Section 5

NOISE, VIBRATION, & HARSHNESS

General Description

Noise and vibration are inherent occurrences in the operation of a motor vehicle. A vehicle, which does not make noise or vibration, simply does not exist. NVH, an acronym for *noise,vibration*, and *harshness*, is used here to collectively represent these phenomena that are regarded as unpleasant to the senses.

Vehicles are comprised of numerous components and the way they resonate among themselves are diverse. If these vibrations and sounds are acceptable to the customer, all is well. However, with the advent of smoother roads, better insulation, and technologically advanced vehicles, customers are demanding a more comfortable ride, and even a slight vibration or noise is often a source of concern to them.

It is important to be sure that the symptom in question is truly an abnormal condition. A noise or vibration level which is acceptable in one type of vehicle might not be acceptable in another.

Noise

A running engine or moving vehicle produces a variety of sounds. Whether these sounds are a “noise” or not depends more on how the listener perceives them than how loud they actually are. Generally, however, we can say that a noise is an inappropriate, unpleasant, or excessively loud sound.

Vibration

Here are some of the typical ways in which you feel vibration:

- The steering wheel shakes up and down, causing your hands to tremble
- The seat shakes, vibrating the person in it
- The shift lever or the accelerator pedal chatters annoyingly

A running engine or a moving vehicle generates various vibrations, just as with noise. The driver or the passenger may consider these vibrations unpleasant, depending on where and how they occur.

Harshness

Harshness is a single and momentary sound created by a strong impact to the tire. It feels like someone has hit the tire with a sledgehammer, and its impact is transmitted to the steering wheel and the floor.

Prevention of Vibration and Noise

The three methods for preventing vibration or noise are:

- preventing the vibrating force from occurring
- isolating the vibration
- soundproofing

Although preventing vibration from occurring in the first place is the most effective method, vibration or noise can also be prevented by removing any of the transmitting media. Soundproofing is also a method to prevent the vibration of possible vibratory elements and/or the transmission of the vibrations through the air.

Preventing Vibrating Force from Occurring

If we could simply reduce the strength of a vibration to zero, we would have neither vibration nor sound. In reality, however, we must confront the nature of an automobile, which emits vibratory forces generated by such widely variant things as the combustion and torque fluctuation of the engine, bumpy roads, etc. Sometimes with all of these normally generated vibrations, all we can hope to do is strive to minimize the strength of the vibration rather than to eliminate it at the source.

Isolating Vibrations

Suppose that a vibratory element vibrating at its natural frequency bothers you; there are two ways in which you can reduce its frequency to an acceptable level. One is to change the existing frequency to a different one. Another method is to disperse that frequency. In other words, an annoying vibration or sound in a vehicle will not bother the driver or the passengers if that source is taken out of the normal usage range of the vehicle, or out of the range that humans can feel or hear.

Tires

Tires are also a significant contributor to NVH. Besides the ordinary problems arising from tire wear and imbalance, there are also problems that arise from the use of incorrect after-market tires. It sometimes even happens that merely remounting a tire onto its wheel increases the run-out and unbalance.

Here is how tires affect NVH:

1. No tire is perfectly balanced or perfectly round, and all tires flex to some extent as they rotate over the surface of the road. All of these factors cause the tires themselves to act as vibrating elements.
2. Irregular road surface causes tire deformation and subsequent vibration.

Uniformity

Tire uniformity refers to uniformity of weight, dimensions and rigidity. However, since uniformity of weight is ordinarily called “wheel balance” and uniformity of dimensions (or rather, the lack there of) is called “runout,” uniformity alone usually refers to “uniformity of rigidity.”

Wheel Balance

Due to improvements in engine performance, handling, and braking performance, as well as in body aerodynamics, it is becoming possible for automobiles to operate at higher and higher speeds every year.

At high speeds, an unbalanced wheel assembly (disc wheel plus tire) can create vibrations that are transmitted to the body through suspension components, causing annoyance to the driver and passengers. Therefore, it is necessary to balance the wheel assemblies properly in order to eliminate such vibrations.

Wheel balancing involves balancing the weight of the entire wheel assembly - that is, the disc wheel with the tire attached. Wheel balance can be divided into “static balance” (when the wheel assembly is at “rest”) and “dynamic balance” (when it is rotating).

Run-out

Run-out is defined as the apparent change in a tire’s dimensions during rotation. The circumference of the tire is not a perfect circle. This imperfection is unavoidable because the tire is made by bonding rubber and cord together piece by piece. Furthermore, even a perfectly round tire mounted on an automobile would appear irregular, when viewed along the axle, if the centers of rotation of the tire and axle were not aligned. In other words, the rotational radius of the tire would change with respect to the axle’s center of rotation.

Run-out is measured by holding a dial gauge against the surface of the tire, rotating the tire, and observing the fluctuation of the indicator needle on the gauge. There are two types of run-out:

- in the tire’s radial direction (radial run-out)
- in the axial direction (lateral run-out)

Uniformity

When a tire receives a load, it flexes, acting almost as if it were a spring. The treads, rubber carcass, belt, and other materials that compose the tire are not uniformly distributed around the circumference of the tire, so tire rigidity is not uniform.

