







## Noise, Vibration and Harshness (NVH)

### Special Tool(s)

 <p>ST2311-A</p>	<p>Electronic Vibration Analyzer (EVA)                  100-F027 (014-00344) or equivalent</p>
 <p>ST2312-A</p>	<p>EngineEAR                  107-R2100 or equivalent</p>
 <p>ST2048-A</p>	<p>EngineEAR/ChassisEAR                  107-R2102 or equivalent</p>
 <p>ST3025-A</p>	<p>Mastertech® Series MTS 4000                  Driveline Balance and NVH Analyzer                  (Vetronix)                  257-00018 or equivalent</p>
 <p>ST3108-A</p>	<p>Squeak and Rattle Repair Kit                  164-R4900</p>
 <p>ST2314-A</p>	<p>Ultrasonic Leak Detector                  134-R0135 or equivalent</p>

### Diagnostic Theory

The shortest route to an accurate diagnosis results from:

- system knowledge, including comparison with a known good system.
- system history, including repair history and usage patterns.

- condition history, especially any relationship to repairs or sudden change.
- knowledge of possible sources.
- using a systematic diagnostic method that divides the system into related areas.

The diagnosis and correction of NVH symptoms requires:

- a road or system test to determine the exact nature of the symptom.
- an analysis of the possible causes.
- testing to verify the cause.
- repairing any symptoms found.
- a road test or system test to make sure the cause has been corrected or brought back to within an acceptable range.

### Diagnostic Procedure Overview

Qualifying the symptom by the particular sensation present can help narrow down the cause. Always use the "symptom" to "system" to "component" to "cause" diagnosis technique. This diagnostic method divides the problem into related areas to correct the customer concern.

- Verify the "symptom".
- Determine which "system(s)" can cause the "symptom" using the diagnostic tools described in this section.
- After determining the possible "system(s)", refer to the appropriate section in this manual to identify the worn or damaged "components".
- After identifying the "components", identify the "cause" of the failure.

### Tools and Techniques

The diagnostic tools allow for a systematic collection of information that is necessary to accurately diagnose and repair NVH problems. Remember that the vibrating source component (originator) may only generate a small vibration. This small vibration can in turn cause a larger vibration/noise to emanate from another receiving component (reactor), due to contact with other components (transfer path). For the best results, carry out the test as follows:

- Test drive the vehicle with the vibration sensor inside the vehicle.
- Place the sensor in the vehicle according to feel.
  - If the condition is felt through the steering wheel, the source is most likely in the front of the vehicle.
  - A vibration that is felt in the seat or floor only will most likely be found in the driveline, drive axle or rear wheels and tires.
- Record the readings. Also note when the condition begins, when it reaches maximum intensity and if it tends to diminish above/below a certain speed.
  - If a vibration symptom is vehicle speed related, the tire and wheel rpm/frequency and driveshaft frequency should be calculated.
  - If a vibration symptom is engine speed related, the engine, engine accessory and engine firing frequencies should be calculated.
  - Frequencies with an amplitude reading of 0.06 Gs or less are barely perceptible NVH levels. No corrective action is necessary.
- Place the vibration sensor on or near the suspect area outside the vehicle.
- Continue the road test, driving the vehicle at the speed the symptom occurs and take another reading.
- Compare the readings.
  - A match in frequency indicates the problem component or area.
  - An unmatched test could indicate the symptom is caused by the engine, torque converter or engine accessory. Use the diagnostic tools in the rpm mode and check if symptom is rpm related.

The following diagnostic tools and techniques can be used separately or in conjunction with each other to aid in the diagnosis of NVH symptoms. They are listed in order of preference for ease in their use for locating these symptoms.

### **NVH Analyzer (Vetronix)**

The Mastertech® Series MTS 4000 Driveline Balance and NVH Analyzer (Vetronix) and the MTS 4100 NVH analyzers are tools to aid in the identification and isolation of a noise, vibration or harshness symptom in a vehicle. They measure noise and vibration data and compare it with data obtained from the vehicle's PCM as well as vehicle variants that were entered by the user such as pulley size, axle ratio and tire size in order to provide possible sources. The Mastertech® Series MTS 4000 Driveline Balance and NVH Analyzer (Vetronix) and the MTS 4100 have the following characteristics:

- Interface with the vehicle's computer system
- Support and store vibration data input from 1 or 2 accelerometers
- Support and store noise data input from 2 microphones
- Provide a photo-tachometer for operation of the driveshaft balancing function
- Provide a strobe output capable of driving a standard timing light
- Contain a real-time clock circuit that provides time and date information which is used for tagging test data
- Have the capability to print to an external printer and interface with a PC
- Can be powered from a variety of power sources: cigarette lighter, AC power or the internal battery pack

The Mastertech® Series MTS 4000 Driveline Balance and NVH Analyzer (Vetronix) and the MTS 4100 NVH analyzers have 4 main operating modes. The first is for vibration diagnosis. This mode measures data from 1 or 2 accelerometers simultaneously while obtaining data from the vehicle. Then it carries out a frequency analysis on the accelerometer information and compares the vibration frequencies with the frequencies associated with various rotating components within the vehicle. The data can be presented in 4 different display modes: principle component, bar chart, frequency spectrum or waterfall. All display mode formats contain the same common elements, such as amplitude.

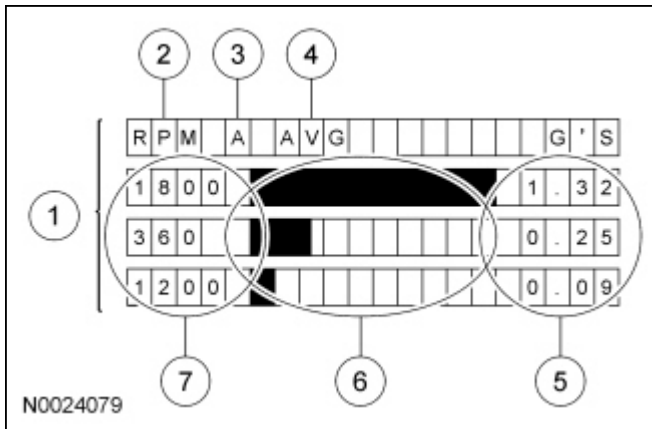
The second is for noise diagnosis. This mode measures noise from 1 or 2 microphones simultaneously. All noise measurements are in decibels (dBs). All frequency bands used for noise measurements are the same as for the vibration measurements, up to 1,000 Hz.

