

Preventing Buzzes, Squeaks & Rattles (BSR) in New Automobiles

Automotive Testing Expo North America
Novi, Michigan
October 25, 2006

Wayne Tustin
Equipment Reliability Institute
Santa Barbara, California

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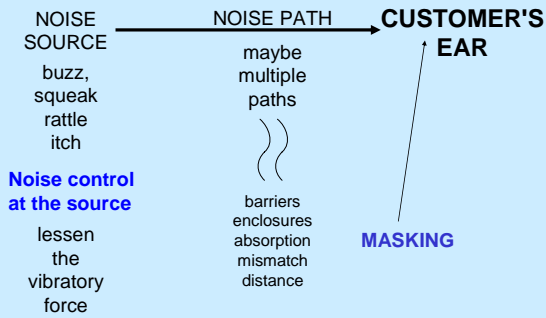
Table 32-1 Familiar sounds

Buzz	Loose laminations on a power distribution transformer, 120 Hz (North America, 100 Hz (elsewhere), and multiples
Squeak	Un-lubricated hinge motion
Rattle	Shake a coffee can of loose steel parts
Itch	Rub a piece of sheet metal on glass or rub two pieces of sandpaper

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Figure 32-2 Classical Noise Reduction Strategies



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How do we hear?

Laboratory excitation

Portion of vehicle such as seat assembly
Shake entire vehicle
Independent of weather

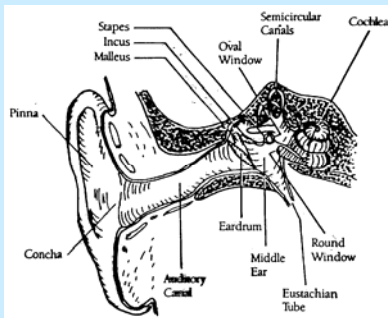
Over-the-road excitation

Ordinary, typical roads
Special BSR strips

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Figure 32-7 Human Hearing Evolved for Survival

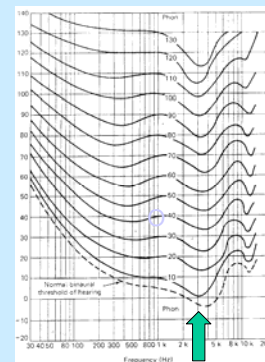


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Figure 32-8 Equal Loudness Curves

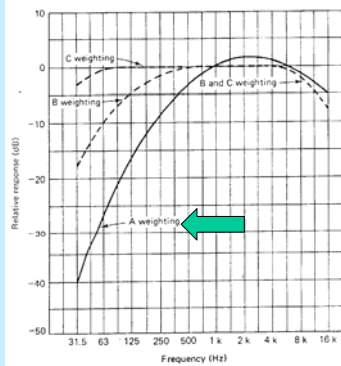
○ 1 sone is the loudness perceived at SPL 40 dB at 1,000 Hz. This is also 40 phons.



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Figure 32-9 Microphone Weighting



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Figure 32-3 Automotive “Sound Quality” Apparatus



courtesy Lear Seating and Head Acoustics

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Figure 32-4A Artificial Ear



courtesy Owens Corning Testing Systems

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How do we hear? ✓

Laboratory excitation

- Shake entire vehicle and listen
- Shake portion of vehicle and listen
- Independent of weather

Over-the-road excitation

- Ordinary, typical roads
- Special BSR strips

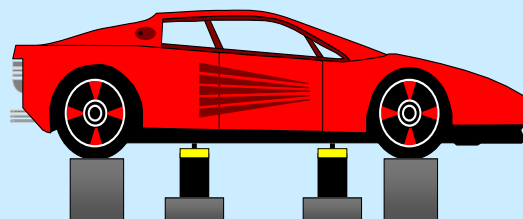
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Figure 32-9C - “Four Poster” shaking for BSR investigation



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Figure 32-10 Full Vehicle BSR Detection



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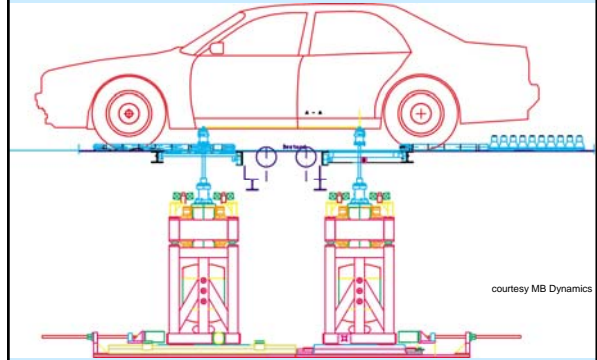
Figure 32-11A Floor Level of Prufstand



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Figure 32-11 Full Vehicle Excitation



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Figure 32-11C Energizer Docked to Car Body

courtesy Ziegler Instruments



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Figure 32-12 Energizer docked to car body

