



Proportioning Valve Performance and Durability

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 test to measure the performance and durability of proportioning valves.

1.2 Applicability. This standard is applicable to all passenger cars and light trucks with proportioning valve(s) (PV) or load-sensing proportioning valve(s) (LSPV) valves.

1.3 Remarks. This standard describes the performance and durability testing for PV and LSPV. This standard can be used during quotation, development, validation, and production control of these components

2 References

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

2.1 External Standards/Specifications.

FMVSS 116

2.2 GM Standards/Specifications.

None

2.3 Additional References.

GM SupplyPower Portal; gmweb.gm.com/gpsc/gpsc1/Pages/SupplyPowerLinks.aspx

3 Resources

3.1 Facilities. Test facility with an actuation system test bench. See drawing of example test bench components in Appendix A, Figure A1. Actual test bench may differ from the example.

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 Test Bench Capability. The actuation system test bench shall be capable of measuring and recording these required performance parameters:

3.2.1.1 Input Line Pressure.

3.2.1.2 Output Line Pressure.

3.2.1.3 Output Fluid Displacement.

3.2.1.4 Source Vacuum.

3.2.2 Test Bench Features. The test bench shall incorporate the following features/functions:

3.2.2.1 Vacuum pump and vacuum reservoir tank with automatic vacuum level control.

3.2.2.2 Displacement simulation devices and/or plumbing for brake corner assemblies.

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3.3 Test Vehicle/Test Piece. New proportioning valve assemblies should be used. Unless otherwise specified, a minimum of three (3) valves should be tested.

3.4 Test Time.

Calendar time: 28 days to 30 days per sample
Test time: 640 hours to 670 hours per sample
Coordination time: 24 hours to 48 hours per sample

3.5 Test Required Information.

3.5.1 Brake corner compliance information shall be provided by the requesting engineer.

3.5.2 For an LSPV, a detailed layout of the LSPV movement should be provided by the requesting engineer. The layout will be used to design a device for the test bench setup to simulate the movement. See Appendix A, Figure A2 for an example movement layout for an LSPV.

3.6 Personnel/Skills. One (1) technician and/or engineer trained in data acquisition, analysis, equipment use and test setup is required.

4 Procedure

4.1 Preparation.

4.1.1 Fabricate the appropriate fixture such that the PV assembly can be mounted to the test bench.

4.1.1.1 For an LSPV, the valve must be installed on the test bench to simulate the mounting position of the valve on the vehicle and should use a device to simulate the mounting position movement for vehicle load conditions.

4.1.2 Install the dry valve into the dry hydraulic circuits of the test bench, including plumbing to the compliance fixtures or brake assemblies. Make connections as specified in the test sections. Test bench should be set to record inlet and outlet pressures.

4.2 Conditions.

4.2.1 Environmental Conditions. All performance and leakage tests shall be performed at ambient temperature between 10 °C and 30 °C unless otherwise specified.

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 test fluid should be brake fluid DOT3 or DOT4 (see 7.1) compliant to FMVSS 116, unless otherwise specified in test request. New brake fluid should be used, unless otherwise specified in test request.

4.2.2.2 The hydraulic tubing connections to the valve assembly should be of the type intended for the vehicle and should be tightened to specified torque requirements.

4.2.2.3 Review 7.1 for definitions of terms used in the following instructions.

4.3 Instructions. For non-load-sensing PV assemblies, test per 4.3.1 and 4.3.3.1. For load sensing assemblies, test per 4.3.2, 4.3.3.2, and 4.3.3.3. Refer to Appendix E, Figure E1 for graphing definitions.

4.3.1 Proportioning Valve(s) (PV).

4.3.1.1 General Conditions. When required, corner compliance shall be simulated within 10% of the stated vehicle corner compliance or shall be reproduced directly using the foundation brake corners assemblies. Record both inlet and output pressures during testing.

4.3.1.2 Vacuum Leakage.

4.3.1.2.1 Connect the dry PV and dry tubing to the vacuum source on the valve inlet ports. Tighten all connections to the minimum recommended torque.

4.3.1.2.2 Outlet ports are not connected to the compliance fixtures. Close the outlet ports.

4.3.1.2.3 Run vacuum pump to establish a vacuum of between 2 mbar and 3 mbar.(200 kPa and 300 kPa)

4.3.1.2.4 Shut off the vacuum supply and within < 0.5 s begin measurement of the vacuum. Set time zero at 3 mbar (300 Kpa) and continue measurements for 20 s.

4.3.1.2.5 Repeat 4.3.1.2.2 and 4.3.1.2.4 two (2) times for a total of three (3) runs.

4.3.1.2.6 Report vacuum leakage as the rise in vacuum for the 20 s time interval.

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4.3.1.3 Hydraulic Leakage.

