Dynamometer Brake Squeal 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. To objectively quantify brake noise performance.

1.2 Applicability. This procedure is applicable to all passenger car, sport utility vehicle and light truck disc brake corners.

1.3 Remarks. This procedure is intended to quantify brake squeal frequencies and amplitudes as well as the operating conditions under which the brake squeal(s) occurs. This procedure is intended to capture brake squeal in the frequency range of 1 kHz to 17 kHz. Due to differences between the dynamometer and the vehicle, there **may** be differences in measured noise below 2 kHz. If squeals below 2 kHz are observed, the noise should be confirmed with accelerometer measurements from the fixture and caliper. A rigid fixture is the required fixture type. The fixture is to be fabricated per GMW17357.

This procedure is intended to encompass the effect of environmental conditions on brake noise as well as normal operating conditions.

The warm section of this procedure is based on the SAE J2521 modules.

2 References

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

2.1 External Standards/Specifications.

SAE J2521

2.2 GM Standards/Specifications.

GMW14974 GMW17357

2.3 Additional References.

- Global Document Management System (GDM) (ID)
- GM Evaluation Report Template (ID)

(ID) = These references are internal to General Motors. The supplier shall work with the GM Design Responsible Engineer to comprehend these requirements.

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.

3.1.3 Brake Noise Dynamometer. The dynamometer shall have the features in 3.1.3.1 through 3.1.3.6.

3.1.3.1 Constant deceleration and drag stop capability.

3.1.3.2 A 3.2 m × 3.2 m × 2.4 m semi-anechoic chamber.

3.1.3.3 Test chamber ambient noise < 60 dB (during noise stops/drags).

© Copyright 2015 General Motors Company All Rights Reserved

Documents Document Sharing Hub

Copyright General Motors Company
Provided by IHS Markit under license with General Motors Company
Reproduction, distribution or publication of these standards is expressly prohib
Licensee=/, User=,
Not for Resale,
Full document details: GMW GMW14591 2015

3.1.3.4 Isolation between test assembly and sub-frame (vibrations < 20 dB may be transmitted).

3.1.3.5 Isolation between test assembly and drive motor.

3.1.3.6 Temperature control of test chamber cooling air between -10 °C and 20 °C. Humidity control between 15% Relative Humidity (RH) and 90% RH, with temperatures between 0 °C and 20 °C.

3.2 Equipment.

3.2.1 Test Equipment Definition. The equipment definition is the same as listed in SAE J2521 with exceptions listed in 3.2.1.1 through 3.2.1.4.

3.2.1.1 Exception to SAE J2521 Section on Environmental Controls. An Environmental Control Unit is required for temperature and humidity control during this procedure. Temperature control between -10 °C and +20 °C is required. Humidity control of up to 90% RH for a minimum soak time of 5 h is required during high humidity sections.

3.2.1.2 Exception to SAE J2521 Section on Inertia. Dynamometer inertia is adjusted to the gross vehicle mass, maximum tire static loaded radius, and 80% of the vehicle energy transferred into the brakes. For front brakes, dynamic loading is set at 0.9G deceleration. For rear brakes, dynamic loading is set at 0.6G deceleration.

3.2.1.3 Exception to SAE J2521 Section on Noise Measurement. Use the criteria in 3.2.1.3.1 through 3.2.1.3.9.

3.2.1.3.1 Sound Pressure Level (SPL), decibels (dB) re 20 µPa shall be measured in the test chamber throughout the duration of each brake application.

3.2.1.3.2 The maximum permissible background noise level within the test chamber is 60 dB(A) above 0.9 kHz.

3.2.1.3.3 A threshold of ≥ 70 dB (A) will be used for recording sound.

3.2.1.3.4 The recommended transducer for sound measurement is a 1.27 cm (0.5 in) free-field condenser microphone.

3.2.1.3.5 Acceleration data shall be measured throughout the duration of each brake application.

3.2.1.3.6 One accelerometer shall be mounted on the caliper and one accelerometer on the fixture (Figure 1). Additional accelerometers can be used if requested.

