Buzz, Squeak, and Rattle Diagnostic Guide

Purpose

The purpose of this document is to define what a buzz, squeak, and rattle (BSR) concern is and to provide insight on how to isolate and repair said concern.

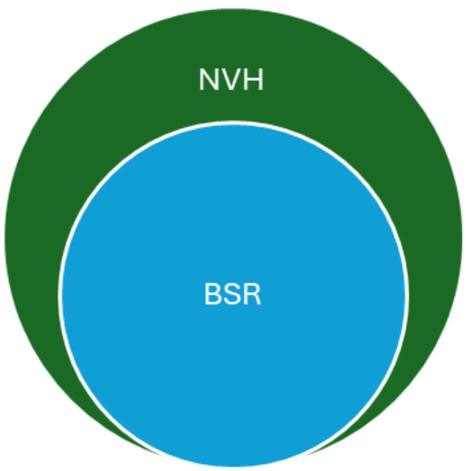
Goals

- Define BSR
    - Examples
- Understand what causes BSR concerns
- Understand how to isolate BSR concerns (diagnosing)
- Repair guidance

Definitions

A buzz, squeak, and rattle (BSR) concern is exactly as its name describes. These words form an onomatopoeia, meaning the word makes the noise that it describes. Although there are 3 different words, the root cause of the noise is normally from 2 sources. The first is when the suspect part can move because it is not properly constrained or because it is incorrectly assembled. The second is when the packaging space for the part is incorrect. BSR is commonly used interchangeably with noise, vibration, and harshness (NVH). While correct, NVH is the overall umbrella that BSR resides in. In other words, all BSR concerns are NVH concerns, but not all NVH concerns are BSR concerns.

Figure 1. NVH - BSR Diagram



BSR concerns are black and white in that they are either recognizable by the user or they are not. If a BSR concern is identified by a Rivian customer that means the BSR for that suspect vehicle is in no-good (NG) condition. A good (G) condition vehicle is one where there is no discernable BSR concern to the customer under normal operation. An identifiable BSR (including tin-canning) places the vehicle into NG condition.

It is important to be able to distinguish between a BSR concern that is normal operation and one that is from an NG condition vehicle. For example, window regulators in Rivian vehicles use an electrically driven mechanical pully system. This device moves the glass up and down as the user directs it to. Since it is a mechanical device, it is normal to hear it make noises while being used. However, in the hypothetical event that there is a build variation issue, the glass might shake or moan as it goes up and down. This is an NG condition from a BSR perspective.

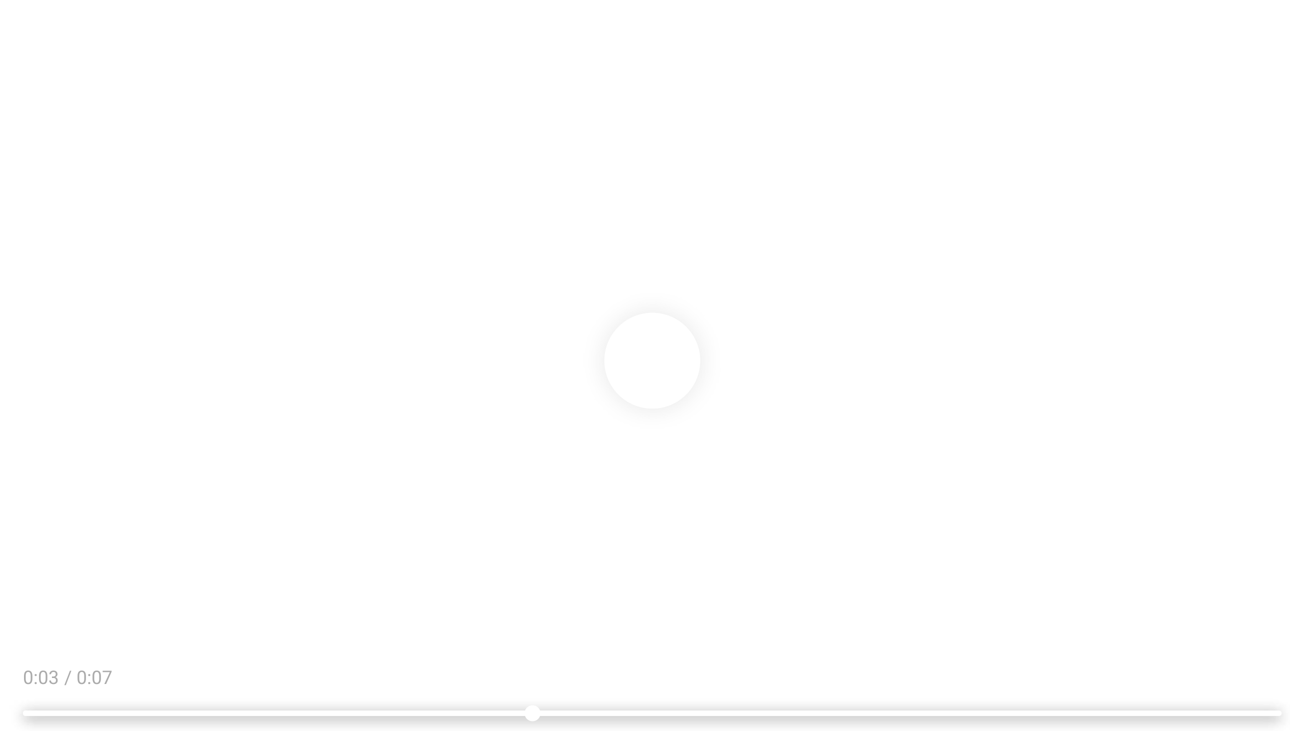
Figure 2. Normal (G) vs Abnormal (NG)

