Park Brake. The park brake without automatic cable adjuster shall be adjusted in accordance with the vehicle program production specifications and shall be requested from GM Design Engineer. Perform initial measurements of the manual force per ratchet tooth at the apply point G perpendicular to the lever effort arm (according to Appendix A, Figure A5), the cable force at the park brake lever cable connection, and the torque at the wheel hubs (both forwards and backwards). In order to measure the torque a manual torque wrench or similar method shall be

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used. Each test cycle should be performed according to 4.3.1.1 or 4.3.1.2. The test loads and number of actuations should be predefined in vehicle program CTS/SSTS. Also, the requirements regarding the survival probability and scatter should be specified.

Component Test: Test according to reliability of 99% with a confidence level of 50% (R99C50).

System Test: Test according to reliability of 95% with a confidence level of 50% (R95C50).

4.3.1.1 Durability Test for Manual Hand and Foot Operated Park Brake. The following is a durability test example for hand and foot operated park brake systems.

The durability test shall be performed in three (3) consecutive cycles, with four (4) load levels/stages each. One (1) cycle comprises 27 775 park brake actuations per Table 4 (standard condition) and Table 5 (simulated environmental condition). The actuation duration shall be $5 \text{ s} \pm 2 \text{ s}$. Park brake systems without automatic adjustment of the cable shall be readjusted to production specifications, if the measured hand force deviates more than 10% compared to the production specifications, or the measured application angle on the lever deviates more than 5% compared to the production specifications. All readjustment measurements must be documented with cycle and load stage information and included in the test report with description of how the adjustment was applied (e.g., torque and travel values that were readjusted). The total number of test actuations is 27 775 multiplied by three (3) to equal 83 325. After every 20 actuations (unless otherwise requested), the service brake shall be applied to $3000 \text{ kPa} \pm 500 \text{ kPa}$ for $2 \text{ s} \pm 0.5 \text{ s}$. The load stages shall be specified as force levels according to Table 6. If these forces cannot be reached with the park brake system, the load stages specified as travel must be used (see Table 7).

In order to indicate that the component resists the requested temperature and humidity range shown in 3.1.3.2 of GMW15395, 30% of the total number of test samples (see Table 3) must be tested for one (1) durability according to the load stages and environmental conditions listed in Table 5.

Note: The release button can be locked in cases where the park brake lever is not a test part. In this case, the lever handle should be pulled to the right load level and released again without using the instructions in 4.3.1.1.1.

Table 3: Test Sample Distribution

Total number of durability samples	3	4	5	6	7	8	9	10	11	12
Number of samples for durability under environmental condition	1	2	2	2	3	3	3	3	4	4

Table 4: Park Brake Actuations per Cycle (Standard)

Load Stage	Number of Actuations
	Standard Condition (room temperature/relative humidity not defined)
Number 1	25 000
Number 2	2500
Number 3	250
Number 4	25
Total	27 775

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Table 5: Park Brake Actuations per Cycle (Environmental Condition)

Load Stage	Number of Actuations Simulated Climate Conditions	Temperature (Degrees Celsius)	Relative Humidity (Percent)	Environmental Condition
Number 1	10 750	23 ± 2	50 ± 5	Room Temperature
Number 2	1075			
Number 3	108			
Number 4	10			
Number 1	5000	45 ± 2	85 ± 5	Monsoon Climate
Number 2	500			
Number 3	50			
Number 4	5			
Number 1	5000	45 ± 2	20 ± 5	Desert Climate
Number 2	500			
Number 3	50			
Number 4	5			
Number 1	2000	-30 ± 2	n/a	Low Temperature
Number 2	200			
Number 3	20			
Number 4	2			
Number 1	2000	80 ± 2	n/a	High Temperature
Number 2	200			
Number 3	20			
Number 4	2			
Number 1	250	85 ± 2	n/a	Excursion Temperature
Number 2	25			
Number 3	2			
Number 4	1			
Total	27 775			

Note: n/a = Not applicable.

Table 6: Load Stage Force Levels

Load Stage	Manual Force, Hand Lever (N)	Manual Force, Foot Pedal (N)
Number 1	350	335
Number 2	400	445
Number 3	450	555
Number 4	550	890

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