Vibration Diagnosis and Correction

Specifications

Tire and Wheel Runout Specifications

Application	Specification	
	Metric	English
Tire and Wheel Assembly– Lateral and Radial		
Off-Vehicle	1.27 mm	0.050 in
On-Vehicle	1.52 mm	0.060 in
Wheel, Aluminum		
Lateral	0.762 mm	0.030 in
Radial	0.762 mm	0.030 in
Wheel, Steel		
Lateral	1.143 mm	0.045 in
Radial	1.015 mm	0.040 in
Wheel Hub/Axle Flange– Guideline	0.132 mm	0.0052 in
Wheel Stud– Guideline	0.25 mm	0.010 in

Diagnostic Information and Procedures

Vibration Diagnosis, Starting Point, and Correction

The information contained in this Vibration Diagnosis and Correction section is designed to cover various vehicle designs and configurations. Not all content will apply to all vehicles.

Note: The following steps must be completed before using the analysis tables or the symptom tables.

1. Perform the *Vibration Analysis - Road Testing on page 1-39* table before using the other Vibration Analysis tables or the Symptom tables in order to effectively diagnose the customer's concern.

   The use of Vibration Analysis - Road Testing will first provide duplication of virtually any vibration concern and then identify the correct procedure for diagnosing the area of concern which has been duplicated.
2. Review the following Vibration Diagnostic Process.
3. Review the general descriptions to familiarize yourself with vibration theory and terminology, the *EL-38792–A* Electronic Vibration Analyzer (EVA) 2, and the *EL-38792–VS* Vibrate Software. Reviewing this information will help you determine whether the condition described by the customer is a potential operating characteristic or not.

   Refer to the following:
   - *Vibration Theory and Terminology on page 1-78*
   - *Electronic Vibration Analyzer (EVA) Description and Operation on page 1-88*
   - *Vibrate Software Description and Operation on page 1-90*
   - *Reed Tachometer Description on page 1-90*

Vibration Diagnostic Process

Note: Using the following steps of the vibration diagnostic process will help you to effectively narrow-down and pin-point the search for the specific source of a vibration concern and to arrive at an accurate repair.

1. Gather specific information on the customer's vibration concern.
2. Perform the road testing steps in sequence as identified in Vibration Analysis - Road Testing in order to duplicate the customer's concern and evaluate the symptoms of the concern under changing conditions. Observe what the vibration feels like and what it sounds like. Observe when the symptoms first appear, when they change, and when they cease.
3. Determine if the customer's vibration concern is truly an abnormal condition or something that is potentially an operating characteristic of the vehicle.
4. Systematically eliminate or "rule-out" possible vehicle systems.
5. Focus diagnostic efforts on the remaining vehicle system and systematically eliminate or "rule-out" possible components of that system.
6. Make a repair on the remaining component, or components, which have not been eliminated systematically, and must therefore be the cause of the vibration.

7. Verify that the customer's concern has been eliminated or at least brought to an acceptable level.
8. Again perform the road testing steps in sequence as identified in Vibration Analysis - Road Testing in order to verify that the vehicle did not have more than one vibration occurring.

Preliminary Visual/Physical Inspection

- Inspect for aftermarket equipment and modifications which could affect the operation of the vehicle rotating component systems.
- Inspect the easily accessible or visible components of the vehicle rotating component systems for obvious damage or conditions which could cause the symptom.
- Inspect the tire inflation pressures for the proper pressure.

Diagnostic Aids

Improper component routing or isolation, or components which are worn or faulty may be the cause of intermittent conditions that are difficult to duplicate. If the vibration concern could not be duplicated by following the steps of the Vibration Diagnostic Process, refer to *Vibration Diagnostic Aids on page 1-60*.

Vibration Analysis - Road Testing

Test Description

The numbers below refer to the step numbers on the diagnostic table.

5. Obtaining rotational speed for the components rotating at tire/wheel speed is critical to systematically eliminating specific vehicle component groups. These component rotational speeds can be generated by using the *EL-38792-VS* Vibrate Software, or through calculating them manually.

Note: Be certain to OBSERVE for disturbances that match the customer description FIRST, then look at the *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) frequency which corresponds with that disturbance.

10. Proper location of the *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2), sensor onto the component which is most excited by the vibration disturbance is critical to obtaining an accurate frequency reading.

    This test will duplicate virtually any disturbance which occurs while the vehicle is in motion.
11. Accelerate to a speed high enough above the speed of the disturbance to allow for the time needed to shift into NEUTRAL and for the engine to decrease in RPM to idle speed, before coasting down through the disturbance range.
12. This test will either eliminate or confirm the engine as a contributing cause of the customer concern.

Vibration Analysis - Road Testing

Step	Action	Yes	No
1	Did you review the Diagnostic Starting Point – Vibration Diagnosis?	Go to *Step 2*	—
2	Did the customer concern indicate that the vibration occurs ONLY while the vehicle is standing still?	Go to *Step 6*	Go to *Step 3*
3	Visually inspect the tire and wheel assemblies, steering components and suspension components for any possible faults. Are the tire and wheel assemblies, steering components and suspension components in good working condition?	Go to *Step 5*	Go to *Step 4*
4	**Note:** Do NOT operate the vehicle until the faults are corrected. Correct the faults with the tire and wheel assemblies, steering components, and/or the suspension components before proceeding. Did you correct the faults with the tire and wheel assemblies, steering components, and/or the suspension components?	Go to *Step 5*	Go to *Step 3*
5	1. Obtain the drive axle final drive ratio. 2. If the *EL-38792-VS* Vibrate Software, IS available, obtain the transmission gear ratios. 3. If the *EL-38792-VS* Vibrate Software is NOT available, take note of the tire size on each axle, then calculate the tire rotational speed for each size tire used. Refer to *Component Rotational Speed Calculation on page 1-41*. Did you obtain the powertrain ratios for use with the *EL-38792-VS* Vibrate Software, or calculate the component rotational speeds, if *EL-38792-VS* Vibrate Software is NOT available?	Go to *Step 6*	—
6	1. Install a scan tool. 2. With the scan tool, bring up the Powertrain Control Module data list and select Engine Speed. Is the scan tool operating properly?	Go to *Step 7*	—

Vibration Analysis - Road Testing (cont'd)

Step	Action	Yes	No
7	Using the *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2), is the preferred method for gathering necessary vibration frequency data. If the *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) is not available, the necessary vibration frequency data will have to be obtained based on symptoms observed during testing. Review *Symptoms - Vibration Diagnosis and Correction on page 1-62* to become familiar with the possible frequency ranges. Is the *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) available for use?	Go to *Step 8*	Go to *Step 9*
8	Install the *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2). Is the *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) operating properly?	Go to *Step 9*	Go to *Electronic Vibration Analyzer (EVA) Description and Operation on page 1-88*
9	Did the customer concern indicate that the vibration occurs ONLY while the vehicle is standing still?	Go to *Vibration Analysis - Engine on page 1-48*	Go to *Step 10*
10	1. Install the *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) sensor, if available, to the component identified by the customer as most respondent to the vibration. If no component was identified, install the *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) sensor, if available, to the steering column. You may have to move the sensor to other locations later. 2. Select a smooth, level road and slowly accelerate the vehicle up to highway speed. 3. Observe the vehicle for disturbances that match the customer description and note the following conditions: • The vehicle speed • The engine RPM • The transmission gear range and the specific gear • The vibration frequency reading, if detected by the *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) • The feel and/or sound of the disturbance 4. If the vibration seems to excite a particular component of the vehicle more than the steering column, then move the *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) sensor, if available, onto that component and repeat steps 2 and 3. Were you able to duplicate the customer concern?	Go to *Step 11*	Go to *Vibration Diagnostic Aids on page 1-60*
11	1. Accelerate the vehicle to a speed higher than the speed at which the disturbance occurs. **Note:** If the vehicle is equipped with an automatic transmission, let the vehicle coast to a stop before shifting back into gear. 2. Shift the vehicle into NEUTRAL and allow the vehicle to coast down through the disturbance range. Does the disturbance still occur while coasting-down in NEUTRAL?	Go to *Step 13*	Go to *Step 12*
12	1. Select a smooth, level road and slowly accelerate the vehicle up to the speed at which the disturbance occurs. 2. Decelerate and safely downshift by one gear range. 3. Operate the vehicle at the same VEHICLE SPEED at which the disturbance occurs. Does the same disturbance still occur while going the same vehicle speed in a lower gear range?	Go to *Vibration Analysis - Hub and/or Axle Input on page 1-46*	Go to *Vibration Analysis - Engine on page 1-48*
13	If the *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) is not available, refer to *Symptoms - Vibration Diagnosis and Correction on page 1-62*. Did the *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) detect a dominant frequency?	Go to *Step 14*	Go to *Symptoms - Vibration Diagnosis and Correction on page 1-62*

Vibration Analysis - Road Testing (cont'd)

Step	Action	Yes	No
14	1. If the *EL-38792-VS* Vibrate Software IS available, use the drive axle final drive ratio, the specific transmission gear ratio, and the engine RPM to make a comparison to the dominant frequency reading recorded. 2. If the *EL-38792-VS* Vibrate Software is NOT available, compare the dominant frequency reading recorded to the component rotational data which you calculated previously. Does the frequency data clearly fall within the tire/wheel parameters ONLY?	Go to *Vibration Analysis - Tire and Wheel on page 1-43*	Go to *Symptoms - Vibration Diagnosis and Correction on page 1-62*

Component Rotational Speed Calculation

Special Tools

EL-38792-A Electronic Vibration Analyzer (EVA) 2

For equivalent regional tools, refer to *Special Tools and Equipment on page 1-91*.

Tire Rotational Speed

Determining Tire Revolutions Per Second at 8 km/h (5 mph) — Using EVA

Tire and wheel assembly rotational speed can be obtained through using the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2. Perform the following steps using the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2 to obtain the rotational speed at 8 km/h (5 mph). Use the Enter key to advance and the Exit key to backup.

1. On the Main Menu screen, select Auto Mode.
2. On the Suspected Source screen, select Vehicle Speed.
3. On the Tire Info Source screen, select Manual Entry.
4. On the Tire Width screen, enter the specific width of the tires.

   For example: For a P245/45/R18 tire, enter 245.
5. On the Aspect Ratio screen, enter the specific aspect ratio of the tires.

   For example: For a P245/45/R18 tire, enter 0.45.
6. On the Rim Diameter screen, enter the specific rim diameter size.

   For example: For a P245/45/R18 tire, enter 18.0.
7. On the Driveshaft Configuration screen, enter FWD, even if the vehicle is a rear wheel drive.
8. The next screen will display the tire size just entered for confirmation.

   For example: 245 0.45 18.0 –Front Wheel Drive. If the tire size displayed is correct, press Enter.
9. On the Vehicle Speed Units screen, press Enter, disregard mph or km/h.
10. Press the Exit key several times slowly while watching the backwards progression of the screens. Stop at the Tire Info Source screen.
11. On the Tire Info Source screen, select RPS at 5 mph.
12. The next screen will display the revolutions per second (RPS) at 8 km/h (5 mph) for that specific tire size.

    For example: The P245/45/R18 will display 1.08 RPS.

Calculating Tire Revolutions Per Second at 8 km/h (5 mph) — Without EVA

If the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2 is not available, the tire and wheel assembly rotational speed can be calculated approximately by performing the following steps.

1. Convert the rim diameter size from inches to centimeters.

   For example: For a P245/45/R18 tire, the rim diameter of 18 in X 2.54 converts to 45.72 cm.
2. Calculate the radius of the rim by dividing the rim diameter by 2.

   For example: For a P245/45/R18 tire, the rim diameter of 18 is converted to 45.72 cm divided by 2 = rim radius 22.86 cm.
3. Calculate the approximate tire sidewall height by multiplying the specific tire tread width by the aspect ratio, then reduce 7 percent from the amount by multiplying by 93 percent to approximate load on the tire reducing the sidewall height.

   For example: For a P245/45/R18 tire, tread width 245 mm X aspect ratio as a decimal 0.45 = 110 mm X 0.93 = approximate sidewall height 102.30 mm.
4. Convert the calculated approximate tire sidewall height from millimeters to centimeters.

   For example: For a P245/45/R18 tire, approximate sidewall height 102.30 mm converts to 10.23 cm.
5. Calculate the approximate tire and wheel assembly radius by adding the rim radius and approximate sidewall height, both in cm.

   For example: For a P245/45/R18 tire, rim radius 22.86 cm + 10.23 cm = approximate tire and wheel assembly radius 33.09 cm.
6. Calculate the approximate circumference of the tire and wheel assembly by multiplying 2 X pi, or 6.283185 X the approximate tire and wheel assembly radius.

   For example: For a P245/45/R18 tire, 6.283185 X approximate tire and wheel assembly radius 33.09 cm = approximate tire and wheel assembly circumference 207.911 cm.

7. Calculate the approximate revolutions per kilometer by dividing the number of cm in 1 km, 100,000 cm by the approximate tire and wheel assembly circumference.

   For example: For a P245/45/R18 tire, 100,000 cm divided by approximate tire and wheel assembly circumference 207.911 cm = approximate revolutions per kilometer 480.975.

8. Calculate the approximate revolutions per second (RPS), or Hz, by dividing the approximate revolutions per kilometer by the number of seconds to travel 1 km at a speed of 8 km per hour, 450 seconds.

   For example: For a P245/45/R18 tire, approximate revolutions per kilometer 480.975 divided by the number of seconds to travel 1 km at a speed of 8 km per hour, 450 seconds = approximate RPS, or Hz 1.069 rounded to 1.07.

Calculating Tire Revolutions Per Second, or Hz at Concern Speed

A size P235/75R15 tire rotates ONE complete revolution per second (RPS), or 1 Hz, at a vehicle speed of 8 km/h (5 mph). This means that at 16 km/h (10 mph), the same tire will make TWO complete revolutions in one second, 2 Hz, and so on.

1. Determine the rotational speed of the tires in revolutions per second (RPS), or Hertz (Hz), at 8 km/h (5 mph), based on the size of the tires. Refer to the preceding Tire Rotational Speed information.

   For example: According to the Tire Rotational Speed information, a P245/45R18 tire makes 1.08 revolutions per second (Hz) at a vehicle speed of 8 km/h (5 mph). This means that for every increment of 8 km/h (5 mph) in vehicle speed, the tire's rotation increases by 1.08 revolutions per second, or Hz.

2. Determine the number of increments of 8 km/h (5 mph) that are present, based on the vehicle speed in km/h (mph) at which the disturbance occurs.

   For example: Assume that a disturbance occurs at a vehicle speed of 96 km/h (60 mph). A speed of 96 km/h (60 mph) has 12 INCREMENTS of 8 km/h (5 mph):

   96 km/h (60 mph) divided by 8 km/h (5 mph) = 12 increments

3. Determine the rotational speed of the tires in revolutions per second, or Hz, at the specific vehicle speed in km/h (mph) at which the disturbance occurs.

   For example: To determine the tire rotational speed at 96 km/h (60 mph), multiply the number of increments of 8 km/h (5 mph) by the revolutions per second, or Hz, for one increment:

   12 increments X 1.08 Hz = 12.96 Hz, rounded to 13 Hz

Note: If the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2 is not available, compare the calculated rotational speed to the frequency range associated with the symptoms of the vibration concern. Refer to *Symptoms - Vibration Diagnosis and Correction on page 1-62*.

4. Compare the rotational speed of the tires at the specific vehicle speed at which the disturbance occurs, to the dominant frequency recorded on the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2 during testing. If the frequencies match, then a first-order disturbance related to the rotation of the tire/wheel assemblies is present.

   If the frequencies do not match, then the disturbance may be related to a higher order of tire/wheel assembly rotation.

5. To compute higher order tire/wheel assembly rotation related disturbances, multiply the rotational speed of the tires at the specific vehicle speed at which the disturbance occurs, by the order number:

   13 Hz X 2, for second order = 26 Hz second-order tire/wheel assembly rotation related

   13 Hz X 3, for third order = 39 Hz third-order tire/wheel assembly rotation related

   If any of these computations match the frequency of the disturbance, a disturbance of that particular order, relating to the rotation of the tire/wheel assemblies and/or driveline components, also rotating at the same speed, is present.

Component Rotational Speed Worksheet

Utilize the following worksheet as an aid in calculating the first, second and third order of tire/wheel assembly rotational speed related disturbances that may be present in the vehicle.

If after completing the Tire/Wheel Rotation Worksheet, the frequencies calculated do NOT match the dominant frequency of the disturbance recorded during testing, either recheck the data, or attempt to rematch the figures allowing for 1½–8 km/h (1–5 mph) of speedometer error.

If the possible tire/wheel assembly rotational speed related frequencies still do not match the dominant frequency of the disturbance, the disturbance is most likely torque/load sensitive.

If after completing the Tire/Wheel Rotation Worksheet, one of the frequencies calculated DOES match the dominant frequency of the disturbance, the disturbance is related to the rotation of that component group – tire/wheel assembly related.

TIRE/WHEEL ROTATION WORKSHEET

Vehicle Information

Complaint Speed: _____ mph
Symptom: _____
Frequency: _____
Engine Speed: _____ rpm
Gear: _____

Year: _____ Model: _____
VIN: _____
Engine: _____ Trans: _____
Tire Size: _____ Axle Ratio: _____ : ___
TPC Spec: _____

Tire/Wheel Speed

Vibration Occurs at: [ ] mph ÷ 8 (km/h) 5 (mph) = [ ] increments of 8 km/h / 5 mph

Tire/Wheel Speed, RPS (Hz)

8 km/h / 5 mph increments [ ] x [ ] tire RPS * at 8 km/h / 5 mph (from table) = [ ] **1st order**

1st order [ ] x 2 = [ ] **2nd order**

1st order [ ] x 3 = [ ] **3rd order**

*RPS revolutions per second, equates to cycles per second (Hz).

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Vibration Analysis - Tire and Wheel

Test Description

The numbers below refer to the step numbers in the diagnostic table:

4. A build-up of foreign material on a tire and wheel assembly and/or a damaged, abnormally or excessively worn tire and wheel assembly could cause a vibration disturbance.
6. Tire and wheel assemblies that exhibit excessive runout when measured while mounted on the vehicle, may or may not be contributing to, or causing a vibration disturbance. On-vehicle runout, if present, could contribute to, or cause a vibration disturbance, but the cause of the on-vehicle runout may not be the tire and wheel assemblies.
7. Tire and wheel assemblies that exhibit excessive runout when measured off of the vehicle could cause a vibration disturbance.
9. Tire and wheel assemblies that exhibit marginal runout—within acceptable limits, but close to the maximum—when measured off of the vehicle could still be contributing to a vibration disturbance, if its mating hub/axle flange also exhibits marginal runout. When the tire and wheel assembly and the hub axle flange are mounted to each other, the combined stack-up of their marginal amounts of runout could combine to produce an excessive amount of runout, which could cause a vibration disturbance.
14. Brake rotors and/or brake drums, if equipped, that exhibit excessive imbalance could contribute to, or possibly cause a vibration disturbance.
15. A hub/axle flange and/or wheel studs that exhibit excessive runout could cause a vibration disturbance.

16. When the tire and wheel assembly and the hub axle flange are mounted to each other, the combined stack-up of their marginal amounts of runout could combine to produce an excessive amount of runout, which could cause a vibration disturbance. Match-mounting or vectoring the tire and wheel assembly to the hub/axle flange will modify the amount of combined runout.
18. Force variation may be present in a tire and wheel assembly that exhibited acceptable balance and runout. Force variation, if present, could contribute to, or cause a vibration disturbance.
20. Vibration disturbances could be affected by, or possibly caused by, components that are susceptible to steering input and/or torque-load input.
22. On-vehicle balancing, or finish-balancing can be used to reduce small amounts of imbalance which may be present as a result of the combined stack-up of the tire and wheel assembly with other components which may exhibit marginal balance.

Vibration Analysis - Tire and Wheel

Step	Action	Yes	No
1	Has the Vibration Analysis – Road Testing table been completed?	Go to *Step 2*	Go to *Vibration Analysis - Road Testing on page 1-39*
2	Based on the Vibration Analysis – Road Testing table, is the concern first-order tire and wheel assembly related?	Go to *Step 4*	Go to *Step 3*
3	Based on the Vibration Analysis – Road Testing table, is the concern second-order, or higher-order tire and wheel assembly related?	Go to *Step 18*	Go to *Vibration Analysis - Road Testing on page 1-39*
4	Visually inspect the tire and wheel assemblies for the following: • Debris build-up, such as packed mud, undercoating, ice/snow buildup, road tar, etc. • Damage, abnormal or excessive wear Refer to *Tire and Wheel Inspection on page 1-64*. Do any of the tire and wheel assemblies exhibit any of the conditions listed?	Go to *Step 5*	Go to *Step 6*
5	1. Remove the debris from the tire and wheel assemblies. 2. Replace the damaged, abnormally or excessively worn wheels or tires as necessary. Did you complete the repair or replacement?	Go to *Step 23*	—
6	Measure the on-vehicle runout of the tire and wheel assemblies. Refer to *Tire and Wheel Assembly Runout Measurement - On-Vehicle on page 1-65*. Does the runout measurement indicate a runout concern?	Go to *Step 7*	Go to *Step 12*
7	Measure the off-vehicle runout of the tire and wheel assemblies. Refer to *Tire and Wheel Assembly Runout Measurement - Off Vehicle on page 1-66*. Does the runout measurement indicate a runout concern?	Go to *Step 19*	Go to *Step 8*
8	Is the vehicle equipped with run-flat tires?	Go to *Step 12*	Go to *Step 9*
9	Are any of the tire and wheel assembly runout measurements marginal; within acceptable limits, but close to the maximum?	Go to *Step 10*	Go to *Step 15*
10	**Note:** Ensure that each tire and wheel assembly that is match-mounted is properly balanced before reinstalling to the vehicle. 1. Match-mount the tire-to-wheel for each tire and wheel assembly with marginal runout. Refer to *Tire-to-Wheel Match-Mounting (Vectoring) on page 1-77*. 2. Measure the runout of each match-mounted tire and wheel assembly. Refer to *Tire and Wheel Assembly Runout Measurement - Off Vehicle on page 1-66*. Were you able to significantly reduce the amount of tire and wheel assembly runout?	Go to *Step 11*	Go to *Step 19*
11	Re-measure the on-vehicle runout of the tire and wheel assemblies. Refer to *Tire and Wheel Assembly Runout Measurement - On-Vehicle on page 1-65*. Does the measurement indicate a runout concern?	Go to *Step 15*	Go to *Step 23*

Vibration Analysis - Tire and Wheel (cont'd)

Step	Action	Yes	No
12	Inspect the balance of the tire and wheel assemblies. Refer to *Tire and Wheel Assembly Balancing - Off Vehicle on page 1-72.* Are any or the tire and wheel assemblies out of balance?	Go to *Step 13*	Go to *Step 14*
13	Balance the tire and wheel assemblies as necessary. Refer to *Tire and Wheel Assembly Balancing - Off Vehicle on page 1-72.* Were you able to achieve balance?	Go to *Step 23*	Go to *Vibration Diagnostic Aids on page 1-60*
14	1. Inspect the brake rotors and brake drums, if equipped, for damage. 2. Inspect the balance of the brake rotors and brake drums, if equipped. Refer to *Brake Rotor/Drum Balance Inspection on page 1-69.* 3. Replace brake rotors and/or brake drums, if equipped, that are damaged and/or out of balance. Did you find and correct a condition?	Go to *Step 23*	Go to *Step 17*
15	1. Measure the runout of the hub/axle flanges and the wheel studs, if equipped. 2. Inspect the wheel bolts, if equipped, for straightness and damage. 3. Refer to *Hub/Axle Flange and Wheel Stud Runout Inspection on page 1-70.* 4. If the inspection procedure indicates a runout concern, replace the appropriate components: • Wheel studs, if equipped • Wheel bolts, if equipped • Wheel bearing/hub assembly Did you find and correct a condition?	Go to *Step 23*	Go to *Step 16*
16	1. Match-mount the tire and wheel assemblies-to-hub/axle flanges. Refer to *Tire and Wheel Assembly-to-Hub/Axle Flange Match-Mounting on page 1-78.* 2. Re-measure the on-vehicle runout of tire and wheel assemblies. Refer to *Tire and Wheel Assembly Runout Measurement - On-Vehicle on page 1-65.* Were you able to significantly reduce the amount of on-vehicle tire and wheel assembly runout?	Go to *Step 23*	Go to *Step 2*
17	Inspect for radial and lateral force variation. Refer to *Tire and Wheel Assembly Isolation Test on page 1-71.* Were you able to isolate one or more of the tire and wheel assemblies as the cause of the disturbance?	Go to *Step 19*	Go to *Step 20*
18	Inspect for radial and lateral force variation. Refer to *Tire and Wheel Assembly Isolation Test on page 1-71.* Were you able to isolate one or more of the tire and wheel assemblies as the cause of the disturbance?	Go to *Step 19*	Go to *Step 21*
19	Replace any tires and/or wheels that were isolated as the cause of the disturbance, as necessary. Did you complete the replacement?	Go to *Step 23*	—
20	Perform the Vibration Analysis – Hub/Axle Input table. Refer to *Vibration Analysis - Hub and/or Axle Input on page 1-46.* Did you find and correct a condition?	Go to *Step 23*	Go to *Step 22*
21	Perform the Vibration Analysis – Hub/Axle Input table. Refer to *Vibration Analysis - Hub and/or Axle Input on page 1-46.* Did you find and correct a condition?	Go to *Step 23*	Go to *Vibration Diagnostic Aids on page 1-60*
22	Finish-balance the tire and wheel assemblies on-vehicle. Refer to *Tire and Wheel Assembly Balancing - On-Vehicle on page 1-76.* Did you complete the on-vehicle finish balancing?	Go to *Step 23*	—

Vibration Analysis - Tire and Wheel (cont'd)

Step	Action	Yes	No
23	1. Install or connect any components that were removed or disconnected during diagnosis. 2. Perform the Vibration Analysis – Road Testing table. Refer to *Vibration Analysis - Road Testing on page 1-39*. Is the vibration still present?	Go to *Step 2*	System OK

Vibration Analysis - Hub and/or Axle Input

Test Description

The numbers below refer to the step numbers on the diagnostic table:

2. This test will determine the effect of turning input on the vibration.
6. This test will determine the effect of an initial heavy torque load on the vibration.
7. Damaged or worn wheel drive shafts may cause a noise or vibration that may be transferred into the passenger compartment.
8. Damaged or worn wheel bearings may cause a noise or vibration that may be transferred into the passenger compartment.
9. Damaged or worn suspension components may cause a noise or vibration that may be transferred into the passenger compartment.
10. Damaged or worn powertrain mounts and/or exhaust mounts may cause a noise or vibration that may be transferred into the passenger compartment.
11. Incorrect trim height may cause binding and/or interference between components that may produce a vibration.

