



General Procedures for Testing Switches

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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 intended to document unique or specific electrical, mechanical, environmental and durability tests for automotive switches.

1.2 Applicability. This procedure covers the laboratory testing of automotive switches containing sliding or separating electrical contacts. The method of actuation includes, but is not limited to, differentials in: temperature, pressure, vacuum, fluid level, mounting angle (tilt), or displacement. This procedure applies to the following types of devices:

- Mechanical Switches, i.e., devices containing electrical contacts without electronic content.
- Electromechanical Switches, i.e., mechanical switches containing any of the following: resistors, capacitors, diodes, Light Emitting Diodes (LED), and discrete transistors.
- Electronic Switches, i.e., electromechanical or solid state (semiconductor based) switches with electronic content for logic or decision making.

1.3 Remarks. This specification defines the test conditions and the test procedures for functional, environmental and durability tests of switches which are installed in the vehicle. Additional necessary requirements, e.g., definition of the function of the switches and the functional accuracy including the determination of the tolerance range, or the establishment of specific test procedures, are specified in relevant specifications, i.e., Component Technical Specification (CTS), circuit diagram, or part drawing.

2 References

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

2.1 External Standards/Specifications.

ASTM B539	IEC 60068-2-6	ISO 12103-1	SAE J1885
ASTM D4728	IEC 60068-2-27	ISO 20653	
CMVSS 206	IEC 60068-2-60	SAE J726	
FMVSS 206	ISO 1431-1	SAE J1330	

2.2 GM Standards/Specifications.

GMW3059	GMW3191	GMW3232	GMW14829
GMW3172	GMW3208	GMW14528	GMW16449

2.3 Additional References.

- Powder Technology, Inc. for packaged dust is available at 14331 Ewing Ave. South, Burnsville, MN 55306 (URL: www.powdertechinc.com)
- Relevant CTS
- Relevant circuit diagrams
- Relevant part drawings

3 Test Preparation and Evaluation

3.1 Resources.

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 Facilities. Refer to the individual parts of Section 4 for details.

3.1.3.1 Various Environmental Chambers. Hot/cold, humidity, salt fog, xenon arc, and dust.

3.1.3.2 Vibration Test System.

3.1.3.3 Force vs. Displacement System

3.1.3.4 Dust Test System.

3.1.4 Equipment. See 3.1.7 for performance, accuracy and repeatability requirements. Refer to the individual parts of Section 4 for more details.

3.1.4.1 Power Sources.

3.1.4.2 Auxiliary Battery. An automotive battery of 450 Cold Cranking Amperes (CCA) to 650 CCA shall be connected in parallel with the power supply. Where all test samples are energized instead of in sequence, or where more than eleven (11) samples are tested, use a battery or batteries capable of at least 100 CCA per sample. The supplier must ensure that the battery maintains consistent operation throughout the test sequence.

3.1.4.3 Various Meters. Voltage, current, sound level, dry circuit resistance, calibrated smoke, megohmmeter, spectroradiometer, and dosimeter.

3.1.4.4 Temperature Probes.

3.1.4.5 Load Cells. Two and six axis.

3.1.4.6 Direct Drive Gear Box.

3.1.4.7 Various Measurement Equipment. Scales, dial indicators, etc.

3.1.4.8 Displacement Transducers.

3.1.5 Test Vehicle/Test Piece. If not otherwise stated, the number of test pieces and conditioning shall be as specified in the relevant CTS, circuit diagram, or part drawing. Production samples shall be selected at random from pieces which have been subjected to all normal processing including final packaging.

3.1.5.1 Failure Determination. Test failure is defined by any of the following conditions:

- Performance outside specification limits, i.e., CTS, circuit diagram, or part drawing.
- Initial or final tear down inspection reveals a condition that could cause customer dissatisfaction.
- A missed cycle during durability test, if verification is provided as follows:
 1. Check basic setup and instrumentation including mounting, stroke, rate of actuation and actuation force.
 2. Attach oscilloscope, chart recorder or other data acquisition equipment across the circuit in question.
 3. Allow test to continue while continuously monitoring for a failure to make, a failure to break, or a nuisance cycle as indicated by the original test equipment.
 4. Check to assure the miss was also captured by the auxiliary monitoring equipment.
 5. Recheck basic setup and instrumentation.

