



Steering Gear Kinematics Test

1 Scope

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. The purpose of this test is to measure the internal ratio and sliding force properties of a rack and pinion steering gear.

1.2 Foreword. The internal ratio of a rack and pinion steering gear is determined from a bench test where the rack position and input shaft angle are measured. The test boundary conditions are; the gear is not powered, the input shaft is free except for attachment to an angular position encoder, and the rack is driven in both directions to within 5 mm of the end of travel.

1.3 Applicability. This test procedure may be applied to any automotive rack and pinion steering gear. It may be electrically or hydraulically assisted, or unassisted.

2 References

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

2.1 External Standards/Specifications.

ISO 9001

SAE J670

2.2 GM Standards/Specifications.

None

2.3 Additional References.

- 33B_VR_Gear_10.xls, Variable Ratio Steering Gear Kinematics Interactive Model
- Report PG 075924
- SAE 2001-01-1353

3 Resources

3.1 Facilities. A steering gear test bench, capable of 15 kN axial rack force and 50 N-m input shaft moment, and an appropriate steering gear power supply (hydraulic or electric) are necessary to conduct the family of steering gear tests. For this test, only the rack axial force capability is necessary.

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 Data Acquisition System (DAS).

3.2.2 Position Transducers. There should be direct measurements of the rack axial position, housing position parallel with the rack, input shaft rotational position, and rack roll angle, all with respect to ground. Encoders are preferred.

3.2.3 Force Transducers. There should be a direct measurement of the rack axial force.

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3.3 Test Vehicle/Test Piece. This test procedure applies to any passenger vehicle rack and pinion steering gear whether powered or manual.

3.4 Test Time.

Calendar time: < 1 day

Test hours: 0.5 hour

Coordination hours: 0.5 hour

3.5 Test Required Information.

3.5.1 Channels. See Table 1.

Table 1: Channel Minimum Resolution and Full Scale Values

Channel Name	Minimum Resolution	Minimum Full Scale Value
Input Shaft Angle	0.025 degree	720 degrees
Rack Axial Position	0.007 mm	125 mm
Rack Housing Position	0.007 mm	20 mm
Rack Axial Force	0.2 N	4500 N
Rack Rotation	0.0005 degree	15 degrees

3.5.2 Sample Rate. 50 samples/s.

3.5.3 Anti-aliasing Filter Frequency. 25 Hz.

3.5.4 Signal Signs. The test gears may be for Left Hand Drive (LHD) or Right Hand Drive (RHD), front steer or rear steer vehicles. It might be better to mount some of the transducers in a manner demanded by the steering gear during test, so the sense of the transducers should all be made positive when the input shaft angle is rotated as if to steer the vehicle to the right from the nominal center of the rack. This is consistent with SAE J670. This can be done in post-processing by using the rotary actuator angle sensor as the reference instead of modifying the data acquisition definition software for each gear being tested.

3.6 Personnel/Skills. Operator must be qualified and documented as capable to run this test as required by ISO 9001.

4 Procedure

4.1 Preparation.

4.1.1 Installation.

4.1.1.1 Mount the gear housing to the fixture as it is mounted to the vehicle sprung mass. For example, if the housing mounts are compliant, those same mounts should be used in the test fixture.

4.1.1.2 The tie rod to housing boots should be removed.

4.1.1.3 All the tie rod joints should lie on the rack axis as much as possible. The effects of radial loads on the inner tie rod end are the subject of other investigations.

4.1.1.4 If the gear is hydraulic, after mounting in the fixture, the cylinder ports should be as near the top as possible to reduce the amount of trapped air.

4.1.1.5 Connect the rack position and rack rotation encoders directly to the rack. Typically, the tie rod inner joint housing is removed from the rack and a fixture is used to fasten the rotary and linear encoder package directly to the rack with a screw, allowing the rack to recede into the housing to the desired travel near stop. See Figure 1.

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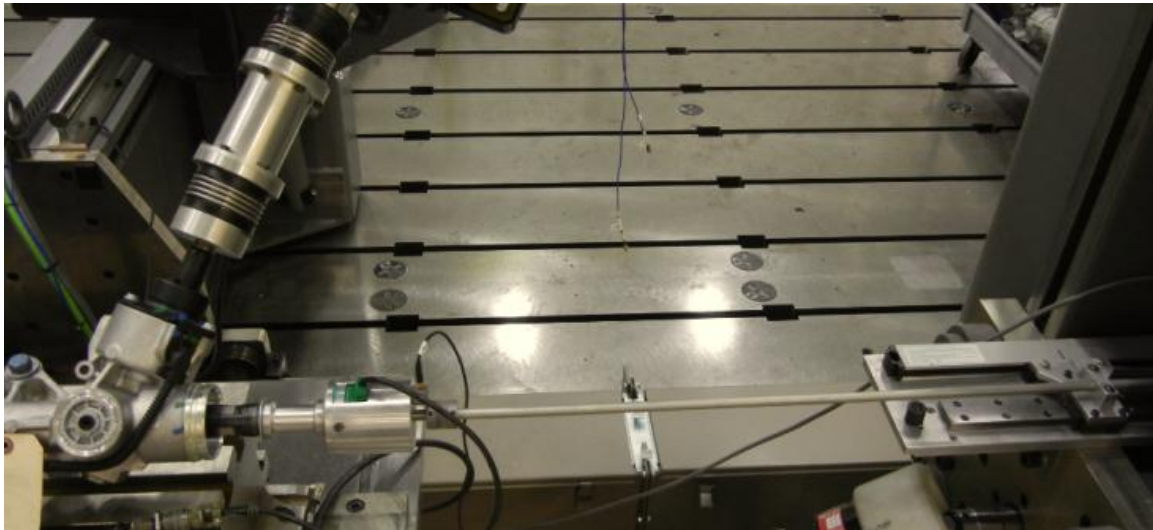


Figure 1: Encoder Attachment

4.1.2 Test Specimen Preparation.

4.1.2.1 Unless requested, do not test the gear if it has loose and/or worn inner tie rod ends, a disturbed preload adjuster plug, or dirt and corrosion inside the housing.

4.1.2.2 Center the steering gear based on the rack position, where half the stop-to-stop travel is defined as center. The input shaft center and rack center can be somewhat different in variable ratio gears.

4.1.2.3 Burnish the steering gear. Rotate the input shaft 20 times total to within 30 degrees of the stops, using a sine wave at 0.050 Hz. During ten cycles, load the rack in tension, and the other ten in compression. The rack load is 4000 N for assisted gears and 750 N for manual gears.

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 Rack Drive Velocity. 10 mm/s, to within 5 mm from stop, five cycles.

4.3.2 Do not drive the rack into the stop during the test execution. That is the purpose of the 5 mm margin from the stop.

4.3.3 Start the data acquisition system at least one second before starting the test and end at least one second after the test stops.

5 Data

5.1 Calculations.

5.1.1 Gear Ratio Analysis.

5.1.1.1 Subtract the housing position from the rack position to obtain the rack position with respect to the housing.

5.1.1.2 Use the Savitzky-Golay derivative technique (Second order, 2.5 mm window) to calculate the rack and input shaft velocities.

5.1.1.3 Divide the rack velocity by the input shaft velocity to obtain the internal ratio. Multiply by 360 to obtain the conventional units of mm/revolution used for "cfactor".

5.1.1.4 Fit a straight line to the result from a straight ratio gear and a describing function to the result from a variable ratio gear. The straight ratio was assumed in SAE 2001-01-1353. The variable ratio describing function, found in report PG 075924, and demonstrated interactively in 33B_VR_Gear_10.xls, is:

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