



Brake System Check Valve and Vacuum System

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. The purpose of this standard is to test check valves which are used in the vacuum system of motor vehicle braking systems.

1.2 Applicability. Applicable to vacuum check valves used in vacuum supply lines to brake vacuum boosters.

2 References

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

2.1 External Standards/Specifications.

ISO 1431-1 ISO 1817

2.2 GM Standards/Specifications.

GMW3059 GMW14729

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 Testing devices according to the respective test methods.

3.2.2 Drawings, measuring devices and gauges for the dimensional test.

3.2.3 Pressure generator for excess pressure up to 1500 kPa maximum with reservoir and 3/2-way valve.

3.2.4 Pressure reducing valve, range 0 kPa to 200 kPa.

3.2.5 Vacuum generator, range -0.5 kPa to 95 kPa.

3.2.6 Pressure vessel with hose fitting for a pressure of 100 kPa, capacity $1.5 \text{ dm}^3 \pm 0.05 \text{ dm}^3$.

3.2.7 Shutoff valve for air.

3.2.8 Pressure gauge, indicating range 0 kPa to 500 kPa.

3.2.9 Differential pressure gauge with a range of 0 to 8 kPa and resolution of 0.02 kPa.

3.2.10 Pressure gauge with a range 0 kPa to 400 kPa and resolution of 2 kPa.

3.2.11 Vacuum gauge with a range 0 kPa to 100 kPa and resolution of 0.1 kPa.

3.2.12 Timing device capable of 600 s minimum.

3.2.13 Thermal chamber with recirculating air and two (2) openings (approximately 50 mm); temperature range -30 °C to +150 °C. The design of the thermal chamber shall ensure that temperatures remain within the tolerances stated in this Test Procedure.

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3.2.14 Test equipment for performing the durability test, comprising one (1) vacuum reservoir with a volume of 1 dm³, one (1) vacuum generator, 3 × 2/2-way valves for actuating the check valves.

3.2.15 Ozone test chamber and 7x magnifying lens or photographic equipment.

3.3 Test Vehicle/Test Piece.

3.3.1 Unless otherwise specified, at least 20 check valves shall be required for initial sample approval and release testing to this procedure.

3.3.2 The submitted test samples are expected to represent the entire scale of parameters found within the tolerance range of production.

3.3.3 Test selection and number of test pieces for inspection testing shall be agreed upon between responsible engineering and supplier. In arbitrary cases, it is up to the decision of the GM Engineer to require complete comprehensive release testing.

3.4 Test Time. Test time dependent on sample size and testing requested. An estimated 30 days is required to complete the sequence, assuming durability testing can be completed in parallel on the five (5) samples.

Calendar time: 30 days

Test time: 3300 hours

Coordination time: 40 hours

3.5 Test Required Information. The tests shall be carried out in accordance with the test schedule in Appendix A, Table A1. Tests shall be performed in the prescribed order.

3.6 Personnel/Skills. Technician or engineer trained to perform the instructions in section 4 is required.

4 Procedure

4.1 Preparation. Inspect the sample check valves in accordance to 4.1.1 thru 4.1.3. Record findings in the test record. Samples not conforming should be tested only after approval by the Design Engineer.

4.1.1 Materials. All materials used for the check valves shall comply with the drawing specifications and release data. If single parts of the check valve consist of material which is prone to stress cracks, such as polyamide, these shall be protected against contact with zinc ions. Materials used must meet the requirements of GMW3059.

4.1.2 Coding. The date of manufacture, the manufacturer's symbol, and an indication of the direction of air flow (arrow and light color for brake servo side and dark color for engine side) shall be shown at a suitable position on the check valve. All markings shall be readily legible and permanent.

4.1.3 Visual Inspection and Dimensional Test. In the as-received condition, the check valves shall not have any visible damage or defects which would adversely affect the function or appearance. The body interior shall not contain contamination, such as material residues, dirt, etc., which could lead to malfunction. The check valves shall comply with the dimensions and tolerances specified in the drawings or releases.