As a result, the tire is subject to subtle fluctuations in the way it flexes as it rotates. These fluctuations introduce a periodic variation in the force that it receives from the road surface. This force can be resolved into three components:

1. Radial Force Variation (RFV) - fluctuation in the vertical force acting upward toward the tire’s center (parallel to the tire’s radius).
2. Lateral Force Variation (LFV) - fluctuation in the horizontal force acting parallel to the tire’s axis.
3. Tractive Force Variation (TFV) - fluctuation in the horizontal force acting parallel to the tire’s direction of motion.

Of these, the most important is RFV. On an actual vehicle, a tire with a high RFV imposes a vertical vibration on the axle, which can lead to excessive vibration during high-speed travel.

Two ways to reduce RFV are:

1. To trim minute quantities of rubber from the tire's circumference.
2. To shift the tire so that the point with the maximum RFV lines up with the point on the wheel rim having the minimum radial run-out, called "phase matching."

Spring Constant

The spring characteristics of tires have been a subject of intensive research, since they are decisive factors in determining a comfortable ride. In general, smaller spring constants in tires increase comfort. The following are the factors that affect spring constants:

Characteristics	Effects
Air pressure	This has the largest influence on the spring constant. At 9,806.65 kPa (1 kg/mm^2) air pressure, the longitudinal spring constant is approximately 10 kg. mm. It has minimum effects on the lateral spring constant.
Load	At a constant air pressure, the longitudinal spring constant increases with the load.
Wheel rim width	Both the longitudinal and lateral spring constants increase with the increase in wheel rim width.
Tire shape	Higher-compression tires offer larger longitudinal and lateral spring constants.
Tread shape	The flatter the tread shape, the larger the longitudinal spring constant.
Carcass plies	As the number of carcass plies increases, both the longitudinal and lateral spring constants also increase.

Body Shake

"Shake" is defined as vertical or lateral vibration of the vehicle body and steering wheel, along with vibration of the seats. Shake usually cannot be felt below a speed of about 80km/h (50 mph). Above this speed, shake increases markedly, but then peaks at a certain speed.

NOTE

The frequency of the vibration called “shake” is similar to the frequency of the vibrations made by an impact wrench when it is being used to tighten nuts, etc.

Main Causes

- Unbalanced tires, excessive run-out or unevenness
- Resonance among engine, springs, steering wheel, seats, and body

The Mechanics of Vibration

1. Run-out and imbalance of a tire will cause the tire to generate a vibrating force during vehicle operation.
2. This vibration is amplified and in turn causes the axles to vibrate.
3. The vibration of the axles is transmitted to the vehicle body and the engine through the suspension.
4. When the transmitted vibrations resonate with the vehicle body, the body vibrates strongly. In addition, when the vibrations of the axles resonate with those of the engine, the engine vibrates vigorously, which in turn, causes the body to vibrate even more.
5. These body vibrations are transmitted to the steering wheel and seats, causing the body, seats, and steering wheel to vibrate.

NOTE

Sometimes body shake alternates in longitudinal and lateral directions at approximately 10-second intervals. This is due to slight differences in the turning radii of the tires, which create differences in relative run-out points between the right and left tires, or between the front and rear tires. For this reason, while test driving for body shake, it is important to maintain the same speed for at least 10 seconds at a time, before moving to another speed.

Body shake usually occurs due to defective tires. For this reason, most body shake can be eliminated by correcting tire balance or reducing run-out.

Steering Flutter

Steering flutter is a condition in which the steering wheel oscillates 5 to 15 times per second in the direction of the turn. It occurs at relatively limited but high speeds between 80 and 120 km/h (50 and 75 mph), and the oscillations on the steering wheel are fairly constant.

Main Causes

- Tire run-out, unevenness, or imbalance
- Resonance between the tires and the steering wheel

Mechanics of Noise Development

1. Any run-out or imbalance in a tire will generate a vibrating force while the vehicle is in motion.
2. This vibrating force generates an inertial moment at the kingpin,causing the tires to vibrate laterally. The steering wheel will oscillate laterally as well.
3. At a certain speed, the lateral vibrations of the tires generated by the centrifugal force resonate with the steering system, causing the steering wheel to oscillate clockwise and counterclockwise.

Steering Shimmy

This is a condition in which the steering wheel oscillates clockwise and counterclockwise, just as in steering flutter, but at lower vehicle speeds (e.g., 60 to 80 km/h [38 to 50 mph]). This symptom traces its origin to uneven road surfaces or to braking when tires or brakes are unevenly worn. The oscillation of the steering wheel increases with the vehicle speed.

Main Causes

- Uneven road surface.
- Tire deformation or an abrupt vertical vibration caused by braking when tires or brakes are unevenly worn.
- Resonance among tires, the steering system, and the suspension.
- Play in the steering linkages, a decrease in resistance due to wear,or lack of hardness or rigidity of the steering linkages.

An uneven road surface, and deformations in the tires or vertical oscillations upon braking all can trigger vibrations around the front kingpin, causing the steering wheel to shimmy. The components that transmit these vibrations and their symptoms are identical to those of steering flutter.