The third is driveshaft balancing. Driveshaft balancing is done using 1 or 2 accelerometers and a photo-tachometer. The accelerometers measure the vibration at both ends of the driveshaft, while the photo-tachometer measures the rotation speed and position reference. Refer to [Section 205-00](#).

The fourth is the strobe. A strobe or standard timing light can be connected to an analyzer, to provide a means for measuring rotation speed. The strobe function is used for isolating the source of a vibration.

### **Electronic Vibration Analyzer (EVA)**

The Electronic Vibration Analyzer (EVA) is a hand-held electronic scan tool which will assist in locating the source of unacceptable vibrations. The vibration sensor can be remotely mounted anywhere in the vehicle for testing purposes. The unit displays the 3 most common vibration frequencies and their corresponding amplitudes simultaneously. A bar graph provides a visual reference of the relative signal strength (amplitude) of each vibration being displayed and its relative G-force. The keypad is arranged to make the EVA simple to program and use. Some of the functions include the ability to average readings as well as record, play back and freeze readings. The EVA has a strobe balancing function that can be used to detect imbalance on rotating components such as a driveshaft or engine accessories.



Item	Description
1	Electronic Vibration Analyzer (EVA) screen
2	Frequency mode displayed in rpm or Hz
3	Active sensor input (A or B)
4	Current active mode
5	G-force indicators or the strongest frequencies in descending strength of each vibration
6	Strength of each vibration
7	Frequency in rpm/Hz of each vibration

Record the readings taken with the diagnostic tool.

- Frequencies should be read in the "average" mode.
- Frequencies have a range of plus or minus 2 Hz. A reading of 10 Hz can be displayed as an 8 Hz through 12 Hz.

### Vibrate Software®

Vibrate Software® (Rotunda tool number 215-00003) is a diagnostic aid which will assist in pinpointing the source of unacceptable vibrations. The engine's crankshaft is the point of reference for vibration diagnosis. Every rotating component will have an angular velocity that is faster, slower or the same as the engine's crankshaft. Vibrate Software® calculates the angular velocity of each component and graphically represents these velocities on a computer screen and on a printed vibration worksheet. The following steps outline how Vibrate Software® helps diagnose a vibration symptom:

- Enter the vehicle information. Vibrate will do all the calculations and display a graph showing tire, driveshaft and engine vibrations.
- Print a Vibration Worksheet graph. The printed graph is to be used during the road test.
- Road test the vehicle at the speed where the vibration is most noticeable. Record the vibration frequency rpm and the engine rpm on the worksheet graph. The point on the graph where the vibration frequency rpm reading and the engine rpm reading intersect indicates the specific component group causing the symptom.
  - A frequency measurement tool capable of measuring vibration frequency and engine rpm will be needed.
- Provides graphics of diagnostic procedures to aid in testing components.

### Reed Tachometer

The Reed tachometer is a hand-held vibration sensor which will assist in locating the source of unacceptable vibrations. The vibration sensor can be placed anywhere in the vehicle for testing purposes. The Reed tachometer contains several reeds that are tuned to vibrate or resonate at different frequencies ranging from 10 to 80 Hz or 600 to 4,800 rpm. Though the Reed tachometer is able to measure multiple frequencies, it does not measure amplitude.

## **Sirometer**

The Sirometer measures frequency in hertz and rpm. To use the Sirometer, place it on any vibrating component and slowly scroll the wire out by turning the knob. As the length of wire changes, so does its natural frequency. Find the length of wire that vibrates with the highest amplitude. This frequency will match that of the vibrating component. Read the frequency for that length of wire.

## **Combination EngineEAR/ChassisEAR**

An electronic listening device used to quickly identify noise and the location under the chassis while the vehicle is being road tested. The ChassisEARs can identify the noise and location of damaged/worn wheel bearings, CV joints, brakes, springs, axle bearings or driveshaft carrier bearings.

## **EngineEAR Basic Unit**

An electronic listening device used to detect even the faintest noises. The EngineEARs can detect the noise of damaged/worn bearings in generators, coolant pumps, A/C compressors and power steering pumps. They are also used to identify noisy lifters, exhaust manifold leaks, chipped gear teeth and for detecting wind noise. The EngineEAR has a sensing tip, amplifier and headphones. The directional sensing tip is used to listen to the various components. Point the sensing tip at the suspect component and adjust the volume with the amplifier. Placing the tip in direct contact with a component will reveal structure-borne noise and vibrations, generated by or passing through, the component. Various volume levels can reveal different sounds.

## **Mechanic's Stethoscope**

A mechanic's stethoscope is an inexpensive tool for locating noises in engines and other moving parts. It can be used to help diagnose piston slap, worn gears, faulty valves, coolant pump failure, damaged gaskets, defective bearings and body squeaks.

## **Squeak and Rattle Repair Kit**

The Squeak and Rattle Repair Kit (Rotunda tool number 164-R4900) contains lubricants and self-adhesive materials that can be used to eliminate interior and exterior squeaks and rattles. The kit consists of the following materials:

- PVC (soft foam) tape
- Urethane (hard foam) tape
- Flocked (black fuzzy) tape
- UHMW (frosted) tape
- Squeak and rattle oil tube
- Squeak and rattle grease tube

## **Ultrasonic Leak Detector**

The Ultrasonic Leak Detector is used to detect wind noises caused by leaks and gaps in areas where there is weatherstripping or other sealing material. It is also used to identify A/C leaks, vacuum leaks and evaporative emission noises. The Ultrasonic Leak Detector includes a multi-directional transmitter (operating in the ultrasonic range) and a hand-held detector. The transmitter is placed inside the vehicle. On the outside of the vehicle, the hand-held detector is used to sweep the area of the suspected leak. As the source of the leak is approached, a beeping sound is produced which increases in both speed and frequency.

## **Write-Up Job Aid**

To assist the service advisor and the technician, a Write-Up Job Aid used during the interview process is included with this material. The Write-Up Job Aid serves as a place to record all important symptom information.



# “WRITE-UP” JOB AID

REPAIR ORDER # \_\_\_\_\_  
 CUSTOMER CONCERN # \_\_\_\_\_

### SPECIFIC SENSE IDENTIFICATION AND LOCATION ON VEHICLE OF CUSTOMER SYMPTOM(S)

INSTRUCTIONS: Check below sense affected and location of concern on the generic vehicle illustration (darken the vehicle area). Plus circle appropriate responses to the right.

