



EPS Steering Rack Rattles

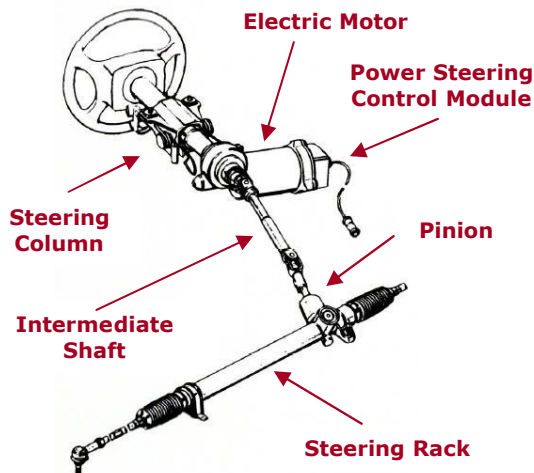
Lab Test System to Diagnose & Help Resolve Root Causes

Electric Power Steering (EPS) offers many advantages over hydraulic power steering:

- ❖ Eliminates power steering pump, saving 5 – 10 horsepower of drag on engine
- ❖ Improves fuel economy and reduces weight of pump and hoses (approx. 4 – 6kg)
- ❖ Ideal for electric vehicles and many hybrids
- ❖ Improves handling and steering refinement by using turning, position, torque & speed sensors plus electronics & control software in the power steering control module (PSCM) plus an electric motor to adjust steering assist under rapidly changing driving conditions

EPS suffers a few disadvantages:

- ❖ Hydraulics had huge damping effects so one hears noise problems in EPS (without the oil damping to suppress lateral motions in the rack) not heard with hydraulics
- ❖ Steering rack rattles in rack & pinion steering systems are more noticeable with column-mounted EPS, compared to rack-mounted, because an isolation joint between the column & rack cannot be employed
- ❖ Rattle elimination is often a trade off with steering effort, based on backlash adjustment



Steering rack rattles and steering column noises:

- ❖ Rattle or knocking or clunking or shudder noise heard & felt at low speeds (up to 25km/h) during slow turns on loose or rough surfaces → caused by backlash in rack and pinion or assist motor gear mechanisms, or elsewhere in column
- ❖ Rattles from inside the rack & pinion get worse through wear, resulting in increased clearances in rack/pinion interface and backlash adjuster
- ❖ Clunking noise during a turn, very random, independent of steering wheel angle and bumpiness of road → caused by poor lubrication of intermediate shaft, or defective shaft

JOBS-TO-BE-DONE to minimize steering rack rattles at their source:

- ❖ Diagnose and resolve rack rattle root causes to reduce warranty costs and satisfy customers
- ❖ Implement a lab test system (equipment and test methods) used by OEMs and suppliers that quietly, reliably and effectively reproduces the rack rattle phenomena
- ❖ Evaluate EPS rattles at component level (easier & more accessible) rather than vehicle level
- ❖ Engineer-out root causes of steering rack rattle through systematic troubleshooting, design modifications, and development work
- ❖ Assess EPS steering systems on many road surfaces to confirm rattles are engineered out
- ❖ Differentiate between different suppliers' products based on their propensity to rattle and use this as a supplier selection criterion; suppliers do the same for their competing designs
- ❖ Utilize a lab test metric to objectively not subjectively evaluate EPS rattle performance
- ❖ Comply with "GMW16216 Steering System Squeak & Rattle Performance Evaluation"

Lab Test Equipment & Specifications:

- ❖ Energizer BLACK or SILVER exciter with Background Noise of 1.5 Sones N10 or <35dBA
- ❖ Stiff load support inside Energizers resists large overturning moments due to side loads
- ❖ Frequency response of Energizers: DC – 2kHz; Displacement: 50mm p-p
- ❖ Energizers capable of vertical as well as horizontal excitation; mobile with air casters (optional)
- ❖ 2:1 Lever Arm for BLACK delivers >5.1kN pk-to-pk instantaneous force
- ❖ 2:1 Lever Arm for SILVER delivers >10kN pk-to-pk instantaneous force
- ❖ S&R Control Console with Time History software control, plus PSD Random and Sine (Win2K5)
- ❖ Instrumentation: IEPE accelerometer (100mV/g, 5kHz frequency response), IEPE microphone (1/2" Free-Field with pre-amp, prepolarized, 50 mV/Pa, 6.3-20 kHz), IEPE power supply, strain gage and full-bridge signal conditioner (capable of measuring 10kN pk)
- ❖ CommanderACQUIRE 4-Channel data recording (102.4kS/s per channel, 24-bit, 100dB dynamic range, AC/DC coupling) for in-vehicle data acq
- ❖ S&R Metrics data analysis software (Hi/Lo/Band pass filtering, resampling, level vs. time feature) for S&R analysis
- ❖ Steering Rack Rattle Rig with Rack Stand and Column Stand for mounting any column and any rack in their in-car positions, with interface brackets
- ❖ Adaptable for Torsional Rattle System using rotational excitation as well as linear excitation, as shown
- ❖ Adaptable to other users' test methods

