# 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 |

## PROPELLER SHAFT RUNOUT SPECIFICATIONS

| Application | Front Runout | | Center Runout | | Rear Runout | | Stub Shaft Runout | |
|---|---|---|---|---|---|---|---|---|
| | Metric | English | Metric | English | Metric | English | Metric | English |
| 1 Piece Propeller Shaft - Guideline | 1.17 mm | 0.046 in | 1.27 mm | 0.050 in | 1.40 mm | 0.055 in | - | - |
| 1 Piece Aluminum Graphite Propeller Shaft - Guideline | 1.17 mm | 0.046 in | - | - | 1.40 mm | 0.055 in | - | - |
| 2 Piece System Front Propeller Shaft with Slip Yoke - Guideline | 0.76 mm | 0.030 in | 0.76 mm | 0.030 in | 0.71 mm | 0.028 in | - | - |
| 2 Piece System Front Propeller Shaft with Stub Shaft - Guideline | 0.76 mm | 0.030 in | 0.76 mm | 0.030 in | - | - | 0.13 mm | 0.005 in |
| 2 Piece System Rear Propeller | 0.71 mm | 0.028 in | 0.76 mm | 0.030 in | 0.89 mm | 0.035 in | - | - |

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| Application | Front Runout | | Center Runout | | Rear Runout | | Stub Shaft Runout | |
|---|---|---|---|---|---|---|---|---|
| | Metric | English | Metric | English | Metric | English | Metric | English |
| Shaft with Slip Yoke - Guideline | | | | | | | | |
| 2 Piece System Rear Propeller Shaft with Stub Shaft - Guideline | - | - | 0.76 mm | 0.030 in | 0.89 mm | 0.035 in | 0.13 mm | 0.005 in |
| These guidelines apply only to propeller systems with 2 or 3 U-joints. | | | | | | | | |

### DRIVELINE RUNOUT SPECIFICATIONS

| Application | Specification | |
|---|---|---|
| | Metric | English |
| Differential Pinion Input Shaft or Flange Pilot | 0.05 mm | 0.002 in |
| Torque Tube Input Flange | 0.20 mm | 0.008 in |
| Transmission or Transfer Case Output Flange | 0.20 mm | 0.008 in |
| These guidelines apply only to propeller shaft systems with a constant velocity (CV) joint, rubber coupling, or bolt-on U-joint yoke. | | |

## 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 (EL-38792-A Electronic Vibration Analyzer)Vibration Analysis - Road Testing (CH-51450-NVH Oscilloscope)** 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 **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) , or 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**
   - **Oscilloscope Diagnostic Kit Description and Operation**
   - **Electronic Vibration Analyzer (EVA) Description and Operation**
   - **Vibrate Software Description and Operation**
   - **Reed Tachometer Description**

**Vibration Diagnostic Process**

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**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**.

## VIBRATION ANALYSIS - ROAD TESTING (EL-38792-A ELECTRONIC VIBRATION ANALYZER)

### Special Tools

- **EL-38792-A** Electronic Vibration Analyzer
- **EL-38792-VS** Vibrate Software

For equivalent regional tools, refer to **Special Tools and Equipment**.

#### 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.

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**14**

**NOTE:** **Be certain to OBSERVE for disturbances that match the customer's description FIRST, then look at the EL-38792-A Electronic Vibration Analyzer frequency which corresponds with that disturbance.**

Proper location of the **EL-38792-A** Electronic Vibration Analyzer , 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.

**17**

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.

**18**

This test will either eliminate or confirm the engine as a contributing cause of the customer concern.

| Step | Action | Yes | No |
|---|---|---|---|
| **WARNING:** **Refer to Road Test Warning .** | | | |
| 1 | Did you review the Diagnostic Starting Point - Vibration Diagnosis? | Go to **Step 2** | Go to **Diagnostic Starting Point - Vehicle** |
| 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.<br>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.**<br><br>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.<br>2. If the **EL-38792-VS** Vibrate Software , IS available, obtain the transmission gear ratios.<br>3. If the **EL-38792-VS** Vibrate Software is NOT | Go to **Step 6** | - |

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| Step | Action | Yes | No |
|---|---|---|---|
| | available, take note of the tire size on each axle, then calculate the tire rotational speed for each size tire used and calculate the propeller shaft rotational speed, if equipped. Refer to **Component Rotational Speed Calculation**.<br><br>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? | | |
| 6 | 1. Install a scan tool.<br>2. With the scan tool, bring up the Powertrain Control Module data list and select Engine Speed.<br><br>Is the scan tool operating properly? | Go to **Step 7** | Go to **Diagnostic System Check - Vehicle** |
| 7 | Using the **EL-38792-A** Electronic Vibration Analyzer , is the preferred method for gathering necessary vibration frequency data.<br>If the **EL-38792-A** Electronic Vibration Analyzer 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** to become familiar with the possible frequency ranges. Review Symptoms - Vibration Diagnosis and Correction, as necessary throughout the remainder of diagnostics.<br>Is the **EL-38792-A** Electronic Vibration Analyzer available for use? | Go to **Step 8** | Go to **Step 9** |
| 8 | Install the **EL-38792-A** Electronic Vibration Analyzer.<br>Is the **EL-38792-A** Electronic Vibration Analyzer operating properly? | Go to **Step 9** | Go to **Electronic Vibration Analyzer (EVA) Description and Operation** |
| 9 | Did the customer concern indicate that the vibration occurs ONLY while the vehicle is standing still? | Go to **Vibration Analysis - Engine** | Go to **Step 10** |
| 10 | Did the customer concern indicate that the vibration occurs ONLY during heavy acceleration at launch? | Go to **Step 11** | Go to **Step 14** |
| 11 | 1. Install the **EL-38792-A** Electronic Vibration Analyzer sensor, if available, to the pinion area of the drive axle. Route the sensor lead wire clear of rotating parts and loosely secure the wire clear of moving parts. If it is not possible to install the **EL-38792-A** Electronic Vibration Analyzer sensor, if available, to the drive axle, install the sensor to an exposed portion of the floor panel or seat track in the area that the customer noted is most respondent to the vibration.<br>2. Select a smooth, level road.<br>3. With the vehicle at a stand-still, apply the regular brake and place the transmission in the lowest forward gear. | Go to **Step 12** | Go to **Step 14** |

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| Step | Action | Yes | No |
|---|---|---|---|
| | **NOTE:**<br>**Do not accelerate to the point of causing the drive wheels to squeal, slip or hop - this would obscure the results of the test.**<br><br>4. Release the regular brakes and accelerate aggressively to 32 km/h (20 mph).<br>5. Observe the vehicle for disturbances that match the customer's description and note the following conditions:<br>• The vibration frequency reading, if detected by the **EL-38792-A** Electronic Vibration Analyzer<br>• The feel and/or sound of the disturbance<br>6. If a reading could not be obtained by the **EL-38792-A** Electronic Vibration Analyzer , move the **EL-38792-A** Electronic Vibration Analyzer sensor, if available, to another part that is respondent to the vibration and repeat steps 3-5.<br><br>Were you able to duplicate the customer's concern? | | |
| 12 | Is the vehicle primary driveline configuration rear wheel drive? | Go to **Step 13** | Go to **Step 14** |
| 13 | Is the vehicle equipped with a solid drive axle? | Go to **Vibration Analysis - Driveline** | Go to **Vibration Analysis - Hub and/or Axle Input** |
| **14** | 1. Install the **EL-38792-A** Electronic Vibration Analyzer 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 sensor, if available, to the steering column. You may have to move the sensor to other locations later.<br>2. Select a smooth, level road and slowly accelerate the vehicle up to highway speed.<br>3. Observe the vehicle for disturbances that match the customer's description and note the following conditions:<br>• The vehicle speed<br>• The engine RPM | Go to **Step 17** | Go to **Step 15** |

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| Step | Action | Yes | No |
|---|---|---|---|
| | • The transmission gear range and the specific gear<br>• The vibration frequency reading, if detected by the **EL-38792-A** Electronic Vibration Analyzer<br>• The feel and/or sound of the disturbance<br>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 sensor, if available, onto that component and repeat steps 2 and 3.<br><br>Were you able to duplicate the customer's concern? | | |
| 15 | Is the vehicle equipped with selectable four-wheel or all-wheel drive? | Go to **Step 16** | Go to **Step 17** |
| 16 | 1. With the **EL-38792-A** Electronic Vibration Analyzer sensor still installed in the same position, activate/engage all-wheel drive.<br>2. Select a smooth, level road and slowly accelerate the vehicle up to highway speed.<br>3. Observe the vehicle for disturbances that match the customer's description and note the following conditions:<br>• The vehicle speed<br>• The engine RPM<br>• The transmission gear range and the specific gear<br>• The vibration frequency reading, if detected by the **EL-38792-A** Electronic Vibration Analyzer<br>• The feel and/or sound of the disturbance<br>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 sensor, if available, onto that component and repeat steps 2 and 3.<br><br>Were you able to duplicate the customer's concern? | Go to **Step 17** | Go to **Vibration Diagnostic Aids** |
| **17** | 1. Accelerate the vehicle to a speed higher than the speed at which the disturbance occurs.<br><br>**NOTE:**<br>**If the vehicle is equipped with a continuously variable type automatic** | Go to **Step 19** | Go to **Step 18** |

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| Step | Action | Yes | No |
|---|---|---|---|
| | **transmission, let the vehicle coast to a stop before shifting back into gear.**<br><br>2. Shift the vehicle into NEUTRAL and allow the vehicle to coast down through the disturbance range.<br><br>Does the disturbance still occur while coasting-down in NEUTRAL? | | |
| **18** | 1. Select a smooth, level road and slowly accelerate the vehicle up to the speed at which the disturbance occurs.<br>2. Decelerate and safely downshift by one gear range.<br>3. Operate the vehicle at the same VEHICLE SPEED at which the disturbance occurs.<br><br>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** | Go to **Vibration Analysis - Engine** |
| 19 | If the **EL-38792-A** Electronic Vibration Analyzer is not available, refer to **Symptoms - Vibration Diagnosis and Correction**.<br>Did the **EL-38792-A** Electronic Vibration Analyzer detect a dominant frequency? | Go to **Step 20** | Go to **Symptoms - Vibration Diagnosis and Correction** |
| 20 | 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.<br>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.<br><br>Does the frequency data clearly fall within the tire/wheel parameters ONLY? | Go to **Vibration Analysis - Tire and Wheel** | Go to **Step 21** |
| 21 | Does the frequency data clearly fall within the propeller shaft parameters ONLY? | Go to **Vibration Analysis - Driveline** | Go to **Step 22** |
| 22 | Is the vehicle equipped with a solid drive axle? | Go to **Symptoms - Vibration Diagnosis and Correction** | Go to **Vibration Analysis - Hub and/or Axle Input** |

## VIBRATION ANALYSIS - ROAD TESTING (CH-51450-NVH OSCILLOSCOPE)

**Special Tools**

- **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH)

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- **EL-47955** Multi Diagnostic Interface (MDI)

For equivalent regional tools, refer to **Special Tools and Equipment**.

### Test Description

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

**NOTE:** **Be certain to OBSERVE for disturbances that match the customers description FIRST, then look at the CH-51450-NVH Oscilloscope Diagnostic Kit (w/NVH) frequency which corresponds with that disturbance.**

**12**

Proper location of the **CH-51450-NVH** oscilloscope accelerometer 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.

**15**

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.

**16**

This test will either eliminate or confirm the engine as a contributing cause of the customer concern.

| Step | Action | Yes | No |
|---|---|---|---|
| **WARNING:** Refer to **Road Test Warning** . | | | |
| 1 | Did you review the Diagnostic Starting Point - Vibration Diagnosis? | Go to **Step 2** | Go to **Vibration Diagnosis, Starting Point, and Correction** |
| 2 | Did the customer concern indicate that the vibration occurs ALSO while the vehicle is idling at a stop? | 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.<br>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.**<br>Correct the faults with the tire and wheel assemblies, | Go to **Step 5** | Go to **Step 3** |

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| Step | Action | Yes | No |
|---|---|---|---|
| | 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? | | |
| 5 | Obtain the drive axle final drive ratio.<br>Did you obtain the drive axle final drive ratio? | Go to **Step 6** | - |
| 6 | Install the **CH-51450-NVH** Oscilloscope and the **EL-47955** MDI.<br>Is the **CH-51450-NVH** Oscilloscope operating properly? | Go to **Step 7** | Go to **Oscilloscope Diagnostic Kit Description and Operation** |
| 7 | Did the customer concern indicate that the vibration occurs ALSO while the vehicle is idling at a stop? | Go to **Vibration Analysis - Engine** | Go to **Step 8** |
| 8 | Did the customer concern indicate that the vibration occurs ONLY during heavy acceleration at launch? | Go to **Step 9** | Go to **Step 12** |
| 9 | 1. Install the **CH-51450-NVH-TA183** accelerometer to the pinion area of the drive axle. Route the accelerometer cable clear of rotating parts and loosely secure the wire clear of moving parts. If it is not possible to install the **CH-51450-NVH-TA183** accelerometer to the drive axle, install the accelerometer to an exposed portion of the floor panel or seat track in the area that the customer noted is most respondent to the vibration.<br>2. Select a smooth, level road.<br>3. With the vehicle at a stand-still, apply the brake pedal and place the transmission in the lowest forward gear.<br>**NOTE:**<br>**Do not accelerate to the point of causing the drive wheels to squeal, slip, or hop. This would obscure the results of the test.**<br>4. Release the brake pedal and accelerate aggressively to 32 km/h (20 mph).<br>5. Observe the vehicle for disturbances that match the customers description and note the following conditions:<br>• The vibration frequency reading, if detected, by the **CH-51450-NVH** Oscilloscope<br>• The feel and/or sound of the disturbance | Go to **Step 10** | Go to **Step 12** |

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| Step | Action | Yes | No |
|---|---|---|---|
| | 6. If a reading could not be obtained by the **CH-51450-NVH** Oscilloscope, move the **CH-51450-NVH-TA183** accelerometer to another part that is respondent to the vibration and repeat Steps 3-5.<br><br>Were you able to duplicate the customer concern? | | |
| 10 | Is the vehicle primary driveline configuration rear wheel drive? | Go to **Step 11** | Go to **Step 12** |
| 11 | Is the vehicle equipped with a solid drive axle? | Go to **Vibration Analysis - Driveline** | Go to **Vibration Analysis - Hub and/or Axle Input** |
| **12** | 1. Install the **CH-51450-NVH-TA183** accelerometer to the component identified by the customer as most respondent to the vibration. If no component was identified, install the **CH-51450-NVH-TA183** accelerometer to the drivers side right seat rail. You may have to move the sensor to other locations later.<br>2. Select a smooth, level road and slowly accelerate the vehicle up to highway speed.<br>3. Observe the vehicle for disturbances that match the customers description and note the following conditions or take a snapshot using the **CH-51450-NVH** software:<br>• The vehicle speed<br>• The engine RPM<br>• The transmission gear range and the specific gear<br>• The vibration frequency reading, if detected, by the **CH-51450-NVH** Oscilloscope<br>• The feel and/or the sound of the disturbance<br>4. If the vibration seems to excite a particular component of the vehicle more than the sear rail, move the **CH-51450-NVH-TA183** accelerometer onto that component and repeat Steps 2 and 3.<br><br>Were you able to duplicate the customer concern? | Go to **Step 15** | Go to **Step 13** |
| 13 | Is the vehicle equipped with selectable four-wheel or all-wheel drive? | Go to **Step 14** | Go to **Step 15** |
| 14 | 1. With the **CH-51450-NVH-TA183** accelerometer still installed in the same position, activate/engage all-wheel drive.<br>2. Select a smooth, level road and slowly accelerate the vehicle up to highway speed.<br>3. Observe the vehicle for disturbances that match the customers description and note the following conditions or take a snapshot using the **CH-51450-NVH** software. | Go to **Step 15** | Go to **Vibration Diagnostic Aids** |

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| Step | Action | Yes | No |
|---|---|---|---|
| | • The vehicle speed<br>• The engine RPM<br>• The transmission gear range and the specific gear<br>• The vibration frequency reading, if detected, by the **CH-51450-NVH** Oscilloscope<br>• The feel and/or sound of the disturbance<br>4. If the vibration seems to excite a particular component of the vehicle more than the seat rail, then move the **CH-51450-NVH-TA183** accelerometer onto that component and repeat Step 2 and 3.<br><br>Were you able to duplicate the customer concern? | | |
| **15** | 1. Accelerate the vehicle to a speed higher than the speed at which the disturbance occurs.<br><br>**NOTE:**<br>**If the vehicle is equipped with a continuously variable type automatic transmission, let the vehicle coast to a stop before shifting back into gear.**<br><br>2. Shift the vehicle into NEUTRAL and allow the vehicle to coast down through the disturbance range.<br><br>Does the disturbance still occur while coasting down in NEUTRAL? | Go to **Step 17** | Go to **Step 16** |
| **16** | 1. Select a smooth, level road and slowly accelerate the vehicle up to the speed at which the disturbance occurs.<br>2. Decelerate and safely downshift by one gear range.<br>3. Operate the vehicle at the same VEHICLE SPEED at which the disturbance occurs.<br><br>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** | Go to **Vibration Analysis - Engine** |
| 17 | If the **CH-51450-NVH** Oscilloscope is not available, refer to **Symptoms - Vibration Diagnosis and Correction**. | Go to **Step 18** | Go to **Symptoms - Vibration Diagnosis and Correction** |

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| Step | Action | Yes | No |
|---|---|---|---|
| | Did the **CH-51450-NVH** Oscilloscope detect a dominant frequency? | | |
| 18 | Does the frequency data clearly fall within the tire/wheel parameters ONLY? | Go to **Vibration Analysis - Tire and Wheel** | Go to **Step 19** |
| 19 | Does the frequency data clearly fall within the propeller shaft parameters ONLY? | Go to **Vibration Analysis - Driveline** | Go to **Step 20** |
| 20 | Is the vehicle equipped with a solid drive axle? | Go to **Symptoms - Vibration Diagnosis and Correction** | Go to **Vibration Analysis - Hub and/or Axle Input** |

## COMPONENT ROTATIONAL SPEED CALCULATION

**Special Tools**

- **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH)
- **EL-38792-A** Electronic Vibration Analyzer (EVA) 2
- **EL-47955** Multi Diagnostic Interface (MDI)

For equivalent regional tools, refer to **Special Tools and Equipment**.

**NOTE:** **If using the CH-51450-NVH Oscilloscope Diagnostic Kit (w/NVH) , the component rotation is integrated into the tool. The diameter of the pulley will need to be measured and manually entered into the NVH software.**

### 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 P275/55R20 tire, enter 275.

5. On the Aspect Ratio screen, enter the specific aspect ratio of the tires.

   For example: For a P275/55R20 tire, enter 0.55.

6. On the Rim Diameter screen, enter the specific rim diameter size.

   For example: For a P275/55R20 tire, enter 20.0.

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: 275 0.55 20.0 - Front Wheel Drive. If the tire size displayed is correct, press Enter.

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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 P275/55R20 will display 0.90 RPS.

**Calculating Tire Revolutions Per Second at 8 km/h (5 mph) - Without Ocilloscope or 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 P275/55R20 tire, the rim diameter of 20 in X 2.54 converts to 50.80 cm.

2. Calculate the radius of the rim by dividing the rim diameter by 2.

   For example: For a P275/55R20 tire, the rim diameter of 20 in converted to 50.80 cm divided by 2 = rim radius 25.40 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 P275/55R20 tire, tread width 275 mm X aspect ratio as a decimal 0.55 = 151 mm X 0.93 = approximate sidewall height 140.43 mm.

4. Convert the calculated approximate tire sidewall height from millimeters to centimeters.

   For example: For a P275/55R20 tire, approximate sidewall height 140.43 mm converts to 14.04 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 P275/55R20 tire, rim radius 25.40 cm + 14.04 cm = approximate tire and wheel assembly radius 39.44 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 P275/55R20 tire, 6.283185 X approximate tire and wheel assembly radius 39.44 cm = approximate tire and wheel assembly circumference 247.809 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 P275/55R20 tire, 100,000 cm divided by approximate tire and wheel assembly circumference 247.809 cm = approximate revolutions per kilometer 403.537.

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 P275/55R20 tire, approximate revolutions per kilometer 403.537 divided by the number of seconds to travel 1 km at a speed of 8 km per hour, 450 seconds = approximate RPS, or Hz 0.897 rounded to

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0.90.

### 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 2 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 P275/55R20 tire makes 0.90 revolutions per second, or 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 rotation increases by 0.90 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 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 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 0.90 Hz = 10.80 Hz, rounded to 11 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.**

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:

   11 Hz X 2, for second order = 22 Hz second-order tire/wheel assembly rotation related

   11 Hz X 3, for third order = 33 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.

### Calculating Propeller Shaft Revolutions Per Second, or Hz at Concern Speed

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1. Determine the first order rotational speed of the propeller shaft system in revolutions per second, or Hz, based on the first-order rotational speed of the tire/wheel assemblies and the drive axle, or axles final drive ratio or ratios.

   11 Hz X 3.42 drive axle final drive ratio = 37.62 Hz, rounded to 38 Hz, first-order propeller shaft rotation related

2. Compare the rotational speed of the propeller shafts 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 propeller shaft is present.

   If the frequencies do not match, then the disturbance may be related to the second-order of propeller shaft rotation.

3. To compute a second order propeller shaft rotation related disturbance, multiply the first order rotational speed of the propeller shaft at the specific vehicle speed at which the disturbance occurs, by the order number of 2:

   38 Hz X 2, for second order = 76 Hz second-order propeller shaft rotation related

   If the computation matches the frequency of the disturbance, a disturbance relating to the second-order rotation of the propeller shaft is present.

**Component Rotational Speed Worksheet**

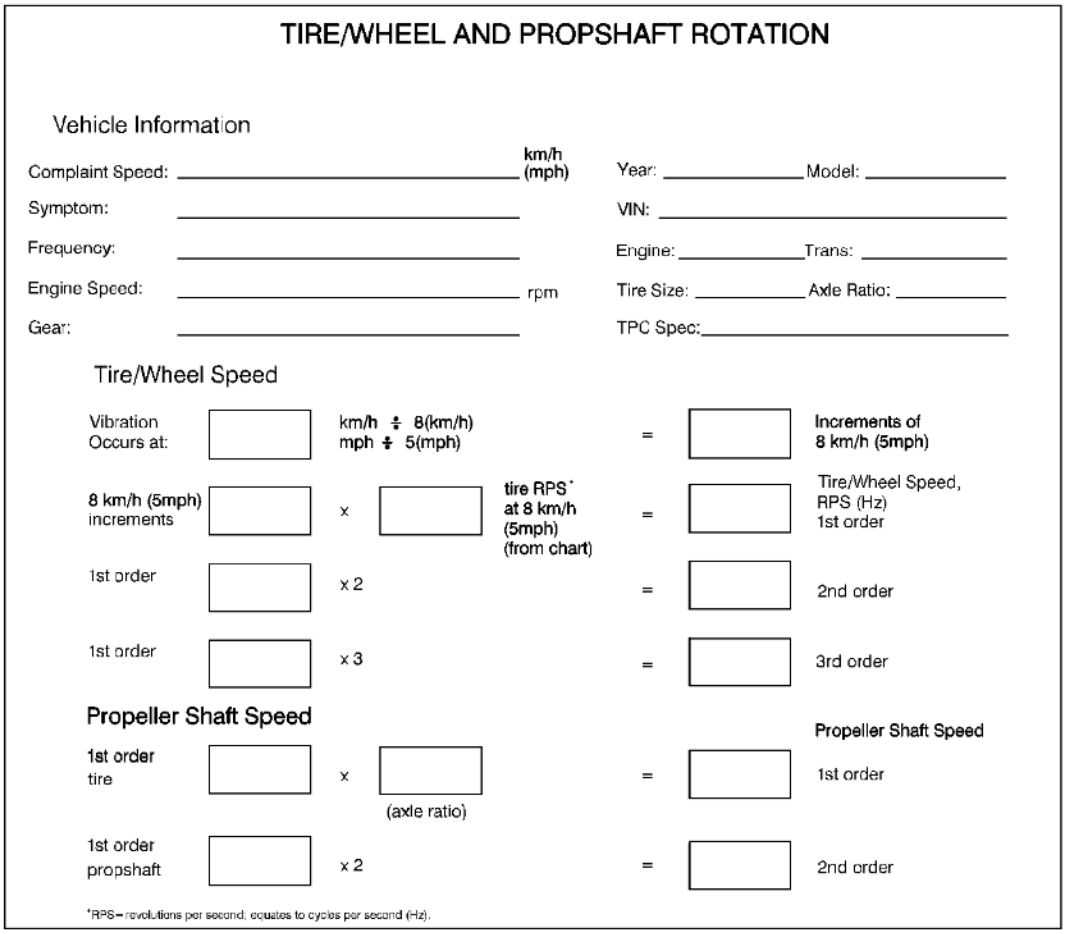
Utilize the following worksheet as an aid in calculating the first, second and third order of tire/wheel assembly rotational speed and the first and second order of propeller shaft rotational speed related disturbances that may be present in the vehicle.

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 1 1/2 -8 km/h (1-5 mph) of speedometer error.

If the possible tire/wheel assembly and/or propeller shaft 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 or propeller shaft related.

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TIRE/WHEEL AND PROPSHAFT ROTATION

Vehicle Information

Complaint Speed: _____ km/h (mph)
Year: _____ Model: _____
Symptom: _____
VIN: _____
Frequency: _____
Engine: _____ Trans: _____
Engine Speed: _____ rpm
Tire Size: _____ Axle Ratio: _____
Gear: _____
TPC Spec: _____

Tire/Wheel Speed

| | | | | | |
|---|---|---|---|---|---|
| Vibration Occurs at: | | km/h ÷ 8(km/h) mph ÷ 5(mph) | | = | Increments of 8 km/h (5mph) |
| 8 km/h (5mph) increments | | x | tire RPS* at 8 km/h (5mph) (from chart) | = | Tire/Wheel Speed, RPS (Hz) 1st order |
| 1st order | | x 2 | | = | 2nd order |
| 1st order | | x 3 | | = | 3rd order |

Propeller Shaft Speed

| | | | | | |
|---|---|---|---|---|---|
| | | | | | Propeller Shaft Speed |
| 1st order tire | | x | (axle ratio) | = | 1st order |
| 1st order propshaft | | x 2 | | = | 2nd order |

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

**Fig. 1: Tire/Wheel Rotation Worksheet**
**Courtesy of GENERAL MOTORS COMPANY**

## 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.

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**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.

| Step | Action | Yes | No |
|---|---|---|---|
| 1 | Has the Vibration Analysis - Road Testing table been completed? | Go to **Step 2** | Go to **Vibration Analysis - Road Testing (EL-38792-A Electronic Vibration Analyzer)Vibration Analysis - Road Testing (CH-51450-NVH Oscilloscope)** |
| 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 (EL-38792-A Electronic Vibration** |

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| Step | Action | Yes | No |
|---|---|---|---|
| | | | Analyzer)Vibration Analysis - Road Testing (CH-51450-NVH Oscilloscope) |
| 4 | Visually inspect the tire and wheel assemblies for the following:<br>• Debris build-up, such as packed mud, undercoating, ice/snow buildup, road tar, etc.<br>• Damage, abnormal or excessive wear<br>Refer to Tire and Wheel Inspection.<br>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.<br>2. Replace the damaged, abnormally or excessively worn wheels or tires as necessary.<br>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.<br>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.<br>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:**<br>**Ensure that each tire and wheel assembly that is match-mounted is properly balanced before reinstalling to the vehicle.**<br>1. Match-mount the tire-to-wheel for each tire and wheel assembly with marginal runout. Refer to | Go to **Step 11** | Go to **Step 19** |

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| Step | Action | Yes | No |
|---|---|---|---|
| | **Tire-to-Wheel Match-Mounting (Vectoring)**.<br>2. Measure the runout of each match-mounted tire and wheel assembly. Refer to **Tire and Wheel Assembly Runout Measurement - Off Vehicle**.<br><br>Were you able to significantly reduce the amount of tire and wheel assembly runout? | | |
| 11 | Re-measure the on-vehicle runout of the tire and wheel assemblies. Refer to **Tire and Wheel Assembly Runout Measurement - On-Vehicle**.<br>Does the measurement indicate a runout concern? | Go to **Step 15** | Go to **Step 23** |
| 12 | Inspect the balance of the tire and wheel assemblies. Refer to **Tire and Wheel Assembly Balancing - Off Vehicle**.<br>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**.<br>Were you able to achieve balance? | Go to **Step 23** | Go to **Vibration Diagnostic Aids** |
| **14** | 1. Inspect the brake rotors and brake drums, if equipped, for damage.<br>2. Inspect the balance of the brake rotors and brake drums, if equipped. Refer to **Brake Rotor/Drum Balance Inspection**.<br>3. Replace brake rotors and/or brake drums, if equipped, that are damaged and/or out of balance.<br><br>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.<br>2. Inspect the wheel bolts, if equipped, for straightness and damage.<br>3. Refer to **Hub/Axle Flange and Wheel Stud Runout Inspection**.<br>4. If the inspection procedure indicates a runout concern, replace the appropriate components:<br>• Wheel studs, if equipped<br>• Wheel bolts, if equipped<br>• Wheel bearing/hub assembly<br><br>Did you find and correct a condition? | Go to **Step 23** | Go to **Step 16** |

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| Step | Action | Yes | No |
|---|---|---|---|
| **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**.<br>2. Re-measure the on-vehicle runout of tire and wheel assemblies. Refer to **Tire and Wheel Assembly Runout Measurement - On-Vehicle**.<br><br>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**.<br>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**.<br>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.<br>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**.<br>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**.<br>Did you find and correct a condition? | Go to **Step 23** | Go to **Vibration Diagnostic Aids** |
| **22** | Finish-balance the tire and wheel assemblies on-vehicle. Refer to **Tire and Wheel Assembly Balancing - On-Vehicle**.<br>Did you complete the on-vehicle finish balancing? | Go to **Step 23** | - |
| 23 | 1. Install or connect any components that were removed or disconnected during diagnosis.<br>2. Perform the Vibration Analysis - Road Testing table. Refer to **Vibration Analysis - Road Testing (EL-38792-A Electronic Vibration Analyzer)Vibration Analysis - Road Testing (CH-51450-NVH Oscilloscope)**.<br><br>Is the vibration still present? | Go to **Step 2** | System OK |

## VIBRATION ANALYSIS - DRIVELINE

| Step | Action | Yes | No |
|---|---|---|---|
| 1 | Has the Vibration Analysis - Road Testing table been completed? | Go to **Step 2** | Go to **Vibration Analysis - Road Testing (EL-38792-A Electronic Vibration Analyzer)Vibration Analysis - Road Testing** |

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| Step | Action | Yes | No |
|---|---|---|---|
| | | | (CH-51450-NVH Oscilloscope) |
| 2 | Did you duplicate a vibration concern that occurs only during heavy acceleration at launch? | Go to **Step 3** | Go to **Step 4** |
| 3 | Is the vehicle equipped with a solid drive axle and at least 1 U-joint in the propeller shaft system? | Go to **Step 26** | Go to **Step 4** |
| 4 | Did you record frequency data from the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or the **EL-38792-A** Electronic Vibration Analyzer (EVA) 2 , during the Vibration Analysis - Road Testing procedure? | Go to **Step 5** | Go to **Step 10** |
| 5 | Based on the Vibration Analysis - Road Testing table, is the concern first order, sixth order, or a slightly higher multiple of first order driveline related? | Go to **Step 6** | Go to **Step 8** |
| 6 | Is the vehicle equipped with a rear mounted transaxle assembly? | Go to **Step 7** | Go to **Step 11** |
| 7 | Inspect the drive axle for proper operation. Refer to the Drive Axle diagnosis information.<br>Did you find and correct a condition? | Go to **Step 32** | Go to **Step 2** |
| 8 | Based on the Vibration Analysis - Road Testing table, is the concern second order driveline related? | Go to **Step 9** | Go to **Step 10** |
| 9 | Does the vehicle driveline contain any U-joints? | Go to **Step 26** | Go to **Vibration Diagnostic Aids** |
| 10 | Based on the Vibration Analysis - Road Testing table, is the concern a noise that is not felt? | Go to **Vibration Diagnostic Aids** | Go to **Vibration Analysis - Road Testing (EL-38792-A Electronic Vibration Analyzer)Vibration Analysis - Road Testing (CH-51450-NVH Oscilloscope)** |
| 11 | 1. Inspect the following components for wear and/or damage:<br>• Inspect the propeller shafts for dents, damage, missing weights, and/or undercoating.<br>• Inspect the U-joint, or joints, if equipped, for excessive wear, looseness, and/or damage.<br>• Inspect the prop shaft constant velocity (CV) joint, or joints, if equipped, for excessive wear, looseness, and/or damage.<br>• Inspect the prop shaft coupler assembly, or assemblies, if equipped, for excessive wear, looseness, and/or damage.<br>• Inspect the prop shaft support bearing, if equipped, for damaged rubber components, worn bearings, looseness, and/or a deformed or cracked bracket. | Go to **Step 32** | Go to **Step 12** |

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| Step | Action | Yes | No |
|---|---|---|---|
| | • Inspect the drive axle mounts, if equipped, for excessive wear, looseness, and/or damage.<br>2. Replace any of the components found to be worn or damaged.<br><br>Did you find and correct a condition? | | |
| 12 | Attempt to duplicate the vibration in the stall. Refer to **Vibration in Service-Stall Test (Non-Torque Sensitive)**.<br>Were you able to duplicate the vibration? | Go to **Step 16** | Go to **Step 13** |
| 13 | Perform the **Vibration in Service-Stall Test (Torque Sensitive)**.<br>Were you able to duplicate the vibration? | Go to **Step 14** | Go to **Vibration Diagnostic Aids** |
| 14 | Is the vehicle front wheel drive with an all wheel drive system? | Go to **Step 15** | Go to **Vibration Diagnostic Aids** |
| 15 | 1. Remove the propeller shaft.<br>2. Perform the **Vibration in Service-Stall Test (Torque Sensitive)**.<br><br>Is the vibration still present? | Go to Transfer Case diagnosis information | Go to Drive Axle diagnosis information |
| 16 | Was the vibration most evident under the transmission or the transfer case, if equipped? | Go to **Step 17** | Go to **Step 20** |
| 17 | 1. If the driveline joint at the transmission or transfer case is a U-joint, measure the prop shaft runout at the end closest to the transmission or transfer case. Refer to **Propeller Shaft Runout Measurement**.<br>2. If the driveline joint at the transmission or transfer case is a CV joint, measure the runout of the transmission or transfer case output flange. Refer to **Transfer Case Output Flange Runout Measurement**.<br>3. If the driveline joint at the transmission or transfer case is a coupler assembly, inspect the coupler assembly for excessive wear, looseness, missing or broken fasteners, and/or damage. Measure the runout of the transmission or transfer case output flange. Refer to **Transfer Case Output Flange Runout Measurement**.<br>4. Replace components as necessary.<br><br>Did you find and correct a condition? | Go to **Step 19** | Go to **Step 18** |
| 18 | 1. Inspect the powertrain mounts for the following:<br>• Loose and/or missing fasteners<br>• Improper alignment<br>• Cracked, dry-rotted, and/or oil-soaked insulators | Go to **Step 19** | Go to **Step 20** |

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| Step | Action | Yes | No |
|---|---|---|---|
| | • Twisted, broken, torn, and/or collapsed insulators<br>• Bent, twisted, and/or deformed brackets<br>2. Replace the powertrain mounts as necessary.<br><br>Did you find and correct a condition? | | |
| 19 | Perform the **Vibration in Service-Stall Test (Non-Torque Sensitive)**.<br>Is the vibration still present? | Go to **Step 20** | Go to **Step 32** |
| 20 | 1. Inspect the prop shaft U-joint, or joints, if equipped, for excessive wear, looseness, and/or damage.<br>2. Inspect the prop shaft CV joint, or joints, if equipped, for excessive wear, looseness, and/or damage.<br>3. Inspect the prop shaft coupler assembly for excessive wear, looseness, broken or missing fasteners, and/or damage.<br>4. Inspect the prop shaft support bearing assembly, if equipped, for damaged rubber components, worn bearings, and/or a deformed or cracked bracket.<br>5. If the driveline joint at the drive axle is a U-joint, measure the runout of the complete prop shaft, or shafts. Refer to **Propeller Shaft Runout Measurement**.<br>6. If the driveline incorporates a torque tube attached to the drive axle and the joint at the torque tube is a CV joint, coupler assembly, or bolt-on U-joint yoke, measure the runout of the torque tube input flange. Refer to **Torque Tube Input Flange Runout Measurement**.<br>7. Replace components as necessary.<br><br>Did you find and correct a condition? | Go to **Step 21** | Go to **Step 22** |
| 21 | Perform the **Vibration in Service-Stall Test (Non-Torque Sensitive)**.<br>Is the vibration still present? | Go to **Step 22** | Go to **Step 32** |
| 22 | 1. Measure the runout of the drive axle pinion input flange or shaft:<br>• If the driveline joint at the drive axle is a U-joint and if the U-joint yoke IS a bolt-on type, refer to **Differential Pinion Input Shaft Runout Measurement**.<br>• If the driveline incorporates a torque tube attached to the drive axle, refer to **Differential Pinion Input Shaft Runout Measurement**. | Go to **Step 23** | Go to **Step 24** |

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| Step | Action | Yes | No |
|---|---|---|---|
| | • If the driveline joint at the drive axle is a coupler assembly or a CV joint, refer to **Differential Pinion Input Shaft Runout Measurement**.<br>2. For a direct-mount drive axle, inspect the mounts and/or bushings for excessive wear, looseness, and/or damage.<br>3. Replace excessively worn or damaged components as necessary.<br><br>Did you find and correct a condition? | | |
| 23 | Perform the **Vibration in Service-Stall Test (Non-Torque Sensitive)**.<br>Is the vibration still present? | Go to **Step 24** | Go to **Step 32** |
| 24 | Re-index the prop shaft. Perform the following steps:<br>1. Raise and support the vehicle.<br>2. Mark the position of the prop shaft to both the transmission or transfer case output shaft flange, and the drive axle input flange.<br>3. Remove the prop shaft.<br>4. Rotate the prop shaft 180 degrees to both of the flanges.<br>5. Reinstall the prop shaft.<br>6. Attempt to duplicate the vibration in the stall. Refer to the **Vibration in Service-Stall Test (Non-Torque Sensitive)**.<br><br>Was the vibration reduced or eliminated? | Go to **Step 32** | Go to **Step 25** |
| 25 | Return the prop shaft to it's original position and balance the prop shaft. Refer to **Driveline System Balance Adjustment**.<br>Were you able to balance the driveline system? | Go to **Step 32** | Go to **Vibration Diagnostic Aids** |
| 26 | 1. Inspect the following components for wear and/or damage:<br>• Inspect the prop shafts for dents, damage, missing weights, and/or undercoating.<br>• Inspect the U-joint, or joints for excessive wear, looseness, and/or damage.<br>• Inspect the prop shaft support bearing, if equipped, for damaged rubber components, worn bearings, looseness, and/or a deformed or cracked bracket.<br>2. Replace components as necessary.<br><br>Did you find and correct a condition? | Go to **Step 32** | Go to **Step 27** |
| 27 | Is the drive axle a direct-mount? | Go to **Step 29** | Go to **Step 28** |

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| Step | Action | Yes | No |
|---|---|---|---|
| 28 | 1. Measure the vehicle trim height.<br>2. Adjust the vehicle trim height if necessary. Refer to the **Trim Height Inspection** .<br><br>Did you find and correct a condition? | Go to **Step 32** | Go to **Step 29** |
| 29 | 1. Measure the prop shaft angles. Refer to **Driveline Working Angles Measurement**.<br>2. If necessary, adjust the prop shaft angles. Refer to **Driveline Working Angles Adjustment**.<br><br>Did you find and correct a condition? | Go to **Step 32** | Go to **Step 30** |
| 30 | Does this prop shaft system have only 1 U-joint? | Go to **Vibration Diagnostic Aids** | Go to **Step 31** |
| 31 | 1. Inspect the prop shafts for proper phasing. Refer to **Propeller Shaft Phasing Inspection**.<br>2. If necessary, correct the prop shaft phasing. Refer to **Propeller Shaft Phasing Correction**.<br><br>Did you find and correct a condition? | Go to **Step 32** | Go to **Vibration Diagnostic Aids** |
| 32 | 1. Install or connect any components that were removed or disconnected during diagnosis.<br>2. Perform the Vibration Analysis - Road Testing table. Refer to **Vibration Analysis - Road Testing (EL-38792-A Electronic Vibration Analyzer)Vibration Analysis - Road Testing (CH-51450-NVH Oscilloscope)**.<br><br>Is the vibration still present? | Go to **Step 5** | 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.