NOTE: Shaded backgrounds indicate caution areas. Selection of two or more caution areas “flag” difficult repairs. In general, shaded areas are the more difficult to verify and repair, and require all applicable columns to be completed.



SEE YES



FEEL YES



HEAR YES



SMELL YES



VEHICLE SYMPTOM AREA	HOW OFTEN?	VEHICLE OPERATING MODE	VEHICLE CONDITIONS	VEHICLE SPEED(mph)	WHEN VEHICLE IS?	AMBIENT CONDITION
Front of Vehicle	Always	Start Up	Accessories On (define below)	0	Turning Left	Below Zero
Engine Compartment	Daily (A.M.   P.M.)	Idle		1-9	Turning Right	Below Freezing (0 -19 )
Dash	Conditional	Gear Selection	Windows Open	10-19	Over Bumps	Below Freezing (20 -32 )
Steering Wheel	Weekly	Accel Light	4x4	20-29	Up Hills	33 -49
Accelerator Pedal	Monthly	Accel Moderate	Hauling	30-39	Down Hills	50 -69
Brake Pedal	Intermittent	Accel Heavy	Towing	40-49	Shifting	70 -89
Clutch Pedal	Unknown	Steady Speed	Snow Plowing	50-59	Parked	90 +
Seat		Deceleration	Other (define below)	60-69	In Traffic	Sunny
Rear of Vehicle		Neutral		70+		Dry
Top of Vehicle		Reverse		ENGINE		Windy
Floor Pan		Stopping/Braking		TEMP		Wet/Humid
Under Vehicle				Cold		Rain
Other (define below)				Normal		Snow
				Hot		Ice

DEALER VERIFICATION	WHAT THE CUSTOMER SAID
SERVICE ADVISOR <input type="checkbox"/> YES <input type="checkbox"/> NO	_____
SHOP FOREMAN <input type="checkbox"/> YES <input type="checkbox"/> NO	_____
SERVICE MANAGER <input type="checkbox"/> YES <input type="checkbox"/> NO	_____
QC MANAGER <input type="checkbox"/> YES <input type="checkbox"/> NO	_____
TECHNICIAN <input type="checkbox"/> YES <input type="checkbox"/> NO	_____
VERIFIED WITH CUSTOMER <input type="checkbox"/> YES <input type="checkbox"/> NO	_____

OASIS SYMPTOM CODE(S)	VIN NUMBER
<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>

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## 1: Customer Interview

The diagnostic process starts with the customer interview. The service advisor must obtain as much information as possible about the symptom and take a test drive with the customer. There are many ways a customer will describe NVH symptoms and this will help minimize confusion arising from descriptive language differences. It is important that the symptom is correctly interpreted and the customer descriptions are recorded. During the interview, complete the write-up job aid and ask the following questions:

- When was it first noticed?
- Did it appear suddenly or gradually?
- Did any abnormal occurrence coincide with or precede its appearance?

Use the information gained from the customer to accurately begin the diagnostic process.

## 2: Pre-Drive Check

It is important to do a pre-drive check before road testing the vehicle. A pre-drive check verifies that the vehicle is relatively safe to drive and eliminates any obvious faults on the vehicle.

The pre-drive check consists of a brief visual inspection. During this brief inspection, take note of anything that will compromise safety during the road test and make those repairs/adjustments before taking the vehicle on the road.

## 3: Preparing for the Road Test

Observe the following when preparing for the road test:

- Review the information recorded on the write-up job aid. It is important to know the specific symptom the customer has with the vehicle.
- Do not be misled by the reported location of the noise/vibration. The cause can actually be some distance away.
- Conduct the road test on a quiet street where it is safe to duplicate the vibration/noise. The ideal testing route is an open, low-traffic area where it is possible to operate the vehicle at the speed in which the condition occurs.
- While observing that they are not related to the symptom, eliminate the following:
  - If possible, lower the radio antenna in order to minimize turbulence.
  - Identify anything that could potentially make noise or be a source of wind noise.
  - Inspect the vehicle for add-on items that create vibration/noise.
  - Turn off the radio and the heating and cooling system blower.
- The engine speed is an important factor in arriving at a final conclusion. Therefore, connect a diagnostic tool, Vetronix, or an accurate tachometer to the engine, even if the vehicle has a tachometer. This will make sure of an exact engine speed reading.

## 4: Verify the Customer Concern

Verify the customer concern by carrying out a road test, an engine run-up test or both.

The decision to carry out a road test, an engine run-up test or both depends on the type of NVH symptom. A road test may be necessary if the symptom relates to the suspension system or is sensitive to torque. A Drive Engine Run-Up (DERU) or a Neutral Engine Run-Up (NERU) test identifies noises and vibrations relating to engine and drivetrain rpm. Remember, a condition will not always be identifiable by carrying out these tests, however, they will eliminate many possibilities if carried out correctly.

## 5: Road Test

**NOTE:** It may be necessary to have the customer ride along or drive the vehicle to point out the symptom. During the road test, take into consideration the customer's driving habits and the driving conditions. The customer's concern just may be an acceptable operating condition for that vehicle.

The following is a brief overview of each test in the order in which it appears. A review of this information helps to quickly identify the most appropriate process necessary to make a successful diagnosis. After reviewing this information, select and carry out the appropriate test(s), proceeding to the next step of this process.

- The Slow Acceleration Test is normally the first test to carry out when identifying an NVH symptom, especially when a road test with the customer is not possible.
- The Heavy Acceleration Test helps to determine if the symptom is torque-related.

- The Neutral Coast Down Speed Test helps to determine if the symptom is vehicle speed-related.
- The Downshift Speed Test helps to determine if the symptom is engine speed-related.
- The Steering Input Test helps to determine how the wheel bearings and other suspension components contribute to a vehicle speed-related symptom.
- The Brake Test helps to identify vibrations or noise that are brake related.
- The Road Test Over Bumps helps isolate a noise that occurs when driving over a rough or bumpy surface.
- The Engine Run-Up Tests consist of the Neutral Engine Run-Up (NERU) Test and the Drive Engine Run-Up (DERU) Load Test. These tests help to determine if the symptom is engine speed-related.
- The Neutral Engine Run-Up (NERU) Test is used as a follow-up test to the Downshift Speed Test when the symptom occurs at idle.
- The Drive Engine Run-Up (DERU) Load Test helps to identify vibration/noise sensitive to engine load or torque. It also helps to reproduce engine speed-related symptoms that cannot be duplicated when carrying out the Neutral Engine Run-Up (NERU) Test or the Neutral Coast Down Test.
- The Engine Accessory Test helps to locate faulty belts and accessories that cause engine speed-related symptoms.
- The Vehicle Cold Soak Procedure helps to identify symptoms occurring during initial start-up and when an extended time lapse occurs between vehicle usage.