Examples

Listed from lowest normal frequency to highest.

1. Rattle – loose bolts

   Rattle Example



2. Buzz – dash rattle

   Buzz Example

0:07 / 0:07

3. Squeak – seal rub

   Squeak Example

0:01 / 0:01

Examples of Normal Operation

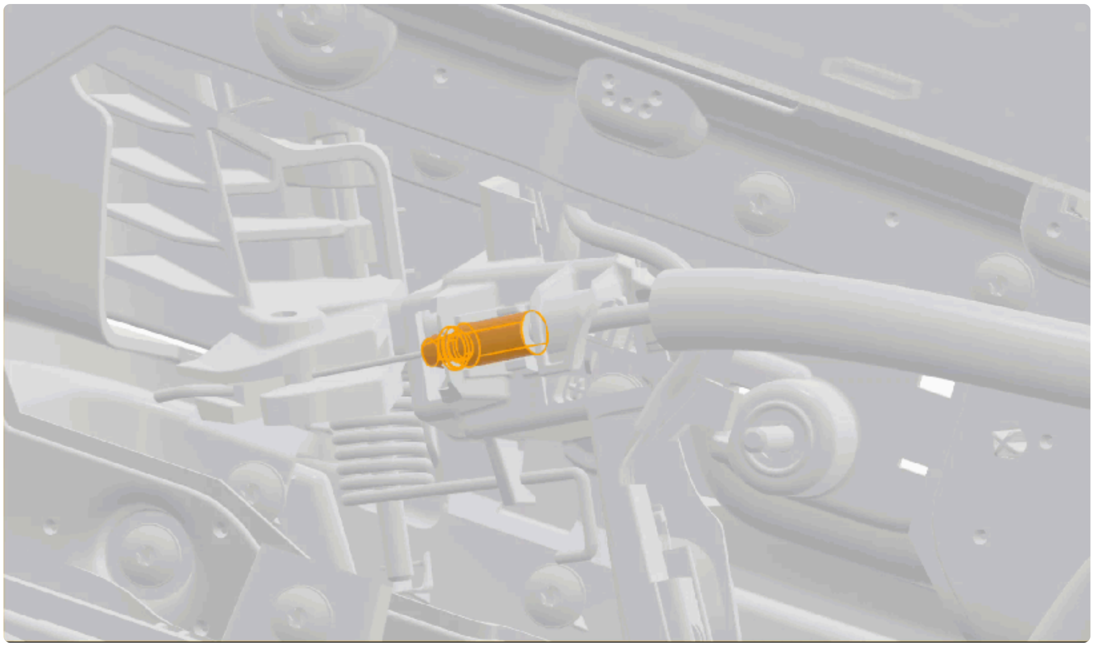
Rivian uses a sound catalog that has examples of normal operation for various parts around the vehicle. Please use this to compare against the suspect system being examined.

Causes

The 2 most common root causes of BSR are incorrect assembly and incorrect packaging space. Incorrect assembly is when a part was not properly installed on the vehicle. Incorrect packaging space is when the space surrounding the part is incorrect.

With incorrect assembly, often these are parts that have become loose or are not fully clipped in. The example below shows a terminal cable that connects the interior door handle to the door latch. In this example, the terminal cable is meant to be clipped into the door inner assembly to hold it in place. However, if not fully seated, this can result in abnormal noise.