Vibration Analysis - Hub and/or Axle Input

Step	Action	Yes	No
1	Has the Vibration Analysis – Road Testing table been completed?	Go to *Step 2*	Go to *Vibration Analysis - Road Testing on page 1-39*
2	1. Operate the vehicle at the speed of the vibration concern. 2. While maintaining the concern speed, drive the vehicle through slow, sweeping turns – first in one direction, then in the other direction. 3. Observe the vehicle for changes in the vibration disturbance. 4. Select a smooth, level surface, such as an empty parking lot or a remote road. 5. While maintaining the vehicle at the concern speed if possible, drive the vehicle through sharp turns; 360 degrees – first in one direction, then in the other direction. 6. Observe the vehicle for changes in the vibration disturbance. Did the characteristics of the vibration change significantly—become worse or go away—during these steps?	Go to *Step 3*	Go to *Step 6*
3	Did you hear a clicking noise and/or feel a shudder during these steps?	Go to *Step 7*	Go to *Step 4*
4	Did you hear a growling noise during these steps?	Go to *Step 8*	Go to *Step 5*
5	Did you hear a popping noise during these steps?	Go to *Step 9*	Go to *Step 12*
6	1. With the vehicle at a stand-still, apply the regular brake and place the transmission in the lowest forward gear. **Note:** Do not accelerate to the point of causing the drive wheels to squeal, slip or hop—this would obscure the results of the test. 3. Release the regular brakes and accelerate aggressively to 32 km/h (20 mph). 4. Observe the vehicle for changes in the vibration disturbance. Did you feel a shudder or shaking during these steps?	Go to *Step 7*	Go to *Vibration Diagnostic Aids on page 1-60*
7	1. Inspect the wheel drive shafts, if equipped, for damage, abnormal and/or excessive wear. 2. If the inspection indicated that a wheel drive shaft is damaged, abnormally and/or excessively worn, replace the shaft. Did you find and correct a condition?	Go to *Step 12*	Go to *Step 9*

Vibration Analysis - Hub and/or Axle Input (cont'd)

Step	Action	Yes	No
8	1. Inspect the wheel bearings for wear and/or damage. 2. Replace any of the wheel bearings found to be worn and/or damaged. Did you find and correct a condition?	Go to *Step 12*	Go to *Vibration Diagnostic Aids on page 1-60*
9	1. Inspect the following suspension components for wear, damage, looseness and/or possible contact with other vehicle components: • Struts/shock absorbers • Springs • Bushings • Insulators 2. Replace any of the suspension components found to be worn, damaged, loose and/or contacting other vehicle components. Did you find and correct a condition?	Go to *Step 12*	Go to *Step 10*
10	1. Inspect the powertrain mounts—engine, transmission, transfer case, and direct-mount differential, if equipped—and any powertrain braces for the following conditions: • Loose and/or missing fasteners • Improper alignment • Cracked, dry-rotted, and/or oil-soaked insulators • Twisted, broken, torn, and/or collapsed insulators • Bent, twisted, and/or deformed brackets 2. Replace powertrain mounts as necessary. 3. Inspect the exhaust system components for the following: • Loose and/or missing fasteners – Heat Shields – Joints and/or coupling, nuts, bolts, studs, clamps, straps – Bracket and/or insulator mounting • Inadequate clearance to body and/or chassis components Inspect with the exhaust system both COLD and HOT; in NEUTRAL, FORWARD and REVERSE gears • Improper alignment • Disconnected and/or missing insulators • Cracked, dry-rotted, and/or oil-soaked insulators • Stretched, twisted, broken, torn, and/or collapsed insulators • Bent, twisted, cracked, and/or deformed brackets 4. Repair, replace, and/or realign exhaust system components as necessary. Did you find and correct a condition?	Go to *Step 12*	Go to *Step 11*
11	Inspect the vehicle trim height and adjust as necessary. Refer to *Trim Height Inspection on page 16-42*. Did you find and correct a condition?	Go to *Step 12*	Go to *Vibration Diagnostic Aids on page 1-60*
12	1. Install or connect any components that were removed or disconnected during diagnosis. 2. Perform the Vibration Analysis – Road Testing table. Refer to *Vibration Analysis - Road Testing on page 1-39*. Is the vibration still present?	Go to *Step 2*	System OK

Vibration Analysis - Engine

Special Tools

EL-38792-A Electronic Vibration Analyzer (EVA) 2

For equivalent regional tools, refer to *Special Tools and Equipment on page 1-91*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. If powertrain related DTCs are present, there may be a powertrain performance condition present which could be a contributing cause to the customer's concern.
5. Making comparisons of the customer's vehicle with an equally equipped, same model year and type, KNOWN GOOD vehicle will help determine if certain disturbances may be characteristic of a vehicle design.

Vibration Analysis - Engine

Step	Action	Yes	No
Warning: Refer to Work Stall Test Warning on page 0-7.			
1	Has the Vibration Analysis – Road Testing table been completed?	Go to *Step 2*	Go to *Vibration Analysis - Road Testing on page 1-39*
2	Using a scan tool, determine if any DTCs are set. Were any DTCs set?	Go to *Diagnostic Starting Point - Vehicle on page 6-66*	Go to *Step 3*
3	1. Block the front wheels. 2. Apply BOTH the service brakes and the park brake. 3. With the scan tool and the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2, if available, still installed, start the engine. 4. Place the transmission in NEUTRAL or PARK. 5. Slowly increase the engine RPM to the level at which the disturbance is most noticeable. 6. Record the engine RPM obtained on the scan tool and the most dominant frequency reading if obtained on the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2, if available. 7. Place the transmission in DRIVE. 8. Slowly increase the engine RPM to the level at which the disturbance is most noticeable. 9. Record the engine RPM obtained on the scan tool and the most dominant frequency reading if obtained on the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2, if available. 10. If no frequency data was obtained, or if the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2, is not available, place the transmission into REVERSE, then repeat steps 8 and 9. Reverse-loading of the powertrain may increase or change the characteristics of the vibration. Were you able to duplicate the customer's concern?	Go to *Step 4*	Go to *Vibration Diagnostic Aids on page 1-60*
4	Did the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2 detect a dominant frequency, or was a significant vibration present?	Go to *Vibration Analysis - Engine/ Accessory Isolation on page 1-52*	Go to *Step 5*

Vibration Analysis - Engine (cont'd)

Step	Action	Yes	No
5	Compare the test results of the customer's vehicle to the results of the same tests run, at the same engine RPM, on an equally-equipped, same model year and type, KNOWN GOOD vehicle. Refer to *Vehicle-to-Vehicle Diagnostic Comparison on page 1-64*. 1. Install a scan tool into the known good vehicle. 2. Install the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2, if available, into the known good vehicle; place the sensor in exactly the same location as it was placed in the customer's vehicle. 3. Block the front wheels. 4. Apply BOTH the service brakes and the park brake. 5. Start the engine. 6. Place the transmission in NEUTRAL or PARK. 7. Slowly increase the engine RPM to the level at which the disturbance was most noticeable in the customer's vehicle. 8. Record the engine RPM obtained on the scan tool and the most dominant frequency reading if obtained on the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2, if available. 9. Place the transmission in DRIVE. 10. Slowly increase the engine RPM to the level at which the disturbance was most noticeable in the customer's vehicle. 11. Record the engine RPM obtained on the scan tool and the most dominant frequency reading if obtained on the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2, if available. 12. If no frequency data was obtained, or if the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2, is not available, place the transmission into REVERSE, then repeat steps 10 and 11. Reverse-loading of the powertrain may increase or change the characteristics of the vibration. Did both of the vehicles exhibit the same characteristics?	Go to *Vibration Diagnostic Aids on page 1-60*	Go to *Vibration Analysis - Engine/ Accessory Isolation on page 1-52*

Engine Order Classification

Engine First Order Classification

1. Convert the engine speed in revolutions per minute (RPM), recorded during duplication of the disturbance into Hertz , revolutions per second (RPS), by dividing the RPM by 60 seconds. Refer to the following example:

   1,200 RPM divided by 60 = 20 Hz (or RPS)
2. Compare the dominant frequency in Hz, recorded during duplication of the disturbance with the engine speed just converted into Hz, to determine if they are related.
3. If the dominant frequency in Hz, recorded during duplication of the disturbance and the engine speed, converted into Hz, ARE related, then an engine FIRST ORDER related disturbance is present. Engine first order disturbances are usually related to an imbalanced component. Refer to the Engine Order Related Disturbances table.
4. If the dominant frequency in Hz, recorded during duplication of the disturbance and the engine speed, converted into Hz, are NOT related, then determine if the disturbance is related to the engine's firing frequency. Proceed to Engine Firing Frequency Classification.

Engine Firing Frequency Classification

Engine firing frequency is a term used to describe the number of firing pulses (one firing pulse = one cylinder firing) that occur during ONE complete revolution of the crankshaft, multiplied by the number of crankshaft revolutions per second, Hz.

1. Calculate the engine firing frequency.
   - To determine the firing frequency of a 4-stroke engine during ONE complete revolution of the crankshaft, multiply the engine speed, converted into Hz, by HALF of the total number of cylinders in the engine.
   - For example: The engine speed, converted into Hz, was 20 Hz; if the vehicle was equipped with a V8 engine, 4 of the 8 cylinders would actually fire during ONE complete revolution of the crankshaft.
     - Multiply the converted engine speed (20 Hz) by 4 cylinders firing.

       20 Hz X 4 = 80 Hz
     - The engine firing frequency for a V8 engine at the original engine speed of 1,200 RPM, recorded during duplication of the disturbance, would be 80 Hz.
     - In like manner, a 6-cylinder engine would have a firing frequency of 60 Hz at the same engine speed of 1,200 RPM.

       20 Hz X 3 = 60 Hz

2. Compare the dominant frequency in Hz, recorded during duplication of the disturbance with the engine firing frequency in Hz, just calculated, to determine if they are related.
3. If the dominant frequency in Hz, recorded during duplication of the disturbance and the engine firing frequency in Hz, just calculated ARE related, then an engine FIRING FREQUENCY related disturbance is present. Engine firing frequency disturbances are usually related to improper isolation of a component. Refer to the Engine Order Related Disturbances table.
4. If the dominant frequency in Hz, recorded during duplication of the disturbance and the engine firing frequency in Hz, just calculated are NOT related, then determine if the disturbance is related to another engine order classification. Proceed to Other Engine Order Classification.

Other Engine Order Classification

1. Multiply the engine speed, converted into Hz, recorded during duplication of the disturbance by different possible order-numbers, other than 1 (first order) or the number used to determine the firing frequency of the engine.
2. Compare the dominant frequency in Hz, recorded during duplication of the disturbance with the other possible engine orders just calculated, to determine if they are related.
3. If the dominant frequency in Hz, recorded during duplication of the disturbance and one of the other engine order frequencies in Hz, just calculated ARE related, then an engine related disturbance of that order is present. If an engine related disturbance is present that is NOT related to first order or firing frequency, then it could be related to an engine driven accessory system. Proceed to Engine Driven Accessories Related to Engine Order.

Engine Driven Accessories Related to Engine Order

Engine driven accessory systems can be related to specific engine orders depending upon the relationship of the accessory pulley diameter to the crankshaft pulley diameter. For example:

- If the crankshaft pulley measured 20 cm (8 in) in diameter and one of the engine driven accessory pulleys measured 10 cm (4 in) in diameter, then that accessory pulley would rotate 2 times for every one rotation of the crankshaft pulley. If that accessory system was not isolated properly, or was not operating properly, it would be identifiable as a 2nd order engine related disturbance.
- In like manner, if an engine driven accessory pulley measured 5 cm (2 in) in diameter, then that accessory pulley would rotate 4 times for every one rotation of the crankshaft pulley. If that accessory system was not isolated properly, or was not operating properly, it would be identifiable as a 4th order engine related disturbance.

Engine driven accessories that contribute to, are excited by, or are the sole cause of a disturbance are usually doing so because of improper isolation that causes a transfer path into the passenger compartment or to another major component of the vehicle body.

Using the *EL-38792-VS* Vibrate Software, accurately measuring the diameters of the accessory pulleys and the crankshaft pulley, and performing the appropriate diagnostic procedures completely will lead to the specific accessory system which is either contributing to, or causing the customer's concern.

Engine Order Related Disturbances

Engine Order	Engine Arrangement						
	L4 W/O Balance Shaft	L4 With Balance Shaft	L5	L6	60 Degree V6	90 Degree V6 With Balance Shaft	90 Degree V8
½ Order Torque Sensitive	Abnormal – Likely Single Cylinder Misfire	Abnormal – Likely Single Cylinder Misfire	Abnormal – Likely Single Cylinder Misfire	Abnormal – Likely Single Cylinder Misfire	Abnormal – Likely Single Cylinder Misfire and/or EGR/Fuel Variance	Abnormal – Likely Single Cylinder Misfire and/or EGR/Fuel Variance	Abnormal – Likely Single Cylinder Misfire
1st Order	Abnormal – Likely Component Imbalance	Abnormal – Likely Component Imbalance	Abnormal – Likely Component Imbalance	Abnormal – Likely Component Imbalance	Abnormal – Likely Component Imbalance	Abnormal – Likely Component Imbalance	Abnormal – Likely Component Imbalance
1½ Order Torque Sensitive	Possible Engine Driven Accessory Related	Possible Engine Driven Accessory Related	Possible Engine Driven Accessory Related	Possible Engine Driven Accessory Related	Abnormal – Likely Bank to Bank EGR/ Fuel Variance Possible Engine Driven Accessory Related	Abnormal – Likely Bank to Bank EGR/ Fuel Variance Possible Engine Driven Accessory Related	Possible Engine Driven Accessory Related

Engine Order Related Disturbances (cont'd)

Engine Order	Engine Arrangement						
	L4 W/O Balance Shaft	L4 With Balance Shaft	L5	L6	60 Degree V6	90 Degree V6 With Balance Shaft	90 Degree V8
2nd Order Non Torque Sensitive	Characteristic of Engine Arrangement – Possible Powertrain Isolation Related	Possible Engine Driven Accessory Related	Possible Engine Driven Accessory Related	Possible Engine Driven Accessory Related	Characteristic of Engine Arrangement – Possible Powertrain Isolation Related	Characteristic of Engine Arrangement – Possible Powertrain Isolation Related	Possible Engine Driven Accessory Related
2nd Order Torque Sensitive	Characteristic – ENGINE FIRING FREQUENCY – Possible Powertrain Isolation Related	Characteristic – ENGINE FIRING FREQUENCY – Possible Powertrain Isolation Related	Possible Engine Driven Accessory Related	Possible Engine Driven Accessory Related	Possible Engine Driven Accessory Related	Possible Engine Driven Accessory Related	Abnormal – Likely Bank to Bank EGR/ Fuel Variance
	Possible Engine Driven Accessory Related	Possible Engine Driven Accessory Related					Possible Engine Driven Accessory Related
2 ½ Order Torque Sensitive	Possible Engine Driven Accessory Related	Possible Engine Driven Accessory Related	Characteristic – ENGINE FIRING FREQUENCY – Possible Powertrain Isolation Related	Possible Engine Driven Accessory Related	Possible Engine Driven Accessory Related	Possible Engine Driven Accessory Related	Possible Engine Driven Accessory Related
			Possible Engine Driven Accessory Related				
3rd Order Torque Sensitive	Possible Engine Driven Accessory Related	Possible Engine Driven Accessory Related	Possible Engine Driven Accessory Related	Characteristic – ENGINE FIRING FREQUENCY – Possible Powertrain Isolation Related	Characteristic – ENGINE FIRING FREQUENCY – Possible Powertrain Isolation Related	Characteristic – ENGINE FIRING FREQUENCY – Possible Powertrain Isolation Related	Possible Engine Driven Accessory Related
				Possible Engine Driven Accessory Related	Possible Engine Driven Accessory Related	Possible Engine Driven Accessory Related	
4th Order Torque Sensitive	Characteristic – Minimal Amount – of Engine Arrangement – Possible Powertrain Isolation Related	Characteristic – Minimal Amount – of Engine Arrangement – Possible Powertrain Isolation Related	Possible Engine Driven Accessory Related	Possible Engine Driven Accessory Related	Possible Engine Driven Accessory Related	Possible Engine Driven Accessory Related	Characteristic – ENGINE FIRING FREQUENCY – Possible Powertrain Isolation Related
	Possible Engine Driven Accessory Related	Possible Engine Driven Accessory Related					Possible Engine Driven Accessory Related

Vibration Analysis - Engine/ Accessory Isolation

Test Description

The numbers below refer to the step numbers on the diagnostic table.

5. A loose, damaged, misaligned, or defective powertrain insulator and/or bracket may create a transfer path into the passenger compartment.
6. A loose, damaged, misaligned, or defective exhaust system insulator and/or bracket may create a transfer path into the passenger compartment.
7. Incorrectly seated and/or aligned powertrain components and/or exhaust system components may create a transfer path into the passenger compartment.

   When loosening powertrain mounts in order to re-bed the powertrain observe the following:

   Do not loosen the mount bracket-to-engine bolts/ nuts, do not loosen the mount bracket-to-vehicle frame bolts/nuts if mount brackets are used.

   Loosen the mount-to-mount bracket bolts/nuts if mount brackets are used, or loosen the mount-to-slotted holes in vehicle frame bolts/nuts if a direct-mount design is used.
8. Non-rotating engine driven accessory component systems can no longer produce a unique disturbance.
9. Non-rotating engine driven accessory components can no longer produce a unique disturbance. If a disturbance is still present, but the characteristics have been altered, it is possible that these component systems are acting as a transfer path for engine firing frequency or a first order engine disturbance.

   If a disturbance is still present, but the characteristics have NOT been altered, it is NOT likely that these component systems are acting as a transfer path for engine firing frequency or a first order engine disturbance.
10. If the mark placed on the face of an engine driven accessory pulley seems to stand still while running this test, then that accessory system is either responding to an existing frequency, such as engine firing pulses, or creating a disturbance.
11. A loose, damaged, misaligned, or defective engine driven accessory system insulator and/or bracket may create a transfer path into the passenger compartment.
12. Removing the engine driven accessory and bracket, or brackets from the engine allows a thorough inspection to determine if any conditions are present that may create a transfer path into the passenger compartment.

Vibration Analysis - Engine/Accessory Isolation

Step	Action	Yes	No
Warning: Refer to Work Stall Test Warning on page 0-7.			
1	Were you sent here from the Vibration Analysis – Engine table?	Go to *Step 2*	Go to *Vibration Analysis - Engine on page 1-48*
2	Is the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2, available?	Go to *Step 3*	Go to *Step 5*
3	1. Using the engine RPM and frequency data recorded for the customer's vehicle, determine the order of engine rotation to which the disturbance is related. 2. Determine the possible causes of the disturbance as it relates to a specific order of engine rotation. Refer to *Engine Order Classification on page 1-49*. Does the Engine Order Classification table indicate that the disturbance is of the same order as the engine firing frequency?	Go to *Step 5*	Go to *Step 4*
4	Does the Engine Order Classification table indicate that the disturbance is likely related to engine driven accessories?	Go to *Step 8*	Go to *Step 5*
5	Inspect the powertrain mounts—engine, transmission, transfer case, and direct-mount drive axle, if equipped—and any powertrain braces for the following conditions: • Loose and/or missing fasteners • Improper alignment • Cracked, dry-rotted, and/or oil-soaked insulators • Twisted, broken, torn, and/or collapsed insulators • Bent, twisted, and/or deformed brackets Realign or replace powertrain mounts as indicated by the inspection. Did you find and correct a condition?	Go to *Step 13*	Go to *Step 6*

Vibration Analysis - Engine/Accessory Isolation (cont'd)

Step	Action	Yes	No
6	Inspect the exhaust system components for the following: • Loose and/or missing fasteners – Heat Shields – Joints and/or couplings: Nuts, bolts, studs, clamps, straps – Bracket and/or insulator mounting • Inadequate clearance to body and/or chassis components Inspect with the exhaust system both COLD and HOT; in NEUTRAL, FORWARD and REVERSE gears • Improper alignment • Disconnected and/or missing insulators • Cracked, dry-rotted, and/or oil-soaked insulators • Stretched, twisted, broken, torn, and/or collapsed insulators • Bent, twisted, cracked, and/or deformed brackets Repair, replace, and/or realign exhaust system components as indicated by the inspection. Did you find and correct a condition?	Go to *Step 13*	Go to *Step 7*
7	Perform the Powertrain Mount Balance Procedure if available or perform the following procedure to re-bed the powertrain: 1. Loosen, but do not remove, all powertrain mounts and exhaust system hangers. 2. Ensure that the exhaust flexible coupling, if equipped, moves freely. 3. Start the engine. 4. Settle the powertrain by shifting the transmission from DRIVE to REVERSE. 5. Place the transmission into NEUTRAL. 6. Turn OFF the ignition. 7. Tighten all of the loosened fasteners with the powertrain in a relaxed position. Did you complete the operation?	Go to *Step 13*	—
8	**Caution:** Do not run the engine for longer than 60 seconds with the accessory drive belt, or belts removed, or overheating and/or damage may result. 1. Remove the engine accessory drive belt, or belts. 2. Block the front wheels. 3. Apply BOTH the service brakes and the park brake. 4. With the scan tool still installed, start the engine. 5. Place the transmission in NEUTRAL or PARK. 6. Increase the engine RPM to the level recorded during duplication of the disturbance. 7. Allow the engine to idle, then place the transmission in DRIVE. 8. Increase the engine RPM to the level recorded during duplication of the disturbance. 9. Turn OFF the ignition. 10. Install the engine accessory drive belt, or belts. Was the disturbance significantly reduced or eliminated?	Go to *Step 10*	Go to *Step 9*
9	Were the characteristics of the disturbance altered but still present?	Go to *Step 11*	Go to *Step 15*

Vibration Analysis - Engine/Accessory Isolation (cont'd)

