FULL VEHICLE BSR TECHNOLOGIES

Squeaks & Rattles (S&Rs) are annoying noises that cause customer dissatisfaction, high warranty costs, and poor quality. The J.D. Power Initial Quality StudySM (IQS) surveys owner-reported problems in the first 90 days of new-vehicle ownership. Body & Interior Quality - Mechanical scores issues including poor interior fit & finish and squeaks & rattles. IQS findings command worldwide attention. Media inform consumers when OEMs fall short: “We get downgraded because of little things like a squeak or a loose part.” As such, OEMs and suppliers welcome technology to help them design & build noise-free vehicles. MB Dynamics delivers effective, low-cost, quiet excitation technology to root source S&Rs in vehicles, trimmed bodies, subsystems and components. MB’s patented Direct Body Excitation (DBE) Road Simulator and Dynamic Vehicle Twist (DVT) technologies help detect vehicle S&Rs during development, launch, and production. Electrodynamic and pneumatic excitations under PC control replace hydraulics.

CUSTOMER TESTIMONIAL: “Your team has done an excellent job in putting together a viable S&-R assessment/root cause determination tool. We have the potential to significantly reduce the root cause/source determination of squeaks and rattles. This will result in a better quality product and higher levels of customer satisfaction. I can see significant improvements concerning (1) redundant S&-R road testing, (2) time required for rapid and accurate S&-R assessments and corrective action determination and validation, and (3) enhanced end-of-the-line throughput to name but a few.”
DBE TECHNICAL SPECIFICATIONS

• Quiet (30 dBA inside vehicle running drive file, not connected to vehicle); no wheel pan slap; no tire noise; no servo-valve hiss; doesn’t mask BSRs

• Higher frequency energy (up to 200 Hz) excites BSRs not found with road simulators (< 70 Hz)

• Requires no seismic mass; minimal disruption to facility; minimal facility cost; pit optional

• Cost is 1/3 to 1/2 that of a Hydraulic 4-Post Road Simulator

• Safe use; no high pressure oil; no disposal/environmental issues

• Low maintenance; simple operation for plants/labs

• Road-load time history, road-measured PSD random vibration, sine vibration

• MIMO control of each of 2 DBE Energizers, different drive files, front and back

• Quiet, therefore feasible & preferable to use for objective measurements (low background noise)

• Direct coupling to vehicle allows realistic reproduction of various recorded road excitations with relatively small forces; not damaging to paint

• BSR detection effectiveness > 90% with 2 Energizers
  • number based on 6-month study by Daimler
  • confirmed by other customers
  • more improvement possible with 4 Energizers

• Safe operation enables effective BSR analysis on interior, exterior and underneath
  • car is standing on its wheels
  • no handling or control needed (hands free)
  • safe to move inside vehicle during excitation
  • safe to get in and out; multiple people

• Realism generates high acceptance; physically feels like and audibly sounds like riding on the road

• Used in factory, quiet room, environmental chamber (-40°C to +60°C) or in combination with sun simulation systems

DIRECT BODY EXCITATION (DBE)
DBE Technology is a quiet and cost-effective alternative to hydraulic 4-posters. Quiet Energizers from MB can be installed in an environmental chamber (Mercedes and Hyundai)
Replicate real driving conditions using proving ground surfaces, assembly plant tracks, and local S&R roads
Control to acceleration time histories, PSD random spectra, speed sweeps from 0–25 mph/kph, sine vibration
Reproduce random-like vibration, chuckhole-type transient events, periodic inputs, & speed-dependent inputs
Use remote control mouse from inside the vehicle to repeat road surfaces over & over to identify root cause(s)
Vary amplitudes from 25% to 150% of recorded accelerations to find/fix amplitude-dependent S&Rs
Sequence, then link, different roads into corporate test procedures or vehicle-specific excitation conditions

REMOTE TABLET
Remote Tablet enables full control over all setting and displays at any time inside vehicle. Direct network connection over WLAN (preferred, no router required) or VPN (long distances). Remote Tablet can also be used for remote control of MB Vibration controller.
DVT FOR LARGE VEHICLE TWIST DISPLACEMENTS

- Dynamic body twist or torsion from long-stroke, low-frequency motion through the wheel & suspension: simulates twist ditch circuit & low-speed curb impacts
- Excites suspension & mount noises, rubber & seal itches, and body creaks
- Twist Sine, Single Wheel Lift, Pitch Bumps, User-defined
- 0 – 2 Hz Frequency Response
- Air spring actuators provide 150mm peak-to-peak of stroke under each wheel
- < 60dBA outside vehicle during DVT moves
- MIMO control of each of 4 wheels, controls displacement amplitude, shape and phasing
- Wheel pans support vehicle during DBE
- Front wheel pans move for various wheelbases
- Wheel pans wide enough for all tracks

DVT RANGE OF TIRE & TRACK DIMENSIONS FOR VARIOUS VEHICLES - WHEELBASE OPTIONS

<table>
<thead>
<tr>
<th>Wheel Pan Width</th>
<th>Distance Between WP</th>
<th>Clearance Tire WP Guard</th>
<th>Tire Size</th>
<th>Tire Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>660.4</td>
<td>1046.80</td>
<td>25</td>
<td>145</td>
<td>145.0</td>
</tr>
<tr>
<td>660.4</td>
<td>1046.80</td>
<td>25</td>
<td>155</td>
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<tr>
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<td>1046.80</td>
<td>25</td>
<td>165</td>
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<tr>
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<td>1046.80</td>
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<tr>
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<td>1046.80</td>
<td>25</td>
<td>185</td>
<td>185.0</td>
</tr>
</tbody>
</table>

DVT FREQUENCY / DISPLACEMENT & PAYLOAD

<table>
<thead>
<tr>
<th>Freq, Hz</th>
<th>Dead Wt., 500kg</th>
<th>Weak Suspension</th>
<th>Stiff Suspension</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>150mm</td>
<td>150mm</td>
<td>75 – 125mm</td>
</tr>
<tr>
<td>0.5</td>
<td>125mm</td>
<td>125mm</td>
<td>50 -- 100mm</td>
</tr>
<tr>
<td>0.75</td>
<td>100mm</td>
<td>100mm</td>
<td>40 -- 60mm</td>
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<tr>
<td>1.0</td>
<td>75mm</td>
<td>75mm</td>
<td>20 -- 40mm</td>
</tr>
<tr>
<td>1.5</td>
<td>50mm</td>
<td>50mm</td>
<td>20 -- 40mm</td>
</tr>
<tr>
<td>2.0</td>
<td>25mm</td>
<td>25mm</td>
<td>10 -- 20mm</td>
</tr>
</tbody>
</table>

* Displacements for different “payloads” or “Suspension” values depend on a vehicle’s suspension stiffness/damping characteristics, desired test displacements, and air flow rates and air line pressures available. Displacements must be iterated upon and tailored to the vehicle-under-test considering safety considerations and risk of overturning.
DYNAMIC VEHICLE TORQUER DVT + DBE

DVT Wheel stands in DOWN position for DVT

DVT Wheel stands locked in full UP position to support vehicle during DBE

ILLUSTRATION OF THE DYNAMIC VEHICLE TORQUER - DVT + DBE