



Steering and Suspension Strength Test, Rim Pull

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 evaluate the strength of steering/front suspension systems and supporting/interface systems when subjected to a 445 N (100 lb) force turning load on the rim of the vehicle design intent steering wheel.

1.2 Applicability. This test procedure applies to all vehicles that have mechanical connections between the steering wheel and steering gear.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

None

2.3 Additional References.

- CG583.
- The Johnson Apparent Elastic Limit (JAEL) is defined in the Universal Joint and Driveshaft Design Manual, Advances in Engineering Series No. 7. Published by SAE International.

3 Resources

3.1 Facilities. Bedplate, 3.05 m x 3.05 m (10 ft x 10 ft).

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 Six (6) angle stands:

- Four (4) angle stands to secure frame or cradle to bedplate.
- One (1) angle stand to secure left steering knuckle to bedplate.
- One (1) angle stands to secure right steering knuckle to bedplate.

3.2.2 Four (4) adjustable angle stand brackets.

3.2.3 Two (2) "A" frames with clevis hangers to hold the suspension in the required position for loading.

3.2.4 Steering gear input shaft adaptor to ½ in square internal socket drive. See Figure C4.

3.2.5 Lebow torque transducer, model 1253-105-100 or equivalent. This torque transducer has a ½ in square external drive for connection to the steering gear input shaft adaptor and a ½ in square internal socket drive.

GM Confidential

© Copyright 2014 General Motors Company All Rights Reserved

November 2014

Page 1 of 15

3.2.6 Torque wrench with $\frac{1}{2}$ in square external socket drive with 0 to 150 N•m (0 to 100 lb-ft) torque capability. Connects to $\frac{1}{2}$ in square internal socket drive on torque transducer. If digital display is available for torque transducer, then a $\frac{1}{2}$ in square socket drive wrench can be substituted in place of the torque wrench, as long as the digital display is within view of the wrench operator.

3.2.7 Strain Indicator Box.

Note: All instrumentation is to be calibrated as required. Record instrumentation details and date of calibration in Table B4 in Appendix B.

3.2.8 Steering Boost Mechanism.

- a. For hydraulic systems – power steering pump specially built by supplier with pressure relief setting at maximum specification.
- b. For electric systems – power supply and Electronic Control Unit (ECU) specifically configured to run outside of the intended vehicle and provide maximum boost capabilities.

3.2.9 Power Boost Conveyance.

- a. For hydraulic systems – all pressure and return hoses.
- b. For electric systems – all wire harnesses.

3.3 Test Vehicle/Test Piece. Three (3) samples of each test piece/material are to be provided.

3.3.1 Complete steering gear/linkage assembly.

3.3.2 Front frame section with sufficient structure to maintain the front suspension components according to design intent or vehicles with front cradles and unibody constructions.

3.3.3 Suspension components such as left and right lower control arms, upper control arms, steering knuckles, and strut assemblies.

3.3.4 All applicable fasteners. Two sets of fasteners will require to be instrumented and calibrated for tension measurement.

3.4 Test Time.

Calendar time: 10 days

Test hours: 8 hours per sample

Coordination hours: 40 hours

3.5 Test Required Information.

3.5.1 Fastener tightening nominal torque and range.

3.5.2 Minimum clamp force of each non-tapered stud joint.

3.5.3 Steering wheel radius.

3.5.4 Calculated value of steering gear input shaft torque from 445 N of applied tangential force at the outside diameter of the steering wheel.

3.5.5 Maximum stress locations in the steering components as shown by engineering analysis. Experience has shown the slender section of the inner tie rods generally exhibit the highest stress during this test, especially if the tie rod buckles. The preferred engineering analysis technique is:

- Finite Element Analysis (FEA).
- Design caster angle.
- Design camber angle.
- Design toe angle.

3.5.6 For hydraulic boost systems – fluid flow rate and maximum pump pressure relief setting.

3.5.7 For electric boost systems – maximum steering system operational voltage and expected maximum current draw of the ECU during the test.

3.6 Personnel/Skills. For electric boosted steering systems, the steering gear and ECU supplier(s) must assist in set up and review at end of test.

GM Confidential

© Copyright 2014 General Motors Company All Rights Reserved

November 2014

Page 2 of 15



Documents

Document Sharing Hub

4 Procedure

4.1 Preparation.

4.1.1 For reference, see Figures C1 thru C4 in Appendix C.

4.1.2 Apply strain gages to the complete steering gear/linkage assembly(s) at all high stress locations as indicated by engineering analysis. If the analysis confirms the slender section of the tie rods require strain gages, the random direction of the buckling phenomenon requires two strain gages per tie rod at the same axial location, and radially 90 degrees apart to capture the maximum strain experienced during this test.

4.1.3 Fasten the frame section to the angle stands using angle stand brackets and secure to a bedplate.

4.1.4 Assemble the front suspension to the frame section.

4.1.5 Attach the steering gear to the frame and assemble the strain gauged steering linkage to the suspension. Also attach the idler arm housing to the frame where applicable.

