

SQUEAK & RATTLE SOLUTIONS

Delivering Affordable Solutions to Help Find and Fix Root Causes of Squeaks & Rattles

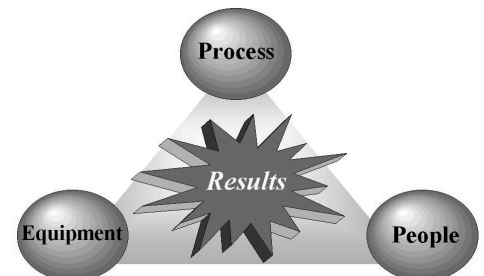


*“Squeaks and Rattles will be the #1 warranty concern of automotive companies in the next 10 years”
(Quality Mgr., major European high-volume car manufacturer)*

S&R technologies from MB have proven effective in many buzz, squeak and rattle test applications involving instrument panels and consoles, HVAC assemblies, seats, seat belt retractors, vent registers, airbag modules, clusters, steering column assemblies, radios and audio equipment, full vehicles, and material pairs.

Proven Technology from a Leader

Buzzes, squeaks and rattles (S&Rs) in vehicles are a major source of warranty claims. Vehicle manufacturers rely heavily on components from quality suppliers and use S&R specifications to control the quality of these components. MB is a well-respected leader in S&R technology, known for delivering proven turnkey solutions to help find and fix the root causes of such noises. Solutions include equipment and systems, test method development, training, engineering services, and help re-skilling people for S&R work. The principals and owners of MB have extensive experience in Automotive NVH, Component Durability, Environmental Stress Screening, Automotive Squeak & Rattle, Combined Dynamic Test & Structural Analysis, Digital Signal Processing, Sound Quality Engineering of Products, Calibration, PC-based Test, and Modal Testing & Analysis.

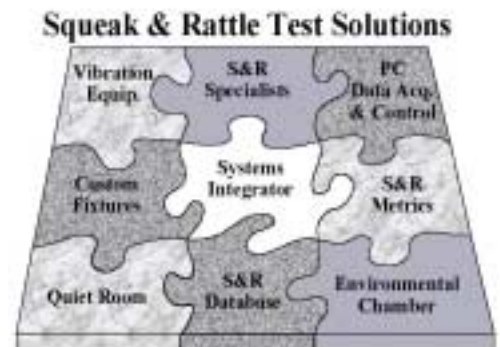


People + Equipment + Process = Results

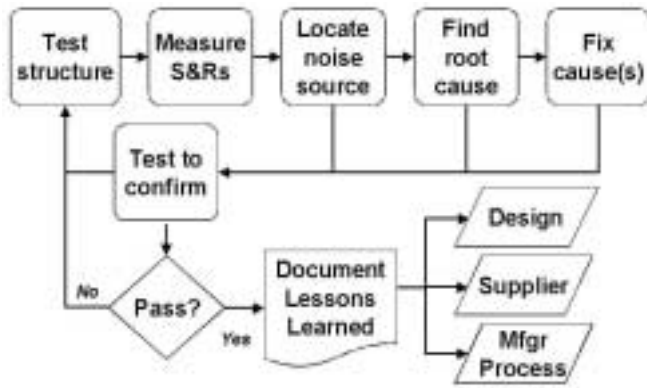
Delivering ‘Whole Solutions’ Sets MB Apart

Forging Strategic Partnerships is Key

MB is more than an equipment supplier – although we have provided vibration test systems since 1938. MB is an engineering company that innovates and delivers vibration and shock test solutions. As a systems integrator we partner with key companies, enabling us to deliver a full spectrum of affordable turnkey solutions -- whether you need to perform S&R tests on vehicles, modules, components, or some combination of these. MB thinks through your problem and solution in its entirety; defines all deliverables – including appropriate test methods -- and then works with you to ensure that all necessary pieces are comprehended to achieve the results promised. In so doing, MB delivers a ‘whole solution’ – one that makes the best use of your equipment and in-house skills long after we’ve completed your project. ❖



Testing to Find & Fix Root Causes of Squeaks & Rattles



The overall Detection Process is simple and systematic:

1. Test the structure
2. Measure, quantify, isolate, characterize each S&R
3. Locate the noise source
4. Find its root cause(s)
5. Fix cause (or document for later correction)
6. Re-test to confirm that the fix worked
7. Document lessons learned: Design guidelines; Supplier specs; Manufacturing process

Equipment, test methods and services tailored to a company's product(s), whether that is a full vehicle, module, or component.