4.2 Conditions.

4.2.1 Environmental Conditions. Unless otherwise specified, testing shall be performed at 23 °C ± 5 °C.

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. Follow the sequence of testing for each of the test check valves as shown in Appendix A, Table A1. The following paragraphs describe the individual tests that are specified. As shown in Appendix A, Table A1, each check valve sample is subjected to only some of the tests. Refer to the test work order which should specify the number of check valves to be tested and which test sequence to use for each check valve.

4.3.1 Opening Pressure Test. The opening pressure shall be tested using the test arrangement illustrated in Appendix A, Figure A1. The opening pressure of the check valve shall be measured within a range of -40 °C to 120 °C ± 2.5 °C. The opening pressure shall be measured using the differential pressure gauge as vacuum continuously increases in the direction of the arrow. A pressure of 45 kPa shall be applied to close the check valve during the temperature soak of 2 h. After the 45 kPa pressure is released, the pressure shall be reduced at a rate of 1 kPa/s to a value of -4 kPa. Measure the elapsed time until the check valve opens and the -4 kPa pressure is no longer held.

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4.3.1.1 Humidity Section. The valve must meet sealing and closing requirements after being held for 24 h at +40 °C with 92% relative humidity and immediately afterwards at -40 °C. The check valve poppet shall be seated with a pressure of 45 kPa in the worst case orientation (poppet sitting on sealing surface). Valve must open in less than 1 s at a vacuum of 4 kPa.

4.3.1.2 Closing Test. After opening, the valve must reclose within 1 s after applying a vacuum of 4 kPa.

4.3.2 Leakage of the Check Valve under Vacuum Test. See Appendix A, Figure A2. With the aid of a vacuum generator, the pressure in the vessel is reduced to $p_e = -80 \text{ kPa} \pm 3 \text{ kPa}$ and held for 5 minutes. The test shall be performed at $23 \text{ °C} \pm 5 \text{ °C}$. Measure the initial pressure at time zero and the final pressure at time 5 minutes.

4.3.3 Durability Test. The check valves shall be connected to the test equipment as shown in Appendix A, Figure A3. Hose "a" and hose "b" shall have an inner volume of 5 cm³ maximum. The volume of hose "c" shall equal $10 \text{ cm}^3 \pm 1 \text{ cm}^3$. The pressure of the vacuum reservoir shall be set to $p_e = -80 \text{ kPa} \pm 3 \text{ kPa}$. The 2/2-way valves V1 to V3 shall be actuated in the repeated 3 s cycle shown in Appendix A, Figure A4.

The check valves shall be submitted to 500 000 stress reversals in this 3 s cycle. At the beginning and after every 100 000 stress reversals, the valves shall be stored for 24 h in Liquid Two per ISO 1817, allowed to drip dry through both openings for 10 minutes and then dried for 2 h at $90 \text{ °C} \pm 2.5 \text{ °C}$. During the durability test, the check valves shall not produce any abnormal noises such as whistling, rattling, etc.

4.3.4 Excess Pressure Test. The check valves shall be subjected to excess pressure using the test arrangement in Appendix A, Figure A5. The check valve body is exposed to 1500 kPa for a duration of 2 s. If actual backfire pressure data is available, a measured value may be substituted for the 1500 kPa value.

4.3.5 Temperature Storage Test. Check valves shall twice undergo the following cycle:

- 4 h at $130 \text{ °C} \pm 2.5 \text{ °C}$ followed by 20 h at $(-40 \text{ °C} \pm 3 \text{ °C})$.
- After being warmed to $23 \text{ °C} \pm 5 \text{ °C}$, continue the test sequence.

4.3.6 Storage in Fuel Test. Check valves shall be stored in fuel as follows:

- 72 h at $23 \text{ °C} \pm 5 \text{ °C}$ storage in Liquid Two per ISO 1817.
- After the valve is allowed to drip dry through both openings for 10 minutes and then dried for 2 h at $90 \text{ °C} \pm 2.5 \text{ °C}$, continue the test sequence.