NOTE

Although steering flutter and shimmy are identical, they have different origins. Flutter is forced upon the steering wheel by the steering system resonating with tire vibrations, which are caused by imbalance, run-out, or unevenness in the tires. Steering shimmy, on the other hand, is a self-perpetuating oscillation triggered by braking or an uneven road surface.

Accelerator Pedal Vibration

This type of vibration occurs at higher engine speeds, but is unrelated to the vehicle speed. You can feel it with the sole of your foot as it rests on the accelerator pedal, but the pedal does not oscillate greatly in the vertical direction.

Main Causes

- Engine vibration
- Vibration and resonance in the accelerator cable or linkage
- Lack of rigidity in the accelerator cable or linkage

Mechanics of Noise Development

1. Engine vibration causes the accelerator cable or linkage to vibrate.
2. The cable or linkage vibrations are transmitted to the accelerator pedal, causing it to vibrate.

NOTE

In addition to vibration coming directly from the engine, there may also be vibration transmitted from the transmission throttle cable to the accelerator cable or linkage.

Shift Lever Vibration

This type of vibration causes the shift lever to oscillate, usually at relatively low engine rpm. It tends to be more selective about the rpm at which it vibrates.

Main Causes

- Out-of-tune engine
- Imbalance in engine rotating or reciprocating components
- Resonance in the shift lever, or lack or rigidity of the shift lever
- Play between the shift lever and linkage, or worn bushings

Mechanics of Noise Development

1. Engine torque fluctuations or imbalances in rotating or reciprocating components generate torsional vibrations in the drive train. Moreover, an unbalanced propeller shaft or a joint angle may further amplify the vibrations.
2. The transmission extension housing is thus vibrated vigorously,generating a vibratory force, which is transmitted to the shift lever.
3. The shift lever oscillates, since it is mounted on the transmission extension housing. Any play in the shift lever further amplifies the vibration.

Front-Engine, Front-Drive Vehicles

An out-of-tune engine runs rough, causing the shift lever assembly to vibrate.

Body Booming Noise

This type of noise is felt as a pressure in your ears, and its origin is often unknown to you. It increases in volume with the vehicle speed. It occurs within a relatively narrow vehicle speed range centered around 10 km/h or around 50 rpm if associated with engine speed.

NOTE

As you may have experienced, when you climb a high peak or drive through a tunnel at high speeds, rapid changes in the atmospheric pressure applies pressure to your eardrums. This may cause discomfort in your ears. The body booming noise applies similar pressure to your ears. This is caused by large fluctuations of air pressure in the interior of the vehicle.

Main Causes

- Out-of-tune engine
- Inertia due to reciprocating motion of pistons, or imbalance in engine
- Unbalanced propeller shaft joint angle
- Resonance in the exhaust pipe
- Exhaust noise
- Resonance in auxiliary engine components
- Vibration due to torsional stresses on the propeller shaft and drive shafts

Mechanics of Noise Development

1. When a joint angle exists in the propeller shaft, there are two torque fluctuations for every revolution of the propeller shaft. These fluctuations become larger as the joint angle increases.
2. At certain vehicle speeds these torque fluctuations vibrate the drivetrain, and are transmitted through the rear suspension arm bushings or springs, causing the body panels to vibrate. This results in the body booming noise.

Vibration During Braking

The dashboard, steering wheel, and seats vibrate abruptly upon braking. A pulsation is felt on the brake pedal at the same frequency as this vibration. Although the frequency is similar to that of body shake, the amplitude of this vibration is greater. It occurs mostly when you apply the brakes while driving at intermediate to high speeds.

Primary Causes

- Excessive run-out of disc brake rotors
- Different thickness of disc rotors
- Excessive run-out of brake drums
- Run-out of rear axle shaft flange

Mechanics of Noise Development

1. Any run-out on the disc brake rotors or drums causes the disc padsor shoes to vibrate when the brakes are applied.
2. These vibrations are then transmitted through the hydraulic system, causing the brake pedal to pulsate.
3. The disc brake rotors are also caused to vibrate simultaneously,causing the steering knuckles, axle shafts, or hubs to shake both vertically and in the fore-and aft direction.
4. These vibrations of the axle shafts are transmitted through the suspension to the body, causing the body to resonate and thus amplifying the vibrations. These vibrations are similar to body shake.

Brake Squeak

There are two types of squeak: one is a high-pitched shriek, and the other is a low-pitched growl. These noises occur when the brake pedal is depressed very hard, almost to the point of locking up the wheels. In disc brakes a squeak may also occur on light braking.

Main Causes

- Fluctuations in brake pad friction or shoe friction (due to hardening of the friction material).
- Resonance in the brake rotors, drums, or backing plates due to lack of rigidity in those components.

Mechanics of Noise Development

Disc Brakes

1. When the brakes are applied, the friction generated by the disc pads and rotors cause the disc pads to vibrate.
2. The disc rotor resonates with this vibration, creating noise.

NOTE

Some disc brakes use rubber-coated anti-squeal shims, and some use double-layered anti-squeal shims. Another method to reduce the brake squeal is to apply disc brake grease to the back of the pads.