Step	Action	Yes	No
10	1. Mark the face of the suspected accessory pulleys, including any related idler pulleys, near the outer edge with a paint mark. 2. Install the *EN-38792-25* Inductive Pickup Timing Light, to the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2. For information on the use of the EVA features, refer to *Electronic Vibration Analyzer (EVA) Description and Operation on page 1-88*. 3. Block the front wheels. 4. Apply BOTH the service brakes and the park brake. 5. With the scan tool and the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2, still installed, start the engine. 6. Select the Smart Strobe feature on the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2. 7. Enter the recorded frequency of the disturbance as the initial frequency for strobe operation. 8. Have an assistant place the transmission in NEUTRAL or PARK. 9. Slowly increase the engine RPM to the level recorded during duplication of the disturbance, then maintain that speed. 10. Using the *EL-38792-A* Inductive Pickup Timing Light, check each of the suspected accessory pulleys to determine if any of them is related to the frequency of the disturbance. Check each of the accessory systems, both engaged and under maximum load and disengaged or under minimum load. 11. Allow the engine to idle, then place the transmission in DRIVE. 12. Slowly increase the engine RPM to the level recorded during duplication of the disturbance, then maintain that speed closely. 13. Using the *EN-38792-25* Inductive Pickup Timing Light, check each of the suspected accessory pulleys to determine if any of them is related to the frequency of the disturbance. Check each of the accessory systems, both engaged and under maximum load and disengaged or under minimum load. 14. Turn OFF the ignition. Did you identify an engine driven accessory system as being related to the frequency of the disturbance?	Go to *Step 11*	Go to *Vibration Diagnostic Aids on page 1-60*
11	Inspect the components of the engine driven accessory system for the following: • Loose and/or missing fasteners – Heat Shields, if equipped – Joints and/or couplings: Nuts, bolts, studs, clamps, straps – Bracket and/or insulator mounting • Inadequate clearance to body and/or chassis components Inspect with the accessory system both under a LOAD and NOT loaded • Improper alignment • Bent or damaged pulleys • Disconnected and/or missing insulators • Cracked, dry-rotted, and/or oil-soaked component insulators • Stretched, twisted, broken, torn, and/or collapsed component insulators • Bent, twisted, cracked and/or deformed component brackets Repair, replace, and/or realign the engine driven accessory system components as indicated by the inspection. Did you find and correct a condition?	Go to *Step 13*	Go to *Step 12*

Vibration Analysis - Engine/Accessory Isolation (cont'd)

Step	Action	Yes	No
12	1. Remove the engine driven accessory and bracket, or brackets from the engine. 2. Thoroughly inspect the accessory bracket, or brackets, bolts/nuts/studs, and the accessory itself for signs of the following: Bent, twisted, cracked and/or deformed conditions 3. Replace any of the components found to exhibit any of these conditions. 4. Reinstall the components to the engine. Did you find and correct a condition?	Go to *Step 13*	Go to *Step 17*
13	Check the vehicle to determine if the disturbance is now significantly reduced or eliminated. Perform the following steps: 1. Install a scan tool into the customer's vehicle. 2. Install the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2, if available, into the customer's vehicle; place the sensor in exactly the same location as it was originally placed in the vehicle. 3. Block the front wheels. 4. Apply BOTH the service brakes and the park brake. 5. Start the engine. 6. Place the transmission in NEUTRAL or PARK. 7. Slowly increase the engine RPM to the level at which the disturbance was most noticeable. 8. Record the engine RPM obtained on the scan tool and the most dominant frequency reading if obtained on the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2, if available. 9. Place the transmission in DRIVE. 10. Slowly increase the engine RPM to the level at which the disturbance was most noticeable. 11. Record the engine RPM obtained on the scan tool and the most dominant frequency reading if obtained on the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2, if available. 12. If the disturbance has been significantly reduced or eliminated, confirm the results by placing the transmission into REVERSE, then repeat steps 10 and 11. Reverse-loading of the powertrain may increase or change the characteristics of the vibration. Has the disturbance been significantly reduced or eliminated?	Go to *Step 18*	Go to *Step 14*
14	Have you investigated powertrain isolation as a possible cause of the disturbance?	Go to *Step 15*	Go to *Step 5*
15	Have you investigated engine driven accessories as a possible cause of the disturbance?	Go to *Vibration Analysis - Engine Balance on page 1-56*	Go to *Step 16*
16	Is the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2 available?	Go to *Step 8*	Go to *Vibration Diagnostic Aids on page 1-60*
17	Replace the engine driven accessory component causing the disturbance. Did you complete the replacement?	Go to *Step 18*	—
18	1. Install or connect any components that were removed or disconnected during diagnosis. 2. Perform the Vibration Analysis – Road Testing table. Refer to *Vibration Analysis - Road Testing on page 1-39*. Is the disturbance still present?	Go to *Step 2*	System OK

Vibration Analysis - Engine Balance

Test Description

The numbers below refer to the step numbers on the diagnostic table.

4. If sufficient clearance exists to separate the transmission torque converter from the engine flywheel/flexplate, then further tests can be used to isolate the transmission from the engine.
5. An engine flywheel/flexplate that has excessive lateral runout, when combined with the mass of the transmission torque converter, can produce a disturbance.
6. An engine flywheel/flexplate that is loose at the engine crankshaft or that is cracked or damaged, when combined with the mass of the transmission torque converter, can produce a disturbance.
7. This step is designed to isolate the transmission from the engine to determine if the disturbance is related to the engine ONLY.
9. Re-indexing the transmission torque converter to the engine flywheel/flexplate alters the balance relationship between the torque converter and the rear of the engine.
11. Placing the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2 sensor onto the underside of the engine oil pan along the FRONT and the REAR edge allows for a determination to be made, which will help to narrow down the cause of the disturbance.
13. An engine flywheel that has excessive lateral runout, when combined with the extra mass of the clutch pressure plate and clutch driven plate, can produce a disturbance.
14. The clutch pressure plate and the engine flywheel are marked for proper indexing of the heavy-spot of one to the light-spot of the other. Improper indexing of the pressure plate to the flywheel can produce a disturbance.
15. An engine flywheel that is loose at the engine crankshaft or that is cracked, damaged and/or missing balance weights; and/or a clutch pressure plate and clutch driven plate that has loose springs, cracks, warpage, damage and/or missing balance weights – can produce a disturbance when their mass is combined.
16. An engine flywheel that is loose at the engine crankshaft or that is cracked, damaged and/or missing balance weights; and/or a clutch pressure plate and clutch driven plate that has loose springs, cracks, warpage, damage and/or missing balance weights – can produce a disturbance when their mass is combined.
17. Re-indexing the pressure plate to the engine flywheel alters the balance relationship between the pressure plate/flywheel assembly and the rear of the engine.
18. An engine flywheel/flexplate that is damaged, misaligned, and/or imbalanced, can produce a disturbance.
19. An engine crankshaft balancer that is damaged, misaligned, and/or imbalanced, can produce a disturbance.

Vibration Analysis - Engine Balance

Step	Action	Yes	No
1	Were you sent here from the Vibration Analysis – Engine/Accessory Isolation table?	Go to *Step 2*	Go to *Vibration Analysis - Engine/ Accessory Isolation on page 1-52*
2	Is the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2, available?	Go to *Step 3*	Go to *Vibration Diagnostic Aids on page 1-60*
3	Is the vehicle equipped with a manual transmission?	Go to *Step 11*	Go to *Step 4*
4	1. Raise and support the vehicle. Refer to *Lifting and Jacking the Vehicle on page 1-31*. 2. Remove the flywheel/flexplate-to-torque converter bolts access cover, if equipped. 3. Determine if sufficient clearance exists to separate the transmission torque converter away from the engine flywheel/ flexplate and safely secure the torque converter from accidentally engaging with the flywheel/flexplate. Is there sufficient clearance to separate and safely secure the transmission torque converter away from the engine flywheel/ flexplate?	Go to *Step 5*	Go to *Step 11*

Vibration Analysis - Engine Balance (cont'd)

Step	Action	Yes	No
5	1. With the flywheel/flexplate-to-torque converter access cover still removed, and with the vehicle still raised, mark the position of the transmission torque converter in relation to the engine flywheel/flexplate. 2. Disconnect the torque converter and move it away from the flywheel/flexplate. 3. Secure the transmission torque converter away from the engine flywheel/flexplate to avoid accidental engagement with the flywheel/flexplate. 4. Lower the vehicle, start the engine and allow the engine to idle. 5. Raise and support the vehicle. Refer to *Lifting and Jacking the Vehicle on page 1-31.* 6. Visually inspect the flywheel/flexplate for excessive lateral runout. 7. Lower the vehicle. 8. Turn OFF the ignition. Did the flywheel/flexplate exhibit excessive lateral runout?	Go to *Step 8*	Go to *Step 6*
6	1. Raise and support the vehicle. Refer to *Lifting and Jacking the Vehicle on page 1-31.* 2. Inspect the flywheel/flexplate for the following: • Looseness at the engine crankshaft • Cracks and/or damage • Missing balance weights Did the flywheel/flexplate exhibit any of the conditions listed?	Go to *Step 8*	Go to *Step 7*
7	1. With the transmission torque converter still secured away from the engine flywheel/flexplate to avoid accidental engagement with the flywheel/flexplate, lower the vehicle. 2. Block the front wheels. 3. Apply BOTH the service brakes and the park brake. 4. With the scan tool and the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2 still installed, start the engine. 5. Place the transmission in NEUTRAL or PARK. 6. Slowly increase the engine RPM to the level at which the disturbance is most noticeable. 7. Record the engine RPM obtained on the scan tool and the most dominant frequency reading if obtained on the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2. 8. Turn OFF the ignition. Has the disturbance been significantly reduced or eliminated?	Go to *Step 9*	Go to *Step 11*
8	1. If the flywheel/flexplate is loose at the engine crankshaft, tighten the flywheel/flexplate mounting bolts in sequence and to specification. 2. If the flywheel/flexplate is cracked, damaged, and/or has missing balance weights, replace the damaged flywheel/flexplate. Did you complete the tightening or replacement?	Go to *Step 20*	—

Vibration Analysis - Engine Balance (cont'd)

Step	Action	Yes	No
9	1. Raise and support the vehicle. Refer to *Lifting and Jacking the Vehicle on page 1-31.* 2. Re-index the transmission torque converter to the engine flywheel/flexplate, 120 degrees from its original position. 3. Reconnect the transmission torque converter to the engine flywheel/flexplate. 4. Lower the vehicle. 5. Block the front wheels. 6. Apply BOTH the service brakes and the park brake. 7. With the scan tool and the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2 still installed, start the engine. 8. Place the transmission in NEUTRAL or PARK. 9. Slowly increase the engine RPM to the level at which the disturbance is most noticeable. 10. Record the engine RPM obtained on the scan tool and the most dominant frequency reading if obtained on the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2. 11. If the disturbance is still noticeable, re-index the torque converter again to obtain the least amount of disturbance. Has the disturbance been significantly reduced or eliminated?	Go to *Step 20*	Go to *Step 10*
10	Replace the out-of-balance transmission torque converter. Did you complete the replacement?	Go to *Step 20*	—
11	1. Raise and support the vehicle. Refer to *Lifting and Jacking the Vehicle on page 1-31.* 2. Position the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2 sensor onto the underside of the engine oil pan, along the FRONT edge. 3. Lower the vehicle. 4. Block the front wheels. 5. Apply BOTH the service brakes and the park brake. 6. With the scan tool and the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2, still installed, start the engine. 7. Place the transmission in NEUTRAL or PARK. 8. Slowly increase the engine RPM to the level at which the disturbance is most noticeable. 9. Record the engine RPM obtained on the scan tool and the most dominant frequency reading if obtained on the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2 from the underside of the engine oil pan. 10. Repeat steps 1 through 9, placing the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2 sensor onto the underside of the engine oil pan, along the REAR edge. Is the disturbance greater along the FRONT of the engine?	Go to *Step 19*	Go to *Step 12*
12	Is the vehicle equipped with an automatic transmission?	Go to *Step 18*	Go to *Step 13*
13	1. Raise and support the vehicle. Refer to *Lifting and Jacking the Vehicle on page 1-31.* 2. Remove the flywheel inspection cover. 3. Start the engine. Allow the engine to idle. 4. Visually inspect the engine flywheel clutch surface for excessive lateral runout. Does the engine flywheel clutch surface exhibit excessive lateral runout?	Go to *Step 18*	Go to *Step 14*

Vibration Analysis - Engine Balance (cont'd)

Step	Action	Yes	No
14	Inspect the clutch pressure plate to engine flywheel mounting for proper factory indexing. Is the clutch pressure plate properly indexed to the engine flywheel?	Go to *Step 16*	Go to *Step 15*
15	1. Remove the clutch pressure plate and clutch driven plate from the engine flywheel. 2. Inspect the engine flywheel for the following: • Looseness at the engine crankshaft • Cracks, warpage and/or damage • Missing balance weights 3. Inspect the clutch pressure plate and clutch driven plate for the following: • Loose and/or damaged clutch driven plate damper springs • Loose and/or damaged clutch pressure plate diaphragm springs • Cracks, warpage and/or damage • Missing balance weights Do any of the above conditions exist?	Go to *Step 18*	Go to *Step 17*
16	1. Remove the clutch pressure plate and clutch driven plate from the engine flywheel. 2. Inspect the engine flywheel for the following: • Looseness at the engine crankshaft • Cracks, warpage and/or damage • Missing balance weights 3. Inspect the clutch pressure plate and clutch driven plate for the following: • Loose and/or damaged clutch driven plate damper springs • Loose and/or damaged clutch pressure plate diaphragm springs • Cracks, warpage and/or damage • Missing balance weights Do any of the above conditions exist?	Go to *Step 18*	Go to *Vibration Diagnostic Aids on page 1-60*
17	Re-index the pressure plate to the engine flywheel. Did you complete the re-indexing?	Go to *Step 20*	—
18	Replace the engine flywheel/flexplate. Did you complete the replacement?	Go to *Step 20*	—
19	Replace the engine crankshaft balancer. Did you complete the replacement?	Go to *Step 20*	—

Vibration Analysis - Engine Balance (cont'd)

Step	Action	Yes	No
20	Check the vehicle to determine if the disturbance is now significantly reduced or eliminated. Perform the following steps: 1. Install or connect any components that were removed or disconnected during diagnosis. 2. Install a scan tool into the customer's vehicle. 3. Install the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2, if available, into the customer's vehicle; place the sensor in exactly the same location as it was originally placed in the vehicle. 4. Block the front wheels. 5. Apply BOTH the service brakes and the park brake. 6. Start the engine. 7. Place the transmission in NEUTRAL or PARK. 8. Slowly increase the engine RPM to the level at which the disturbance was most noticeable. 9. Record the engine RPM obtained on the scan tool and the most dominant frequency reading if obtained on the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2, if available. 10. Place the transmission in DRIVE. 11. Slowly increase the engine RPM to the level at which the disturbance was most noticeable. 12. Record the engine RPM obtained on the scan tool and the most dominant frequency reading if obtained on the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2, if available. 13. If the disturbance has been significantly reduced or eliminated, confirm the results by placing the transmission into REVERSE, then repeat steps 11 and 12. Reverse-loading of the powertrain may increase or change the characteristics of the vibration. Has the disturbance been significantly reduced or eliminated?	Go to *Step 21*	Go to *Vibration Diagnostic Aids on page 1-60*
21	Perform the Vibration Analysis – Road Testing table. Refer to *Vibration Analysis - Road Testing on page 1-39*. Is the disturbance still present?	Go to *Vibration Diagnostic Aids on page 1-60*	System OK

Vibration Diagnostic Aids

Note: If you have not reviewed the Diagnostic Starting Point – Vehicle and completed the Vibration Analysis tables as indicated, refer to *Diagnostic Starting Point - Vehicle on page 6-66* BEFORE proceeding.

The diagnostic information contained in this Diagnostic Aids section will help you determine the correct course of action to take for the following 4 main conditions. Refer to the appropriate condition from this list:

- *Vibration Diagnostic Aids - Vibration Intermittent or Not Duplicated on page 1-60*
- *Vibration Diagnostic Aids - Vibration Duplicated, Component Not Identified on page 1-61*
- *Vibration Diagnostic Aids - Vibration Duplicated, Difficult to Isolate/Balance Component on page 1-62*
- *Vibration Diagnostic Aids - Vibration Duplicated, Appears to Be Potential Operating Characteristic on page 1-62*

Vibration Diagnostic Aids - Vibration Intermittent or Not Duplicated

Note: If you have not completed the Vibration Analysis tables as indicated and reviewed Vibration Diagnostic Aids, refer to *Vibration Diagnostic Aids on page 1-60* BEFORE proceeding.

If you have not been able to duplicate the vibration concern or have only been able to duplicate the concern intermittently, review the following information.

Most vibration concerns that cannot be duplicated are due to either specific conditions that are not present during the duplicating attempts, or due to not following the procedures designed to duplicate concerns properly and in the sequence indicated.

Specific Conditions Can Affect the Condition

Consider the following conditions which may not have been present while attempts were made to duplicate the vibration concern. Attempt to obtain more specific information from the customer as to the EXACT conditions that are present when they experience the vibration which they are concerned about. Attempt to duplicate the vibration concern again while recreating the EXACT conditions necessary, except those which pose a safety concern or are outside the boundaries of normal operating conditions, such as loading the vehicle beyond its designed weight ratings, etc.

Most attempts to duplicate a vibration concern are made after the vehicle has been driven to the repair facility and perhaps even sat inside the building for a time; the vehicle may be too warm to detect the concern during duplication efforts. The opposite could

also occur; perhaps the vehicle has sat out in the cold for a time and fails to reach full operating temperatures during attempts to duplicate the concern.

Temperature, Ground-Out, Accessory Load

Flat Spots on Tires

Tires which have sat and been cool for a time can develop flat spots.

Irregular Wear on Tire Treads

Tires which have sat and been cool for a time will be stiffer and any irregular wear conditions will be more noticeable than they will be once the tires have warmed and softened.

Exhaust System Growth

Exhaust systems may exhibit a ground-out condition when cool which goes away once the system is hot. The opposite may be true that the exhaust system is fine when cool but a ground-out condition occurs once the system reaches operating temperatures. Exhaust systems can grow by 2½–5 cm (1–2 in) when hot.

Engine-Driven Accessory Noises

Note: When a stethoscope equipped with a probe is used to assist in identifying possible vibrating components, the results must be compared to the sound quality of the same accessory, in a equally-equipped, same model year and type, KNOWN GOOD vehicle, and under the same conditions. Refer to *Vehicle-to-Vehicle Diagnostic Comparison on page 1-64*.

A stethoscope equipped with a probe can be used as an additional means to assist in identifying accessories which may be causing or contributing to a vibration concern.

- Belt Whipping

  An engine accessory drive belt, or belts could exhibit a whipping condition if a belt is deteriorating and deposits are building up on the underside of the belt.
- Loose Mounting Brackets or Component Ground-Out

  Engine-driven accessories such as a generator, a power steering pump, or an air conditioning compressor could exhibit noise conditions due to either loose mounting brackets or due to related components of the system in a ground-out condition during certain operation of that accessory system.
- Cold or Hot

  Accessories could exhibit noise conditions when cool which go away once they are fully warmed-up, or the opposite may be true.
- Load on an Accessory Component

  Accessories could exhibit a noise condition while under a heavy load – perhaps when combined with a cool or fully warmed-up condition.
- Bent or Misaligned Pulleys

  Bent or mis-aligned pulleys in one or more engine-driven accessory systems could contribute to a noise or vibration condition.
- Fluid Level in Accessory Systems

  Accessories could exhibit a noise condition due to an abnormal amount of fluid contained in the system of which the accessory is a part. For example:
  - An improper power steering fluid level could produce noises in the power steering system.
  - An improper air conditioning refrigerant level or an excessive amount of refrigerant oil could produce noises or possibly vibrations in the air conditioning system.
- Incorrect Fluid Type in Accessory Systems

  Accessories could exhibit a noise condition due to the incorrect type of fluid contained in the system of which the accessory is a part.

Vehicle Payload

The vibration concern may only occur when the vehicle is carrying heavy payloads or towing a trailer; the vehicle may have been empty during duplication efforts.

Heavy Payload

The vehicle may have been empty during attempts to duplicate the vibration concern, but the customer may actually experience the vibration concern while the vehicle is carrying a large payload.

Trailer Towing

The customer may experience the vibration concern only while towing a trailer.

Roadway Selection

The selection of roadways used to perform the vibration duplication procedures is likely to be in the near vicinity of the repair facility and may not provide a road surface that is similar enough to the surface on which the customer usually drives the vehicle.

The customer may only experience the vibration on a particular roadway. Perhaps the roadway is overly crowned or is very bumpy or rough.

Vibration Diagnostic Aids - Vibration Duplicated, Component Not Identified

Note: If you have not completed the Vibration Analysis tables as indicated and reviewed Vibration Diagnostic Aids, refer to *Vibration Diagnostic Aids on page 1-60* BEFORE proceeding.

Aftermarket Add-On Accessories

Aftermarket accessories which have been added to the vehicle can actually transmit and magnify INHERENT component rotational frequencies, if the accessories were not installed correctly.

An accessory should be installed in such a way that it is isolated from becoming a possible transfer path into the rest of the vehicle. For example, if a set of running boards has been installed improperly and they are sensitive to a particular frequency of a rotating component, the running boards could begin to respond

to the frequency and actually create a disturbance once the amplitude of the frequency reaches a high enough point , probably at a higher vehicle speed.

If the same set of running boards were installed properly—isolated properly—the transfer path would be removed and the disturbance would no longer be present.

Vibration Diagnostic Aids - Vibration Duplicated, Difficult to Isolate/ Balance Component

Note: If you have not completed the Vibration Analysis tables as indicated and reviewed Vibration Diagnostic Aids, refer to *Vibration Diagnostic Aids on page 1-60* BEFORE proceeding.

If you have duplicated the vibration concern but have had difficulty in balancing a component or isolating a component, refer to the following information.

Most vibration concerns are corrected or eliminated through correcting excessive runout of a component, correcting balance of a component or isolating a component which has come into abnormal contact with another object/component.

Components which can generate a lot of energy and are experiencing excessive runout, imbalance or ground-out can produce a vibration with a strong enough amplitude that the vibration can transmit to components which are closely related. This type of a condition is usually related to and sensitive to torque-load. The most likely system that could exhibit this type of a condition is the driveline.

Vibration Diagnostic Aids - Vibration Duplicated, Appears to Be Potential Operating Characteristic

Note: If you have not completed the Vibration Analysis tables as indicated and reviewed Vibration Diagnostic Aids, refer to *Vibration Diagnostic Aids on page 1-60* BEFORE proceeding.

Check Service Bulletins

If BOTH of the following statements are TRUE, then check service bulletins for the condition identified. If the condition has already been identified and investigated prior to this vehicle, and has been determined to be something that is not truly an operating characteristic or that perhaps is not design-intent, there will likely be adjustments or corrections identified which will address the condition.

- You CAREFULLY followed the steps indicated through reviewing the Diagnostic Starting Point – Vibration Diagnosis and completing the Vibration Analysis tables identified and you have duplicated the vibration concern.
- You have come to the conclusion through comparison with a very equally-equipped, same model year and type, KNOWN GOOD vehicle that the customer's concern is a condition that appears to be a potential operating characteristic of the vehicle.

Symptoms - Vibration Diagnosis and Correction

Note: Perform the following steps in sequence BEFORE using these symptom tables.

1. Begin the diagnosis of a vibration concern by reviewing *Diagnostic Starting Point - Vehicle on page 6-66* to become familiar with the diagnostic process used to properly diagnose vibration concerns.
2. Perform the *Vibration Analysis - Road Testing on page 1-39* table before using these symptom tables in order to duplicate and effectively diagnose the customer's concern.

Symptom Tables

Refer to a Vibration Analysis table as indicated in the following symptom tables, based on the most dominant characteristic of the customer's vibration concern, felt or heard, that is evident during the appropriate condition of the occurrence.