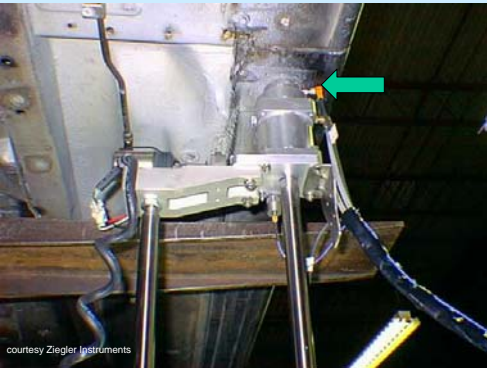
courtesy Ziegler Instruments



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Figure 32-12A Energizer Docked to Car Body



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Figure 32-12B View of Camera, Lights & Clamp

courtesy Ziegler Instruments



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Figure 32-13 FORD BSR R&D



courtesy MB Dynamics

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How do we hear? ✓

Laboratory excitation

Shake entire vehicle and listen ✓

Shake assemblies, parts and listen

How do we listen?

Independent of weather

Over-the-road excitation

Ordinary, typical roads

Special BSR strips

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Figure 32-1 Seat Construction



courtesy Lear Seating

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Figure 32-5 Localized Measurements



courtesy Lear Seating

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Test Setup

Conformal microphone array

courtesy of SenSound



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Figure 32-5A



courtesy Fred Fey

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Figure 32-5A Multi-axis Driven Platform for BSR Investigation of Seat Assemblies



(Courtesy Lear Seating and Team)

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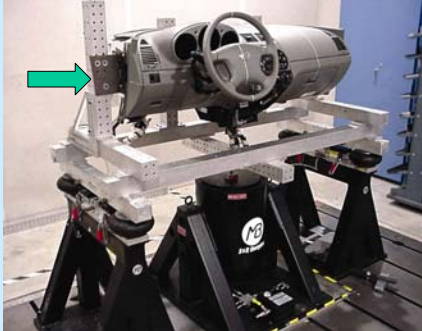
Figure 32-6 Sound direction apparatus



courtesy Lear Seating

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Figure 32-14 Investigation into IP BSR



courtesy MB Dynamics

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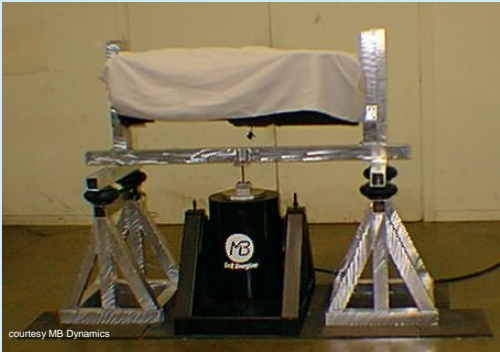
Figure 32-15 BSR door investigation



courtesy MB Dynamics

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Figure 32-16A Entire IP driven by Fixture



courtesy MB Dynamics

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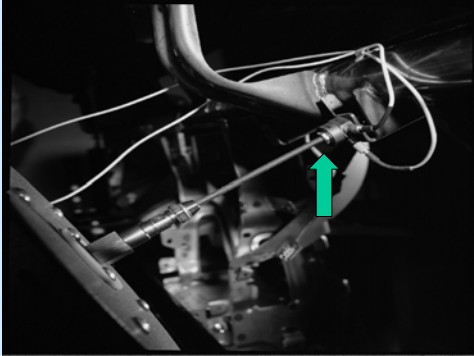
Figure 32-16B BSR Investigation of Instrument Panel



courtesy MB Dynamics

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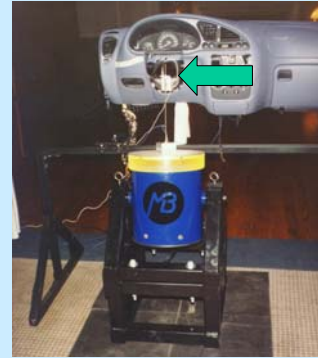
Figure 32-16C BSR Investigation of Instrument Panel



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Figure 32-17 ED Shaker Driving Instrument Cluster



courtesy MB Dynamics

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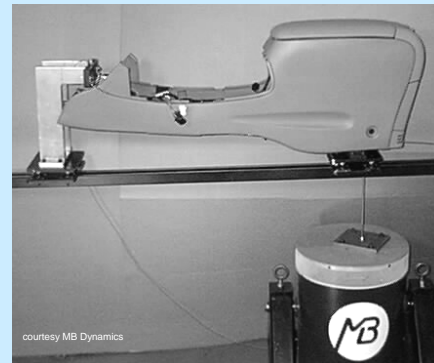