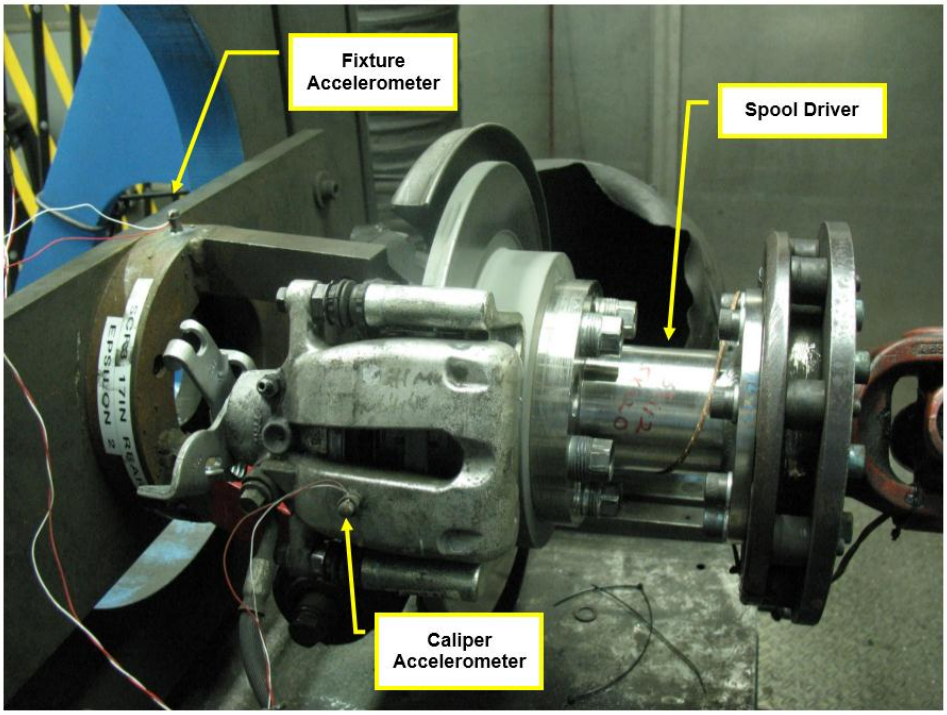

Figure 1: Accelerometer Mounting Example

© Copyright 2015 General Motors Company All Rights Reserved

Documents
Document Sharing Hub
Copyright General Motors Company
Provided by IHS Markit under license with General Motors Company
Reproduction, distribution or publication of these standards is expressly prohib
Licensee=/, User=,
Not for Resale,
Full document details: GMW GMW14591 2015

3.2.1.3.7 The recommended transducer for acceleration measurement is shown in Table 1.

Table 1: Accelerometer Specifications

Equipment	Specifications
Uniaxial Accelerometers	Mass: < 2.0 g Sensitivity: ≥ 1 mV/(m/s^2) Frequency Range: 1 Hz to 20 000 Hz (± 3 dB) Maximum Range: 500 m/s^2 Resolution: > 0.0005 m/s^2 Transverse Sensitivity and Non-Linearity: ≤ 5% and ≤ 1%
Triaxial Accelerometers	Mass: < 5.0 g Sensitivity: ≥ 1 mV/(m/s^2) Frequency Range: 1 Hz to 20 000 Hz (± 3 dB) Maximum Range: 500 m/s^2 Resolution: > 0.0005 m/s^2 Transverse Sensitivity and Non-Linearity: ≤ 5% and ≤ 1%

3.2.1.3.8 Microphone and accelerometer information shall be saved as peak hold spectra, time recordings, peak-hold history at fixed intervals, and peak dB(A) and corresponding frequency at fixed intervals.

3.2.1.3.9 A frequency analyzer and/or digital data acquisition system shall be used to acquire the sound and acceleration measurements. The system must compute and record narrowband sound pressure spectra using the parameters and capabilities in 3.2.1.3.9.1 through 3.2.1.3.9.4.

