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

<table>
<thead>
<tr>
<th></th>
<th>Ambient (Just before the events)</th>
<th>Audio Level during the 5 events</th>
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<tbody>
<tr>
<td>sBA (Pna rum)</td>
<td>25.5 sBA</td>
<td>29.3 sBA</td>
</tr>
<tr>
<td>Loundist (LpA 00110)</td>
<td>0.25 Swhs</td>
<td>0.46 Swhs</td>
</tr>
</tbody>
</table>

- 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

![Rack Rattle Road Excitation and Lab Simulation](image-url)