



Steering Gear and Idler Arm to Frame Structure Attachment System Durability

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 determine the fatigue life characteristics of the steering gear, cradle/frame, structure and attachment system

1.2 Applicability. This procedure is applicable to all vehicles with parallelogram type steering systems.

1.3 Remarks. This steering gear and idler arm test provides lateral and vertical **real-time** multi-axial loads into the relay rod. See Appendix A, Figures A1 thru A4 for specific test configuration information.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW15242 GMW15268

2.3 Additional References.

- CG583 Form.doc, Development/Validation Test and Vehicle Review
- GM Road to Rig software
- Subsystem Technical Specifications (SSTS)
- Vehicle Technical Specifications (VTS)

3 Resources

3.1 Facilities. This procedure requires facilities and equipment as described in 3.2.

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 Bedplate area about 3 m square with hydraulic oil, cooling water and air supplies.

3.2.2 Angle stands and associated equipment to constrain the test specimen as described in 4.1.3.1.

3.2.3 Depending on the configuration being tested, sufficient number of angle stands to support four (4) load actuators. If necessary, two (2) angle stands and one (1) cross beam to support the four (4) load actuators (see Appendix A, Figures A3 and A4).

3.2.4 Four (4) servo-hydraulic actuators and one (1) rotary motor and associated control equipment. Actuators must have sufficient capacity to generate the peak measured loads at **real-time** frequencies, (see Appendix A, Figures A2 thru A6). Loads collected on vehicle line specific major durability schedule including schedules and repetitions indicated in the Steering Test Option Portion of the procedure.

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3.2.5 Four (4) load cells rated 20% higher than the peak measured loads for their particular location (maximum vertical and lateral load measurements on both the right and left hand side of the relay rod).

3.2.6 Fixture designed to attach the rotational linear displacement transducer, attached to the rotary actuator to the steering gear input shaft.

3.2.7 Fixtures designed to attach the load cells, attached to the laterally loading actuators, to the threaded portion of the inner tie rod. See **Note** in 4.1.3.5.

3.2.8 Fixtures designed to attach the load cells, attached to the vertically loading actuators, to the inner tie rod ball housing. This shall be done with a revolute joint in such a way as to avoid side loading the interface between this fixture and the inner tie rod ball housing during steering system lateral actuation.

3.2.9 Power steering pump and associated equipment including a functional heat exchanger, if required, to maintain the system power steering fluid temperature in the 65 °C to 120 °C range and oil reservoir to provide pressurized power steering fluid to the steering gear at production intent flow rates and pressures unless otherwise specified by the Design Engineer (DE). An additional method of using test laboratory hydraulic oil may be used by creating a control loop which monitors pressure and flow (see Appendix A, Figures A7 and A8).

3.2.10 Programmable Test Site Controller.

3.2.11 Instrumented and calibrated steering system frame attachment bolts and the support equipment required for monitoring tension on each of the bolts.

Note: All instrumentation is to be calibrated as required. Record instrumentation details, and date of calibration, on Appendix B, Data Sheet B1 unless the information is preserved in the laboratory records.

3.2.12 Fans to cool any articulating joint to 90 °C maximum during test, or as specified by the DE.

3.3 Test Vehicle/Test Piece.

3.3.1 The following parts shall be included in the pre-production test kits requested by the Validation Engineer (VE) to support this testing or provided by the DE.

3.3.2 All test material shall be dimensionally certified prior to receipt to confirm that it is representative of design intent. The Test Engineer (TE), VE and DE should consider testing worst case scenarios such as minimum gauge thickness materials, minimum/maximum stack up of parts, parts designed to the maximum stress level, etc. (See Subsystem Technical Specifications (SSTS) for number of samples and reliability requirement).

3.3.3 Vehicle frame must include production intent coatings. Frame must include production intent cross members. See Appendix A, Figures A2, A3, A4 and A11. Frame may need to be modified for clearance of fixtures (Appendix A, Figure A12).