Figure 3. Loose Terminal Cable Example



Packaging space concerns are when an incorrect amount of space exists for the part. An example of a packaging concern would be a mounting hole for a push pin that is too large. When designing physical parts, design engineers rely on a root sum squared (RSS) examination, commonly called an RSS stack up or simply RSS.

Figure 4. Push Pin Mounting Holes

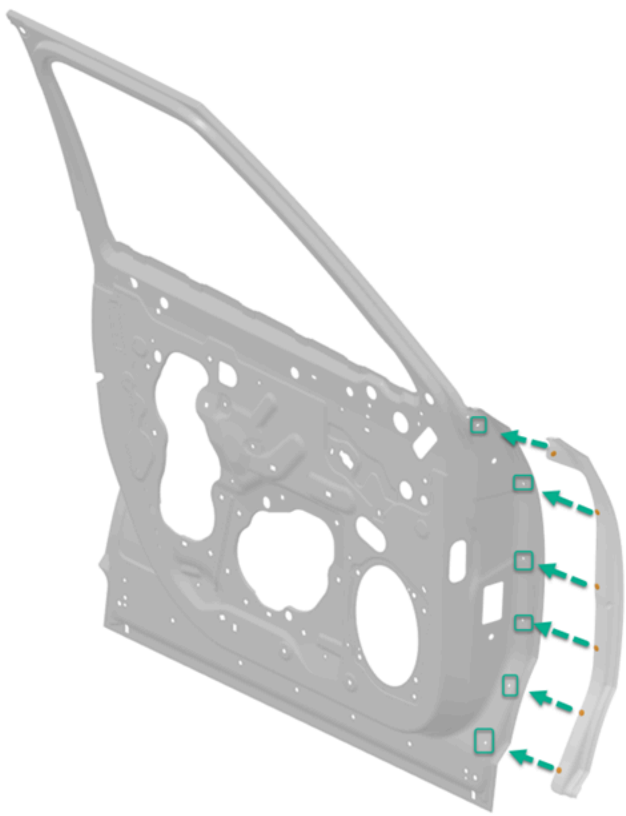


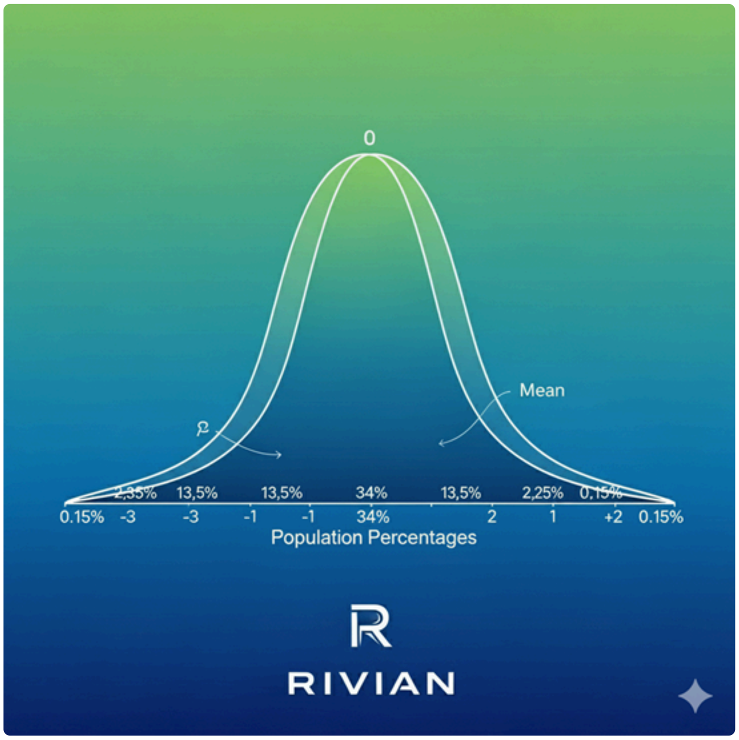
Figure 5. RSS Equation

$$RSS = \sqrt{\sum_{i=1}^{n} \sigma_i^2}$$

The RSS looks at all the inputs' tolerances and aggregates them together. When reading a 2D drawing or 3D cad with general dimensioning and tolerances (GD&T), there are tolerance values that state something like "X mm +/- Y mm". For the purposes of the RSS stack up, we are interested in the Y value. This is what dictates the target build variation value for the hole, as it allows the design engineer to size the hole large enough to allow the push pins to mount but small enough to retain them. This is because of build variation. While parts might seem the exact same to the naked eye, and in most cases they are for practical application, they never are if measured closely enough.