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**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.

| Step | Action | Yes | No |
|---|---|---|---|
| **WARNING:** **Refer to Road Test Warning .** | | | |
| 1 | Has the Vibration Analysis - Road Testing table been completed? | Go to **Step 2** | Go to **Vibration Analysis - Road Testing (EL-38792-A Electronic Vibration Analyzer)Vibration Analysis - Road Testing (CH-51450-NVH Oscilloscope)** |
| **2** | 1. Operate the vehicle at the speed of the vibration concern.<br>2. While maintaining the concern speed, drive the vehicle through slow, sweeping turns - first in one direction, then in the other direction.<br>3. Observe the vehicle for changes in the vibration disturbance.<br>4. Select a smooth, level surface, such as an empty parking lot or a remote road.<br>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.<br>6. Observe the vehicle for changes in the vibration disturbance.<br>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 13** |

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| Step | Action | Yes | No |
|---|---|---|---|
| 6 | 1. With the vehicle at a stand-still, apply the regular brake and place the transmission in the lowest forward gear.<br><br>**NOTE:**<br>**Do not accelerate to the point of causing the drive wheels to squeal, slip or hop, this would obscure the results of the test.**<br><br>2. Release the regular brakes and accelerate aggressively to 32 km/h (20 mph).<br>3. Observe the vehicle for changes in the vibration disturbance.<br><br>Did you feel a shudder or shaking during these steps? | Go to **Step 7** | Go to **Vibration Diagnostic Aids** |
| 7 | 1. Inspect the wheel drive shafts, if equipped, for damage, abnormal and/or excessive wear.<br>2. If the inspection indicated that a wheel drive shaft is damaged, abnormally and/or excessively worn, replace the shaft.<br><br>Did you find and correct a condition? | Go to **Step 13** | Go to **Step 9** |
| 8 | 1. Inspect the wheel bearings for wear and/or damage. Refer to the wheel bearing inspection procedure.<br>2. Replace any of the wheel bearings found to be worn and/or damaged.<br><br>Did you find and correct a condition? | Go to **Step 13** | Go to **Step 12** |
| 9 | 1. Inspect the following suspension components for wear, damage, looseness and/or possible contact with other vehicle components:<br>• Struts/shock absorbers<br>• Springs<br>• Bushings<br>• Insulators<br>2. Replace any of the suspension components found to be worn, damaged, loose and/or contacting other vehicle components.<br><br>Did you find and correct a condition? | Go to **Step 13** | Go to **Step 10** |

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| Step | Action | Yes | No |
|---|---|---|---|
| 10 | 1. Inspect the powertrain mounts-engine, transmission, transfer case, and direct-mount differential, if equipped-and any powertrain braces for the following conditions:<br>• Loose and/or missing fasteners<br>• Improper alignment<br>• Cracked, dry-rotted, and/or oil-soaked insulators<br>• Twisted, broken, torn, and/or collapsed insulators<br>• Bent, twisted, and/or deformed brackets<br>2. Replace powertrain mounts as necessary.<br>3. Inspect the exhaust system components for the following:<br>• Loose and/or missing fasteners<br>• Heat Shields<br>• Joints and/or couplings:<br>Nuts, bolts, studs, clamps, straps<br>• Bracket and/or insulator mounting<br>• Inadequate clearance to body and/or chassis components<br>Inspect with the exhaust system both COLD and HOT; in NEUTRAL, FORWARD and REVERSE gears<br>• Improper alignment<br>• Disconnected and/or missing insulators<br>• Cracked, dry-rotted, and/or oil-soaked insulators<br>• Stretched, twisted, broken, torn, and/or collapsed insulators<br>• Bent, twisted, cracked, and/or deformed brackets<br>4. Repair, replace, and/or realign exhaust system components as necessary.<br>Did you find and correct a condition? | Go to **Step 13** | Go to **Step 11** |
| 11 | Inspect the vehicle trim height and adjust as necessary. Refer to **Trim Height Inspection** .<br>Did you find and correct a condition? | Go to **Step 13** | Go to **Step 12** |
| 12 | Is the vehicle primary driveline configuration rear wheel drive equipped with a direct-mount drive axle, or front wheel drive and equipped with all-wheel drive? | Go to **Vibration Analysis - Driveline** | Go to **Vibration Diagnostic Aids** |

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| Step | Action | Yes | No |
|---|---|---|---|
| 13 | 1. Install or connect any components that were removed or disconnected during diagnosis.<br>2. Perform the Vibration Analysis - Road Testing table. Refer to **Vibration Analysis - Road Testing (EL-38792-A Electronic Vibration Analyzer)Vibration Analysis - Road Testing (CH-51450-NVH Oscilloscope)**.<br>Is the vibration still present? | Go to **Step 2** | System OK |

## VIBRATION ANALYSIS - ENGINE

### Special Tools

- **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) , or
- **EL-38792-A** Electronic Vibration Analyzer (EVA) 2

For equivalent regional tools, refer to **Special Tools and Equipment**.

#### 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.

| Step | Action | Yes | No |
|---|---|---|---|
| **WARNING:**<br>**Refer to**<br>**Work Stall**<br>**Test Warning**<br>. | | | |
| 1 | Has the Vibration Analysis - Road Testing table been completed? | Go to **Step 2** | Go to **Vibration Analysis - Road Testing (EL-38792-A Electronic Vibration Analyzer)Vibration Analysis - Road Testing (CH-51450-NVH Oscilloscope)** |
| **2** | Using a scan tool, determine if any DTCs are set. Were any DTCs set? | Go to **Diagnostic Starting Point - Vehicle** | Go to **Step 3** |
| 3 | 1. Block the front wheels.<br>2. Apply BOTH the service brakes and the | Go to **Step 4** | Go to **Vibration Diagnostic Aids** |

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| Step | Action | Yes | No |
|---|---|---|---|
| | park brake.<br>3. With the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) and the **EL-47955** Multi Diagnostic Interface (MDI) , or the scan tool and the **EL-38792-A** Electronic Vibration Analyzer (EVA) 2 , if available, still installed, start the engine.<br>4. Place the transmission in NEUTRAL or PARK.<br>5. Slowly increase the engine RPM to the level at which the disturbance is most noticeable.<br>6. Record the engine RPM obtained on the scan tool and the most dominant frequency reading if obtained on the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or the **EL-38792-A** Electronic Vibration Analyzer (EVA) 2 , if available.<br>7. Place the transmission in DRIVE.<br>8. Slowly increase the engine RPM to the level at which the disturbance is most noticeable.<br>9. Record the engine RPM obtained on the scan tool and the most dominant frequency reading if obtained on the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or the **EL-38792-A** Electronic Vibration Analyzer (EVA) 2 , if available.<br>10. If no frequency data was obtained, or if the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or 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.<br><br>Were you able to duplicate the customer's concern? | | |
| 4 | Did the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or 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** | Go to **Step 5** |
| **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**.<br><br>1. Install a scan tool into the known good vehicle.<br>2. Install the **CH-51450-NVH** Oscilloscope | Go to **Vibration Diagnostic Aids** | Go to **Vibration Analysis - Engine/Accessory Isolation** |

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| Step | Action | Yes | No |
|---|---|---|---|
| | Diagnostic Kit (w/NVH) or 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.<br>3. Block the front wheels.<br>4. Apply BOTH the service brakes and the park brake.<br>5. Start the engine.<br>6. Place the transmission in NEUTRAL or PARK.<br>7. Slowly increase the engine RPM to the level at which the disturbance was most noticeable in the customer's vehicle.<br>8. Record the engine RPM obtained on the scan tool and the most dominant frequency reading if obtained on the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or the **EL-38792-A** Electronic Vibration Analyzer (EVA) 2 , if available.<br>9. Place the transmission in DRIVE.<br>10. Slowly increase the engine RPM to the level at which the disturbance was most noticeable in the customer's vehicle.<br>11. Record the engine RPM obtained on the scan tool and the most dominant frequency reading if obtained on the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or the **EL-38792-A** Electronic Vibration Analyzer (EVA) 2 , if available.<br>12. If no frequency data was obtained, or if the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or 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.<br><br>Did both of the vehicles exhibit the same characteristics? | | |

## 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:

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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.

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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** |
| 1/2 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 |
| 1 1/2 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<br>Possible Engine Driven Accessory Related | Abnormal - Likely Bank to Bank EGR/Fuel Variance<br>Possible Engine Driven Accessory Related | Possible Engine Driven Accessory Related |
| 2nd Order Non Torque | Characteristic of Engine Arrangement - Possible | Possible Engine Driven Accessory Related | Possible Engine Driven Accessory Related | Possible Engine Driven Accessory Related | Characteristic of Engine Arrangement - Possible | Characteristic of Engine Arrangement - Possible | Possible Engine Driven Accessory Related |

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| 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** |
| Sensitive | Powertrain Isolation Related | | | | Powertrain Isolation Related | Powertrain Isolation 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 1/2 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 |

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| 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 |
| | Possible Engine Driven Accessory Related | Possible Engine Driven Accessory Related | | | | | Possible Engine Driven Accessory Related |

## VIBRATION ANALYSIS - ENGINE/ACCESSORY ISOLATION

### Special Tools

- **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH)
- **EL-38792-A** Electronic Vibration Analyzer (EVA) 2
- **EL-38792-25** Inductive Pickup Timing Light
- **EL-47955** Multi Diagnostic Interface MDI

For equivalent regional tools, refer to **Special Tools and Equipment**.

#### 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

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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.

**12**

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.

**13**

A loose, damaged, misaligned, or defective engine driven accessory system insulator and/or bracket may create a transfer path into the passenger compartment.

**15**

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.

| Step | Action | Yes | No |
|---|---|---|---|
| **WARNING:** Refer to Work Stall Test Warning . | | | |
| 1 | Were you sent here from the Vibration Analysis - Engine table? | Go to **Step 2** | Go to **Vibration Analysis - Engine** |
| 2 | Is the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or 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.<br>2. Determine the possible causes of the disturbance as it relates to a specific order of engine rotation.<br><br>Refer to **Engine Order Classification**.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:<br>• Loose and/or missing fasteners<br>• Improper alignment<br>• Cracked, dry-rotted, and/or oil-soaked insulators<br>• Twisted, broken, torn, and/or collapsed insulators | Go to **Step 15** | Go to **Step 6** |

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| Step | Action | Yes | No |
|---|---|---|---|
| | • Bent, twisted, and/or deformed brackets<br><br>Realign or replace powertrain mounts as indicated by the inspection.<br>Did you find and correct a condition? | | |
| 6 | Inspect the exhaust system components for the following:<br>• Loose and/or missing fasteners<br>  • Heat Shields<br>  • Joints and/or couplings:<br>  Nuts, bolts, studs, clamps, straps<br>  • Bracket and/or insulator mounting<br>• Inadequate clearance to body and/or chassis components<br>Inspect with the exhaust system both COLD and HOT; in NEUTRAL, FORWARD and REVERSE gears<br>• Improper alignment<br>• Disconnected and/or missing insulators<br>• Cracked, dry-rotted, and/or oil-soaked insulators<br>• Stretched, twisted, broken, torn, and/or collapsed insulators<br>• Bent, twisted, cracked, and/or deformed brackets<br><br>Repair, replace, and/or realign exhaust system components as indicated by the inspection.<br>Did you find and correct a condition? | Go to **Step 15** | Go to **Step 7** |
| 7 | Perform the Powertrain Mount Balance Procedure if available or perform the following procedure to re-bed the powertrain:<br>1. Loosen, but do not remove, all powertrain mounts and exhaust system hangers.<br>2. Ensure that the exhaust flexible coupling, if equipped, moves freely.<br>3. Start the engine.<br>4. Settle the powertrain by shifting the transmission from DRIVE to REVERSE.<br>5. Place the transmission into NEUTRAL.<br>6. Turn OFF the ignition.<br>7. Tighten all of the loosened fasteners with the powertrain in a relaxed position. | Go to **Step 15** | - |

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| Step | Action | Yes | No |
|---|---|---|---|
| | Did you complete the operation? | | |
| 8 | **CAUTION:**<br>**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.**<br>1. Remove the engine accessory drive belt, or belts.<br>2. Block the front wheels.<br>3. Apply BOTH the service brakes and the park brake.<br>4. With the scan tool still installed, start the engine.<br>5. Place the transmission in NEUTRAL or PARK.<br>6. Increase the engine RPM to the level recorded during duplication of the disturbance.<br>7. Allow the engine to idle, then place the transmission in DRIVE.<br>8. Increase the engine RPM to the level recorded during duplication of the disturbance.<br>9. Turn OFF the ignition.<br>10. Install the engine accessory drive belt, or belts.<br>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 13** | Go to **Step 17** |
| 10 | Is the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) being used for diagnosis? | Go to **Step 11** | Go to **Step 12** |
| 11 | 1. Measure the diameter of the suspected accessory pulleys, including any related idler pulleys, and enter this information into the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH).<br>2. Block the front wheels.<br>3. Apply BOTH the service brakes and the park brake.<br>4. With the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) and the **EL-47955** Multi Diagnostic Interface MDI still installed, start the engine.<br>5. Have an assistant place the transmission in NEUTRAL or PARK. | Go to **Step 13** | Go to **Vibration Diagnostic Aids** |

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| Step | Action | Yes | No |
|---|---|---|---|
| | 6. Slowly increase the engine RPM to the level recorded during the duplication of the disturbance, then maintain that speed. The frequency of the suspected pulleys will show up on the Record and Analyze tab within the software.<br>7. Turn OFF the engine.<br><br>Did you identify an engine driven accessory system as being related to the disturbance? | | |
| **12** | 1. Mark the face of the suspected accessory pulleys, including any related idler pulleys, near the outer edge with a paint mark.<br>2. Install the **EN-38792-25** Inductive Pickup Timing Light , to the **EL-38792-A** Electronic Vibration Analyzer (EVA) 2.<br><br>For information on the use of the EVA features, refer to **Electronic Vibration Analyzer (EVA) Description and Operation**.<br><br>3. Block the front wheels.<br>4. Apply BOTH the service brakes and the park brake.<br>5. With the scan tool and the **EL-38792-A** Electronic Vibration Analyzer (EVA) 2 , still installed, start the engine.<br>6. Select the Smart Strobe feature on the **EL-38792-A** Electronic Vibration Analyzer (EVA) 2.<br>7. Enter the recorded frequency of the disturbance as the initial frequency for strobe operation.<br>8. Have an assistant place the transmission in NEUTRAL or PARK.<br>9. Slowly increase the engine RPM to the level recorded during duplication of the disturbance, then maintain that speed.<br>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.<br><br>Check each of the accessory systems, both engaged and under maximum load and disengaged or under minimum load.<br><br>11. Allow the engine to idle, then place the transmission in DRIVE.<br>12. Slowly increase the engine RPM to the level recorded during duplication of the disturbance, then maintain that speed closely.<br>13. Using the **EL-38792-25** Inductive Pickup Timing Light , check each of the suspected accessory | Go to **Step 13** | Go to **Vibration Diagnostic Aids** |

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| Step | Action | Yes | No |
|---|---|---|---|
| | pulleys to determine if any of them is related to the frequency of the disturbance.<br><br>Check each of the accessory systems, both engaged and under maximum load and disengaged or under minimum load.<br><br>14. Turn OFF the ignition.<br><br>Did you identify an engine driven accessory system as being related to the frequency of the disturbance? | | |
| 13 | Inspect the components of the engine driven accessory system for the following:<br><br>• Loose and/or missing fasteners<br>  • Heat Shields, if equipped<br>  • Joints and/or couplings:<br><br>  Nuts, bolts, studs, clamps, straps<br><br>  • Bracket and/or insulator mounting<br>• Inadequate clearance to body and/or chassis components<br><br>Inspect with the accessory system both under a LOAD and NOT loaded<br><br>• Improper alignment<br>• Bent or damaged pulleys<br>• Disconnected and/or missing insulators<br>• Cracked, dry-rotted, and/or oil-soaked component insulators<br>• Stretched, twisted, broken, torn, and/or collapsed component insulators<br>• Bent, twisted, cracked and/or deformed component brackets<br><br>Repair, replace, and/or realign the engine driven accessory system components as indicated by the inspection.<br>Did you find and correct a condition? | Go to **Step 15** | Go to **Step 14** |
| 14 | 1. Remove the engine driven accessory and bracket, or brackets from the engine.<br>2. Thoroughly inspect the accessory bracket, or brackets, bolts/nuts/studs, and the accessory itself for signs of the following:<br><br>Bent, twisted, cracked and/or deformed conditions<br><br>3. Replace any of the components found to exhibit any of these conditions. | Go to **Step 15** | Go to **Step 19** |

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| Step | Action | Yes | No |
|---|---|---|---|
| | 4. Reinstall the components to the engine.<br><br>Did you find and correct a condition? | | |
| 15 | Check the vehicle to determine if the disturbance is now significantly reduced or eliminated. Perform the following steps:<br><br>1. Install a scan tool into the customer's vehicle.<br>2. Install the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or 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.<br>3. Block the front wheels.<br>4. Apply BOTH the service brakes and the park brake.<br>5. Start the engine.<br>6. Place the transmission in NEUTRAL or PARK.<br>7. Slowly increase the engine RPM to the level at which the disturbance was most noticeable.<br>8. Record the engine RPM obtained on the scan tool and the most dominant frequency reading if obtained on the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or the **EL-38792-A** Electronic Vibration Analyzer (EVA) 2 , if available.<br>9. Place the transmission in DRIVE.<br>10. Slowly increase the engine RPM to the level at which the disturbance was most noticeable.<br>11. Record the engine RPM obtained on the scan tool and the most dominant frequency reading if obtained on the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or the **EL-38792-A** Electronic Vibration Analyzer (EVA) 2 , if available.<br>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.<br><br>Has the disturbance been significantly reduced or eliminated? | Go to **Step 20** | Go to **Step 16** |
| 16 | Have you investigated powertrain isolation as a possible cause of the disturbance? | Go to **Step 17** | Go to **Step 5** |
| 17 | Have you investigated engine driven accessories as a possible cause of the disturbance? | Go to **Vibration Analysis - Engine** | Go to **Step 18** |

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| Step | Action | Yes | No |
|---|---|---|---|
| | | Balance | |
| 18 | Is the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or the **EL-38792-A** Electronic Vibration Analyzer (EVA) 2 available? | Go to **Step 8** | Go to **Vibration Diagnostic Aids** |
| 19 | Replace the engine driven accessory component causing the disturbance.<br>Did you complete the replacement? | Go to **Step 20** | - |
| 20 | 1. Install or connect any components that were removed or disconnected during diagnosis.<br>2. Perform the Vibration Analysis - Road Testing table. Refer to **Vibration Analysis - Road Testing (EL-38792-A Electronic Vibration Analyzer)Vibration Analysis - Road Testing (CH-51450-NVH Oscilloscope)**.<br><br>Is the disturbance still present? | Go to **Step 2** | System OK |

## VIBRATION ANALYSIS - ENGINE BALANCE

### Special Tools

- **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH)
- **EL-38792-A** Electronic Vibration Analyzer (EVA) 2
- **EL-47955** Multi Diagnostic Interface MDI

For equivalent regional tools, refer to **Special Tools and Equipment**.

#### 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**

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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 **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or 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.

| 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** |
| 2 | Is the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or the **EL-38792-A** Electronic Vibration Analyzer (EVA) 2 , available? | Go to **Step 3** | Go to **Vibration Diagnostic Aids** |
| 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** . | Go to **Step 5** | Go to **Step 11** |

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| Step | Action | Yes | No |
|---|---|---|---|
| | 2. Remove the flywheel/flexplate-to-torque converter bolts access cover, if equipped.<br>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.<br><br>Is there sufficient clearance to separate and safely secure the transmission torque converter away from the engine flywheel/flexplate? | | |
| **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.<br>2. Disconnect the torque converter and move it away from the flywheel/flexplate.<br>3. Secure the transmission torque converter away from the engine flywheel/flexplate to avoid accidental engagement with the flywheel/flexplate.<br>4. Lower the vehicle, start the engine and allow the engine to idle.<br>5. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .<br>6. Visually inspect the flywheel/flexplate for excessive lateral runout.<br>7. Lower the vehicle.<br>8. Turn OFF the ignition.<br><br>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** .<br>2. Inspect the flywheel/flexplate for the following:<br>• Looseness at the engine crankshaft<br>• Cracks and/or damage<br>• Missing balance weights<br><br>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.<br>2. Block the front wheels.<br>3. Apply BOTH the service brakes and the park | Go to **Step 9** | Go to **Step 11** |

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| Step | Action | Yes | No |
|---|---|---|---|
| | brake.<br>4. With the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) and the **EL-47955** Multi Diagnostic Interface MDI or the scan tool and the **EL-38792-A** Electronic Vibration Analyzer (EVA) 2 still installed, start the engine.<br>5. Place the transmission in NEUTRAL or PARK.<br>6. Slowly increase the engine RPM to the level at which the disturbance is most noticeable.<br>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.<br>8. Turn OFF the ignition.<br><br>Has the disturbance been significantly reduced or eliminated? | | |
| 8 | 1. If the flywheel/flexplate is loose at the engine crankshaft, tighten the flywheel/flexplate mounting bolts in sequence and to specification.<br>2. If the flywheel/flexplate is cracked, damaged, and/or has missing balance weights, replace the damaged flywheel/flexplate.<br><br>Did you complete the tightening or replacement? | Go to **Step 20** | - |
| **9** | 1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .<br>2. Re-index the transmission torque converter to the engine flywheel/flexplate, 120 degrees from its original position.<br>3. Reconnect the transmission torque converter to the engine flywheel/flexplate.<br>4. Lower the vehicle.<br>5. Block the front wheels.<br>6. Apply BOTH the service brakes and the park brake.<br>7. With the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) and the **EL-47955** Multi Diagnostic Interface MDI or the scan tool and the **EL-38792-A** Electronic Vibration Analyzer (EVA) 2 still installed, start the engine.<br>8. Place the transmission in NEUTRAL or PARK.<br>9. Slowly increase the engine RPM to the level at which the disturbance is most noticeable.<br>10. Record the engine RPM obtained on the scan tool and the most dominant frequency reading if obtained on the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or the **EL-38792-A** | Go to **Step 20** | Go to **Step 10** |

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| Step | Action | Yes | No |
|---|---|---|---|
| | Electronic Vibration Analyzer (EVA) 2.<br>11. If the disturbance is still noticeable, re-index the torque converter again to obtain the least amount of disturbance.<br><br>Has the disturbance been significantly reduced or eliminated? | | |
| 10 | Replace the out-of-balance transmission torque converter.<br>Did you complete the replacement? | Go to **Step 20** | - |
| **11** | 1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .<br>2. Position the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) accelerometer or the **EL-38792-A** Electronic Vibration Analyzer (EVA) 2 sensor onto the underside of the engine oil pan, along the FRONT edge.<br>3. Lower the vehicle.<br>4. Block the front wheels.<br>5. Apply BOTH the service brakes and the park brake.<br>6. With the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) and the **EL-47955** Multi Diagnostic Interface MDI or the scan tool and the **EL-38792-A** Electronic Vibration Analyzer (EVA) 2 , still installed, start the engine.<br>7. Place the transmission in NEUTRAL or PARK.<br>8. Slowly increase the engine RPM to the level at which the disturbance is most noticeable.<br>9. Record the engine RPM obtained on the scan tool and the most dominant frequency reading if obtained on the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or the **EL-38792-A** Electronic Vibration Analyzer (EVA) 2 from the underside of the engine oil pan.<br>10. Repeat steps 1 through 9, placing the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) accelerometer or the **EL-38792-A** Electronic Vibration Analyzer (EVA) 2 sensor onto the underside of the engine oil pan, along the REAR edge.<br><br>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** |

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| Step | Action | Yes | No |
|---|---|---|---|
| 13 | 1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .<br>2. Remove the flywheel inspection cover.<br>3. Start the engine. Allow the engine to idle.<br>4. Visually inspect the engine flywheel clutch surface for excessive lateral runout.<br><br>Does the engine flywheel clutch surface exhibit excessive lateral runout? | Go to **Step 18** | Go to **Step 14** |
| 14 | Inspect the clutch pressure plate to engine flywheel mounting for proper factory indexing.<br>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.<br>2. Inspect the engine flywheel for the following:<br>• Looseness at the engine crankshaft<br>• Cracks, warpage and/or damage<br>• Missing balance weights<br>3. Inspect the clutch pressure plate and clutch driven plate for the following:<br>• Loose and/or damaged clutch driven plate damper springs<br>• Loose and/or damaged clutch pressure plate diaphragm springs<br>• Cracks, warpage and/or damage<br>• Missing balance weights<br><br>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.<br>2. Inspect the engine flywheel for the following:<br>• Looseness at the engine crankshaft<br>• Cracks, warpage and/or damage<br>• Missing balance weights<br>3. Inspect the clutch pressure plate and clutch driven plate for the following:<br>• Loose and/or damaged clutch driven plate damper springs<br>• Loose and/or damaged clutch pressure plate diaphragm springs<br>• Cracks, warpage and/or damage<br>• Missing balance weights<br><br>Do any of the above conditions exist? | Go to **Step 18** | Go to **Vibration Diagnostic Aids** |

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| Step | Action | Yes | No |
|---|---|---|---|
| **17** | Re-index the pressure plate to the engine flywheel.<br>Did you complete the re-indexing? | Go to **Step 20** | - |
| **18** | Replace the engine flywheel/flexplate.<br>Did you complete the replacement? | Go to **Step 20** | - |
| **19** | Replace the engine crankshaft balancer.<br>Did you complete the replacement? | Go to **Step 20** | - |
| 20 | Check the vehicle to determine if the disturbance is now significantly reduced or eliminated. Perform the following steps:<br>1. Install or connect any components that were removed or disconnected during diagnosis.<br>2. Install a scan tool into the customer's vehicle.<br>3. Install the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or 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.<br>4. Block the front wheels.<br>5. Apply BOTH the service brakes and the park brake.<br>6. Start the engine.<br>7. Place the transmission in NEUTRAL or PARK.<br>8. Slowly increase the engine RPM to the level at which the disturbance was most noticeable.<br>9. Record the engine RPM obtained on the scan tool and the most dominant frequency reading if obtained on the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or the **EL-38792-A** Electronic Vibration Analyzer (EVA) 2 , if available.<br>10. Place the transmission in DRIVE.<br>11. Slowly increase the engine RPM to the level at which the disturbance was most noticeable.<br>12. Record the engine RPM obtained on the scan tool and the most dominant frequency reading if obtained on the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or the **EL-38792-A** Electronic Vibration Analyzer (EVA) 2 , if available.<br>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. | Go to **Step 21** | Go to **Vibration Diagnostic Aids** |

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| Step | Action | Yes | No |
|---|---|---|---|
| | Has the disturbance been significantly reduced or eliminated? | | |
| 21 | Perform the Vibration Analysis - Road Testing table. Refer to **Vibration Analysis - Road Testing (EL-38792-A Electronic Vibration Analyzer)Vibration Analysis - Road Testing (CH-51450-NVH Oscilloscope)**. Is the disturbance still present? | Go to **Vibration Diagnostic Aids** | 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 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**
- **Vibration Diagnostic Aids - Vibration Duplicated, Component Not Identified**
- **Vibration Diagnostic Aids - Vibration Duplicated, Difficult to Isolate/Balance Component**
- **Vibration Diagnostic Aids - Vibration Duplicated, Appears to Be Potential Operating Characteristic**

## 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 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**

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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 2 1/2 -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.**

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.

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- 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 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 BEFORE proceeding.**

If you have duplicated the vibration concern but have had difficulty in balancing a component or isolating a

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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.

#### Driveline Torque-Load Conditions

A drive axle that has internal conditions such as excessive runout of components, misalignment of components, imbalance, etc., can produce vibration concerns which may be transmitted into the propeller shaft, or shafts. This sort of a vibration occurrence can increase or decrease in severity based primarily upon torque-load, but can also be affected by cold or hot conditions.

The propeller shaft and other related components may or may not pass inspections for wear or damage, runout, alignment, etc., depending upon whether there is only one vibration source or more than one.

#### Difficult to System Balance the Driveline

If after following the Vibration Analysis - Driveline table you were instructed to system balance the driveline and you experienced difficulty in doing so while CAREFULLY following the procedures indicated-the EVA strobe readings seem to keep changing-then the axle differential to which the propeller shaft is attached should be suspected to have internal problems which are being transmitted to the propeller shaft. Refer to the drive axle diagnosis information, for internal axle diagnostics.

## 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 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** to become familiar with the diagnostic process used to properly diagnose vibration concerns.

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2. Perform the **Vibration Analysis - Road Testing (EL-38792-A Electronic Vibration Analyzer)Vibration Analysis - Road Testing (CH-51450-NVH Oscilloscope)** 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** |
| | | | Vehicle Speed Sensitive Affected by torque/load | Go to **Vibration Analysis - Driveline** |
| | | | Vehicle Speed Sensitive Affected by steering input | Go to **Vibration Analysis - Hub and/or Axle Input** |
| | | | Engine Speed Sensitive | Go to **Vibration Analysis - Engine** |
| 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** |
| | | | Vehicle Speed Sensitive Affected by torque/load | Go to **Vibration Analysis - Driveline** |
| | | | Vehicle Speed Sensitive Affected by steering input | Go to **Vibration Analysis - Hub and/or Axle Input** |
| | | | Engine Speed Sensitive | Go to **Vibration Analysis - Engine** |
| 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 | Go to **Vibration Analysis - Driveline** |
| | | | Vehicle Speed Sensitive Affected by steering input | Go to **Vibration Analysis - Hub and/or Axle Input** |
| | | | Engine Speed Sensitive | Go to **Vibration Analysis - Engine** |
| 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 | Go to **Vibration Analysis - Driveline** |
| | | | Vehicle Speed Sensitive Affected by steering input | Go to **Vibration Analysis - Hub and/or Axle Input** |
| | | | Engine Speed Sensitive | Go to **Vibration Analysis - Engine** |

**Vibration Symptoms that are Heard**

| Category | Description | Typical Frequency | Condition of Occurrence | Area of Focus |
|---|---|---|---|---|

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| | | Range | | |
|---|---|---|---|---|
| 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.<br>• Related terminology - droning, growling, moaning, roaring, rumbling, humming<br>• May not be accompanied by a perceptible vibration (roughness) | 20-60 Hz | Vehicle Speed Sensitive Still occurs during coast down in NEUTRAL | Go to **Vibration Analysis - Tire and Wheel** |
| | | | Vehicle Speed Sensitive Affected by torque/load | Go to **Vibration Analysis - Driveline** |
| | | | Vehicle Speed Sensitive Affected by steering input | Go to **Vibration Analysis - Hub and/or Axle Input** |
| Moan or Drone | Similar to the sound of a bumblebee or blowing air across the top of a bottle.<br>• Related terminology - humming, buzzing, resonance<br>• May be accompanied by a perceptible vibration (buzz) | 60-120 Hz | Vehicle Speed Sensitive Affected by torque/load | Go to **Vibration Analysis - Driveline** |
| | | | Vehicle Speed Sensitive Affected by steering input | Go to **Vibration Analysis - Hub and/or Axle Input** |
| | | | Engine Speed Sensitive | Go to **Vibration Analysis - Engine** |
| Howl | Similar to the sound of the wind howling. | 120-300 Hz | Vehicle Speed Sensitive Affected by torque/load | Go to **Vibration Analysis - Driveline** |
| | | | Vehicle Speed Sensitive Affected by steering input | Go to **Vibration Analysis - Hub and/or Axle Input** |
| | | | Engine Speed Sensitive | Go to **Vibration Analysis - Engine** |
| Whine | Similar to the sound of mosquitoes, turbine engines, or vacuum cleaners. | 300-500 Hz | Vehicle Speed Sensitive Affected by torque/load - 2WD mode | Go to Transmission diagnostic information |
| | | | Vehicle Speed Sensitive Affected by torque/load - 4WD mode | Go to Transfer Case 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

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- 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

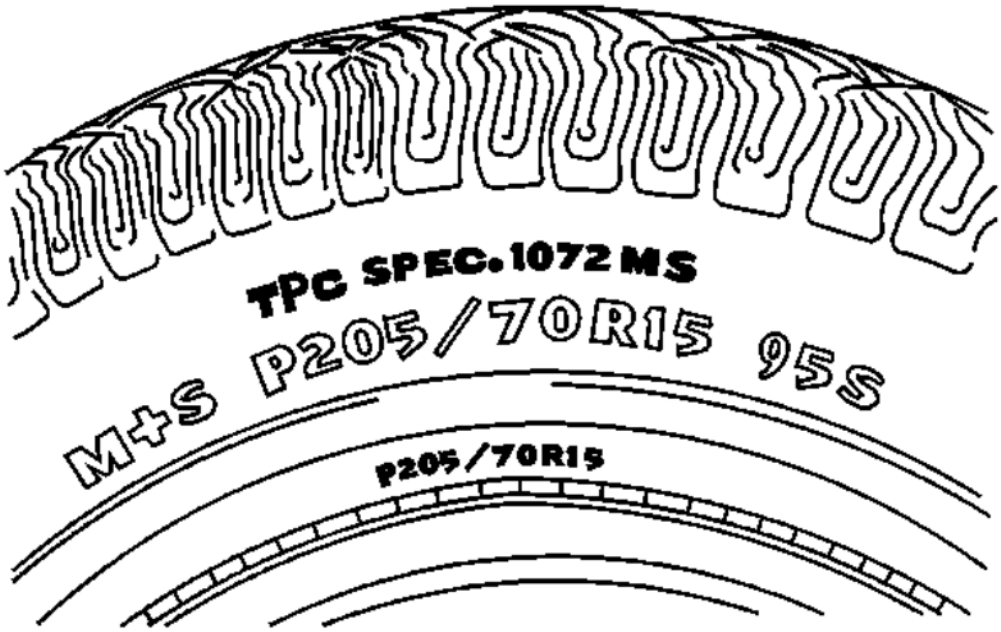



**Fig. 2: Identifying Tire Performance Criteria (TPC) Rating Markings**
**Courtesy of GENERAL MOTORS COMPANY**

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

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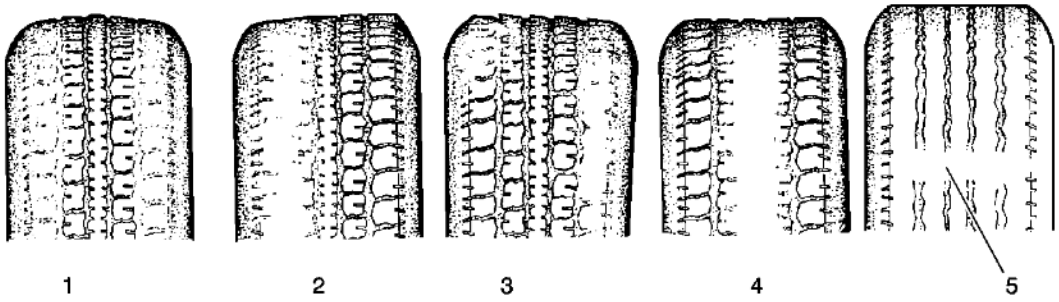



**Fig. 3: Identifying Types Of Tire Wear**
**Courtesy of GENERAL MOTORS COMPANY**

| Callout | Component Name |
|---|---|
| 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 (6-Lug Wheel)** **Tire and Wheel Removal and Installation (8-Lug Wheel)** **Tire and Wheel Removal and Installation (Dual Rear Wheels)** .
4. Following the tire inflation placard on the drivers door, inspect and if necessary adjust the tire inflation pressures.

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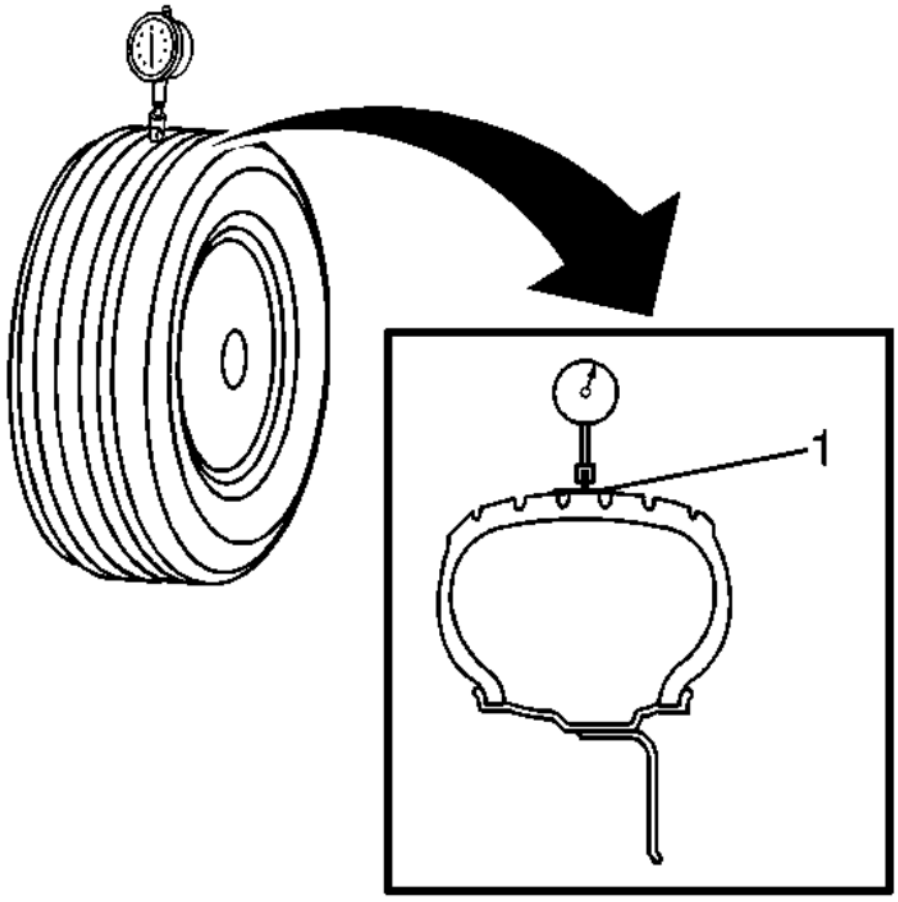



**Fig. 4: Measuring Tire & Wheel Assembly Radial Runout**
**Courtesy of GENERAL MOTORS COMPANY**

5. 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.

6. Position the dial indicator on the taped portion of the tire tread such that the dial indicator is perpendicular to the tire tread surface.
7. Slowly rotate the tire and wheel assembly one complete revolution in order to find the low spot.
8. Set the dial indicator to zero at the low spot.
9. 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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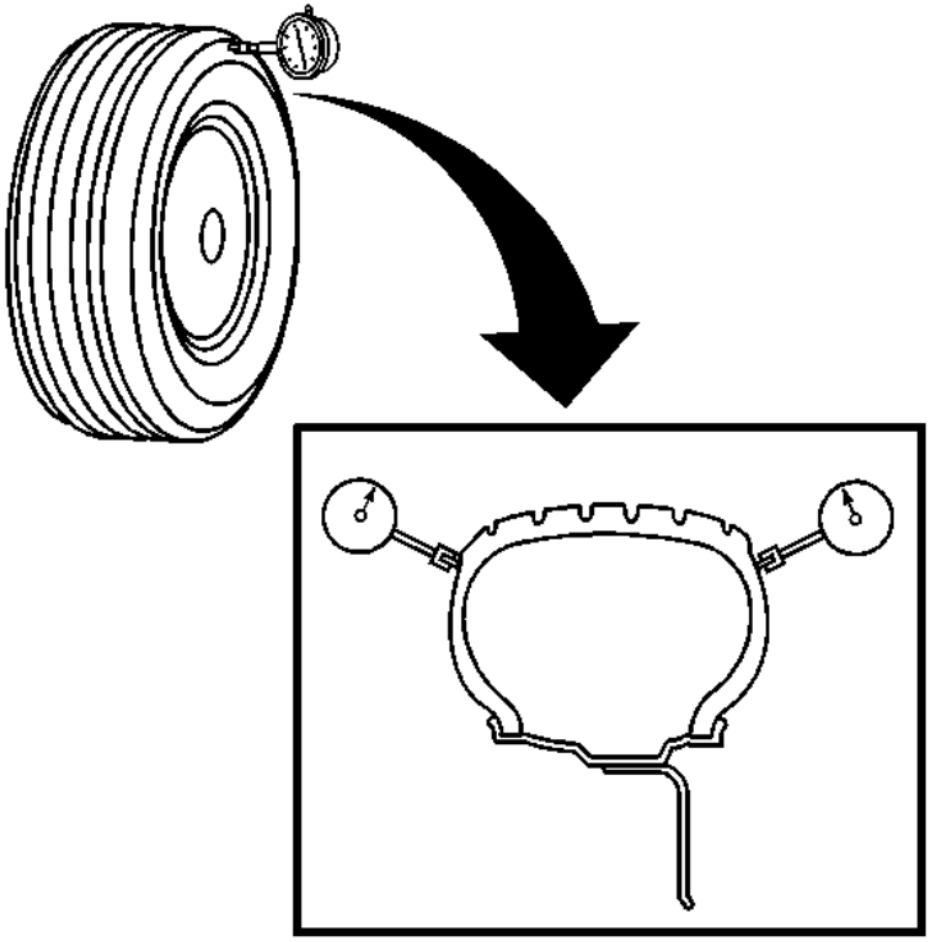


Fig. 5: Measuring Tire & Wheel Assembly Lateral Runout
**Courtesy of GENERAL MOTORS COMPANY**

10. 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.
11. 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.
12. Set the dial indicator to zero at the low spot.
13. 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)

14. Repeat steps 4 through 12 until all of the tire and wheel assembly radial and lateral runout measurements have been taken.
15. 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

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- 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 (6-Lug Wheel)** **Tire and Wheel Removal and Installation (8-Lug Wheel)** **Tire and Wheel Removal and Installation (Dual Rear Wheels)** .
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.