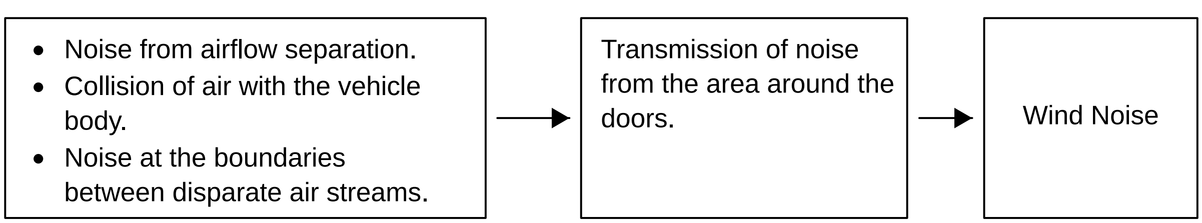
Types of Wind Noise

Wind Noise Generated by the Body Surface

As air flows along the surface of the vehicle, a disturbance is created, and eddies form. The noise thus generated leaks in through gaps around the window glass, etc. and is transmitted through parts with low sound deadening properties, causing noise inside the vehicle. The following are considered to be causes of noise generated at the body surface.

1. Projections or level differences, etc. On the body which cause air molecules to separate from the airflow.
2. Collision of air with the body's surface as it flows.
3. Turbulence at the boundaries between disparate streams of air, etc.

Wind noise is a composite of all these different noises, and its manifestations are extremely complex.



Mechanism of Noise Generation Due to Turbulence in the Air Flow at the Body Surface

Aspiration Noise

This is wind noise, but it differs slightly in the mechanism by which it is generated in that it is an aspiration noise. When driving at high speeds, separation of air from the air stream causes the air pressure inside the vehicle to be lower than the outside air pressure. If there are gaps at the weatherstrips or panel joints, etc., the pressure forces air to flow out of the vehicle. This air makes noise in the process of escaping from the vehicle and as it comes out, it interferes with the flow of air over the vehicles outside surface, which also generates noise. These noises penetrate inside the vehicle and raise the noise level in the interior.

TIP

The source of this type of noise may be identified with a vehicle in a static state in your dealership by pressurizing the passenger compartment of the vehicle.

- Start the vehicle (so the blower runs as fast as it is able)
- Set the fan speed to the FRESH, HIGH (maximum) position
- Set the flow control mode to “PANEL Mode” (directs air flow at the face level)
- Stuff shop towels into the body exhaust vent(s)
- Confirm that all windows and doors are closed tightly
- Listen with a stethoscope along the window (or door) area where the wind noise has been identified as emitting from

Identifying Wind Noise

Wind noise can be heard as airflow hissing in the window or door areas. It occurs usually at high speeds. Changes in the vehicle speed or direction of the wind may alter this noise. Usually the volume of the noise increases with the vehicle speed, and occasionally becomes inaudible dependent upon the wind direction.

Main Causes

- Air disturbances created by irregularities in the vehicle body
- Air leaking through gaps between body panels

Mechanics of Noise Development

Noises Created by Air Disturbances Due to Body Irregularities

When air flows over protrusions or recesses on the vehicle surface, air disturbances are created behind them. The noises created by these disturbances then enter the passenger compartment through the doors or windows.

Aspiration

At high speed, the air pressure in the interior of the vehicle becomes lower than that of the atmosphere. When this low-pressure air leaks out through gaps in the weather-strip or body panels, and comes into contact with the exterior air flow, noise is generated.

Important Points in Diagnosis

A certain amount of wind noise cannot be avoided simply because of the mechanism that generates it during driving. Besides the driving conditions and the speed of travel, external factors (such as wind direction, wind speed, place where the vehicle is driven, etc.) can have a great influence on wind noise. For this reason, it is important to determine of the wind noise identified by the customer has been correctly interpreted and to confirm that a real problem exists by conducting a thorough check.

It is also important to determine if the wind noise identified by the customer is due to accessories mounted on the outside of the vehicle (such as a roof rack, side visor, etc.) or if the noise occurs under special conditions. For example, opening of the sunroof, or raising the antenna, etc., all cause added wind noise, so it is important to have the customer describe the conditions under which the noise occurs.

Diagnostic Procedure for Wind Noise Concerns

Describe the Specific Occurrence Conditions

1. Determine the specific occurrence conditions either by having the customer describe them or by test driving the vehicle. In particular, when trying to specify the type of noise, it is important to clarify what the customer's complaint is by taking a drive together with him or her.
2. When a noise has been confirmed, it is important to clarify the occurrence conditions and driving conditions (as, for example, the wind direction, wind speed, vehicle speed, place the vehicle is being driven, the weather conditions, the temperature, and whether the wipers or sunroof are operating at the time, etc.).
3. Confirm whether accessories are installed or not, and if so, check whether or not they are the cause of the wind noise. If necessary, the noise should be checked with the accessories removed.

Locate the Cause of the Problem

Tape Suspected Noise Area

1. Attach adhesive tape along all areas that are likely to cause wind noise.
   - Panel joints
   - Protrusions
   - Molding joints
   - Door mirrors

Drive the vehicle and check that wind noise is no longer audible. If it is audible, attach tape along other areas and test again.