### **Slow Acceleration Test**

To carry out this test, proceed as follows:

- Slowly accelerate to the speed where the reported symptom occurs. Note the vehicle speed, the engine rpm and, if possible, determine the vibration frequency.
- Attempt to identify from what part of the vehicle the symptom is coming.
- Attempt to identify the source of the symptom.
- If the source of the symptom has been identified as a result of this test, proceed to the appropriate section for further diagnosis and repair. If the source has not been identified, continue with the road test.

### **Heavy Acceleration Test**

To carry out this test, proceed as follows:

- Accelerate hard from 0-64 km/h (0-40 mph).
- Decelerate in a lower gear.
- The symptom is torque-related if duplicated while carrying out this test.
- If the source of the symptom has been identified as a result of this test, proceed to the appropriate section for further diagnosis and repair. If the source has not been identified, continue with the road test.

### **Neutral Coast Down Speed Test**

To carry out this test, proceed as follows:

- Drive at a higher rate of speed than where the symptom occurred when carrying out the Slow Acceleration Test.
- Place the transmission in NEUTRAL and coast down past the speed where the symptom occurs.
- The symptom is vehicle speed-related if duplicated while carrying out this test. This eliminates the engine and the torque converter as sources.
- If the symptom was not duplicated while carrying out this test, carry out the Downshift Speed Test to verify if



the symptom is engine speed related.

- If the source of the symptom has been identified as a result of this test, proceed to the appropriate section for further diagnosis and repair. If the source has not been identified, continue with the road test.

### **Downshift Speed Test**

To carry out this test, proceed as follows:

- Shift into a lower gear than the gear used when carrying out the Slow Acceleration Test.
- Drive at the engine rpm where the symptom occurs.
- The symptom is engine speed related if duplicated while carrying out this test. This eliminates the tires, wheels, brakes and the suspension components as sources.
- If necessary, repeat this test using other gears and NEUTRAL to verify the results.
- If the source of the symptom has been identified as a result of this test, proceed to the appropriate section for further diagnosis and repair. If the source has not been identified, continue with the road test.

### **Steering Input Test**

To carry out this test, proceed as follows:

- Drive at the speed where the symptom occurs, while making sweeping turns in both directions.
- If the symptom goes away or gets worse, the wheel bearings, hubs, U-joints (contained in the axles of Four-Wheel Drive (4WD) applications), and tire tread wear are all possible sources.
- If the source of the symptom has been identified as a result of this test, proceed to the appropriate section for further diagnosis and repair. If the source has not been identified, continue with the road test.

### **Brake Test**

To carry out this test, proceed as follows:

- With the brake released, accelerate the vehicle. While coasting (brake pedal released) to a stop in NEUTRAL, note any abnormal rate of deceleration. Abnormal deceleration could indicate a parking brake or service brake that is not fully releasing.
- Warm the brakes by slowing the vehicle a few times from 80-32 km/h (50-20 mph) using light braking applications.
- Accelerate to 89-97 km/h (55-60 mph). Moderately apply the brakes and slow the vehicle to a stop.
- A brake vibration can be felt in the steering wheel, seat or brake pedal. A brake noise can be heard upon brake application and should diminish when the brake is released. For vehicles with separate park brake shoes, noise or vibration from the parking brake system will not be affected by applying the hydraulic brakes. On these systems, the parking brake system requires inspection if a parking brake concern is suspected.
- If the source of the symptom has been identified as a result of this test, proceed to the appropriate brake section(s) for further diagnosis and repair. If the source has not been identified, continue with the road test.

### **Road Test Over Bumps**

To carry out this test, proceed as follows:

- Drive the vehicle over a bump or rough surface one wheel at a time to determine if the noise is coming from

the front or the back and the left or the right side of the vehicle.

- If the source of the symptom has been identified as a result of this test, proceed to the appropriate section for further diagnosis and repair. If the source has not been identified, continue with the road test.

### Neutral Engine Run-Up (NERU) Test

To carry out this test, proceed as follows:

- Install a tachometer.
- Increase the engine rpm up from an idle to approximately 4,000 rpm while in PARK on Front Wheel Drive (FWD) vehicles with automatic transmissions, or NEUTRAL for all other vehicles. Note the engine rpm and, if possible, determine the vibration frequency.
- Attempt to identify what part of the vehicle the symptom is coming from.
- Attempt to identify the source of the symptom.
- If the source of the symptom has been identified as a result of this test, proceed to the appropriate section for further diagnosis and repair. If the source has not been identified, continue with the road test.

### Drive Engine Run-Up (DERU) Load Test

To carry out this test, proceed as follows:



**WARNING:** Block all wheels, set the parking brake and firmly apply the service brake to reduce the risk of vehicle movement during this procedure. Failure to follow these instructions may result in serious personal injury.

**NOTICE:** Do not carry out the Engine Load Test for more than 5 seconds or damage to the transmission or transaxle may result.

- Block the front and rear wheels.
- Apply the parking brake and the service brake.
- Install a tachometer.
- Shift the transmission into DRIVE, and increase and decrease the engine rpm between an idle to approximately 2,000 rpm. Note the engine rpm and, if possible, determine the vibration frequency.
- Repeat the test in REVERSE.
- If the vibration/noise is duplicated when carrying out this test, inspect the engine and transmission or transaxle mounts.
- If the symptom is definitely engine speed-related, carry out the Engine Accessory Test to narrow down the source.
- If the source of the symptom has been identified as a result of this test, proceed to the appropriate section for further diagnosis and repair. If the source has not been identified, continue with the road test.

### Engine Accessory Test

To carry out this test, proceed as follows:



**WARNING:** Block all wheels, set the parking brake and firmly apply the service brake to reduce the risk of vehicle movement during this procedure. Failure to follow these instructions may result in serious personal injury.

**NOTICE:** Limit engine running time to one minute or less with belts removed or serious engine damage will result.

**NOTE:** Use a frequency measurement tool to pinpoint accessory vibrations. A listening device, such as an EngineEAR, will also help to identify noises from specific accessories.

- Remove the accessory drive belt(s).
- Increase the engine rpm to where the symptom occurs.
- If the vibration/noise is duplicated when carrying out this test, the belt(s) and accessories are not sources.
- If the vibration/noise was not duplicated when carrying out this test, install the accessory belt(s), one at a time, to locate the source.
- If the source of the symptom has been identified as a result of this test, proceed to the appropriate section for further diagnosis and repair. If the source has not been identified, continue with the road test.