Note: Failures observed during product validation or compliance testing shall require resolution through the submission of an irreversible corrective action plan, e.g., 5 Phase, 7 Diamond, 8D, or equivalent (see 6.1 Glossary), to the appropriate responsible GM Engineer, containing a problem description, root cause analysis, interim and permanent corrective action and action verification plan.

3.1.5.2 Test Restart after Failure. Should a test failure occur, contact the appropriate responsible GM Engineer to determine if the test is to be continued to gain additional product experience or if testing is to be stopped. When contact cannot be immediately made, the type of test, i.e., Investigative or Validation (see 6.1 Glossary), shall determine the disposition of the samples. If the test order indicates the test is investigative in nature, continue until the requesting party is available. If the test order is for sample approval or validation testing, stop the test and wait for further instructions.

3.1.6 Test Time. Varies based on switch design and implementation in vehicle. Refer to the individual parts of Section 4 for details.

3.1.7 Test Required Information.

3.1.7.1 Parameters and Tolerances and Rates. Test setups and equipment shall be capable of maintaining test parameters within the limits found in Table 1 and Table 2 unless otherwise stipulated in the relevant CTS, circuit diagram, part drawing or elsewhere in this procedure.

Table 1: Parameters and Tolerances

Test Parameter	Applied Tolerance
Air Pressure (Laboratory)	106.6 kPa to 872.0 kPa (15.5 psi to 126.5 psi) Traditionally 800 mmHg to 6540 mmHg
Room Temperature	$(23 \pm 5) ^\circ\text{C}$
High Ambient Temperature, Reference GMW3172	$(T_{\max} -0/+5) ^\circ\text{C}$
Low Ambient Temperature, Reference GMW3172	$(T_{\min} -5/+0) ^\circ\text{C}$
Chamber Humidity	As specified $\pm 5\%$
Time	As specified $\pm 5\%$
Forces	As specified $\pm 5\%$
Distances	As specified $\pm 1\%$
Nominal Operating Voltage	$(14.0 \pm 0.1) \text{ V}$
Voltage	$(\text{As specified} \pm 0.1) \text{ V}$
Current (Performance Test)	As specified $\pm 15\%$
Current (Durability Test)	As specified $\pm 15\%$
Vibration	As specified $\pm 2.0 \text{ m/s}^2 (\pm 0.2\text{G})$ or $\pm 20\%$ (whichever is greater)
Shock	As specified $\pm 20\%$
Frequency	As specified $\pm 1\%$

Table 2: Rate of Actuation

Mode of Actuation	Rate of Actuation
Air Temperature	$(3 \pm 1) ^\circ\text{C/minute}$
Pressure	$(333.3 \pm 66.7) \text{ kPa } ((48.3 \pm 9.7) \text{ psi})$ Traditionally $(2500 \pm 500) \text{ mmHg/s}$
Vacuum	$(40 \pm 10) \text{ mm/s}$
Fluid Level	$(25.0 \pm 5) \text{ mm/minute}$
Angular Displacement	$(5.0 \pm 1) \text{ degrees/s}$
Linear Displacement	$(20.0 \pm 5) \text{ mm/s}$
Fluid Temperature	$(10 \pm 3) ^\circ\text{C/minute}$

3.1.7.2 Power Source Performance.

3.1.7.2.1 Output Current. The power source shall be capable of supplying a continuous output current as required by the design loads including inrush and stall currents.

3.1.7.2.2 Regulation. The output voltage shall not deviate more than 1.0 V from zero to maximum load (including surges) and shall recover 63% of its maximum excursion within 5.0 ms.