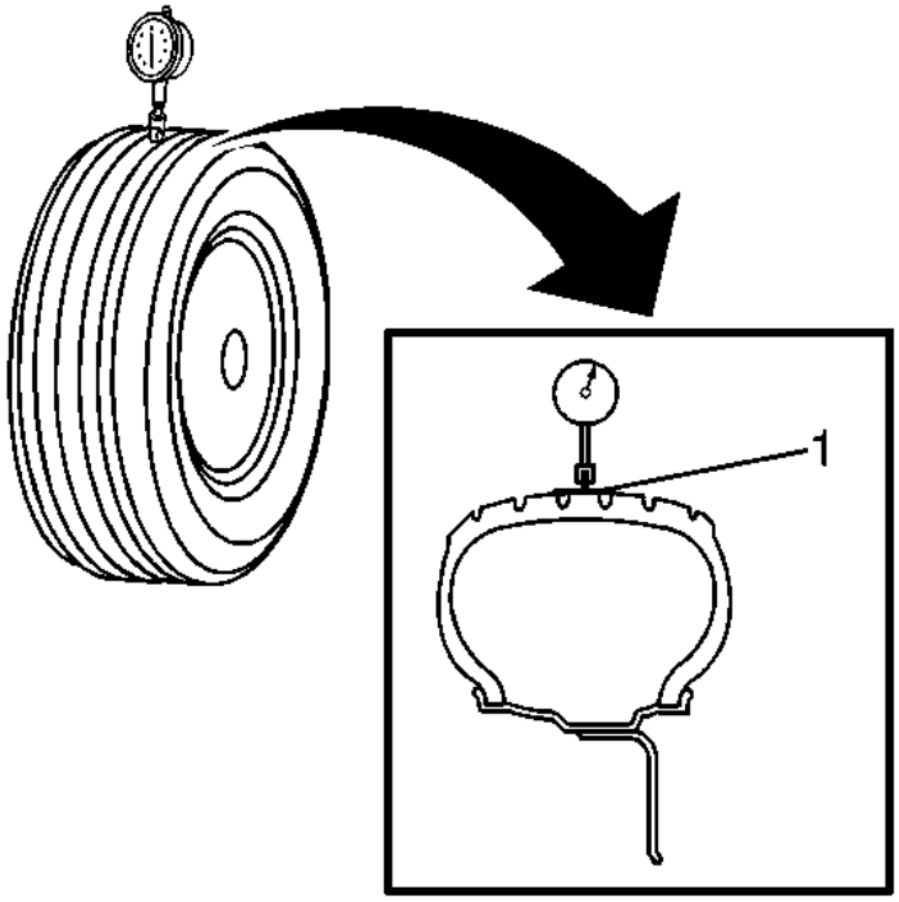



**Fig. 6: Measuring Tire & Wheel Assembly Radial Runout**
**Courtesy of GENERAL MOTORS COMPANY**

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.

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**Specification**

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

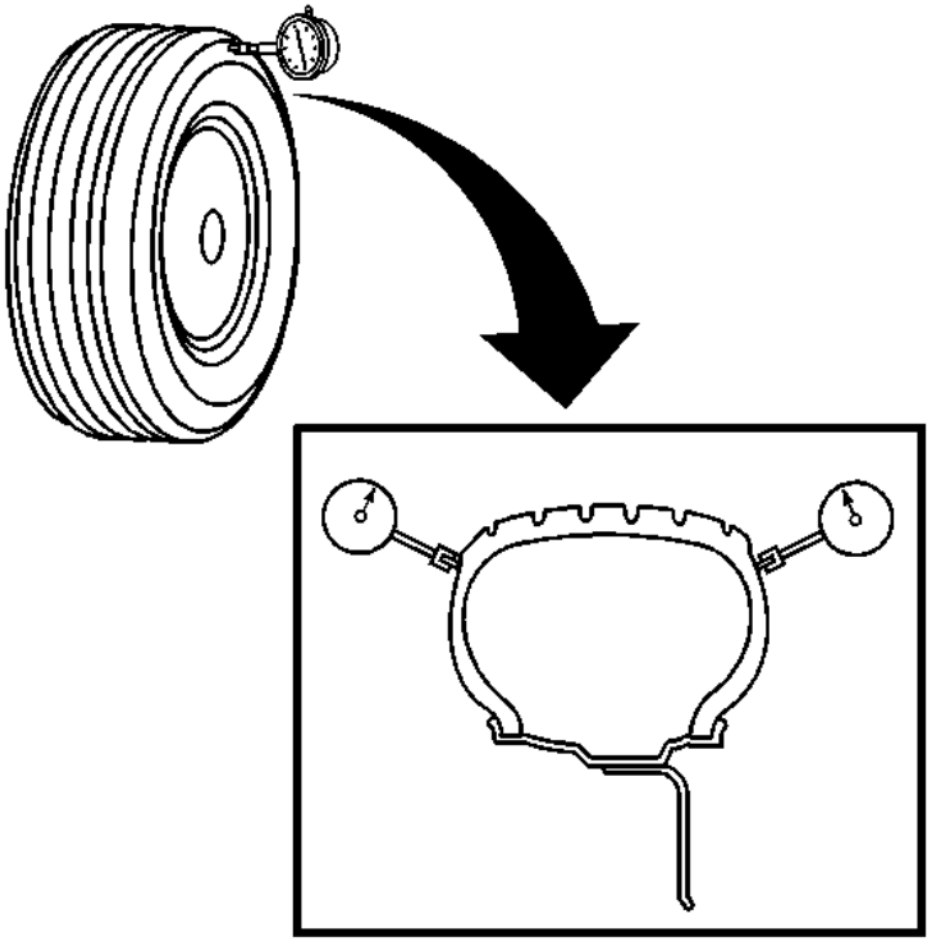


**Fig. 7: Measuring Tire & Wheel Assembly Lateral Runout**
**Courtesy of GENERAL MOTORS COMPANY**

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.

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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.

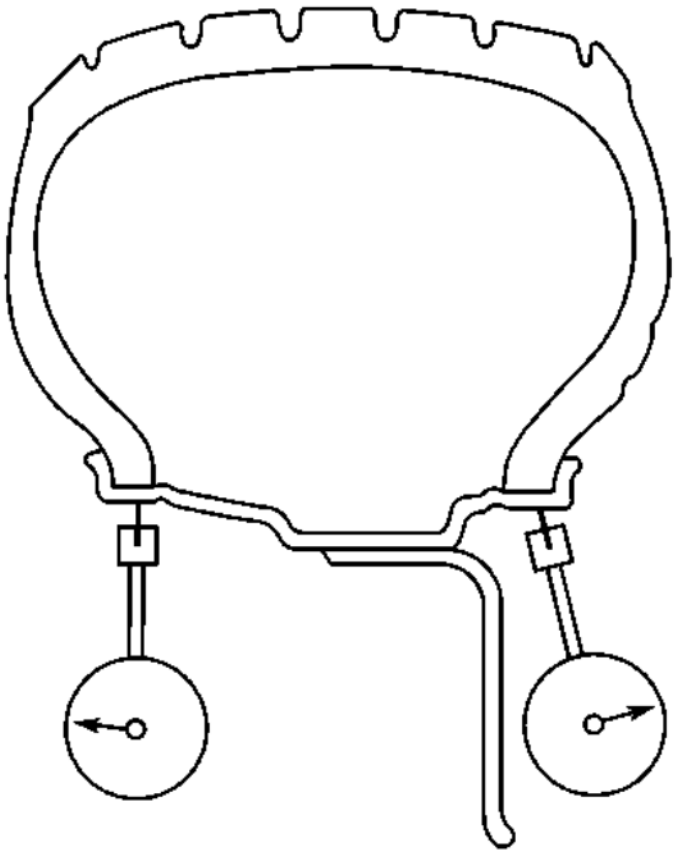


**Fig. 8: Measuring Wheel Radial Runout (Off-Vehicle, Tire Mounted)**
**Courtesy of GENERAL MOTORS COMPANY**

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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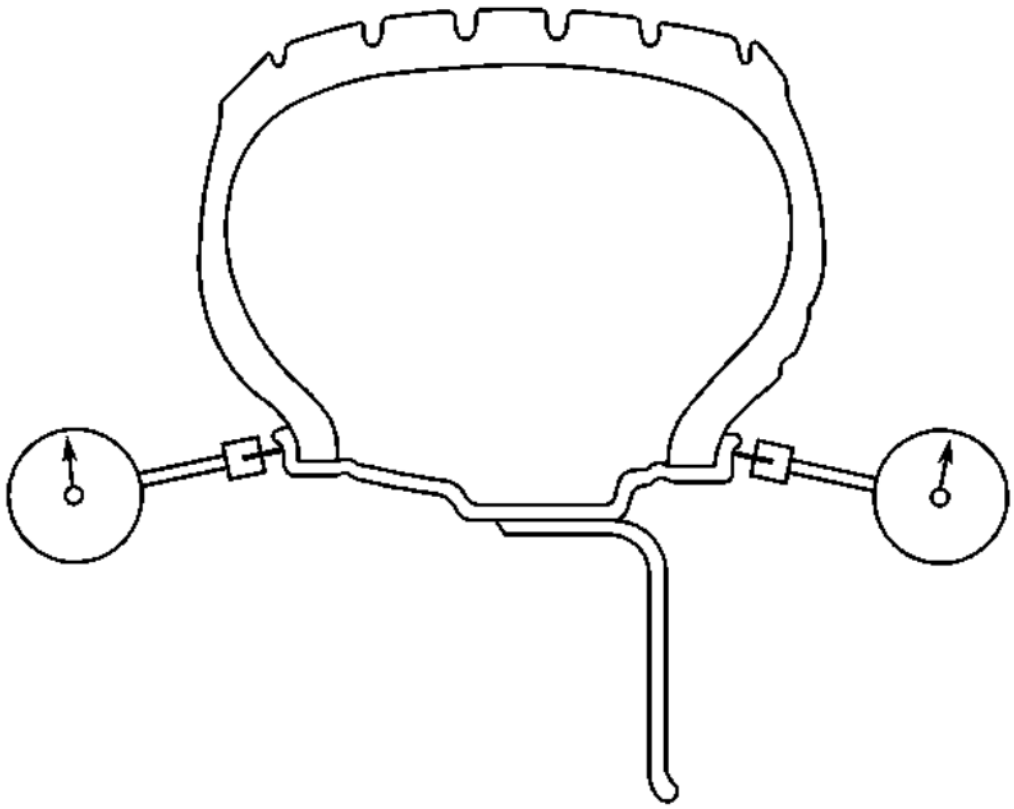


Fig. 9: Measuring Wheel Lateral Runout (Off-Vehicle, Tire Mounted)
**Courtesy of GENERAL MOTORS COMPANY**

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

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- 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**.
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.
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.

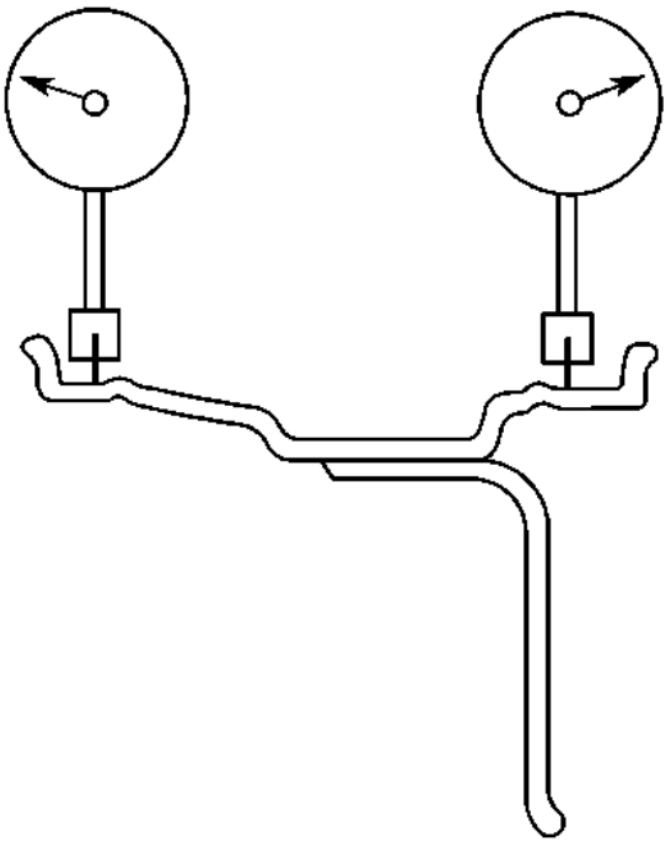


**Fig. 10: Measuring Wheel Radial Runout (Off-Vehicle, Tire Dismounted)**
**Courtesy of GENERAL MOTORS COMPANY**

5. Position the dial indicator on the horizontal inner surface of the wheel rim flange - with the tire dismounted -

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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)

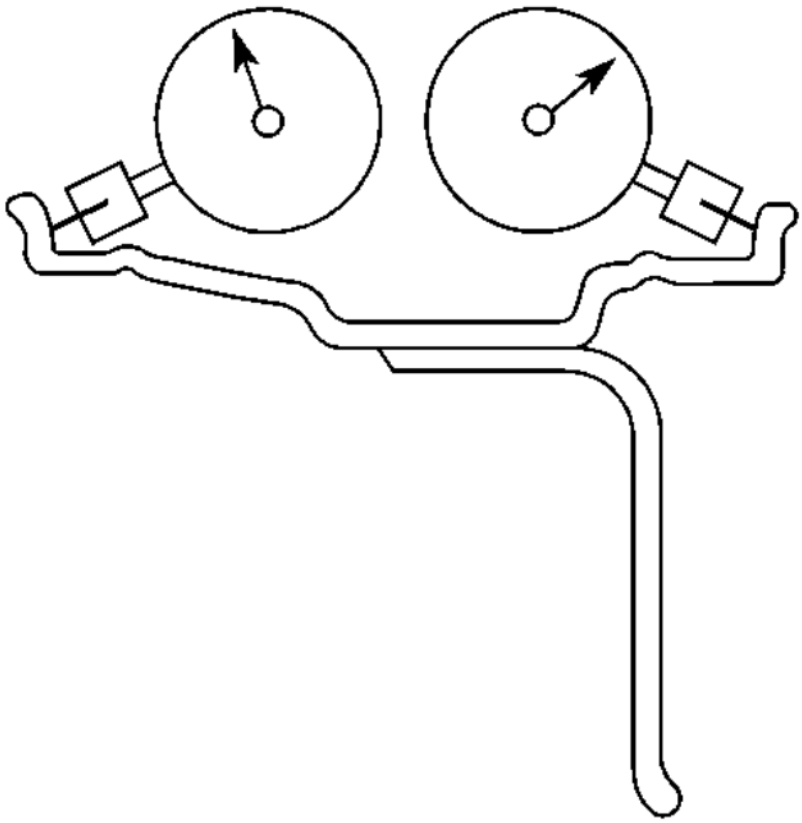


**Fig. 11: Measuring Wheel Lateral Runout (Off-Vehicle, Tire Dismounted)**
**Courtesy of GENERAL MOTORS COMPANY**

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.

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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**.
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**.

    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** .
2. Remove the tire and wheel assemblies from the drive axle. Refer to **Tire and Wheel Removal and Installation (6-Lug Wheel)** **Tire and Wheel Removal and Installation (8-Lug Wheel)** **Tire and Wheel Removal and Installation (Dual Rear Wheels)** .

   **WARNING: Refer to Work Stall Test Warning .**

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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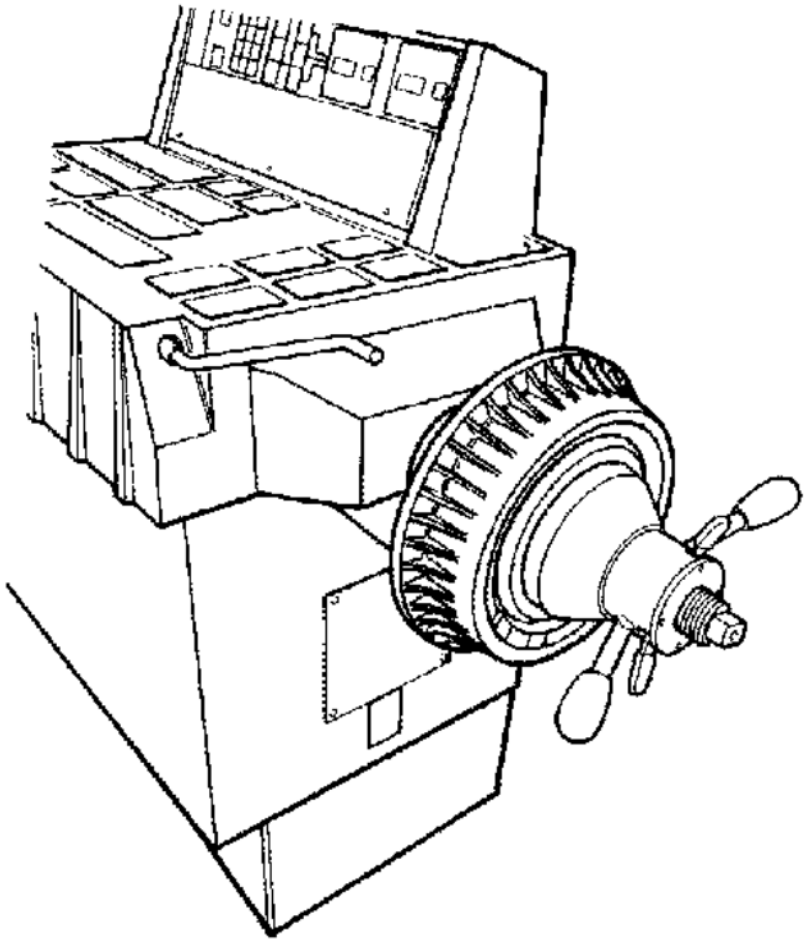


Fig. 12: Balancing Brake Drum
**Courtesy of GENERAL MOTORS COMPANY**

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:
    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.**

    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 ( 3/4 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

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1. Raise and support the vehicle. Refer to **Lifting and Jacking 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. Refer to **Tire and Wheel Removal and Installation (6-Lug Wheel)** **Tire and Wheel Removal and Installation (8-Lug Wheel)** **Tire and Wheel Removal and Installation (Dual Rear Wheels)** .
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.

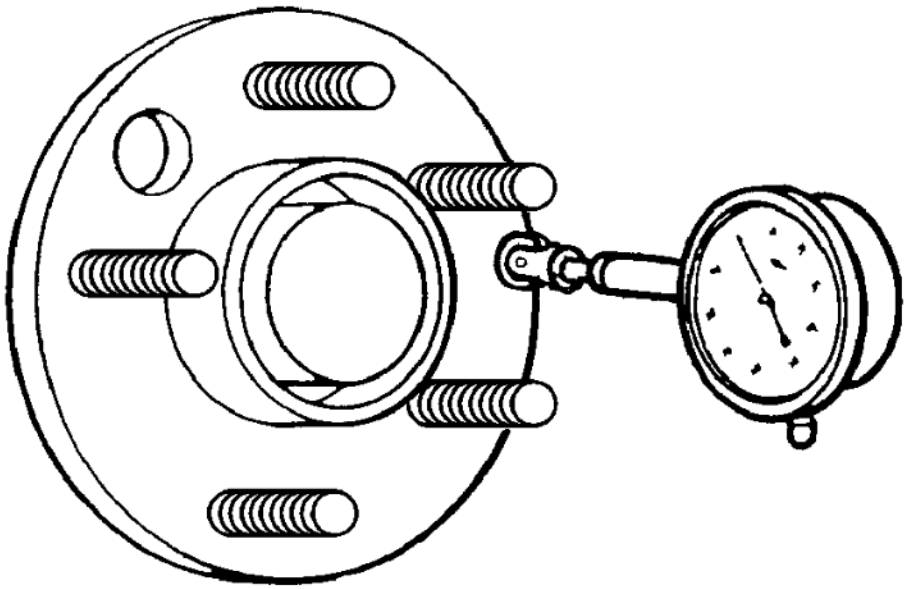


**Fig. 13: Measuring Wheel Hub/Axle Flange Runout**
**Courtesy of GENERAL MOTORS COMPANY**

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)

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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.

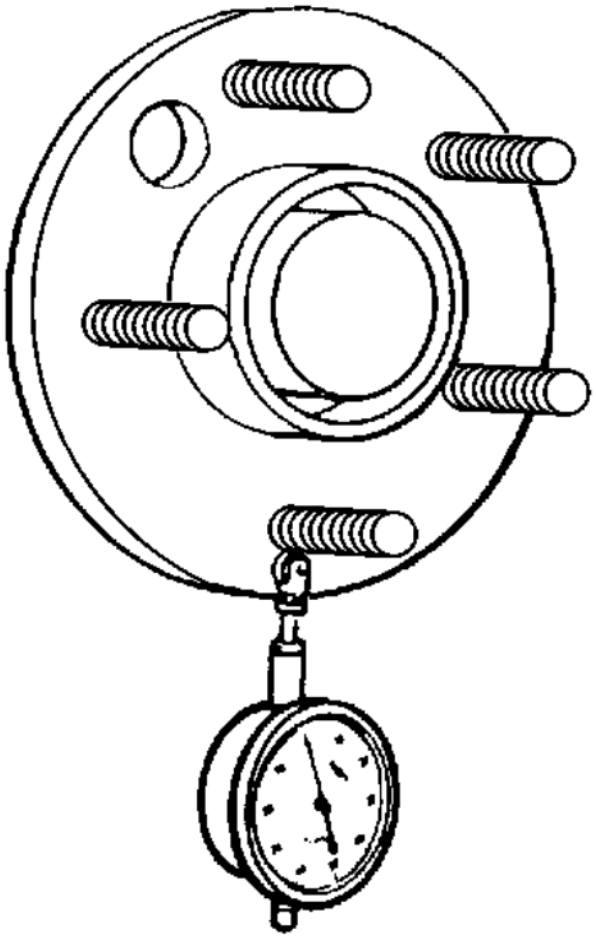


**Fig. 14: Measuring Wheel Stud Runout**
**Courtesy of GENERAL MOTORS COMPANY**

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**

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Wheel stud runout tolerance guideline: 0.254 mm (0.010 in)

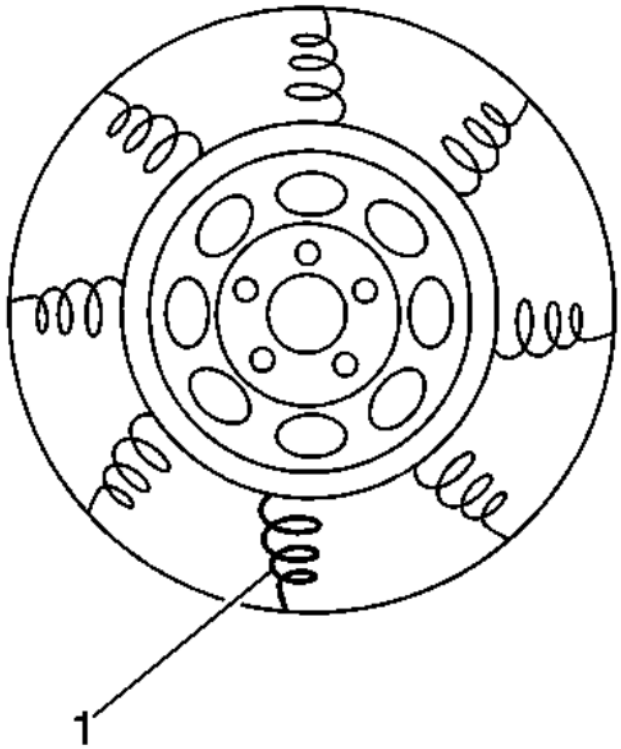
17. If the runout of the wheel studs - stud circle - is marginal, the wheel studs may or may not be contributing to the disturbance.
18. If the runout of the wheel studs - stud circle - is excessive, replace the wheel studs as necessary. Measure the runout of the new wheel studs.
19. Inspect the threads and the tapered seat portion on each of the wheel bolts for damage.
20. Wheel bolts exhibiting 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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**Fig. 15: Identifying Radial Force Variation**
**Courtesy of GENERAL MOTORS COMPANY**

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 Variation

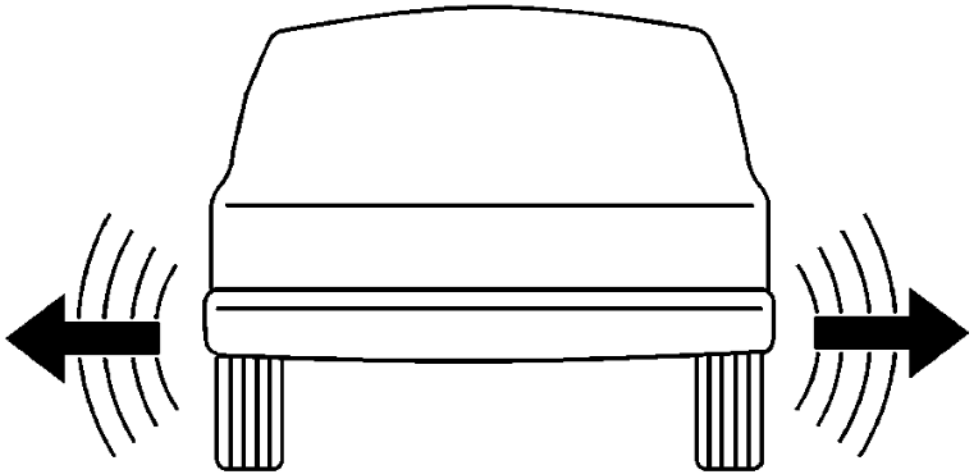


**Fig. 16: Identifying Tire Wobble/Waddle**
**Courtesy of GENERAL MOTORS COMPANY**

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.

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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 (6-Lug Wheel)** **Tire and Wheel Removal and Installation (8-Lug Wheel)** **Tire and Wheel Removal and Installation (Dual Rear Wheels)** .
2. Road test the vehicle to determine if the vibration is still present. Refer to **Vibration Analysis - Road Testing (EL-38792-A Electronic Vibration Analyzer)** **Vibration Analysis - Road Testing (CH-51450-NVH Oscilloscope)**.
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 (6-Lug Wheel)** **Tire and Wheel Removal and Installation (8-Lug Wheel)** **Tire and Wheel Removal and Installation (Dual Rear Wheels)** , . Road test the vehicle to determine if the vibration has returned. Refer to **Vibration Analysis - Road Testing (EL-38792-A Electronic Vibration Analyzer)** **Vibration Analysis - Road Testing (CH-51450-NVH Oscilloscope)**.
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**.

## VIBRATION IN SERVICE-STALL TEST (NON-TORQUE SENSITIVE)

**Special Tools**

- **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or
- **EL-38792-A** Electronic Vibration Analyzer (EVA) 2

For equivalent regional tools, refer to **Special Tools and Equipment**.

**CAUTION: Do not fill the propeller shaft with foam, oil, or any other substance in order to correct a vibration. Filling the propeller shaft is only effective in reducing an unrelated condition called Torsional Rattle. Filling the propeller shaft should only be done in strict adherence to the procedure outlined in corporate bulletins that address Torsional Rattle. Failure to follow the correct procedure will induce a vibration and/or affect the structural integrity of the propeller shaft. The propeller shaft will then have to be replaced.**

1. Turn the ignition ON but do not start the engine.
2. Place the transmission in NEUTRAL.
3. Raise and support the vehicle. Support the drive axle or axles at curb height. Refer to **Lifting and Jacking the Vehicle** .
4. Remove the tire and wheel assemblies from the vehicle. Refer to **Tire and Wheel Removal and Installation (6-Lug Wheel)** **Tire and Wheel Removal and Installation (8-Lug Wheel)** **Tire and Wheel Removal and Installation (Dual Rear Wheels)** .
5. Remove the brake rotors or drums, if equipped, from the drive axle or axles.
6. Inspect the propeller shaft or shafts. All propeller shafts should be free of undercoating before continuing.

**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.**

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7. Have an assistant start the engine.
8. Place the transmission in the highest forward gear.
9. Accelerate and decelerate the vehicle through the speed range at which the vibration was first noted during the Vibration Analysis-Road Testing procedure.
10. Record whether the vibration was present, and at what speed.
11. If the vibration is present, determine which end of the propeller shaft is vibrating the most. Hold the accelerometer of the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or the vibration sensor of the **EL-38792-A** Electronic Vibration Analyzer (EVA) 2 , up to the pinion nose and the transmission or transfer case tailshaft housing.
12. If the vehicle is equipped with a multiple-piece propeller shaft, hold the accelerometer of the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or the vibration sensor of the **EL-38792-A** EVA 2 up to the propeller shaft support bearing assembly, or assemblies to inspect for vibration.
13. If the transmission or transfer case output shaft housing is vibrating, hold the accelerometer of the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or the vibration sensor of the **EL-38792-A** EVA 2 up to the transmission crossmember under the transmission mount. If there is no vibration on the crossmember, then the transmission mount is working properly.
14. Record which end of the propeller shaft is vibrating the most, and how severe the vibration is. The inspection will be a reference by which to judge future progress.

## VIBRATION IN SERVICE-STALL TEST (TORQUE SENSITIVE)

**Special Tools**

- **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or
- **EL-38792-A** Electronic Vibration Analyzer (EVA) 2

For equivalent regional tools, refer to **Special Tools and Equipment**.

**CAUTION: Do not fill the propeller shaft with foam, oil, or any other substance in order to correct a vibration. Filling the propeller shaft is only effective in reducing an unrelated condition called Torsional Rattle. Filling the propeller shaft should only be done in strict adherence to the procedure outlined in corporate bulletins that address Torsional Rattle. Failure to follow the correct procedure will induce a vibration and/or affect the structural integrity of the propeller shaft. The propeller shaft will then have to be replaced.**

1. Turn the ignition ON but do not start the engine.
2. Place the transmission in NEUTRAL.
3. Raise and support the vehicle. Support the drive axle or axles at curb height. Refer to **Lifting and Jacking the Vehicle** .
4. Remove the tire and wheel assemblies from the vehicle. Refer to **Tire and Wheel Removal and Installation (6-Lug Wheel)** **Tire and Wheel Removal and Installation (8-Lug Wheel)** **Tire and Wheel Removal and Installation (Dual Rear Wheels)** .
5. Remove the brake rotors or drums, if equipped, from the drive axle or axles.
6. Hold the accelerometer of the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or the vibration sensor of the **EL-38792-A** Electronic Vibration Analyzer (EVA) 2 , against the pinion nose.

**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.**

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7. Have an assistant start the vehicle.
8. Place the transmission in the highest forward gear.
9. Accelerate and decelerate the vehicle through the speed range at which the vibration was first noted during the Vibration Analysis - Road Testing procedure.
10. If a vibration is present, note the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or the **EL-38792-A** EVA 2 reading during acceleration or deceleration.
11. Note as to whether or not the pinion nose vibrates under load during acceleration or deceleration.
12. If the vibration is not reproduced, reinstall the brake rotors and/or drums and the wheel/tire assemblies to put an additional load on the system. Perform steps 7-11 and check the components again.
13. If the vibration is still not reproduced with rotors and/or drums reinstalled, lightly apply the brakes to further load the system while maintaining the vibration concern speed.
14. If the pinion nose vibrates under acceleration or deceleration, and other driveline components have been eliminated as a cause, the vibration may be an internal axle problem.

## TRANSFER CASE OUTPUT FLANGE RUNOUT MEASUREMENT

**Special Tools**

**GE-7872** Magnetic Base Dial Indicator Set , or equivalent

**NOTE:** **This measurement procedure is intended to measure transmission or transfer case output flange runout for systems with a constant velocity (CV) joint, rubber coupling or bolt-on U-joint yoke at the transmission or transfer case.**

1. Place the transmission in NEUTRAL.
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
3. If equipped with a CV joint, measure the transmission or transfer case output flange radial runout on the machined surface of the prop shaft front CV joint housing, as close to the flange as possible:
    1. Clean the surface of the prop shaft front CV joint housing just rear of the transmission or transfer case output flange.
    2. Mount a dial indicator set, **GE-7872** Magnetic Base Dial Indicator Set , or equivalent, and position the dial indicator to contact the prop shaft front CV joint housing as close to the transfer case output flange as possible.
4. If equipped with a rubber coupling or bolt-on U-joint yoke, measure the transfer case output flange radial runout on the machined surface of the flange pilot area:
    1. Mark the position of the prop shaft to the transmission or transfer case output flange.
    2. Separate the propshaft from the transmission or transfer case output flange.
    3. Clean the surface of the flange pilot area.
    4. Mount a dial indicator set, **GE-7872** Magnetic Base Dial Indicator Set , or equivalent, and position the dial indicator to contact the pilot area as close to the end of the pilot as possible.
5. Rotate the transmission or transfer case output flange by hand to locate the low spot.
6. Set the dial indicator to zero on the low spot.
7. Rotate the flange or shaft by hand and record the amount of radial runout.
8. Compare the runout of the flange or shaft to the runout tolerance specifications guideline.
9. If the transmission or transfer case output flange runout exceeds the specification, the flange or shaft requires replacement.

## PROPELLER SHAFT RUNOUT MEASUREMENT

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**Special Tools**

- **GE-7872** Magnetic Base Dial Indicator Set , or equivalent
- **GE-8001** Dial Indicator Set , or equivalent

For equivalent regional tools, refer to **Special Tools and Equipment**.

**NOTE:**

- **This measurement procedure is intended to measure propeller shaft runout for prop shaft systems with 2 or 3 U-joints only. This is not for prop systems with only 1 U-joint, or with only constant velocity (CV) joints, and/or coupler assemblies.**
- **When measuring runout of propeller shafts, do not include fluctuations on the dial indicator due to welds or surface irregularities.**
- **Always inspect the runout of any replacement propeller shaft.**

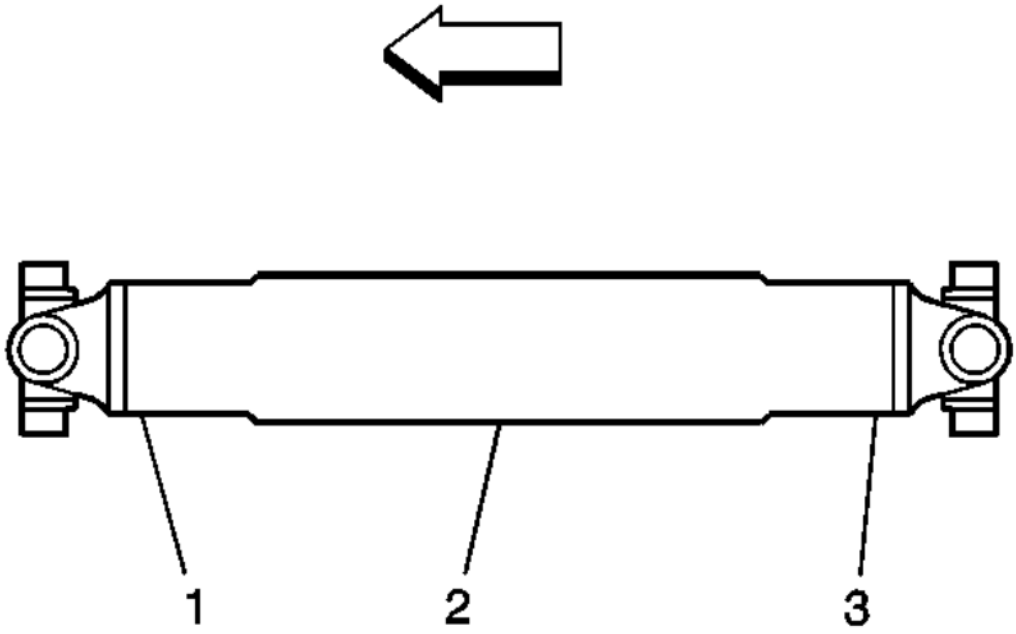



**Fig. 17: Identifying Propeller Shaft Runout Measurement Points**
**Courtesy of GENERAL MOTORS COMPANY**

1. Raise and support the vehicle. On vehicles with solid axles, ensure that the drive axle is supported at ride height - vehicle body supported by suspension components. Ensure the wheels are free to rotate. Refer to **Lifting and Jacking the Vehicle** .
2. Place the transmission in NEUTRAL.

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3. Clean the circumference of the propeller shaft or shafts of any debris and/or undercoating along the front (1), center (2), and rear (3) positions.
4. Inspect the propeller shaft or shafts for dents, damage, and/or missing weights. Any propeller shaft that is dented or damaged requires replacement.

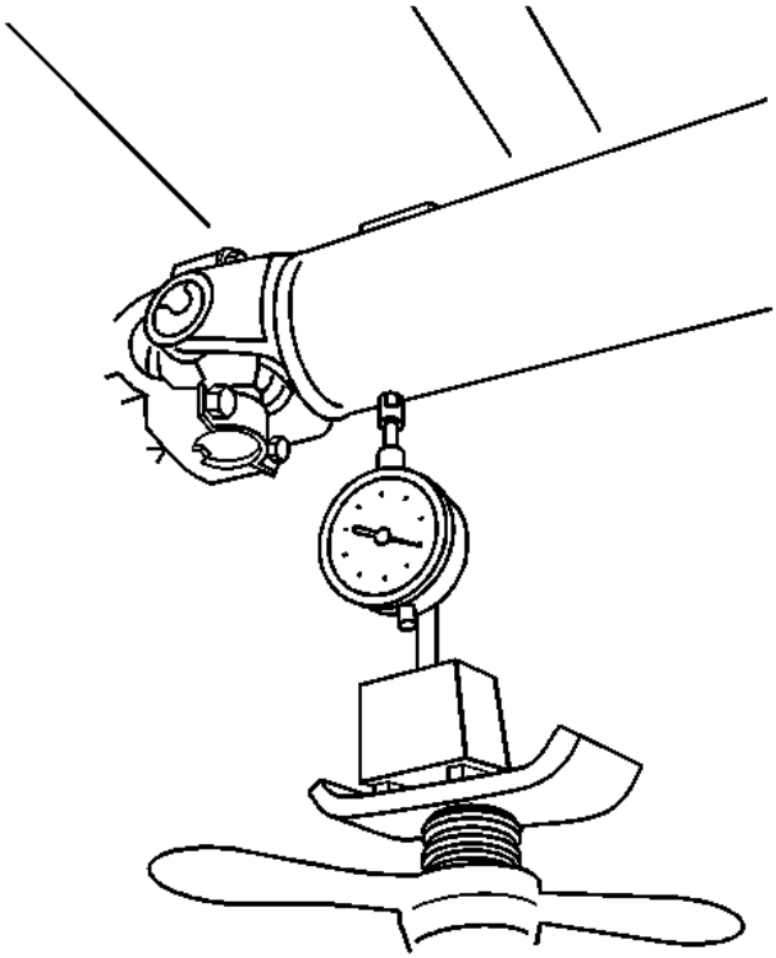


**Fig. 18: Measuring Runout Of Propeller Shaft**
**Courtesy of GENERAL MOTORS COMPANY**

5. For 1-piece and 2-piece prop systems, mount the **GE-7872** Magnetic Base Dial Indicator Set , or equivalent, or the **GE-8001** Dial Indicator Set , or equivalent, to the vehicle underbody or to a service stand positioned just clear of the U-joint yoke weld on the prop shaft.