4.3.7 Storage in Fuel/Oil Mixture Test. Check valves shall be stored as follows:

- 72 h at $23 \text{ °C} \pm 5 \text{ °C}$ storage in a mixture of fuel and oil: 50% by volume Liquid Two per ISO 1817 and 50 by volume aged Heavy Duty engine oil per GMEL0005.
- After this, the opening pressure per 4.3.1 and leakage per 4.3.2 of the check valves shall be tested.

4.3.8 High Humidity Environment Test. Check valves shall undergo testing in a high humidity environment per GMW14729. The check valve is tested as a complete component and is in the chamber for 72 h at a constant temperature of $40 \text{ °C} \pm 3 \text{ °C}$ and constant relative humidity of approximately 100%. After check valves being cooled to $23 \text{ °C} \pm 5 \text{ °C}$ and dried, continue the test sequence. See also the humidity opening test in 4.3.1.1.

4.3.9 Storage at High Temperature Test. Check valves which have been tested according to paragraph 4.3.2 shall be stored for 72 h at $130 \text{ °C} \pm 2.5 \text{ °C}$. After being cooled to $23 \text{ °C} \pm 5 \text{ °C}$, continue the test sequence.

4.3.10 Elastomer Washer of Check Valves Ozone Exposure Test. The check valve washer is removed from the check valve and is tested under strain in an ozonized test chamber. Test resistance to ozone per ISO 1431-1, 50 pphm, 20% strain on a mandrel; $40 \text{ °C} \pm 2 \text{ °C}$ test temperature for $72 \text{ h} \pm 2 \text{ h}$; visual examination with $\times 7$ magnification lens or photograph. The evaluation criteria: No cracks.

4.3.11 Check Valve Flow Rate. Using the GM Milford Proving Ground setup shown in Appendix A, Figure A6 (or equivalent setup), the evacuation time of the valve should be measured. The valve should have sufficient flow to evacuate a 6.2 l volume from a vacuum of 10 kPa to 50 kPa in 1.0 s or less on a mean $+3 \sigma$ basis.

5 Data

5.1 Calculations. Not applicable.

5.2 Interpretation of Results.

5.2.1 Document any issues noted during the visual inspection and dimension checks.

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5.2.2 Complete the data sheets in Appendix A, Table A2 and A3 or similar sheets containing the requested information. If any sample failed during its test sequence, document the point of loss of function and the type of failure.

5.2.3 Compare the times for the opening pressure test to the applicable requirements in the technical specifications. Unless otherwise specified, the check valve shall open in < 1 s after -4 kPa pressure is reached.

5.2.4 Compare the pressure leak test results to the applicable requirements in the technical specifications. Unless otherwise specified, the check valve shall maintain the pressure within 0.5 kPa maximum of the initial pressure for the 5 minute period (or 6 kPa/h).

5.2.5 Compare the inspection results after the ozone exposure test to the applicable requirements in the technical specifications. Unless otherwise specified, the check valve shall have no cracking visible at the ×7 magnification level.

5.3 Test Documentation. Publish the test results following GM protocol using the Evaluation Report template and the Global Document Management (GDM) system.

6 Safety

This Engineering Standard may involve safety requirements for hazardous materials, the method of operations and equipment. This standard does not propose to address all the safety issues associated with its use. It is the responsibility of the user of this standard to ensure compliance with all appropriate safety and health practices. This would include any specific training that may be required. The safety and health standards include site specific rules and procedures, company rules and procedures, and Government Standards. Contact shall be made with the appropriate site Safety and Health personnel for further direction and guidance in these matters.

7 Notes

7.1 Glossary. Not applicable.

7.2 Acronyms, Abbreviations, and Symbols.

GDM	Global Document Management
GSSLT	Global Subsystem Leadership Team
NOK	Not Okay

8 Coding System

This standard shall be referenced in other documents, drawings, etc., as follows:

Test to GMW14562

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