



Frame Static Stiffness Master Test 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. To provide guidelines for setting up and performing frame static stiffness tests. This document will not provide any information on specific static stiffness tests (e.g., front frame torsional), which have separate evaluation test procedures.

1.2 Applicability. Frames from GM and competitive full-frame vehicles.

1.3 Remarks. Frame static stiffness metrics are included in the Chassis SSTS Template. These requirements are important for improving the noise and vibration performance of full-frame vehicles.

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

2.3 Additional References.

Subsystem Technical Specification (SSTS)

3 Resources

3.1 Facilities. A large bedplate.

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 Displacement transducers (e.g., digital dial indicators) with 0.005 mm resolution.

3.2.1.2 Force transducers with minimum range of 3000 N static load and 5 N resolution, and associated power supplies and readouts. See GMW14172.

3.2.2 Test Fixtures.

3.2.2.1 Elephant's feet, or similar, to mount the frame to the bedplate.

3.2.2.2 Spacer plates for constraining the frame through body mount brackets.

3.2.2.3 For engine mount and transmission mount bracket frame stiffness tests, modified mounts with the rubber removed.

3.2.2.4 Wedge blocks for providing level surfaces at dial indicator tips.

3.2.2.5 Spherical Bearings (Heim Joints).

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3.2.2.6 Threaded Rod/Washers/Nuts.

3.2.2.7 For front/rear frame torsional tests, an aluminum reference bar to be hot-glued across the frame rails.

3.2.3 Spreadsheet program capable of performing linear regression and stiffness calculations (i.e., MS Excel).

3.3 Test Vehicle/Test Piece. A frame including bolt-on hardware (e.g., bumpers and bolt-on cross members). The frame should be qualified to ensure that it represents design intent. Deviations should be corrected or noted. The requester should fully describe the condition of the frame to be tested if it is non-standard.

3.4 Test Time.

Calendar time: 3 days

Test time: 1 hours

Coordination time: 2 hours

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. To complete these tests, one (1) technician and/or one (1) engineer skilled in calibration and data acquisition using force transducers and dial indicators is required.

4 Procedure**4.1 Preparation.**

4.1.1 Boundary Conditions. Boundary conditions/constraints are applied through Elephant Feet (Appendix A, Figure A1) and spherical bearings (Heim Joints, Appendix A, Figure A2). The Heim joint allows for constraining the frame in all translational directions (X, Y, Z) without inducing a moment. This assembly must be positioned so that the Heim joint is centered in the body mount bracket location to be constrained. When all components are positioned correctly, torque all constraint bolts to 300 Nm. Constraint setups are shown in Appendix A, Figures A3 and A4.

4.1.2 Force Application. Forces are applied to the frame through the use of threaded rods and Heim joints (Appendix B, Figures B1 thru B6). Two (2) setups are possible depending upon which specific static stiffness test is being performed.

4.1.2.1 "One Heim" Method. The "One Heim" method (Appendix B, Figure B1) uses a single Heim joint attached to the reacting body (usually an elephant's foot, Appendix B, Figures B5 and B6). A force transducer is then perpendicularly attached to the test object. The force transducer can be either bolted (via a fixture, see Appendix D, Figures D1 thru D4) or hot glued to the test object.

Note: Caution should be used because the force transducer can only be glued to the test object if the force being applied is a compression force (Appendix B, Figure B2).

A single threaded rod with two (2) nuts and one (1) washer is passed through the reacting bodies of the Heim joint and then attached to the other end of the force transducer. One (1) of the nuts is used to tighten the threaded rod to the force transducer and the other is used with the washer to apply the force to the test object.

Note: Make sure that all components are adjusted so that the applied force is always perpendicular to the test object.

4.1.2.2 "Two Heim" Method. The "Two Heim" is used when a flat surface perpendicular to the direction of loading is not available. Additionally, the "Two Heim" can be used for both tension and compression force applications. A Heim joint is placed on either end of the force transducer (Appendix B, Figures B2 and B3). A threaded rod (with nuts and washers) is then connected between the Heim joints and the force transducer. The setup is aligned and loaded in the same manner as in 4.1.2.1. A variation is presented in Appendix B, Figure B4.