Vibration Symptoms that are Felt

Category	Description	Typical Frequency Range	Condition of Occurrence	Area of Focus
Shake	Can sometimes be seen or felt in the steering wheel, seat or console. Related terminology: shimmy, wobble, waddle, shudder, hop	5–20 Hz	Vehicle Speed Sensitive Still occurs during coast down in NEUTRAL	Go to *Vibration Analysis - Tire and Wheel on page 1-43*
			Vehicle Speed Sensitive Affected by torque/load and/or steering input	Go to *Vibration Analysis - Hub and/or Axle Input on page 1-46*
			Engine Speed Sensitive	Go to *Vibration Analysis - Engine on page 1-48*

Vibration Symptoms that are Felt (cont'd)

Category	Description	Typical Frequency Range	Condition of Occurrence	Area of Focus
Roughness	Similar to the feeling of holding a jigsaw.	20–50 Hz	Vehicle Speed Sensitive Still occurs during coast down in NEUTRAL	Go to *Vibration Analysis - Tire and Wheel on page 1-43*
			Vehicle Speed Sensitive Affected by torque/load and/or steering input	Go to *Vibration Analysis - Hub and/or Axle Input on page 1-46*
			Engine Speed Sensitive	Go to *Vibration Analysis - Engine on page 1-48*
Buzz	Similar to the feeling of holding an electric razor. May be felt in the hands through the steering wheel, in the feet through the floor, or in the seat of the pants.	50–100 Hz	Vehicle Speed Sensitive Affected by torque/load and/or steering input	Go to *Vibration Analysis - Hub and/or Axle Input on page 1-46*
			Engine Speed Sensitive	Go to *Vibration Analysis - Engine on page 1-48*
Tingling	May produce a "pins and needles" sensation or may put hands or feet "to sleep". Highest vibration frequency range that can still be felt.	Greater than 100 Hz	Vehicle Speed Sensitive Affected by torque/load and/or steering input	Go to *Vibration Analysis - Hub and/or Axle Input on page 1-46*
			Engine Speed Sensitive	Go to *Vibration Analysis - Engine on page 1-48*

Vibration Symptoms that are Heard

Category	Description	Typical Frequency Range	Condition of Occurrence	Area of Focus
Boom	Usually heard as an interior noise similar to the noise of a bowling ball rolling down an alley, deep thunder, or a bass drum. • Related terminology—droning, growling, moaning, roaring, rumbling, humming • May not be accompanied by a perceptible vibration or roughness	20–60 Hz	Vehicle Speed Sensitive Still occurs during coast down in NEUTRAL	Go to *Vibration Analysis - Tire and Wheel on page 1-43*
			Vehicle Speed Sensitive Affected by torque/load and/or steering input	Go to *Vibration Analysis - Hub and/or Axle Input on page 1-46*
Moan or Drone	Similar to the sound of a bumblebee or blowing air across the top of a bottle. • Related terminology—humming, buzzing, resonance • May be accompanied by a perceptible vibration such as a buzz	60–120 Hz	Vehicle Speed Sensitive Affected by torque/load and/or steering input	Go to *Vibration Analysis - Hub and/or Axle Input on page 1-46*
			Engine Speed Sensitive	Go to *Vibration Analysis - Engine on page 1-48*
Howl	Similar to the sound of the wind howling.	120–300 Hz	Vehicle Speed Sensitive Affected by torque/load and/or steering input	Go to *Vibration Analysis - Hub and/or Axle Input on page 1-46*
			Engine Speed Sensitive	Go to *Vibration Analysis - Engine on page 1-48*
Whine	Similar to the sound of mosquitoes, turbine engines, or vacuum cleaners.	300–500 Hz	Vehicle Speed Sensitive Affected by torque/load	Go to transmission diagnostic information

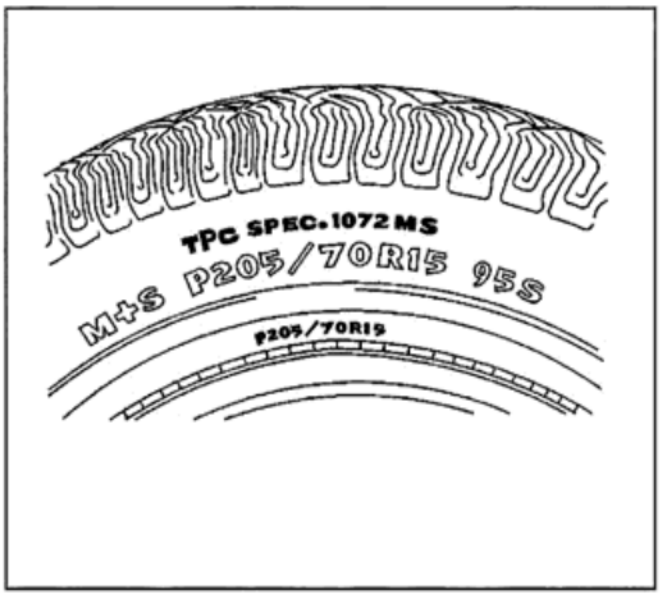
Vehicle-to-Vehicle Diagnostic Comparison

Comparing the customer's vehicle to a KNOWN GOOD vehicle that is essentially identical will help determine if the customer's concern may be characteristic of a vehicle design. To arrive at a valid conclusion, the comparison must be performed under the same conditions, using the same criteria, on a vehicle that has the same option content as the customer's vehicle.

The comparison vehicle must match the customer's vehicle in the following areas:

- Model Year
- Make
- Model
- Body style
- Powertrain configuration
- Driveline configuration
- Final drive ratio
- Tire/wheel size and type
- Suspension package
- Trailering package
- GVW rating
- Performance options
- Luxury options

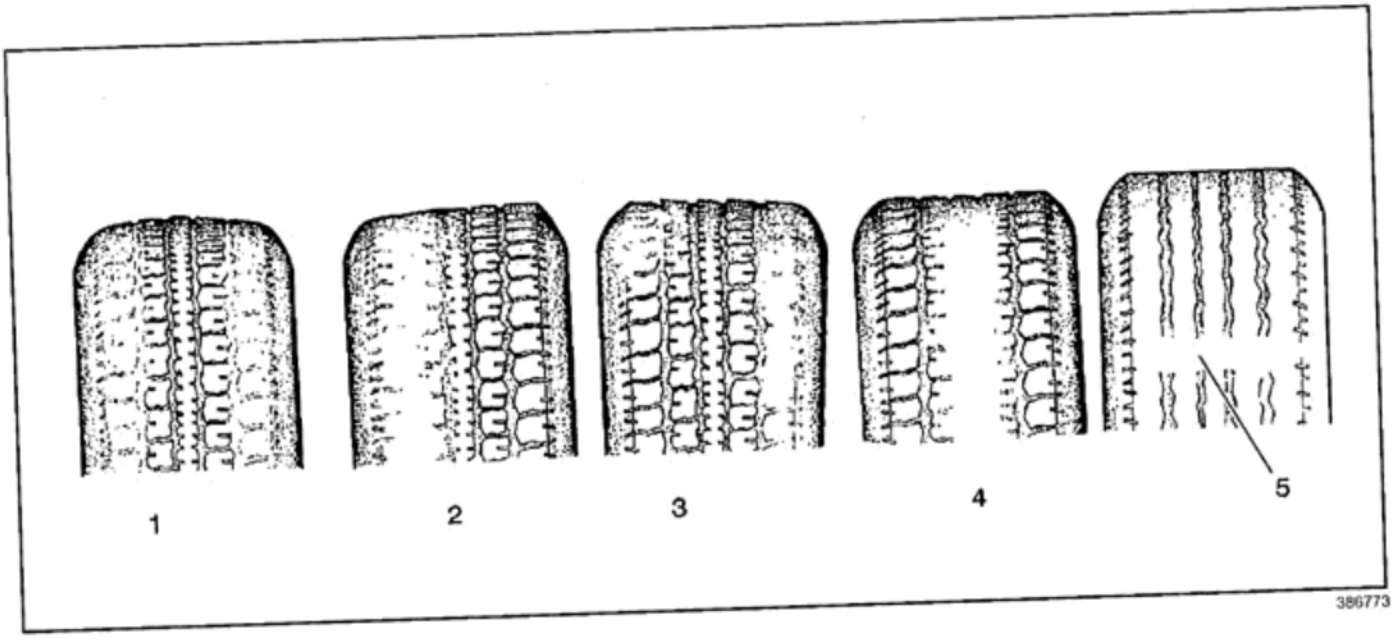
Tire and Wheel Inspection



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The tires on all new production models have a tire performance criteria (TPC) rating number molded on the sidewall. The TPC rating will appear as a 4-digit number preceded by the letters TPC SPEC on the tire wall near the tire size. A replacement tire should have the same TPC rating.

Tire Wear



Legend

(1) Hard Cornering/Underinflation
(2) Incorrect Alignment/Lack of Rotation
(3) Incorrect Alignment/Non-uniform Tire
(4) Heavy Acceleration/Over inflation
(5) Wear Indicator

Inspect the tire and wheel assemblies for the following conditions:

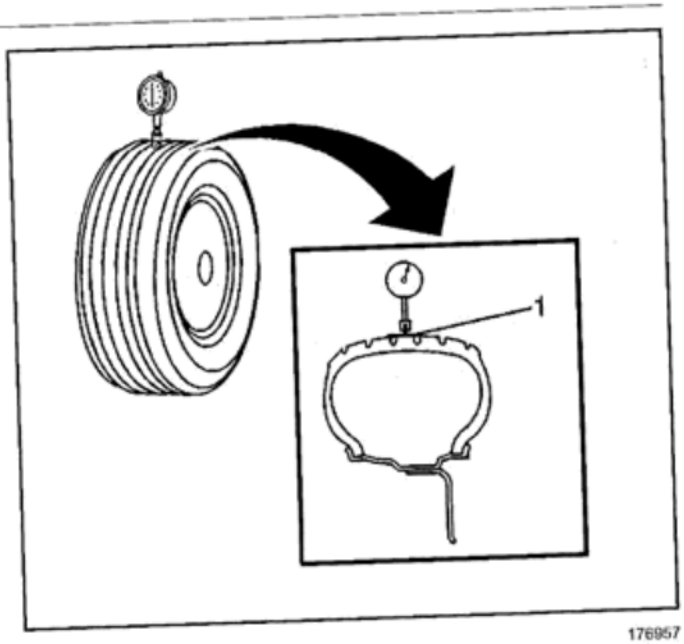
- Unusual wear such as cupping, flat spots, and/or heel-and-toe wear

  These conditions can cause tire growl, tire howl, slapping noises, and/or vibrations throughout the vehicle.
- Proper inflation to specifications for the vehicle
- Bulges in the sidewalls

  Do not confuse bulges, which are an abnormal condition, with normal ply splices which are commonly seen as indentations in the sidewall.
- Bent rim flanges

Tire and Wheel Assembly Runout Measurement - On-Vehicle

1. Raise and support the vehicle.
2. Closely inspect each tire for proper and even bead seating.
3. If any of the tire beads were not properly or evenly seated, reseat the tire bead, then proceed to step 4. Refer to *Tire and Wheel Removal and Installation on page 16-60*.



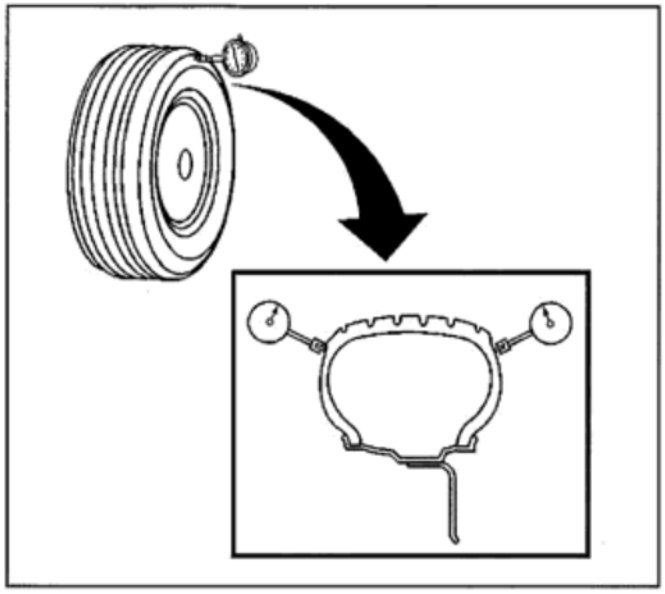
4. Wrap the circumference of each tire with tape (1) in the center tread area.

   Wrapping the tread with tape allows for a smooth and accurate reading of radial runout to be obtained.
5. Position the dial indicator on the taped portion of the tire tread such that the dial indicator is perpendicular to the tire tread surface.
6. Slowly rotate the tire and wheel assembly one complete revolution in order to find the low spot.
7. Set the dial indicator to zero at the low spot.

8. Slowly rotate the tire and wheel assembly one more complete revolution and measure the total amount of radial runout.

   Specification

   Maximum tire and wheel assembly radial runout – measured on-vehicle: 1.52 mm (0.060 in)



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9. Position the dial indicator on a smooth portion of the tire sidewall, as close to the tread as possible, such that the dial indicator is perpendicular to the tire sidewall surface.
10. Slowly rotate the tire and wheel assembly one complete revolution in order to find the low spot. Ignore any jumps or dips due to sidewall splices.
11. Set the dial indicator to zero at the low spot.
12. Slowly rotate the tire and wheel assembly one more complete revolution and measure the total amount of lateral runout. Ignore any jumps or dips due to sidewall splices and attain an average runout measurement.

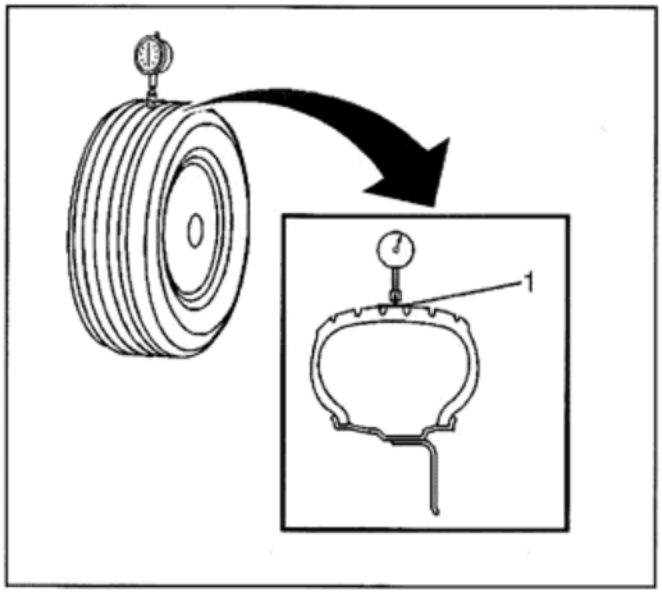
    Specification

    Maximum tire and wheel assembly lateral runout – measured on-vehicle: 1.52 mm (0.060 in)
13. Repeat steps 4 through 12 until all of the tire and wheel assembly radial and lateral runout measurements have been taken.
14. Lower the vehicle.

Tire and Wheel Assembly Runout Measurement - Off Vehicle

1. Raise and support the vehicle.
2. Mark the location of the wheels to the wheel studs and mark the specific vehicle position on each tire and wheel – LF, LR, RF, RR.
3. Remove the tire and wheel assemblies from the vehicle.
4. Closely inspect each tire for proper and even bead seating.
5. If any of the tire beads were not properly or evenly seated, reseat the tire bead, then proceed to step 6. Refer to *Tire and Wheel Removal and Installation on page 16-60*.
6. Mount a tire and wheel assembly on a spin-type wheel balancer.

   Locate the tire and wheel assembly on the balancer with a cone through the back side of the center pilot hole.



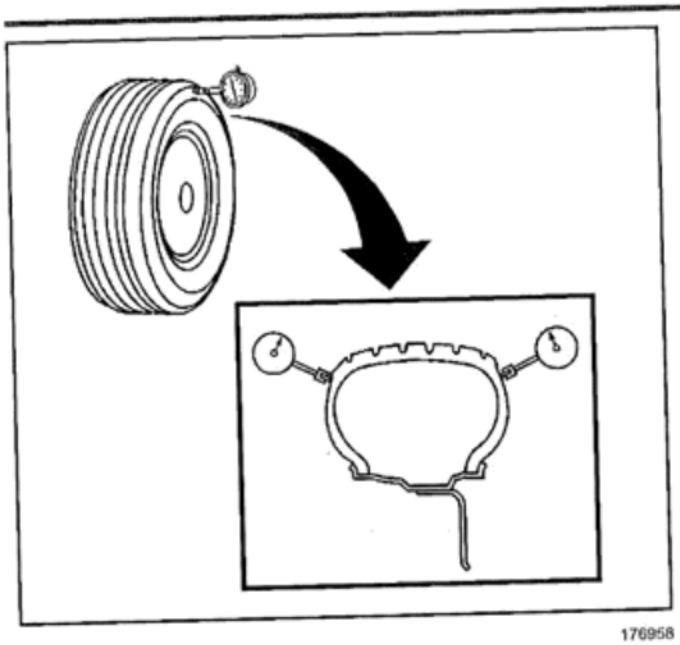
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7. Wrap the outer circumference of each tire with tape (1) in the center tread area.

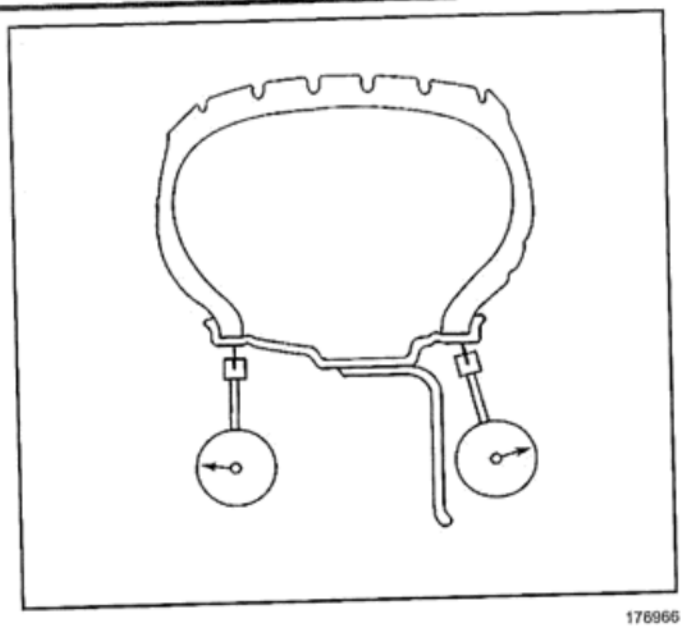
   Wrapping the tread with tape allows for a smooth and accurate reading of radial runout to be obtained.
8. Position the dial indicator on the taped portion of the tire tread such that the dial indicator is perpendicular to the tire tread surface.
9. Slowly rotate the tire and wheel assembly one complete revolution in order to find the low spot.
10. Set the dial indicator to zero at the low spot.
11. Slowly rotate the tire and wheel assembly one more complete revolution and measure the total amount of radial runout.

    Specification

    Maximum tire and wheel assembly radial runout – measured off-vehicle: 1.27 mm (0.050 in)



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12. Position the dial indicator on a smooth portion of the tire sidewall, as close to the tread as possible, such that the dial indicator is perpendicular to the tire sidewall surface.
13. Slowly rotate the tire and wheel assembly one complete revolution in order to find the low spot. Ignore any jumps or dips due to sidewall splices.
14. Set the dial indicator to zero at the low spot.
15. Slowly rotate the tire and wheel assembly one more complete revolution and measure the total amount of lateral runout. Ignore any jumps or dips due to sidewall splices and attain an average runout measurement.

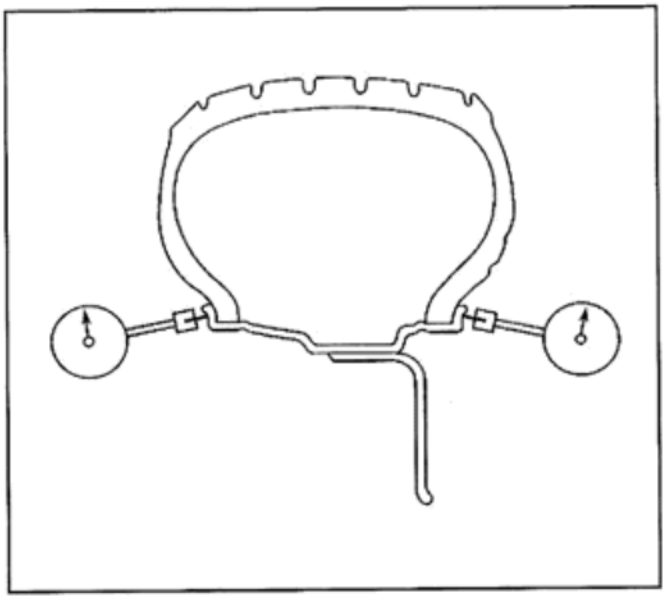
    Specification

    Maximum tire and wheel assembly lateral runout – measured off-vehicle: 1.27 mm (0.050 in)
16. Repeat steps 6 through 15 until all of the tire and wheel assembly radial and lateral runout measurements have been taken.
17. If ANY of the tire and wheel assembly runout measurements were NOT within specifications, proceed to step 19.
18. If ALL of the tire and wheel assembly runout measurements WERE within specifications, then the off-vehicle tire and wheel assembly runout is considered acceptable.
19. Position the dial indicator on the horizontal outer surface of the wheel rim flange – with the tire still mounted – such that the dial indicator is perpendicular to the rim flange surface.

    Wheel runout should be measured on both the inboard and outboard rim flanges, unless wheel design will not permit. Ignore any jumps or dips due to paint drips, chips, or welds.
20. Slowly rotate the tire and wheel assembly one complete revolution in order to find the low spot.
21. Set the dial indicator to zero at the low spot.
22. Slowly rotate the tire and wheel assembly one more complete revolution and measure the total amount of wheel radial runout.

    Specification

    - Maximum aluminum wheel radial runout – measured off-vehicle, tire mounted: 0.762 mm (0.030 in)
    - Maximum steel wheel radial runout – measured off-vehicle, tire mounted: 1.015 mm (0.040 in)



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23. Position the dial indicator on the vertical outer surface of the wheel rim flange – with the tire still mounted – such that the dial indicator is perpendicular to the rim flange surface.

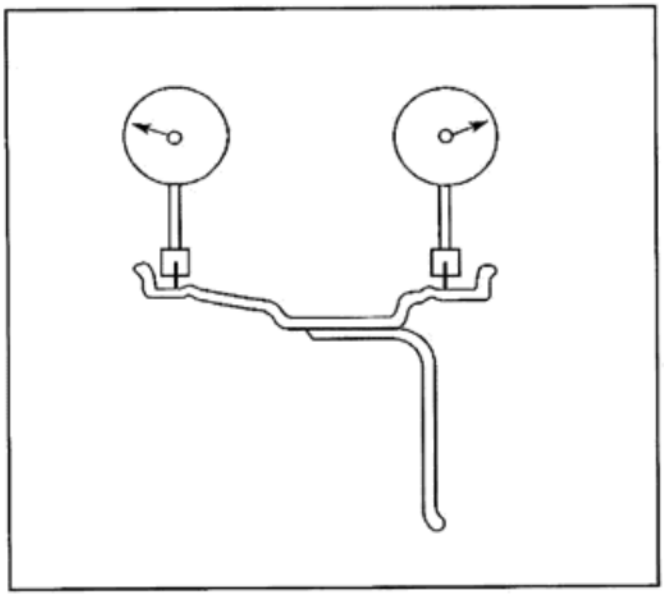
    Wheel runout should be measured on both the inboard and outboard rim flanges, unless wheel design will not permit. Ignore any jumps or dips due to paint drips, chips, or welds.
24. Slowly rotate the tire and wheel assembly one complete revolution in order to find the low spot.
25. Set the dial indicator to zero at the low spot.
26. Slowly rotate the tire and wheel assembly one more complete revolution and measure the total amount of wheel lateral runout.

    Specification

    - Maximum aluminum wheel lateral runout – measured off-vehicle, tire mounted: 0.762 mm (0.030 in)
    - Maximum steel wheel lateral runout – measured off-vehicle, tire mounted: 1.143 mm (0.045 in)
27. Repeat steps 19 through 26 until all of the wheel radial and lateral runout measurements have been taken on each of the – tire and wheel – assemblies with assembly runout measurements which were NOT within specifications.
28. If any of the wheel runout measurements were NOT within specifications, proceed to Measuring Wheel Runout – Tire Dismounted.
29. For any of the wheel runout measurements which WERE within specifications, while the – tire and wheel – assembly runout measurements were NOT within specifications, replace the tire, then balance the assembly. Refer to *Tire and Wheel Assembly Balancing - Off Vehicle on page 1-72*.
30. After replacement of any tires, always re-measure the runout of the affected tire and wheel assembly, or assemblies.
31. Using the matchmarks made prior to removal, install the tire and wheel assemblies to the vehicle.
32. Lower the vehicle.

Wheel Runout Measurement – Tire Dismounted

1. On the tire and wheel assembly, or assemblies with wheel runout measurements – tire mounted – which were NOT within specifications, mark each tire and wheel in relation to each other.
2. Dismount the tire from the wheel. Refer to *Tire Dismounting and Mounting on page 16-63*.
3. Mount the wheel on a spin-type wheel balancer.
4. Locate the wheel on the balancer with a cone through the back side of the center pilot hole.