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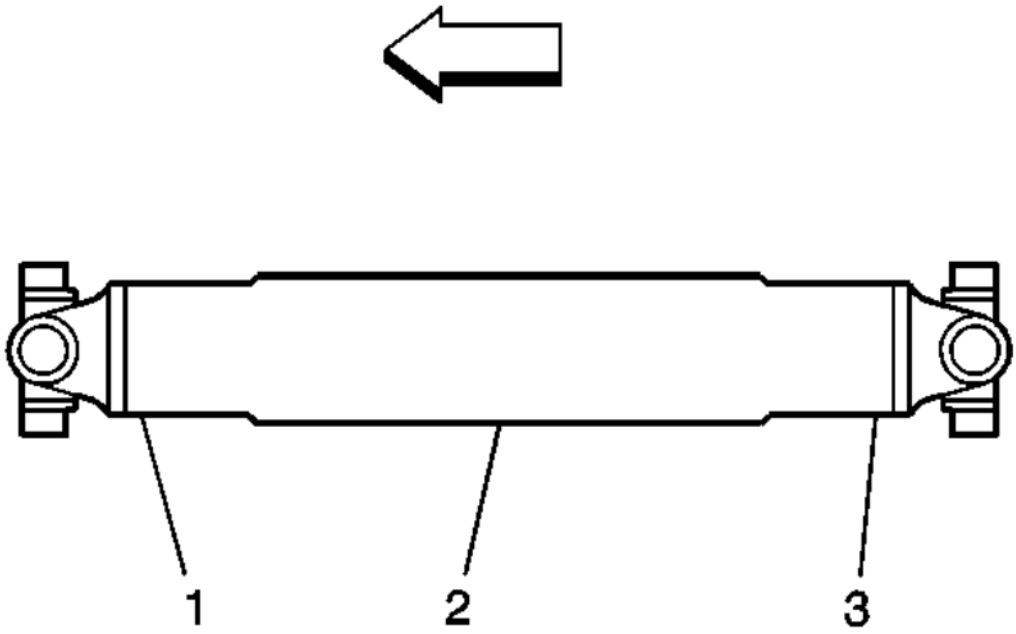



**Fig. 19: Identifying Propeller Shaft Runout Measurement Points**
**Courtesy of GENERAL MOTORS COMPANY**

6. Rotate the drive axle pinion flange, torque tube input flange, transmission output, or transfer case output flange by hand while taking runout measurements of the prop shaft or shafts. The prop shaft will rotate more easily in one direction than in the other. If necessary, the tire and wheel assemblies and even the brake caliper assemblies can be positioned and supported aside, or the brake drums can be removed from the drive axle to provide easier rotation of the prop shaft or shafts.
7. For all prop systems, measure and record the runout at each U-joint welded yoke location (1, 3) and at the center (2) of each prop shaft.
8. For 1-piece prop systems, proceed to step 10.

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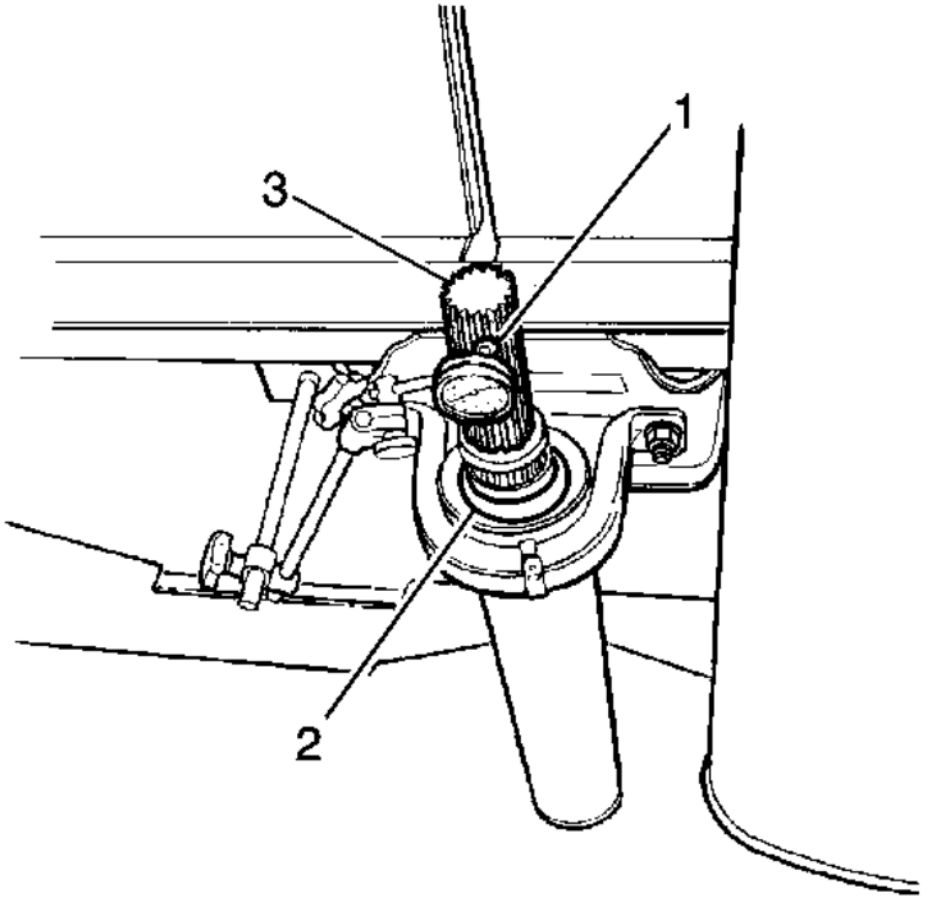



**Fig. 20: Positioning Dial Indicator At Stub Shaft**
**Courtesy of GENERAL MOTORS COMPANY**

9. For 2-piece prop systems, perform the following inspections and measurement of the stub shaft:
    1. Mark the mating position for each end of the prop shaft containing the slip yoke, then remove the shaft.
    2. Inspect the prop shaft support bearing assembly (2) for damaged rubber components, worn bearing or bearings, or a damaged/cracked bracket which could be affecting the runout of the propeller shafts.
    3. If the support bearing assembly exhibited any of these conditions, it requires replacement before proceeding.
    4. Inspect the support bearing assembly (2) for loose or missing shims/washers if equipped. Reinstall correctly or replace any shims/washers as necessary to ensure proper alignment of the support bearing assembly.
    5. Position the **GE-7872** Magnetic Base Dial Indicator Set , or equivalent (1), or the **GE-8001** Dial Indicator Set , or equivalent (1), approximately 13 mm ( 1/2 in) from the end of the stub shaft (3).
    6. Record the runout measurement at the stub shaft splines.
10. Compare the prop shaft runout measurements recorded to the runout tolerance specifications. Refer to **Propeller Shaft Runout Specifications**.
11. If the prop system has a U-joint at the transmission or transfer case output flange, and if the prop shaft runout measurements exceed runout tolerance specifications for that prop shaft at that location, or at the stub shaft if part of the front shaft, perform the following:

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1. Inspect the deflection of the transmission or transfer case output shaft for indications of a worn or damaged bushing which could be affecting the runout of the prop shaft.

   A leaking transmission or transfer case output shaft seal may be an indication of an output shaft bushing concern.

2. If the transmission or transfer case output shaft bushing is found to be worn or damaged, the bushing must be replaced before proceeding.
3. If the transmission or transfer case output shaft bushing was replaced; re-measure and record the runout of the prop shaft at the same locations measured previously.
4. Compare the prop shaft runout re-measurements recorded to the runout tolerance specifications.
5. If the prop shaft runout re-measurements still exceed runout tolerances at the same location or at the stub shaft, if part of the front shaft, the prop shaft requires replacement before proceeding. Check the runout of the replacement prop shaft.
6. If the transmission or transfer case output shaft bushing was not found to be worn or damaged, the prop shaft requires replacement before proceeding. Check the runout of the replacement prop shaft.

12. If the prop system has a U-joint at the drive axle pinion or torque tube input flange, and if the prop shaft runout measurements exceed runout tolerance specifications for that prop shaft at that location, or at the stub shaft if part of the rear shaft, perform the following:
    1. Mark the mating position for each end of the prop shaft, then remove the shaft from the pinion input, or torque tube input flange.
    2. Rotate the shaft 180 degrees from its original position.
    3. Reinstall the shaft to the pinion or torque tube input flange.
    4. Re-measure and record the runout of the shaft at the same locations measured previously.
    5. Compare the shaft runout re-measurements recorded to the runout tolerance specifications.
    6. If any of the runout re-measurements still exceed runout tolerances, perform the following:
        1. Inspect the pinion or torque tube input flange runout to determine if it is affecting the runout of the prop shaft. Refer to the appropriate procedure: **Torque Tube Input Flange Runout Measurement**, or **Differential Pinion Input Shaft Runout Measurement**.
        2. If the pinion or torque tube input flange runout exceeds runout tolerances, the flange must be re-indexed or replaced to bring the runout within tolerances before proceeding.
        3. If the pinion or torque tube input flange was re-indexed or replaced, return the prop shaft to its original relationship when reinstalling the shaft to the flange.
        4. If the first measurement of pinion or torque tube input flange runout was within tolerances, the prop shaft requires replacement. Check the runout of the replacement prop shaft.
        5. If the pinion or torque tube input flange was re-indexed or replaced, re-measure and record the runout of the shaft at the same locations measured previously.
        6. Compare the shaft runout re-measurements recorded to the runout tolerance specifications.
        7. If any of the runout re-measurements still exceed the runout tolerances, remove and rotate the shaft 180 degrees from it's original position to the pinion or torque tube input flange that has been re-indexed or replaced.
        8. Reinstall the shaft then re-measure and record the runout of the shaft at the same locations measured previously.
        9. Compare the shaft runout re-measurements recorded to the runout tolerance specifications.
        10. If any of the shaft runout re-measurements still exceed the runout tolerances, the shaft requires replacement. Check the runout of the replacement prop shaft.
13. For 2-piece prop systems; if the prop shaft runout measurements at the welded yoke mating to the slip yoke exceed runout tolerance specifications for that prop shaft at that location, perform the following:

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1. If the stub shaft is keyed to ensure proper alignment of the slip yoke, then the prop shaft requires replacement.
2. If the stub shaft is not keyed, mark the mating position for each end of the prop shaft, then remove the slip yoke from the stub shaft.
3. Rotate the shaft 180 degrees from it's original position.
4. Reinstall the slip yoke to the stub shaft.
5. Re-measure and record the runout of the shaft at the welded yoke to slip yoke location.
6. Compare the shaft runout re-measurements recorded to the runout tolerance specifications.
7. If the prop shaft runout re-measurements still exceed runout tolerances at the welded yoke mating to slip yoke location, the prop shaft requires replacement. Check the runout of the replacement prop shaft.

## TORQUE TUBE INPUT FLANGE RUNOUT MEASUREMENT

**Special Tools**

**GE-7872** Magnetic Base Dial Indicator Set , or equivalent

**NOTE:** **This measurement procedure is intended to measure torque tube runout for systems with a constant velocity (CV) joint, rubber coupling or bolt-on U-joint yoke at the torque tube.**

1. Place the transmission in NEUTRAL.
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
3. If equipped with a CV joint, measure the torque tube input flange radial runout on the machined surface of the prop shaft rear CV joint housing, as close to the flange as possible:
    1. Clean the surface of the prop shaft rear CV joint housing just ahead of the torque tube input flange.
    2. Mount a dial indicator set, **GE-7872** Magnetic Base Dial Indicator Set , or equivalent, and position the dial indicator to contact the prop shaft rear CV joint housing as close to the torque tube input flange as possible.
4. If equipped with a rubber coupling or bolt-on U-joint yoke, measure the torque tube input flange radial runout on the machined surface of the flange pilot area:
    1. Mark the position of the prop shaft to the torque tube input flange.
    2. Separate the propshaft from the torque tube input flange.
    3. Clean the surface of the flange pilot area.
    4. Mount a dial indicator set, **GE-7872** Magnetic Base Dial Indicator Set , or equivalent, and position the dial indicator to contact the pilot area as close to the end of the pilot as possible.
5. Rotate the torque tube input flange by hand to locate the low spot.
6. Set the dial indicator to zero on the low spot.
7. Rotate the flange by hand and record the amount of radial runout.
8. Compare the runout of the flange to the runout tolerance specifications guideline.
9. If the torque tube input flange runout exceeds the specification, the flange requires replacement.

## DIFFERENTIAL PINION INPUT SHAFT RUNOUT MEASUREMENT

**Special Tools**

**GE-7872** Magnetic Base Dial Indicator Set , or equivalent

**NOTE:** **This measurement procedure is intended to measure drive axle pinion input shaft**

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**runout for systems with a constant velocity (CV) joint, rubber coupling, bolt-on U-joint yoke, or strap style U-joint at the drive axle**

1. Place the transmission in NEUTRAL.
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
3. If equipped with a CV joint, measure the drive axle pinion input shaft radial runout on the splined surface of the prop shaft rear CV joint housing, as close to the flange as possible:
    1. Clean the surface of the prop shaft rear CV joint housing just ahead of the torque tube input flange.
    2. Mount a dial indicator set, **GE-7872** Magnetic Base Dial Indicator Set , or equivalent, and position the dial indicator to contact the prop shaft rear CV joint housing as close to the drive axle input flange as possible.
4. If equipped with a rubber coupling or bolt-on U-joint yoke, measure the differential pinion input shaft radial runout on the machined surface of the flange pilot area:
    1. Mark the position of the prop shaft to the drive axle input flange.
    2. Separate the propeller shaft from the drive axle input flange.
    3. Clean the surface of the flange pilot area.
    4. Mount a dial indicator set, **GE-7872** Magnetic Base Dial Indicator Set , or equivalent, and position the dial indicator to contact the pilot area as close to the drive axle input flange as possible.
5. If equipped with a torque tube, measure the radial runout on the machined surface of the splined shaft:
    1. Remove the torque tube assembly from the vehicle.
    2. Clean the surface of the splined shaft.
    3. Mount a dial indicator set, **GE-7872** Magnetic Base Dial Indicator Set , or equivalent, and position the dial indicator to contact the machined area as close to the end of the shaft as possible.
6. If equipped with a strap style U-joint flange, measure the differential pinion input shaft radial runout at the propeller shaft, as close to the flange as possible:
    1. Clean the surface of the propeller shaft just ahead of the input flange.
    2. Mount a dial indicator set, **GE-7872** Magnetic Base Dial Indicator Set , or equivalent, and position the dial indicator to contact a smooth area of the propeller shaft as close to the end of the shaft as possible.
7. Rotate the drive axle input shaft by hand to locate the low spot.
8. Set the dial indicator to zero on the low spot.
9. Rotate the shaft by hand and record the amount of radial runout.
10. If equipped with a constant velocity (CV) joint, rubber coupling, or bolt on U-joint yoke:
    1. Compare the runout of the shaft to the runout tolerance specifications guidelines.
    2. If the drive axle input shaft runout exceeds the specification, the flange requires replacement.
11. If equipped with a strap style U-joint flange:
    1. Remove the propeller shaft, rotate the shaft 180 degrees, and reinstall.
    2. Rotate the drive axle input shaft by hand to locate the low spot.
    3. Set the dial indicator to zero on the low spot.
    4. Rotate the shaft by hand and record the amount of radial runout.
    5. Compare the two radial runout measurements and if the difference exceeds the axle flange runout specification, the flange requires replacement.

## DRIVELINE WORKING ANGLES MEASUREMENT

**Special Tools**

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- **J-23498-A** Driveshaft Inclinometer , or equivalent
- **J-23498-20** Driveshaft Inclinometer Adapter , or equivalent

**NOTE:** **This measurement procedure is intended to measure U-joints working angles only, not constant velocity (CV) joint or coupler assembly working angles.**

**NOTE:** **This procedure is intended to be used for vehicles where the following conditions are met:**

- **Vehicle trim heights are within specification guidelines.**
- **The vehicle exhibits no signs of aftermarket modifications that may affect driveline working angles.**
- **The vehicle exhibits no signs of accident damage which may affect the position of the drive axle, or axles, the propeller shaft support bearing, if equipped, or the transmission or transfer case, if equipped.**

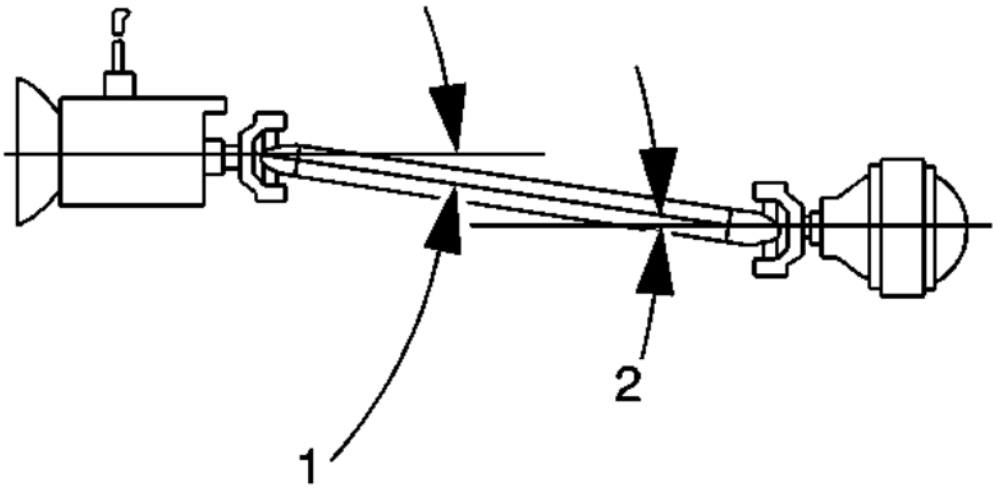



**Fig. 21: Identifying Working Angles (One-Piece Propeller Shaft)**
**Courtesy of GENERAL MOTORS COMPANY**

The working angle of a U-joint is formed by the difference between the angles of any 2 shafts that intersect. Propeller shaft systems that have 1 U-joint have 1 working angle; systems with 2 U-joints have 2 working angles, and so on. In

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a typical 1-piece prop system with 2 U-joints, the working angles are front (1) and rear (2):

- The front working angle (1) is formed by the intersection of the transmission or transfer case output shaft and the prop shaft.
- The rear working angle (2) is formed by the intersection of the prop shaft and the drive axle pinion.

**NOTE: When measuring and evaluating U-joint working angles, observe the following:**

- No U-joint working angle should be equal to zero. An angle of 0 degrees will cause premature U-joint wear due to a lack of rotation of the needle bearings in the U-joint.
- No U-joint working angle should exceed 4 degrees.
- Prop systems containing only 1 U-joint: The U-joint working angle should be within the range specified in this procedure.
- Prop systems containing 2 or 3 U-joints: The 2 U-joint angles each formed with the prop shaft that contains 2 welded yokes are designed to cancel each other during operation. These 2 working, or cancelling U-joint angles should be equal to each other within the range specified in this procedure provide effective cancellation of the U-joints.
- Prop systems containing 3 U-joints: The U-joint angle formed by the prop shaft that contains only 1 welded yoke is an odd, or non-cancelled angle. This working angle should be within the range specified in this procedure.
- Always orientate the **J-23498-A** Driveshaft Inclinometer , or equivalent so that it faces the same side of the vehicle for each measurement taken.

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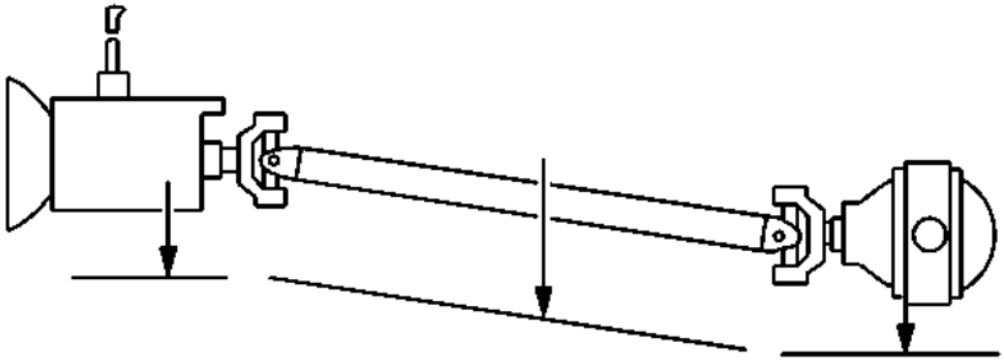


Fig. 22: Identifying Propeller Shaft Measurement Recording Points
Courtesy of GENERAL MOTORS COMPANY

- Be sure to accurately record the measurements taken on a diagram, similar to the one shown.

**Measurement Procedure**

**NOTE:** **If it is necessary to use the J-23498-20 Driveshaft Inclinometer Adapter , or equivalent adapter, first verify the accuracy of the J-23498-20 Driveshaft Inclinometer Adapter , or equivalent by inspecting the angle of an accessible joint using the J-23498-A Driveshaft Inclinometer , or equivalent, then inspecting the same joint angle using the J-23498-20 Driveshaft Inclinometer Adapter , or equivalent.**

1. For vehicles with solid axles, ensure that the vehicle has a full tank of fuel or the equivalent amount of weight in the correct location to simulate a full tank. The weight of 3.8 L (1 gal) of gasoline is approximately 2.8 kg (6.2 lb).
2. Raise and support the vehicle. On vehicles with solid axles, ensure that the drive axle is supported at ride height-vehicle body supported by suspension components. Suspension travel will not affect driveline angles on vehicles with direct-mounted drive axles. Ensure the wheels are free to rotate. Refer to **Lifting and Jacking the Vehicle** .
3. For vehicles with 2-piece prop shaft systems, inspect the lateral alignment of the propeller shafts before proceeding:

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1. From underneath the propeller shafts, look down the length of the shafts from front to rear. Inspect the alignment of the shafts to each other.
2. From underneath the shafts, if the propeller shafts are not aligned to each other in a straight line, then the lateral alignment of the prop shafts needs to be adjusted before proceeding.

   The propeller shaft support bearing assembly can be relocated slightly to one side in order to improve the alignment of the shafts. Ensure that you do not create a ground-out condition against the exhaust or any other component.

4. Place the transmission in NEUTRAL.
5. Clean any corrosion or foreign material from the U-joint bearing caps.
6. Remove any of the U-joint bearing cap snap rings that may interfere with the correct placement of the **J-23498-A** Driveshaft Inclinometer , or equivalent .

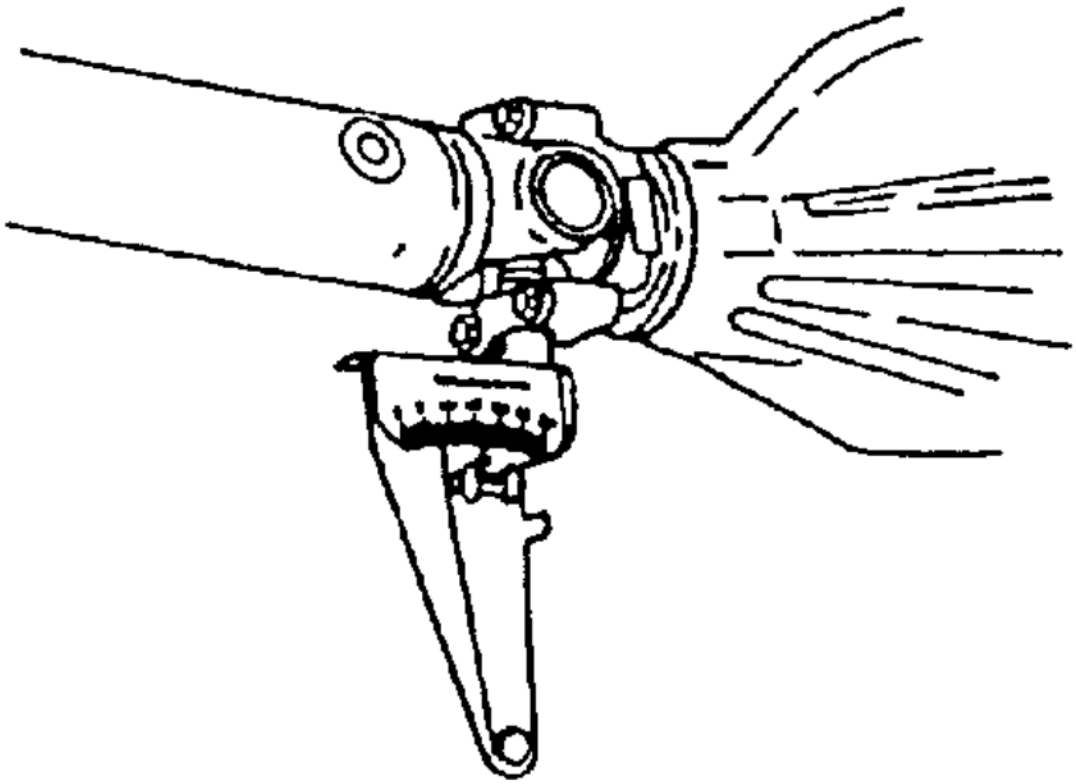


**Fig. 23: Measuring Angle Of Drive Axle Pinion**
**Courtesy of GENERAL MOTORS COMPANY**

7. For all prop systems perform the first measurement:
   1. Rotate the prop shaft to align the rear-most yoke flanges vertically.
   2. Install the **J-23498-A** Driveshaft Inclinometer , or equivalent to the lower U-joint bearing cap of the rear-

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most yoke. This yoke may be part of a prop shaft, torque tube input shaft, or a drive axle pinion shaft. Measure and record the angle of the shaft.

8. For prop systems with 2 or 3 U-joints, perform this additional measurement:

   Without rotating the prop, install the **J-23498-A** Driveshaft Inclinometer , or equivalent to the lower U-joint bearing cap of the forward-most, vertically-aligned yoke. This yoke may be part of a prop shaft, transmission output shaft, or a transfer case output shaft. Measure and record the angle of the shaft.

9. For all prop systems perform the second measurement:
   1. Rotate the prop shaft 1/4 turn to vertically align the flanges of the forward yoke that mates to the rear-most yoke.
   2. Install the **J-23498-A** Driveshaft Inclinometer , or equivalent to the lower U-joint bearing cap of the forward mating yoke. This yoke may be part of a prop shaft, transmission output shaft, or a transfer case output shaft. Measure and record the angle of the shaft.
10. For prop systems with 3 U-joints, perform this additional measurement:

    Without rotating the prop, install the **J-23498-A** Driveshaft Inclinometer , or equivalent to the lower U-joint bearing cap of the forward-most, vertically-aligned yoke. This yoke may be part of a transmission output shaft, or a transfer case output shaft. Measure and record the angle of the shaft.

11. Remove the **J-23498-A** Driveshaft Inclinometer , or equivalent .
12. Install any U-joint bearing cap snap rings that were removed prior to installing the **J-23498-A** Driveshaft Inclinometer , or equivalent .
13. Calculate the U-joint working angle at each intersection of two shafts.

    Subtract the smaller number from the larger to obtain the working angle. For example: If the drive axle pinion has an angle of 16 degrees and the connecting propeller shaft has an angle of 13 degrees, then the working angle of that intersection is 3 degrees.

14. For prop systems with 1 U-joint; compare the working angle to the following specification guideline:

    **Specification Guideline**

    Prop systems containing only 1 U-joint: The U-joint working angle should be between 1/2 and 3/4 degrees.

15. For prop systems with 2 or 3 U-joints; compare the difference between the working angles of the cancelling U-joints to the following specification guidelines:

    **Specification Guideline**

    Allowable range of difference between cancelling U-joint working angles: 0.25 to 1.0 degrees

16. For prop systems with 3 U-joints; compare the working angle of the odd, or non-cancelled U-joint to the following specification guideline:

    **Specification Guideline**

    Prop systems containing 3 U-joints: The odd, or non-cancelled U-joint working angle should be between 1/10 and 1/2 degrees.

17. Any working angle that is not within the specification guidelines requires adjustment.

## PROPELLER SHAFT PHASING INSPECTION

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**Special Tools**

**J-23498-A** Driveshaft Inclinometer , or equivalent

**NOTE:** **This inspection procedure is intended to inspect propeller shaft systems with 2 or 3 U-joints only.**

Correct phasing of a propeller shaft refers to the relative alignment of the U-joint yoke flanges to each other to provide proper cancellation of the U-joints. The yokes should be directly aligned to within the range specified in this procedure.

1. Raise and support the vehicle. On vehicles with solid axles, ensure that the drive axle is supported at ride height-vehicle body supported by suspension components. Ensure the wheels are free to rotate. Refer to **Lifting and Jacking the Vehicle** .
2. Place the transmission in NEUTRAL.
3. Clean any corrosion or foreign material from the U-joint bearing caps.
4. Remove any of the U-joint bearing cap snap rings that may interfere with the correct placement of the **J-23498-A** Driveshaft Inclinometer , or equivalent.

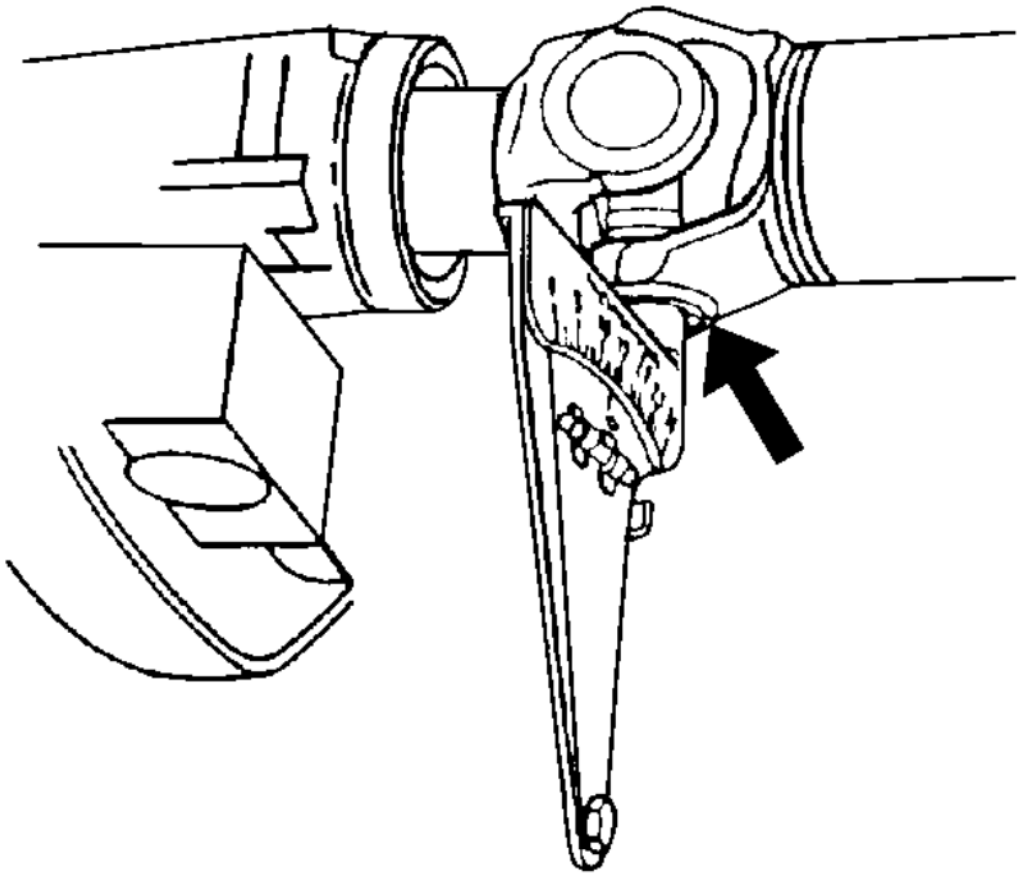


**Fig. 24: Inspecting Rear Propeller Shaft For Proper Phasing**
**Courtesy of GENERAL MOTORS COMPANY**

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5. Inspect the prop shaft for proper phasing.
    1. Rotate the prop shaft or shafts to align the shaft yoke flanges vertically.
    2. Install the **J-23498-A** Driveshaft Inclinometer , or equivalent to the lower U-joint bearing cap of the rear U-joint of the shaft. The **J-23498-A** Driveshaft Inclinometer , or equivalent should be aligned perpendicular to the propeller shaft.
    3. Set the indicator line on the **J-23498-A** Driveshaft Inclinometer , or equivalent to 15, the horizontal reference.
    4. Rotate the propeller shaft slightly to center the bubble to the indicator. The U-joint is now vertical.
    5. Without disturbing the setting on the **J-23498-A** Driveshaft Inclinometer , or equivalent, remove the **J-23498-A** Driveshaft Inclinometer , or equivalent from the rear U-joint bearing cap.
    6. Install the **J-23498-A** Driveshaft Inclinometer , or equivalent to the lower U-joint bearing cap of the front U-joint of the same shaft.
    7. Observe and record the reading of the front U-joint with the **J-23498-A** Driveshaft Inclinometer , or equivalent still set to 15, the horizontal reference.
6. For prop systems with 3 U-joints, rotate the shafts 1/4 turn and repeat steps 5.1-5.7 for the other prop shaft.
7. If the difference between the front and rear U-joints of a welded yoke propeller shaft is 3 degrees or less, the propeller shaft is properly phased.
8. If the difference between the front and rear U-joints of a welded-yoke propeller shaft is greater than 3 degrees, the propeller shaft is either constructed improperly, or damaged from twisting. Refer to **Propeller Shaft Phasing Correction**.
9. If the difference between the welded yoke and slip yoke of a propeller shaft is 1.5 degrees or less, the prop shaft is properly phased.
10. If the difference between the welded yoke and slip yoke of a propeller shaft is greater than 1.5 degrees, the propeller shaft is either constructed improperly, or damaged from twisting. Refer to **Propeller Shaft Phasing Correction**.

# 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

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**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.

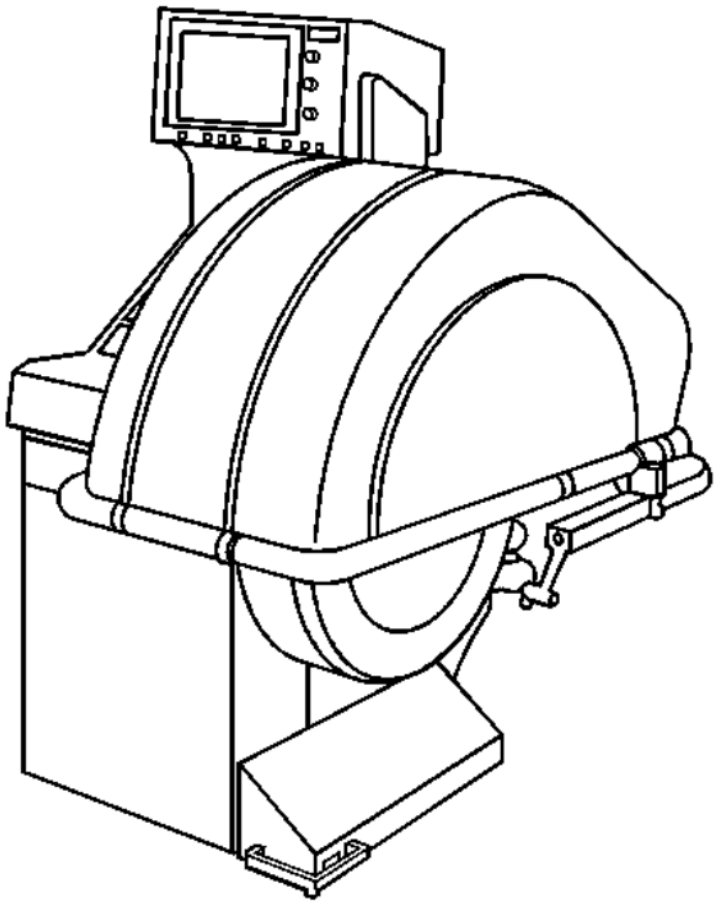


**Fig. 25: View Of Tire & Wheel Assembly Balancer**
**Courtesy of GENERAL MOTORS COMPANY**

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 ( 1/4 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.

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- 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 ( 1/4 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 ( 1/4 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** before proceeding.