S&R Testing Differs from Durability and Other Forms of Vibration Test

Traditional ways to specify shakers are not relevant for S&R work. For example, talking “force ratings” can result in over-sizing -- and overspending -- merely as a means of carrying heavy payloads with big footprints that require large mounting surfaces and stiff load support. When discerning subtle sources of S&R's, test equipment cannot introduce noises that mask those trying to be heard. Fixtures can't rattle. Shakers must be electrodynamic (E/D) not hydraulic, not mechanical. E/D shakers do not have high-pressure oil flow, valve hiss, or seal rubbing – all of which generate unwanted noises. Shakers must not be forced-air cooled because blowers are noisy, and turning them off to listen for S&R's is risky because the shaker may overheat and damage coils. Shakers would ideally use permanent magnets not electrically powered field coils because they can cause hum and noise perceptible in 30 dBA environments. The internal suspension cannot make noises during random and sine tests down to 5 Hz or up to frequencies as high as 200 Hz, so there should not be mechanical elements that *cause* S&R's. The shaker should be as quiet as 30-35 dBA (1.0 to 1.5 sones) when running a typical S&R profile at 0.5 g_{RMS}.

Low g's and low forces are also the norm. Accelerations of 0.5 g_{RMS} or lower are typical. 1.0 g_{RMS} is the upper bound. S&R testing an instrument panel weighing 120 lbs (55 kg), for example, or an HVAC unit weighing 30 lbs (14 kg) requires less than 100 lbf_{RMS} (450N). S&R work does not require large displacements either. 2" pk-pk (50mm) is never required. Even 1" (25mm) is rare. It does not demand high velocities. What is needed are shakers with “whisper quiet” operation, capacity to carry 75 lbs (35 kg) or more of payload, large mounting surface to handle large footprints, and a stiff suspension and load support system to resist unwanted cross-axis motion and resist overturning moments when large or unwieldy payloads with high cg's (center of gravity or center of mass) are positioned offset from the center of the shaker.

Low frequencies are also common. So are unwieldy test items that are cumbersome to fixture. For example, instrument panels are long with cg's not easily determined; seats can have high cg's and high overturning moments; door modules aren't very heavy but can be difficult to mount; HVAC units can be top-heavy. It is easy to be misled into thinking that rigid, massive fixtures are needed for S&R testing: they are not. With a maximum frequency of 100 Hz (200 Hz max), fixtures don't have to be resonant-free out to 2000, 1000, or even 500 Hz. They can be lightweight, stiff, and useable to 250 Hz. Over-designing and over-sizing fixtures ends up oversizing the shaker, and exceeding reasonable budgets for a S&R test system.

Road load inputs and real-world boundary conditions are not important for S&R work either. S&R testing does not need 6 degree of freedom inputs, “rigid” boundary conditions at connect points, highly accurate replication of time domain drive files, compensation for phase and “cross talk” between control channels, accommodation of test system non-linearities, or the most accurate simulation of actual operating conditions possible. Demanding road load vibration inputs and requiring “rigid” or in-vehicle boundary conditions is a carryover from durability testing -- and a very expensive one. *What is important is the responses that cause S&R's.* Vibration responses of the test item should be *reasonably representative* of in-vehicle conditions, as measured in-vehicle. Focusing on and controlling to *typical* responses in the time and frequency domain that cause S&R's simplifies control, and reduces controller cost. Effective and affordable S&R Solutions result –ones that help find and fix the root causes of S&R's, not overspend budgets. ❖

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Proven S&R Solutions -- Delivered

MB has an established and growing S&R customer base in North America, South America, Europe, and Asia including Ford, General Motors, Chrysler, Delphi, Visteon, Denso, ACT Labs, TRW, Breed Technologies, Autoliv, Takata, etc. Delivered solutions include:

Full-Vehicle Test Systems

S&R testing of full vehicles is no longer the exclusive province of four-posters. MB's alternative finds more S&R's, costs less, requires no foundation or seismic mass, is quieter, doesn't use 3,000 psi (200 kg/cm²) oil, and is safer. This technology can be applied end-of-line, in engineering development, or perhaps even by dealers!

Durability, Aging & Traditional Excitation Test Facilities

There are times to combine S&R test with conditioning, aging, durability, and traditional excitation. MB has provided such facilities for S&R testing of IP's, consoles, HVAC, and components. Deliverables included combinations of customized vibration, thermal, and acoustic test equipment. Stiff, lightweight, durable, *non*-massive fixtures are the key.