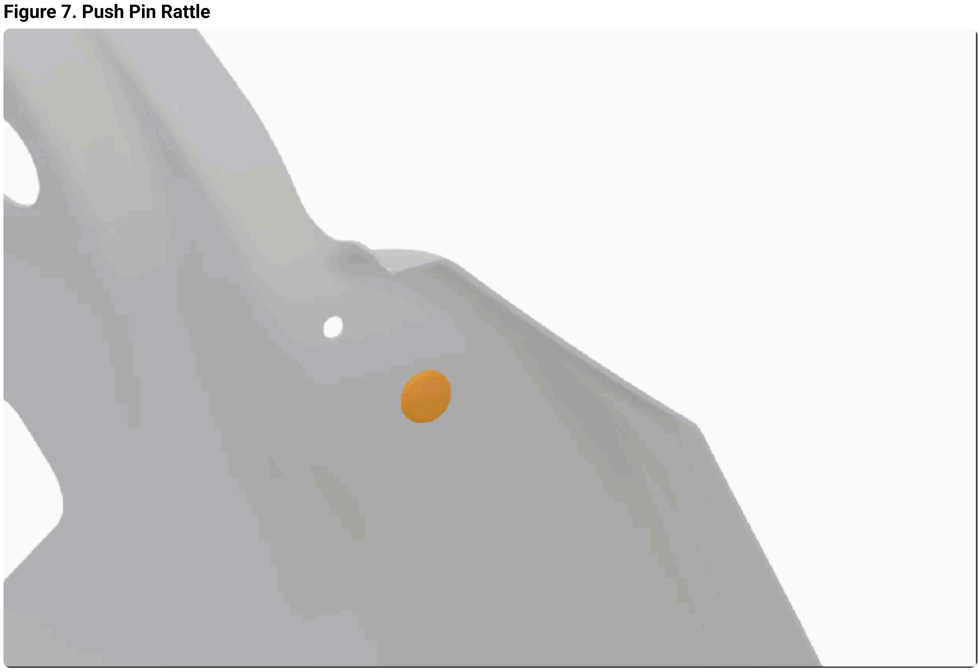
If we measure the holes outlined in *Push Pin Mounting Holes* for example, we would not see only 5.5 mm. Some of the measurements might be 5.56 mm or 5.48 mm, etc. When we chart the values in a histogram to look at the population of measurements, we see a bell curve. The bell curve informs us of our actual population if measured, and our theoretical limits should match up with what our tolerance values are from the GD&T. With this information, we now can both practically size the holes and have real information on the actual tolerances. In this example, the holes are made by a "punch" during the stamping process. As the name implies, it's a piece of the tool that literally punches through the sheet metal to create the hole.

Figure 6. Bell Curve with Z Values



For this example, a rattle can occur if the hole becomes too large. Let's say hypothetically that the size impacts of adding E-coat and paint to the door inner were not considered. When applied, the hole is now too small. The stamping facility uses a "Mikomi" or modifies the tool out of specification to assist with assembly of the vehicle, but they accidentally make it too large. In this example, we could have a hole that is too large and results in a potential rattle of the pin when mounted in the mounting hole.

Figure 7. Push Pin Rattle



Diagnosing

Diagnosing these issues can be exceptionally time-consuming and difficult. BSR concerns can occur essentially anywhere in the vehicle, and there are essentially infinite failure points that can have BSR concerns. These concerns can manifest themselves at varying speeds, temperatures, build variations, accelerations, etc. To correctly diagnose BSR concerns, the concern must be isolated and recreated.

What exacerbates the diagnostic difficulty is that BSR concerns are often in C-surfaces or areas that the customer will never see. Earlier in this guide we discussed how a loose terminal cable can cause a BSR concern. However, if the door inner panel is removed and reassembled correctly the BSR concern is unintentionally fixed, even if the loose cable was not noticed.

Diagnostics Quick Reference List

Below is a robust list of methods that can be used to locate BSR concerns.

1. Make note of where the customer heard the noise.
2. Review customer media.
3. Tap or knock on the suspect area with a soft rubber mallet or with your hand.
4. Turn the base up on the audio system and play various songs that use base.
    - Use the sample audio files below to play through the stereo and attempt to recreate the noise. Leave the stereo at low volume and increase volume as you test.

      > **Note:**
      > It is normal for the human ear to not be able to hear 20 Hertz or less.

