CRFM Flexural Mode 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.

1.1 Purpose. Define the process of determining the Condenser Radiator Fan Module (CRFM) flexural modal frequency or frequencies when mounted to a fixture to represent “free free” boundary conditions. The product of this procedure will be a frequency value in Hertz.

1.2 Applicability. This test procedure is appropriate for benchmarking competitive and GM passenger vehicles CRFMs. The procedure is valid for use with both Body Frame Integral (BFI) and Body on Frame (BOF) full vehicles.

The testing standards defined in this document are intended to pertain only to work being done for the corporate database and validation. Other testing methods and interpretations are useful and valid, and should continue to be used for normal development work where appropriate.

1.3 Remarks. In road-induced and powertrain-induced conditions, vibrations of the CRFM can be perceived by the driver as unacceptable Noise and Vibration (N&V) or tactile vibration and thus being of lower perceived quality and refinement.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW14181 GMW14229

2.3 Additional References.

- Subsystem Technical Specification (SSTS)

3 Resources

3.1 Facilities. A test room.

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.

3.2.1.1 Fifteen (15) to twenty two (22) triaxial acceleration transducers (e.g., PCB-356A15 with Integrated Circuit Piezoelectric (ICP) signal amplifiers, available from PCB Piezotronics, Inc.)

3.2.1.2 Modally tuned impulse hammer (e.g., PCB-086D05 with PCB-084A51 Adaptor and hammer tips range from 084A50 to 086C05, the super soft tip (Grey 15.101, 1 in 10SS) is recommended and available from PCB Piezotronics, Inc.)

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3.2.1.3 Hot glue or light weight mounting clamps are used for positioning the accelerometer transducers on the CRFM. It shall be ensured that no relative motion between the accelerometer and module is possible.

3.2.1.4 Multi-channel spectrum analyzer front end with Analog/Digital (A/D) converter, computer and software for measurement and analysis (e.g., LMS SCADAS Front End and LMS Test Lab software, available from Siemens PLM Software, Siemens Industry, Inc.). A multi-channel Data Acquisition System (DAS) is required to receive all signals simultaneously.

Note: See GMW14181, Appendix A, Transducer Examples for transducer key characteristics.

3.3 Test Vehicle/Test Piece. A CRFM assembly of the desired design level is required out of a vehicle.

3.4 Test Time.

Calendar time:	1 d
Test hours:	6 h
Coordination hours:	2 h

3.5 Test Required Information.

3.6 Personnel/Skills. Engineer and/or technician skilled in vibration data acquisition and analysis, and operation of the equipment.

4 Procedure

4.1 Preparation. Place test piece into test room using free-free boundary conditions. Reference GMW14181.

4.1.1 Remove all hoses and coolant lines from CRFM.

4.1.2 Plug radiator connections as required to contain fluid for testing. Typical locations to plug are inlet hose, outlet hose, and overflow hose using rubber stops.

4.1.3 Fill radiator with water. The condenser remains empty.

4.1.4 Support CRFM using free-free boundary conditions.

4.1.5 Record the mass of the assembly under test.

4.2 Conditions.

4.2.1 Environmental Conditions. Test with CRFM at room ambient temperature (23 °C ± 5 °C). Reference GMW14181.

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. Mount accelerometers on the CRFM – locations should include but not be limited to the Condenser, Radiator, Shroud and Fan(s). Orientation will be in the plane of the CRFM. (See Appendix A, Figure A1 through Figure A6 for examples.)

4.3.1 Setup for Measurement System.

- Frequency range: 0 Hz to 128 Hz.
- Resolution: 0.25 Hz.
- Trigger mode: Hammer Input channel.
- Time windows: Uniform Window. If event cannot be completely observed, use Force/Exponential Windows.
- Trigger level: 10% to 50% slope channel. Sign of the slope may vary depending on transducer type and DAS.
- 1% (of time block) trigger delay (pre-trigger) for all channels.
- AC Coupled (1 Hz high pass filter) Enable overload detection.
- Measuring function: Frequency Response Function (FRF) with force as reference.
- Number of average: Five (5) minimum.
- Force level input: Select hammer tip to achieve an approximate 12 dB roll off 5 Hz to 100 Hz. Typical time domain input xxx N peak (approximately xxx N to xxx N Root Mean Square (RMS) from 5 Hz to 100 Hz). Note that values (xxx) may differ depending upon the design under evaluation.

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4.3.2 Note: The use of a roving accelerometer is acceptable if concurrent measurements with multiple accelerometers is not possible.

4.3.3 Measurement. During the acquisition time, impact the module with the modally tuned impulse hammer near one transducer position. Repeat at additional locations and directions to ensure that all modes of interest have been captured. Conduct this measurement three (3) times for repeatability comparison.

If mass loading due to the accelerometers is a concern, conduct a supplementary test with all except one accelerometer removed. Compare the FRF between this test and the test conducted with all accelerometers mounted to the property.

Carefully document all locations, directions and corresponding measured response accelerations (see Appendix A, Table A1 and Table A2 for examples).

4.3.4 Saving the Data. Save the FRFs of all response points for each applied force direction for further comparisons.

5 Data

5.1 Calculations. The result of this test is the lowest frequency at which the first high amplitude peak occurs in the imaginary portion of the FRF. This is generally in the 15 Hz to 60 Hz range.

5.1.1 Develop the natural frequencies and mode shapes of the CRFM assembly from 0 Hz to 100 Hz using the process specified in GMW14229 (Figure A1).

5.2 Interpretation of Results. Reference Subsystem Technical Specification (SSTS).

5.3 Test Documentation. Wholly contained in GMW14181.

6 Safety

This standard may involve hazardous materials, operations, and equipment. This standard does not propose to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7 Notes

7.1 Glossary. Wholly contained in GMW14181.

7.2 Acronyms, Abbreviations, and Symbols.

A/D	Analog/Digital
A/F	Acceleration over Force
BFI	Body Frame Integral
BOF	Body on Frame
CRFM	Condenser Radiator Fan Module
DAS	Data Acquisition System
FRF	Frequency Response Function
HVAC	Heating Ventilation and Air Conditioning
ICP	Integrated Circuit Piezoelectric
N&V	Noise and Vibration
RMS	Root Mean Square
SSTS	Sub System Technical Specification
VPO	Vehicle Performance Owner

8 Coding System

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

Test to GMW14237

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