Locate the Cause of the Problem

1. Remove tape from one area at a time. (Repeat until wind noise is audible.)
2. Tear a strip of tape into several pieces and attach them along the suspected area to pinpoint the exact location.
3. Repeat removing and attaching smaller pieces of tape, one at a time, until you find a place where wind noise is audible without tape and disappears when the tape is reapplied.
4. Once you identify the place where the sound originates, seal that place using following components:
    - Butyl tape
    - Body sealer

Visual Check of the Parts Causing the Noise

1. Check weather-strips for faulty installation, deterioration, break-age, etc. to determine if they seal poorly.
2. Check the installation condition of the moldings and protectors, whether any of them are coming off, are loose or are pushed in, etc.
3. Check the door glass and glass runs as well as the seal of the weather-strip around the windows.
4. Check the installation condition of the outside mirrors and inner garnish for looseness, rattling, improper sealing, etc.
5. Check the fit of each body panel.
   Check that adjoining panels are flush with each other with a proper gap in between.

Squeaks, Rattles, & Interior Noise

What are "Squeaks & Rattles?"

The noise heard inside the vehicle caused by interference or vibration of parts while it is running or stopped or when a component is operated (example: opening or closing a door) is called "Squeaks & Rattles." "Squeaks & Rattles" are classified differently than those sounds transmitted from the engine or generated from the wiper motor. The causes are classified into design and manufacturing factors. The types of noise tones are classified into 3 types: squeaks, rattles and vibration noise.

