

BSR (Buzz, Squeak, Rattle) Cheat Sheet

Mechanisms, root causes, prevention and test methods

ENGINEERING
CHEAT SHEET

Key equations

Quantity	Equation	Notes
Stick-slip condition	$\mu_s > \mu_k$	Static friction above kinetic friction drives squeak. The Stribeck region acts like negative damping
Natural frequency	$f_n = (1 / 2\pi) \sqrt{(k / m)}$	Detune local modes away from body and suspension modes
Resonance sharpness	$Q = 1 / (2\zeta)$	Buzz is a high-Q local resonance. Add damping (raise ζ)
Squeak rig range	Stiffness 8-89 N/mm, speed 1-10 mm/s	Severity and frequency rise with both (Yoon et al., 2025)
Psychoacoustic ranking	Loudness, sharpness, roughness, fluctuation, N10/N50	Used to rank which fixes customers will actually hear

Key takeaways

- **Buzz:** short, resonant, impact-triggered. **Squeak:** friction stick-slip between two parts. **Rattle:** impact between loose components.
- Common enablers: relative motion at interfaces, low local stiffness, and incompatible material pairs. BSR gets more noticeable as EVs make cabins quieter.
- Prevent with **KISS**: generous clearances, isolate contact paths, add structure/stiffness, secure interfaces, choose compatible materials.
- Also cut excitation at the source (tires, suspension, mounts) and keep component modes away from major body modes.
- Test with shaker rigs and four-poster rigs (one actuator per wheel), proving-ground squeak tracks, thermal and humidity chambers, and a semi-anechoic room.
- Use both subjective rating by trained listeners and objective microphone/sensor metrics.
- A hum near 40 mph from the front may be a wheel bearing or uneven tire wear, so inspect it promptly.

Common sounds and usual causes

Sound	Usual cause
Rattle	Poor fastening, lack of clearance
Squeak	Part chafing, material incompatibility
Creak	Metal-to-metal chafing
Itch	Material incompatibility (seals, leather)
Clunk	Large underbody component contact
Buzz	Two surfaces just barely touching