EPS Steering Rack Rattle

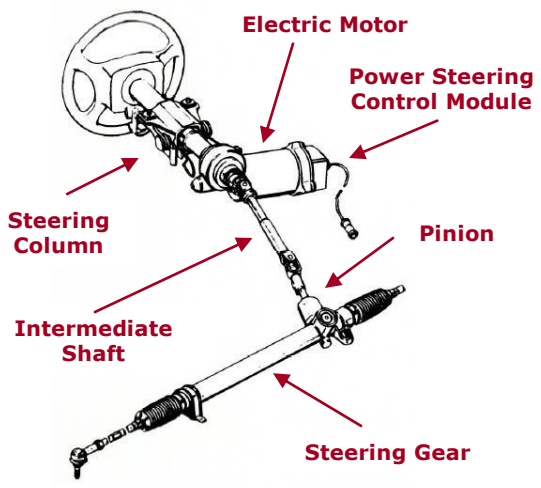
Lab Test System to Diagnose & Help Resolve Root Causes

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 (ECU) 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"***

MB Dynamics Inc • 25865 Richmond Rd • Cleveland OH 44146 USA • 216.292.5850 • sales@mbdynamics.com
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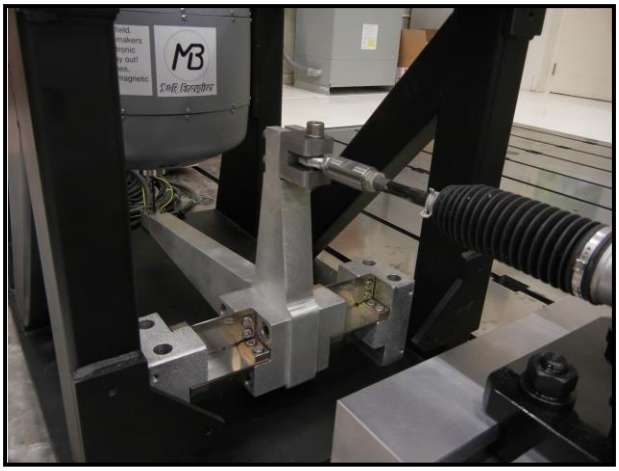
Lab Test Equipment & Specifications:

- Steering Module Test Simulator PC-based, Multi-Test Head, Closed - Loop control applications include single-Energizer and dual-Energizer dynamic loads using time history replication or random vibration (PSD control); static and quasi-static loads applied to tie rods through Energizers; position and torque control over steering wheel inputs using Driver Simulator; and combinations; profiles are acceleration, velocity, displacement, force, position – and mixed profiles to simulate the end-use environment
- Driver Simulator
  - Rack Load Simulator, with available actuators:
    - Electrodynamic
    - Pneumatic
    - Electric (Linear Motor)
    - Electro-Pneumatic
- Separate, Moveable, Height-Adjustable Column Stand and separate Gear Fixture, with interface brackets to steering system
- Torque, Force, Angle, Displacement, and Acceleration Sensors & Conditioning
- Objective Noise Measurement System, *S&R Metrics* data analysis software for S&R analysis
- Road Load Data Acquisition
- Steering Column Excitation & Fixtures



NOTE: No hydraulics, all electric & air

- Energizer BLACK or SILVER electrodynamic (not hydraulic) exciter; low Background Noise

	Ambient (Just before the events)	Audio Level during the 5 events
dBA (Peak Hold)	25.5 dBA	29.3 dBA
Loudness (per GMW14011)	0.25 Sones	0.40 Sones

- SILVER with 2:1 Lever Arm delivers >10kN pk instantaneous
- Stiff load support inside Energizers resists large moments from side or offset loads
- Frequency response with lever arm: DC - 500Hz
- Stroke: Lever arm end, 20mm p-p; Energizer, 50mm p-p
- Integral dual-acting air spring can apply pre-loads or static and quasi-static forces up to ± 12kN
- Energizers capable of vertical as well as horizontal excitation; mobile with air casters (optional)
- Adaptable for Torsional Rattle System using rotational excitation as well as linear excitation, as shown

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