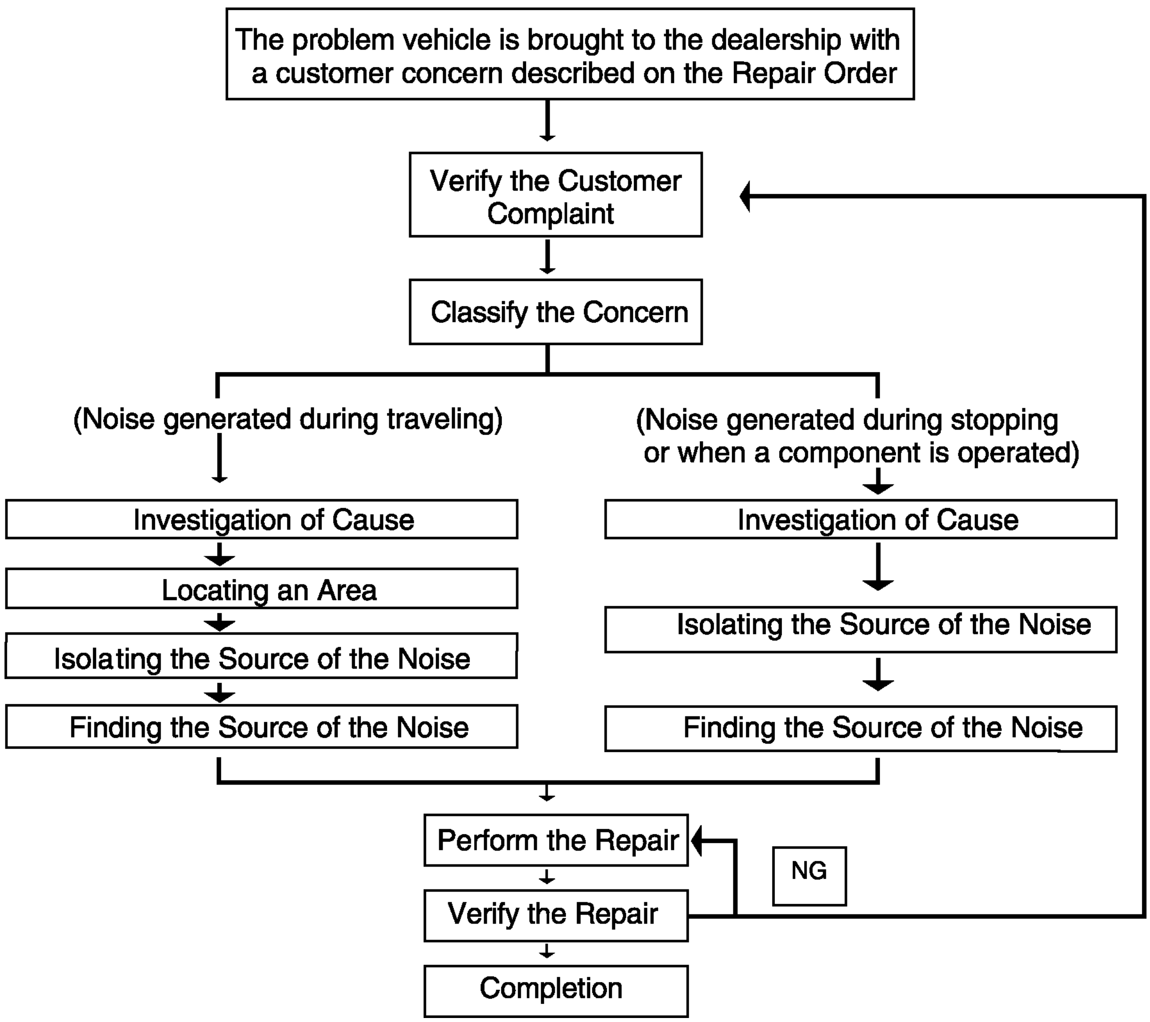
Noise Sources and Types

GENERAL NAME		TONE	CAUSE	TYPICAL EXAMPLE	
				AREA	COMPONENT
Interior	Rattles	• Rattles • Knocking • Clatter • Flapping • Pat • Popping Clicking	Noise generated by parts hitting each other	• Instrument panel • Door • Seat	• Instrument panel x Wiring harness • Window regulator x Door panel • Play of seat track
Interior	Squeaks	• Squeaks • Creak • Rubbing	Noise generated by parts rubbing each other	• Instrument panel • Instrument panel • Door	• Instrument Panel x • Meter cluster • CD player x Bracket Door trim x Door panel
Interior	Vibration Noise	• Vibration • Buzz	Noise generated by vibration	• Instrument panel • Instrument panel	• Instrument panel x Steering column upper cover • Glove compartment x Blower resistor wire
Exterior	Rattles	• Rattles • Knocking • Clatter	Noise generated by parts hitting each other	• Luggage compartment • Chassis • Chassis	• Play of luggage compartment door hinge • Rear coil spring x Spring seat • Muffler support x Muffler bracket
Exterior	Squeaks	• Squeaks • Bushings • Creak • Rubbing	Noise generated by parts rubbing each other	• Chassis • Bumper • Fuel tank	• Rear stabilizer bushing x Stabilizer bar • Bumper extension x Body • Fuel tank band x Tank
Exterior	Vibration Noise	• Vibration	Noise generated by vibration	• Chassis • Transmission • Body	• Heat insulator x O2 sensor • Play of transmission gear shift rod • Quarter panel x Jack carrier

There are three main reasons why repair of "Squeaks & Rattles" is difficult.

- First is confirming the customer's complaint is difficult.
- Second is the difficulty in locating the source of the noise.
- Third is to affect the repair to the satisfaction of the customer.

Although sufficient consideration on "Squeaks & Rattles" is made when a vehicle is designed, there are cases when customers subjectively complain even if the sounds are not caused by malfunctions. The most important point in trouble shooting is to identify if the problem is clearly a malfunction or if it is a normal sound but an annoyance to the customer. The customer's complaint must be verified and analyzed. Be certain to understand the operating conditions when the concern is experienced.



Diagnosis The first step of troubleshooting is to correctly understand the customer's complaint. For this reason, asking questions regarding the content of the complaint is extremely important. Lexus has developed a customer interview sheet to help.

The following 7 points should be determined.

ITEM		EXAMPLE
1.	Type of noise	Squeaks, Rattles, Vibration, etc.
2.	Direction of the noise	Instrument panel, left front door, luggage compartment, etc.
3.	Vehicle condition	During stopping, starting, braking, constant speed traveling, etc.
4.	Road condition	Paved road, cobblestone road, wavy road, slope, etc.
5.	Accessory operating condition	Position of heater control lever, when the power window or wiper is operated, etc.
6.	Time and weather (*1)	Time: Early morning, mid-day or at night Weather: Fine, cloudy or rainy days Temperature: Hot or cold (high or low humidity)
7.	When the problem first noticed	From the new car, after installing accessories, etc.

Plastic parts such as the instrument panel are subject to deformation due to temperature and humidity, these factors affect the noise. For example, squeak sounds of plastic parts often disappear when the temperature and humidity are high.

Checking Symptom

The purpose of the symptom check is to confirm the content of customer's complaint by road testing the vehicle or by operating the suspected functional component and using the check sheet.

Whenever possible, ask the customer to join the drive test to confirm the problem jointly. If a road similar to the road condition of the customer's complaint is not available near your dealership or the customer cannot identify a road condition that causes the noise, most of noises can be reproduced by carrying out a road test as described below.

OPERATING CONDITION		REPRODUCING SOUND
1.	Start and stop of engine	Rattles
2.	Engine racing	Vibration noise
3.	Starting and stopping the vehicle	Squeaks
4.	Turn	Rattles
5.	Driving over a bump	Squeaks
6.	Paved, smooth road	Squeaks, Rattles and Vibration noise
7.	Cobblestones and wavy road	Squeaks, Rattles and Vibration noise

Investigation of Cause

When the content of complaint has been confirmed, reproduce the noise in a static condition.

First, locate an area where the noise is most prominent and then isolate the source of the noise.

METHOD	PROCEDURE	APPLICABLE SOUND		
		SQUEAKS	RATTLES	VIBRATION NOISE
1. Visual check	Visually check for possible noise source	—	○	—
2. Functional component operating method	To reproduce the noise by operating a functional component	○	○	○
3. Tapping method	Tap a suspicious area (instrument panel, door body, etc.) to reproduce the noise	○	○	○
4. Swinging method	Swing a suspicious area (bumper, door, body, etc.) to reproduce the noise	○	○	○
5. Cover opening / Closing method	Open and close a door or cover to reproduce the noise	○	○	○