3.2.1.3.9.1 A 0 kHz to 20 kHz frequency bandwidth with a 25 Hz frequency resolution.

3.2.1.3.9.2 Peak hold averaging with 50% overlap processing and Hanning windowing applied to the time records.

3.2.1.3.9.3 Anti-aliasing filtering.

3.2.1.3.9.4 A weighting for sound pressure level.

3.2.1.4 Exception to SAE J2521 Section on Test Apparatus Definition.

3.2.1.4.1 A rigid fixture is the required fixture type. A rigid fixture shall include the knuckle, bearing, and splash shield (if equipped). See Figure 2 for an example of a rigid fixture. The rigid fixture shall be fabricated per GMW17357, which contains more detailed information.

3.2.1.4.2 A spool driver shall be used as the interface between the brake hardware and drive shaft (Figures 3 and 4).

3.3 Test Vehicle/Test Piece. Brake corner components.

3.4 Test Time.

Calendar time:	2 days
Test hours:	36 hours
Coordination hours:	4 hours

3.5 Test Required Information. This standard does not include all the information needed to perform the dynamometer squeal evaluation. The required additional information is in the SAE J2521 standard.

3.6 Personnel/Skills. A technician or engineer trained to perform the instructions in Section 4.

© Copyright 2015 General Motors Company All Rights Reserved

Documents
Document Sharing Hub

Copyright General Motors Company
Provided by IHS Markit under license with General Motors Company
Reproduction, distribution or publication of these standards is expressly prohib
Licensee=/, User=,
Not for Resale,
Full document details: GMW GMW14591 2015

