
S&R DETECTOR FOR SEAT BELT RETRACTORS

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



“MB was a critical partner in the seat belt retractor rattle noise team. Concerning the development of our test specification, MB -- in typical MB fashion -- helped define the customer needs, addressed the root issues from a deep background in shaker technology, and converted solutions into affordable, turnkey testing systems.”

M. Schneider, Seat Belt Retractor S&R Common Cause Team Leader

S&R Detector for Seat Belt Retractors

At Ford's urging, a workgroup from Ford, TRW, Breed, Autoliv, and Takata convened to improve the current seat belt retractor bench test noise specification to provide a more robust test, *i.e.*, one less sensitive to variations from lab to lab. MB was invited to assist in developing appropriate test methods and prove that commercially available and affordable test equipment could meet the prescribed vibration conditions. The MB S&R Detector for Seat Belt Retractors successfully and repeatably performed to this specification. This led to orders from TRW, Breed Technologies, Autoliv, and Takata.

A S&R Detector System for Seat Belt Retractors includes an Energizer Black vibration exciter that is “whisper quiet”. It has low cross-axis motion caused by unbalanced or offset loads because its patented flexure design and base are optimized for S&R testing. MB's PC-based S&R Control Console running under Windows NT controls vibration responses which cause

S&R's, using time domain waveform replication, random and/or sine vibration. It acquires and analyzes acoustic data for measuring S&R's, performs FFT analyses for generating FRF's, archives data and generates reports. Instrumentation, fixturing, installation, training and test method development are included.

Uniquely Tailored for S&R Test

There is much more to this S&R System than just a shaker. The following is a summation of what makes this solution so uniquely tailored for squeak & rattle work.

Sound Levels Caused by the Exciter Itself

The sound levels produced by the S&R Energizer Exciter are in the range of 30 dBA or an N10 Zwicker Loudness of 1.5 sones as measured 200 mm above a 4 lb (1.8 kg) test article bolted to the mounting table, and when shaking at 0.5 gRMS. It is vital that the test system is quiet when shaking – and MB's is!

Type of Vibration to Use

Time Domain Waveform Replication

This Detector uses *time domain control* technology. Road-load data can be recorded over long periods, edited to only contain those time segments during which S&R's were heard (even as short as 30 seconds) and then played back as a standard unchanging, repeatable input drive signal to the Detector. Time domain waveform replication is a better test for squeak and rattle detection because it replicates the real world and is the same time history *every* time it is used.

Random Vibration (PSD profiles)

The optimum setup for DSP parameters is 800 Hz Fmax and 1600 spectral lines *i.e.*, one that maintains tight control. To minimize repeatability problems caused by the infrequent 3 sigma events, limit the Gaussian random vibration to 2 sigma. Sigma limiting causes clipping, which causes severe problems during rattle tests. Clipped peaks produce high frequency energy, which produce audible *clicks* -- with any exciter (similar to the sound of a rattling component). It is therefore vital to round off those clipped peaks. MB provides a special circuit that gracefully does this, thereby eliminating any audible *clicks*.

Sine Vibration

Swept sine, dwell, and ramped dwell are effective vibration inputs for diagnosing a specific noise.

Out-of-Band Energy Caused by Rattling Test Item

Impacting within the seat belt retractor acts as an independent force generator and these impacts cause spurious vibration of lightweight armatures in small shakers. This causes unwanted noises that contaminate S&R detection. Traditional, small shakers sized for the low forces required can be inappropriate for buzz, squeak, and rattle. A massive armature is not only good – *it is essential!* Requiring this heavy armature is in direct contradiction with traditional shaker practices where the preferred shaker has the lightest possible armature, given its

force rating. The Energizer Black has an armature and mounting table weighing 18 lbs (8.2 kg).

Resonances of the Excitation System

It is important for the exciter, mounting table, and fixture to not have any resonances below 1,500 Hz since the vibration responses include energy out to high frequencies due to the rattling of the retractor. MB's Detector meets that spec. Therefore it is necessary to treat rattle tests the same as 1,500 Hz tests from the view of resonances in the exciter and fixture even if the PSD of the random vibration input has a 100 Hz fmax.

Off-Axis Motion (or Cross-Axis Motion)

A seat belt retractor is extremely sensitive to fore-aft and lateral vibration. Noises are due to vibration in not only the driven direction, but also the off-axis directions. So, to discriminate noises due only to the driven direction, off-axis motion must be minimized. For doing root cause analysis and taking corrective action, one must know whether the governing physical actions causing noises are in the driven or cross-axis directions. When a small shaker is used for seat belt retractors, inevitably the payload is off-set, which causes an unbalance, which in turn results in cross-axis motion (either fore-aft or lateral or both). It is very important therefore to have a shaker that is insensitive to unbalanced loads – like the Energizer Black.

Instrumentation Problems

As little as 0.01 gRMS of ground loop induced vibration can cause the ambient vibration to be larger than the target PSD at some frequencies. The S&R Detector eliminates ground loops. A 0.5 gRMS test measured by a 10 mV/g accelerometer only produces 5 mVRMS of output, which is not enough signal no matter how many bits the ADC has or how careful the engineer is with routing cables, etc. Furthermore, using a high gain signal conditioner usually just amplifies the spurious electrical noise along with the good signal. The best choice is a 500 mV/g accelerometer with a unity gain signal conditioner. These are standard in a S&R Detector for Seat Belt Retractors.

S&R Detector for Seat Belt Retractors – *consists of:*

S&R Energizer Black Vibration Exciter System

- Quiet Package -- no exciter noise – no cooling system – no blower
- Stiff load support resists large overturning moments due to offset or 'hi cg' payloads
- Large payload carrying capacity – 75 lbs (35 kg) for test item and fixture
- Large, versatile mounting surface – 10" (250 mm) diam. table, usable to 2,000 Hz
- Thermal shutdown circuit to protect exciter from overheating
- 2"x2" (50mm x 50mm) grid pattern; ¼"-28 (M6) threaded holes
- Power supply – rack mountable – 208-240 VAC, single-phase, 50/60 Hz

Trunnion Base for S&R Energizer Black

- Allows rotation of the S&R Energizer Black to +/- 90° from vertical
- Positions mounting table at height of approx. 29" (735 mm) above floor
- Footprint of 36-3/8" x 27-1/4" (925 mm x 700 mm)

Instrumentation Cabinet, low profile (on casters) for power supply

- 19" style cabinet; 29" (735 mm) of panel height; 22" (560 mm) deep
- ### S&R Control Console running under Windows NT
- Dual channel feedback for vibration control
 - Desktop Pentium PC for control, data acquisition and report generation
 - TTH-Time Domain Waveform Replication, Random & Sine vibration ctrl software
 - Filters out audible "clicks" due to sigma clipping
 - Remote monitor/mouse/keyboard up to 25 ft (8 m) from PC
 - S&R Detection software, including Microsoft Office Professional
 - Two 500 mV/g accelerometers: one for control, one for monitoring
 - 4-channel unity gain signal conditioner for accelerometers

One Year Warranty, Return-to-Factory, Parts & Labor

Two Days for Installation, Start-Up, and System Training