3.3.4 Steering gear attachment fasteners and associated hardware.

3.3.5 Frame to body mounts. It is permissible to simulate the compliance of the body mounts to frame using appropriate material on the steering gear side of the frame. Refer to Appendix A, Figures A9 and A10.

3.4 Test Time.

Calendar time:	90 days
Test hours:	900 hours
Coordination hours:	100 hours

Note: Coordination hours can be referred to Setup and Remote Parameter Control (RPC).

3.5 Test Required Information.

3.5.1 The DE shall supply layout/math data showing tie rod position in the Design Plan view and a method of converting the measured Lower Control Arm (LCA) angles to corresponding tie rod angles.

3.5.2 Assembly information, such as Master Process Documents (MPD), showing assembly position, sequence, etc., shall be provided by the DE.

3.5.3 The Fastener Engineer (FE) shall supply bolt tensile preload minimum and maximum specification.

3.5.4 Hydraulic power steering assist pressure, flow and steering gear maximum turn angle capability shall be supplied by the DE.

3.5.5 Performance objectives for development and/or validation tests are established in the vehicle Subsystem Technical Specifications (SSTS).

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3.6 Personnel/Skills. One (1) laboratory test technician skilled in the setup, tuning and use of hydraulic test equipment and controllers. One (1) TE for test planning, data preparation, direction and incident analysis. One (1) VE to request part kits and track the status of parts from Pre-Production Operations (PPO).

4 Procedure

4.1 Preparation.

4.1.1 Proving Ground Data Acquisition.

4.1.1.1 Install the following strain-gauged parts in a representative Proving Ground vehicle:

- Pitman Arm: gauged to measure vertical and lateral load
- Idler Arm: gauged to measure vertical load
- Relay Rod: to measure axial force
- Strain-gauged inner tie rods
- Rotary Variable Differential Transformers (RVDT) on right and left LCAs to measure angles for conversion to tie rod angles.

Note: Also install transducers to measure hand wheel angle for conversion to tie rod angles.

4.1.1.2 Utilize production intent wheels and tires, which generate the highest steering loads.

4.1.1.3 To collect the Road Load Data Acquisition (RLDA) files, run vehicle through all the events listed in the appropriate vehicle line specific major durability schedule including schedules and repetitions indicated in the Steering Test Option Portion of the procedure (reference GMW15268).

4.1.2 Data Reduction (for Correlation).

4.1.2.1 Using GM Road to Rig software, convert the LCA angles to tie rod angles using the method provided in 3.5.1.

4.1.2.2 Using the TIEROD program in GM Road to Rig software, create four (4) new channels of data that represent left tie rod vertical load, left tie rod lateral load, right tie rod vertical load, and right tie rod lateral load. The polarity of the data input to TIEROD must be positive tension for the tie rods and positive up for the lower control arm angles.

4.1.2.3 Data Editing (for Drive Control).

4.1.2.3.1 Create a file matrix with the appropriate repetitions for each test module based on 160 900 km (100 000 mi) durability. Adjust the repetitions to reflect the reliability evaluation point requirement specified in the appropriate Vehicle Technical Specifications (VTS), i.e., multiply the repeats by 1.5 to adjust from 160 900 km to 241 400 km (100 000 mi to 150 000 mi) VTS requirement.

4.1.2.3.2 Perform a Baseline Damage Calculation using the file matrix described in 4.1.2.3.1 and the data from the RLDA.

4.1.2.3.3 Remove non-damaging road load data from each event file according to current laboratory real time data editing procedures, and prepare for drive file development.

Note: Perform an Auto-Spectral Density (ASD) on edited high frequency, dynamic data to ensure that the steering system/frame assembly is not being subjected to unnatural resonant frequencies caused by data editing.

4.1.2.3.4 When editing the data, the steering wheel angle channel must be monitored.

4.1.2.3.4.1 The steering wheel channel is capable of moving large displacements. While editing the pitman arm load channel, allow enough time to permit the steering wheel rotary actuator to move, e.g., full left steer to full right steer. The rotary actuator will obtain the commanded position and the intermediate shaft can over torque if not enough time is allocated for the actuator to make angle adjustments.