3.1.7.2.3 Ripple Voltage. Ripple voltage shall not exceed 300 mV peak to peak for nominal 12 V sources or 100 mV peak to peak for nominal 5 V sources.

3.1.7.3 Measurement Accuracy. Meters and gauges used to assess the performance dependent variable as defined by the basic function of the test sample shall be capable of measuring to one count better than the specified value. For example, even though a 0.1 mm shaft and a 0.10 mm shaft might be the same diameter, a technician could use calipers capable of 0.01 mm resolution to measure the first, but would need a micrometer to obtain 0.001 mm resolution for the latter value.

3.1.7.4 Test Repeatability. Equipment repeatability studies shall be performed on all laboratory equipment after initial calibration and before use for product evaluation. Individual meters and gauges may be certified by manufacturer specifications. All equipment used for product evaluation shall be repeatable to within 10% of the specification value, e.g., ten (10) consecutive readings on the same switch which actuates at 0.10 mm must be within a 0.01 mm range.

3.1.8 Personnel/Skills. Types of personnel and skills varies based on switch design and implementation in vehicle. Refer to the individual parts of Section 4 for details.

3.2 Preparation. Preparation varies based on types of tests to be run. Refer to the individual parts of Section 4 for details.

3.3 Conditions. Unless otherwise specified, all test samples shall be mounted in the in car position with the appropriate trim piece or bezel attached. When specific test conditions are not given either by the relevant CTS, circuit diagram, part drawing or elsewhere in this specification, consult with the appropriate responsible GM Engineer. Otherwise, the following basic conditions shall apply:

- When a mounting view is not provided by the part drawing, samples shall be mounted with terminal centerlines as indicated in Table 3. The mounting environment shall include baffles or enclosures which simulate vehicle air flow restrictions and production, prototype, or simulated bezels and bolts which may pinch or stress mounting lugs or case side walls.

Table 3: Terminal Centerline Position

Vehicle Mounting Position	Terminal Centerlines
Instrument Panel	Horizontal
Door/Console/Trunk Lid	Vertical Pointing Down
Engine/Chassis	45 Degrees from Horizontal

- Open Circuit Voltage (OCV) shall be 14.0 V at switch terminals for nominal 12 V system, 5.0 V at switch terminals for nominal 5 V system, 28.0 V at the switch terminals for nominal 24 V system and 42.0 V at the switch terminals for nominal 36 V system.
- Load current shall be the resistive, inductive or bulb load given by the test specification. Inrush and stall currents shall be considered. Duty cycles are as shown in Table 4

Table 4: Load Duty Cycles ^{Note 1}

Load	Normal Duty Cycle	Option Duty Cycle
Resistive or Inductive	3 s "on", 5 s "off"	1 s "on", 2 s "off" (load current < 20 mA)
Bulb	3 s "on", 25 s "off"	3 s "on", 5 s "off" (100% inrush current cycle to cycle ^{Note 2})

Note 1: Electrical load simulation may also be used with agreement from the appropriate responsible GM Engineer.

Note 2: This can be accomplished by cooling the bulb filaments with a fan or ventilator and switching between lamp racks or banks after every cycle.

- Connections shall be made using the production approved connection system, including connector body, terminal, seals, crimp, Terminal Position Assurance (TPA), Connector Position Assurance (CPA), listed on the part drawing. Deviation from this requirement shall require the appropriate responsible GM Engineer approval.

- Application test circuits used for performance and durability testing shall use the appropriate application specific wire gage and length. The actual in vehicle length or maximum of 3 m should be used if possible. Table 5 depicts recommended wire gage selection as a function of test load for use when application specific wire gage information is not available.

Table 5: Wire Gauge Selection

Test Load	Metric	Acceptable Customary
< 3.0 A	0.5 mm ²	20 gauge
3.1 A to 15.0 A	1.0 mm ²	18 gauge
15.1 A to 20.0 A	2.5 mm ²	14 gauge
> 20.0 A	6.0 mm ²	10 gauge

3.3.1 Environmental Conditions. Test or measurement shall be performed at room temperature unless otherwise stated.

3.3.2 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.