Figure 32-17A Quiet ED Shaker for BSR Investigations

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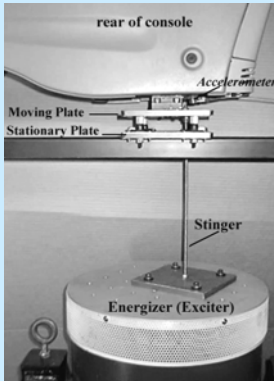
Figure 32-17B "Push Rod" drives Console Specimen



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Figure 32-17C "Push Rod" drives Console Specimen



courtesy MB Dynamics

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Figure 32-17D Massive Fixture drives Console Specimen



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Figure 32-18 Seat Assembly on two ED Shakers



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Figure 32-18A ED Shaker for BSR Investigations



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Figure 32-14 A Instrument Panel on ED Shaker

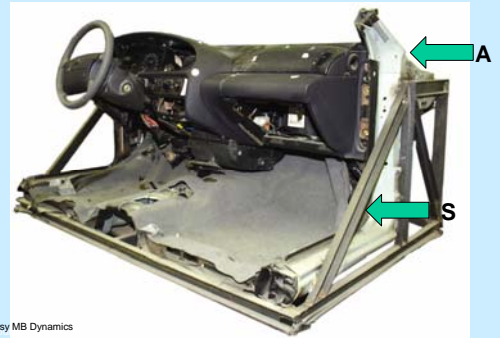


courtesy LDS

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Figure 32-16 Traditional "body buck" fixture

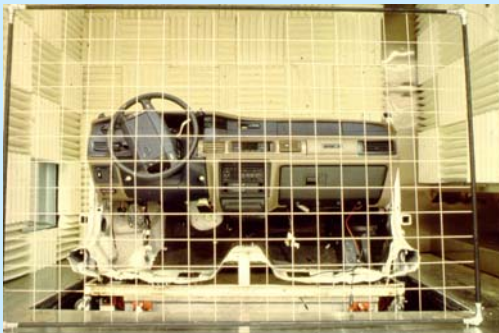


courtesy MB Dynamics

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Figure 32-20 Instrument Panel Noise Intensity Mapping

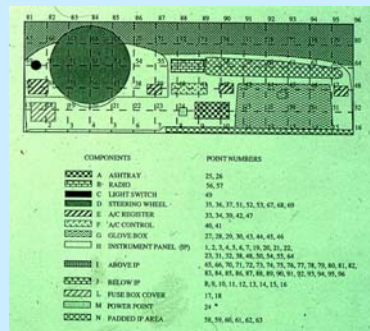


courtesy Ford

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Figure 32-20A Instrument Panel Noise Intensity



courtesy Ford

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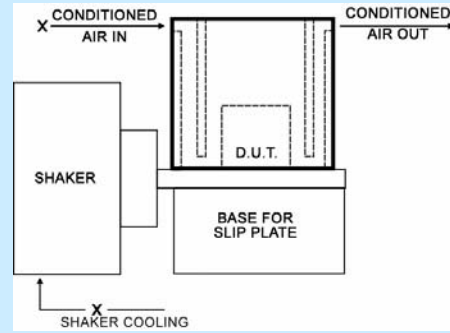
Figure 32-21 Acoustic Enclosure

courtesy Sigma Systems

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Figure 32-23 Quiet thermal chamber



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Figure 32-22A Seat Belt Retractor BSR Investigation inside a "Quiet Room"

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Figure 32-22 Erecting a "Quiet Room" Inside a Factory



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Figure 32-24 Remote controller

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How do we hear? ✓

Laboratory excitation

Shake entire vehicle and listen ✓

Shake assemblies, parts and listen ✓

Independent of weather ✓

Over-the-road excitation - seeking PowerPoint slides

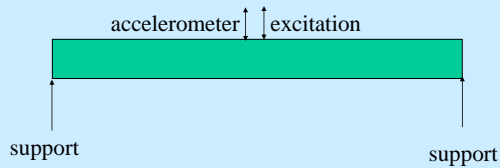
Ordinary, typical roads

Special BSR strips

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Figure 32-19 Instrument Panel, Beam Concept



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Video-clip 32-1 Cars continue to get Quieter



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Fundamentals of Random Vibration and Shock Testing, HALT, ESS, HASS Measurements, Analysis and Calibration

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Land vehicles are emphasized in this presentation, which includes discussion of NVH (noise, vibration and harshness) also BSR (buzz, squeak and rattle) engineering and test.

presented by
Wayne Tustin

December 5-7, 2006
(8am - 4pm)

at
National Technical Systems (NTS)
12601 Southfield Road
Detroit, MI 48223

Wayne's first involvement in vibration and shock measurement and testing was at Boeing/Seattle in 1948. Boeing was not only measuring in flight vibrations but also pioneering (on the B247 and B262 bombers) the use of (homemade) electrodynamic shakers for what much later came to

Thanks for listening to me discuss

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