(2) Isolating the source of the n

METHOD	PROCEDURE	APPLICABLE SOUND		
		SQUEAKS	RATTLES	VIBRATION NOISE
1. Visual check	Visually check for possible noise source	—	○	○
2. Tactile method	Touch parts of the noise source area to find a part that eliminates the noise	—	○	○
3. Insertion method	Insert a thickness gauge or other thin item between parts to find a position that eliminates the noise	○	—	—
4. Push/pull method	Push and/or pull parts near the source of the noise to find a part that eliminates the noise	○	○	○
5. Lubrication method	Apply lubrication spray to stop the noise	○	—	—

Accurate information can be derived by asking the right question

1. What kind of noise is audible?	Example: Rattle, Squeak, Buzz, Click, Creak, Squeal, Rolling (as in a loose part in a cavity), Abnormal operating noise.
2. What are the road and driving conditions when the noise is audible?	Example: Severe bump only, railroad track crossing, moderately bumpy roads, at highway speeds, etc.
3. When is the noise audible?	Example: During starting, when stopping, with engine idling, etc.
4. Where is the sound coming from?	Example: Instrument panel, left front door, center console, rear package tray, etc.
5. Is noise affected by the operation of any vehicle system?	Example: Position of heater control lever, door window partially down, windshield wipers on, when closing door, etc.
6. Does the time of day or the weather conditions affect noise? (Some interior noises are affected by humidity).	Time: Early morning, mid-day, at night. Weather: Hot days, cold days, high temperature or humidity.
7. When was the problem first noticed?	Example: Since car was new, after radio was installed, since picking up from body shop, etc.

Interior Noise

Diagnostic Procedure

An organized and systematic procedure is important in all types of diagnosis. It is the most efficient/cost effective way to resolve concerns the first time.

A good systematic diagnostic procedure is critical because the symptoms may not clearly pinpoint the source of the noise. It will successfully resolve difficult interior noise concerns just as it does with electrical concerns.

Elements incorporated in a systematic diagnostic procedure are:

- An organized process of elimination which prioritizes activities to quickly isolate the concern.
- A thorough visual inspection for obvious conditions and clues to help diagnose the concern.

Step #1: Verify the Customer Concern

Verification of the customer concern is a key starting point in an interior noise diagnostic procedure for two reasons:

- If the customer concern cannot be verified, a plan can be implemented that involves satisfying the customer through consultation or returning the vehicle for service when the concern can be duplicated.
- It is important that the technician experiences exactly what the customer is concerned about and knows what is involved to satisfy them.

The verification process should include a thorough customer interview and test drive.

Customer Interview Sheet

As a tool in this verification process, Lexus has developed a customer interview sheet to help the technician solve one of the largest problems identified in NVH concerns; poor communication between the customer and the technician.

Good communication skills include:

- Description or terminology that means the same thing to all parties involved.
- Time to help the customer clarify the concern. (The customer is not expected to know the technical terms of the automotive industry).
- Information collected in an organized manner.

The interview process is designed to help the customer focus on details of the concern and vehicle conditions when the concern occurs. The customer should be made aware of the key role they play in resolving the concern.

The customer interview sheet is designed to be as short and concise as possible. The information is collected and divided into the following areas:

- Customer Data
- Vehicle Data
- NVH Data

NVH Data

NVH data is organized to provide the details of the concern and data on conditions present when the concern occurs.

Begin the interview by asking the customer to classify the concern by selecting one or more of the following:

- Noise
- Vibration
- Harshness

If the customer's classification of the concern includes Vibration or Harshness, refer to the NVH diagnosis materials for additional assistance.

Standard terminology used to describe noises include squeak, rattle or wind noise. Specific types of noise within these areas can include descriptive terminology such as buzz, click, creak, snap, clunk, squeal, rolling (as in a loose part in a cavity), and abnormal operating noise.

The Operating Condition section of the interview sheet is designed to collect data for the following subjects:

- Operating conditions
- Vehicle conditions
- Road conditions
- Weather conditions

Each of these areas have specific conditions to select which will provide the technician with the details necessary to duplicate the concern.

The interviewer should cover all areas that apply to the concern. N/A should be entered in areas that do not apply, indicating to the technician that the customer considered the subject and did not overlook it.

Step #2: Classify the Concern

Once the concern has been classified as a squeak, a specific diagnostic approach can be applied which will identify the source of the noise.

Interior squeaks and rattles are usually not as difficult to repair as they are to find. The difficulty in finding the source of a noise is caused by the many possible transmission paths of the noise. As a result, people sitting in different locations in the vehicle may have different opinions on the location of the noise.

Using a combination of road and static test procedures, the technician must reproduce the noise and narrow down the areas which may be causing it in order to pinpoint its location.

Step #3: Road Test

It is important for the technician to road test the vehicle during the diagnostic process. Diagnostic road testing is done after the concern has been verified and allows the technician to focus on specific test parameters that will help in reproducing and isolating the noise. Customers are helpful in verifying the concern but do not need to be part of the complete diagnostic process.

The road test is designed to get the most information in the shortest amount of time. During the road test the technician duplicates driving conditions identified on the customer interview sheet to reproduce the concern. This will allow the technician to listen to the noise and locate the general areas it is coming from.

For example:

Using the information on the customer interview sheet illustration, the technician would focus his road test on driving over a rough road surface between 20 and 40 mph.