3.4 Instructions. Refer to the individual parts of Section 4 for details.

Note: Validation schedule test flows for electromechanical and electronic switches are in Appendix B.

3.5 Data. See example Data Sheet A1 in Appendix A. Refer to the individual parts of Section 4 for details.

3.6 Safety. This standard may involve hazardous materials, operations, and equipment. This standard does not propose to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

3.7 Documentation. Samples of components or material released to this standard shall be tested for conformity with the requirements of this standard and approved by the responsible GM Department prior to the start of delivery of production level components or materials.

Any change to the component or material, e.g., design, function, properties, manufacturing process and/or location of manufacture requires a new release of the product. It is the sole responsibility of the supplier to provide the customer, unsolicited, with documentation of any change or modification to the product/process, and to apply for a new release.

If not otherwise agreed to, the entire verification test shall be repeated and documented by the supplier prior to start of delivery of the modified or changed product. In some cases, a shorter test can be agreed to between the responsible GM department and the supplier.

3.7.1 Test Results. A formal test report shall be due immediately after test completion, unless otherwise stipulated and sent to the responsible GM department. The test report shall contain, at a minimum, the following for each test performed:

- Title page
- Forward
- Objective
- Criterion
- Conclusion
- Test material
- Test equipment
- Procedure
- Results
- Appendix

The test report should also detail any irreversible corrective action plans, 5 Phase, 7 Diamond, 8D, or equivalent, (see 6.1 Glossary), necessary to correct failures observed during testing.

Note: The laboratory test order shall provide location and documentation of test samples, identify the type of test to be performed, i.e., Investigative or Validation (see 6.1 Glossary), and describe special tests when not part of this specification.

4 Requirements and Procedure

4.1 Performance Requirements. The tests detailed in 4.2 through 4.5 are not expected to stress any part or component beyond its anticipated application limit. Performance measurements are performed at room temperature using test heads or new production or prototype connectors unless otherwise noted. Tests which are not called out by the relevant CTS, circuit diagram, part drawing or test order do not need to be performed. See Table 6.

Table 6: Performance Checks and Frequencies

Performance Check	Performance Check Frequency
Voltage Drop (Recommended for High Current devices)	Initial; Continuous
Open Circuit Resistance	Initial; 100% Expected Life; End of Test (3 × Life, typically)
Isolation Resistance	Initial; 100% Expected Life; End of Test (3 × Life, typically)
Temperature Rise	Initial
Function Check	Initial; After Individual Test; 100% Expected Life; End of Test (3 × Life, typically)
Displacement	Initial; Conditioning, Dust, Humidity, Corrosion; 100% Expected Life; End of Test (3 × Life, typically)
Force or Torque to Actuate	Initial; Conditioning, Dust, Humidity, Corrosion; 100% Expected Life; End of Test (3 × Life, typically)
Illumination	Initial; 100% Expected Life; End of Test (3 × Life, typically)
Appearance	Initial; After Individual Test; 100% Expected Life; End of Test (3 × Life, typically)
Audible Sound	Initial; 100% Expected Life; End of Test (3 × Life, typically)
Contact Bounce	Initial; 100% Expected Life; End of Test (3 × Life, typically)
Leak Check	Initial; 100% Expected Life; End of Test (3 × Life, typically)
Rattle Test	Initial; After: Drop, Mechanical Shock, Vibration; 100% Expected Life; End of Test (3 × Life, typically)
Contact Resistance (Recommended for Low Current devices)	Initial; 100% Expected Life; End of Test (3 × Life, typically)

4.1.1 Voltage Drop. This check is applicable for devices carrying 500 mA or greater.

4.1.1.1 Purpose. Voltage drop is a measure of the power and associated temperature rise a circuit is generating as it passes current. Voltage drop measurements conducted across contacts which have remained open for sustained periods will be higher than measurements taken after one (1) or two (2) cycles of operation. For this reason, start the voltage drop test by measuring contact interfaces which require actuation; then return to the contacts which make circuit in the de-energized state.