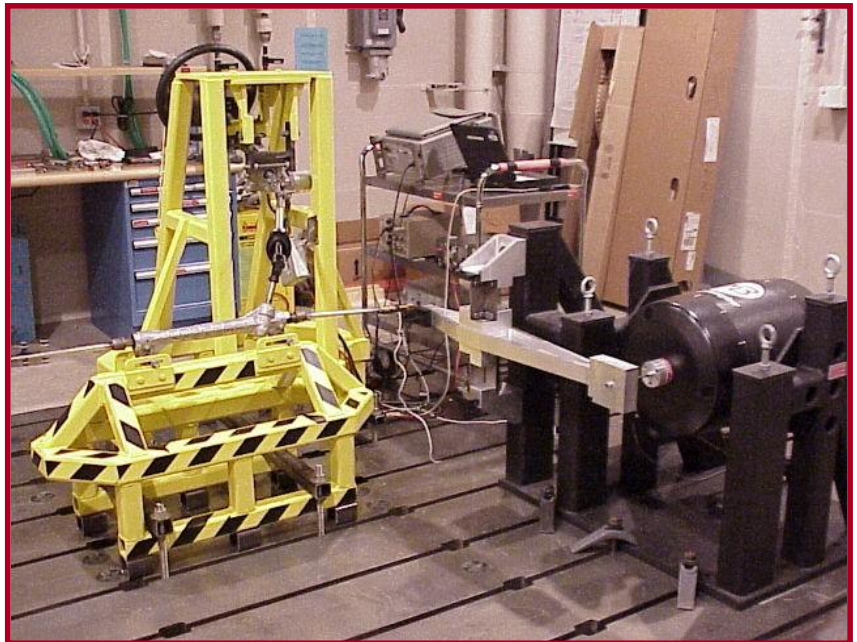
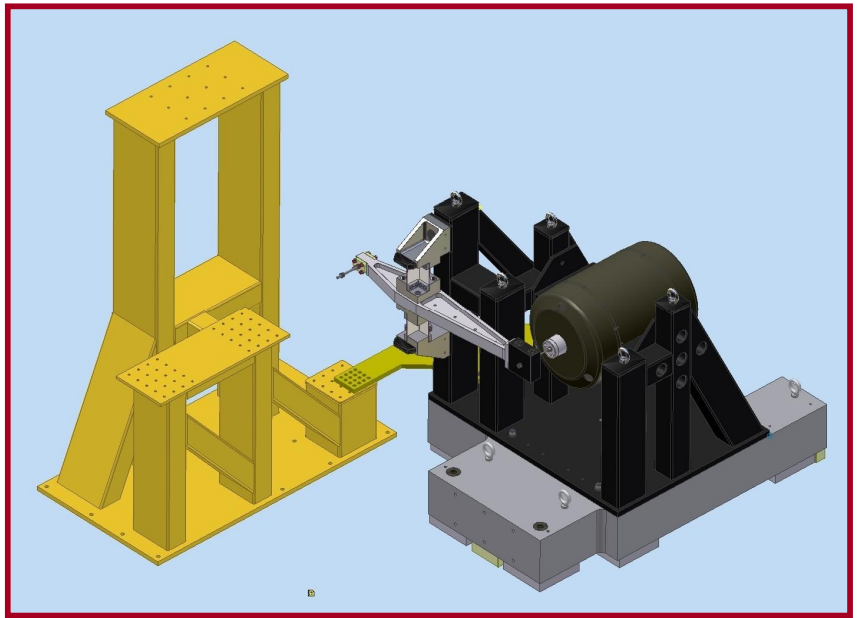


Photo courtesy of General Motors Corporation

Rack Rattle Road Excitation and Lab Simulation

- ❖ Reproduce chuckhole-type transient events, impacts, and random-like vibration
- ❖ Replicate real driving conditions and synthesized events that accentuate rack rattles
- ❖ Control to load or acceleration time histories, classical shock pulse events, and PSD random spectra