There are 2 types of tire and wheel balance:

**Static Balance**

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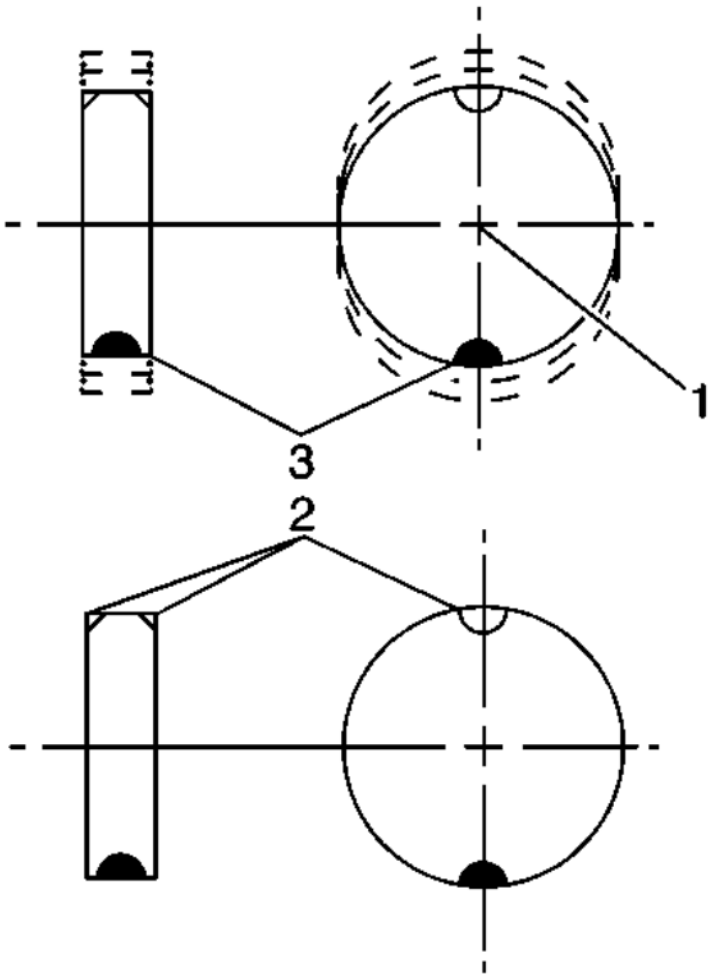



**Fig. 26: View Of Static Balance**
**Courtesy of GENERAL MOTORS COMPANY**

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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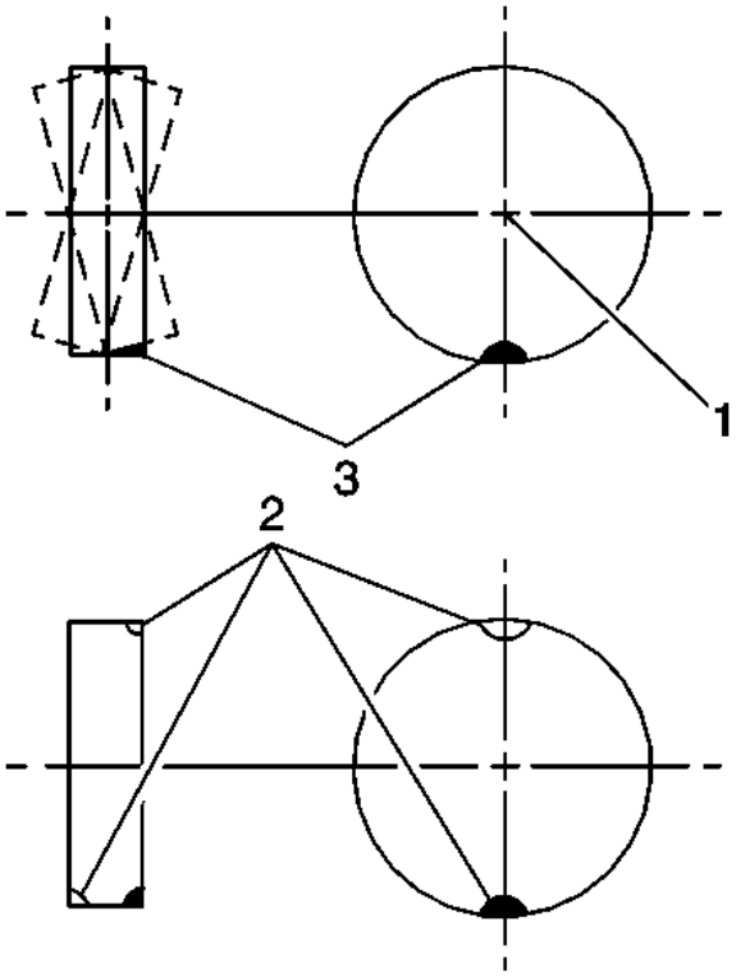



**Fig. 27: View Of Dynamic Balance**
**Courtesy of GENERAL MOTORS COMPANY**

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 ( 1/2 - 3/4 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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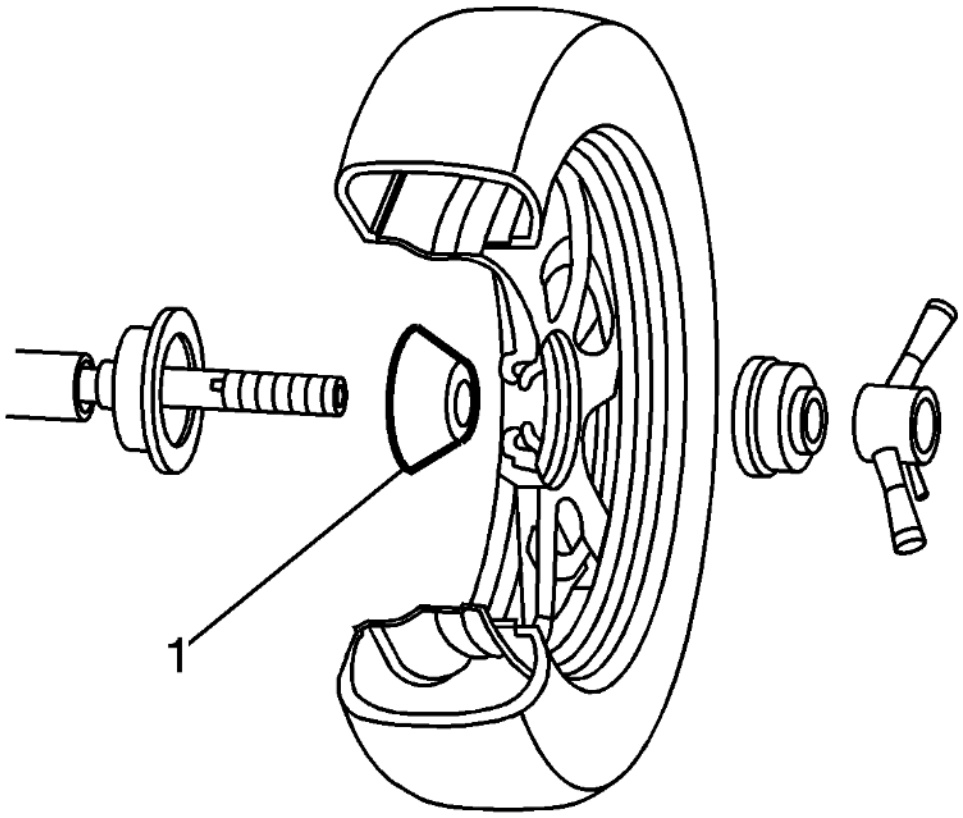



**Fig. 28: Wheel Balancer Center Cone**
**Courtesy of GENERAL MOTORS COMPANY**

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

1. Raise and support the vehicle. **Lifting and Jacking 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 one at a time and mount on a spin-type wheel balancer. **Tire and Wheel Removal and Installation (6-Lug Wheel)** **Tire and Wheel Removal and Installation (8-Lug Wheel)** **Tire and Wheel Removal and Installation (Dual Rear Wheels)**
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. **Tire and Wheel Removal and Installation (6-Lug Wheel)** **Tire and Wheel Removal and Installation (8-Lug Wheel)**

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[Tire and Wheel Removal and Installation (Dual Rear Wheels)]

8. Lower the vehicle.

### Wheel Weight Usage

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

**Clip-on Weights**

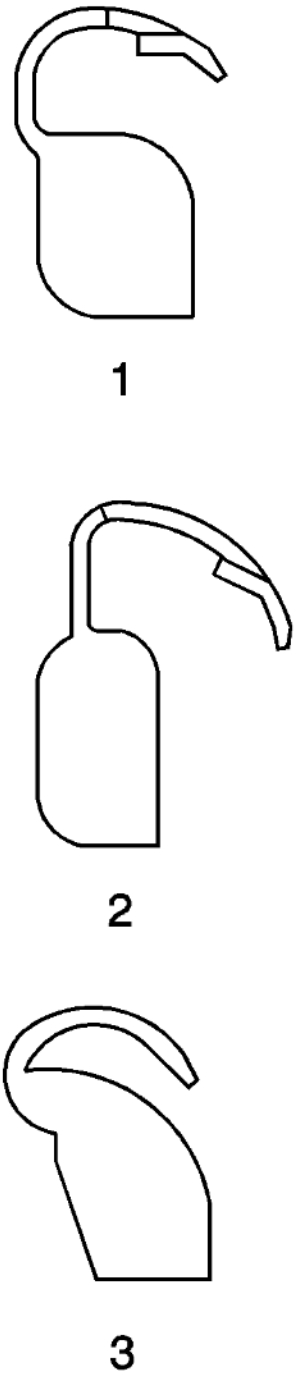



Fig. 29: Identifying Clip-On Wheel Weight Types

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**Courtesy of GENERAL MOTORS COMPANY**

**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.

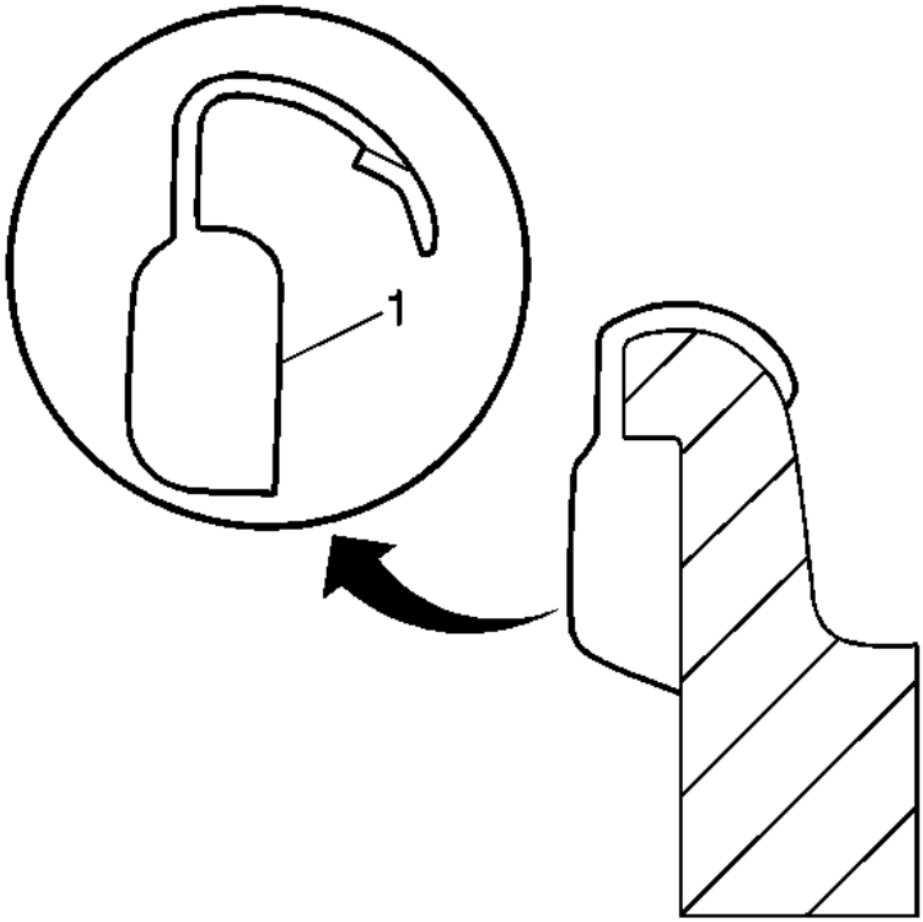



**Fig. 30: Attaching Clip-On Wheel Weight**
**Courtesy of GENERAL MOTORS COMPANY**

**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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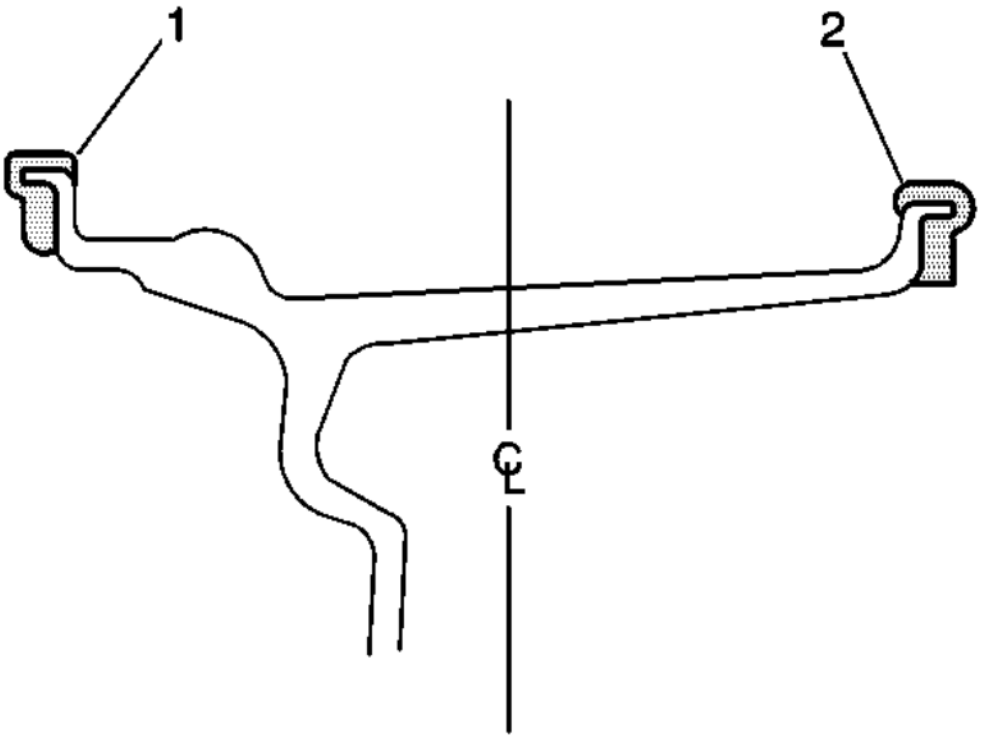



**Fig. 31: Clip-On Weight Placement**
**Courtesy of GENERAL MOTORS COMPANY**

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**

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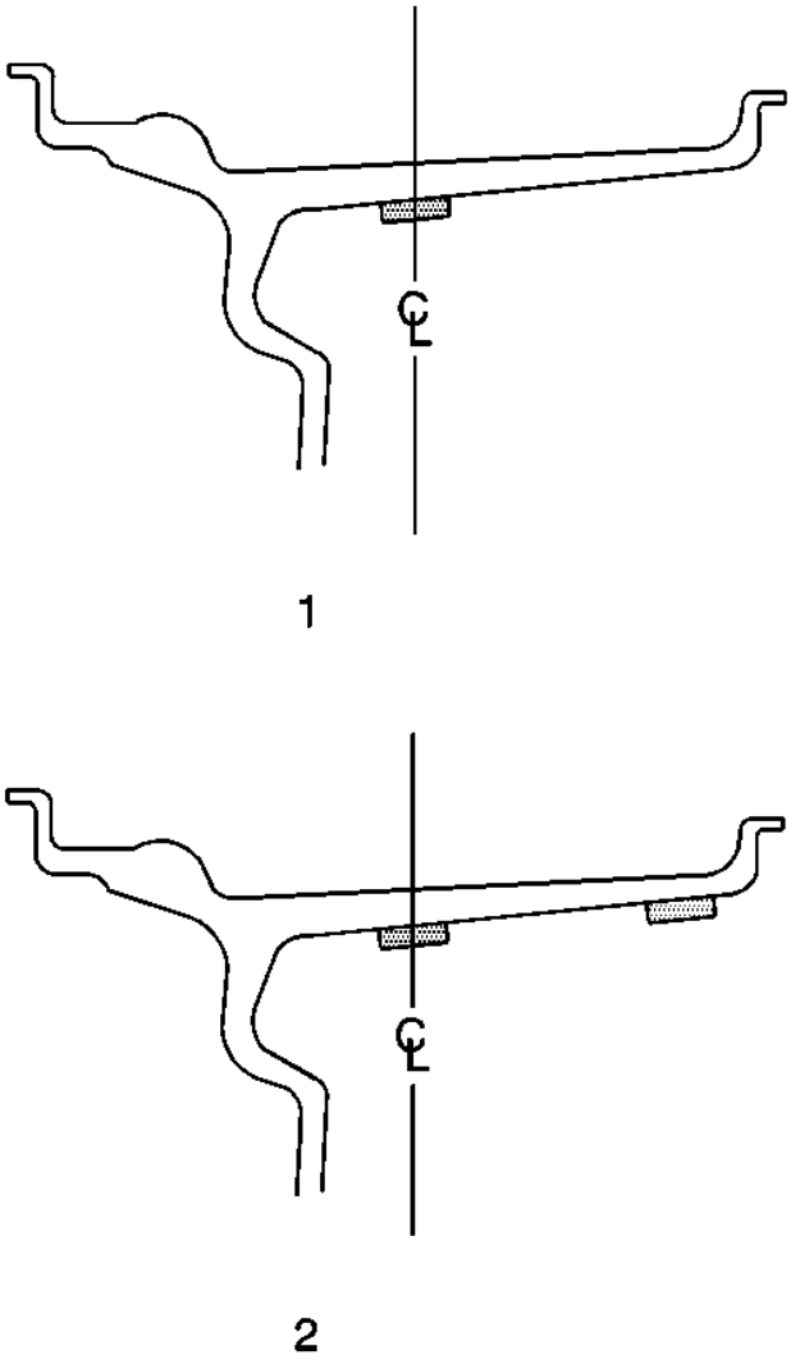



**Fig. 32: Identifying Adhesive Weight Wheel Placement**
**Courtesy of GENERAL MOTORS COMPANY**

**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.

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- 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 -**

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Off Vehicle.

- 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)

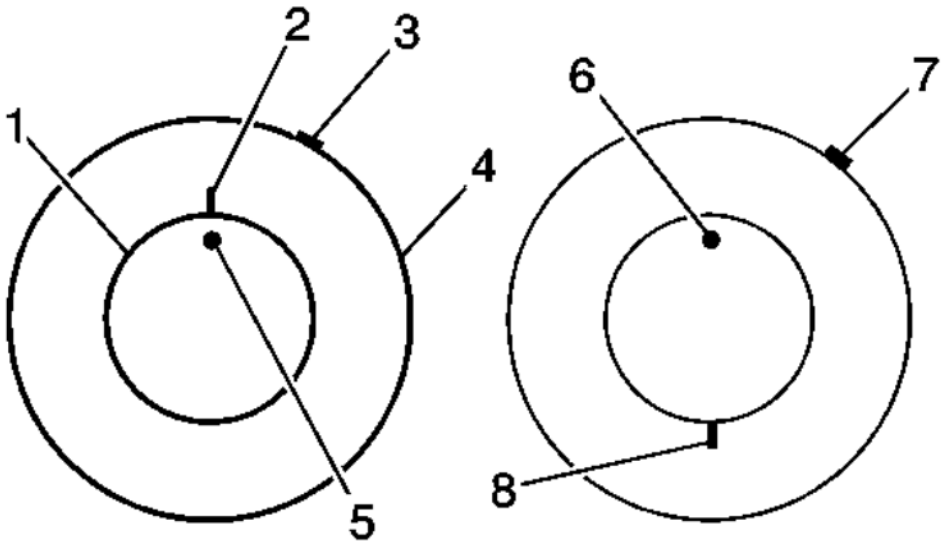



Fig. 33: View Of Tire-to-Wheel Match-Mounting
Courtesy of GENERAL MOTORS COMPANY

**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.

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- 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**
   - **Tire and Wheel Removal and Installation (6-Lug Wheel) Tire and Wheel Removal and Installation (8-Lug Wheel) Tire and Wheel Removal and Installation (Dual Rear Wheels)**
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.

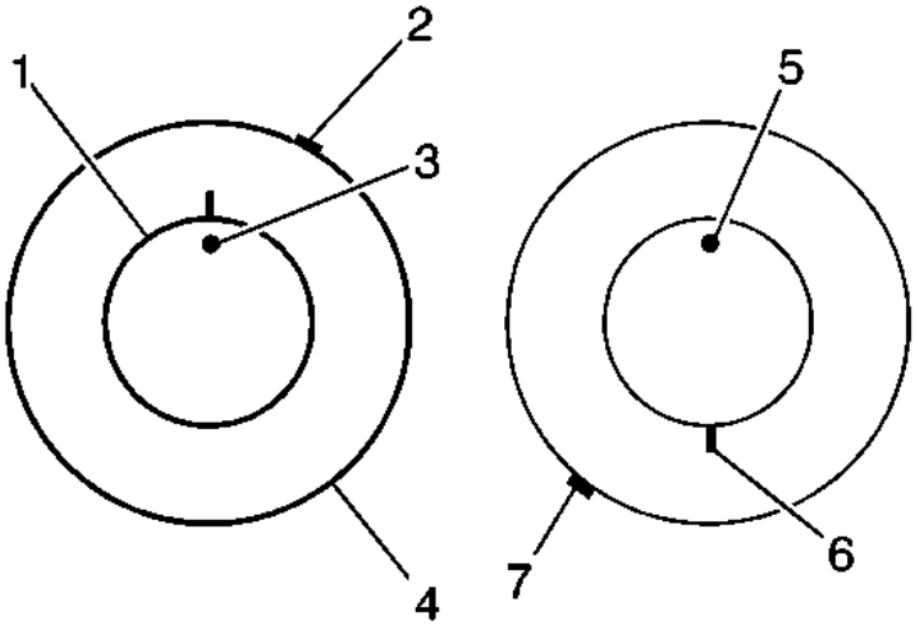



**Fig. 34: View Of Match-Mounting Tire-To-Wheel**
**Courtesy of GENERAL MOTORS COMPANY**

9. If the clock location of the high spot has moved, however the assembly runout has NOT been reduced, perform

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the following steps:

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.
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 (6-Lug Wheel)** **Tire and Wheel Removal and Installation (8-Lug Wheel)** **Tire and Wheel Removal and Installation (Dual Rear Wheels)** .
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 (6-Lug Wheel)** **Tire and Wheel Removal and Installation (8-Lug Wheel)** **Tire and Wheel Removal and Installation (Dual Rear Wheels)** .
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**.
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:
   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.
   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.
   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.

## DRIVELINE SYSTEM BALANCE ADJUSTMENT

**Special Tools**

- **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or
- **EL-38792-A** Electronic Vibration Analyzer (EVA) 2
- **EL-38792-20** 20-Foot Timing Light Power Cord Extension
- **EL-38792-25** Inductive Pickup Timing Light, or equivalent

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- **EL-38792-27** 6-Foot EVA Power Cord Extension

For equivalent regional tools, refer to **Special Tools and Equipment**.

This procedure is designed to fine-tune the balance of a propeller shaft while it is mounted in the vehicle. Small amounts of residual imbalance which could be present in other related driveline system components could be compensated for as a result of performing this procedure. The end result of properly fine-tuning a propeller shaft balance may be either a significant reduction or an elimination of a vibration disturbance that is related to the first-order rotation of a propeller shaft.

Fine-tuning the balance of a propeller shaft can aid in achieving a more balanced total driveline system.

**NOTE:** **The runout of the propeller shaft to be balanced and the runout of the components that the propeller shaft mates to must be within tolerances before an attempt should be made to perform this procedure.**

If the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) is available, use the following procedure, Adjustment Procedure Using Oscilloscope. If the Oscilloscope is not available but the EVA 2 is available, use the second procedure, Adjustment Procedure Using EVA. If neither the Oscilloscope nor the EVA 2 is available, use the third procedure, Adjustment Procedure Without Oscilloscope or EVA.

### Adjustment Procedure Using Oscilloscope

**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.**

The balance procedure is integrated into the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) in its Driveline Balancing utility. There are two methods for balancing:

- Hose Clamp Method
- Pinion Flange Method (vehicles with rubber couplers on the propeller shaft)

The following is an overview of the two driveline balancing methods.

**Hose Clamp Method**

1. Raise and support the vehicle; ensure that the drive axle or axles are supported at ride height - vehicle body supported by suspension components. Refer to **Lifting and Jacking the Vehicle** .
2. Connect the Oscilloscope to the USB port of the computer using the blue USB cable, **CH-51450-M1106** .
3. Connect the Accelerometer **CH-51450-TA183** to the NVH Interface **CH-51450-TA148** .
4. Connect the NVH Interface to Channel B of the Oscilloscope using the **CH-51450-TA098** BNC to BNC cable.

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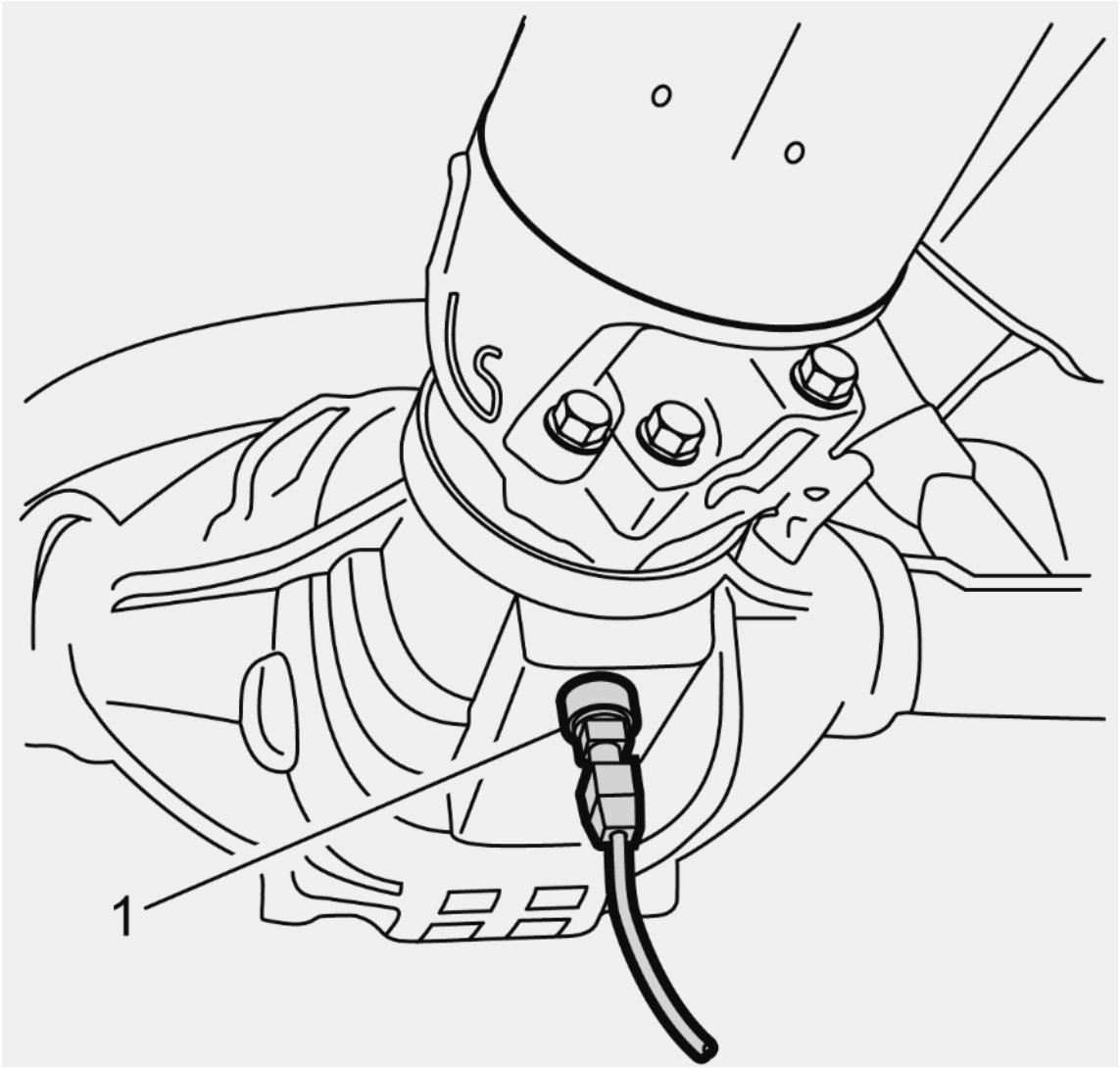



**Fig. 35: Accelerometer**
**Courtesy of GENERAL MOTORS COMPANY**

5. Mount the Accelerometer (1) to a suitable surface on the vehicle differential. If the differential case is non-ferrous, a steel washer can be glued on the differential case in order to secure the magnetic Accelerometer.

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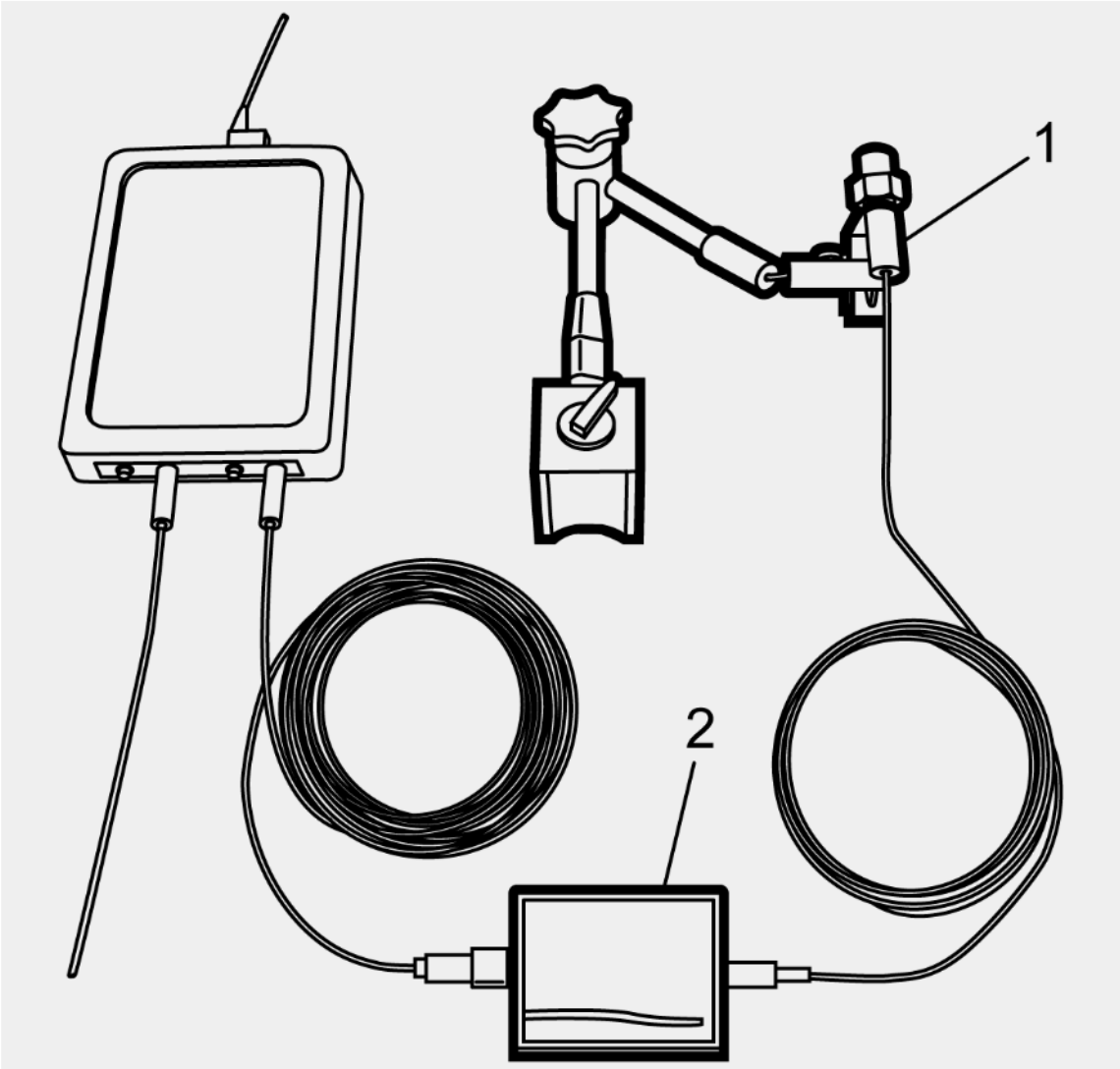



**Fig. 36: Optical Sensor And Interface**
**Courtesy of GENERAL MOTORS COMPANY**

6. Connect the Optical Sensor **CH-51450-TA186** (1) to the Optical Sensor Interface **CH-51450-TA185** (2).
7. Connect the Optical Sensor Interface to Channel D of the Oscilloscope using the **CH-51450-TA098** BNC to BNB cable.

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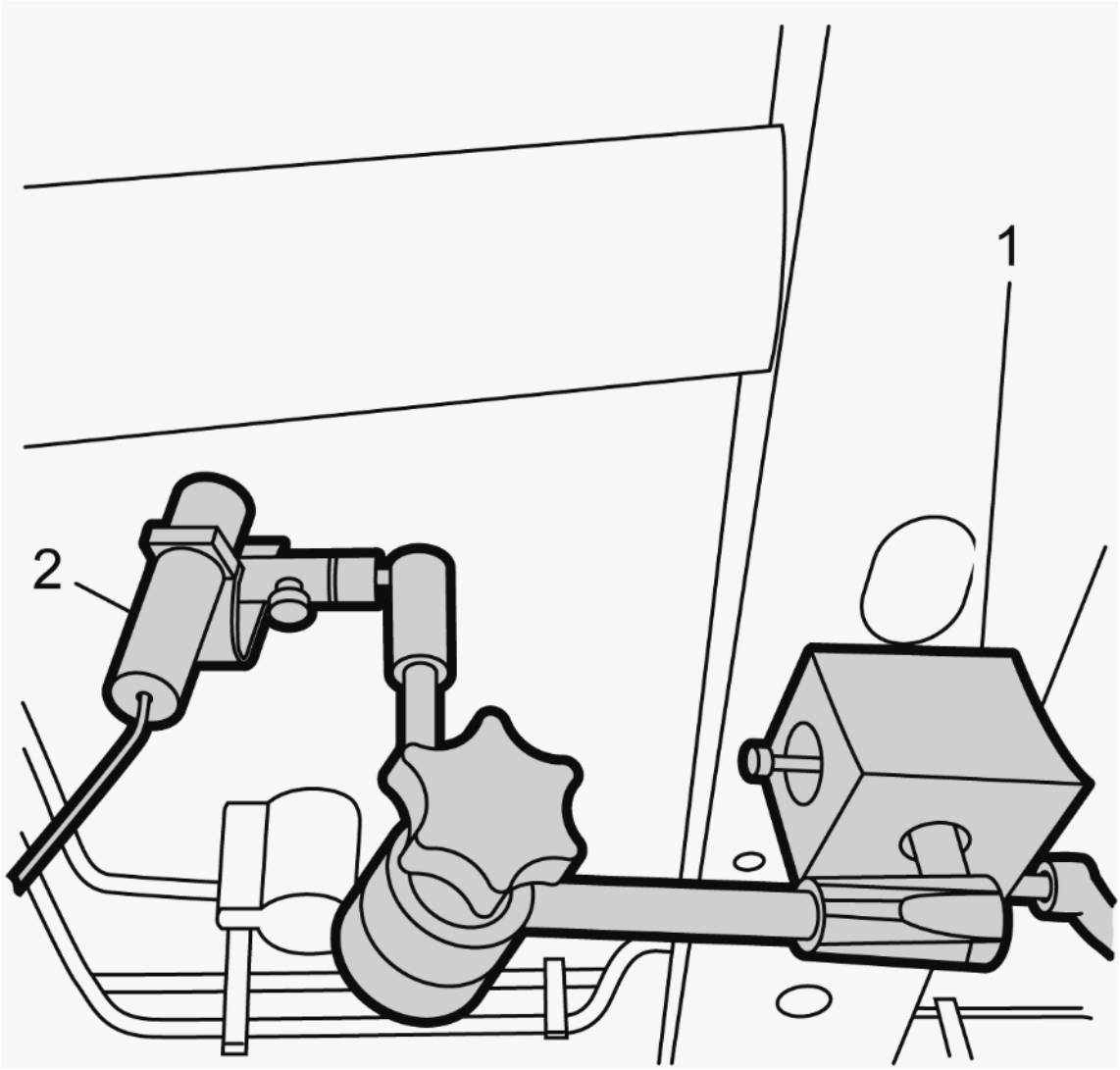



**Fig. 37: Magnetic Mounting Fixture**
**Courtesy of GENERAL MOTORS COMPANY**

8. Mount the Magnetic Mounting Fixture **CH-51450-TA187** (1) to a suitable surface on the vehicle underbody.
9. Place a 1/2 inch strip of reflective tape to the propeller shaft.
10. Focus the laser (2) on the reflective tape.
11. Install 2 hose clamps side by side to the propeller shaft near the differential, on an area clear of any factory balance weights.
12. Mark the excess band on the hose clamps.
13. Remove the hose clamps and trim the excess from the hose clamp bands.
14. Enter the weight of the hose clamp, in grams, into the balancing software.
15. To determine the weight of the hose clamp, use the following:
    - Cut the screw body off of the clamp, even with end of the screw.
    - Weigh the screw body on a gram scale (14 g is typical).
16. Measure the circumference of the propeller shaft near the hose clamps using the supplied ruler and enter that figure, in millimeters, into the balancing software.
17. Alternatively, enter the diameter, in millimeters, of the propeller shaft into the balancing software.
18. Before beginning the test, inspect for the following:
    - The vehicle is properly supported. Refer to **Lifting and Jacking the Vehicle** .

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- Remove any rocks or debris embedded in the tire treads.
- Secure all test leads clear of rotating components.
- Disable the ABS and traction control, if equipped.
- Turn OFF the A/C, and any other accessories.

19. Determine a suitable propeller shaft speed.
    - Start the engine.
    - Place the transmission in the highest forward gear.
    - Run the engine to highway speed, typically 104-112 km/h (65-70 mph).
    - When the RPM can be held stable for longer than 3 seconds, the balancing software will capture and enter the propeller shaft speed.
    - Alternatively, click the Edit Manually check box and enter the desired propeller shaft speed.
    - Place the transmission in NEUTRAL.
    - Turn OFF the engine.
20. Begin the propeller shaft balancing.

**Initial Run**

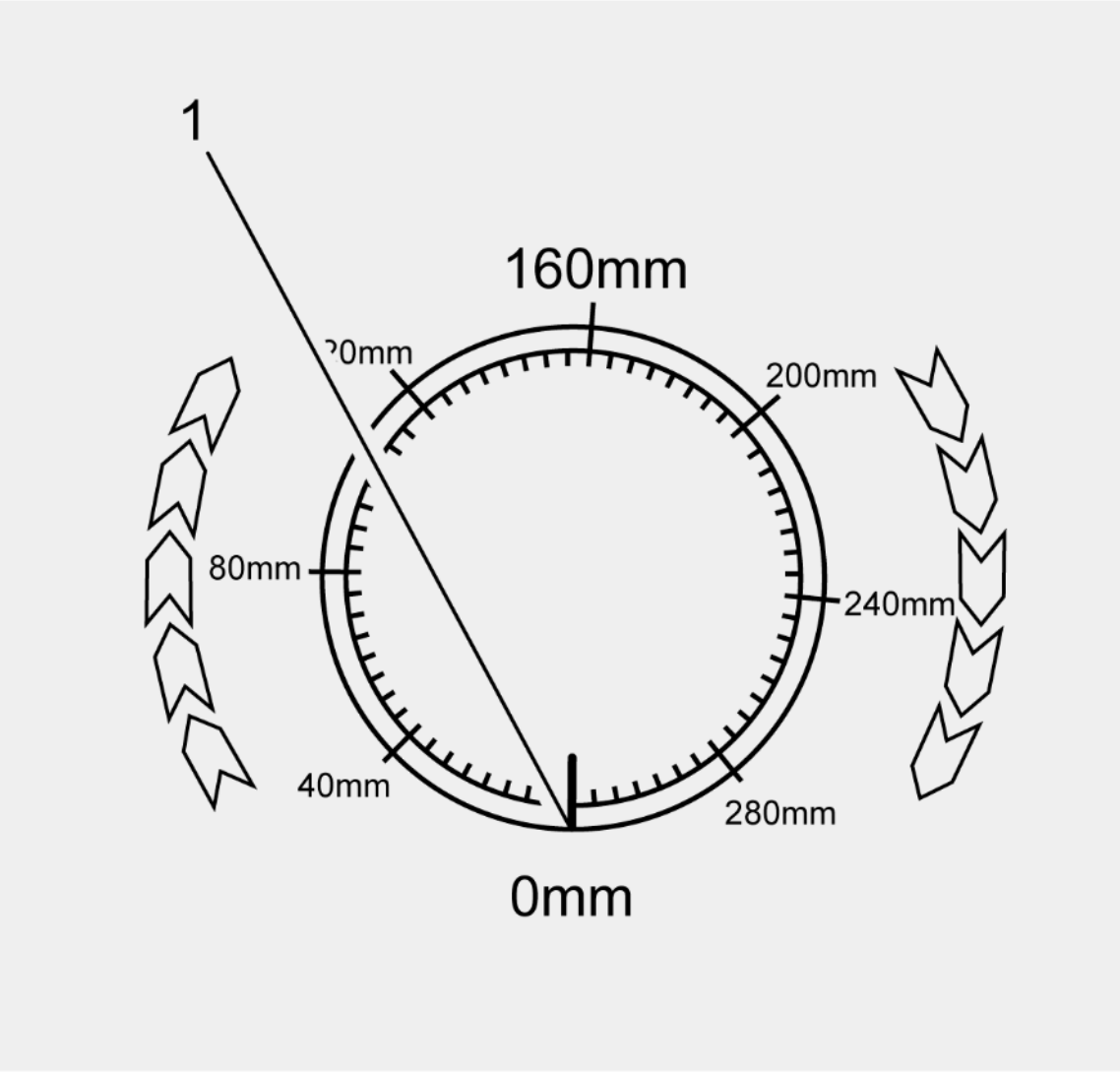



**Fig. 38: 0 mm Mark**
**Courtesy of GENERAL MOTORS COMPANY**

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1. Place the first clamp on the propeller shaft near the differential.
2. Clearly mark the location of the clamp as reference for all remaining measurements.
3. Label the mark (1) as 0 mm.
4. Measure the distance specified by the software and place the second clamp next to the first clamp.
5. Measure the distance specified by the software and place the second clamp next to the first clamp.
6. Press the green Initial Run button to start the test.
7. Start the engine.
8. Place the transmission in the highest forward gear.
9. Accelerate the engine until the required speed is reached.
10. The RPM graph will highlight green when the RPM is within the specified range, and data will only be gathered while within this range.

21. When the Complete % bar graph is filled, place the transmission in NEUTRAL and turn OFF the engine.
22. Perform the first calibration run.

**Calibration Run 1**

1. Place both hose clamps at the 0 mm label.
2. Press the green Calibration Run 1 button.
3. Start the engine.
4. Place the transmission in the highest forward gear.
5. Accelerate the engine until the required speed is reached.

23. When the Complete % bar graph is filled, place the transmission in NEUTRAL and turn OFF the engine.
24. Perform the second calibration run.

**Calibration Run 2**

1. Measuring in the direction of forward propeller shaft rotation, mark the point as indicated on the balancing software.
2. Place both hose clamps at this mark.
3. Press the green Calibration Run 2 button.
4. Start the engine.
5. Place the transmission in the highest forward gear.
6. Accelerate the engine until the required speed is reached.

25. When the Complete % bar graph is filled, place the transmission in NEUTRAL and turn OFF the engine.
26. Perform the third calibration run.