4.1.1.2 Procedure. Apply the nominal test specification operating parameter (temperature, pressure, displacement, etc.), which causes an electrical circuit change of state to occur. See Tables 1 and 2. Maintain the operating parameter until electrical or mechanical stability is achieved.

A Kelvin or four wire approach shall be used to assure the connector interface is not part of the recorded measurement. When a Kelvin approach is not practical due to device design, such as in the case of skirted or sealed switches, voltage drop shall be determined by placing the voltmeter probes on the female connectors or at a point on the harness 75 mm from the connector interface. Note any non-Kelvin method on the test data sheet. See example Data Sheet A1 in Appendix A.

Use an analog or digital voltmeter capable of 0.001 V resolution and apply the rated resistive load as defined by the test specification. Refer to the circuit schematic for terminal identification; then check all contact interfaces for all Normally Open (N.O.) and Normally Closed (N.C.) circuits.

Take the voltage drop measurements 0.5 s to 3.0 s after the load current has stabilized. If reading is out of specification limits, repeat measurements three (3) times while switching the rated load and average readings to assure the value will be repeatable when returned to the design source. If the switch load current is pulsing or intermittent, test at a steady state resistive load equal to the steady state application load.

4.1.1.3 Acceptance Criteria. Meet relevant CTS, circuit diagram, or part drawing requirements.

4.1.2 Open Circuit Resistance.

4.1.2.1 Purpose. Open circuit resistance is a measure of the air gap across contacts and is made by impressing a high voltage across the air gap. Separating contacts with a physical air gap will have a very high open circuit resistance, while sliding contacts may break down as low as 30 V to 80 V due to wear and debris which accumulate during durability testing.

4.1.2.2 Procedure. Apply the nominal test specification actuation parameter which causes the electrical contacts to rest in an open state. See Tables 1 and 2. Maintain the operating parameter until electrical or mechanical stability is achieved.

Use a megohmmeter or hi-pot tester capable of placing 24 V Direct Current (DC) to 500 VDC potential across the contact air gap. Read the open circuit resistance directly or calculate it by measuring the microampere leakage current and applying Ohm's Law:

$$V = I \times R$$

Where:

V = Voltage

I = Current

R = Resistance

Check the open circuit resistance for each contact air gap in both the energized and not energized positions. Refer to the circuit schematic for identification of circuits. Apply the sufficient operating parameter to maintain stable switch position.

Note: Do not exceed 500 VDC potential when performing pre-endurance performance evaluations to prevent dielectric breakdown, tracking or other forms of sample degradation.

Note: When checking sliding contact switch assemblies, either as an interim durability performance check or at the conclusion of endurance tests, proceed as follows:

1. In the "off" or open circuit position, apply 24.0 VDC across the accessible switch terminal as indicated by the circuit schematic. The leakage current shall not exceed 4.8 μ A (equivalent to 5.0 M Ω isolation resistance).
2. Raise the DC potential to 110 VDC while monitoring for dielectric breakdown or leakage exceeding 22.0 μ A (equivalent to 5.0 M Ω isolation resistance).
3. Raise the DC potential to 250 VDC while monitoring for dielectric breakdown or leakage exceeding 50.0 μ A (equivalent to 5.0 M Ω isolation resistance).

4. Raise the DC potential to 500 VDC while monitoring for dielectric breakdown or leakage exceeding 100.0 μ A (equivalent to 5.0 M Ω isolation resistance).
5. Record the last OCV at which the isolation resistance was greater than 5 M Ω . Do not continue to raise the OCV. Test equipment must current limit to prevent arcing, charging of particulates, or carbonization as a result of breakdown.

Note: The voltage potential may be raised to increase the leakage current as a means of evaluating open circuit resistance at the conclusion of durability testing.

Note: Alternating current breakdown testers are more severe at equivalent voltages and, therefore, results will be acceptable provided the device passes the test.

