



Tire Crown Bending Frequency Evaluation Procedure

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.

Note: The Transducer Calibration Master Test Procedure, GMW14172 and the Hand Held Force Input Frequency Response Function (FRF) Acquisition Master Test Procedure, GMW14181, shall be referenced for more detailed information corresponding to the procedure contained herein.

1.1 Purpose. Define the process for obtaining the tire crown bending frequency. The measurement is used to compare tire crown bending frequency to the specification.

1.2 Applicability. The test procedure is appropriate to use for all passenger cars, vans and small bus tire wheel systems.

1.3 Remarks. The tire crown bending frequency is an important factor in structure borne road noise performance.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW14172 GMW14181

2.3 Additional References.

- Brüel & Kjær (B&K) North America Incorporated, Norcross, Georgia
- Fluke Precision Measurement Limited, San Diego, California
- LMS International, A Siemens Business, Leuven, Belgium
- OROS Incorporated, Dulles, Virginia
- PCB Piezotronics, Incorporated, Depew, New York
- Subsystem Technical Specification (SSTS)

3 Resources

3.1 Facilities. A test room or an area which is free of extraneous vibration (see GMW14181).

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 Equipment. Two (2) measuring methods can be used to measure the tire crown bending frequency under either free-free or fixed boundary conditions. The tire can be excited by impact hammer or hand held shaker. The required equipment for both methods is different; however, the measurement results are comparable. Equivalent measurement equipment may be used in place of the suggested equipment.

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3.2.1.1 Equipment (Excitation with Impact Hammer).

Note: Integrated Circuit Piezoelectric (ICP) is the most commonly used accelerometer technology.

3.2.1.1.1 One (1) four (4) channel Fast Fourier Transform (FFT) analyzer (e.g., OROS 25, available through OROS Incorporated) or one (1) commercial measurement system (e.g., LMS Test.Lab, available through LMS International).

3.2.1.1.2 One (1) impact hammer with force transducer and nylon hammer tip (e.g., PCB small impact hammer, available through PCB Piezotronics Incorporated).

3.2.1.1.3 Two (2) single axis accelerometers for acceleration on tire surface (e.g., PCB 353 B65 ICP, available through PCB Piezotronics Incorporated).

3.2.1.1.4 Accelerometer Calibrator.

3.2.1.1.5 Calibration Mass.

Note: Refer to GMW14172 for more calibration details.

3.2.1.2 Equipment (Excitation with Hand Held Shaker).

3.2.1.2.1 One (1), four (4) channel FFT analyzer (e.g., OROS 25, available through OROS Incorporated) or one (1) commercial measurement system (e.g., LMS Test.Lab, available through LMS International).

3.2.1.2.2 One (1) waveform generator (e.g., WAVETEK Model 395, available through Fluke Precision Measurement Limited).

3.2.1.2.3 Hand held shaker with force transducer (e.g., Shaker: B&K Type 4819 and Force Transducer B&K B200 185 524 60, available through Brüel & Kjær North America Incorporated).

3.2.1.2.4 Power amplifier (e.g., B&K 2706, available through Brüel & Kjær North America Incorporated).

3.2.1.2.5 Two (2) single axis accelerometers for acceleration on tire surface (e.g., PCB 353 B65 ICP, available through PCB Piezotronics Incorporated).

3.2.1.2.6 Accelerometer Calibrator.

3.2.1.2.7 Calibration Mass.

Note: Refer to GMW14172 for more calibration details.

Note: Alternative equipment by other manufacturers are useable.

3.3 Test Vehicle/Test Piece. Tire and wheel.

3.4 Test Time.

Calendar time: 0.5 days

Test hours: 2 hours

Coordination hours: 2 hours

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. At least one (1) technician or engineer skilled in noise and vibration data acquisition, analysis, equipment usage and test setup is required.

4 Procedure

4.1 Preparation.

4.1.1 Check tire pressure and insure that the pressure is set to design intent level. Weigh the tire/wheel assembly to obtain the mass of the assembly.

4.1.2 The test tire and wheel can be either hung from elastic cords to allow the free-free condition as shown in Appendix A, Figure A1 or mounted on any fixture to allow a fixed boundary condition as in Appendix A, Figure A2. The tire/wheel assembly is not subject to any static loads. In the free-free condition, the rigid body mode of the tire and wheel shall be below 10 Hz. The loading limits of the cords shall not be exceeded.

4.1.3 Two (2) single axis accelerometers (M1 and M2) shall be attached with **hot glue** with M1 at the edge from the sidewall to the crown and with M2 at the center of the sidewall (see Appendix A, for single axis accelerometers (M1 and M2) placement). The straight line between the two (2) accelerometers shall go through

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the hub center as shown in the tire/wheel assembly side view (see Appendix A, Figure A3). Accelerometer directions shall be positioned normal to the tire surface.

4.1.4 For accelerometer and force transducer calibrations, see GMW14172.

4.2 Conditions.

4.2.1 Environmental Conditions.

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.

4.3.1 Impact Hammer Excitation.

4.3.1.1 Analyzer Acquisition Parameters.

- Channel 1 (CH1): Force signal Impact Hammer (F1) ICP coupled auto range
- Channel 2 (CH2): Acceleration signal (M1) ICP coupled auto range
- Channel 3 (CH3): Acceleration signal (M2) ICP coupled auto range
- Trigger: 10% slope channel and around 0.03 s pre-trigger
- Average: Six (6) averages (minimum)
- Overlap: None
- Window: Rectangular (uniform)
- Maximum frequency: 1024 Hz
- Minimum frequency resolution: 1 Hz
- Overload detection: Enabled

4.3.1.1.1 Impact the hammer at the top of the crown center in a direction normal to the tire surface, refer to Appendix A, Figures A1 thru A3. Therefore, two (2) transfer FRFs between F1 and M1 or M2 are measured. Make sure that the hammer impact position and both accelerometers M1 and M2 are in the line to the wheel center, as shown in Appendix A, Figure A3.

4.3.1.2 Measurement functions:

- a. Transfer FRFs
- b. Coherence

4.3.1.3 Start the analyzer or measurement system.

4.3.1.4 Measurement will be stopped automatically after six (6) averages.

4.3.1.5 Store the measured data on hard disk.

The following two (2) transfer functions are measured:

- a. Transfer FRFs (H_{11} and H_{21})

Where: H_{ij} represents the FRF of a response at position i from a force at position j . Where $i = 1$ or 2 respectively, denoting the accelerometer position M1 or M2 and $j = 1$ denotes the force position F1 on a tire crown center, (see Appendix A, Figures A1 thru A3).

4.3.2 Hand Held Shaker Excitation.

4.3.2.1 Select on waveform generator a sine signal (frequency 10 Hz to 512 Hz). The frequency range should be continuously driven in UP/DOWN mode. The time duration for each run should be 15 s. Store the setup for the waveform generator attitudes.

4.3.2.2 Adjust the power amplifier (see 3.2.1.2.4) with a small input as a start point until the tire is properly excited and the measured coherence is close to 1.

4.3.2.3 Select the right sensitivity of the force transducer at the charge amplifier (see force transducer documentation).

4.3.2.4 Analyzer Acquisition Parameters.

- Channel 1 (CH1): Force signal Impact Hammer (F1) ICP coupled auto range
- Channel 2 (CH2): Acceleration signal (M1) ICP coupled auto range

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