### Vehicle Cold Soak Procedure

To carry out this procedure, proceed as follows:

- Test preparations include matching customer conditions (if known). If not known, document the test conditions: gear selection and engine rpm. Monitor the vibration/noise duration with a watch for up to 3 minutes.
- Park the vehicle where testing will occur. The vehicle must remain at or below the symptom temperature (if known) for 6-8 hours.
- Before starting the engine, conduct a visual inspection under the hood.
- Turn the key on, but do not start the engine. Listen for the fuel pump, ABS and air suspension system noises.
- Start the engine.
- Isolate the vibration/noise by carefully listening. Move around the vehicle while listening to find the general location of the vibration/noise. Then, search for a more precise location by using a stethoscope or EngineEAR.
- If the source of the symptom has been identified as a result of this test, proceed to the appropriate section for further diagnosis and repair. If the source has not been identified, continue with the road test.

### Classify NVH Symptom

For NVH concerns, it is necessary to classify the customer's concern into one of the 3 categories: noise, vibration or harshness. The reason for this is that a customer concern may consist of a combination of symptoms involving noise and vibration, or vibration and harshness. In cases where there are combination symptoms, determine which diagnostic path to follow: noise, vibration or harshness. For example, if a customer has a concern involving a noise and a vibration, and it is determined that it is vehicle speed-related, follow the vibration diagnostic path.

### Noise Symptoms

Once a symptom is classified as a noise, the particular conditions under which the noise occurs need to be identified. These conditions are identified and verified during the road test. For example, a noise may only occur while turning. The next step is to determine which systems on the vehicle are related to that condition. In this case, the steering system and wheel/tire system may be suspect. After identifying possible systems, a preliminary inspection of these systems should be done. If the source of noise is still unidentified, use a listening device (such as the ChassisEAR) to pinpoint the source. Once the source has been identified, determine if this source is related to the suspected system previously identified. If it is related, then complete the repair to resolve the customer concern. If it is unrelated, then it is possible that the source of the noise is a reactor to a noise being transmitted through a transfer path. If this is the case, repairing the reactor will not resolve the customer concern. The transfer path must

be identified and a determination made if the noise is normal, but accentuated by the transfer path (conductor), or if the originator is the fault causing excessive noise to transfer to another component through a conductor. There is a relationship between systems identified as related to conditions and the noise transfer path. In some cases, the condition under which the noise occurs has nothing to do with the identified source. This relationship is important in the diagnosis of noise concerns. It is the first clue that the identified source of noise might be a reactor and that further investigation is needed to diagnose a possible noise transfer path concern. Based on the results from the road test, make a determination of which action in the symptom chart to take first.

**Vibration Symptoms**

Most vibrations consist of movements back and forth or up and down that repeat. Every time the vibrating component goes through its complete range of motion and returns to the starting point is called a cycle. The rate at which these cycles occur within a given time is called the frequency. Frequency is measured in cycles per second or Hertz (Hz). One cycle per second equals one Hz. Once the frequency of a vibration is known, calculations can be done to determine the system that is the source of the concern.

**Order of Vibration**

The order of a vibration refers to how often the vibration is present in one revolution of the component. For example, a vibration that is present once each revolution of a component would be a first order vibration. A vibration present twice each revolution of the component would be a second order vibration. Vibration orders do not have to be whole numbers, they can have decimal values such as 1.5 order vibration or 3.08 order vibration.

The concept of order of vibration is important to remember when the measured frequency of a vibration does not seem to match the frequency calculations of any of the likely systems or components. As the order increases, the frequency of the vibration will also increase by a multiple of that number.

For example, vibration may be present where the frequency is measured at 14 Hz. After doing the necessary calculations it is determined the first order tire and wheel frequency is 7 Hz and the first order driveshaft frequency is 22 Hz. Based on this information it can be determined the vibration is most likely a second order tire and wheel vibration: 7 Hz (first order tire and wheel frequency) multiplied by 2 (second order) equals 14 Hz (second order tire and wheel frequency).

**Relationship of Vibration Frequency to Order of Vibration**

After carrying out the road test as described in this section, the vibration was determined to be either vehicle-speed related or engine-speed related. That determination will identify the vibration frequency calculations that should be done.

Vibration Type	Calculate
Vehicle-speed related	Tire-speed vibration frequency
	Driveshaft-speed vibration frequency
Engine-speed related	Engine vibration frequency
	Engine accessory vibration frequency
	Engine firing vibration frequency

In calculating and using frequency readings, it is important to remember the direct relationship between Hz and rpm. One Hz is equal to 60 rpm. This is easy to remember; think of Hz as cycles per second. There are 60 seconds in a minute, therefore multiply Hz reading by 60 to get rpm. Conversely, divide rpm by 60 to get Hz.

Use the Frequency and RPM Calculations Worksheet to calculate system/component frequencies. The worksheet provides the necessary steps to determine each system/component group frequency.

## Frequency Calculations

### Calculating Tire and Wheel Frequency

For a vibration concern, use the vehicle speed to determine tire/wheel frequency and rpm. Calculate tire and wheel rpm and frequency by carrying out the following:

- Measure the diameter of the tire.
- Record the speed at which the vibration occurs.
- Obtain the corresponding tire and wheel rpm and frequency from the Tire Speed and Frequency Chart.
- If the vehicle speed is not listed, calculate the tire and wheel frequency as follows:
  - Divide the vehicle speed at which the vibration occurs by 16 km/h (10 mph). Multiply that number by the 16 km/h (10 mph) tire rpm listed for that tire diameter in the chart. Then divide that number by 60.
  - For example, if calculating the frequency based on vehicle speed in km/h for a 64 km/h vibration with 835 mm tires, divide 64 km/h by 16 km/h = 4. Multiply 4 by 105 rpm = 420. Divide 420 by 60 seconds = 7 Hz at 64 km/h.
  - If calculating the frequency based on vehicle speed in mph for a 40 mph vibration with 33 inch tires, divide 40 mph by 10 mph = 4. Multiply 4 by 105 rpm = 420. Divide 420 by 60 seconds = 7 Hz at 40 mph.
  - The calculated frequency of 7 Hz is the first order tire and wheel vibration; the second order tire and wheel vibration would be twice this number at 14 Hz; the third order tire and wheel vibration would be 21 Hz; and so on.