4.1.2.3 Acceptance Criteria. Meet relevant CTS, circuit diagram, or part drawing requirements.

4.1.3 Isolation Resistance.

4.1.3.1 Purpose. Isolation resistance is a measure of the dielectric breakdown between the electrically hot contact structure and other isolated circuits, or the switch case, base, cover, etc.

4.1.3.2 Procedure. Use a megohmmeter or hi-pot tester capable of producing a 500 VDC potential from all isolated terminals to the switch base, cover and all isolated circuits as externally measurable. Refer to the circuit schematic to determine where isolation occurs.

Note: Do not exceed 500 VDC potential when performing pre-endurance and interim performance evaluations as a precaution to prevent dielectric breakdown, tracking or other forms of sample degradation.

Note: Alternating current breakdown testers are considered more severe at equivalent voltages and, therefore, results will be acceptable provided the device passes the test.

4.3.1.3 Acceptance Criteria. Meet relevant CTS, circuit diagram, or part drawing requirements.

4.1.4 Temperature Rise.

4.1.4.1 Purpose. Test the stabilized temperature on any touchable surface of the switch actuator or housing.

4.1.4.2 Procedure. Mount the test sample, including baffles or enclosures, which simulate actual airflow, in a manner consistent with its application and energize all continuous circuits at room temperature. Continuous circuits shall be any circuit which is normally expected to be energized for any period exceeding 10 minutes. Where a switch is intermittent in operation or combines continuous and intermittent circuits, pulse the intermittent.

Apply the rated load to each switch circuit using the application test circuit defined in the relevant CTS, circuit diagram, or part drawing.

Monitor sample temperature at the location given by the relevant CTS, circuit diagram, or part drawing using a thermocouple or thermal imaging device. Where no temperature measurement location is specified by the part drawing or test order, place the thermocouple on the switch housing at a point nearest the switch terminal with the highest current per square unit of cross sectional area.

Note: Temperature stabilization is defined as the temperature level at which three consecutive readings, taken 5 minutes apart, change less than 2 °C.

4.1.4.3 Acceptance Criteria. Switches that are warm to the touch can be misinterpreted as a bad switch by the customer. Thus, the touchable surface temperature should not exceed 35 °C (unless otherwise stipulated in the relevant CTS, circuit diagram, or part drawing) when tested at rated load with full illumination.

Note: Non-touchable surfaces (such as the rear connector area) shall not exceed 70 °C.

4.1.5 Function Check.

4.1.5.1 Purpose. Monitor all N.O. and all N.C circuits for proper operation during each evaluation sequence.

Basic displacement type switches may be operated by hand.

4.1.5.2 Acceptance Criteria. Meet relevant CTS, circuit diagram, or part drawing requirements.

4.1.6 Displacement. Switch travel and specifics regarding points of electrical make and break may be critical to customer satisfaction. Total travel to actuate, over travel after actuation and travel to reset shall be determined for basic displacement type switches when required by the product design specification.

4.1.6.1 Equipment. Appropriate equipment shall be used to measure linear or angular displacement. An optical encoder capable of 0.005 degree resolution shall be required for all angular displacement measurements. Test

sample shall be directly coupled to the optical encoder using a direct drive gearbox. Torque measurements shall be collected using a six axis load cell. A two axis load cell may be used provided all side loading induced by the mounting fixture is eliminated. Other means including gage blocks, dial indicators or tensile testers may also be acceptable.

4.1.6.2 Positioning and Mounting. Position the switch so that the displacement transducer and the switch actuator are both approximately in the center of their travel. Centering the pickup at the center of the switch travel is required to maintain accuracy and to minimize the measurement error on linear type switches which have a slight rotary action. When using a six axis load cell for angular displacement measurements, zero all forces and moments about the switch actuator centerline effectively canceling the side loading induced during sample mounting.