4.1.2.3.4.2 The steering gear has a designed full maximum steering angle capability. The Design Engineer (DE) is to provide this information. In order to keep the steering wheel angle channel within the steering gear capability, set the full scale of the steering wheel angle channel five (5) degrees less than the maximum angle to clip the peaks to avoid hitting the steering gear hard stops.

4.1.3 Instructions for Test Setup. Deviations from the requirements of the procedure shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

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4.1.3.1 Secure frame section to bedplate by clamping the frame with angle stands (or by any other means necessary). This can be done with the frame section inverted to simplify access to the steering assembly (see Appendix A, Figures A9 and A10). One (1) in thick die rubber can be used as a dampener between the angle stand and frame interface.

Note: Frame angle stands and associated fixtures should be located as far as possible from the steering system mounting locations to prevent over-constraining the frame section.

Note: Full frame may be shortened to conserve bedplate space by cutting the frame rearward of the number one body mount.

4.1.3.2 Clean frame surfaces adjacent to steering system interfaces. Do not remove coating from gear to frame interface locations.

4.1.3.3 Install the instrumented pitman arm, idler arm(s) and relay rod to the frame with production intent fasteners.

4.1.3.4 Attach the power steering hoses to provide appropriate pressure and flow to the steering gear.

4.1.3.5 Mount two (2) servo-hydraulic actuators to apply the lateral test loads. Attach the load cells to the tie rods using the fixture described in 3.2.7.

Note: The two (2) load inputs in the horizontal plane (one (1) per side) must be oriented to match the plan view angle of the tie rod relative to the relay rod during straight ahead driving at the vehicles design height position.

4.1.3.6 Mount two (2) servo-hydraulic actuators to apply a purely vertical load into the inner tie rod ball housing. Attach the load cells to the inner tie rod ball housing using the fixtures described in 3.2.8.

4.1.3.7 Mount a rotary servo-hydraulic motor and torque measuring device to the intermediate shaft. The steering system must be in the straight ahead position and the rotary motor must be in the approximate center of its travel. The rotary servo-hydraulic motor must be equipped with an RVDT or Linear Variable Differential Transformers (LVDT) to measure rotary displacement. The displacement measuring device must be zeroed with the steering system in the straight ahead position.

Note: It may be necessary to modify the intermediate shaft to attach the torque measurement instrumentation.

4.2 Conditions.

4.2.1 Environmental Conditions. Test laboratory environment.

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 Instructions for Remote Parameter Control (RPC) Drive File Development.

4.3.1.1 Tighten steering system to frame attachment fasteners to nominal fastener torque.

4.3.1.2 Start the power steering fluid pump and cooling assembly to power the steering gear hydraulic assist system in 3.2.9.

4.3.1.3 Perform RPC Drive File Development using the data from 4.1.2.3.3. The vertical and lateral actuators should be in load control and the rotary actuator should be in stroke control. Test site load cell responses should be recorded to ensure test repeatability if necessary. Use the following channels for RPC.

4.3.1.3.1 Control Channels:

- a. Pitman Arm lateral force
- b. Pitman Arm vertical force
- c. Idler Arm vertical force
- d. Relay Rod axial force
- e. Steering Wheel angle
- f. Steering Wheel torque

4.3.1.3.2 Correlation Channels:

- a. Left and right tie rod axial force (calculated from TIEROD program)
- b. Left and right tie rod vertical force (calculated from TIEROD program)

4.3.1.4 If necessary, perform an ASD on the response data to ensure that the steering system/frame assembly is not being subjected to unnatural resonant frequencies caused by data editing.

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4.3.1.5 Perform a post-PRC Drive File Development damage comparison in GM Road to Rig using the repetitions and statistics from the Baseline Damage Calculation and the unfiltered load cell response data collected during the RPD Drive File Development.

4.3.1.6 Based on the results from 4.3.1.5, optimize the durability schedule from 4.1.2.3.1 in accordance with current laboratory procedures to create a test site file matrix.