**Calibration Run 3**

1. Measuring from the 0 mm mark in the direction of forward propeller shaft rotation, mark the point as indicated on the balancing software.
2. Place both hose clamps at this mark.
3. Press the green Calibration Run 3 button.
4. Start the engine.
5. Place the transmission in the highest forward gear.
6. Accelerate the engine until the required speed is reached.

27. When the Complete % bar graph is filled, place the transmission in NEUTRAL and turn OFF the engine.

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28. Perform the final propeller shaft balancing.

    **Final Balance**

    1. Measure and mark the locations as indicated on the balancing software.
    2. Place the hose clamps at these locations.
    3. Press the green Verification button.
    4. Start the engine.
    5. Place the transmission in the highest forward gear.
    6. Accelerate the engine until the required speed is reached.
29. When the Complete % bar graph is filled, place the transmission in NEUTRAL and turn OFF the engine.
30. The software will display the final imbalance.
31. If the imbalance exceeds the minimum requirement, the software will recommend removing the rear tire and wheel assemblies and, after securing the brake rotors or brake drums, restarting the test.

**Pinion Flange Method**

1. Raise and support the vehicle; ensure that the drive axle or axles are supported at ride height - vehicle body supported by suspension components. Refer to **Lifting and Jacking the Vehicle** .
2. Connect the Oscilloscope to the USB port of the computer using the blue USB cable, **CH-51450-M1106** .
3. Connect the Accelerometer **CH-51450-TA183** to the NVH Interface **CH-51450-TA148** .
4. Connect the NVH Interface to Channel B of the Oscilloscope using the **CH-51450-TA098** BNC to BNC cable.

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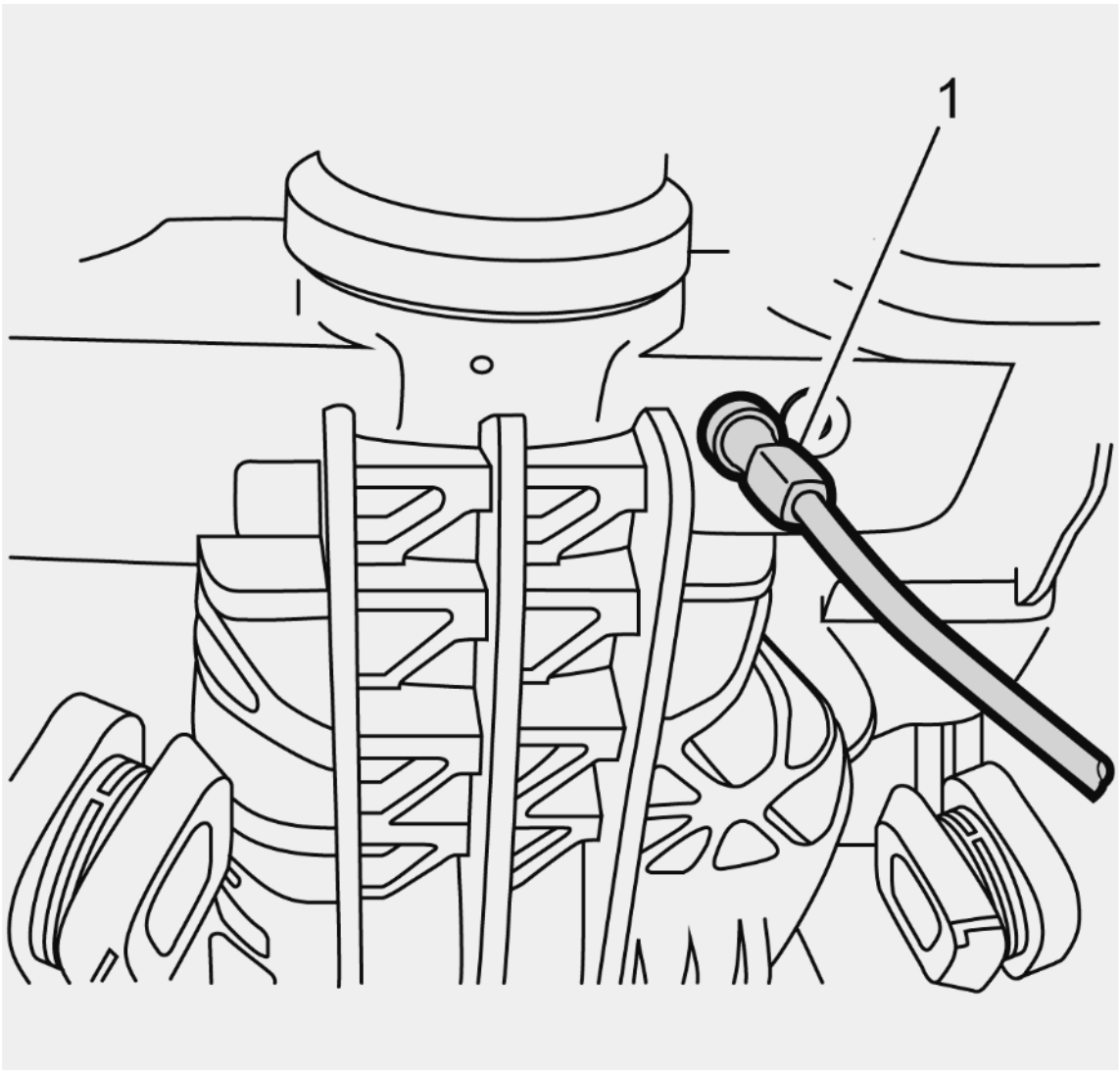



**Fig. 39: Accelerometer**
**Courtesy of GENERAL MOTORS COMPANY**

5. Mount the Accelerometer (1) to a suitable surface near the front of the differential. If the surface is non-ferrous, a steel washer can be glued to the surface in order to secure the magnetic Accelerometer.

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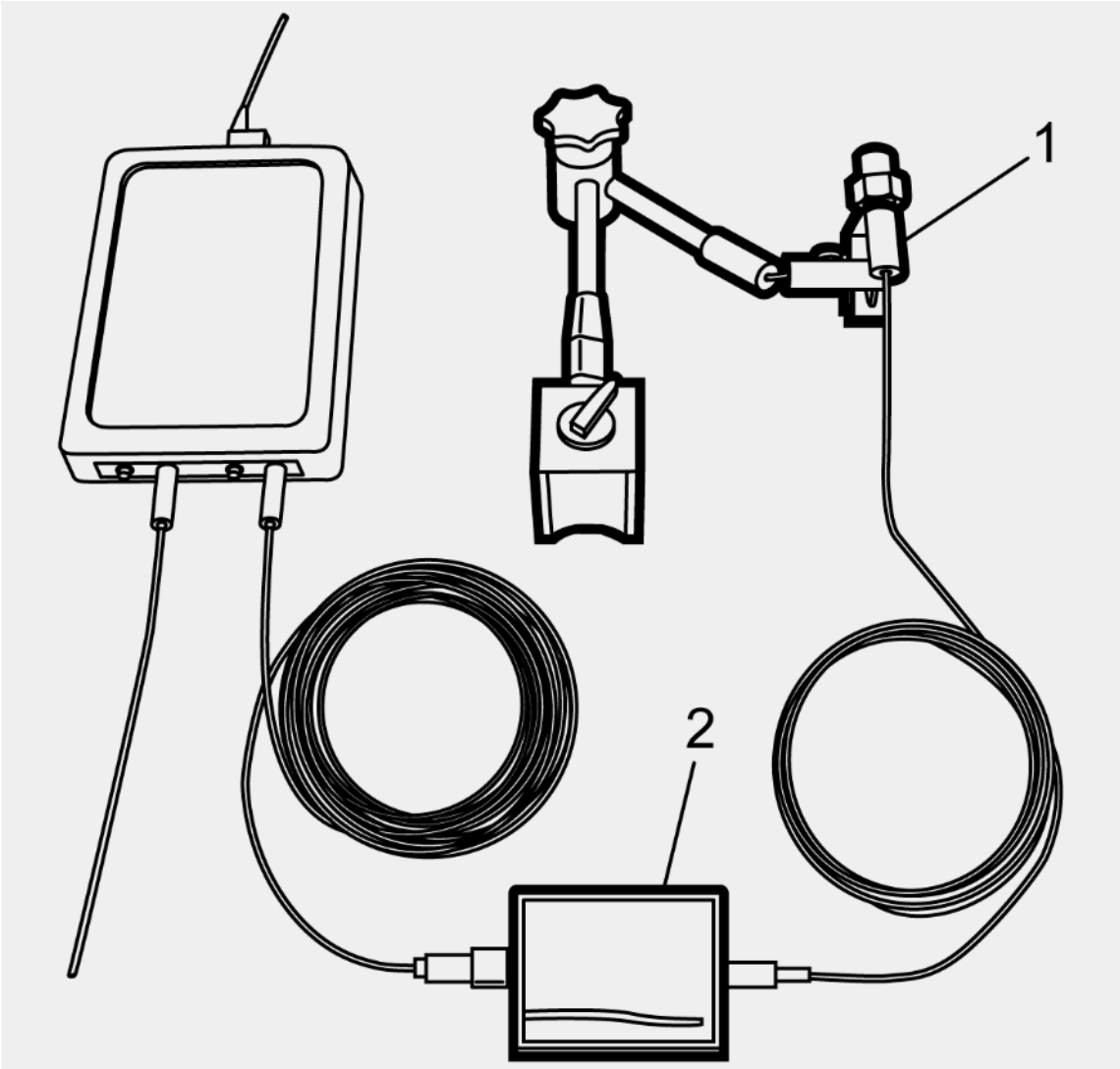



**Fig. 40: Optical Sensor And Interface**
**Courtesy of GENERAL MOTORS COMPANY**

6. Connect the Optical Sensor **CH-51450-TA186** (1) to the Optical Sensor Interface **CH-51450-TA185** (2).
7. Connect the NVH Interface to Channel D of the Oscilloscope using the **CH-51450-TA098** BNC to BNB cable.

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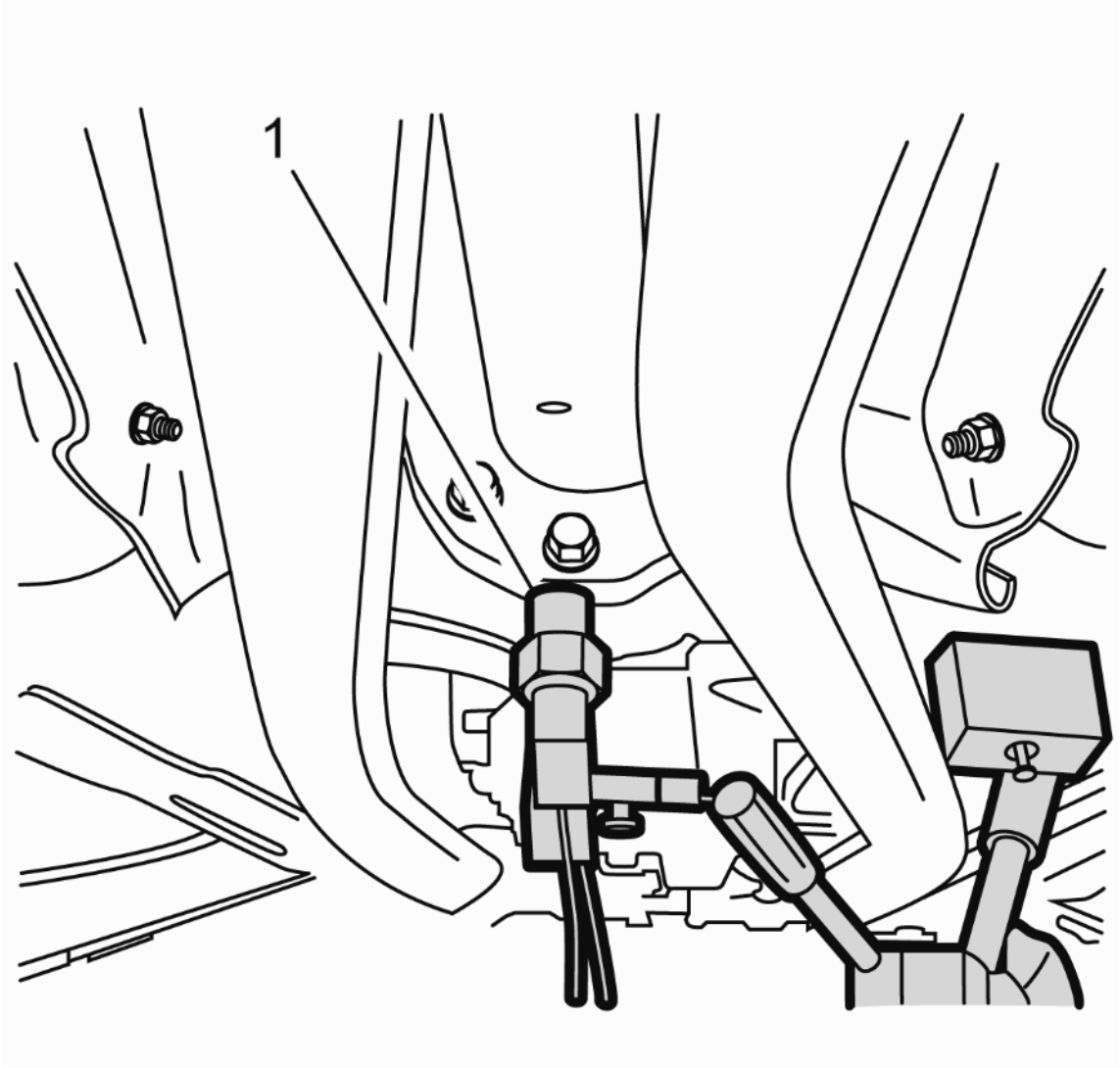



**Fig. 41: Magnetic Mounting Fixture**
**Courtesy of GENERAL MOTORS COMPANY**

8. Mount the Magnetic Mounting Fixture **CH-51450-TA187** (1) to a suitable surface on the vehicle underbody.
9. Place a 1/2 inch strip of reflective tape to the propeller shaft.
10. Focus the laser on the reflective tape.
11. Measure the circumference of the pinion flange bolt circle and enter that figure, in millimeters, into the balancing software.
12. Alternatively, enter the diameter, in millimeters, of the pinion flange into the balancing software.

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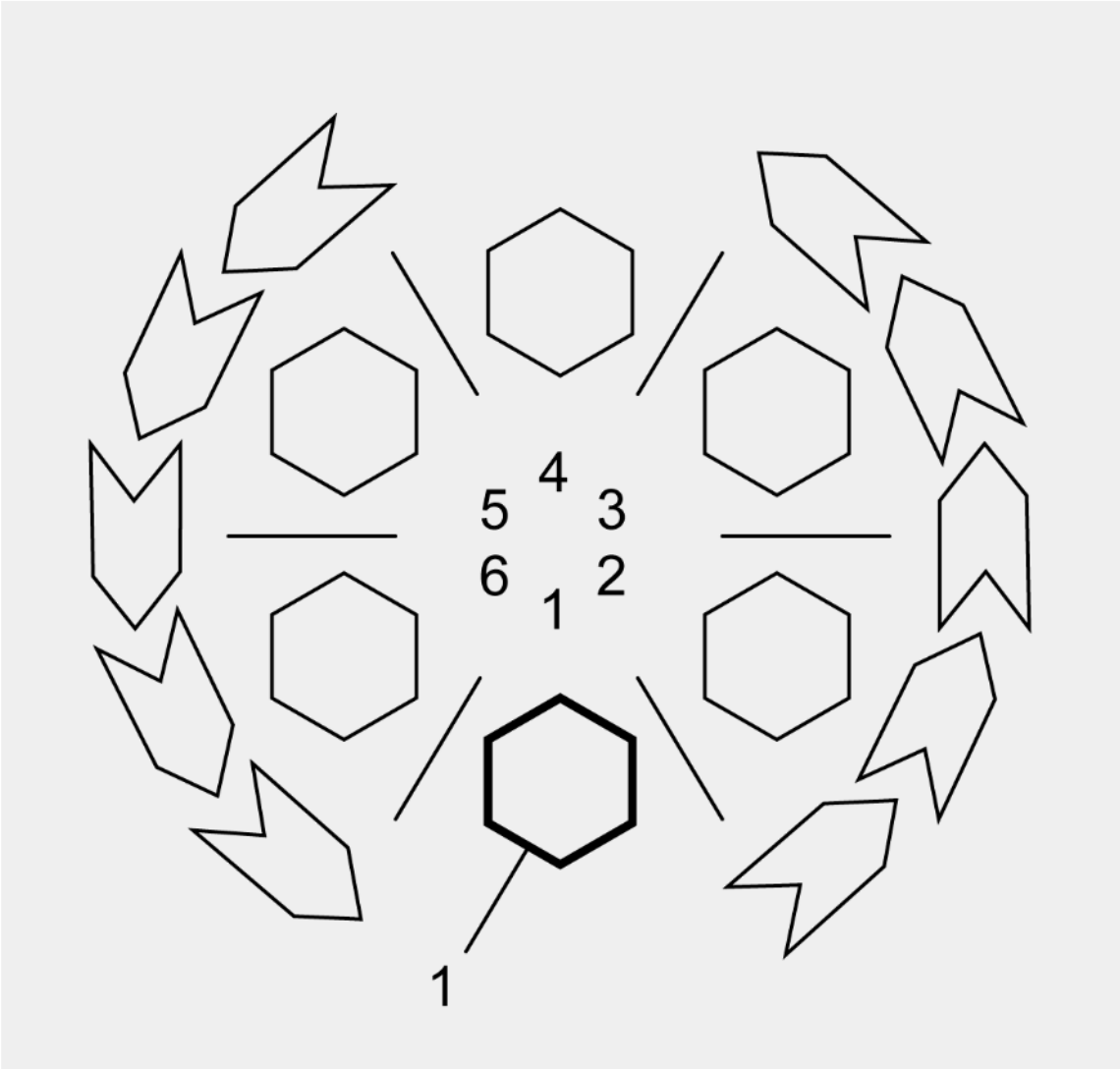



**Fig. 42: Numbering Pinion Flange Bolts And/Or Studs**
**Courtesy of GENERAL MOTORS COMPANY**

13. Enter the number of pinion flange bolts into the balancing software.
14. Number the pinion flange bolts and/or studs (1) in the direction of propeller shaft rotation.
15. Before beginning the test, inspect for the following:
    - The vehicle is properly supported. Refer to **Lifting and Jacking the Vehicle** .
    - Remove any rocks or debris embedded in the tire treads.
    - Secure all test leads clear of rotating components.
    - Disable the ABS and traction control, if equipped.
    - Turn OFF the A/C, and any other accessories.
16. Determine a suitable propeller shaft speed.
    - Start the engine.
    - Place the transmission in the highest forward gear.
    - Run the engine to highway speed, typically 104-112 km/h (65-70 mph).
    - When the RPM can be held stable for longer than 3 seconds, the balancing software will capture and enter the propeller shaft speed.
    - Alternatively, click the Edit Manually check box and enter the desired propeller shaft speed.
    - Place the transmission in NEUTRAL.

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- Turn OFF the engine.

17. Begin balancing the propeller shaft.

**Initial Run**

1. Press the green Initial Run button to start the test.

   An initial measurement of the propeller shaft will be taken.

2. Start the engine.
3. Place the transmission in the highest forward gear.
4. Accelerate the engine until the required speed is reached.
5. The RPM graph will highlight green when the RPM is within the specified range, and data will only be gathered while within this range.

18. When the Complete % bar graph is filled, place the transmission in NEUTRAL and turn OFF the engine.
19. Perform the first calibration run.

**Calibration Run 1**

1. Place 4.5 g of weight at location 1 by stacking 3 of the balancing weights (1.5 g each). The weights may be affixed to the front or the rear of the pinion flange.
2. Press the green Calibration Run 1 button.
3. Start the engine.
4. Place the transmission in the highest forward gear.
5. Accelerate the engine until the required speed is reached.

20. When the Complete % bar graph is filled, place the transmission in NEUTRAL and turn OFF the engine.
21. Perform the second calibration run.

**Calibration Run 2**

1. Remove the balancing weights from location 1.
2. Install the balancing weights at location 3.
3. Press the green Calibration Run 2 button.
4. Start the engine.
5. Place the transmission in the highest forward gear.
6. Accelerate the engine until the required speed is reached.

22. When the Complete % bar graph is filled, place the transmission in NEUTRAL and turn OFF the engine.
23. Perform the third calibration run.

**Calibration Run 3**

1. Remove the balancing weights from location 3.
2. Install the balancing weights at location 5.
3. Press the green Calibration Run 3 button.
4. Start the engine.
5. Place the transmission in the highest forward gear.
6. Accelerate the engine until the required speed is reached.

24. When the Complete % bar graph is filled, place the transmission in NEUTRAL and turn OFF the engine.

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25. Perform the final propeller shaft balancing.

    **Final Balance**

    1. Remove the balancing weights from location 5.
    2. Install the balancing washers to the location(s) indicated by the balancing software.
    3. Press the green Verification button.
    4. Start the engine.
    5. Place the transmission in the highest forward gear.
    6. Accelerate the engine until the required speed is reached.
26. When the Complete % bar graph is filled, place the transmission in NEUTRAL and turn OFF the engine..
27. The software will display the final imbalance.
28. If the imbalance exceeds the minimum requirement, the software will recommend removing the rear tire and wheel assemblies and, after securing the brake rotors or brake drums, and restarting the test.
29. If the test is to be restarted, remove all of the balancing weights.
30. The test can then be restarted by either of the following methods:
    - Press the Initial Run button to restart the test.
    - Press the Balancing button to enter the test through the setup wizard.

**Adjustment Procedure Using EVA**

**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.**

1. Raise and support the vehicle; ensure that the drive axle or axles are supported at ride height - vehicle body supported by suspension components. Refer to **Lifting and Jacking the Vehicle** .
2. With the tire and wheel assemblies, and the brake rotors and/or brake drums removed from the drive axle, or axles, start the engine and turn OFF all engine accessories.
3. Place the transmission in forward gear.
4. Run the vehicle at the speed which causes the most vibration in the propeller shaft; observe which end of the propeller shaft exhibits the greatest amount of vibration disturbance.
5. Turn the engine OFF to slow and stop the rotation of the propeller shaft.

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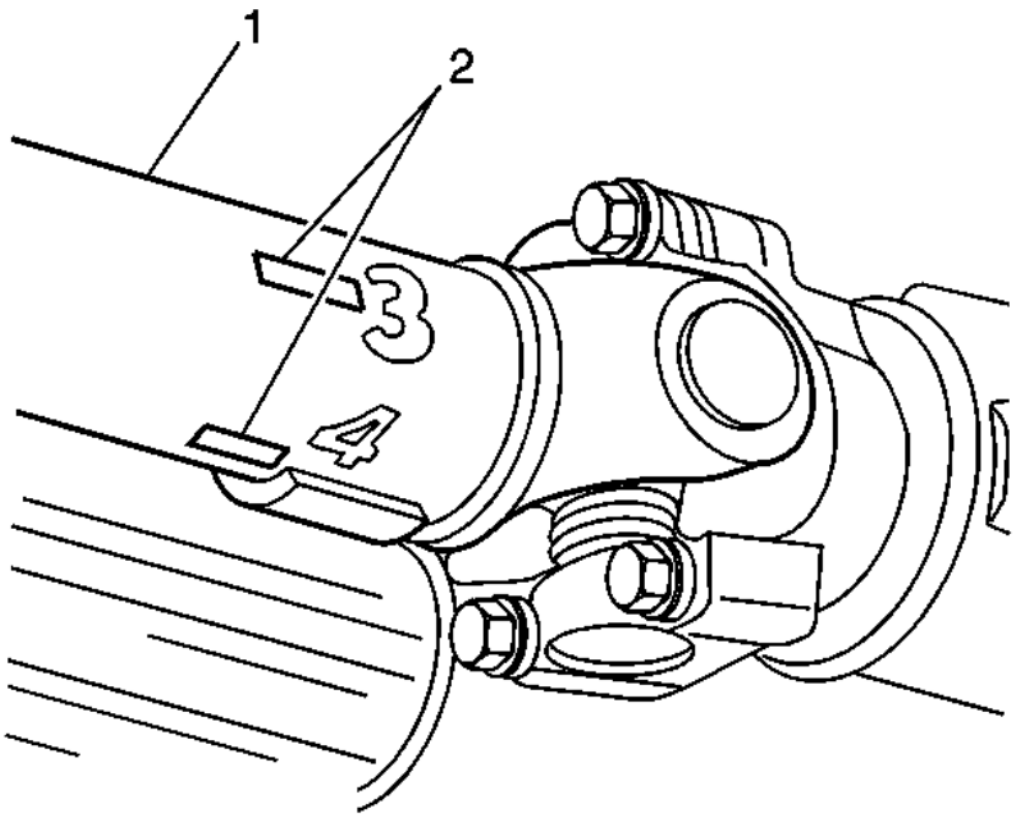



Fig. 43: Marking Circumference Of Propeller Shaft At Four Points 90 Degrees Apart
**Courtesy of GENERAL MOTORS COMPANY**

6. Mark the circumference of the propeller shaft (1) to be balanced at four points 90 degrees apart (2), nearest the end that exhibited the greatest amount of vibration. Number the marks 1-4.
7. Install the **EL-38792-A** EVA 2 , the **EL-38792-27** 6-foot EVA power cord extension , the **EL-38792-25** inductive pickup timing light , or equivalent, and the **EL-38792-20** 20-foot extension to the vehicle.
8. Connect the clip of the **EL-38792-25** inductive pickup timing light , or equivalent, onto the trigger wire of the **EL-38792-A** EVA 2.
9. Mount the **EL-38792-A** EVA 2 vibration sensor to the bottom of the driveline component nearest to the end of the propeller shaft that exhibited the greatest amount of vibration.

   Ensure that the side of the sensor marked UP faces upward and that the sensor is positioned as close to horizontal as possible.

10. Plug the vibration sensor cord into Input A of the **EL-38792-A** EVA 2. Input B is not used with the strobe function.
11. Run the vehicle at the speed which causes the most vibration in the propeller shaft; observe the frequency readings displayed on the **EL-38792-A** EVA 2.

**NOTE:** **Do NOT continue with fine-tuning the balance of a propeller shaft if the dominant frequency displayed is not related to the first-order rotational speed**

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**of the propeller shaft.**

12. Verify that the dominant frequency displayed on the **EL-38792-A** EVA 2 matches the recorded frequency of the vibration concern.
13. Record the amplitude reading of the dominant frequency displayed.
14. Using the strobe function of the **EL-38792-A** EVA 2 , select the correct filter range to use for the balance adjustment, so that the dominant frequency would be near the middle of the filter range. Use the full range filter only as a last resort if one of the specific range filters will not cover the frequency adequately.
15. The **EL-38792-A** EVA 2 display will show the dominant frequency, the amplitude and the selected filter range.
16. Aim the **EL-38792-25** inductive pickup timing light , or equivalent, at the marks placed on the propeller shaft. When activated, the strobe effect will appear to freeze the marks placed on the rotating propeller shaft. Record which of the numbered marks appears to be at the bottom of the propeller shaft, or the 6 o'clock position. This position identifies the light spot of the propeller shaft.
17. Turn the engine OFF to slow and stop the rotation of the propeller shaft.
18. Install a band-type hose clamp as a weight, with the head of the clamp directly on the light spot.
19. Run the vehicle at the speed which causes the most vibration in the propeller shaft.
20. Using the **EL-38792-25** inductive pickup timing light , or equivalent, observe the positioning of the marks placed on the propeller shaft.
21. If the marks on the propeller shaft now appear to move erratically, compare the current amplitude of the vibration frequency to the original amplitude recorded previously.

    If the amplitude has decreased from the amplitude recorded, the balance achieved may be sufficient and the vehicle should be road tested to determine the effect on the vibration concern.

22. If the clamp head over the original light spot, is now near the top of the propeller shaft, within 180 degrees - near or below the 12 o'clock position - of the original position at the bottom of the propeller shaft - 6 o'clock position - the position of the weight needs adjusting. Perform the following steps:
    1. Move the position of the clamp head toward the 6 o'clock position.
    2. Using the **EL-38792-25** inductive pickup timing light , or equivalent, recheck the positioning of the propeller shaft marks.
    3. If necessary, continue to move the position of the clamp head toward the 6 o'clock position and recheck progress until an improvement in balance is achieved.

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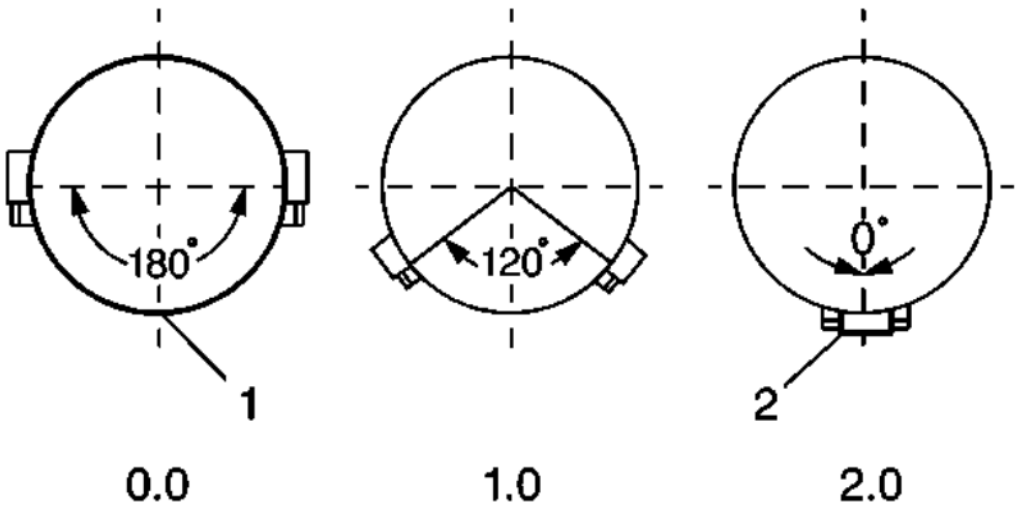



**Fig. 44: Positioning Clamps On Propeller Shaft**
**Courtesy of GENERAL MOTORS COMPANY**

23. If the clamp head over the original light spot, is still positioned at the bottom of the propeller shaft - 6 o'clock position - additional weight is required. Perform the following steps:
    1. Add a second clamp to the propeller shaft, next to the first clamp and with the clamp heads aligned.
    2. Using the **EL-38792-25** inductive pickup timing light , or equivalent, recheck the positioning of the propeller shaft marks.
    3. If the clamp heads over the original light spot, are now 90-180 degrees - at or above the 9 o'clock or the 3 o'clock positions - from the original position at the bottom of the propeller shaft - 6 o'clock position (1) - less total weight is required. Proceed to step 23.4.
    4. Move the position of the clamp heads an equal distance on either side of the light spot between 1 and 120 degrees apart from each other to reduce the total amount of weight in relation to the light spot.
    5. Using the **EL-38792-25** inductive pickup timing light , or equivalent, recheck the positioning of the propeller shaft marks.
    6. If necessary, continue to move the position of the clamp heads an equal distance on either side of the light spot to a maximum of 120 degrees apart from each other, until the greatest improvement to balance is achieved.
    7. If improvement has been made to the balance of the propeller shaft, but the balance is still not satisfactory, still more total weight may be required. Perform the following steps:
        1. Add a third clamp to the propeller shaft, next to the first and second clamps and with the clamp

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head directly (2) on the light spot.

2. Move the position of the first and second clamp heads an equal distance on either side of the light spot between 1 and 120 degrees apart from each other to arrive at a total amount of weight greater than two weights, but less than three weights in relation to the light spot.
3. Using the **EL-38792-25** inductive pickup timing light , or equivalent, recheck the positioning of the propeller shaft marks.
4. If necessary, continue to move the position of the first and second clamp heads an equal distance on either side of the light spot to a maximum of 120 degrees apart from each other, until the greatest improvement to balance is achieved.

8. If a third clamp was used on the propeller shaft and sufficient balance could still not be achieved, the propeller shaft requires replacement.

24. If the clamp head over the original light spot is now 90-180 degrees - at or above the 9 o'clock or the 3 o'clock positions - from the original position at the bottom of the propeller shaft - 6 o'clock position - less total weight is required. Perform the following steps:
    1. Add a second clamp to the propeller shaft, next to the first clamp and with the clamp heads aligned.
    2. Move the position of the clamp heads an equal distance on either side of the light spot between 120 and 180 degrees apart from each other to reduce the total amount of weight in relation to the light spot.
    3. Using the **EL-38792-25** inductive pickup timing light , or equivalent, recheck the positioning of the propeller shaft marks.
    4. If necessary, continue to move the position of the clamp heads an equal distance on either side of the light spot to a maximum of 180 degrees apart from each other, but not less than 120 degrees apart, until the greatest improvement to balance is achieved.
25. If the marks on the propeller shaft now appear to move erratically, compare the current amplitude of the vibration frequency to the original amplitude recorded previously.

    If the amplitude has decreased from the amplitude recorded, the balance achieved may be sufficient and the vehicle should be road tested to determine the effect on the vibration concern.

**Adjustment Procedure Without Oscilloscope or EVA**

**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.**

1. Raise and support the vehicle; ensure that the drive axle, or axles are supported at ride height - vehicle body supported by suspension components.
2. With the tire and wheel assemblies, and the brake rotors and/or brake drums removed from the drive axle or axles, start the engine and turn OFF all engine accessories.
3. Place the transmission in forward gear.
4. Run the vehicle at the speed which causes the most vibration in the propeller shaft; observe which end of the propeller shaft exhibits the greatest amount of vibration disturbance.
5. Carefully hold a piece of chalk up to the end of the propeller shaft in order to just make contact as the shaft rotates.
6. Turn the engine OFF to slow and stop the rotation of the propeller shaft.
7. Observe the location of the chalk mark on the propeller shaft.
    - If the chalk mark circles the entire propeller shaft after the first attempt, remove the mark from the shaft and repeat steps 2 through 7; touch the chalk more gently to the propeller shaft.
    - If the chalk mark circles the entire propeller shaft after the second attempt, runout of the propeller shaft may not be the cause of the disturbance. Proceed to step 16.

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- If the chalk mark is only on a small portion of the propeller shaft, the mark identifies the heavy spot of the propeller shaft. The heavy spot of the propeller shaft will deflect downward during rotation. Place a small mark on the shaft 180 degrees, directly opposite the heavy spot, and identify the mark as the light spot. Proceed to step 8.

8. Install a band-type hose clamp to the propeller shaft as a weight, with the head of the clamp directly on the light spot, or 180 degrees, directly opposite the heavy spot.
9. Observe the amount of disturbance to the propeller shaft.
    - If the amount of disturbance to the propeller shaft appears to be significantly reduced, the balance achieved may be sufficient and the vehicle should be road tested to determine the effect on the vibration concern. The head of the clamp can be moved very slightly, if necessary to refine the balance achieved.
    - If the amount of disturbance to the propeller shaft appears to be almost unchanged or even increased, proceed to step 10.
10. Add a second clamp to the propeller shaft, next to the first clamp and with the clamp heads aligned.
11. Observe the amount of disturbance to the propeller shaft.
    - If the amount of disturbance to the propeller shaft appears to be significantly reduced, the balance achieved may be sufficient and the vehicle should be road tested to determine the effect on the vibration concern. The head of the clamps can be moved very slightly an equal distance apart on either side of the light spot, or moved slightly while still aligned, if necessary to refine the balance achieved.
    - If the amount of disturbance to the propeller shaft appears to be almost unchanged or even increased, proceed to step 12.
12. Move the position of the clamp heads an equal distance on either side of the light spot between 1 and 120 degrees apart from each other to reduce the total amount of weight in relation to the light spot.
13. Observe the amount of disturbance to the propeller shaft.
    - If the amount of disturbance to the propeller shaft appears to be significantly reduced, the balance achieved may be sufficient and the vehicle should be road tested to determine the effect on the vibration concern. If necessary, continue to move the position of the clamp heads an equal distance on either side of the light spot to a maximum of 120 degrees apart from each other, until the greatest amount of reduction in the vibration disturbance is achieved.
    - If the amount of disturbance to the propeller shaft appears to be almost unchanged or even increased, proceed to step 14.
14. Add a third clamp to the propeller shaft, next to the first and second clamps and with the head of the clamp directly on the light spot.
15. Observe the amount of disturbance to the propeller shaft.
    - If the amount of disturbance to the propeller shaft appears to be significantly reduced, the balance achieved may be sufficient and the vehicle should be road tested to determine the effect on the vibration concern. If necessary, continue to move the position of the first and second clamp heads an equal distance on either side of the light spot to a maximum of 120 degrees apart from each other, until the greatest amount of reduction in the vibration disturbance is achieved.
    - If the amount of disturbance to the propeller shaft appears to be almost unchanged or even increased after a third clamp was used on the propeller shaft, the propeller shaft likely requires replacement.
16. If the heavy spot of the propeller shaft could not be identified, install a band-type hose clamp to the propeller shaft as a weight, with the head of the clamp directly in-line with an existing factory-installed weight.
17. Observe the amount of disturbance to the propeller shaft.
    - If the amount of disturbance to the propeller shaft appears to be significantly reduced, the balance achieved may be sufficient and the vehicle should be road tested to determine the effect on the vibration concern. The head of the clamp can be moved very slightly, if necessary to refine the balance achieved.
    - If the amount of disturbance to the propeller shaft appears to be almost unchanged or even increased, proceed to step 18.

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18. Move the head of the clamp 180 degrees, directly opposite the factory-installed weight.
19. Observe the amount of disturbance to the propeller shaft.
    - If the amount of disturbance to the propeller shaft appears to be significantly reduced, the balance achieved may be sufficient and the vehicle should be road tested to determine the effect on the vibration concern. The head of the clamp can be moved very slightly, if necessary to refine the balance achieved.
    - If the amount of disturbance to the propeller shaft appears to be almost unchanged or even increased, the propeller shaft may require replacement.

## DRIVELINE WORKING ANGLES ADJUSTMENT

**NOTE:** **This procedure is intended to be used for vehicles where the following conditions are met:**

- **Vehicle trim heights are within specification guidelines.**
- **The vehicle exhibits no signs of aftermarket modifications that may affect driveline working angles.**
- **The vehicle exhibits no signs of accident damage which may affect the position of the drive axle, or axles, the propeller shaft support bearing, if equipped, or the transmission or transfer case, if equipped.**

Drive axle wind-up may cause a launch shudder condition even when all of the driveline working angles are within specifications. Drive axle wind-up occurs when heavy torque during acceleration causes the pinion nose to pivot upward. Excessively worn or damaged axle mounting components and/or overloading or unevenly loading the vehicle may contribute to a launch shudder condition.

1. For solid axles equipped with a leaf spring suspension, inspect the leaf springs, mount bushings, and mounting hardware for excessive wear or damage.
2. For solid axles equipped with a non-leaf spring suspension, inspect the suspension links and link mounts and/or bushings for excessive wear or damage.
3. For direct-mount axles, inspect any axle mount brackets for damage and inspect the axle mounts and/or bushings for excessive wear or damage.
4. Inspect the structure to which the suspension attaches to ensure no deformities or damage exists.
5. Inspect the propeller shaft support bearing assembly for damaged rubber components, worn bearings, and/or a deformed/cracked bracket.
6. Inspect the propeller shaft support bearing assembly and mounting bracket, if equipped, for loose or missing shims. Reinstall correctly or replace any shims as necessary to ensure proper alignment of the support bearing assembly.
7. Inspect the structure to which the support bearing assembly attaches to ensure no deformities or damage exists.
8. Inspect any transmission or transfer case mount bracket or brackets for damage and inspect the mount or mounts for excessive wear, damage, and/or deformities.
9. Inspect the structure to which the transmission or transfer case attaches to ensure no deformities or damage exists.
10. Repair or replace parts as indicated by the inspections.
11. If excessively worn or damaged parts were repaired or replaced, re-measure the driveline working angles and road test the vehicle to ensure proper operation of the driveline system.

## PROPELLER SHAFT PHASING CORRECTION

### One Piece Propeller Shaft Phasing Correction

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An out of phase single-piece propeller shaft is very unusual. If the phasing inspection procedure revealed that prop shaft is not phased correctly, the welded yokes are in the wrong position, or the shaft is damaged due to twisting and the propeller shaft requires replacement to restore proper cancellation of the U-joints.