4.1.6 Fastener Tightening Strategy.

4.1.6.1 For two of the test samples, secure all non-tapered stud fasteners to minimum clamp load with the instrumented fasteners. Secure all tapered stud fasteners to minimum torque.

4.1.6.2 For one of the test samples, secure all fasteners to maximum torque.

4.1.7 Attach the torque wrench to the steering gear input shaft.

4.1.8 Support each side of the suspension at normal design "Z" height with an angle stand secured to the steering knuckle.

4.1.9 Secure Boost Mechanism.

4.1.9.1 For hydraulic boosted systems, secure power steering pump and hoses to the steering gear. Pump shall be electric motor driven or simulated with laboratory source pressurized hydraulic fluid.

4.1.9.2 For electric boosted systems, secure wire harness(es) and ECU to the steering gear.

4.2 Conditions.

4.2.1 Environmental Conditions. Testing to be conducted at room temperature and humidity.

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 Deviations from the requirements of this standard shall have been agreed upon by Test Engineer, Validation Engineer and Designing Engineer/Design Release Engineer. Such requirements shall be specified on form CG583, along with the signatures of all parties agreeing to the deviation(s).

4.3 Instructions.

4.3.1 Secure one of the angle stands attached to the steering knuckles to the bedplate. Reference Table B1 for which angle stand to secure and at what position.

4.3.2 Apply Steering Loads.

4.3.2.1 Turn on steering boost mechanism, i.e., power steering pump or ECU.

4.3.2.2 Apply torque to the steering gear input shaft with the torque wrench up to 445 N (100 lb) tangential force on the rim of the steering wheel. Turning direction per Table B1.

4.3.2.3 Check for indications of high stresses that indicate potential yielding of steering gear/linkage assemblies, front suspension and support/interface systems at each increment of applied force using the strain gaged steering gear/linkage assemblies and record yield from the strain indicator. If yield occurs, Appendix A, Figure A1 and Figure A2 provide two variations of yield.

4.3.2.4 Repeat 4.3.2.2 in opposite direction per Table B1.

4.3.2.5 Repeat 4.3.2.2, 4.3.2.3, and 4.3.2.4 until all of the positions in Table B1 have been evaluated.

4.4 General Information.

4.4.1 Analytical methods shall be used to identify high stress locations. Strain gages are to be used as a quantitative indicator of yield.

4.4.2 Steering, front suspension and supporting/interface systems shall be inspected for plastic deformation/yield. At design engineer's discretion, the supplier shall function test and perform a Design Review Based on Test Result (DRBTR) on the steering gear after test to verify absence of plastic deformation/yield.

GM Confidential

© Copyright 2014 General Motors Company All Rights Reserved

November 2014

Page 3 of 15

Documents
Document Sharing Hub

5 Data

5.1 Calculations.

5.1.1 For Figures A1 and Figure A2, referencing 4.3.2.3 calculation method is determined by the Design Engineer.

Calculated value of steering gear input shaft torque from 445 N of applied tangential force at the outside diameter of the steering wheel.

5.2 Interpretation of Results. Not applicable.

5.3 Test Documentation. Test report to include the following design information (recorded on Table B2 in Appendix B):

- a. Steering wheel radius.
- b. Design caster angle.
- c. Design camber angle.
- d. Design toe angle.
- e. For hydraulic boost systems – pump pressure relief setting.
- f. For electric boost systems – system voltage and current draw during test.
- g. Test report to include the following test information (recorded on Table B3 in Appendix B):
- h. Fastener torques, pre and posttest.
- i. Fastener clamp loads (if applicable), pre and posttest.
- j. Test report to include the following calibration information (recorded on Table B4 in Appendix B): Strain gage locations.
- k. Test report to also include:
 1. Photographs of test setup.
 2. Strain gages output, steering boost input and rim pull input from each torque application along a timeline.
 3. Strain gage output versus rim pull input on an X/Y chart for each torque application. Each torque application must consist of data from input shaft at rest to input shaft at maximum torque back to input shaft at rest.

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. Not applicable.

7.2 Acronyms, Abbreviations, and Symbols.

CTS	Component Technical Specification
DRBTR	Design Review Based on Test Result
ECU	Electronic Control Unit
FEA	Finite Element Analysis
JAEL	Johnson Apparent Elastic Limit
SAE	SAE International
SSTS	Subsystem Technical Specification

8 Coding System

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

GM Confidential

© Copyright 2014 General Motors Company All Rights Reserved

November 2014

Page 4 of 15

Test to GMW15861

9 Release and Revisions

This standard was originated in March 2008. It was first approved by Structural Development Lab Global Chassis Team in June 2008. It was first published in June 2008.

Issue	Publication Date	Description (Organization)
1	JUN 2008	Initial publication.
2	NOV 2014	Five year refresh of standard. (Chassis - Steering Global Subsystem Leadership Team)

GM Confidential

© Copyright 2014 General Motors Company All Rights Reserved

November 2014

Page 5 of 15