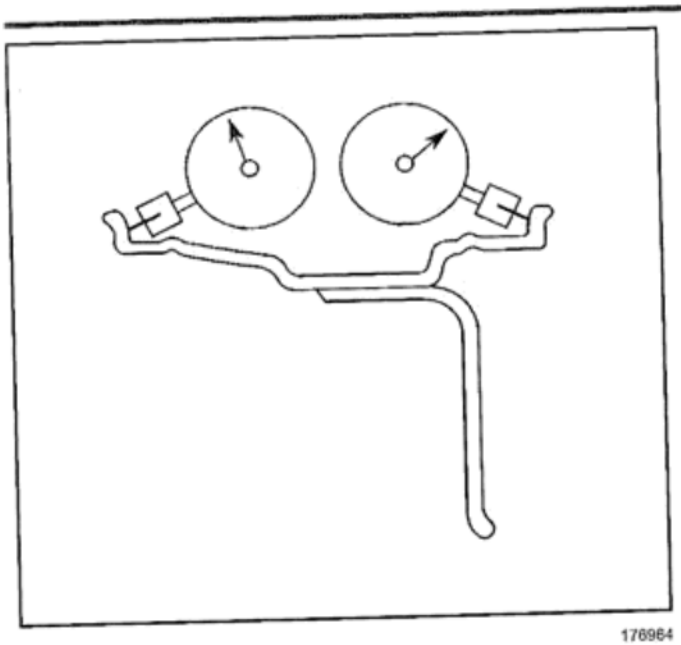
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5. Position the dial indicator on the horizontal inner surface of the wheel rim flange – with the tire dismounted – such that the dial indicator is perpendicular to the rim flange surface.

    Wheel runout should be measured on both the inboard and outboard rim flanges. Ignore any jumps or dips due to paint drips, chips, or welds.
6. Slowly rotate the wheel one complete revolution in order to find the low spot.
7. Set the dial indicator to zero at the low spot.
8. Slowly rotate the wheel one more complete revolution and measure the total amount of wheel radial runout.

    Specification

    - Maximum aluminum wheel radial runout – measured off-vehicle, tire dismounted: 0.762 mm (0.030 in)
    - Maximum steel wheel radial runout – measured off-vehicle, tire dismounted: 1.015 mm (0.040 in)



176964

9. Position the dial indicator on the vertical inner surface of the wheel rim flange – with the tire dismounted – such that the dial indicator is perpendicular to the rim flange surface.

   Wheel runout should be measured on both the inboard and outboard rim flanges. Ignore any jumps or dips due to paint drips, chips, or welds.
10. Slowly rotate the wheel one complete revolution in order to find the low spot.
11. Set the dial indicator to zero at the low spot.
12. Slowly rotate the wheel one more complete revolution and measure the total amount of wheel lateral runout.

    Specification

    - Maximum aluminum wheel lateral runout – measured off-vehicle, tire dismounted: 0.762 mm (0.030 in)
    - Maximum steel wheel lateral runout – measured off-vehicle, tire dismounted: 1.143 mm (0.045 in)
13. Repeat steps 2 through 12 until all of the wheel radial and lateral runout measurements – tire dismounted – have been taken on each wheel with runout measurements – tire mounted – which were NOT within specifications.
14. If any of the wheel runout measurements – tire dismounted – were NOT within specifications, replace the wheel.

    Always measure the runout of any replacement wheels.
15. For any of the wheel runout measurements which WERE within specifications, while the – tire and wheel – assembly runout measurements were NOT within specifications, replace the tire, then balance the assembly. Refer to *Tire and Wheel Assembly Balancing - Off Vehicle on page 1-72*.
16. Using the matchmarks made prior to dismounting the tire, or tires, mount the tire, or tires to the wheel, or wheels, then balance the assembly, or assemblies. Refer to *Tire and Wheel Assembly Balancing - Off Vehicle on page 1-72*.

    Always measure the runout of any of the tire and wheel assemblies which have had the tires dismounted and mounted.
17. Using the matchmarks made prior to removal, install the tire and wheel assemblies to the vehicle.
18. Lower the vehicle.

Brake Rotor/Drum Balance Inspection

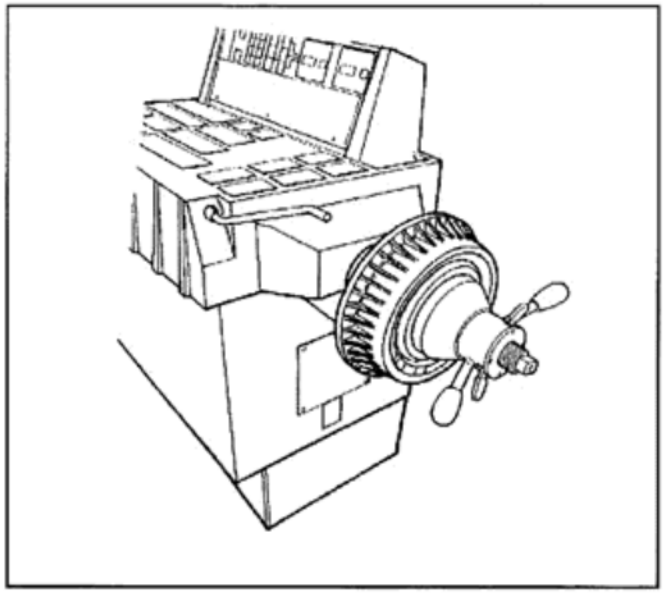
1. Support the vehicle drive axle on a suitable hoist. Refer to *Lifting and Jacking the Vehicle on page 1-31*.
2. Remove the tire and wheel assemblies from the drive axle. Refer to *Tire and Wheel Removal and Installation on page 16-60*.

Warning: Refer to Work Stall Test Warning on page 0-7.

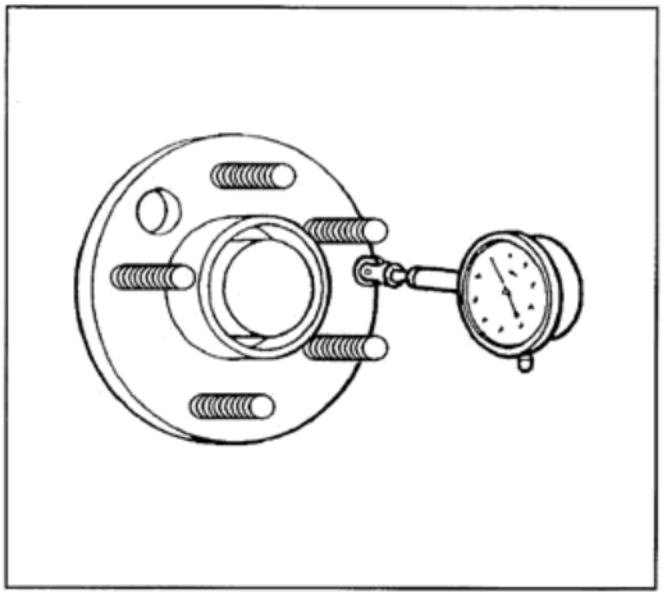
3. Reinstall the wheel nuts in order to retain the brake rotors.
4. Run the vehicle at the concern speed while inspecting for the presence of the vibration.

Caution: Do not depress the brake pedal with the brake rotors and/or the brake drums removed, or with the brake calipers repositioned away from the brake rotors, or damage to the brake system may result.

5. If the vibration is still present, remove the rotors from the drive axle, then run the vehicle back to the concern speed.
6. If the vibration is eliminated when the brake rotors are removed from the drive axle, repeat the test with one rotor installed at a time. Replace the rotor that is causing or contributing to the vibration concern.



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7. If a brake rotor was replaced as a result of following the previous steps, or if necessary to confirm the results obtained during the previous steps, and/or to check the non-drive axle components, perform the following:
   7.1. Mount the brake rotor/drum on a balancer in the same manner as a tire and wheel assembly.

Note: Check brake rotors/drums for static imbalance only; ignore the dynamic imbalance readings.

   7.2. Inspect the rotor/drum for static imbalance.

There is not a set tolerance for brake rotor/drum static imbalance. However, any brake rotor/drum measured in this same manner which is over 21 g (¾ oz) may have the potential to cause or contribute to a vibration. Rotors/drums suspected of causing or contributing to a vibration should be replaced. Any rotor/drum that is replaced should be checked for imbalance in the same manner.

Hub/Axle Flange and Wheel Stud Runout Inspection

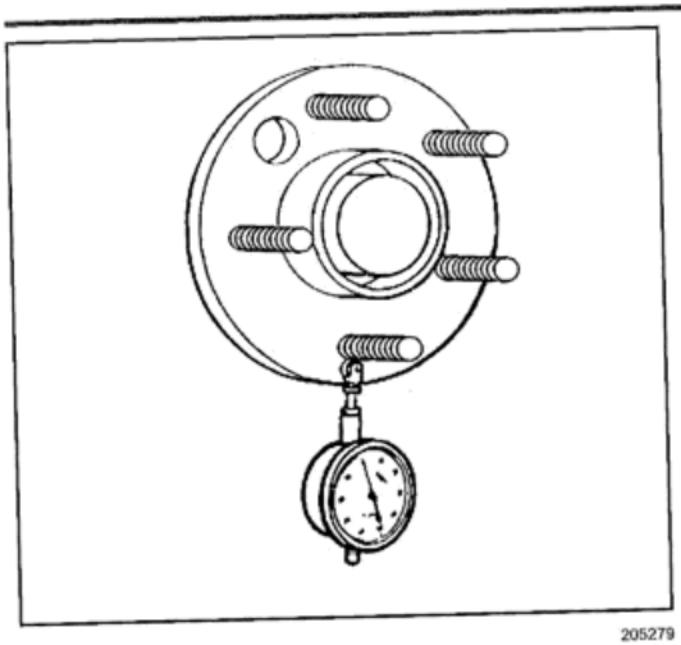
Special Tools

GE-8001 Dial Indicator Set, or equivalent

1. Raise and support the vehicle. Refer to *Lifting and Jacking the Vehicle on page 1-31*.
2. Mark the location of the wheels to the wheel studs and mark the specific vehicle position on each tire and wheel – LF, LR, RF, RR.
3. Remove the tire and wheel assemblies from the vehicle. Refer to *Tire and Wheel Removal and Installation on page 16-60*.
4. Remove the brake rotors and/or brake drums from the vehicle. Clean the mounting surfaces of the brake rotors, the brake drums, if equipped, and the hub/axle flanges of any loose debris, rust, and corrosion.
5. Position the *GE-8001* Dial Indicator Set, or equivalent, on the machined surface of the wheel hub/axle flange outside of the wheel studs.
6. Rotate the hub one complete revolution in order to find the low spot.
7. Set the *GE-8001* Dial Indicator Set, or equivalent, to zero at the low spot.
8. Rotate the hub one more complete revolution and measure the total amount of wheel hub/axle flange runout.

   Specification – Guideline

   Wheel hub/axle flange runout tolerance guideline: 0.132 mm (0.005 in)
9. If the runout of the wheel hub/axle flange IS within specification and the vehicle is equipped with wheel studs, proceed to step 13.
10. If the runout of the wheel hub/axle flange IS within specification and the vehicle is equipped with wheel bolts, proceed to step 19.
11. If the runout of the wheel hub/axle flange is marginal, the wheel hub may or may not be the source of the disturbance.
12. If the runout of the wheel hub/axle flange is excessive, replace the wheel hub/axle flange. Measure the runout of the new wheel hub/axle flange.



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13. Position the *GE-8001* Dial Indicator Set, or equivalent, in order to contact the wheel mounting studs.

    Measure the stud runout as close to the flange as possible.
14. Turn the hub one complete revolution to register on each of the wheel studs.
15. Zero the *GE-8001* Dial Indicator Set, or equivalent, on the lowest stud.
16. Rotate the hub one more complete revolution and measure the total amount of wheel stud – stud circle – runout.

    Specification – Guideline

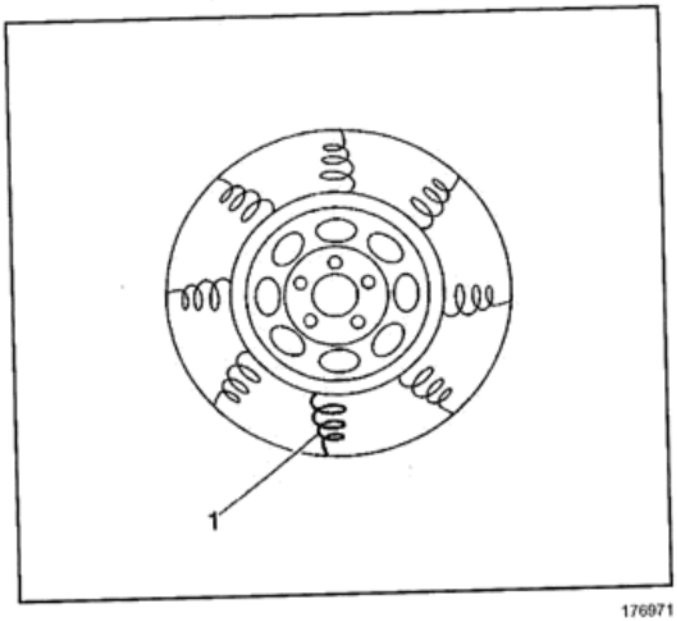
    Wheel stud runout tolerance guideline: 0.254 mm (0.010 in)
17. If the runout of the wheel studs – stud circle – is marginal, the wheel studs may or may not be contributing to the disturbance.
18. If the runout of the wheel studs – stud circle – is excessive, replace the wheel studs as necessary. Measure the runout of the new wheel studs.
19. Inspect the threads and the tapered seat portion on each of the wheel bolts for damage.
20. Wheel bolts exibiting damaged threads and/or damaged tapered seats require replacement.
21. Place the threaded portion of each wheel bolt along a straight edge to inspect for straightness.
22. Wheel bolts that are not straight require replacement.

Tire and Wheel Assembly Isolation Test

Force Variation

Force variation refers to a radial or lateral movement of the tire and wheel assembly which acts much like runout, however, force variation has to do with variations in the construction of the tire. These variations in tire construction may actually cause vibration in a vehicle, even though the tire and wheel assembly runout and balance may be within specifications.

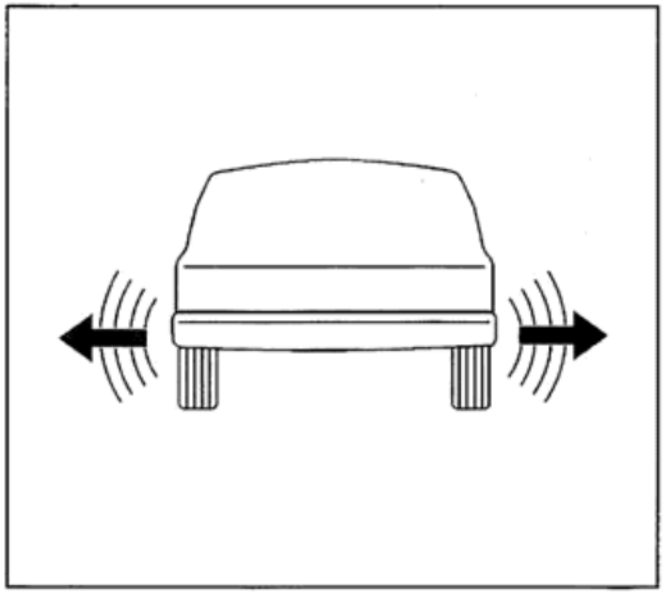
Radial Force Variation



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Radial force variation refers to the difference in the stiffness of a tire sidewall as the tire rotates and contacts the road. Tire sidewalls have some stiffness due to splices in the different plies of the tire, but these stiffness differences do not cause a problem unless the force variation is excessive. Stiff spots (1) in a tire sidewall can deflect a tire and wheel assembly upward as the assembly contacts the road.

Lateral Force Runout



175760

Lateral force variation refers to the difference in the stiffness or conformity of the belts within a tire as the tire rotates and contacts the road. Tire belts may have some stiffness or conformity differences, but these differences do not cause a problem unless the force variation is excessive. These variations in the belts of the tire can deflect the vehicle sideways or laterally. A shifted belt inside a tire may cause lateral force variation.

In most cases where excessive lateral force variation exists, the vehicle will display a wobble or waddle at low speeds, 8–40 km/h (5–25 mph), on a smooth road surface.

Isolation Test Procedure

Perform the following test in order to determine if force variation is present in the vehicle.

1. Substitute a set of KNOWN GOOD, pre-tested tire and wheel assemblies of the same size and type for the suspected original assemblies. Refer to *Tire and Wheel Removal and Installation on page 16-60*.
2. Road test the vehicle to determine if the vibration is still present. Refer to *Vibration Analysis - Road Testing on page 1-39*.
3. If the vibration is still present while using the known good set of tire and wheel assemblies, then force variation is not the cause of the vibration.
4. If the vibration is eliminated when using the known good set of tire and wheel assemblies, install one of the original tire and wheel assemblies using the matchmarks made prior to removal. Refer to *Tire and Wheel Removal and Installation on page 16-60*. Road test the vehicle to determine if the vibration has returned. Refer to *Vibration Analysis - Road Testing on page 1-39*.
5. Continue the process of installing the original tire and wheel assemblies one at a time, then road testing the vehicle, until the tire and wheel assembly, or assemblies which is causing the vibration has been identified.
6. Replace the tire, or tires on the vibration-causing tire and wheel assembly, or assemblies, then balance the assembly, or assemblies. Refer to *Tire and Wheel Assembly Balancing - Off Vehicle on page 1-72*.

Repair Instructions

Tire and Wheel Assembly Balancing - Off Vehicle

Warning: Failure to adhere to the following precautions before tire balancing can result in personal injury or damage to components:

- ***Clean away any dirt or deposits from the inside of the wheels.***
- ***Remove any stones from the tread.***
- ***Wear eye protection.***
- ***Use coated weights on aluminum wheels.***

Tire and Wheel Assembly Balancer Calibration

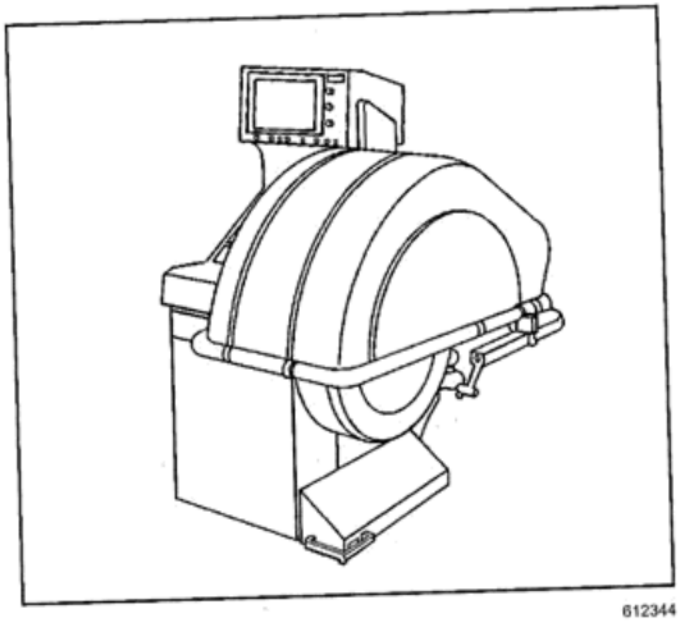
Tire and wheel balancers can drift out of calibration over time, or can become inaccurate as a result of heavy use. There will likely not be any visual evidence that a calibration problem exists. If a balancer is not calibrated within specifications, and a tire and wheel assembly is balanced on that machine, the assembly may actually be imbalanced.

Tire and wheel assembly balancer calibration should be checked approximately every 2 weeks, if the machine is used frequently, and/or whenever the balance readings are questionable.

Tire and Wheel Assembly Balancer Calibration Test

Note: If the balancer fails any of the steps in this calibration test, the balancer should be calibrated according to the manufacturer's instructions. If the balancer cannot be calibrated, contact the manufacturer for assistance.

Inspect the calibration of the tire and wheel assembly balancer according to the manufacturer's recommendations, or perform the following test.



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1. Spin the balancer without a wheel or any of the adapters on the shaft.
2. Inspect the balancer readings.

   Specification

   Zero within 7 g (¼ oz)
3. If the balancer is within the specification range, balance a tire and wheel assembly – that is within radial and lateral runout tolerances – to ZERO, using the same balancer.
4. After the tire and wheel assembly has been balanced, add an 85 g (3 oz) test weight to the wheel at any location.
5. Spin the tire and wheel assembly again. Note the readings.
   - In the static and dynamic modes, the balancer should call for 85 g (3 oz) of weight, 180 degrees opposite the test weight.
   - In the dynamic mode, the weight should be called for on the flange of the wheel opposite the test weight.
6. With the assembly imbalanced to 85 g (3 oz), cycle the balancer 5 times.
7. Inspect the balancer readings:

   Specification

   Maximum variation: 7 g (¼ oz)
8. Index the tire and wheel assembly on the balancer shaft, 90 degrees from the previous location.
9. Cycle the balancer with the assembly at the new location.
10. Inspect the balancer readings:

    Specification

    Maximum variation: 7 g (¼ oz)
11. Repeat steps 8 through 10 until the tire and wheel assembly has been cycled and checked at each of the 4 locations on the balancer shaft.

Tire and Wheel Assembly Balancing Guidelines

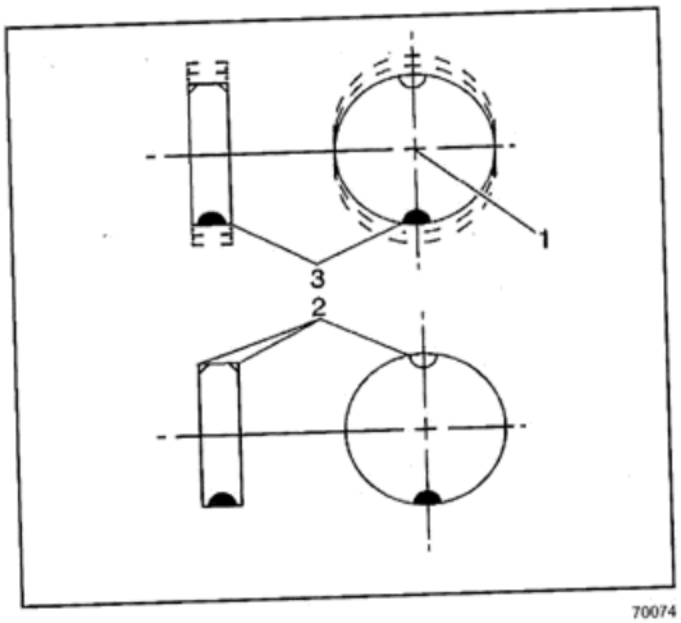
Note: Tire and wheel assemblies which exhibit excessive runout can produce vibrations even if the assemblies are balanced.

It is strongly recommended that the tire and wheel assembly runout be measured and corrected if necessary BEFORE the assemblies are balanced.

If the runout of the tire and wheel assemblies has not yet been measured, refer to *Tire and Wheel Assembly Runout Measurement - Off Vehicle on page 1-66* before proceeding.

There are 2 types of tire and wheel balance:

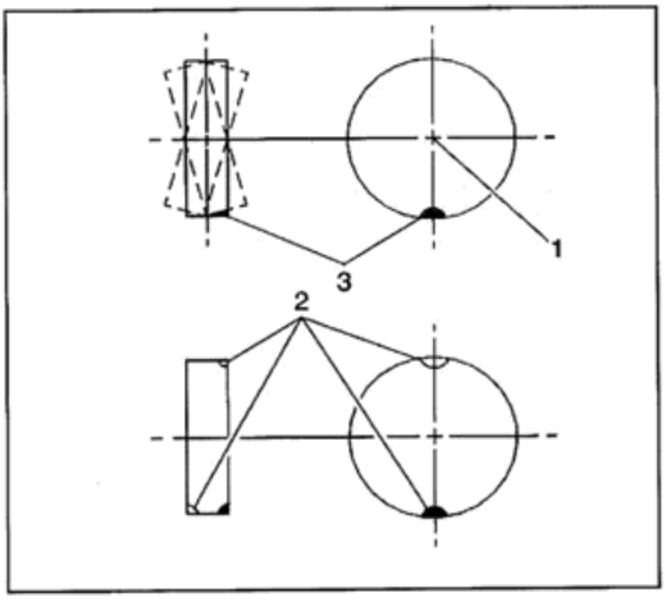
Static Balance



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Static balance is the equal distribution of weight around the wheel circumference. The wheel balance weights (2) are positioned on the wheel in order to offset the effects of a heavy spot (3). Wheels that have static imbalance can produce a bouncing action called tramp.