        - **5 Hertz**

          0:06 / 3:00
        - **10 Hertz**

          0:02 / 3:00
        - **20 Hertz**

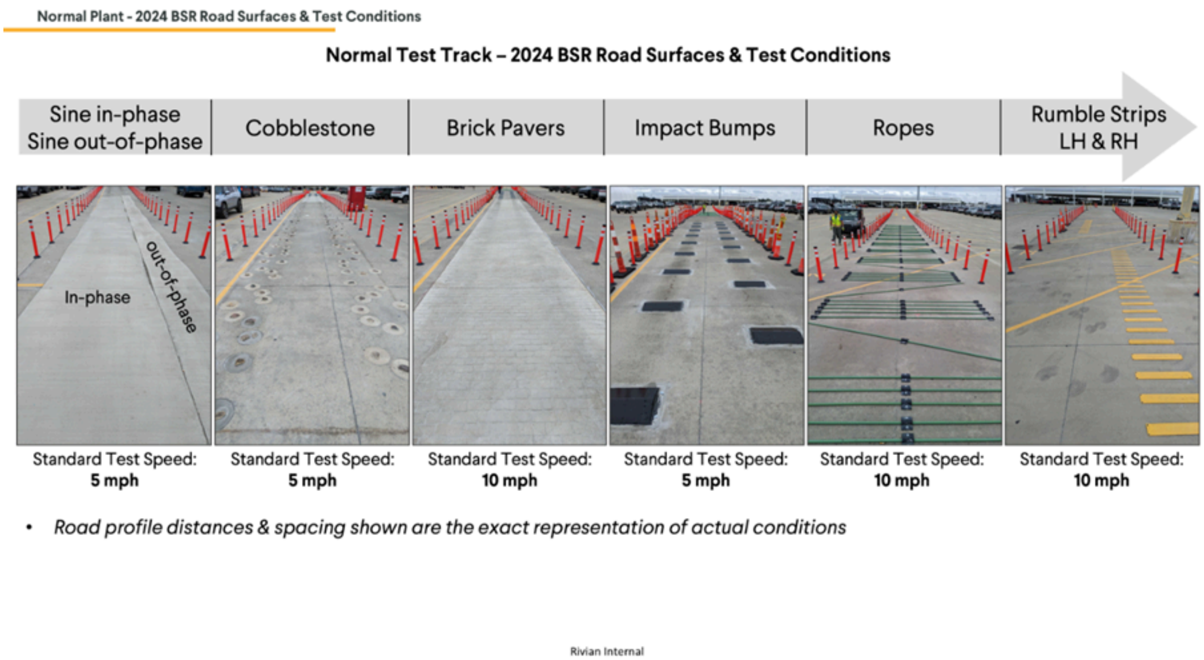
          0:02 / 3:00
        - **40 Hertz**

          1:43 / 3:00
        - **80 Hertz**

          0:01 / 3:00
        - **100 Hertz**

          0:01 / 3:00
5. Take the vehicle out on test drive.
    a. Have a fellow technician or responsible person drive.
    b. Use varying road surface and speeds.

    Figure 8. Test Conditions at the Factory



c. Use a stethoscope and listen all around the vehicle.

Figure 9. Using a Stethoscope

Figure 10. Using a Stethoscope While Driving

d. Apply pressure to the suspect area once identified and see if that improves or removes the concern.

> **Note:**
> It is possible for the customer to get the BSR location incorrect as sound travels and reverberates off different surfaces.

6. Note where the BSR concern was found during the drive.
7. Carefully examine the area for loose items or concerns.
8. Slowly tear the area down and make note of anything that is out of place.
9. Tap on the suspect parts to confirm the BSR once isolated.

Repair Guidance

At a high level, the repair guidance is to stop the BSR from occurring. There isn't one single method that works every time, as these concerns can occur in a multitude of positions and at almost every part. However, there are commonly used items that can be used for repair.

1. Felt tape: a single sided tape that has a soft felt on the other side. This is common to use on clips or areas where there is a slight gap that is allowing the BSR to occur.

   Figure 11. Plastic Clip with Felt Tape

2. Foam tape: like felt tape but fills in more space than flat felt tape. Often used when there is excess packaging space that must be filled to remove the BSR concern.

   Figure 12. Plastic Clip with Foam Tape

3. Shims: used to push parts together or apart. There are 2 ways to shim: shim the suspect part or shim the surrounding part(s).

Figure 13. Various Shims

4. Greases and lubricants: useful to remove friction on parts that are intended to move under normal conditions (like sunroofs).

Figure 14. Shop Approved Grease