4.3.1.3.1 For the hydraulic leakage test, the compliance fixtures are not used. Shut off the outlet ports beyond the valve connections. Tighten all connections to nominal torque specified by vehicle manufacturer. Fill the test setup with new fluid and bleed the hydraulic system as necessary to remove all air. Perform three (3) applications with 110 bar $\pm$ 5 bar (11 Mpa $\pm$ 0.5 Mpa) to assure proper setting of the internal valve parts.

4.3.1.3.2 To test, apply inlet pressure of 110 bar $\pm$ 5 bar (11 Mpa $\pm$ 0.5 Mpa) within 1 s to 3 s.

4.3.1.3.3 Start measurement of the pressure then shut off the pressure source. Measure the pressure for at least 10 s after shutoff.

4.3.1.3.4 Repeat 4.3.1.3.2 to 4.3.1.3.3 two (2) times for a total of three (3) runs.

4.3.1.3.5 Report hydraulic leakage as the drop in pressure across the 10 s interval using the pressure shutoff as time zero.

4.3.1.4 Performance Tests.

4.3.1.4.1 Install the valve into the hydraulic circuits of the test bench, including plumbing to the compliance fixtures or brake assemblies. Tighten all connections to nominal torque specified by vehicle manufacturer. Test bench should be set to record inlet and outlet pressures.

4.3.1.4.2 Bleed the hydraulic system as necessary to remove all air. Perform three (3) applications with 110 bar $\pm$ 5 bar (11 Mpa $\pm$ 0.5 Mpa) to assure proper setting of the internal valve parts.

4.3.1.4.3 To test, apply the inlet pressure to 110 bar $\pm$ 5 bar (11 Mpa $\pm$ 0.5 Mpa) with a rate of 10 bar $\pm$ 2 bar (1 Mpa $\pm$ 0.2 Mpa) and hold pressure for 5 s.

4.3.1.4.4 After the 5 s hold, release the inlet pressure at the same rate as in 4.3.1.4.3.

4.3.1.4.5 Repeat 4.3.1.3.3 to 4.3.2.3.4 two (2) times for a total of three (3) runs.

4.3.1.5 Lost Volume.

4.3.1.5.1 Apply an inlet pressure of 110 bar $\pm$ 5 bar (11 Mpa $\pm$ 0.5 Mpa).

4.3.1.5.2 Determine the fluid volume loss per instructions in the test request.

4.3.1.6 Leakage Minimum Torque.

4.3.1.6.1 Use new connections and pipes.

4.3.1.6.2 Make connections with a torque equal to the minimum recommended torque.

4.3.1.6.3. As necessary, bleed the system to remove any air. Perform three (3) applications with 110 bar $\pm$ 5 bar (11 Mpa $\pm$ 0.5 Mpa) to assure proper setting of the internal valve parts.

4.3.1.6.4 To test, apply 190 bar $\pm$ 5 bar (19 Mpa $\pm$ 0.5 Mpa) pressure. Measure the pressure for at least 10 s.

4.3.1.6.5 Repeat 4.3.2.6.4 two (2) times for a total of three (3) runs.

4.3.1.6.6 Report leakage as the change in pressure during the 10 s interval.

4.3.2 Load-Sensing Proportioning Valve (LSPV).

4.3.2.1 General Conditions. Corner compliance shall be simulated within 10% of the stated vehicle corner compliance or shall be reproduced directly using the foundation brake corners assemblies. Record both inlet and output pressures during testing.

4.3.2.2 Vacuum Leakage. Test the LSPV for vacuum leakage using the same test as for the PV. Test per 4.3.1.2.

4.3.2.3 Hydraulic Leakage. Test the LSPV without the rod and spring load mechanism. Perform test for each hydraulic circuit. Use the same test as for the PV. Test per 4.3.1.3.

4.3.2.4 Performance Tests.

4.3.2.4.1 The test request should state each rod and spring positions to be tested. Perform the test at each position. Recommendation is to run a test at spring positions equivalent to vehicle loading of lightly loaded vehicle weight (LLVW), gross vehicle weight rating (GVWR), and midpoint between.

4.3.2.4.2 Use the same test as for the PV. Test per 4.3.1.4. Perform the test for each requested rod and spring position.

4.3.2.5 Lost Volume. Test the LSPV for leakage minimum torque using the same test as for the PV. Test per 4.3.1.5.

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4.3.2.6 Leakage Minimum Torque. Test the LSPV for leakage minimum torque using the same test as for the PV. Test per 4.3.1.6.

4.3.3 Endurance Tests.

4.3.3.1 Durability for PV.

4.3.3.1.1 Install the proportioning valve on a suitable durability test bench. Use new fluid and new connections and pipes unless otherwise instructed. Tighten all connections to nominal torque specified by vehicle manufacturer. Fill the test setup with fluid and bleed the hydraulic system as necessary to remove all air. Connect a device to generate consumption within 10% of the stated vehicle corner compliance or reproduce compliance directly using the foundation brake corners assemblies.