Dynamic Balance



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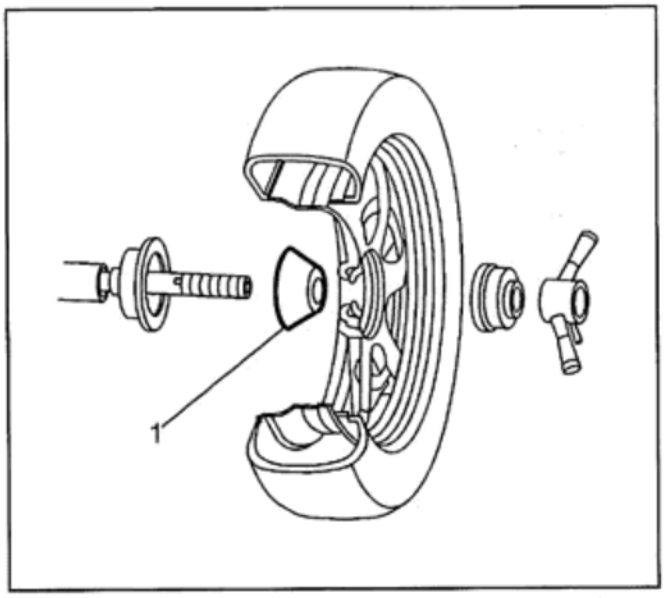
Dynamic balance is the equal distribution of weight on each side of the tire and wheel assembly centerline. The wheel balance weights (2) are positioned on the wheel in order to offset the effects of a heavy spot (3). Wheels that have dynamic imbalance have a tendency to move from side to side and can cause an action called shimmy.

Most off-vehicle balancers are capable of checking both types of balance simultaneously.

As a general rule, most vehicles are more sensitive to static imbalance than to dynamic imbalance; however, vehicles equipped with low profile, wide tread path, high performance tires and wheels are susceptible to small amounts of dynamic imbalance. As little as 14–21 g (½–¾ oz) imbalance is capable of inducing a vibration in some vehicle models.

Balancing Procedure

Note: When balancing tire and wheel assemblies, use a known good, recently calibrated, off-vehicle, two-plane dynamic balancer set to the finest balance mode available.



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Note: Carefully follow the wheel balancer manufacturers's instructions for proper mounting of the center cone (1).

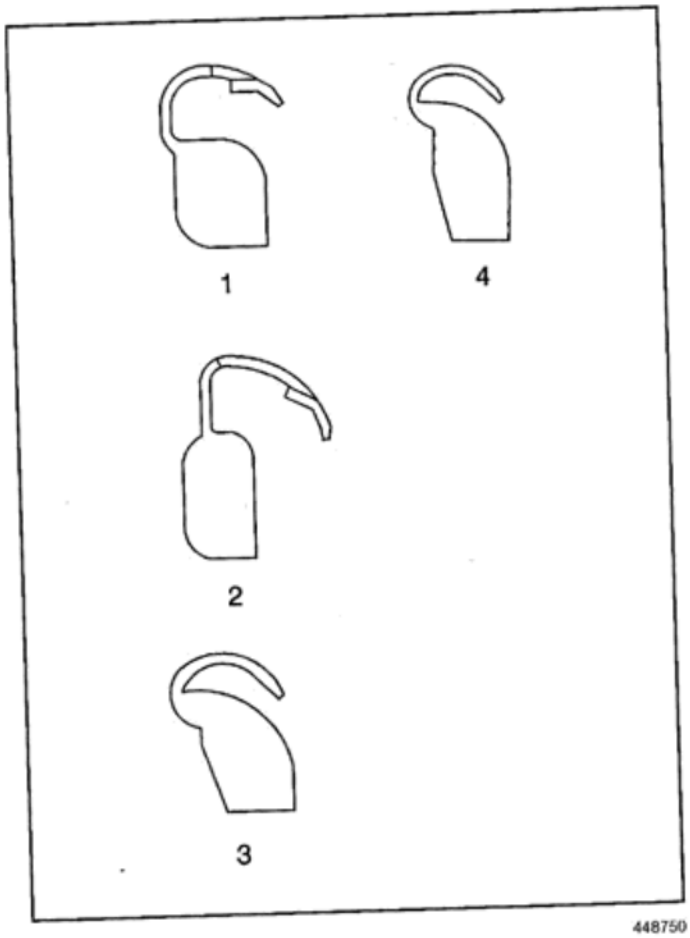
1. Raise and support the vehicle. Refer to *Lifting and Jacking the Vehicle on page 1-31*.
2. Mark the location of the wheels to the wheel studs and mark the specific vehicle position on each tire and wheel – LF, LR, RF, RR.
3. Remove the tire and wheel assemblies one at a time and mount on a spin-type wheel balancer. Refer to *Tire and Wheel Removal and Installation on page 16-60*.
4. Carefully follow the wheel balancer manufacturer's instructions for proper mounting techniques to be used on different types of wheels.

   Regard aftermarket wheels, especially those incorporating universal lug patterns, as potential sources of runout and mounting concerns.
5. Be sure to use the correct type of wheel balance weights for the type of wheel rim being balanced. Be sure to use the correct type of coated wheel balance weights on aluminum wheels. Refer to Wheel Weight Usage.
6. Balance all four tire and wheel assemblies as close to zero as possible.
7. Using the matchmarks made prior to removal, install the tire and wheel assemblies to the vehicle. Refer to *Tire and Wheel Removal and Installation on page 16-60*.
8. Lower the vehicle.

Wheel Weight Usage

Tire and wheel assemblies can be balanced using either the static or dynamic method.

Clip-on Weights

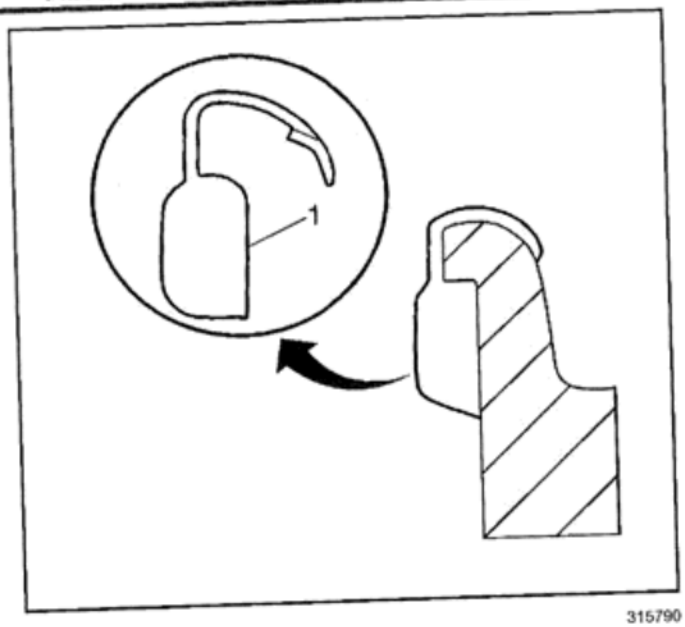


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Note: When balancing factory aluminum wheels with clip-on wheel balance weights, be sure to use special polyester-coated weights. These coated weights reduce the potential for corrosion and damage to aluminum wheels.

These coated weights reduce the potential for corrosion and damage to aluminum wheels.

- MC (1) and AW (2) series weights are approved for use on aluminum wheels.
- P (3) series weights are approved for use on steel wheels only.
- T (4) series coated weights are approved for use on both steel and aluminum wheels.

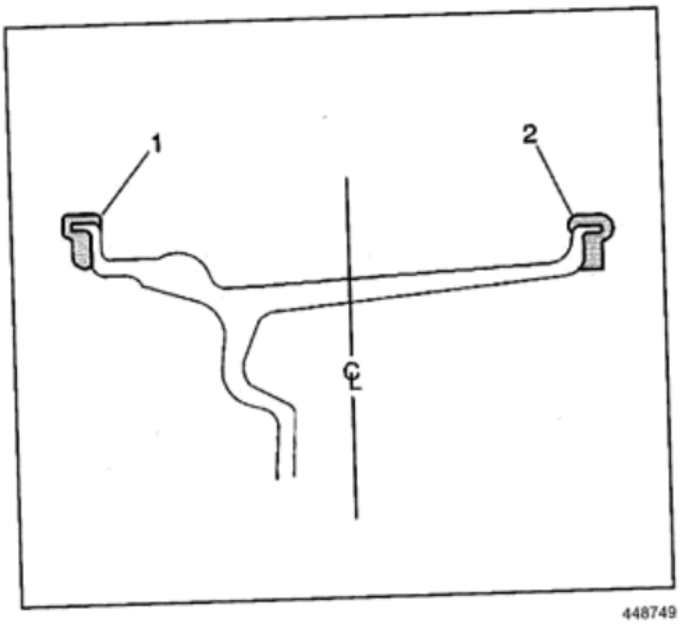


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Note: Use a nylon or plastic-tipped hammer when installing coated clip-on wheel balance weights to minimize the possibility of damage to the polyester coating.

The contour and style of the wheel rim flange will determine which type of clip-on wheel weight (1) should be used. The weight should follow the contour of the rim flange. The weight clip should firmly grip the rim flange.

Wheel Weight Placement – Clip-on Weights

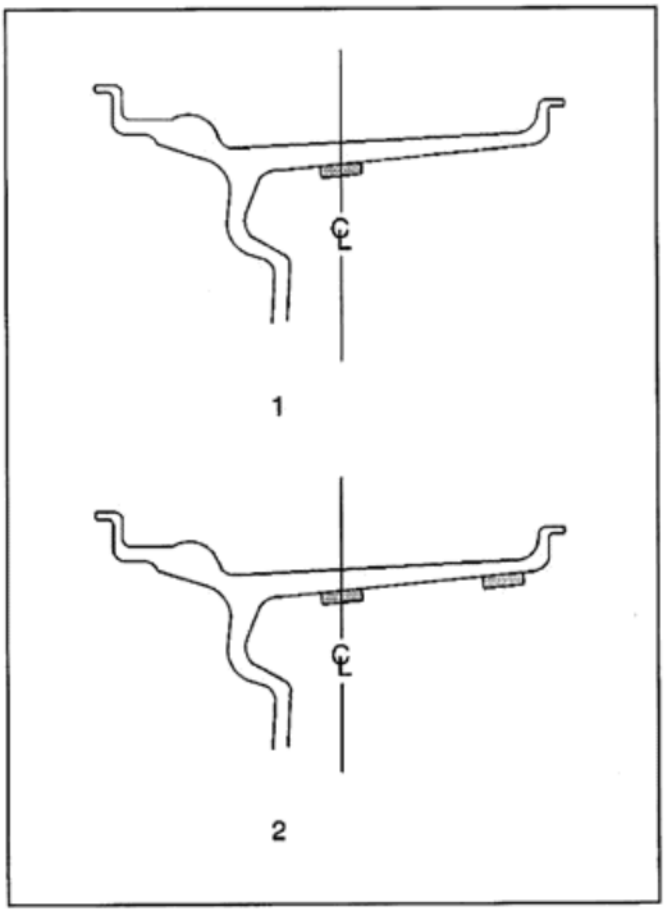


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When static balancing, locate the wheel balance weights on the inboard flange (2) if only 28 g (1 oz) or less is called for. If more than 28 g (1 oz) is called for, split the weights as equally as possible between the inboard (2) and outboard (1) flanges.

When dynamic balancing, locate the wheel balance weights on the inboard (2) and outboard (1) rim flanges at the positions specified by the wheel balancer.

Adhesive Weights



448752

Note: When installing adhesive balance weights on flangeless wheels, do NOT install the weight on the outboard surface of the rim.

Adhesive wheel balance weights may be used on factory aluminum wheels. Perform the following procedure to install adhesive wheel balance weights.

1. Determine the correct areas for placement of the wheel weights on the wheel.
   - When static balancing, locate the wheel balance weights along the wheel centerline (1) on the inner wheel surface if only 28 g (1 oz) or less is called for. If more than 28 g (1 oz) is called for, split the weights as equally as possible between the wheel centerline and the inboard edge of the inner wheel surface (2).
   - When dynamic balancing, locate the wheel balance weights along the wheel centerline and the inboard edge of the inner wheel surface (2) at the positions specified by the wheel balancer.
2. Ensure that there is sufficient clearance between the wheel weights and brake system components.

Note: Do not use abrasives to clean any surface of the wheel.

3. Using a clean cloth or paper towel with a general purpose cleaner, thoroughly clean the designated balance weight attachment areas of any corrosion, overspray, dirt or any other foreign material.
4. To ensure there is no remaining residue, wipe the balance weight attachment areas again, using a clean cloth or paper towel with a mixture of half isopropyl alcohol and half water.
5. Dry the attachment areas with hot air until the wheel surface is warm to the touch.
6. Warm the adhesive backing on the wheel balance weights to room temperature.
7. Remove the protective covering from the adhesive backing on the back of the balance weights. DO NOT touch the adhesive surface.
8. Apply the wheel balance weights to the wheel, press into place with hand pressure.
9. Secure the wheel balance weights to the wheel with a 90 N (21 lb) force applied with a roller.

Tire and Wheel Assembly Balancing - On-Vehicle

Special Tools

EL-38792-A Electronic Vibration Analyzer (EVA) 2

If after following the tire and wheel vibration diagnostic process, some amount of tire and wheel vibration is still evident, an on-vehicle high-speed spin balancer may be used to perform an on-vehicle balance in an attempt to finish balance the tire and wheel assemblies, wheel hubs, brake rotors, brake drums, if equipped, and wheel trim, if equipped, simultaneously. On-vehicle balancing can also compensate for minor amounts of residual runout encountered as a result of mounting the tire and wheel assembly on the vehicle, as opposed to the balance which was achieved on the off-vehicle balancer.

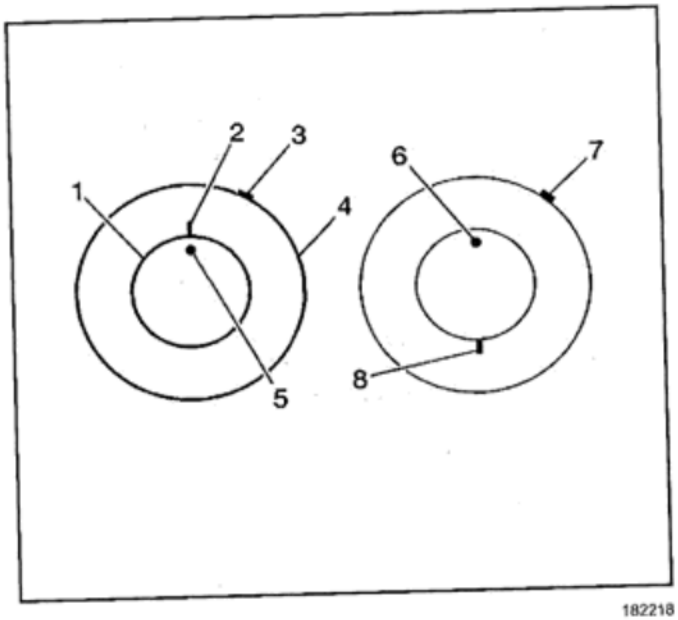
In order to perform an on-vehicle balancing procedure, carefully follow the on-vehicle balancer manufacturer's specific operating instructions and carefully consider the following information before proceeding:

- Vehicles equipped with low profile, wide tread path, high performance tires and wheels are susceptible to small amounts of dynamic imbalance.
- When performing an on-vehicle balance, great care must be taken when placing the wheel balance weights on the wheels. If the wheel balance weights are not placed accurately, they can actually induce dynamic imbalance and thus increase the severity of the vibration.
- Inspect the vehicle wheel bearings to ensure that they are in good condition.
- Thoroughly inspect all on-vehicle balancing equipment and ensure that it is fully within the manufacturer's recommended specifications.
- Do not remove the off-vehicle balance weights. The purpose of on-vehicle balance is to fine tune the assembly balance already achieved off-vehicle, not to start over.
- Leave all wheel trim installed whenever possible.

- If the on-vehicle balancer calls for more than 56 g (2 oz) of additional weight, split the weight between the inboard and outboard flanges of the wheel, so as not to upset the dynamic balance of the assembly achieved in the off-vehicle balance. For wheel balance weight information, refer to *Tire and Wheel Assembly Balancing - Off Vehicle on page 1-72*.
- If available, tape-off an area on top of the fenders and the quarter panels, then place the vibration sensor of the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2 on the fender or quarter panel above the specific tire and wheel assembly while it is being on-vehicle balanced.

  The *EL-38792-A* Electronic Vibration Analyzer (EVA) 2 will provide a visual indication of the amplitude of the vibration, and the effect that the on-vehicle balance has on it.

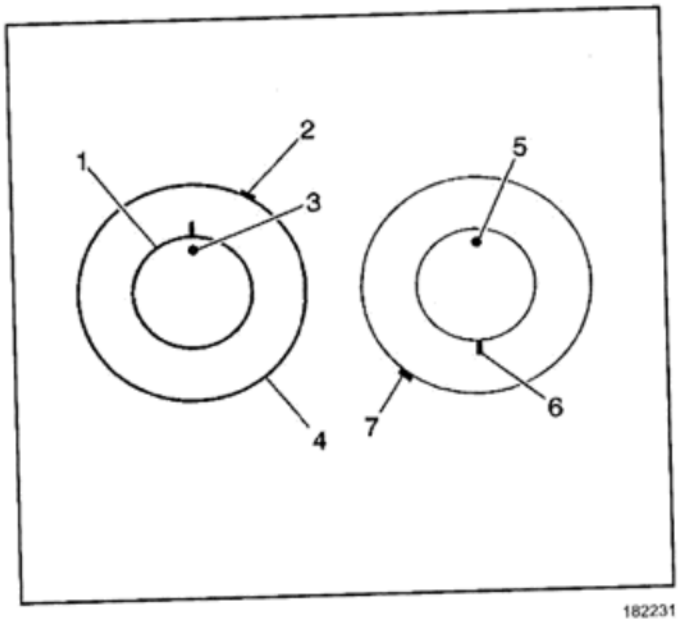
Tire-to-Wheel Match-Mounting (Vectoring)



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Note: After remounting a tire to a wheel or after replacing a tire and/or a wheel, remeasure the tire and wheel assembly runout in order to verify that the amount of runout has been reduced and brought to within tolerances. Ensure that the tire and wheel assembly is properly balanced before reinstalling to the vehicle.

1. Mark the location of the high spot (3) on the tire as determined during the off-vehicle tire and wheel assembly runout measurement.
2. Place a reference mark (2) on the tire sidewall at the location of the valve stem (5).
   - Always refer to the valve stem as the 12 o'clock position.
   - Refer to the location of the high spot (3) by its clock position on the wheel, relative to the valve stem.
3. Mount the tire and wheel assembly on a tire machine and break down the bead. Do not dismount the tire from the wheel at this time.
4. Rotate the tire 180 degrees on the rim so that the valve stem reference mark (8) is now at the 6 o'clock position in relation to the valve stem (6). You may need to lubricate the bead in order to easily rotate the tire on the wheel.
5. Reinflate the tire and seat the bead properly.
6. Mount the assembly on the tire balancer and remeasure the runout. Mark the new location of the assembly runout high spot on the tire.
7. If the assembly runout has been reduced and is within tolerance, no further steps are necessary. Balance the tire and wheel assembly, then install the assembly to the vehicle. Refer to the following:
   - *Tire and Wheel Assembly Balancing - Off Vehicle on page 1-72*
   - *Tire and Wheel Removal and Installation on page 16-60*
8. If the clock location of the high spot remained at or near the original clock location of the high spot (7) and the assembly runout has NOT been reduced, the wheel is the major contributor to the assembly runout concern.



182231

9. If the clock location of the high spot has moved, however the assembly runout has NOT been reduced, perform the following steps:
   9.1. If the clock location of the high spot (7) is now at or near a position 180 degrees from the original clock location of the high spot, the tire is the major contributor to the assembly runout concern.
   9.2. If the clock location of the high spot is now in-between the 2 extremes, then both the tire and the wheel are both contributing to the assembly runout concern. Rotate the tire an additional 90 degrees in both the clockwise and the counterclockwise directions to obtain the lowest amount of assembly runout.

Tire and Wheel Assembly-to-Hub/ Axle Flange Match-Mounting

Note: After remounting a tire and wheel assembly to a hub/axle flange, remeasure the tire and wheel assembly on-vehicle runout in order to verify that the amount of runout has been reduced and brought to within tolerances.

1. Mark the location of the high spot on the tire and wheel assembly as determined during the on-vehicle tire and wheel assembly runout measurement.
2. Place a reference mark on the wheel stud that is located closest to the wheel valve stem.
   - Always refer to the reference mark on the wheel stud as the 12 o'clock position.
   - Refer to the location of the high spot by its clock position on the tire and wheel assembly, relative to the marked wheel stud.
3. Remove the tire and wheel assembly from the hub/ axle flange. Refer to *Tire and Wheel Removal and Installation on page 16-60*.
4. Rotate the tire and wheel assembly as close to 180 degrees as possible on the hub/axle flange, so that the wheel valve stem is now approximately at the 6 o'clock position in relation to the marked wheel stud.
5. Reinstall the wheel lug nuts to secure the tire and wheel assembly in the new position. Refer to *Tire and Wheel Removal and Installation on page 16-60*.
6. Remeasure the tire and wheel assembly on-vehicle runout. Mark the new location of the assembly on-vehicle runout high spot on the tire. Refer to *Tire and Wheel Assembly Runout Measurement - On-Vehicle on page 1-65*.
7. If the assembly on-vehicle runout has been reduced and is within tolerance, no further steps are necessary.
8. If the assembly runout has NOT been reduced, perform the following steps:
   8.1. If the clock location of the high spot remained at or near the original clock location of the high spot, the hub/axle flange and/or the brake rotor/drum mounting flange is the major contributor to the assembly on-vehicle runout concern.
   8.2. If the clock location of the high spot is now at or near a position 180 degrees from the original clock location of the high spot, the tire and wheel assembly is the major contributor to the assembly on-vehicle runout concern.
   8.3. If the clock location of the high spot is now in-between the 2 extremes, then both the tire and wheel assembly and the hub/axle flange are contributing to the assembly on-vehicle runout concern. Rotate the tire and wheel assembly as close to an additional 90 degrees as possible in both the clockwise and the counterclockwise directions to obtain the lowest amount of assembly on-vehicle runout.

Description and Operation

Vibration Theory and Terminology

Vibration Theory

The designs and engineering requirements of vehicles have undergone drastic changes over the last several years.

Vehicles are stiffer and provide more isolation from road input than they did previously. The structures of today's stiffer vehicles are less susceptible to many of the vibrations which could be present in vehicles of earlier designs, however, vibrations can still be detected in a more modern vehicle if a transfer path is created between a rotating component and the body of the vehicle.

There are not as many points of isolation from the road in many vehicles today. If a component produces a strong enough vibration, it may overcome the existing isolation and the component needs to be repaired or replaced.

The presence/absence of unwanted noise and vibration is linked to the customer's perception of the overall quality of the vehicle.

Vibration is the repetitive motion of an object, back and forth, or up and down. The following components cause most vehicle vibrations:

- A rotating component
- The engine combustion process firing impulses

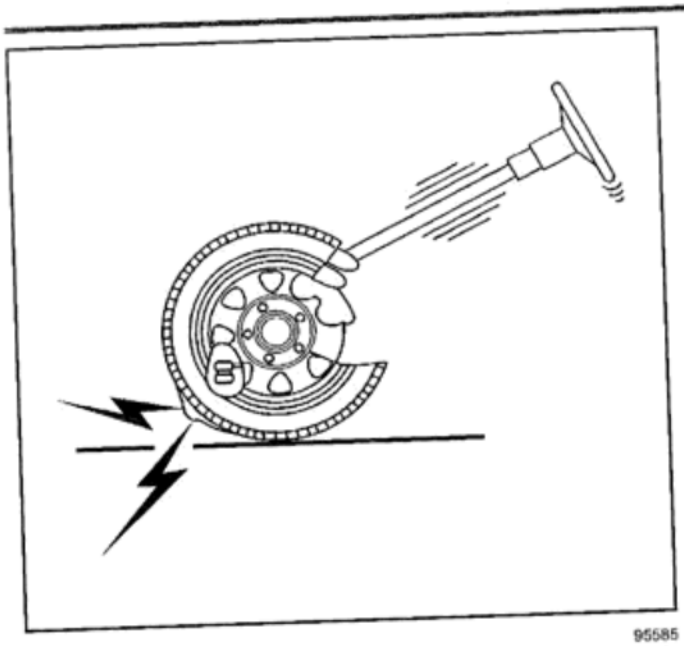
Rotating components will cause vibrations when excessive imbalance or runout is present. During vibration diagnosis, the amount of allowable imbalance or runout should be considered a TOLERANCE and not a SPECIFICATION. In other words, the less imbalance or runout the better.

