



Brake Actuation System Sound Quality Evaluation

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 procedure describes a method of objectively measuring and evaluating the noise that is emitted from a brake actuation system during a braking event in a laboratory environment.

1.2 Applicability. This procedure applies to any vacuum-boosted brake actuation system.

2 References

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

2.1 External Standards/Specifications.

DIN 45631/A1 IEC 651

2.2 GM Standards/Specifications.

GMW14172 GMW14590

3 Resources

3.1 Facilities. See 3.2.

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 Fully anechoic chamber with a cutoff frequency less than 350 Hz and an ambient noise background noise level a minimum of 5 dB below the signal being measured (10 dB of separation is recommended for best signal to noise ratio).

3.2.2 Actuation system test machine capable of meeting the requirements in 3.2 of GMW14590.

3.2.3 Rigid connecting rod between the input rod of the actuation system and the test machine.

3.2.4 Noise Measurement Equipment.

3.2.4.1 Free-field microphone with appropriate signal conditioning and cables.

3.2.4.2 Sound Level Calibrator.

3.2.4.3 High gain accelerometer with at least a 5 kHz cutoff frequency.

3.2.4.4 Acoustical-quality data acquisition system with a minimum sampling rate of 44.1 kHz (80 dB dynamic range) and at least 16 bit quantization. This hardware shall meet Class 1 accuracy corresponding to IEC 651 or be equivalent for the application (precision ± 0.7 dB or $\pm 8\%$).

3.2.4.5 Data processing system capable of performing Zwicker Loudness (DIN 45631/A1), Sound Pressure Level calculations, and sound data analysis.

3.3 Test Vehicle/Test Piece. If the test is conducted for the purpose of validation, a minimum of three samples shall be tested.

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3.4 Test Time.

Calendar time: 1 d to 2 d per sample
 Test time: 6 h to 12 h per sample
 Coordination time: 2 h to 4 h per sample

3.5 Test Required Information. Brake circuit compliance at 0.5 MPa, 5 MPa, and 12 MPa of line pressure.

3.6 Personnel/Skills. One (1) technician trained in the operation of the actuation system test bench and the noise measurement equipment.

4 Procedure

4.1 Preparation. Attach the anechoic chamber to the test bench and install the actuation system inside of the anechoic chamber.

4.2 Conditions.

4.2.1 Environmental Conditions. Ambient conditions during the test shall be $23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$.

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.

4.2.2.1 Corner compliance shall either be simulated within $\pm 10\%$ of the representative values or reproduced using the foundation brake corners.

4.3 Instructions.

4.3.1 Booster Sound Quality Test - Setup Information.

4.3.1.1 With the actuation system mounted inside of the chamber, bleed all of the air from both brake circuits.

4.3.1.2 Select the appropriate combination of compliance simulators or plumb the representative brake corner hardware into the two brake circuits.

4.3.1.3 Attach the vacuum hose to the booster.

4.3.1.4 Calibration Verification: Check equipment for valid calibration date. Replace out of date equipment. Perform microphone calibration verification. Record calibration tone, if applicable. See GMW14172.

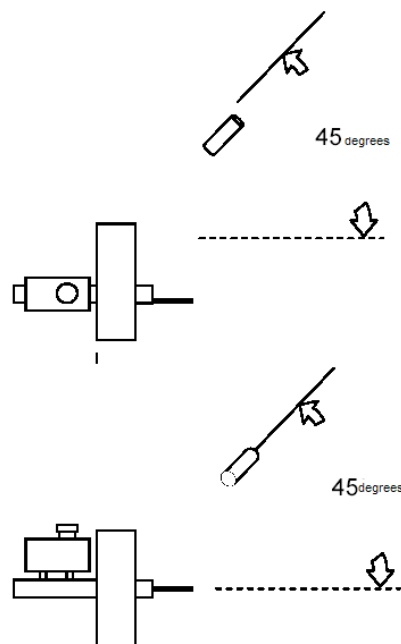


Figure 1: Top and Side Views of Test Setup

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4.3.1.5 Mount the microphone on the microphone stand. The microphone shall be positioned 0.5 m from the booster air inlet and oriented along a line that is 45 degrees above the horizontal plane that contains the booster axis; and 45 degrees left/right the vertical longitudinal plane that contains the booster axis. The microphone diaphragm should point toward the booster air inlet. Refer to Figure 1.

4.3.1.6 Determine the input pushrod force at which booster runout occurs. Run the Full Power Performance Test (4.3.3 of GMW14590); or reference previous test results, if available.

4.3.2 Step Apply and Release Noise Evaluation Test.

Note: This test is an adaptation of 4.3.4 Pressure Response Time Test of GMW14590. The test shall be conducted according to the specifications in GMW14590. Refer to the procedure for additional information.

4.3.2.1 Prepare the noise and test data acquisition system to record the microphone signal for a period of 10 s. Set up the recording device to initiate the recording 2 s prior to the input force application (i.e., 2 s pre-trigger). If two separate acquisition systems are utilized, the systems do not need to be synchronized.

4.3.2.2 Apply a step input to the booster with amplitude of 80% of the runout force and hold the force level for 5 s. Rapidly release the input force. The step input shall meet the qualifications as specified in GMW14590.

4.3.2.3 Record the noise and save the data.

4.3.2.4 Repeat the test until a minimum of three trials has been recorded.

4.3.3 Ramp Apply and Release Noise Evaluation Test (Optional).

Note: This test is intended to assess the sound emitted from the booster during at a low, middle and high input force apply rate to the brake pedal.

4.3.3.1 Prepare the noise and test data acquisition system to record the microphone for a duration that will contain the entire test event and two additional seconds. Set up the recording device to initiate the recording 2 s prior to the input force application (i.e., 2 s pre-trigger). If two separate acquisition systems are utilized, the systems do not need to be synchronized.

4.3.3.2 Applies should be made such that a maximum brake pedal force of 150 N to 200 N is achieved in approximately 0.3 s (500 N/s to 667 N/s pedal force apply rate in brake pedal). Determine the corresponding booster input rod forces, from the defined pedal forces, using the representative brake pedal ratio.

4.3.3.3 Record the noise that occurred during the entire apply and release event and save the data.

4.3.3.4 Repeat the test at 150 N/s above and below the pedal force apply rate used in 4.3.3.2, or at a pedal force apply rate that better corresponds to a lower and higher apply force rate level in the vehicle.

4.4 Instructions for Master Cylinder Sound Quality Test.

4.4.1 Test Setup Information.

4.4.1.1 Mount the actuation system (with 0 cycles) inside of the anechoic chamber. Add the required brake fluid in the reservoir and bleed until no air is in the hydraulic system.

4.4.1.2 Attach the vacuum pump hose to the booster. The vacuum source level must be 67 kPa.

4.4.1.3 Mount the microphone per 4.3.1.4 and 4.3.1.5.

4.4.1.4 Attach the accelerometer to the front of the master cylinder as shown in Figure 2.

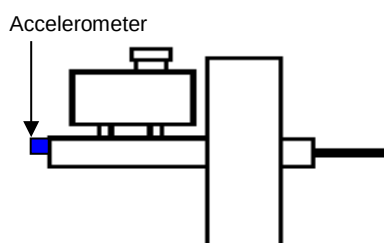


Figure 2: Side View of Test Setup

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