S&R Detector Systems

Turnkey solutions consist of an S&R Energizer Vibration Exciter, an MB S&R Control Console running under Windows NT, S&R Metrics software, instrumentation, custom fixturing, installation, training, and test method development. A new line of S&R Energizers (*patent pending*) were developed, in part, to meet the needs of General Motors for S&R testing. These Energizers met and even exceeded GM expectations because of their "whisper quiet" operation and high radial stiffness in the suspension system that freed them from worrying about overturning moments and cross-axis motion. Additionally, the exciters use permanent magnets and operate without cooling air, with an N10 (90th percentile) Zwicker Loudness Level of 1.5 sones when excited with a typical S&R profile. The MB flexure system can be used in a noiseless, friction-free horizontal shake table. The S&R Control Console running under Windows NT controls vibration responses which cause S&R's using random and/or sine vibration plus time-domain waveform replication. It acquires and analyzes acoustic data for measuring S&R's, performs FFT analyses for generating FRFs, archives data, and generates reports. Again, fixtures are paramount.

S&R Detector for Components

The S&R Detector "base model" is used for component testing, as seen here testing a radio



S&R Detector for IP's and Consoles

Self-contained turnkey system for design/development, QA, or end-of-line. Cycle time for S&R detection is less than 5 minutes. Re-fixturing for complete new assemblies takes 1-15 minutes, as required. These Detectors work in conjunction with one's own senses of hearing, sight, and touch. Pass/Fail diagnostics can be subjective or objective with S&R Metrics.



S&R Detector for Seat Belt Retractors

At Ford's urging, a workgroup of representatives from Ford, TRW, Breed, Autoliv, and Takata convened to improve the current seat belt retractor bench test noise specification to provide more robust test methods, *i.e.*, one less sensitive to variations from lab to lab. MB was invited to assist

the group in developing appropriate test methods and to prove that commercially available and affordable test equipment could meet the prescribed vibration conditions. MB's S&R Detector for Seat Belt Retractors successfully and repeatably performed to this specification. This led to orders -- worldwide -- from TRW, Breed Technologies, Autoliv, and Takata.





S&R Detector for HVAC Systems

Delphi uses MB S&R Detectors -- including environmental conditioning -- for S&R engineering work on HVAC systems and for production audit to assure quiet products are shipped to assembly plants. Custom fixtures (to accommodate different HVAC designs) can include an ultra-lightweight, quiet head expander (that uses an adaptation of the patented flexure assemblies) to provide further restraint to high cg loads and ones offset from the center of the table – conditions all too common with HVAC units.



S&I Tester for Material Pair Compatibility Testing

The Squeak & Itch (S&I) Tester is designed to subject contacting pairs of automotive materials to precisely controlled interference and motion in order to acquire, monitor, analyze, and report acoustic and friction characteristics under in-vehicle environment conditions. This apparatus helps to better understand material compatibility and stick-slip behavior by obtaining test information to help guide the vehicle design process in order to prevent squeaks and itches. It helps to select mating materials, lubricants and coatings; modify resins by polymer blending; emboss or texture materials; specify tolerances and interferences between mating pairs; and provide design guidelines so that material pairs used are less susceptible to creating objectionable noises. While all materials will squeak or itch under certain conditions, the key is to find those combinations which best perform over a broad range of conditions or in those applications considered crucial. Using the S&I Tester is superior to iterative trial-and-error methods of selecting material combinations that are installed and evaluated in vehicles. Such approaches are expensive in time and money, are at best empirical, and lengthen development schedules.

Who Performs Squeak & Rattle Tests?

Companies involved in automotive and truck design and/or manufacture can benefit from a S&R program. For example:

Design & Development - to benchmark competitive designs, troubleshoot unwanted noises, understand the physics causing such noises, and evolve corrective actions. Testing helps develop design guidelines for static and dynamic stiffness, set tolerances and clearances, understand the controlling shake frequencies, validate finite element methods for improving rattle performance of vehicle components, set frequency targets, and select materials to minimize noises when components rub.

Quality and Manufacturing – as an audit strategy during production to assure that manufacturing process changes and substitute materials/product from new suppliers have not jeopardized the S&R integrity of the original design; that tooling wear has not unwittingly allowed S&R's to creep into a product. Or, at end-of-line to find and repair products with defects introduced during production; assure that substandard product is not inadvertently shipped; or to reduce costs of taking corrective actions by quickly detecting S&R's prior to shipping product to customers. ❖

The systems introduced here are just that – *an introduction*.
Contact MB to discuss a more comprehensive solution
customized to your particular product(s).

RECENT TECHNICAL PAPERS:

1. "Next Generation Means for Detecting Squeaks and Rattles in Instrument Panels" (Ford Motor Co., MB Dynamics 1997)
2. "A Comparison of Different Squeak & Rattle Test Methods for Large Modules and Subsystems" (Visteon Automotive Systems, MB Dynamics, 1999)
3. "Developing Robust Vibration Simulation Control Methods for Evaluating Rattle Noise in Automotive Components" (Visteon Climate Control Division, MB Dynamics, 1999)

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