Rotating components will cause a vibration concern when they not properly isolated from the passenger compartment: Engine firing pulses can be detected as a vibration if a motor mount is collapsed.

A vibrating component operates at a consistent rate (km/h, mph, or RPM). Measure the rate of vibration in question. When the rate/speed is determined, relate the vibration to a component that operates at an equal rate/ speed in order to pinpoint the source. Vibrations also tend to transmit through the body structure to other components. Therefore, just because the seat vibrates does not mean the source of vibration is in the seat.

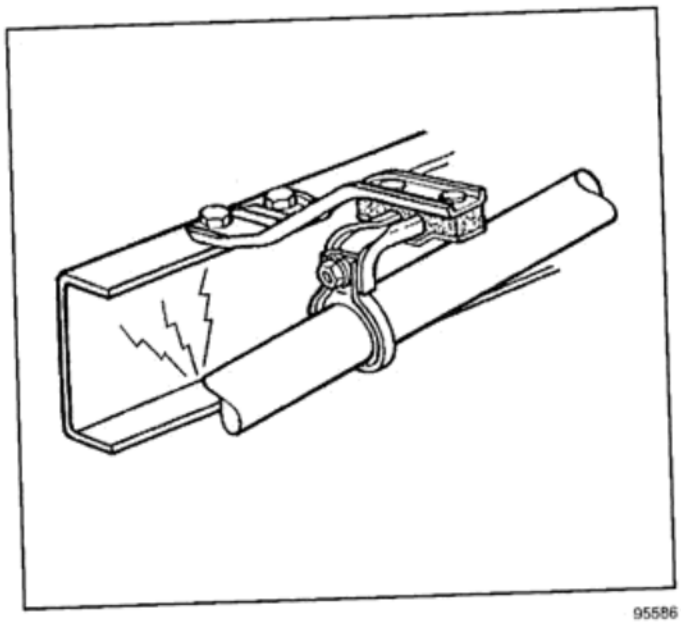
Vibrations consist of the following three elements:

- The source – the cause of the vibration
- The transfer path – the path the vibration travels through the vehicle
- The responder – the component where the vibration is felt



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In the preceding picture, the source is the unbalanced tire. The transfer path is the route the vibrations travels through the vehicle's suspension system into the steering column. The responder is the steering wheel, which the customer reports as vibrating. Eliminating any one of these three elements will usually correct the condition. Decide, from the gathered information, which element makes the most sense to repair. Adding a brace to the steering column may keep the steering wheel from vibrating, but adding a brace is not a practical solution. The most direct and effective repair would be to properly balance the tire.



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Vibration can also produce noise. As an example, consider a vehicle that has an exhaust pipe grounded to the frame. The source of the vibration is the engine firing impulses traveling through the exhaust. The transfer path is a grounded or bound-up exhaust hanger. The responder is the frame. The floor panel vibrates, acting as a large speaker, which produces noise. The best repair would be to eliminate the transfer path. Aligning the exhaust system and correcting the grounded condition at the frame would eliminate the transfer path.

Basic Vibration Terminology

The following are the 2 primary components of vibration diagnosis:

- The physical properties of objects
- The object's properties of conducting mechanical energy

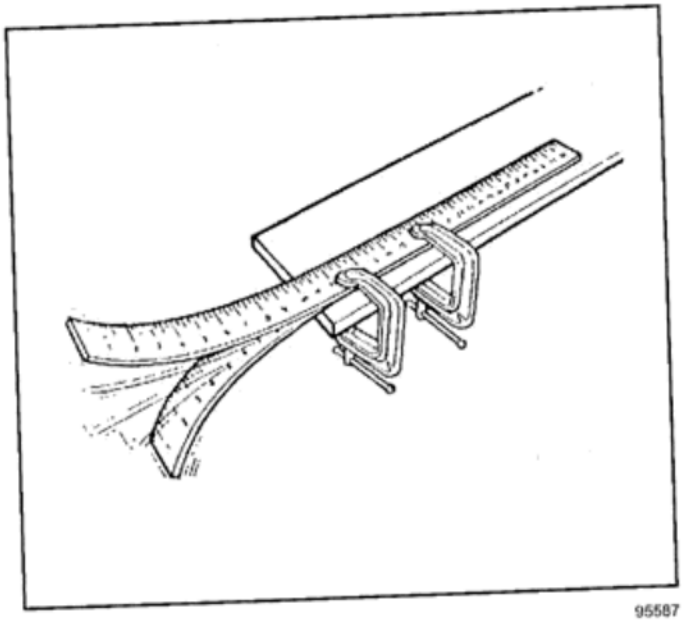
The repetitive up and down or back and forth movement of a component cause most customer vibration complaints. The following are the common components that vibrate:

- The steering wheel
- The seat cushion
- The frame
- The IP

Vibration diagnosis involves the following simple outline:

1. Measure the repetitive motion and assign a value to the measurement in cycles per second or cycles per minute.
2. Relate the frequency back on terms of the rotational speed of a component that is operating at the same rate or speed.
3. Inspect and test the components for conditions that cause vibration.

For example, performing the following steps will help demonstrate the vibration theory:



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1. Clamp a yardstick to the edge of a table, leaving about 50 cm (20 in) hanging over the edge of the table.
2. Pull down on the edge of the stick and release while observing the movement of the stick.

The motion of the stick occurs in repetitive cycles. The cycle begins at midpoint, continues through the lowest extreme of travel, then back past the midpoint, through the upper extreme of travel, and back to the midpoint where the cycle begins again.

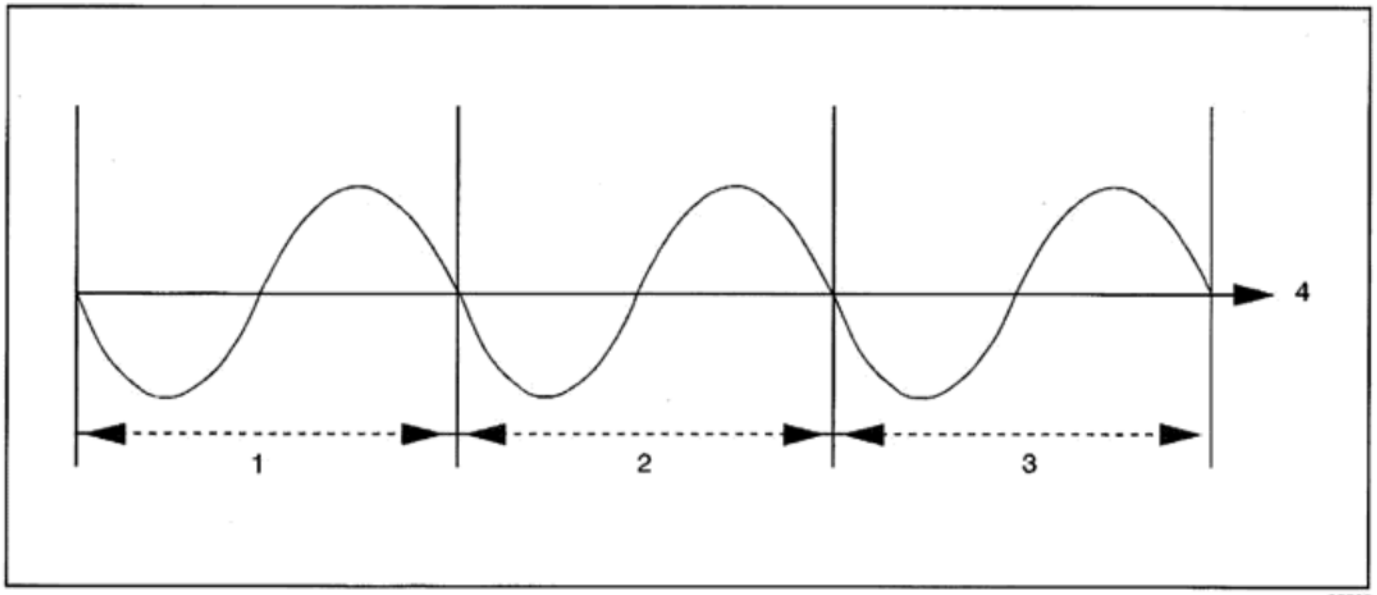
The cycle occurs over and over again at the same rate, or frequency. In this case, about 10 cycles in one second. If we measure the frequency to reflect the number of complete cycles that the yardstick made in one minute, the measure would be 10 cycles x 60 seconds = 600 cycles per minute (cpm).

We have also found a specific amount of motion, or amplitude, in the total travel of the yardstick from the very top to the very bottom. Redo the experiment as follows:

1. Reclamp the yardstick to the edge of a table, leaving about 25 cm (10 in) hanging over the edge of the table.
2. Pull down on the edge of the stick and release while observing the movement of the stick.

The stick vibrates at a much faster frequency: 30 cycles per second (1,800 cycles per minute).

Cycle

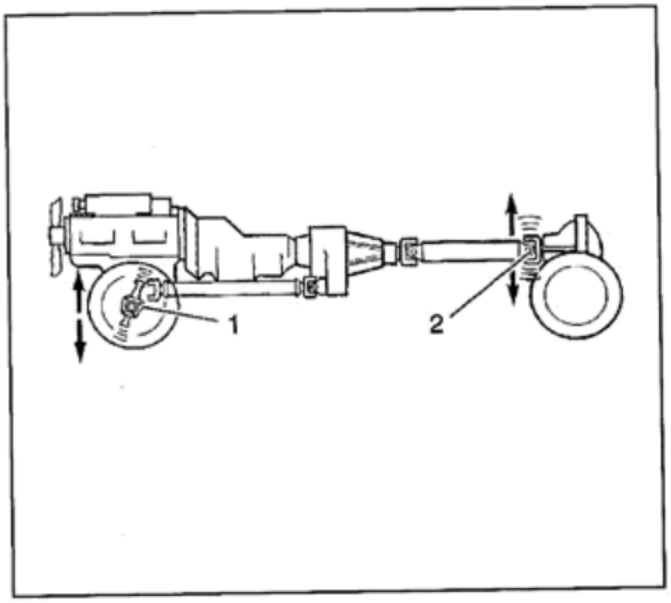


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Legend

(1) 1st Cycle
(2) 2nd Cycle
(3) 3rd Cycle
(4) Time

Vibration Cycles in Powertrain Components



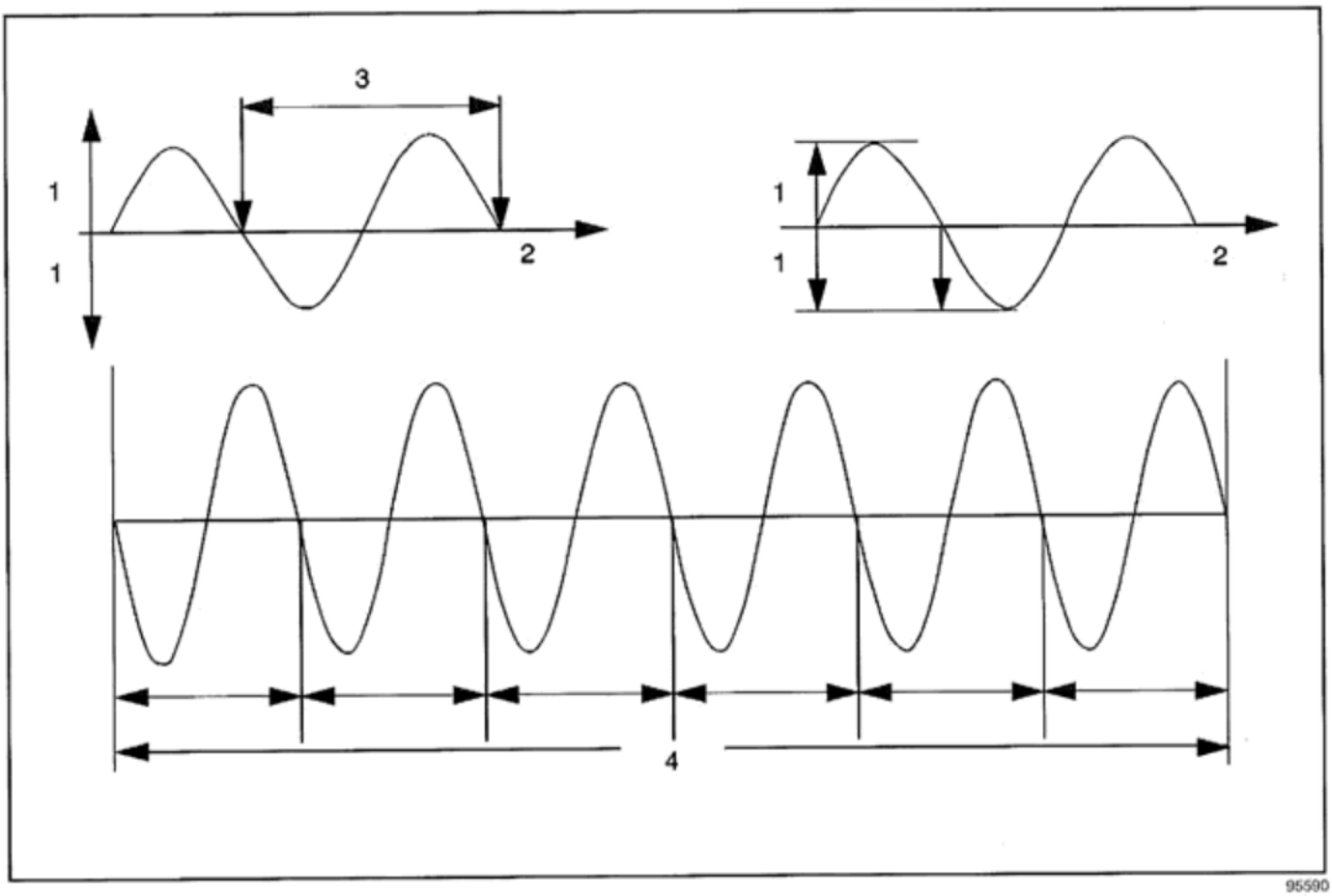
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Legend

(1) Spindle
(2) Pinion Nose

The word cycle comes from the same root as the word circle. A circle begins and ends at the same point, as thus, so does a cycle. All vibrations consist of repetitive cycles.

Frequency



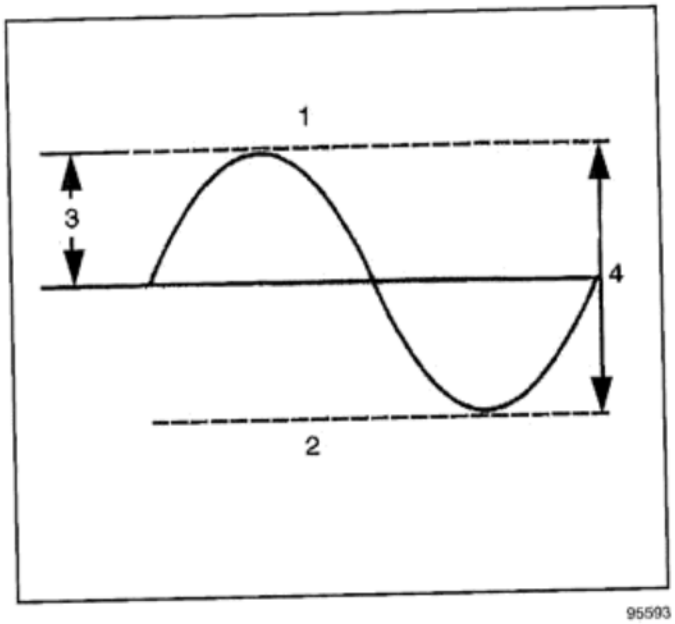
Legend

(1) Amplitude
(2) Reference
(3) Time in Seconds
(4) 1 Second

Frequency is defined as the rate at which an event occurs during a given period of time. With a vibration, the event is a cycle, and the period of time is 1 second. Thus, frequency is expressed in cycles per second.

The proper term for cycles per seconds is Hertz (Hz). This is the most common way to measure frequency. Multiply the Hertz by 60 to get the cycles or revolutions per minute (RPM).

Amplitude



Legend

(1) Maximum
(2) Minimum
(3) Zero-to-Peak Amplitude
(4) Peak-to-Peak Amplitude

Amplitude is the maximum value of a periodically varying quantity. Used in vibration diagnostics, we are referring it to the magnitude of the disturbance. A severe disturbance would have a high amplitude; a minor disturbance would have a low amplitude.

Amplitude is measured by the amount of actual movement, or the displacement. For example, consider the vibration caused by an out-of-balance wheel at 80 km/h (50 mph) as opposed to 40 km/h (25 mph). As the speed increases, the amplitude increases.

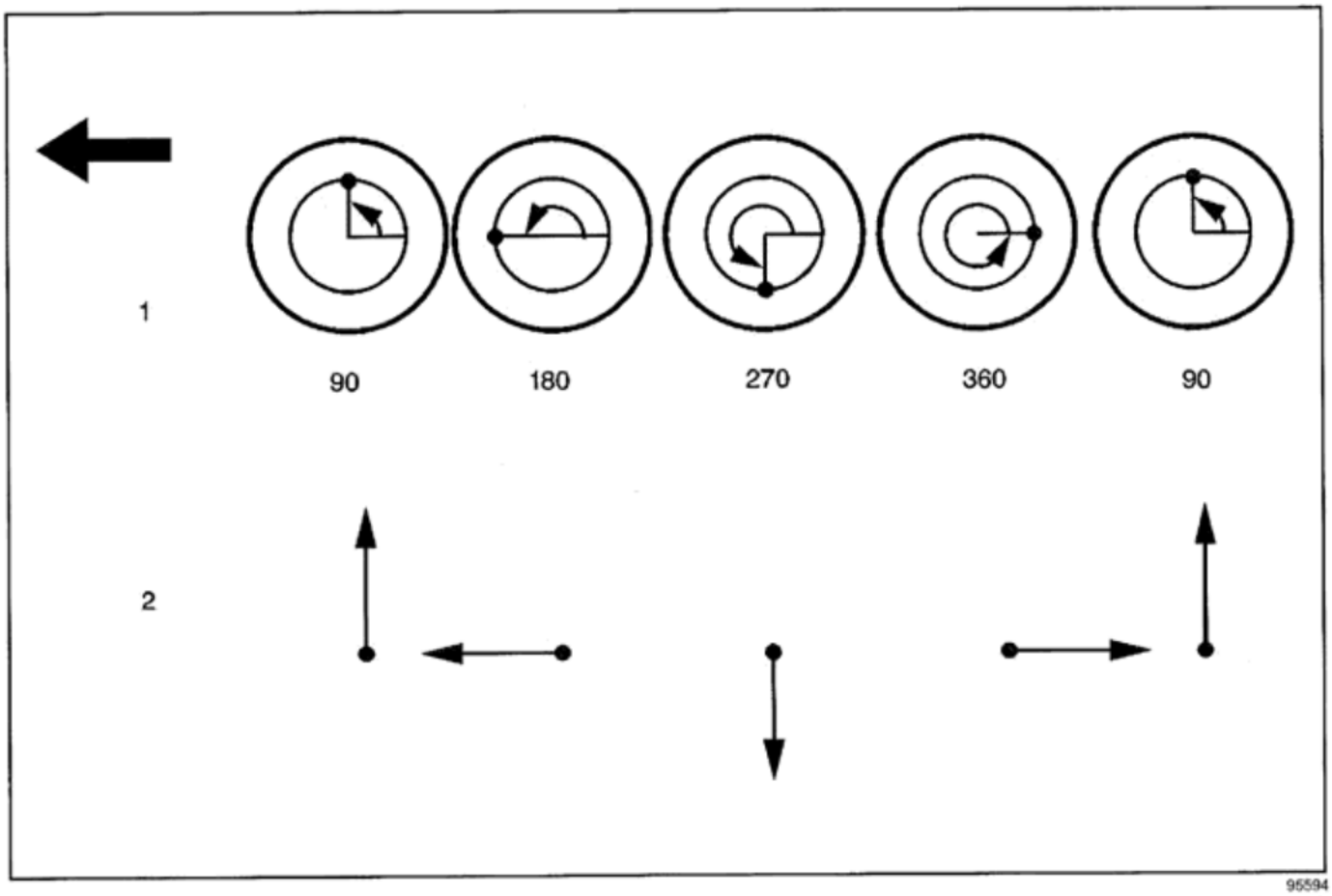
Free Vibration

Free vibration is the continued vibration in the absence of any outside force. In the yardstick example, the yardstick continued to vibrate even after the end was released.

Forced Vibration

Forced vibration is when an object is vibrating continuously as a result of an outside force.

Centrifugal Force Due to an Imbalance



Legend

(1) Location of Imbalance (Degrees)

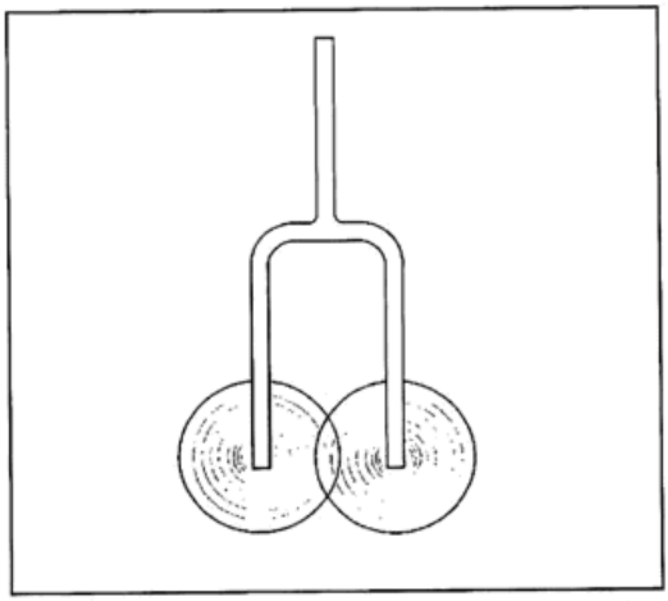
(2) Centrifugal Force Acting on Spindle

A spinning object with an imbalance generates a centrifugal force. Performing the following steps will help to demonstrate centrifugal force:

1. Tie a nut to a string.
2. Hold the string. The nut hangs vertically due to gravity.
3. Spin the string. The nut will spin in a circle.

Centrifugal force is trying to make the nut fly outward, causing the pull you feel on your hand. An unbalanced tire follows the same example. The nut is the imbalance in the tire. The string is the tire, wheel, and suspension assembly. As the vehicle speed increases, the disturbing force of the unbalanced tire can be felt in the steering wheel, the seat, and the floor. This disturbance will be repetitive (Hz) and the amplitude will increase. At higher speeds, both the frequency and the amplitude will increase. As the tire revolves, the imbalance, or the centrifugal force, will alternately lift the tire up and force the tire downward, along with the spindle, once for each revolution of the tire.

Natural or Resonant Frequency



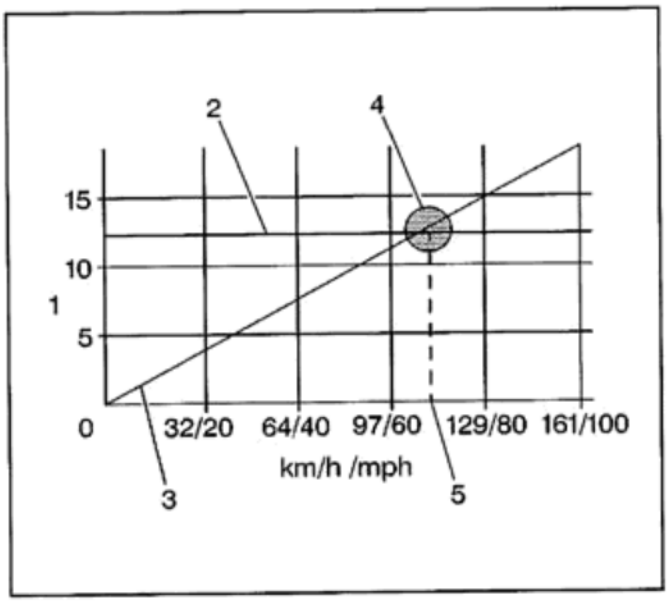
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The natural frequency is the frequency at which an object tends to vibrate. Bells, guitar strings, and tuning forks are all examples of objects that tend to vibrate at specific frequencies when excited by an external force.

Suspension systems, and even engines within the mounts, have a tendency to vibrate at certain frequencies. This is why some vibration complaints occur only at specific vehicle speeds or engine RPM.