Here are some specific road test examples that are helpful in isolating interior noise concerns.

Acceleration and Braking

Accelerate quickly to 5-7 mph and stop quickly. Repeat several times. Certain interior squeak noises as well as suspension groans and clunks may be heard using this technique.

Turning

Make a number of right and left turns at 2-15 mph. Loose objects, such as an extra screw in a door cavity, can be heard this way.

Cruising on Rough Road Surfaces

The majority of interior noises occur when driving on a rough road surface. Choose a road with small pot holes or surface irregularities to reproduce the customer's concern.

Step #4: Pinpoint Diagnosis

When the approximate location of the noise has been established, the noise must be reproduced in the stationary vehicle to help in pinpointing the diagnosis. With no background road noise the conditions are ideal for locating the exact source. Many noises can be reproduced in a stationary vehicle by using the following Static Testing methods.

Static Testing Procedures

Using a hand, the technician carefully taps in the area of the noise source found during the road test.

Impact Method

Start by tapping very gently and increase the force of the tap as needed to reproduce the noise.

This tapping technique requires some practice because tapping too hard will cause noises that would never be reproduced in the vehicle while driving. Tap just hard enough to reproduce the sound taking extreme care not to damage the surface being worked on.

Change the direction of the taps from top to bottom, right to left, front to rear, etc.

On the doors, tap the arm rest several times. Tap the entire door trim panel varying the force of your taps. Rattles from door lock knobs, linkages, window tracks and wire harnesses and connectors may be found in this manner.

Jouncing Method

Squeaking noises can be reproduced using the jouncing method. Squeaks are produced when adjacent pieces touch each other and there is relative movement between the pieces.

The jouncing method simulates a car in motion and by varying the force and direction of the jouncing action, squeaks can be reproduced. Squeaks from A-pillars, cowl, rocker panel areas, C-pillars and rear quarter panel areas can be found using this method.

NOTE

In some situations, it may not be possible to recreate the concern in a static situation. Some interior noises are caused by resonance with another vibrating force, such as a rotating tire, driveshaft or engine. In these conditions the concern can only be duplicated at the specific frequency that the two components resonate called the resonance point. This frequency will only be generated during vehicle operation.

Once the noise is reproduced in the shop, the next step is to pinpoint the diagnosis by locating the exact source.

A sound will stop when the item making it is touched. It will also change when something attached to it is touched. With this in mind, the following methods of isolating and pinpointing an interior noise can be used in conjunction with the noise reproduction techniques discussed in the previous section. Use these techniques while tapping the component to reproduce the noise.

Finger Touch Method

As you tap with one hand, use your other fingers to apply force against the instrument panel, interior garnish, door panels, etc., and continue moving over the area until the sound stops. If necessary, use a screwdriver to reach areas that cannot be reached by hand. If the noise changes, but does not go away when an area is touched, the noise source is physically connected to that area.

Insertion Method

In gaps which are too small for fingers or a screwdriver, insert a feeler gauge or other thin item. The noise source can often be touched and therefore located using this method. Insert the feeler gauge into the gap between parts at several locations until the noise stops.

Pull Method

Hook your fingers onto a part and gently pull on it. Do the same at different sections until you come to a point where the noise stops. When the noise stops or changes, the part making the noise is connected to the part being pulled.

Step #5: Perform the Repair

Once the concern has been pinpointed, the repair is often obvious. It is important though that the repair:

- Does not detract from the appearance of the area being repaired.
- Can be done quickly.
- Does not hamper the operation of any accessory systems.
- Is long lasting.

An interior noise repair kit is available through the Lexus parts system. Its contents, and other suggested repair materials, are listed below:

Felt Felt with an adhesive backing is supplied in two thicknesses, 0.030 inches and 0.060 inches. Felt is used to provide a buffer between two adjacent pieces of plastic to prevent squeaking or as a cushion between two pieces of metal to prevent them from rattling. Generally, use the thinnest material that will do the job. This will help prevent too tight a fit between the parts.

Urethane Foam Two thicknesses of urethane foam tape are supplied, 0.125 inches and 0.250 inches. Foam tape is primarily used to wrap objects such as wire harnesses or connectors to provide insulation and prevent a rattle with adjacent body parts.

Additional Suggested Items

The following items are not supplied in the kit, but are readily available.

Vinyl Tape "Electrician's Tape" is useful for wrapping items to prevent rattles. It may be layered to reduce clearances and it provides a cushion between two metal pieces.

Paraffin Paraffin wax is used as a lubricant between plastic parts. In areas where a piece of felt would be unsightly, such as between a safety pad and a door trim panel, lubricating the pieces with paraffin will stop squeaks.

Talcum Powder Talcum powder can be used as a lubricant between plastic and leather parts to eliminate a scrunching noise.

Step #6: Verify the Concern has been Repaired

This is the critical last step in the diagnostic procedure which will guarantee customer satisfaction. After repairing the vehicle, road test it again simulating the same test parameters used during classification, and try to reproduce the noise. If you cannot objectively verify that the concern has been resolved, then the opportunity exists to go back through the process to find the concern without the customer's involvement.

When the concern is successfully resolved and verified, the vehicle is ready to be returned to the customer.

Notes