Mount the sample in a manner consistent with its application mounting using applicable mounting hardware. Care should be taken to assure the mounting method does not alter the body of the switch in a manner inconsistent with its intended application mounting. Zero the measurement on the graph paper, or data acquisition calibration screen, with the switch completely depressed and with a 50 N actuation force for linear application and 120% maximum operating torque for rotary application unless otherwise specified. By forcing the switch actuator against its own mechanical stop to zero, the measurement provides a repeatable zero point for switches which are preloaded in their application, e.g., beam change switch, and for bidirectional switches in which hysteresis may cause shifts in the neutral position, e.g., three position rocker switch with center "off" position. Forcing the switch against its own stop also ensures the switch will not shift mounting position during the test run.

4.1.6.3 Rate of Actuation. Due to the need for accurate measurements of distances, the rate of actuation may be as little as 1/100 the application rate of actuation. The rate of application shall be as near the intended rate of application as practical. Evaluate the effects of actuation rate by performing the test at various speeds. As the speed of actuation is increased, the detrimental effects of friction will yield to inertial energy allowing acceptable consistent measurements. Operate the device at a speed such that small changes in displacement rate do not yield changes in dimensions at which switching occurs. Note the rate of actuation on the test data sheet or load vs. displacement curve. See example Data Sheet A1 in Appendix A.

4.1.6.4 Repeatability. Tests have shown that switches are repeatable in nature, however, some switch mechanisms may require multiple tests due to their design, e.g., "push-push" switch with two detent positions.

4.1.6.5 Definitions.

4.1.6.5.1 Travel to Actuate. See Figure 1, Item 1. The distance from the switch preload or free position (or from the point at which the plunger or button exerts a friction force opposing the direction of travel) to the point at which the last N.O. contact indicates a voltage at least 98% of the OCV.

4.1.6.5.2 Pre-travel. See Figure 1, Item 2. The distance from the switch preload or free position to the point at which the electrical contacts or mechanism first starts to move perceived electrically or by a sharp change in force.

4.1.6.5.3 Over Travel. See Figure 1, Item 3. The distance from the last contact make to the zero point at which the plunger or button stops with 50 N actuation force.

4.1.6.5.4 Total Travel. See Figure 1, Item 4. The sum of travel to actuate and over travel.

4.1.6.5.5 Reset Travel. See Figure 1, Item 5. The distance from the zero point to the last reset point to which the switch may be again actuated.

Note: For switches with no N.O. contacts, the procedure is the same except that the point of actuation is at a point where the contact voltage is at least 98% less than the OCV.

Note: During the displacement measurement, note the make and break points on the Force vs. Displacement curve.