### Tire Speed and Frequency Chart

Tire Diameter	Tire RPM/Hz	Tire RPM/Hz	Tire RPM/Hz	Tire RPM/Hz
mm (in)	@ 16 km/h (10 mph)	@ 80 km/h (50 mph)	@ 97 km/h (60 mph)	@ 113 km/h (70 mph)
483 (19)	182	910/15	1,092/18	1,274/21
508 (20)	173	865/14	1,038/17	1,211/20
533 (21)	165	825/14	990/16	1,155/19
560 (22)	158	790/13	948/16	1,106/18
585 (23)	151	755/13	906/15	1,057/18
610 (24)	145	725/12	870/14	1,015/17
635 (25)	139	695/12	834/14	973/16
660 (26)	134	670/11	804/13	938/16
685 (27)	129	645/11	774/13	903/15
710 (28)	124	620/10	744/12	868/14

735 (29)	119	595/10	714/12	833/14
760 (30)	115	575/10	690/11	805/13
785 (31)	111	555/9	666/11	777/13
810 (32)	108	540/9	648/11	756/13
835 (33)	105	525/9	630/10	735/12
864 (34)	102	510/8	612/10	714/12

### Calculating Driveshaft Frequency

Knowing the tire and wheel frequency allows for easy calculation of driveshaft frequency. The driveshaft drives the tires through the rear axle. Therefore, to determine driveshaft frequency, multiply tire and wheel frequency by the ratio of the rear axle. Calculate driveshaft frequency by performing the following steps:

- Obtain the axle ratio of the vehicle. Suppose the vehicle has a vibration problem at 64 km/h (40 mph) and a rear axle ratio of 2.93:1.
- Multiply the tire and wheel frequency of 7 Hz (calculated previously) with the rear axle ratio of 2.93:1. This results in a driveshaft frequency of 21 Hz at a vehicle speed of 64 km/h (40 mph).

The calculated frequency of 21 Hz is the first order driveshaft frequency; the second order frequency of the driveshaft is twice this number, or 42 Hz; and so on.

### Calculating Engine Frequency

Use the engine rpm where the vibration symptom occurs to determine engine frequency. Calculate engine frequency by dividing the engine rpm by 60 (the number of seconds in a minute). For example, if the corresponding engine rpm of a vibration concern on a vehicle is 2,400 rpm, the resulting engine frequency is 40 Hz. Therefore, a 40 Hz vibration is a first order engine vibration. For purposes of vibration diagnosis, the engine also includes the torque converter and exhaust system.

### Calculating Engine Accessory Frequency

Belt-driven engine accessories often produce vibrations at different frequencies than the engine itself. This is because the drive ratio created by the different size pulleys causes them to rotate at different speeds. Determining engine accessory frequency is comparable to calculating driveshaft frequency.

Calculate engine accessory frequency by performing the following steps:

- Determine the size ratio factor between the accessory pulley and the crankshaft pulley. For example, if the diameter of the crankshaft pulley is 6 inches and the accessory pulley diameter is 2 inches, the accessory pulley rotates 3 times for every crankshaft rotation (6 divided by 2).
- Multiply the engine rpm where the vibration condition occurs by the number of times the accessory pulley is rotating per crankshaft revolution. For example, if the engine rpm is 2,400 rpm, the accessory is rotating at 7,200 rpm (2,400 rpm multiplied by 3).
- Divide the accessory rpm by 60 (the number of seconds in a minute). In this example, the engine accessory frequency is 120 Hz (7,200 divided by 60).

### Calculating Engine Firing Frequency

Engine firing frequency is a term used to describe the pulses an engine creates from the firing of the cylinders. Engine firing frequency depends on how many cylinders an engine has. The number of times an engine fires a cylinder with each crankshaft revolution is equal to one-half the number of cylinders. A 4-cylinder engine fires 2 cylinders with each crankshaft revolution. Two revolutions of the crankshaft fire all 4 cylinders. A 6-cylinder engine fires 3 cylinders with each crankshaft revolution. An 8-cylinder engine fires 4 cylinders for each crankshaft revolution.

Calculate engine firing frequency by performing the following steps:

- Multiply the engine rpm where the vibration symptom occurs by the number of cylinders fired with each crankshaft revolution. For example, a vehicle with a 6-cylinder engine experiences a vibration concern at 2,400 rpm. The engine is firing the cylinders at 7,200 times per minute (3 multiplied by 2,400).
- Divide this number by 60 (the number of seconds in a minute) to obtain the engine firing frequency. In this example, the engine firing frequency is 120 Hz (7,200 divided by 60) at 2,400 rpm.

## **Frequency and RPM Calculations Worksheet**

## FREQUENCY AND RPM CALCULATIONS

### TIRE AND WHEEL

Vibration occurs at \_\_\_\_\_ mph (km/h)

Tire diameter \_\_\_\_\_

Tire speed RPM and frequency from chart \_\_\_\_\_ RPM \_\_\_\_\_ Hz

### DRIVESHAFT

Tire/wheel frequency \_\_\_\_\_ x axle ratio = \_\_\_\_\_ Hz

Tire/wheel RPM \_\_\_\_\_ x axle ratio = \_\_\_\_\_ RPM

### ENGINE FREQUENCIES AND ASSOCIATED RPMS

Engine RPM divided by 60 equals 1st order frequency \_\_\_\_\_ Hz

1st order RPM x 2 = 2nd order RPM (normal for 4 cylinder engines)

Cylinders fired per engine revolutions \_\_\_\_\_ RPM

1st order Hz x 2 = 2nd order Hz (normal for 4 cylinder engines) \_\_\_\_\_ Hz

1st order RPM x 3 = 3rd order RPM (normal for 6 cylinder engines)

1st order Hz x 3 = 3rd order Hz (normal for 6 cylinder engines)

x 4 = 4th order vibrations (normal for 8 cylinder engines)

x 5 = 5th order, x 6 = 6th order, etc.