Note: Some additional fittings (e.g., eyebolts, spacer plates, and large washers) may be required to apply forces depending upon the test object.

4.1.3 Spherical Bearings (Heim Joints). When installing, make sure the bearing is oriented perpendicular to the direction of the load or constraint (see Appendix A and Appendix B). Center the loading device or constraining device within the bearing.

4.1.4 Wedge Blocks. These are used to obtain a flat, smooth, horizontal surface for the dial indicators to measure from. These blocks are usually made of aluminum. Install these blocks onto the measuring surface by hot glue (Appendix C, Figure C1).

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4.1.5 Digital Dial Displacement Indicators. These are placed as close as possible to the location where the load is being applied. When installing, make sure they are positioned perpendicular to the surface that is being measured (see Appendix C, Figures C1 and C2). They should be parallel to the applied force direction.

4.1.6 Vertical-Only Constraint. This is used when a portion of the frame needs to be supported vertically for safety reasons, but a full X, Y, Z constraint is not desired (frame matchboxing test). These supports are very similar to the normal constraint setup except an additional Heim joint is used at its base (Appendix C, Figure C3). The support uses two (2) Heim joints, a turnbuckle and two (2) threaded rods.

4.1.7 Force Transducers. Align these transducers perpendicular to the test object. When using threaded rods in combination with the force transducers, make sure that nuts are placed on either side of the force transducer to prevent independent motion.

4.1.8 Threaded Rod, Washers and Nuts. All Threaded Rods, Washers and Nuts shall be of significant cross section and material so that they will not bend when loaded up to 2500 N.

4.1.9 Special Fixtures. Additional fixtures are required for some static stiffness tests. These tests require the force application be applied at a mount's centroid in all three (3) directions (see the specific static stiffness test belonging to the test being performed). Ideally, the rubber is removed from the mount and a suitably rigid surface fabricated. If it is not feasible to destroy the original mounts, fixtures are made that allow for this type of testing. Examples of these fixtures are provided in Appendix D, Figures D1 thru D4.

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.

4.3.1 Remove any hysteresis in the frame by applying the maximum load case (usually 1800 N) and maintaining for 15 minutes. The source of any creaking or popping noises in the fixtures or the frame should be found and corrected. Release the load.

4.3.2 Set all dial indicators to zero (0).

4.3.3 Apply the first load at a 450 N increment and record the prescribed displacements. Continue in 450 N increments, up to 1800 N, recording displacements at each load increment.

4.3.4 Reduce the load in 450 N increments, recording the displacement at each load, until the frame is no longer under load.

4.3.5 Repeat 4.3.2 thru 4.3.4 for a total of three (3) times to check repeatability.

See the specific static stiffness test procedure belonging to the test being performed for details of load application locations.

5 Data

5.1 Calculations. Calculations should be made according to the specific static stiffness test procedure belonging to the test being performed.

5.2 Interpretation of Results. Compare results to those for previously measured frames, and to the SSTS requirements.

5.3 Test Documentation. Each static stiffness test procedure will provide instructions to calculate a single number stiffness value, to be databased.

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.

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7 Notes

7.1 Glossary.

Applied Forces: Static loads that are induced onto the frame at specific locations (e.g., front shock attachments).

Boundary Condition: Constraining forces applied to the frame that prevent frame gross motion during applied forces.

Static Stiffness: The slope of the force versus deflection curve for the frame when it is subjected to a given static load case while constrained by specified boundary conditions.

Torsional Static Stiffness: The slope of the moment versus angular deflection curve for the frame when it is subject to a given static moment load case while constrained by specified boundary conditions.

7.2 Acronyms, Abbreviations, and Symbols.

IDSR Integration Driven Subsystem Requirements

N&V Noise and Vibration

VPO Vehicle Performance Owner

8 Coding System

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

Test to GMW14336

9 Release and Revisions

This standard was originated in September 2005. It was first approved by the Global N&V Structural Vibrations IDSR Harmonization in October 2005. It was first published in October 2005.

Issue	Publication Date	Description (Organization)
1	OCT 2005	Initial publication.
2	JAN 2011	Summarize changes for 5 year refresh. (Global N&V Center - Structural Vibration VPO)
3	SEP 2016	Revise to current template. (Global N&V VPO Team – Structural Vibration)

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