



Power Liftgate Failed Counterbalance Mitigation Performance 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 provides the procedure for performance verification of the Power Liftgate (PLG) System Failed Counterbalance Mitigation feature.

1.2 Applicability. All vehicles equipped with a Power Liftgate feature.

1.3 Remarks. The Power Liftgate System is required to safely lower the liftgate after a power open cycle is completed when the counterbalance force, provided by the supporting struts, has failed or degraded to an extent that the liftgate will not hold open. The Failed Counterbalance Mitigation software algorithm is designed to satisfy this requirement. This test is required to verify the performance the Failed Counterbalance Mitigation software algorithm when subjected to all potential counterbalance failure modes.

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.

- Component Technical Specification (CTS)

3 Resources

3.1 Facilities. The test facility shall be a lab or garage area with a level surface and means of restricting access to the vehicle under test to protect passersby from the potential of being struck by a falling liftgate during the test.

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 Digital Data Recorder. The data acquisition system must have the ability to adjust sample rate and anti-alias filter.

3.2.2 Post-processing Software. Must be capable of plotting and performing mathematical computations on collected data.

3.2.3 String Potentiometers. Two string potentiometers are to be mounted on opposite sides of the liftgate.

3.2.4 Inclinator. An inclinometer shall be used to develop the calibration of the string pots for liftgate gate angle in degrees.

3.2.5 Vehicle Battery Charger.

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3.3 Test Vehicle/Test Piece. The test property may be a full vehicle, or rear end buck. The property shall be equipped with full power rear closure system. The closure content (defining the swung mass and center of gravity) shall be complete and confirmed by the program Design Release Engineer (DRE) prior to start of test. Typical rear closure content includes, but is not limited to, garnish trim, sill plate, wire harnesses and tail lamps.

3.4 Test Time.

Calendar time:	1.5 d
Test hours:	4 h
Coordination hours:	4 h
Data analysis hours:	4 h

3.5 Test Required Information.

3.5.1 The requesting engineer is responsible for providing the Component Technical Specification (CTS) which must include the performance objectives and failure criteria.

3.5.2 Failed Counter Balance Samples. The program power liftgate DRE shall provide a set counterbalance parts simulating known potential counterbalance failure modes and the resulting range of force loss levels. The test parts will typically be either federbeins or gas struts, depending upon the program PLG execution. Guidance for defining the set of simulated failed parts is given in the paragraphs below.

3.5.2.1 Test Samples for Gas Strut Counterbalanced PLG. A vehicle example of a power liftgate system with the liftgate counterbalanced by gas struts only is shown in Figure A2 in Appendix A.

Gas strut failure modes result in the potential for a continuous range of counterbalance force loss. (e.g., gas strut pressure loss over time.) A set of seven test samples per strut part number shall be fabricated with evenly spaced incremental levels of force representing the range from 15% to 95% counterbalance force loss with respect to nominal design force ($F1$). Therefore, the force outputs of sample numbers 1 and 7 are calculated as shown in Table 1.

Table 1: Force Calculations for Gas Strut Test Samples

Gas Strut Sample Number	F1 or Gas Strut Samples (N)
1	$0.85 F1$
2	$F1_{sample_1} - \frac{0.8}{6} F1$
3	$F1_{sample_2} - \frac{0.8}{6} F1$
4	$F1_{sample_3} - \frac{0.8}{6} F1$
5	$F1_{sample_4} - \frac{0.8}{6} F1$
6	$F1_{sample_5} - \frac{0.8}{6} F1$
7	$0.05 F1$

Note: A force tolerance of $\pm 10\%$ must be allowed for when fabricating the gas struts in a prototype process. With typical liftgate strut $F1$ values, using more than seven evenly spaced force values will result in excessive overlap in tolerance ranges in the higher output samples. If finer sample to sample resolution is required, samples may be combined to create total force values lying between the standard set defined above. Example force calculation results with tolerances are shown in Figure B1 and Figure B2 in Appendix B.

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Note: If the vehicle uses a pair of gas struts, the total number of strut samples shall be fourteen, where seven are right hand and seven are left hand part numbers.

3.5.2.2 Test Samples for Single Federbein Counterbalanced PLG. A vehicle example of a power liftgate system with the liftgate counterbalanced by a single federbein and single spindle actuator is shown in Figure A1 in Appendix A.

Review the federbein and spindle actuator drawings and determine the percentage of total counterbalance force provided by the gas strut component in the federbein. If the percentage is greater than or equal to 25%, fabricate all three test samples as shown in Table 2.

If the percentage is less than 25%, fabricate only sample numbers 2 and 3 from Table 2. Sample number one is not required when gas pressure contributes less than 25% of the total counterbalance force.

Table 2: Gas Strut and Spring Selection for Federbein Sample Assemblies ^{Note 1}

Sample Number	F3 for Part of Assembly (POA) Gas Strut Test Samples (N)	Compression Spring F3 (N)
1	$0.85 \cdot F3_T - F3_{fb} - F3_{actuator} + F3_{fb\ gas}$	Nominal ^{Note 2}
2	0	Nominal
3	$F3_{fb\ gas}$	No spring assembled

Note 1: The total F3 force for the federbein test samples is the sum of the values in columns two and three.

Note 2: The nominal compression spring F3 may not be explicitly listed on the federbein drawing. It can be calculated as the difference between the federbein nominal F3 total and the F3 of the POA gas strut.

Where:

$F3_T$ = Total liftgate nominal design F3 (e.g., sum of nominal actuator and federbein assembly F3 values).

$F3_{fb}$ = Drawing nominal F3 for the federbein assembly.

$F3_{actuator}$ = Drawing nominal F3 for the spindle actuator assembly.

$F3_{fb\ gas}$ = Drawing nominal F3 for gas strut POA to the federbein assembly.

3.6 Personnel/Skills. A test engineer is required to run this test. The test engineer shall be proficient with the required instrumentation and data acquisition. The test engineer shall also be able to interpret the test results and create reports as appropriate, which includes the use of software to post-process data.

4 Procedure

4.1 Preparation.

4.1.1 Mount two string potentiometers on opposite sides of the liftgate. The purpose of redundant string pots is to mathematically cancel out some of the local vibration during sudden liftgate accelerations. See the example in Figure C1 in Appendix C.

4.1.2 Mount the inclinometer on the liftgate as shown in Figure C2 in Appendix C.

4.1.3 Setup the data recorder to monitor the signal voltage (in units of Volts) of each string potentiometer. Zero the inclinometer and string potentiometer channels with the liftgate in the fully closed position.

4.1.4 Turn the power liftgate function off to be able to manually control the liftgate motion. Move the liftgate in 10 degree increments using the inclinometer to determine the liftgate angular position. At each 10 degree increment record the signal voltage of each string potentiometer.

4.1.5 Generate a linear or polynomial fit of Voltage versus Liftgate Angle for each string potentiometer using MS Excel or an application with similar capability. Ensure the fit for each string potentiometer has a statistical R^2 value of at least 0.95. The inclinometer may be removed from the liftgate after completion of this step.

4.1.6 Setup additional channels for information only, if requested. (e.g. actuator motor current, latch switch state, etc.)

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