Order of vibration x engine RPM equals cylinders fired per minute \_\_\_\_\_ RPM

Order of vibration (2nd, 3rd, 4th etc.) x 1st order Hz equals \_\_\_\_\_ Hz

### ENGINE ACCESSORY FREQUENCIES AND RPMS

Crankshaft pulley diameter \_\_\_\_\_ divided by accessory pulley diameter \_\_\_\_\_ = \_\_\_\_\_ pulley size ratio

Engine speed \_\_\_\_\_ RPM x pulley ratio = accessory \_\_\_\_\_ RPM

Accessory pulley \_\_\_\_\_ RPM divided by 60 = \_\_\_\_\_ Hz

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### Harshness Symptoms

Harshness is customer perception which gives the impression of no isolation from the tire/wheel and suspension system. Harshness may be caused by road conditions, temperature changes, component damage and/or incorrect customer modifications on original components/specifications. Customers usually experience harshness when the



vehicle is driving over bumps or potholes and in cold weather conditions. Harshness can also be experienced with excessive tire pressure, sporty tires, heavy-duty springs and shocks, or other vehicle modifications. Some aftermarket tires, even with the correct size, may change vehicle behavior and produce customer concerns. The first step in diagnosing a harshness concern is to determine if the concern was experienced only in certain specific operating conditions, such as large potholes or extremely cold weather. In these cases, harshness should be considered normal. A known good vehicle can be driven under the same conditions and the rides can be compared to determine whether the concern is normal or vehicle specific. The second step is to check tire pressure and make sure it was set within vehicle specifications. The third step is to inspect for aftermarket or modified components and determine if they are the cause of the harshness complaint. If the harshness concern persists after the above steps, it is possible that some components are damaged. Based on the results from the road test, make a determination of which action in the symptom chart to take first.

### NVH Symptom Chart Categories

A good diagnostic process is a logical sequence of steps that lead to the identification of a causal system. Use the symptom and possible system categories as follows:

- Identify the operating condition that the vehicle is exhibiting.
- Match the operating condition to the symptom.
- Verify the symptom.
- Calculate the frequency and order of the symptom.
- Identify which category or system(s) could cause the symptom.
- Refer to the section indicated to identify and diagnose the symptom or confirm that the system is not the source of the condition.

Use the diagnostic instructions in this section along with the necessary listed tools to identify the vibration order and to isolate the symptom and the possible systems associated with that symptom. Then based on the results from the road test, make a determination of which action in the symptom chart to take first. Since it is possible any one of multiple systems may be the cause of the symptom, it may be necessary to use a process of elimination type diagnostic approach to pinpoint the concern. Refer to the section(s) indicated to identify and isolate the cause or rule that system out as being the causal system for the symptom.

### Vehicle-Speed Related Vibrations

**NOTE:** Any assembly that is out of balance will only cause a first order vibration, it will not cause a higher order vibration.

When a vehicle-speed related vibration is present, both tire-speed related vibration and driveshaft-speed related vibration calculations should be carried out.

### Symptom Chart — Tire-Speed Related Vibrations

#### Symptom Chart — Tire-Speed Related Vibrations

Condition	Possible Sources	Action
<ul style="list-style-type: none"> <li>● First order tire vibration</li> </ul>	<ul style="list-style-type: none"> <li>● Tire or wheel</li> <li>● Wheel bearings</li> <li>● Drive axle</li> <li>● Halfshaft</li> <li>● Brake rotor or drum</li> </ul>	<ul style="list-style-type: none"> <li>● REFER to <a href="#">Section 204-04</a>.</li> <li>● REFER to <a href="#">Section 204-00</a>.</li> <li>● REFER to <a href="#">Section 205-00</a>.</li> <li>● REFER to <a href="#">Section 205-00</a>.</li> <li>● REFER to <a href="#">Section 206-00</a>.</li> </ul>

<ul style="list-style-type: none"> <li>• Second order tire vibration</li> </ul>	<ul style="list-style-type: none"> <li>• Tire or wheel</li> </ul>	<ul style="list-style-type: none"> <li>• REFER to <a href="#">Section 204-04</a>.</li> </ul>
<ul style="list-style-type: none"> <li>• Third order tire vibration</li> </ul>	<ul style="list-style-type: none"> <li>• Tire or wheel</li> <li>• Drive axle</li> <li>• Driveshaft</li> <li>• Halfshaft</li> </ul>	<ul style="list-style-type: none"> <li>• REFER to <a href="#">Section 204-04</a>.</li> <li>• REFER to <a href="#">Section 205-00</a>.</li> <li>• REFER to <a href="#">Section 205-00</a>.</li> <li>• REFER to <a href="#">Section 205-00</a>.</li> </ul>

**Symptom Chart — Driveshaft-Speed Related Vibrations**

**Symptom Chart — Driveshaft-Speed Related Vibrations**

**NOTE:** Any assembly that is out of balance will only cause a first order vibration, it will not cause a higher order vibration.

Condition	Possible Sources	Action
<ul style="list-style-type: none"> <li>• First order driveshaft vibration</li> </ul>	<ul style="list-style-type: none"> <li>• Driveshaft</li> <li>• Rear drive axle/differential</li> </ul>	<ul style="list-style-type: none"> <li>• REFER to <a href="#">Section 205-00</a>.</li> <li>• REFER to <a href="#">Section 205-00</a>.</li> </ul>
<ul style="list-style-type: none"> <li>• Second order driveshaft vibration</li> </ul>	<ul style="list-style-type: none"> <li>• U-joint</li> <li>• Output shaft bushing in transmission/transaxle</li> </ul>	<ul style="list-style-type: none"> <li>• REFER to <a href="#">Section 205-00</a>.</li> <li>• Refer to the appropriate section in Group <a href="#">307</a> for the procedure. Refer to the appropriate section in Group <a href="#">308</a> for the procedure. GO to the Symptom Chart in the appropriate section.</li> </ul>
<ul style="list-style-type: none"> <li>• Third order driveshaft vibration</li> </ul>	<ul style="list-style-type: none"> <li>• Rear drive axle/differential</li> </ul>	<ul style="list-style-type: none"> <li>• REFER to <a href="#">Section 205-00</a>.</li> </ul>

**Symptom Chart — Engine-Speed Related Vibrations**

**Symptom Chart — Engine-Speed Related Vibrations**

**NOTE:** When an engine-speed related vibration is present, engine, engine accessory and engine firing calculations should be carried out.

**NOTE:** Any assembly that is out of balance will only cause a first order vibration, it will not cause a higher order vibration.