4.3.3.1.2 A cycle consists of a (brake pedal) apply and release of the inlet pressure to 70 bar $\pm$ 5 bar (7 Mpa $\pm$ 0.5 Mpa).

4.3.3.1.3 Frequency of cycles for room temperature and hot temperature tests equals 1000 cycles/hour. Frequency of cycles for the cold temperature tests equals 600 cycles/hour.

4.3.3.1.4 The testing schedule is in Table 1.

Table 1: PV Durability Test Schedule

Number of Cycles	Test Temperature
500 000	Room Temperature 23 °C $\pm$ 5 °C
120 000	Hot Temperature 120 °C $\pm$ 5 °C
10 000	Cold Temperature -40 °C $\pm$ 5 °C
630 000 Total	

4.3.3.2 Durability for LSPV.

4.3.3.2.1 Install the proportioning valve on a suitable durability test bench. Use new fluid and new connections and pipes unless otherwise instructed. Tighten all connections to nominal torque specified by vehicle manufacturer. Fill the test setup with fluid and bleed the hydraulic system as necessary to remove all air. Connect a device to generate consumption within 10% of the stated vehicle corner compliance or reproduce compliance directly using the foundation brake corners assemblies. Position the LSPV rod and lever to obtain the knee point for vehicle loading of LLVW unless otherwise specified.

4.3.3.2.2 A cycle consists of a (brake pedal) apply and release of the inlet pressure to 70 bar $\pm$ 5 bar (7 Mpa $\pm$ 0.5 Mpa).

4.3.3.2.3 Frequency of cycles for room temperature and hot temperature tests equals 1000 cycles/hour. Frequency of cycles for the cold temperature tests equals 600 cycles/hour.

4.3.3.2.4 The testing schedule is in Table 2.

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Table 2: LSPV Durability Test Schedule

Number of Cycles	Test Temperature
500 000	Room Temperature 23 °C ± 5 °C
70 000	Hot Temperature 80 °C ± 5 °C
25 000	Hot Temperature 120 °C ± 5 °C
45 000	Cold Temperature -40 °C ± 5 °C
640 000 Total	

4.3.3.3 LSPV Traction Spring Durability. Using a suitable durability test bench, cycle the LSPV traction spring from the length for curb loading of vehicle to the length for GVWR loading of the vehicle 1 000 000 times or as specified in the test request.

5 Data

5.1 Calculations.

5.1.1 Performance Tests. Graph the outlet pressure as a function of inlet pressure for each test run as shown in the example graph in Appendix D, Figure D1. For each performance metric following, report the results for each run and the average.

5.1.1.1 Knee Point. The knee is the inlet pressure at the intersection of theoretical lines thru the data both before and after the proportioning of the pressure begins during the pressure apply. For the line fit before proportioning, draw a line from the zero pressure point at a slope of 1. For the line fit after proportioning, perform a regression of the outlet pressure data after the overshoot. Extend the regression line toward the y-axis so that it intersects the line through the non-proportioned pressure data. The reading of the knee point is done at the intersection of the lines, as shown in Appendix D, Figure D1. For a LSPV, the proportioning valve knee is dependent on vehicle loading. The data from multiple runs that represent different vehicle loads should be graphed and analyzed as just described. Appendix E, Figure E1 shows an example graph of data for curb loading and GVWR loading

5.1.1.2 Slope. Using the analysis in 5.1.1.1, the slope is the slope of the regression line of the data after proportioning.

5.1.1.3 Overshoot. Using the analysis in 5.1.1.1, find the difference between the measured outlet data and the regression line of the outlet data after the knee point for selected inlet pressures. The selected inlet pressures should be points where the variation appears greatest. The overshoot will be the maximum calculated difference.

5.1.1.4 Hysteresis. Using the measured pressure (not the regression data) determine the difference in outlet pressure on the release from the outlet pressure on the (brake pedal) apply for specific inlet pressures. The hysteresis should be determined for the inlet pressure range from 25 bar (2.5 Mpa) greater than the proportioning valve knee to 100 bar (10 Mpa) or maximum apply. The maximum difference across the range should be the reported hysteresis.

5.1.2 Vacuum Leakage. Determine and document the pressure rise at 20 s after the vacuum source was shut off. Report the results for each run and the average.

5.1.3 Hydraulic Leakage. Determine and document the pressure drop at 10 s after apply pressure is released. Report the results for each run and the average.

5.1.4 Lost Volume. Document the volume loss.

5.1.5 Leakage at Minimum Torque. Determine and document any leakage within 10 s. Report the results for each run and the average.

5.1.6 Endurance Tests. Document the results from the durability testing: number of cycles completed, test conditions, operator notes, etc. If applicable, report the results of the LSPV traction spring testing.

5.2 Interpretation of Results. Results should be compared to applicable requirements in technical specifications for the component.

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