



# EPS Steering Rack Rattle

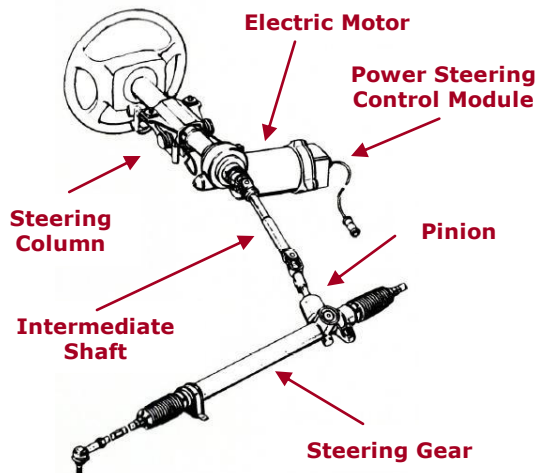
Lab Test System to Diagnose & Help Resolve Root Causes

## 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"*

## 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

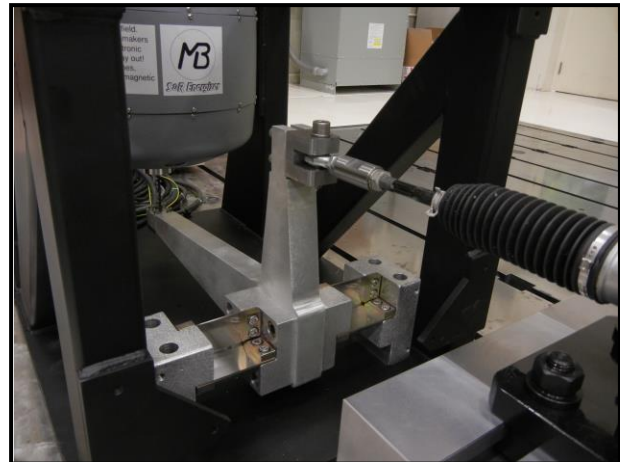


## NOTE: No hydraulics, all electric & air

- ❖ 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  $\pm 12$ kN
- ❖ 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