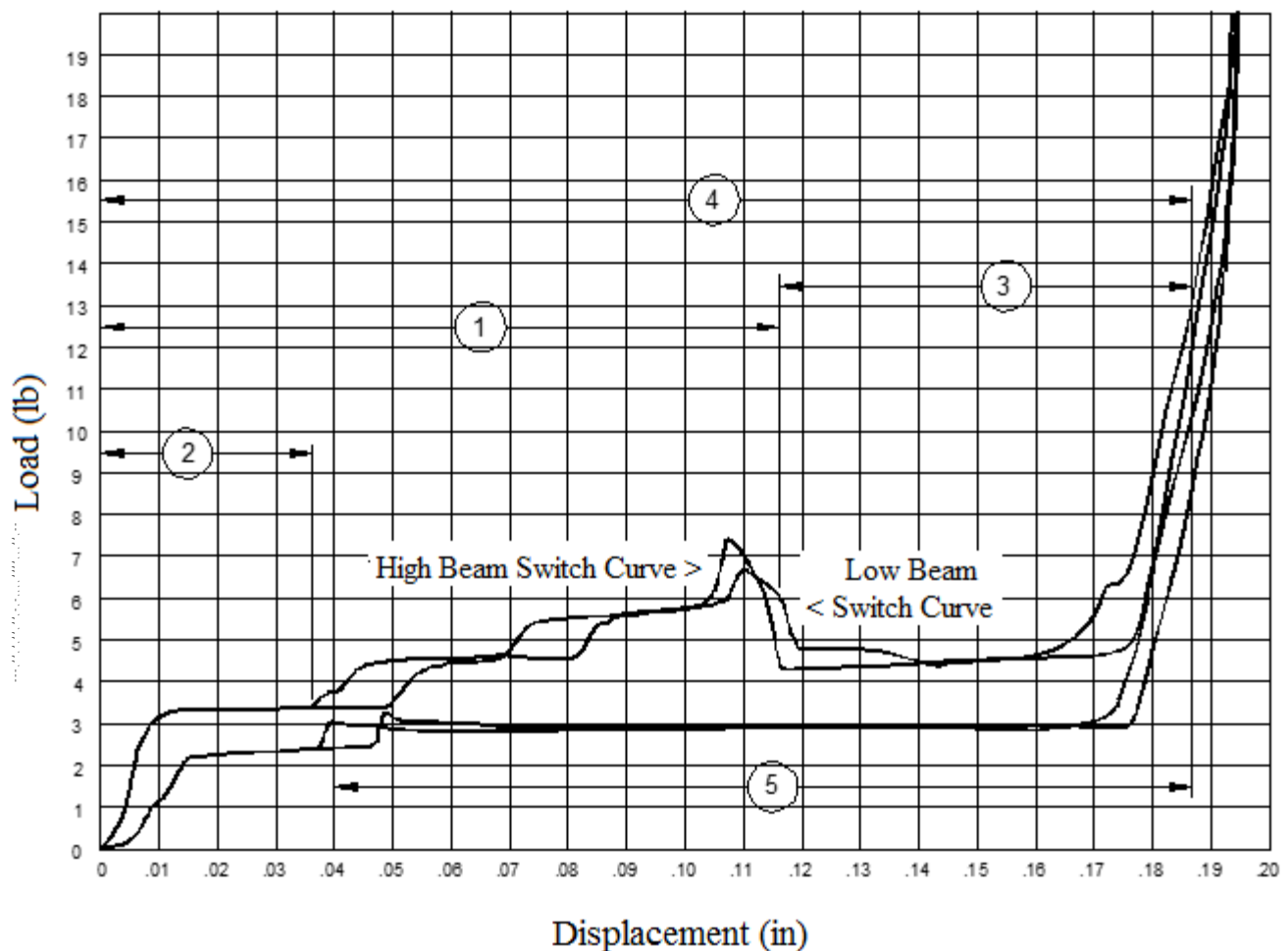


Figure 1: Definition of Displacement Terms (Example Curve)

4.1.7 Force or Torque to Actuate. Switch forces or torques and specifics regarding points of electrical make or break may be critical to system function or critical to customer satisfaction. Force or torque to actuate, feel, and return force shall be determined for basic displacement type switches. Refer to the part drawing for switch actuation point. If no actuation point is referenced, pick the center of any obvious or consistent feature and note the location on the test data sheet. See example Data Sheet A1 in Appendix A.

4.1.7.1 Equipment. All torque measurements shall require a six axis load cell unless otherwise specified. Other means including spring scale and subjective ratings may also be acceptable based on the appropriate responsible GM Engineer approval.

4.1.7.2 Position and Mounting. The switch shall be mounted in a manner consistent with its application mounting perpendicular (at right angle) to the force probe. When using a six axis load cell for torque vs. angular displacement measurements, zero all forces and moments after mounting the test sample to remove any side loading that may exist due to mounting. Care should be taken to assure the mounting method does not alter the body of the switch in a manner inconsistent with its mounting.

4.1.7.3 Rate of Actuation. The importance of overcoming frictional forces and operating as near to the intended rate of application as practical is explained in 4.1.6.3. Operate the device at a rate of actuation such that small changes in displacement rate do not yield changes in force to actuate the device. Note the rate of actuation on the test data sheet or load vs. displacement curve. See example Data Sheet A1 in Appendix A.