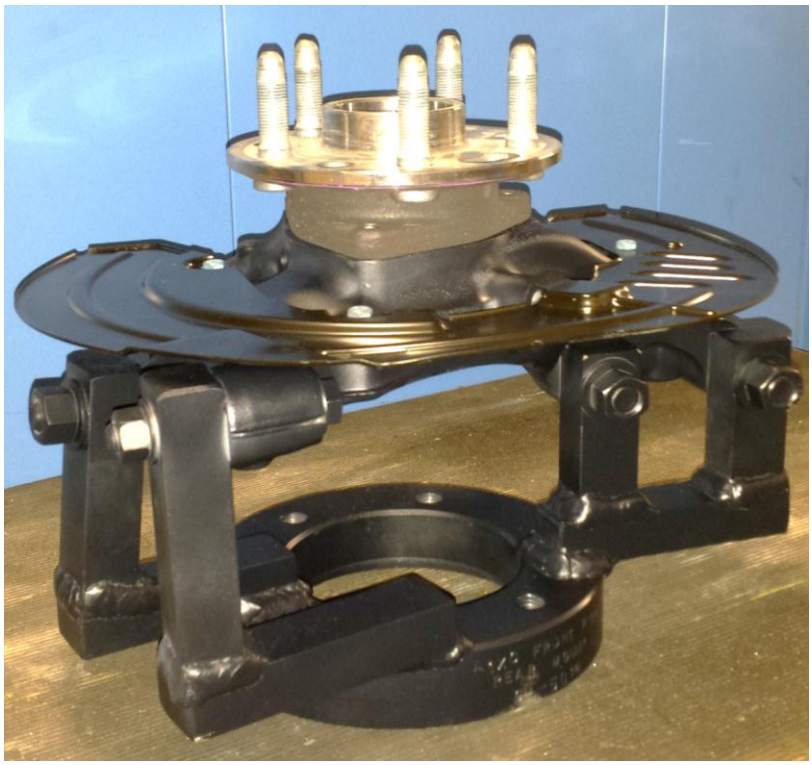

Figure 2: Rigid Fixture Example

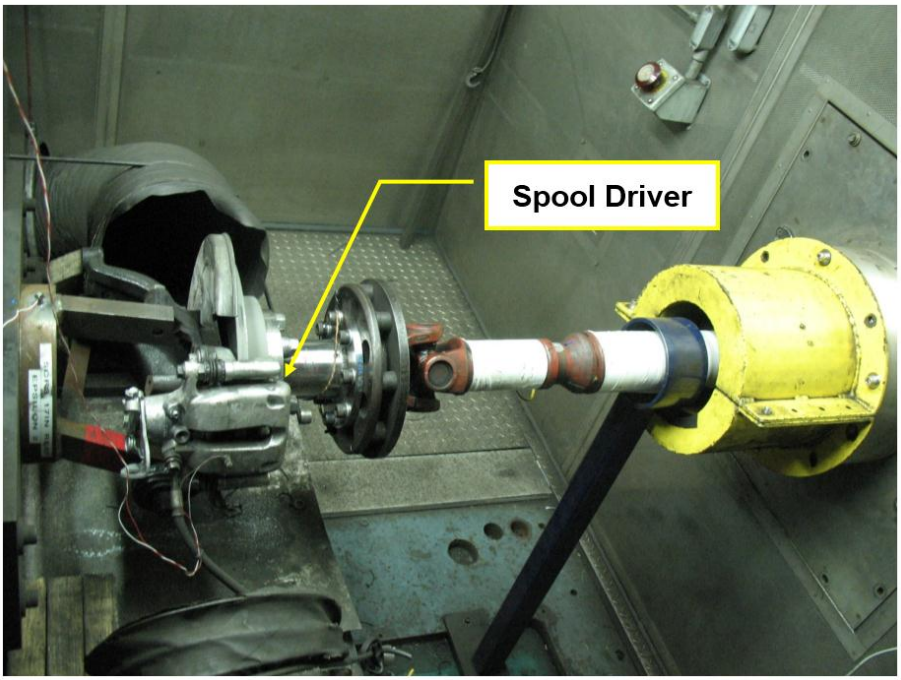

Figure 3: Setup with Spool Driver

© Copyright 2015 General Motors Company All Rights Reserved

Documents
Document Sharing Hub

Copyright General Motors Company
Provided by IHS Markit under license with General Motors Company
Reproduction, distribution or publication of these standards is expressly prohib
Full document details: GMW GMW14591 2015

Licensee=/, User=,
Not for Resale,

Figure 4: Spool Driver

4 Procedure

4.1 Preparation.

4.1.1 New brake hardware (pads/linings and rotors/drums) should be used.

4.1.2 For a disc brake corner, install embedded thermocouple in the brake rotor per GMW14974. If an embedded thermocouple is not possible, utilize an infrared measurement on the inboard face of the outside diameter of the disc per SAE J2521.

4.1.3 For a drum brake corner, install embedded thermocouple in the brake drum per GMW14974. A telemetry system or slips rings will be required.

4.1.4 Install corner fixture into dynamometer and connect to drive shaft.

4.1.5 Calibrate the microphone and accelerometers.

4.1.6 Mount the accelerometers.

4.1.7 Bleed the brake corner.

4.2 Conditions.

4.2.1 Environmental Conditions. Not applicable.

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. Part A: Disc Brake Test Matrix. This standard consists of a sequence of test modules, divided into Warm, Cold, and Fade and Recovery classifications. These instructions define each test sequence. The referenced tables that detail the tests and conditions are in Appendix A.

4.3.1 Warm: First Sequence. Cooling air should be maintained at 15 °C, and cooling air relative humidity should be maintained at 50% RH for the Warm Sequence. Reference Table 2.

4.3.2 Cold: First Sequence. The noise data from these modules will represent the squeals generated under low temperature operating conditions. For the initial 0 °C condition, the brake corner should be soaked at 0 °C for a period of at least 45 minutes after the rotor/drum has reached 0 °C. Cooling air should be maintained at -10 °C, and cooling air relative humidity should be maintained at 50% RH for the Cold Sequence. Reference Table 3.