#### Multiple-Piece Propeller Shaft Phasing Correction

1. If the phasing inspection procedure revealed that a prop shaft is not phased correctly to the mating slip yoke, the end yoke is welded on in the wrong position, the slip yoke is mis-aligned to the stub shaft, or the shaft is damaged due to twisting.
2. If the shaft if visibly damaged, it requires replacement.
3. If the shaft exhibits no visual physical defects or damage, perform the following:
    1. Remove the slip yoke from the stub shaft to determine if it is possible to reinstall the slip yoke in a different position on the stub shaft.
    2. If the stub shaft is keyed to ensure proper alignment of the stub shaft and the slip yoke, then the propeller shafts require replacement to restore proper cancellation of the U-joints.
    3. If the stub shaft is not keyed, attempt to re-align the front shaft and slip yoke to each other. Repeat the inspection procedure to confirm the results.
    4. If proper phasing cannot be obtained, the propeller shaft requires replacement to restore proper cancellation of the U-joints.

# 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 are 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

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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

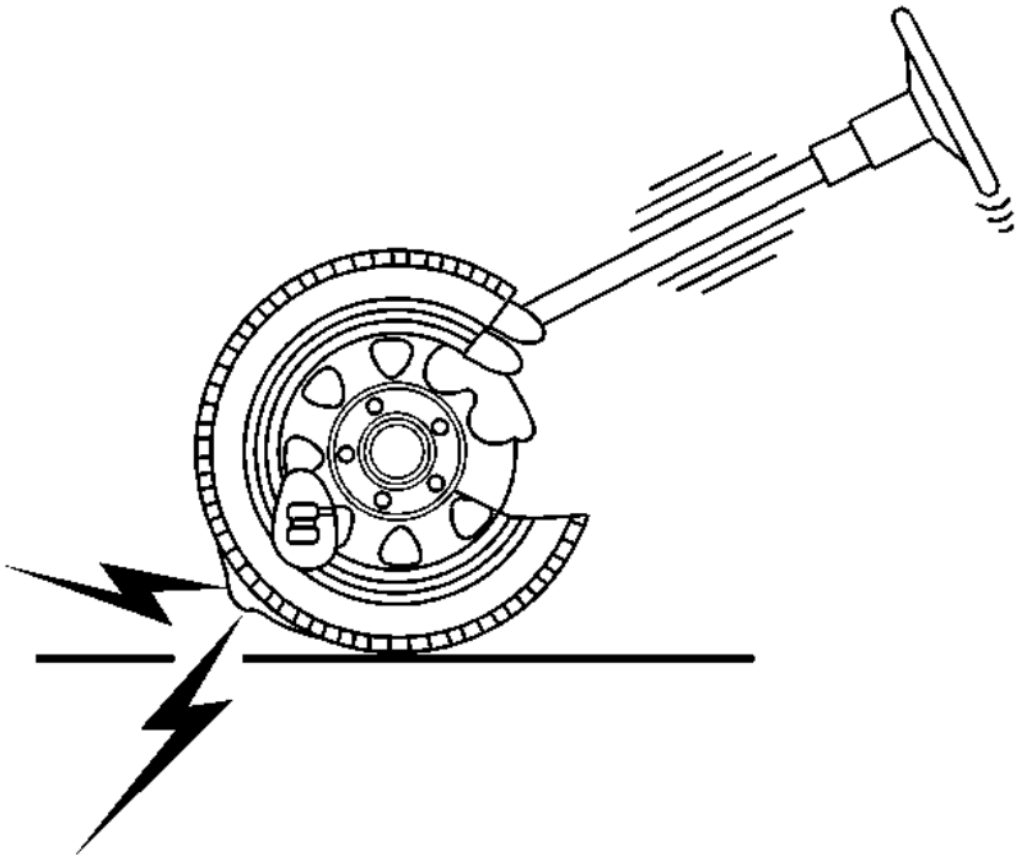


**Fig. 45: Identifying Unbalanced Tire Vibration**
**Courtesy of GENERAL MOTORS COMPANY**

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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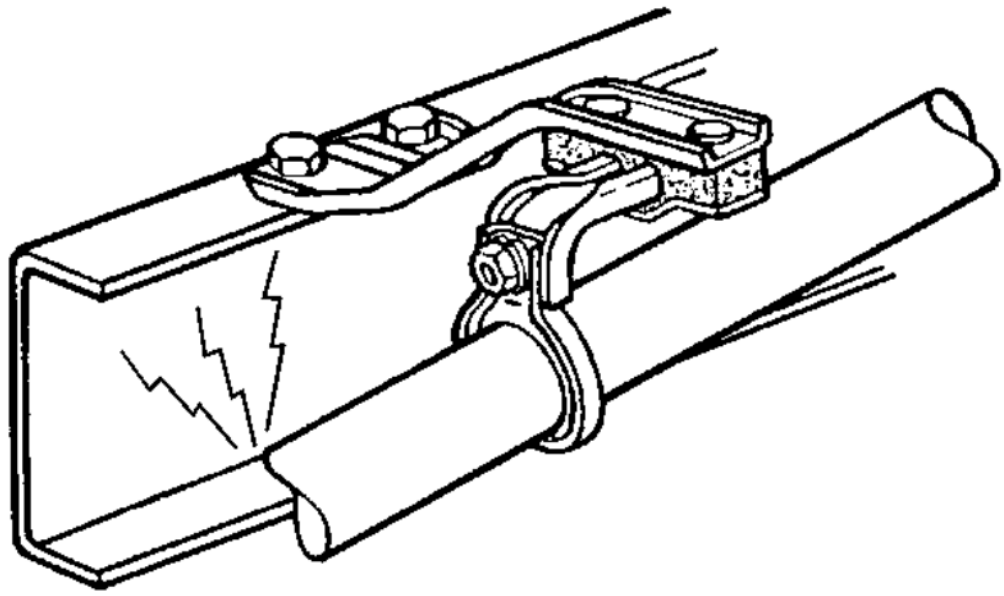


**Fig. 46: Identifying Exhaust Pipe Noise**
**Courtesy of GENERAL MOTORS COMPANY**

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

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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:

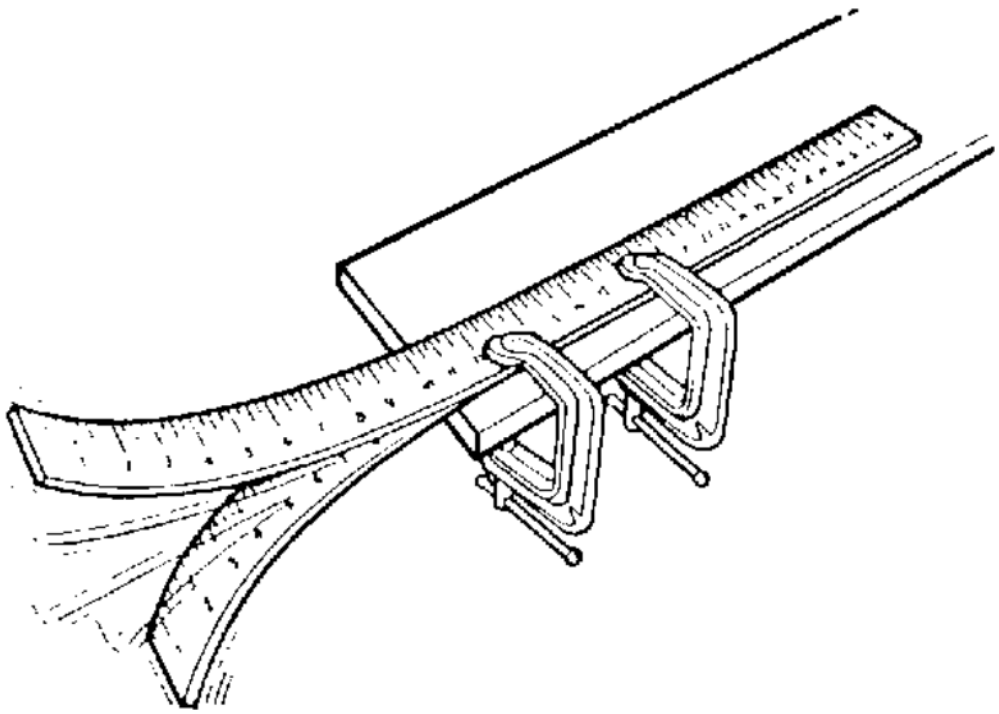


**Fig. 47: Demonstrating Vibration Theory**
**Courtesy of GENERAL MOTORS COMPANY**

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).

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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**

**NO TITLE**

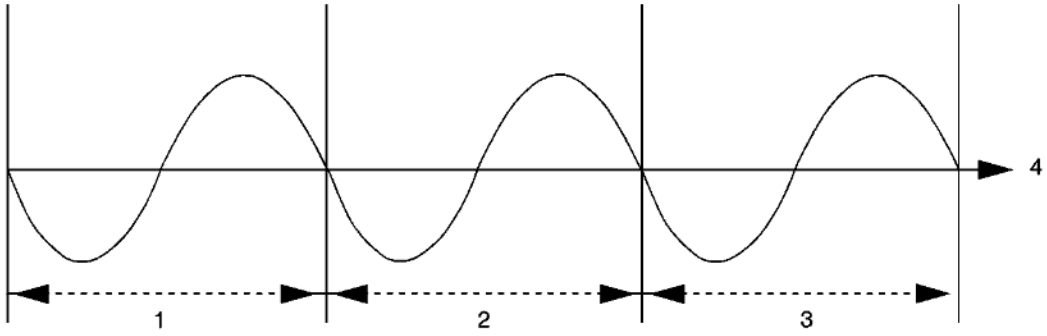



**Fig. 48: Identifying Powertrain Vibration Cycles**
**Courtesy of GENERAL MOTORS COMPANY**

| Callout | Component Name |
|---|---|
| 1 | 1st Cycle |
| 2 | 2nd Cycle |
| 3 | 3rd Cycle |
| 4 | Time |

**Vibration Cycles in Powertrain Components**

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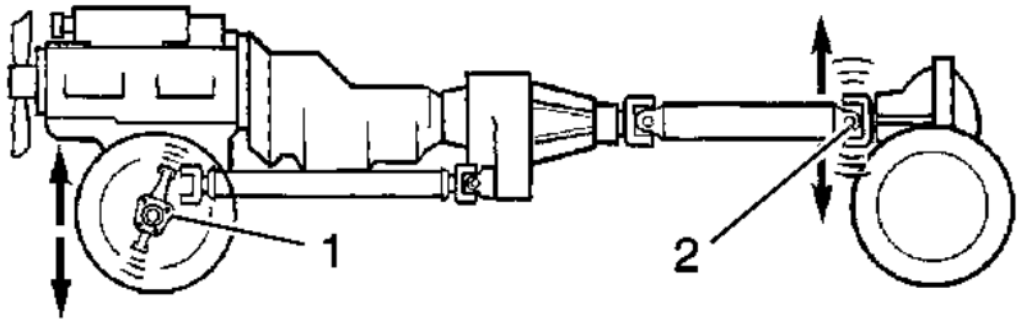



**Fig. 49: Identifying Vibration Cycles In Powertrain Components**
**Courtesy of GENERAL MOTORS COMPANY**

| Callout | Component Name |
|---|---|
| 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**

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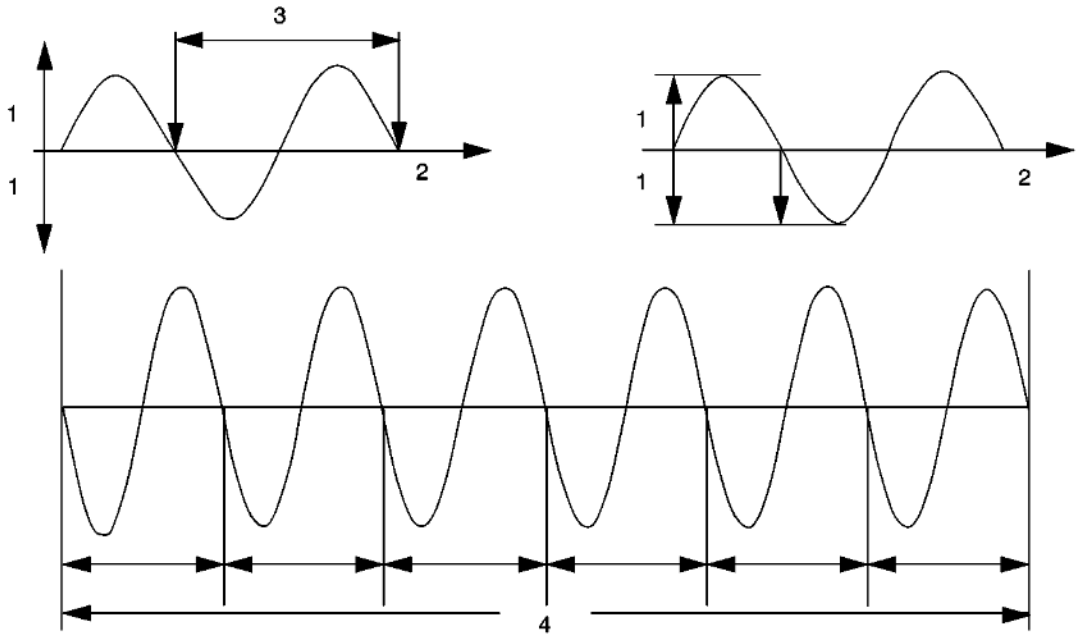



**Fig. 50: Identifying Vibration Frequency**
**Courtesy of GENERAL MOTORS COMPANY**

| Callout | Component Name |
|---|---|
| 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**

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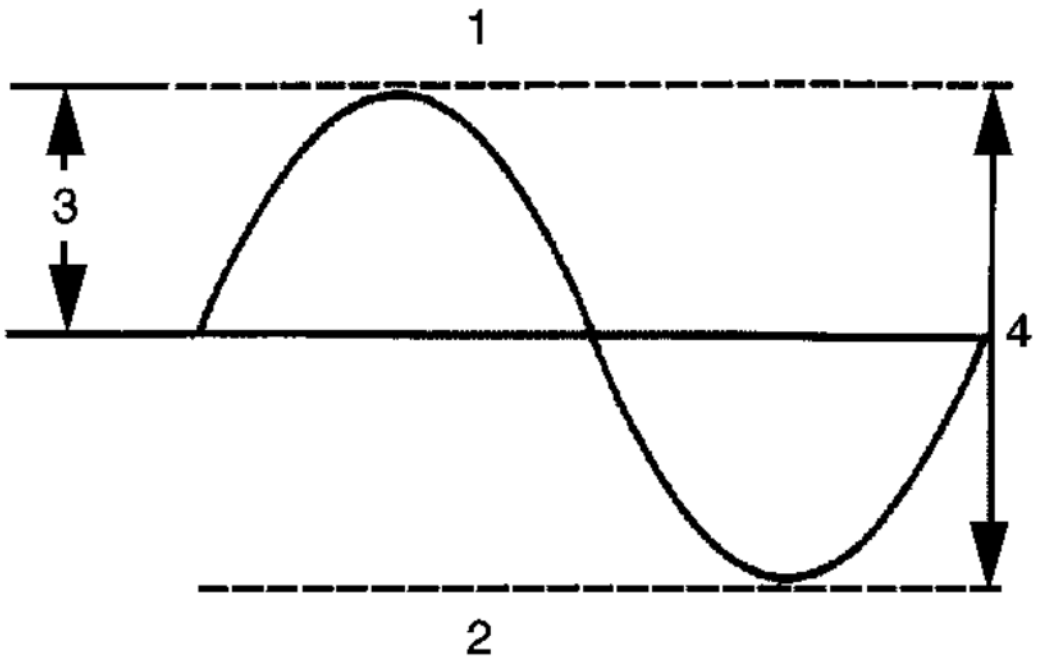



**Fig. 51: Identifying Vibration Amplitude**
**Courtesy of GENERAL MOTORS COMPANY**

| Callout | Component Name |
|---|---|
| 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

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

### Centrifugal Force Due to an Imbalance

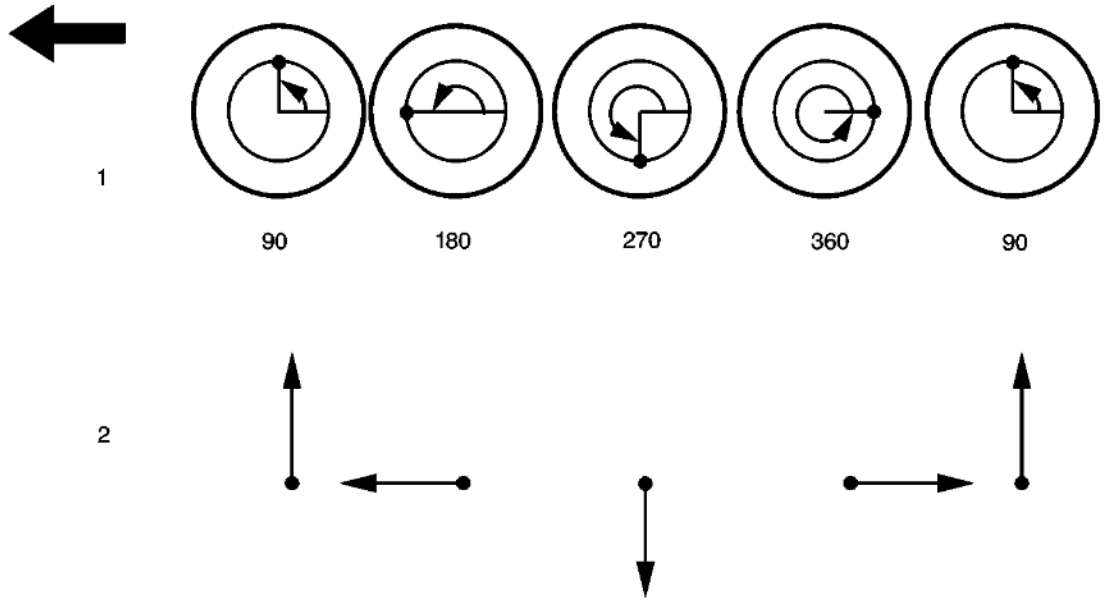



**Fig. 52: Identifying Centrifugal Force Components**
**Courtesy of GENERAL MOTORS COMPANY**

| Callout | Component Name |
|---|---|
| 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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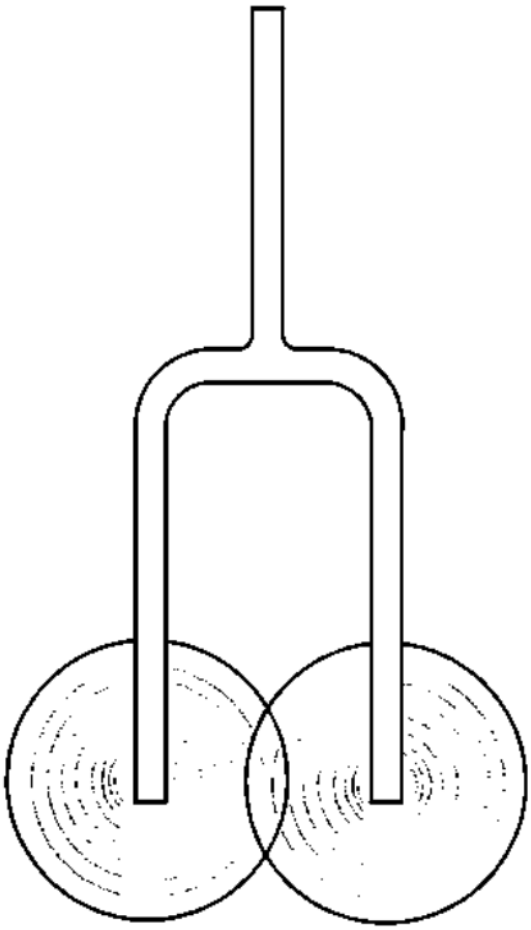


**Fig. 53: View Of Natural Frequency**
**Courtesy of GENERAL MOTORS COMPANY**

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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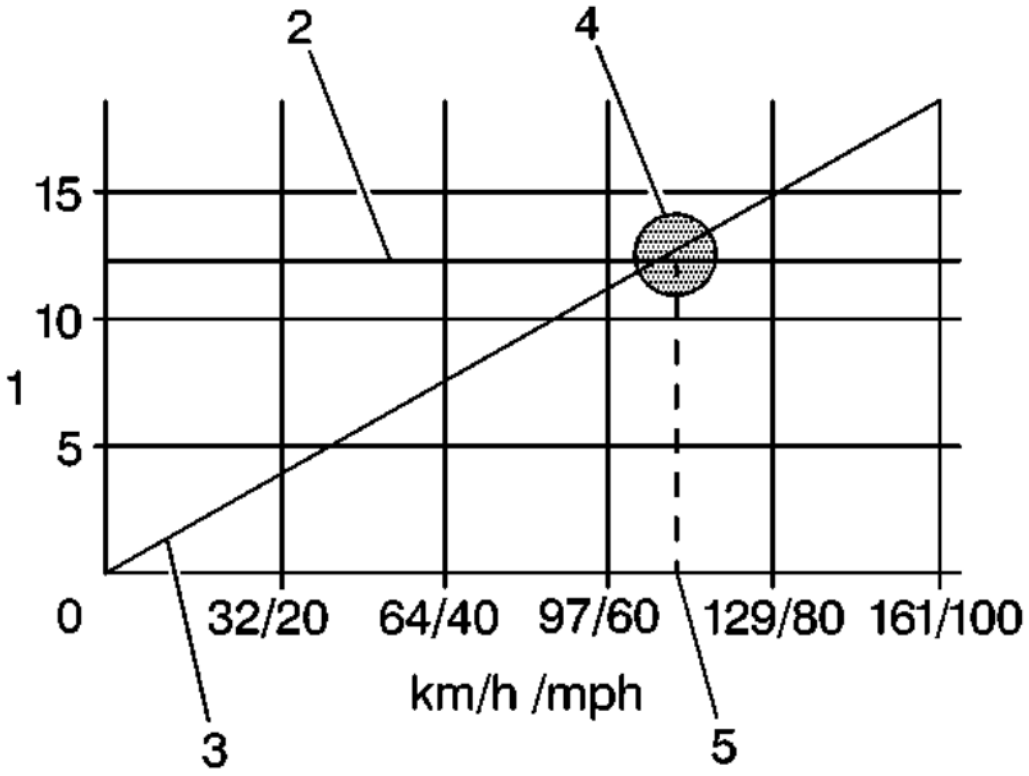



**Fig. 54: Natural Frequency Of A Typical Automotive Front Suspension**
**Courtesy of GENERAL MOTORS COMPANY**

| Callout | Component Name |
|---|---|
| 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**

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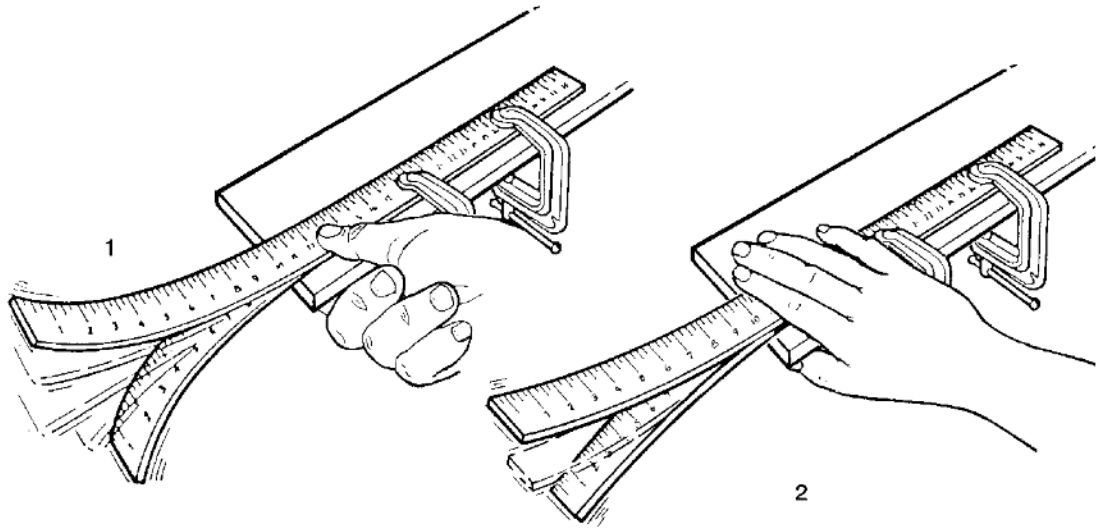



**Fig. 55: Identifying Low & High Damping**
**Courtesy of GENERAL MOTORS COMPANY**

| Callout | Component Name |
|---|---|
| 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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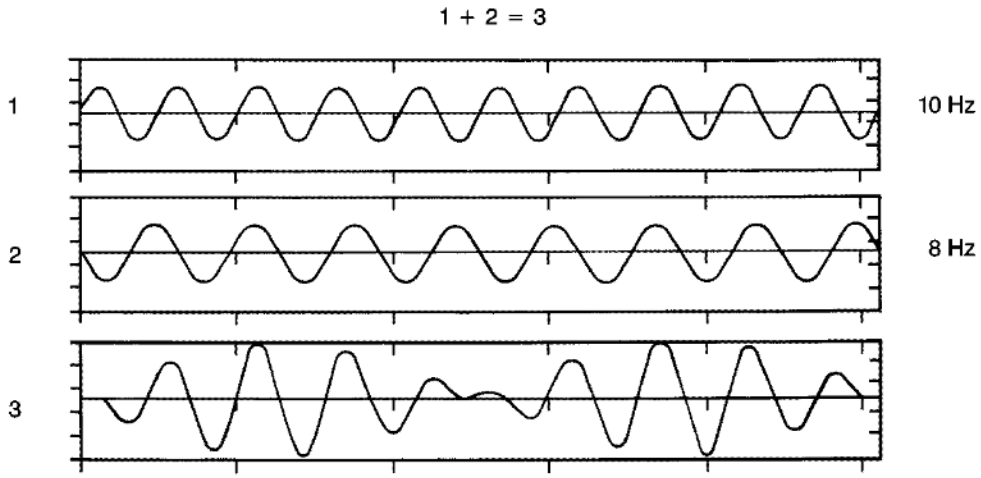



**Fig. 56: Identifying Beating Or Phasing**
**Courtesy of GENERAL MOTORS COMPANY**

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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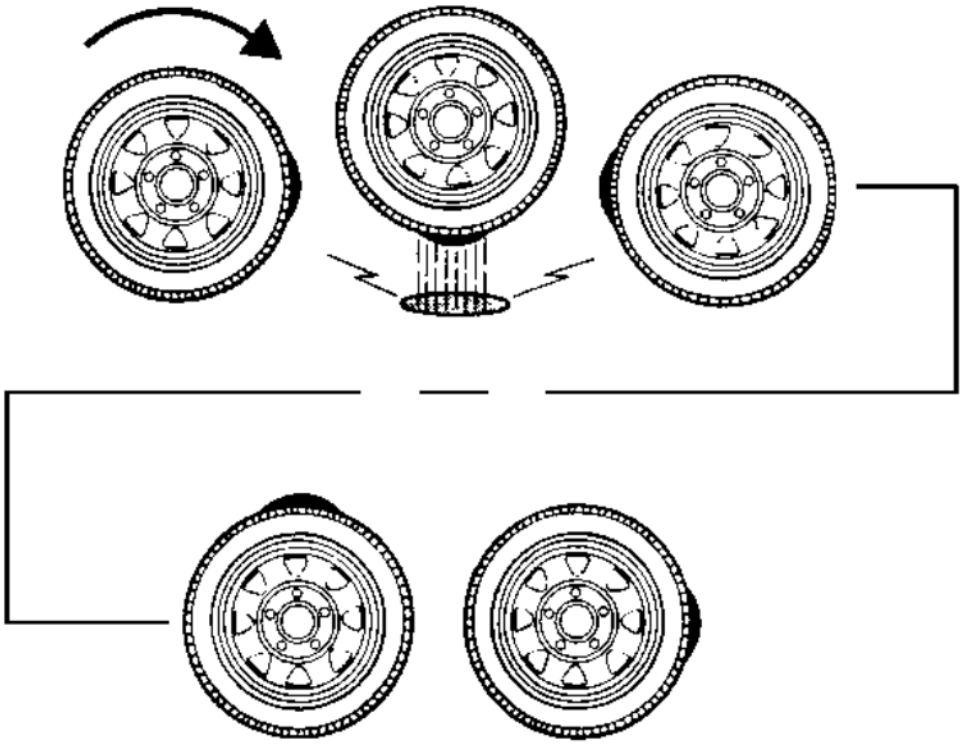


**Fig. 57: Identifying First-Order Vibration**
**Courtesy of GENERAL MOTORS COMPANY**

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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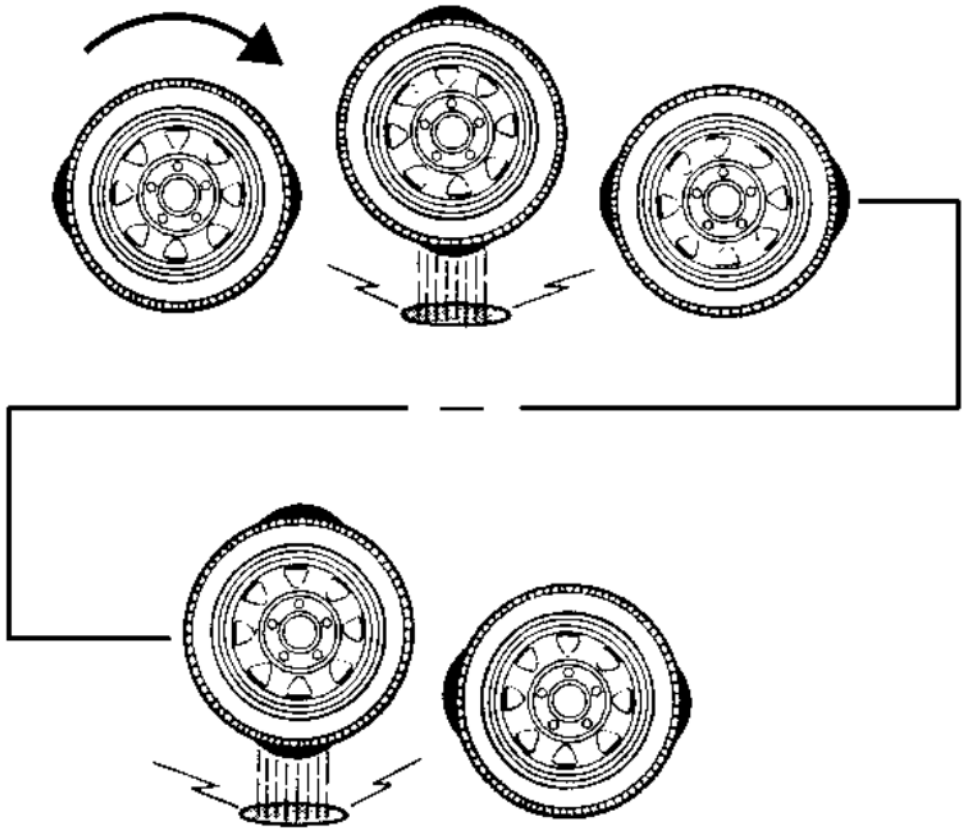


**Fig. 58: Identifying Second-Order Vibration**
**Courtesy of GENERAL MOTORS COMPANY**

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**.

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.

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### 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

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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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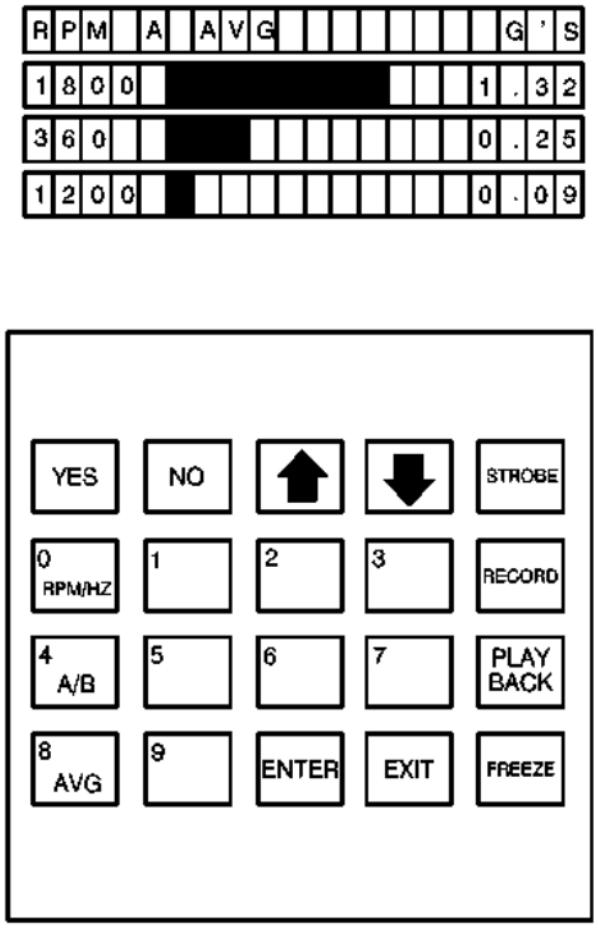



**Fig. 59: View Of EVA Display**
**Courtesy of GENERAL MOTORS COMPANY**

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-

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acceleration force.

## OSCILLOSCOPE DIAGNOSTIC KIT DESCRIPTION AND OPERATION

### Special Tools

- **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH)
- **EL-47966** Multi Diagnostic Interface MDI

For equivalent regional tools, refer to **Special Tools and Equipment**.

The **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) is an automotive oscilloscope which receives input from an attached accelerometer and displays all input frequencies on a laptop or tablet computer. The vibration concern frequency(ies) are obtained through the use of the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) hardware, while vehicle component speed data is gathered through the **EL-47966** Multi Diagnostic Interface MDI. The MDI data is integrated into the Oscilloscope software so that vibration(s) can be tied to specific vehicle components based on their speed to determine the source of the vibration concern.

#### Oscilloscope Inputs

The **CH-51450-TA183** accelerometer incorporates a 3 m (9.8 ft) cord that allows the sensor to be placed on virtually any component of the vehicle where a vibration concern is felt. The accelerometer uses a self-powered NVH interface module. The NVH interface module uses a replaceable battery. Input B is the default port for a single accelerometer. The cord used to connect the NVH interface module to the **CH-51450-NVH** Oscilloscope is 5 m (16.4 ft) long.

Input D is used for the **CH-51450-TA186** optical tachometer sensor which is used during driveline balancing. It incorporates a 2.5 m (8.2 ft) cord and a 5 m (16.4 ft) cord.

There is also an optional microphone that can be used with the **CH-51450-NVH** Oscilloscope.

### Oscilloscope Accelerometer Placement

Proper placement of the **CH-51450-TA183** accelerometer is critical to ensure that proper vibration readings are obtained by the **CH-51450-NVH** Oscilloscope. The accelerometer should be placed on the drivers side inboard seat track. Once a baseline reading has been taken, the accelerometer can be placed on the point of the customer concern to verify what the customer is hearing or feeling.

### Oscilloscope Accelerometer-to-Component Attachment

**NOTE:** **The CH-51450-TA183 accelerometer must be attached to vehicle components in the manner indicated in order to achieve accurate frequency readings of the vibration disturbance.**

The accelerometer of the **CH-51450-NVH** Oscilloscope is designed to pick up disturbances which primarily occur in the vertical plane, since most vibrations are felt in that same up-and-down direction. The **CH-51450-TA183** accelerometer is therefore directionally sensitive, and must be attached to vehicle components such that the cord end 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 **CH-51450-TA183** accelerometer 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 the **CH-51450-TA096** magnet supplied with the sensor. For hard aluminum surfaces, a ferrous washer can be glued on using a cyanoacrylate (super glue) and then the magnet can be used.

#### NVH Software Set-up

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**Fig. 60: Identifying NVH Software Set-Up Display Screen**
**Courtesy of GENERAL MOTORS COMPANY**

When the NVH software is first opened and the NVH tab is selected, there is a set-up wizard within the **CH-51450-NVH** NVH software which has a step-by-step guide to ensure the **CH-51450-NVH** Oscilloscope and MDI are connected correctly, and to input the vehicle information.

### Oscilloscope NVH Display

The **CH-51450-NVH** Oscilloscope display consists of three tabs:

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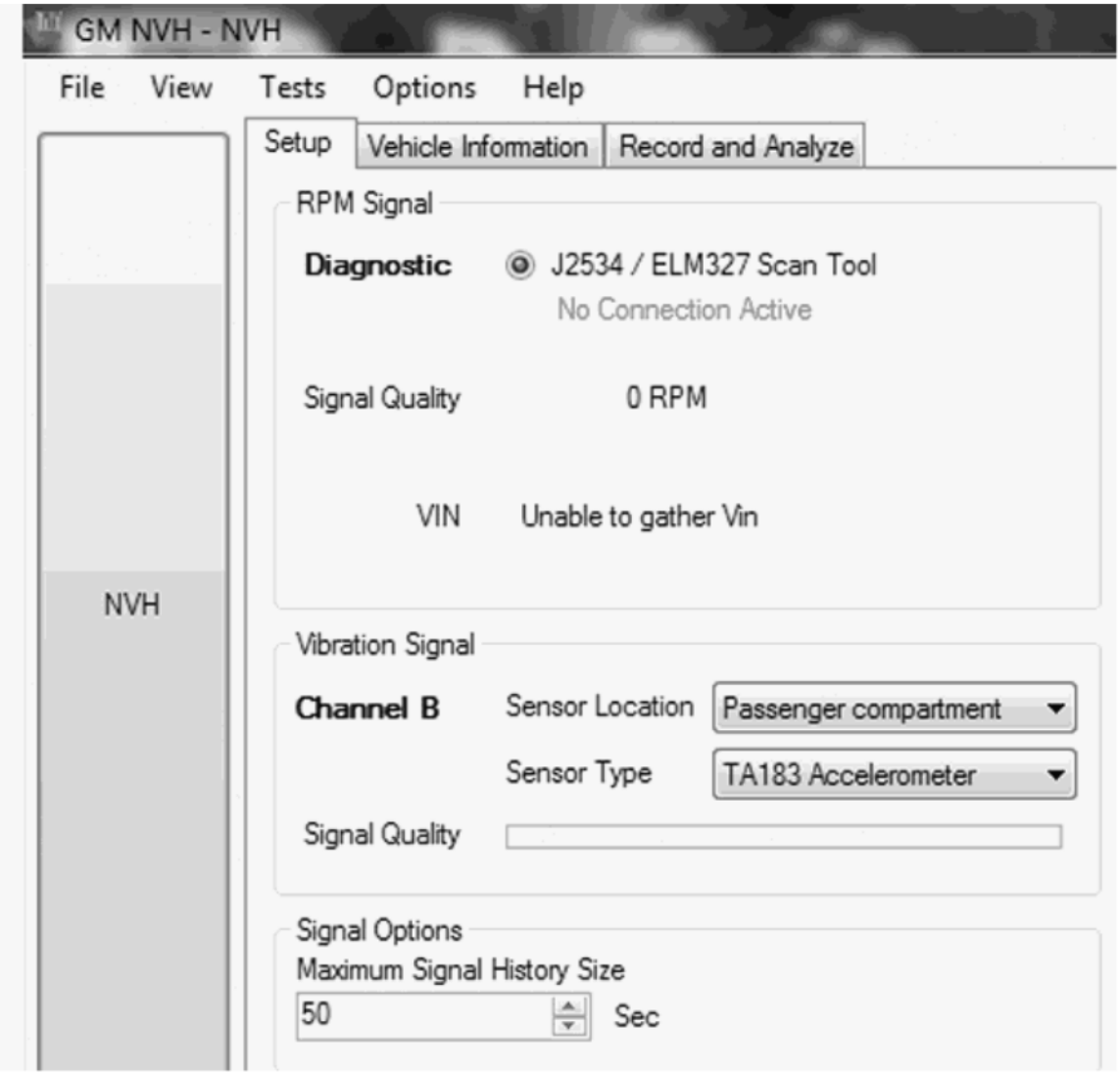



**Fig. 61: Identifying Oscilloscope NVH Set-Up Display Screen**
**Courtesy of GENERAL MOTORS COMPANY**

The first tab is set-up. The set-up information can be entered here if not already done through the set-up wizard. It can also be updated here, if necessary. A laptop or desktop computer, **EL-47966** Multi Diagnostic Interface MDI , **CH-51450-NVH** Oscilloscope , **CH-51450-TA148** NVH interface, and **CH-51450-TA183** accelerometer are needed to do a vibration analysis.