The stiffness and the natural frequency of a material have a relationship. Generally, the stiffer the material, the higher the natural frequency. The opposite is also true. The softer a material, the lower the natural frequency. Conversely, the greater the mass, the lower the natural frequency.

Resonance



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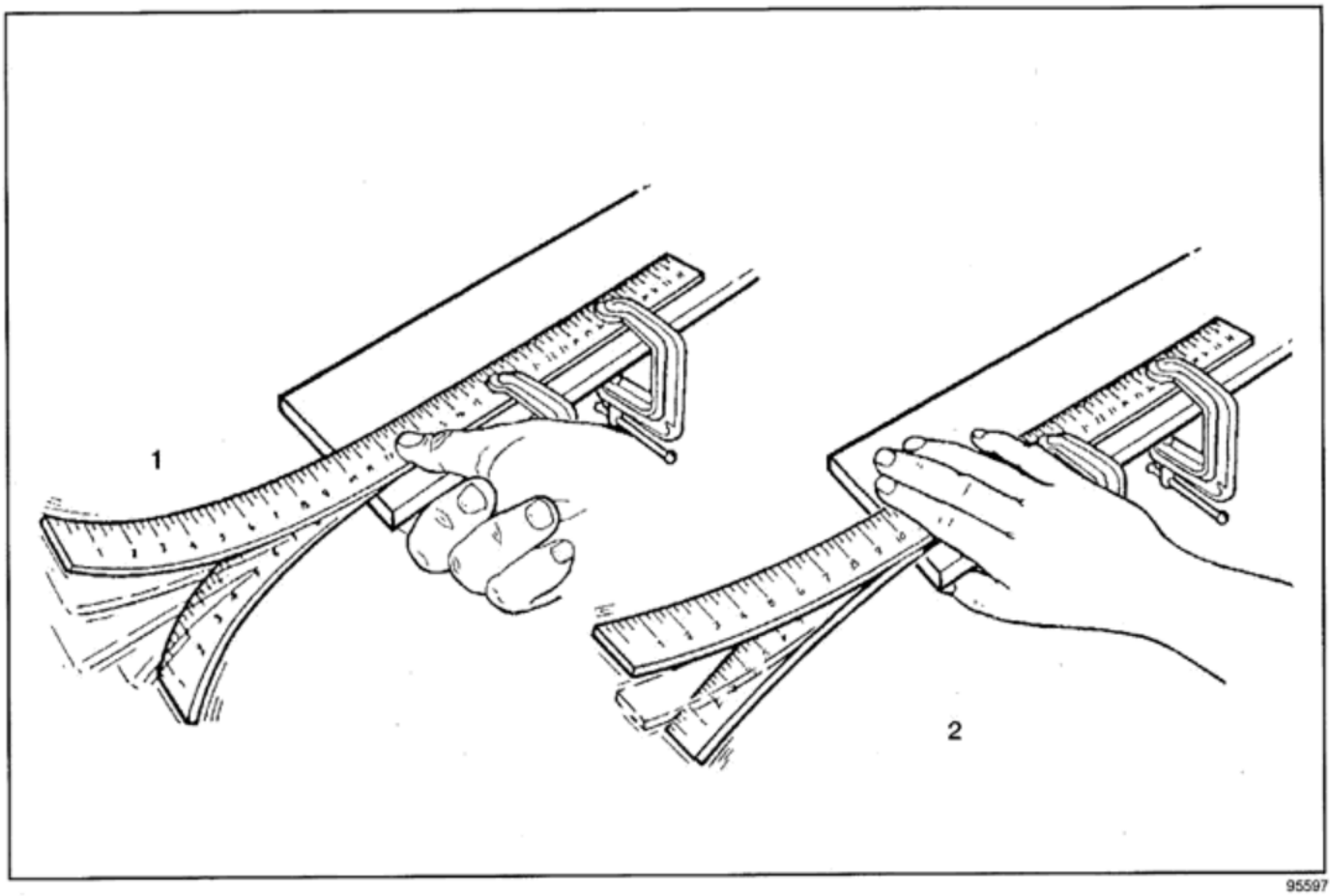
Legend

(1) Frequency – cps
(2) Suspension Frequency
(3) Unbalanced Excitation
(4) Point of Resonance
(5) Problem Speed

All objects have natural frequencies. The natural frequency of a typical automotive front suspension is in the 10–15 Hz range. This natural frequency is the result of the suspension design. The suspension's natural frequency is the same at all vehicle speeds. As the tire speed increases along with the vehicle speed, the disturbance created by the tire increases in frequency. Eventually, the frequency of the unbalanced tire will intersect with the natural frequency of the suspension. This causes the suspension to vibrate. The intersecting point is called the resonance.

The amplitude of a vibration will be greatest at the point of resonance. While the vibration may be felt above and below the problem speed, the vibration may be felt the most at the point of resonance.

Damping



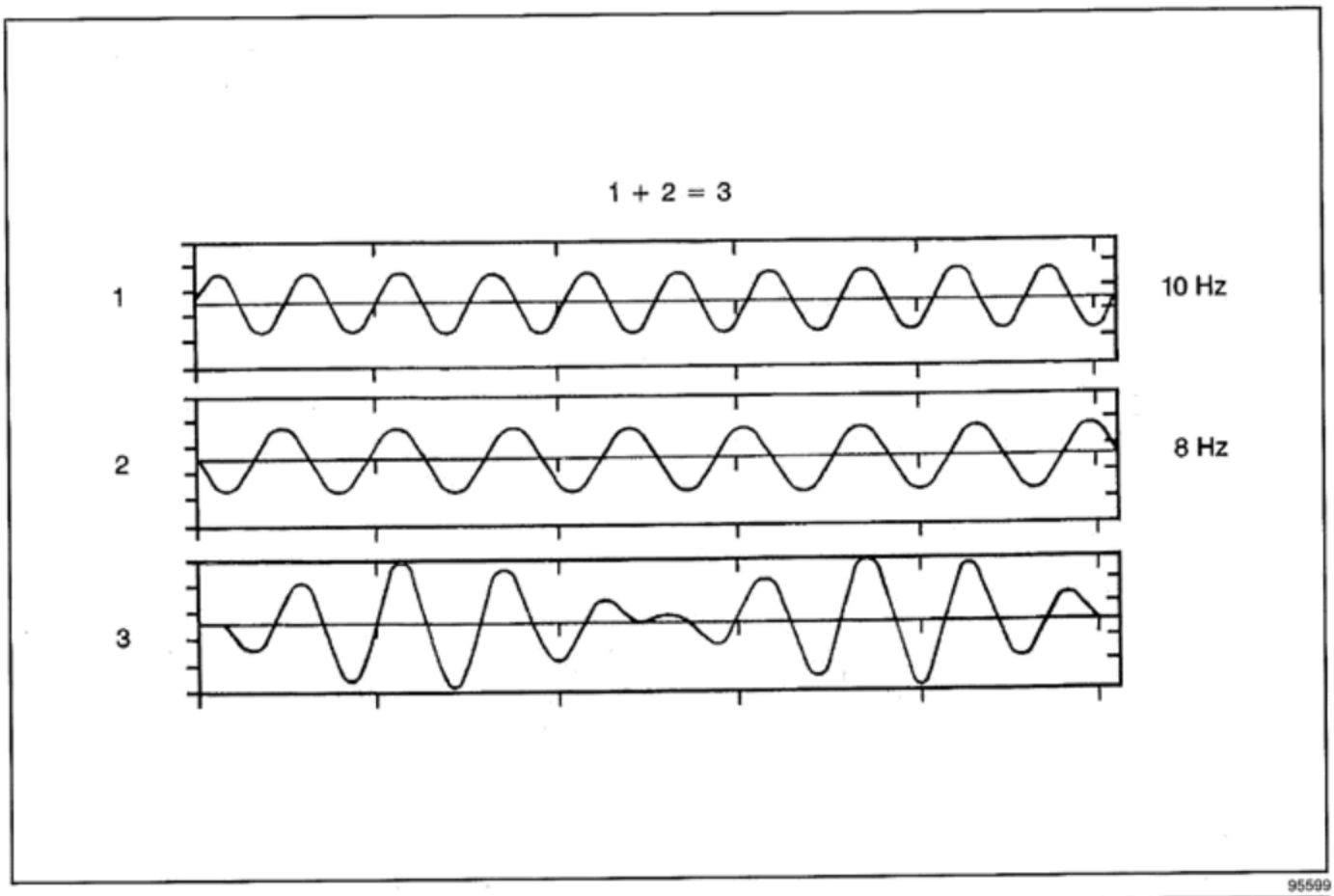
Legend

(1) Low Damping

(2) High Damping

Damping is the ability of an object or material to dissipate or absorb vibration. The automotive shock absorber is a good example. The function of the shock absorber is to absorb or dampen the oscillations of the suspension system.

Beating (Phasing)



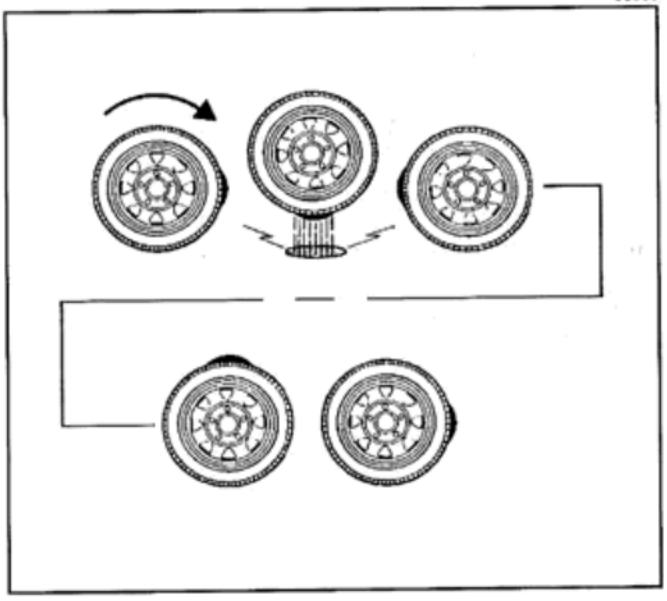
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Two separate disturbances that are relatively close together in frequency will lead to a condition called beating, or phasing. A beating vibration condition will increase in intensity or amplitude in a repetitive fashion as the vehicle travels at a steady speed. This beating vibration can produce the familiar droning noise heard in some vehicles.

Beating occurs when 2 vibrating forces are adding to each other's amplitude. However, 2 vibrating forces can also subtract from each other's amplitude. The adding and subtracting of amplitudes in similar frequencies is called beating. In many cases, eliminating either one of the disturbances can correct the condition.

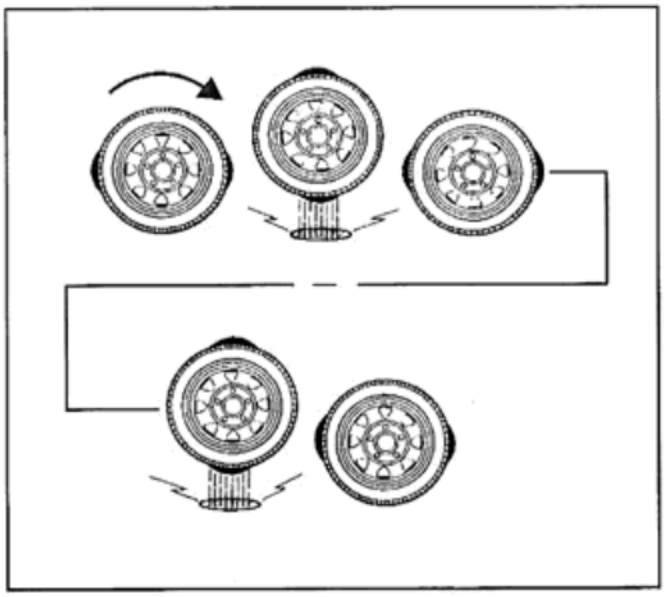
Order

Order refers to how many times an event occurs during 1 revolution of a rotating component.



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For example, a tire with 1 high spot would create a disturbance once for every revolution of the tire. This is called first-order vibration.



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An oval-shaped tire with 2 high spots would create a disturbance twice for every revolution. This is called second-order vibration. Three high spots would be third-order, and so forth. Two first-order vibrations may add or subtract from the overall amplitude of the disturbance, but that is all. Two first-order vibrations do not equal a second-order. Due to centrifugal force, an unbalanced component will always create at least a first-order vibration.

Electronic Vibration Analyzer (EVA) Description and Operation

Special Tools

- *EL-38792-25* Inductive Pickup Timing Light
- *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2)

For equivalent regional tools, refer to *Special Tools and Equipment on page 1-91*.

The *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2), is a 12--volt powered hand-held device, similar to a scan tool, which receives input from an attached vibration sensor or accelerometer and displays the most dominate input frequency(ies) (up to three) on its liquid crystal display. The vibration concern frequency(ies) are obtained through the use of the *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) while following the Vibration Analysis Diagnostic Tables. The frequency(ies) obtained, when applied to the Vibration Analysis Diagnostic Tables, are used as a primary input to help determine the source of the vibration concern.

EVA Vibration Sensor

The *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) vibration sensor incorporates a 6.1 m (20 ft) cord, that allows the sensor to be placed on virtually any component of the vehicle where a vibration concern is felt.

The *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) contains 2 sensor input ports which can be activated individually to allow for 2 individual vibration sensor inputs. The vibration sensors can then be placed in 2 different locations in the vehicle and their individual inputs can be read without having to stop a test, move the sensor and resume the test. The use of 2 vibration sensors can help in more quickly finding and recording an accurate frequency of the vibration concern, and in more quickly making comparisons between 2 different areas of a single component, or a vehicle system, during the diagnostic process.

EVA Vibration Sensor Placement

Proper placement of the *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) vibration sensor (accelerometer) is critical to ensure that proper vibration readings are obtained by the *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2). The vibration sensor should be placed on the specific vehicle component identified as being the most respondent to the vibration. If no component has been identified, install the sensor to the steering column as a starting point.

EVA Vibration Sensor-to-Component Attachment

Note: The *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) vibration sensor must be attached to vehicle components in the manner indicated in order to achieve accurate frequency readings of the vibration disturbance.

The vibration sensor of the *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) is designed to pickup disturbances which primarily occur in the vertical plane, since most vibrations are felt in that same up-and-down direction. The *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) vibration sensor is therefore directional sensitive and must be attached to vehicle components such that the side of the sensor marked UP is always facing upright and the sensor body is as close to horizontal as possible. The sensor must be installed in the exact same position each time tests are repeated or comparisons are made to other vehicles.

The *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) vibration sensor can be attached to vehicle components in various ways. For non-ferrous surfaces, such as the shroud of a steering column, the sensor can be attached using putty, or hook and loop fasteners. For ferrous surfaces, the sensor can be attached using a magnet supplied with the sensor.

EVA Software Cartridge

The *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) uses a software cartridge, the GE-38792-60, which provides various information to the *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2). The GE-38792-60 provides the *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) with an additional feature which can be selected and utilized to assist in diagnosing vibration concerns.

Note: The Auto-Mode function of the *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) cartridge, GE-38792-60, is designed to be used in SUPPORT of the Vibration Analysis Diagnostic Tables ONLY.

This support-feature is available through the *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) Auto-Mode function. When selected, the *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) will prompt the user to select which one of 2 vehicle systems (vehicle speed or engine speed), is the SUSPECTED source of the vibration concern. Using the inputted vehicle data parameters along with the most dominate vibration frequency obtained, it will identify a SUSPECTED source of the vibration concern, such as first-order tire and wheel. This can be a useful feature when used in conjunction with the Vibration Analysis Diagnostic Tables, to confirm results obtained through the diagnostic process.

EVA Smart Strobe Function

The *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) can be used to identify some rotating components/systems which exhibit imbalance IF the component rotational speed is the dominant frequency of the vibration concern. The *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) is equipped with a strobe light trigger wire which can be used with an inductive pickup timing light, *EL-38792-25* Inductive Pickup Timing Light, or equivalent included with the GE-38792-25–KIT, or available separately. Using the Smart Strobe function enables the user to input the vibration frequency to which the strobe will flash. By marking the suspected rotating component, such as a pulley, adjusting the strobe frequency to match the dominant vibration frequency at the engine RPM noted during diagnosis, and then operating the engine at that specific RPM, the mark on the object will appear to be stationary if that object is imbalanced.

EVA Strobe Balancing Function

The *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) can be used to identify the light spot on a propeller shaft IF the propeller shaft rotational speed is the dominant frequency of the vibration concern. The *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) is equipped with a strobe light trigger wire which can be used with an inductive pickup timing light, *GE-38792-25* Inductive Pickup Timing Light, or equivalent included with the J-38792-25–KIT, or available separately, and in conjunction with the *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) vibration sensor to identify the light spot on a propeller shaft and to help in making a determination as to when propeller shaft balance is obtained.

Averaging/Non-Averaging Modes

The EVA provides 2 modes of displaying the most dominate frequencies which the EVA vibration sensor (accelerometer) detects; averaging and non-averaging (instantaneous).

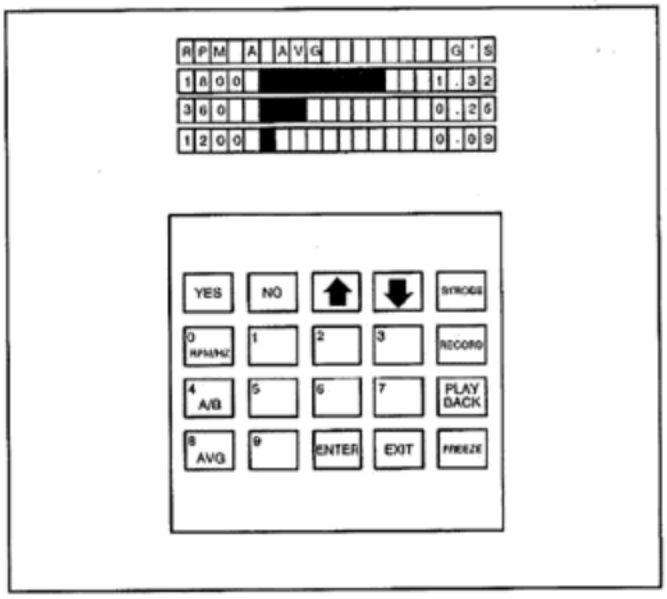
The averaging mode uses multiple vibration samples taken over a period of time and then displays the most dominant frequencies which have been averaged-out. Using the averaging mode minimizes the distractions caused by a sudden vibration frequency being displayed that is not related to the concern vibration, such as from pot holes or from uneven road surfaces.

The non-averaging (instantaneous) mode is more sensitive to vibration disturbances than the averaging mode. Using the non-averaging mode will generate instantaneous frequency displays which are not averaged across multiple samples over a period of time; the specific vibration frequencies that occur at a specific moment during diagnostic testing will be displayed at that moment. The non-averaging (instantaneous) mode is useful when measuring a vibration disturbance that exists for only a short period of time or during acceleration/deceleration testing.

When operating the EVA in the averaging mode along with the Auto Mode, "A" will be displayed along the top of the screen to the left of the vibration sensor input port being used. When operating the EVA in the averaging mode and the Manual Mode, "AVG" will be displayed along the top center of the screen.

When operating the EVA in the non-averaging (instantaneous) mode along with the Auto Mode, "I" will be displayed along the top of the screen to the left of the vibration sensor input port being used. When operating the EVA in the non-averaging (instantaneous) mode and the Manual Mode, the top center of the screen will be blank.

EVA Display



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The most dominant input frequencies, up to three, received from the *EL-38792-A* Electronic Vibration Analyzer 2 (EVA 2) vibration sensor, are displayed in descending order of amplitude strength.

The frequency readings are displayed along the left side of the screen, followed to the right by either a bar graph or the suspected source of the vibration – depending upon the mode selected, then the amplitude reading for each frequency along the right side of the screen. The top row of the screen indicates the units of measure being displayed for the frequencies along the left side and for the amplitudes along the right side. The top row also indicates the vibration sensor input port which was selected on the keypad (A or B) and which mode was selected: averaging or non-averaging (instantaneous).

The frequency(ies) can be displayed in either revolutions per minute (RPM) or revolutions per second; Hertz (Hz). The selected display type (RPM or Hz) will be indicated at the left side of the screen, above the frequency readings.

When the AUTO MODE function is not in use, a bar graph is displayed next to each frequency to provide a quick visual indication of the relative amplitude strength.

When the AUTO MODE function is being used, the suspected source of the vibration is displayed next to each frequency to provide support to the diagnostic process.

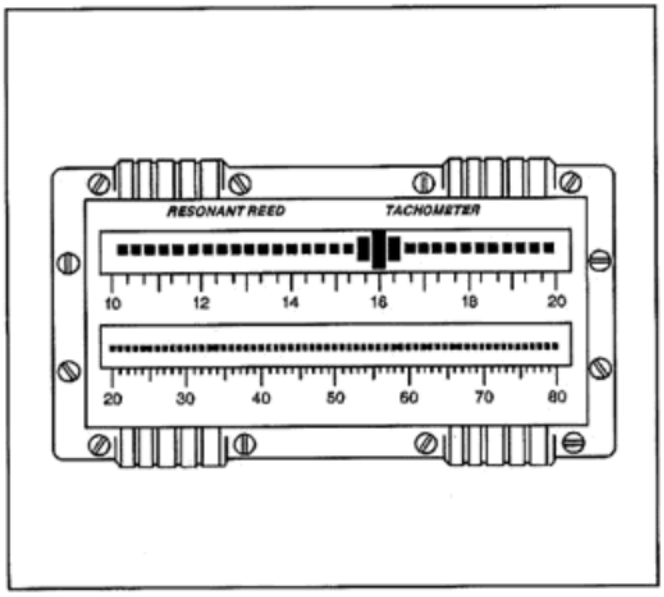
The actual amplitude strength of each frequency is displayed at the right side of the screen and shown in G's-of-acceleration force.

Vibrate Software Description and Operation

The *EL-38792-VS* Vibrate Software, is a computer software program which is designed to be used in support of the Vibration Analysis diagnostic tables, along with the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2, and a scan tool, to help in determining the source of a vibration concern. The *EL-38792-VS* Vibrate Software is designed to provide quick calculations and produce a chart of the rotational speeds and frequency ranges for specific vehicle systems and components, based upon vehicle data parameters inputted by the user.

The *EL-38792-VS* Vibrate Software uses the vehicle data parameters, such as axle ratio, number of engine cylinders, etc. to create the base chart, depicting the relationships of the various vehicle systems and/or components. The chart view can be modified to show data related to vehicle speed only, engine speed only, or both vehicle speed and engine speed. The user can then plot the dominant frequency reading obtained on the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2 which correlates with the vibration concern, and the engine RPM obtained on a scan tool which correlates with the concern. Once these pieces of data are correctly plotted, the chart will point to the source of the vibration concern, which should confirm the results obtained through the Vibration Analysis diagnostic tables.

Reed Tachometer Description



386790

The reed tachometer consists of 2 rows of reeds arranged side-by-side. Each reed is tuned to vibrate or resonate when it is excited by a specific frequency. The reeds are arranged by their specific resonant frequency, increasing from left to right, ranging from 10–80 Hz. This arrangement allows for a visual display of the most dominate frequencies which fall within this range.

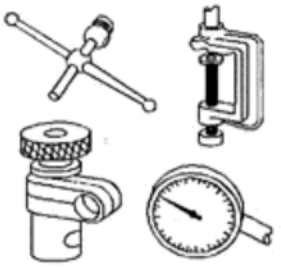
The reed tachometer can be a helpful diagnostic tool, however it is extremely sensitive to external inputs that are not related to the vibration concern, such as rough road surfaces, etc., and it is difficult to master its use. Due to these conditions, the reed tachometer has limited diagnostic capability.

Due to the limited diagnostic capability, limited availability and increasing costs of the reed tachometer, it is NOT recommended as the primary tool to use in diagnosing a vibration concern.

When diagnosing a vibration concern, use the *EL-38792-A* Electronic Vibration Analyzer (EVA) 2. The *EL-38792-A* Electronic Vibration Analyzer (EVA) 2 has been designed to overcome the shortcomings to the reed tachometer. Refer to *Electronic Vibration Analyzer (EVA) Description and Operation on page 1-88*.

Special Tools and Equipment

Illustration	Tool Number/Description
 694161	EL 38792-A J 38792-A Electronic Vibration Analyzer (EVA) 2
 694124	EL 38792-VS J 38792-VS Vibration Software

Illustration	Tool Number/Description
 694115	EN 38792-25 J 38792-25 Inductive Pickup Timing Light
 2014	GE 8001 J 8001 Dial Indicator Set