4.3.3 Fade and Recovery. Reference Table 4.

© Copyright 2015 General Motors Company All Rights Reserved

Documents
Document Sharing Hub

Copyright General Motors Company
Provided by IHS Markit under license with General Motors Company
Reproduction, distribution or publication of these standards is expressly prohib
Licensee=/, User=,
Not for Resale,
Full document details: GMW GMW14591 2015

Table 2: Warm – First Test Sequence (Disc Brake)

Sequence Number	Module Title	Appendix A Reference
1	Break-in	Table A1
2	Bedding	Table A2
3	Drag	Table A3
4	Intermediate Conditioning and Warm Up	Table A4
5	Backward/Forward	Table A5
6	Deceleration	Table A6
7	Condensed Drag	Table A7
8	Intermediate Conditioning and Warm Up	Table A4
9	Condensed Backward/Forward	Table A8
10	Condensed Deceleration	Table A9
11	Drag	Table A3
12	Intermediate Conditioning and Warm Up	Table A4
13	Backward/Forward	Table A5
14	Deceleration	Table A6

Table 3: Cold – First Test Sequence (Disc Brake)

Sequence Number	Module Title	Appendix A Reference
15	Cold Backward/Forward	Table A10
16	Cold Matrix 1	Table A11
17	Cold Matrix 2	Table A12
18	Cold Backward/Forward	Table A10
19	Cold Matrix 1	Table A11
20	Cold Matrix 2	Table A12

Table 4: Fade and Recovery (Disc Brake)

Sequence Number	Module Title	Appendix A Reference
21	Temperature Fade Optional Temperature Fade for High Performance Vehicles	Table A13 Table A14
22	Recovery	Table A15

4.3.4 Warm: Second Sequence. Cooling air should be maintained at 15 °C and cooling air relative humidity should be maintained at 50% RH for the Warm Sequence. Reference Table 5.

4.3.5 Cold: Second Sequence. The noise data from these modules will represent the squeals generated under low temperature operating conditions. For the initial 0 °C condition the brake corner should be soaked at 0 °C for a period of at least 45 minutes after the rotor/drum has reached 0 °C. Cooling air should be maintained at -10 °C, and cooling air relative humidity should be maintained at 50% RH for the Cold Sequence. Reference Table 6.

© Copyright 2015 General Motors Company All Rights Reserved

Documents
Document Sharing Hub

Copyright General Motors Company
Provided by IHS Markit under license with General Motors Company
Reproduction, distribution or publication of these standards is expressly prohib
Licensee=/, User=,
Not for Resale,
Full document details: GMW GMW14591 2015

Table 5: Warm – Second Test Sequence (Disc Brake)

Sequence Number	Module Title	Appendix A Reference
23	Condensed Drag	Table A7
24	Intermediate Conditioning and Warm Up	Table A4
25	Condensed Backward/Forward	Table A8
26	Condensed Deceleration	Table A9

Table 6: Cold – Second Test Sequence (Disc Brake)

Sequence Number	Module Title	Appendix A Reference
27	Cold Backward/Forward	Table A10
28	Cold Matrix 1	Table A11
29	Cold Matrix 2	Table A12

4.4 Instructions. Part B: Drum Brake Test Matrix. This standard consists of a sequence of test modules, divided into warm and cold. These instructions define each test sequence. The referenced tables that detail the tests and conditions are in Appendix B.

4.4.1 Warm Sequence. Cooling air should be maintained at 15 °C and cooling air relative humidity should be maintained at 50% RH for the Warm Sequence. Reference Table 7.

Table 7: Warm Sequence (Drum Brake)

Sequence Number	Module Title	Appendix B Reference
1	First Bedding	Table B1
2	Friction Evaluation	Table B2
3	Drag Noise	Table B3
4	Conditioning Stops	Table B4
5	Backward/Forward Drag	Table B5
6	Deceleration Noise Stops	Table B6
7	Second Bedding	Table B7
8	Friction Evaluation	Table B2
9	Drag Noise	Table B3
10	Conditioning Stops	Table B4
11	Backward/Forward Drag	Table B5
12	Deceleration Noise Stops	Table B6
13	Friction Evaluation	Table B2
14	Drag Noise	Table B3
15	Conditioning Stops	Table B4
16	Backward/Forward Drag	Table B5
17	Deceleration Stops	Table B6

© Copyright 2015 General Motors Company All Rights Reserved

Documents
Document Sharing Hub
Copyright General Motors Company
Provided by IHS Markit under license with General Motors Company
Reproduction, distribution or publication of these standards is expressly prohib
Licensee=/, User=,
Not for Resale,
Full document details: GMW GMW14591 2015