**NOTE:** Some engine-speed related vibrations are normal though they should not be felt in the passenger compartment.

Condition	Possible Sources	Action
<ul style="list-style-type: none"> <li>• 0.5 order engine vibration</li> </ul>	<ul style="list-style-type: none"> <li>• Engine</li> </ul>	<ul style="list-style-type: none"> <li>• REFER to <a href="#">Section 303-00</a>.</li> </ul>
<ul style="list-style-type: none"> <li>• First through sixth order engine vibration</li> </ul>	<ul style="list-style-type: none"> <li>• Engine</li> <li>• Transmission/transaxle</li> </ul>	<ul style="list-style-type: none"> <li>• REFER to <a href="#">Section 303-00</a>.</li> <li>• Refer to the appropriate section in Group <a href="#">307</a> for the procedure. Refer to</li> </ul>

	<ul style="list-style-type: none"> <li>• Engine mounts</li> <li>• Transmission/transaxle mounts</li> <li>• Exhaust system</li> </ul>	<p>the appropriate section in Group <a href="#">308</a> for the procedure. GO to the Symptom Chart in the appropriate section.</p> <ul style="list-style-type: none"> <li>• REFER to <a href="#">Section 303-00</a>.</li> <li>• Refer to the appropriate section in Group <a href="#">307</a> for the procedure. Refer to the appropriate section in Group <a href="#">308</a> for the procedure. GO to the Symptom Chart in the appropriate section.</li> <li>• REFER to <a href="#">Section 309-00</a>.</li> </ul>
<ul style="list-style-type: none"> <li>• Belt driven accessory speed vibration</li> </ul>	<ul style="list-style-type: none"> <li>• Engine pulley</li> <li>• Coolant pump</li> <li>• Generator</li> <li>• A/C compressor</li> <li>• Power steering pump</li> <li>• Vacuum pump</li> <li>• Accessory drive belt</li> </ul>	<ul style="list-style-type: none"> <li>• REFER to <a href="#">Section 303-00</a>.</li> <li>• REFER to <a href="#">Section 303-00</a>.</li> <li>• REFER to <a href="#">Section 414-00</a>.</li> <li>• REFER to <a href="#">Section 412-00</a>.</li> <li>• REFER to <a href="#">Section 211-00</a>.</li> <li>• REFER to <a href="#">Section 303-00</a>.</li> <li>• REFER to <a href="#">Section 303-00</a>.</li> </ul>

**Symptom Chart — Noise, Air Leaks or Water Leaks**

**Symptom Chart — Noise, Air Leaks or Water Leaks**

Condition	Possible Sources	Action
<ul style="list-style-type: none"> <li>• Wind noise, air or water leaks</li> </ul>	<ul style="list-style-type: none"> <li>• Body</li> <li>• Roof opening panel</li> </ul>	<ul style="list-style-type: none"> <li>• REFER to the Symptom Chart in <a href="#">Section 501-00</a>.</li> <li>• REFER to the Symptom Chart in <a href="#">Section 501-00</a>.</li> </ul>
<ul style="list-style-type: none"> <li>• Belt driven accessory noise/squeal or chirping</li> </ul>	<ul style="list-style-type: none"> <li>• Accessory drive belt</li> <li>• Pulleys</li> </ul>	<ul style="list-style-type: none"> <li>• REFER to <a href="#">Section 303-05</a>.</li> </ul>
<ul style="list-style-type: none"> <li>• Front end noise while driving vehicle</li> </ul>	<ul style="list-style-type: none"> <li>• Front suspension</li> <li>• Drive axle or differential</li> <li>• Brake system</li> <li>• Steering linkage or gear</li> <li>• Transmission/transaxle</li> <li>• Engine</li> <li>• Exhaust system</li> <li>• Body</li> </ul>	<ul style="list-style-type: none"> <li>• REFER to <a href="#">Section 204-00</a>.</li> <li>• REFER to <a href="#">Section 205-00</a>.</li> <li>• REFER to <a href="#">Section 206-00</a>.</li> <li>• REFER to <a href="#">Section 211-00</a>.</li> <li>• Refer to the appropriate section in Group <a href="#">307</a> for the procedure. Refer to the appropriate section in Group <a href="#">308</a> for the procedure. GO to the Symptom Chart in the appropriate section.</li> <li>• REFER to <a href="#">Section 303-00</a>.</li> <li>• REFER to <a href="#">Section 309-00</a>.</li> <li>• REFER to the Symptom Chart in <a href="#">Section 501-00</a>.</li> </ul>

<ul style="list-style-type: none"> <li>• Rear end noise while driving vehicle</li> </ul>	<ul style="list-style-type: none"> <li>• Rear suspension</li> <li>• Drive axle or differential</li> <li>• Brake system</li> <li>• Transmission/transaxle</li> <li>• Exhaust system</li> <li>• Body</li> </ul>	<ul style="list-style-type: none"> <li>• REFER to <a href="#">Section 204-00</a>.</li> <li>• REFER to <a href="#">Section 205-00</a>.</li> <li>• REFER to <a href="#">Section 206-00</a>.</li> <li>• Refer to the appropriate section in Group <a href="#">307</a> for the procedure. Refer to the appropriate section in Group <a href="#">308</a> for the procedure. GO to the Symptom Chart in the appropriate section.</li> <li>• REFER to <a href="#">Section 309-00</a>.</li> <li>• REFER to the Symptom Chart in <a href="#">Section 501-00</a>.</li> </ul>
<ul style="list-style-type: none"> <li>• Noise with vehicle stopped</li> </ul>	<ul style="list-style-type: none"> <li>• Engine</li> <li>• Transmission/transaxle</li> <li>• Exhaust system</li> <li>• Power steering pump</li> <li>• Generator</li> <li>• A/C compressor</li> <li>• Body</li> </ul>	<ul style="list-style-type: none"> <li>• REFER to <a href="#">Section 303-00</a>.</li> <li>• Refer to the appropriate section in Group <a href="#">307</a> for the procedure. Refer to the appropriate section in Group <a href="#">308</a> for the procedure. GO to the Symptom Chart in the appropriate section.</li> <li>• REFER to <a href="#">Section 309-00</a>.</li> <li>• REFER to <a href="#">Section 211-00</a>.</li> <li>• REFER to <a href="#">Section 414-00</a>.</li> <li>• REFER to <a href="#">Section 412-00</a>.</li> <li>• REFER to the Symptom Chart in <a href="#">Section 501-00</a>.</li> </ul>

**Symptom Chart — Harshness**

**Symptom Chart — Harshness**

Condition	Possible Sources	Action
<ul style="list-style-type: none"> <li>• Harsh vehicle ride</li> </ul>	<ul style="list-style-type: none"> <li>• Front suspension</li> <li>• Rear suspension</li> </ul>	<ul style="list-style-type: none"> <li>• REFER to <a href="#">Section 204-00</a>.</li> <li>• REFER to <a href="#">Section 204-00</a>.</li> </ul>

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