4.3.1.7 Repeat the matrix from 4.3.1.6 to satisfy the reliability requirement (see SSTs for the number of test lives and reliability requirement). Create a randomized load profile schedule based on the preceding and enter it into a programmable test site controller.

4.3.2 Instructions for Test Execution.

4.3.2.1 Install Test Specimen.

4.3.2.1.1 Install frame test specimen in same manner as 4.1.3.1 and 4.1.3.2.

4.3.2.1.2 Install steering system test specimen to the frame test specimen with instrumented and calibrated production intent bolts.

4.3.2.1.3 Monitor and record the fastener tensile preloads and installation torques on Appendix B, Data Sheet B2. Permit sufficient time for fastener tensile preload to relax and stabilize before starting test. Record fastener preload once per hour until tensile preload stabilizes. One (1) sample shall be tested at maximum fastener tensile preload and the balance samples tested at minimum tensile preload.

Note: Tightening procedure for steering gear to frame attachments shall tighten all fasteners to 50% of desired preload. Then tighten all fasteners to 100% desired preload.

Note: For bolts with an adhesive patch allow appropriate time for curing.

4.3.2.2 Set hydraulic control limits slightly higher than the measured peaks.

4.3.2.3 Start test.

4.3.2.4 Inspect the steering system; for wear, cracks, loss of fastener torques, etc., at predetermined inspection intervals.

4.3.2.5 After completing the profile (number of test lives and reliability requirement), record final fastener tensile preloads and audit torques on Appendix B, Data Sheet B2. Disassemble the test sample and prepare a new test sample as directed in 4.3.2.1 and 4.3.2.2. Repeat 4.3.2.3 and 4.3.2.4 for the number of samples as specified.

5 Data

Record pertinent test results on the supplied Data Sheets, reference Appendix B, Data Sheets B1 and B2.

5.1 Calculations. Not applicable.

5.2 Interpretation of Results. Not applicable.

5.3 Test Documentation.

5.3.1 Photographs of test setup and issue observation.

5.3.2 Issue Problem Resolution Tracking System (PRTS) documents as required.

5.3.3 Issue final report including CG583 and associated data sheets.

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.

Audit Torque: The torque required to initiate fastener rotation in the tightening direction, also known as torque-to-tighten.

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Auto-Spectral Density: A function in the frequency domain that shows the strength at each frequency band for a stationary random signal (not to be used for transient signals), reference GMW15242.

Design Height: The position of the front suspension as shown on the front suspension layout at **design** vertical suspension position.

GM TIEROD Program: A specially developed software program that creates a purely vertical component and purely lateral component of the tie rod loads from a single tie rod axial load and tie rod angular measurements collected on a data acquisition vehicle. The program is contained within GM Road to Rig.

Hot Melt Wax: The coating used on some vehicle to prevent frame corrosion during shipping, storage and vehicle service.

Instrumented Bolts: Mounting bolts used to monitor tensile preload. Tensile preload can be determined using special bolts equipped with instrumented inserts, strain-gauged bolts, diaphragm-gauged bolts, or through the use of ultrasonic transducers. The instrumented bolt selection should be done in consultation with Fastener Engineering.

Remote Parameter Control: A process used to set up the test such that the loads at the test site are comparable to those measured at the Proving Grounds, reference GMW15242.

Tensile Preload: The amount of tension in a bolt as a result of stretching induced by tightening the bolt. This tension is the tensile load that holds a compressed joint together.

7.2 Acronyms, Abbreviations, and Symbols.

ASD	Auto-Spectral Density
DE	Design Engineer
FE	Fastener Engineer
kN	kilonewton(s)
LCA	Lower Control Arm
LVDT	Linear Variable Differential Transformer
MPD	Master Process Document(s)
Nm	newton meter(s)
PPO	Pre-Production Operations
PRTS	Problem Resolution Tracking System
RLDA	Road Load Data Acquisition
RPC	Remote Parameter Control
RVDT	Rotary Variable Differential Transformer
SSTS	Subsystem Technical Specifications
TE	Test Engineer
VE	Validation Engineer
VTS	Vehicle Technical Specifications

8 Coding System

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

Test to GMW15714

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