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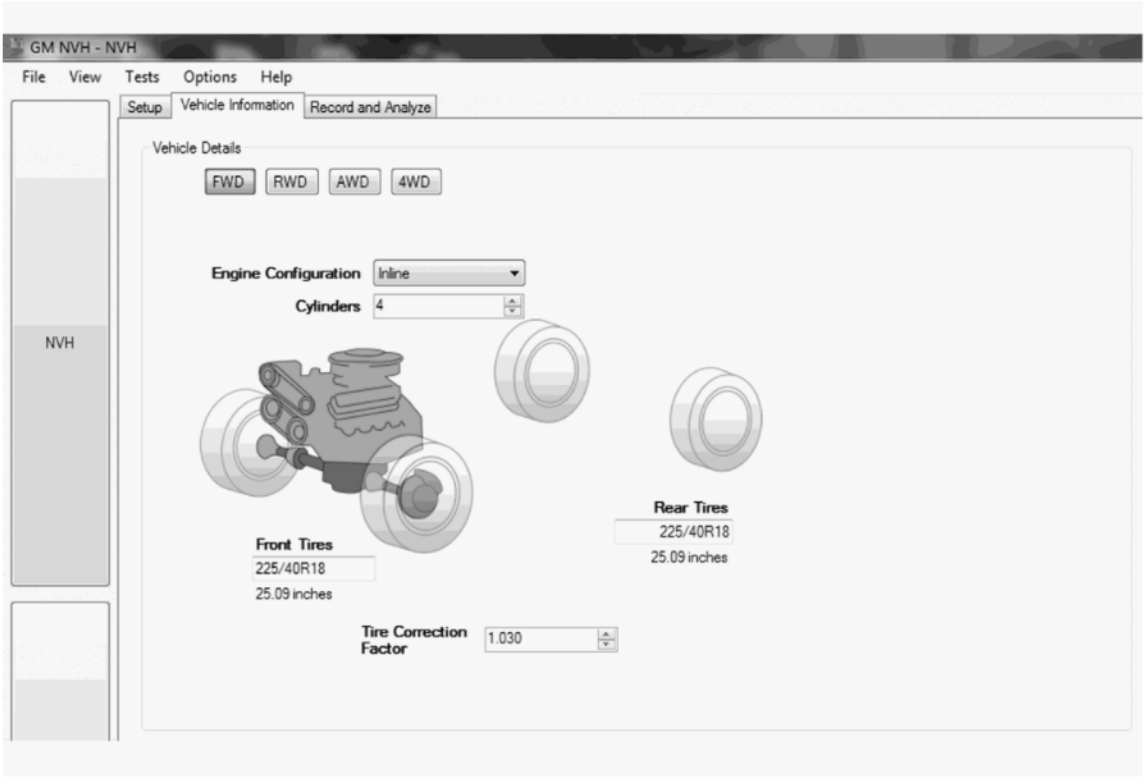



**Fig. 62: Identifying Oscilloscope NVH Vehicle Information Display Screen**
**Courtesy of GENERAL MOTORS COMPANY**

The second tab is vehicle information. The vehicle information can be entered here if not already done through the set-up wizard. It can also be updated here, if necessary.

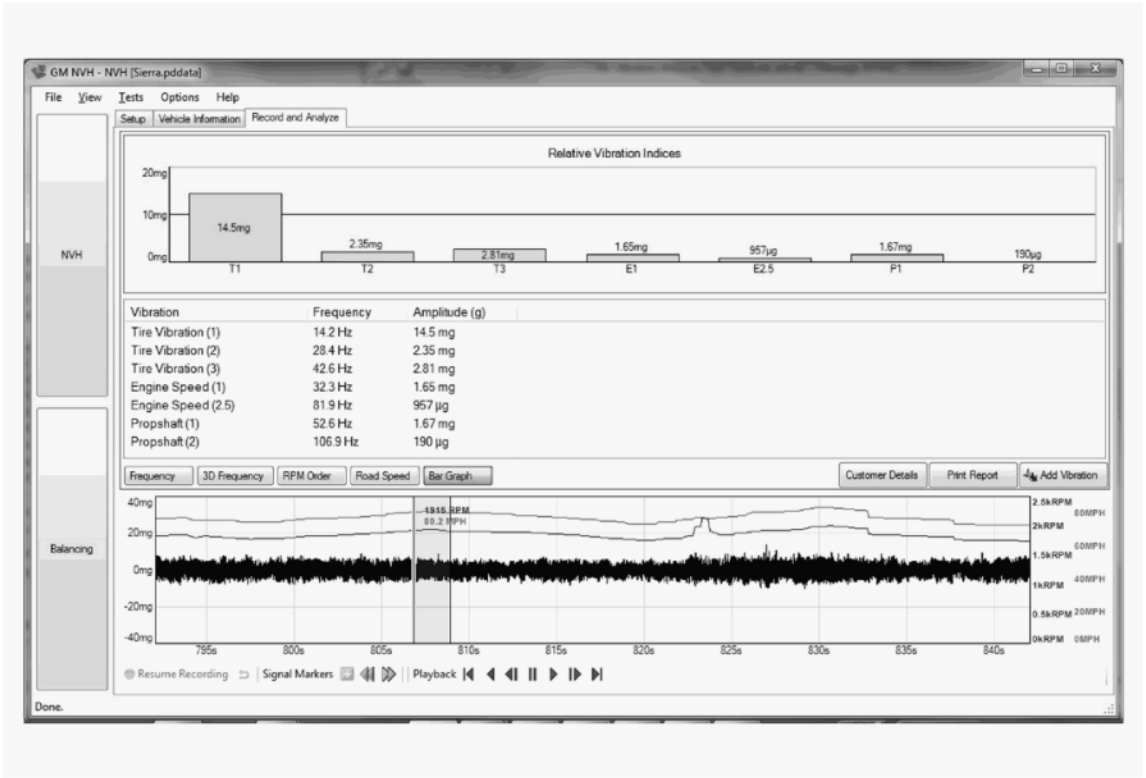



**Fig. 63: Identifying Oscilloscope NVH Record And Analyze Display Screen**
**Courtesy of GENERAL MOTORS COMPANY**

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The third tab is the record and analyze tab. The standard display will show the known input frequencies received from the **CH-51450-TA183** accelerometer as a bar graph at the top of the screen. At the middle of the screen, the input frequencies are listed as text. The frequency(ies) are displayed in Hertz (Hz). If desired, the frequency(ies) can be displayed in RPM by clicking Options, then Advanced Options. The actual amplitude strength of each frequency is displayed and shown in g's of acceleration (expressed to the thousandth of a force of gravity, or "milli-g"). At the bottom of the screen, it also shows a plot of all frequency inputs along with engine speed in blue, and vehicle speed in red. The data can be saved in 50 second increments. The data can then be saved by clicking File, then Save. Files that are saved can then be loaded into the software by clicking File, then Load.

### Oscilloscope Balancing

The **CH-51450-NVH** Oscilloscope with balancing software can be used to identify some rotating component/systems which exhibit imbalance IF the component rotational speed is the dominant frequency of the vibration concern. The **CH-51450-NVH** Oscilloscope is used with the **CH-51450-TA186** optical tachometer sensor. The optical tachometer sensor directly measures component rotational speed so a known weight can be added for a baseline reading. Then the oscilloscope will determine where to add a specific amount of weight to the component.

For example, the **CH-51450-NVH** Oscilloscope can be used to balance the driveline on rear wheel drive and all wheel drive vehicles. The methods that can be employed are a tuned weight approach for drivelines that use couplers and a dual hose clamp approach for drivelines that use CV or two-axis universal joints. The balancing process consists of the **CH-51450-TA186** optical tachometer sensor to directly read the driveline speed and software that directs where the weights should be placed depending on the type of driveline/propeller shaft being balanced.

### Oscilloscope Balancing Software Set-up

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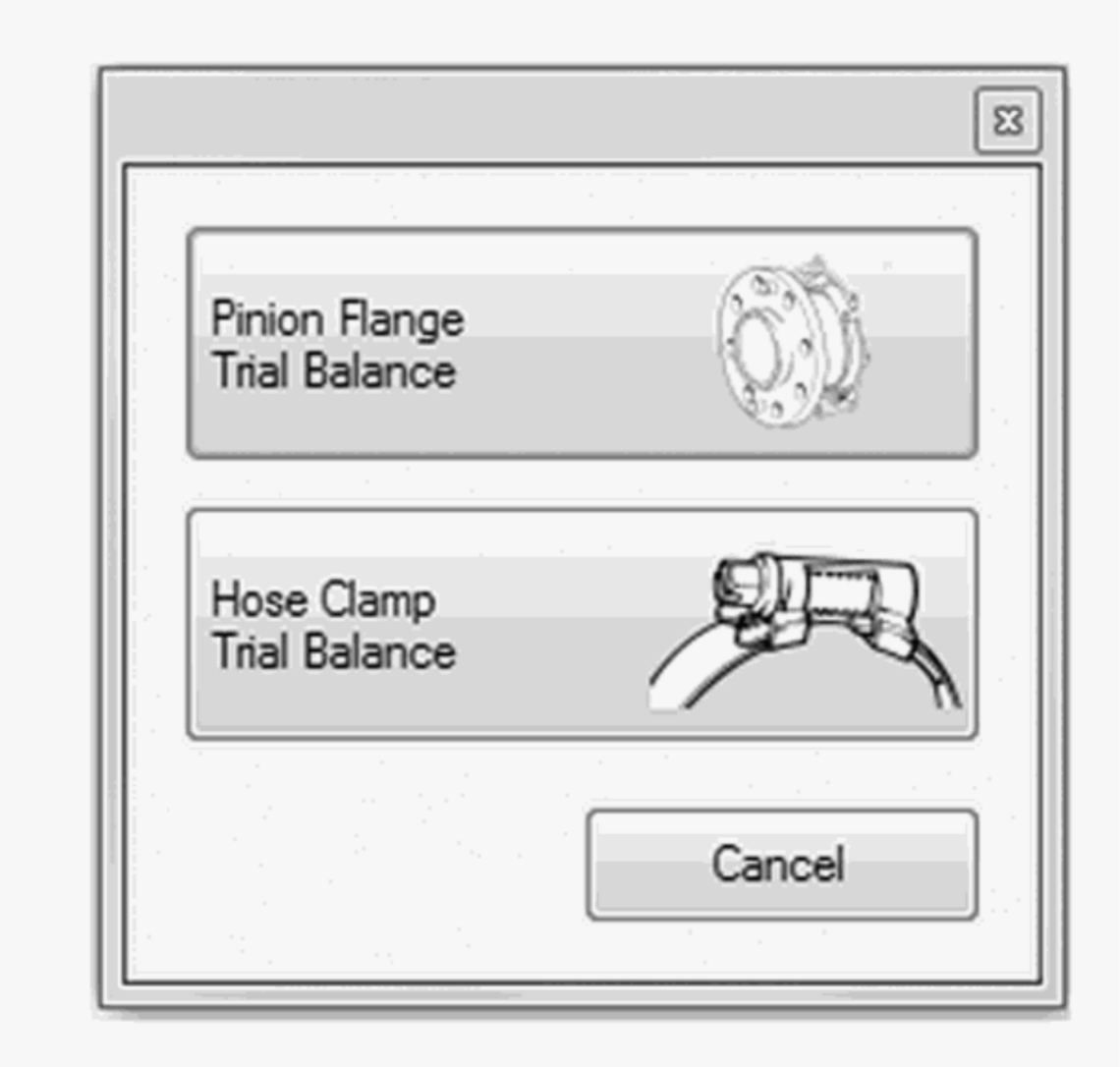



**Fig. 64: Identifying Oscilloscope Balancing Software Set-Up Display Screen**
**Courtesy of GENERAL MOTORS COMPANY**

When the NVH software is first opened and the Balancing tab is selected, a pop-up box within the **CH-51450-NVH** balancing software will ask which type of balancing method is to be used. The two methods are pinion flange or hose clamp. Then either the wizard (which will walk through the connections and input data) or advanced configuration can be chosen to input the initial information and start the balancing procedure.

### Oscilloscope Balancing Display

The propeller shaft balancing will consist of an initial run, three calibration runs, and a verification run. The software will walk through what is required for each run.

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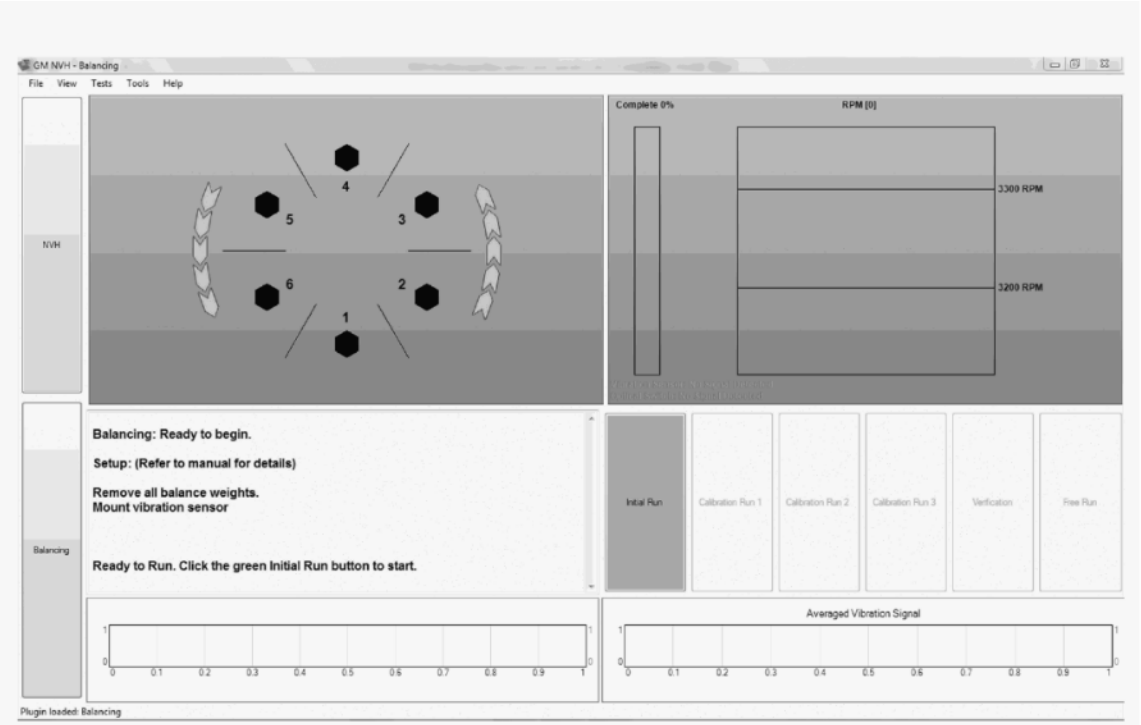



**Fig. 65: Identifying Pinion Flange Balancing Screen**
**Courtesy of GENERAL MOTORS COMPANY**

An example of the pinion flange balancing screen is shown above.

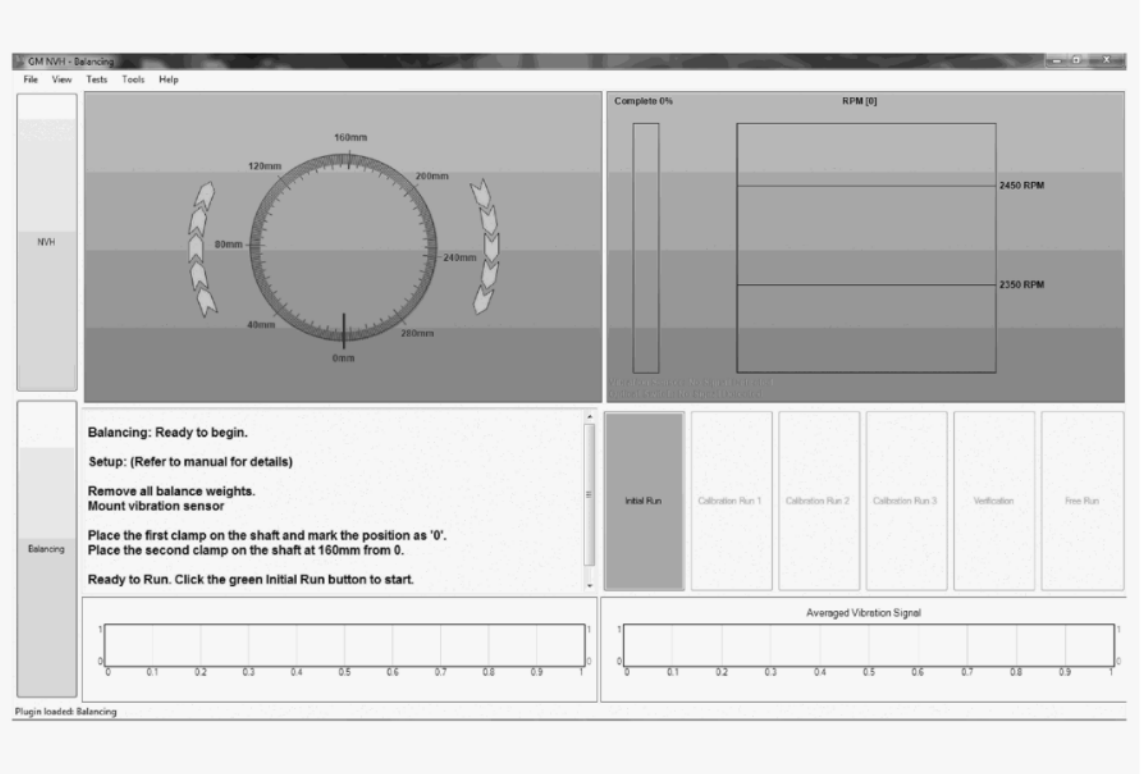



**Fig. 66: Identifying Hose Clamp Balancing Screen**
**Courtesy of GENERAL MOTORS COMPANY**

An example of the hose clamp balancing screen is shown above.

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## 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.

The **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) includes a version of the vibrate software within its help file.

## REED TACHOMETER DESCRIPTION

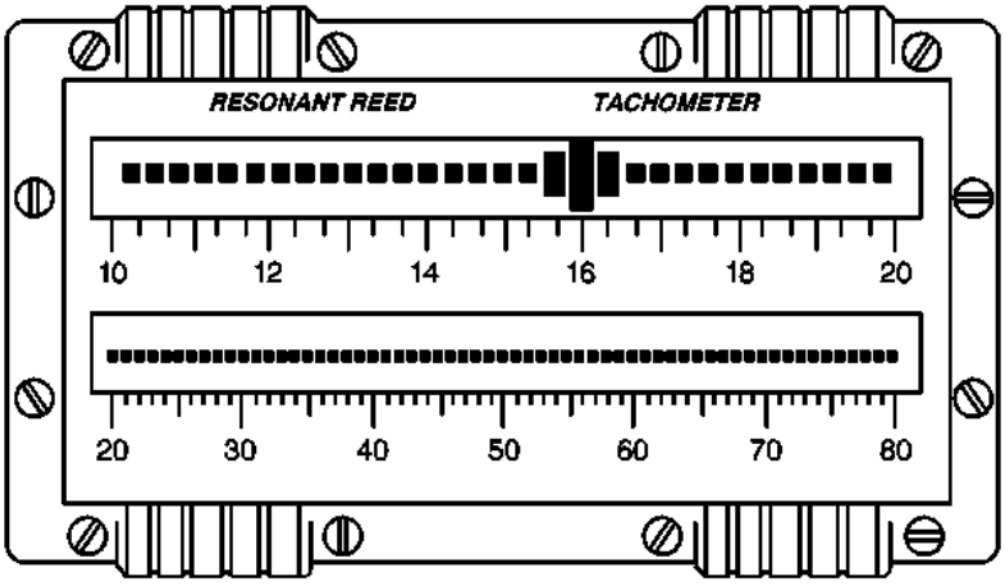



**Fig. 67: Identifying Reed Tachometer**
**Courtesy of GENERAL MOTORS COMPANY**

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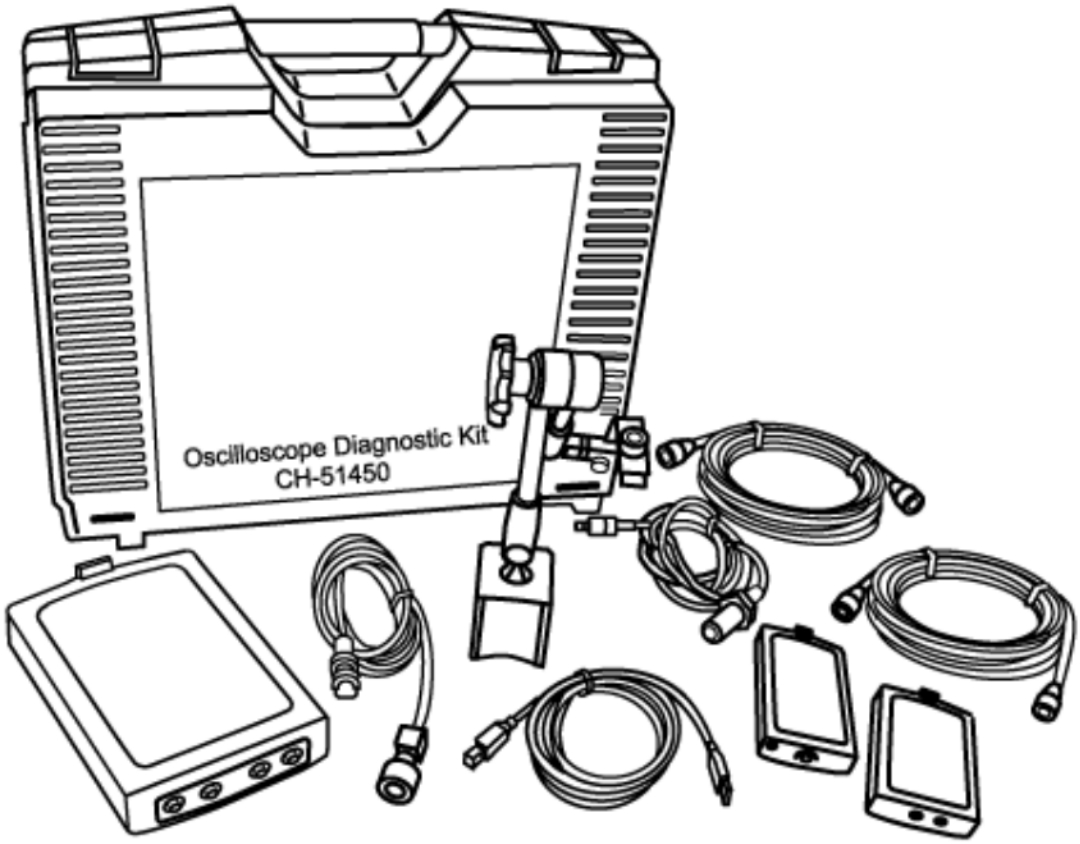
The reed tachometer consists of 2 rows of reeds arranged side-by-side. Each reed is tuned to vibrate or resonate when it is excited by a specific frequency. The reeds are arranged by their specific resonant frequency, increasing from left to right, ranging from 10-80 Hz. This arrangement allows for a 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.

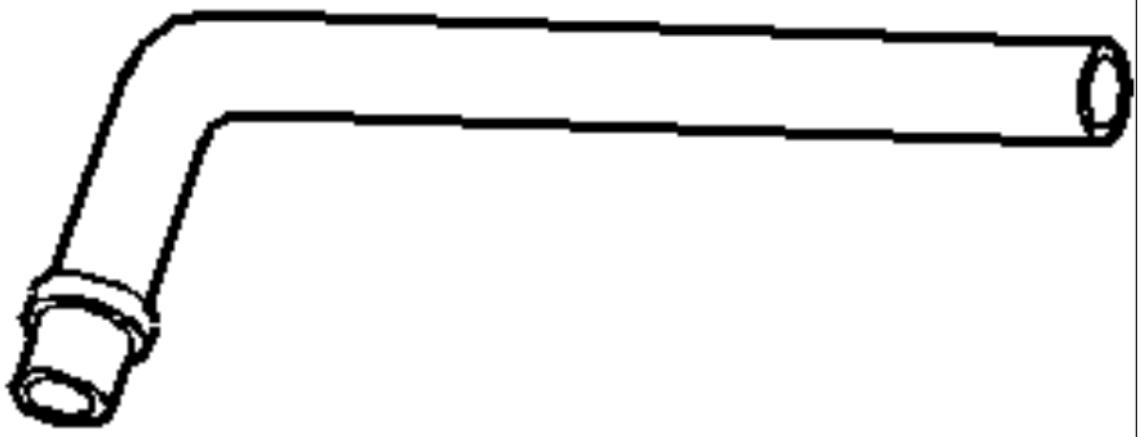
Due to the limited diagnostic capability, limited availability and increasing costs of the reed tachometer, it is NOT recommended as the primary tool to use in diagnosing a vibration concern.

When diagnosing a vibration concern, use the **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or the **EL-38792-A** Electronic Vibration Analyzer (EVA) 2. The **CH-51450-NVH** Oscilloscope Diagnostic Kit (w/NVH) or the **EL-38792-A** Electronic Vibration Analyzer (EVA) 2 have been designed to overcome the shortcomings to the reed tachometer. Refer to **Oscilloscope Diagnostic Kit Description and Operation**, or **Electronic Vibration Analyzer (EVA) Description and Operation**.

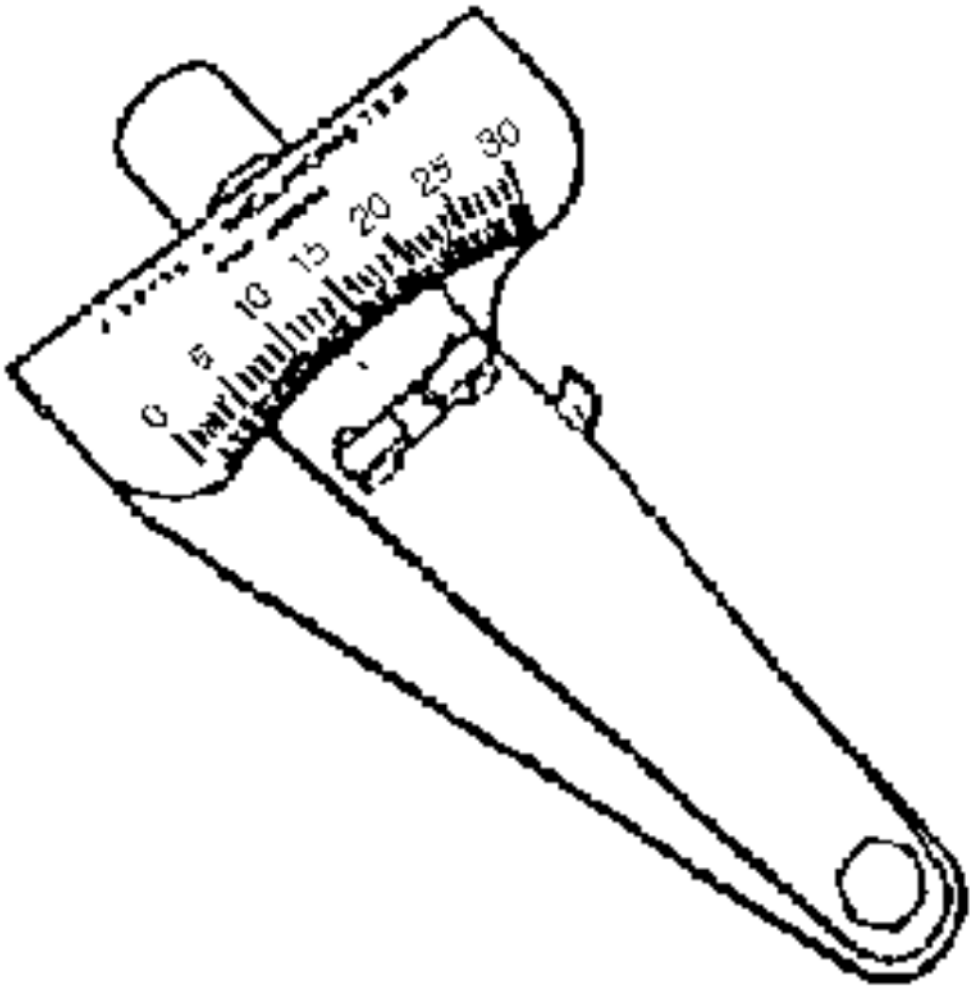
## SPECIAL TOOLS AND EQUIPMENT

| Illustration | Tool Number/Description |
|---|---|
|  | CH 51450-NVH Oscilloscope Diagnostic Kit (w/NVH) |

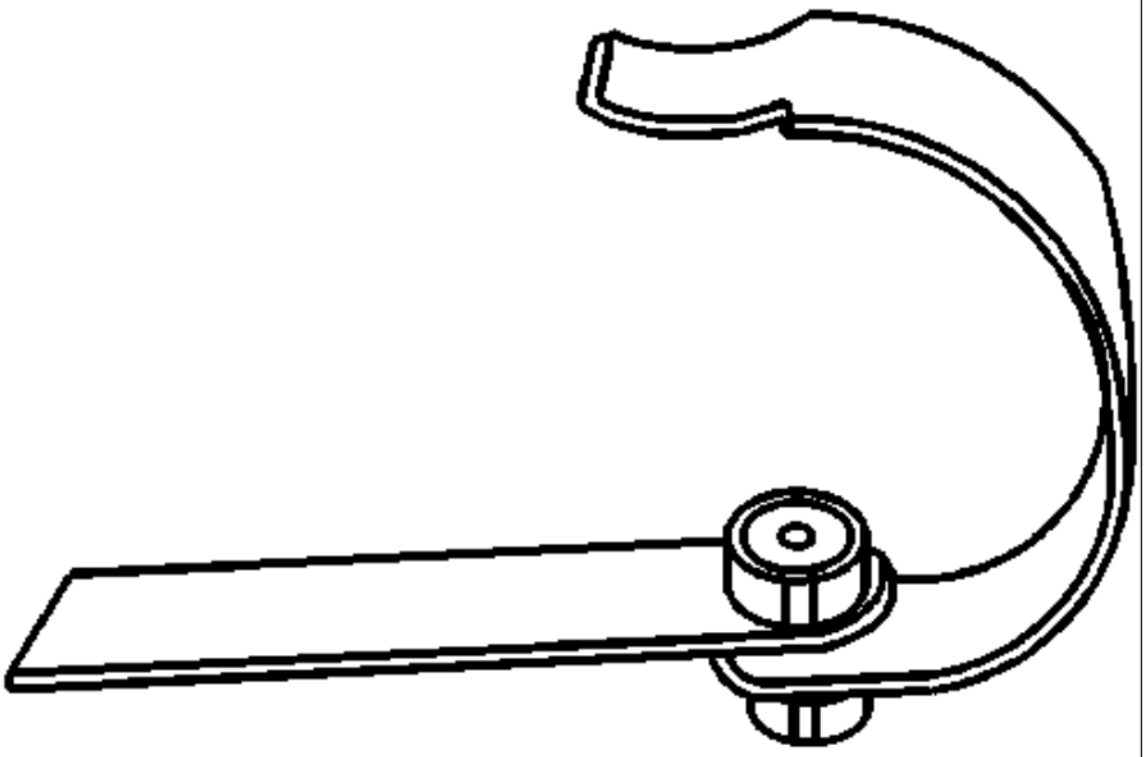
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| Illustration | Tool Number/Description |
| --- | --- |
|  | DT 23409<br>J 23409<br>Dial Indicator Extension - 7 5/8 in |

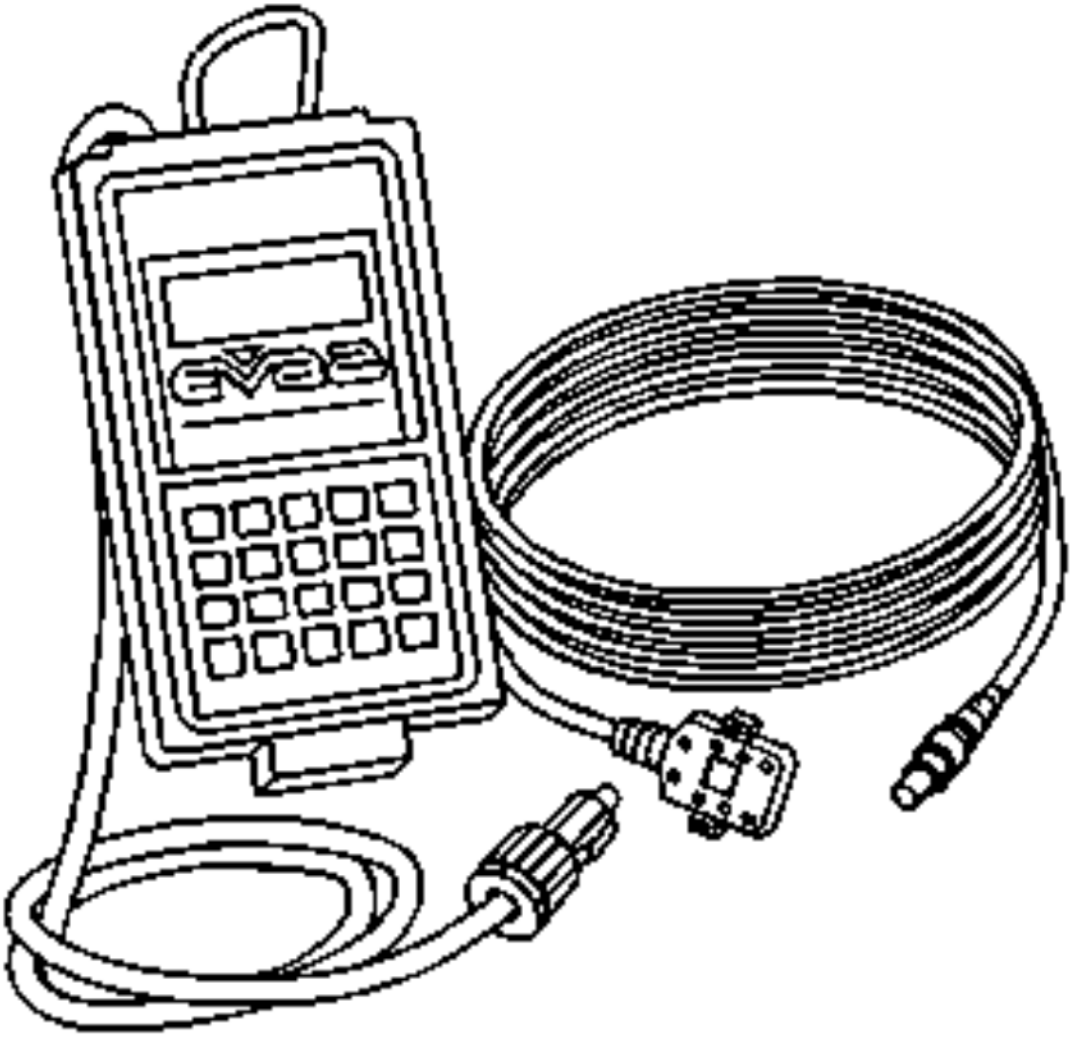
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| Illustration | Tool Number/Description |
| --- | --- |
|  | DT 23498-A<br>J 23498-A<br>Driveshaft<br>Inclinometer |

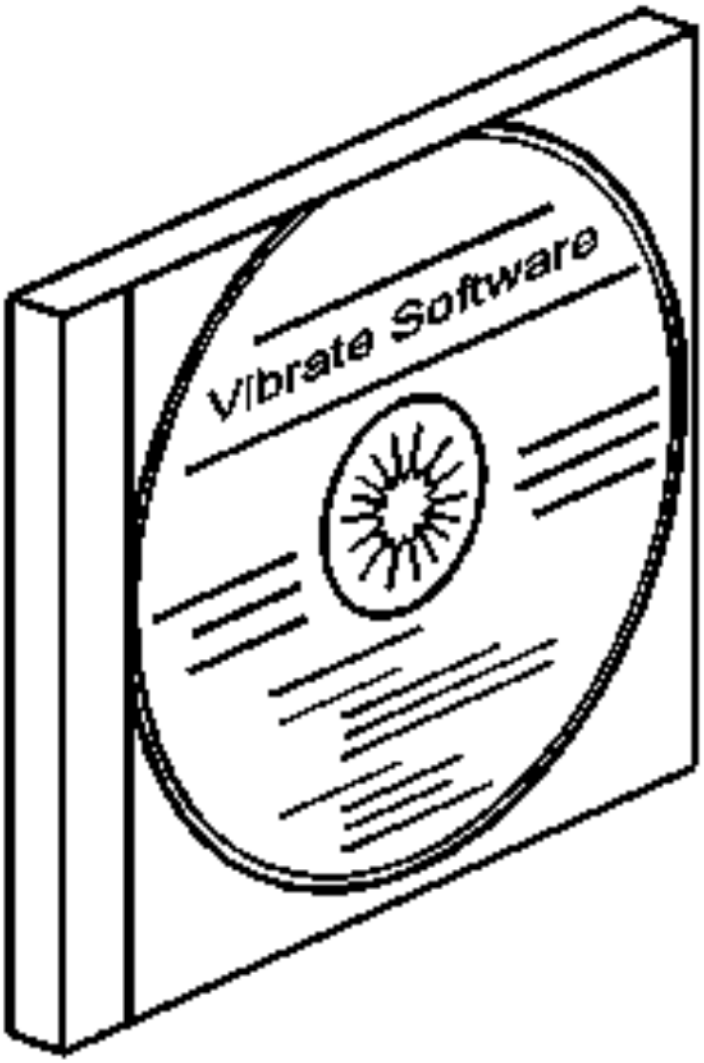
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| Illustration | Tool Number/Description |
| --- | --- |
|  | DT 23498-20<br>J 23498-20<br>Driveshaft<br>Inclinometer Adapter |

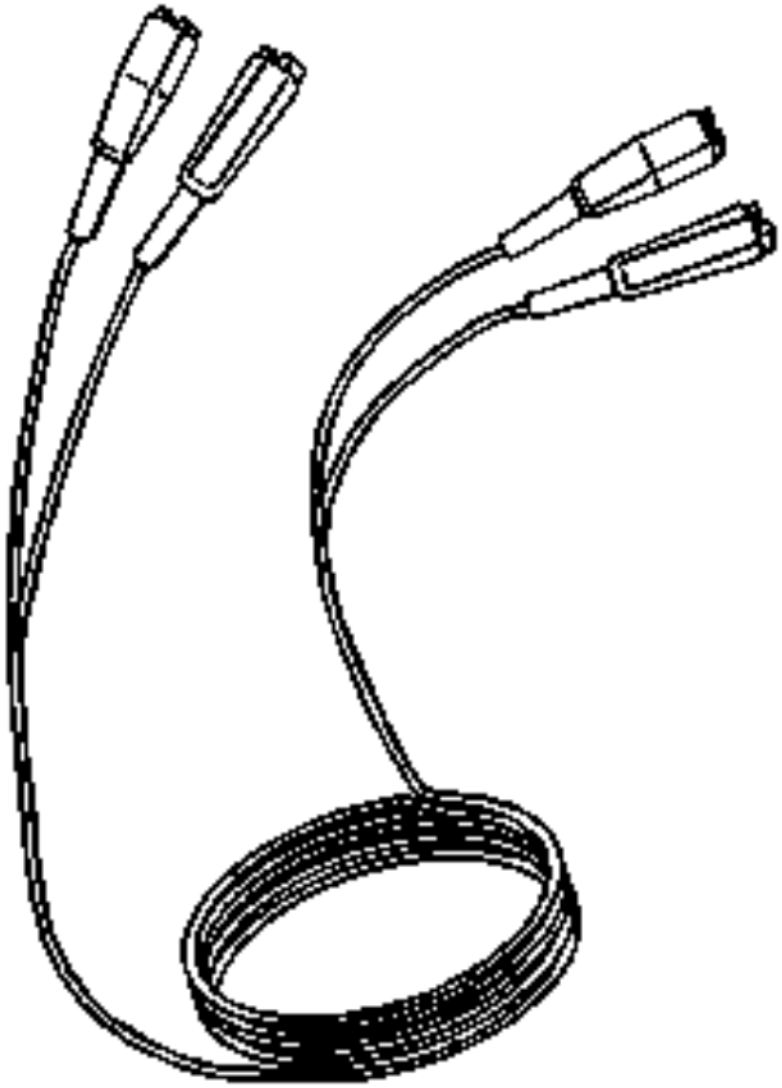
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| Illustration | Tool Number/Description |
| --- | --- |
|  | EL 38792-A<br>J 38792-A<br>Electronic Vibration Analyzer 2 |

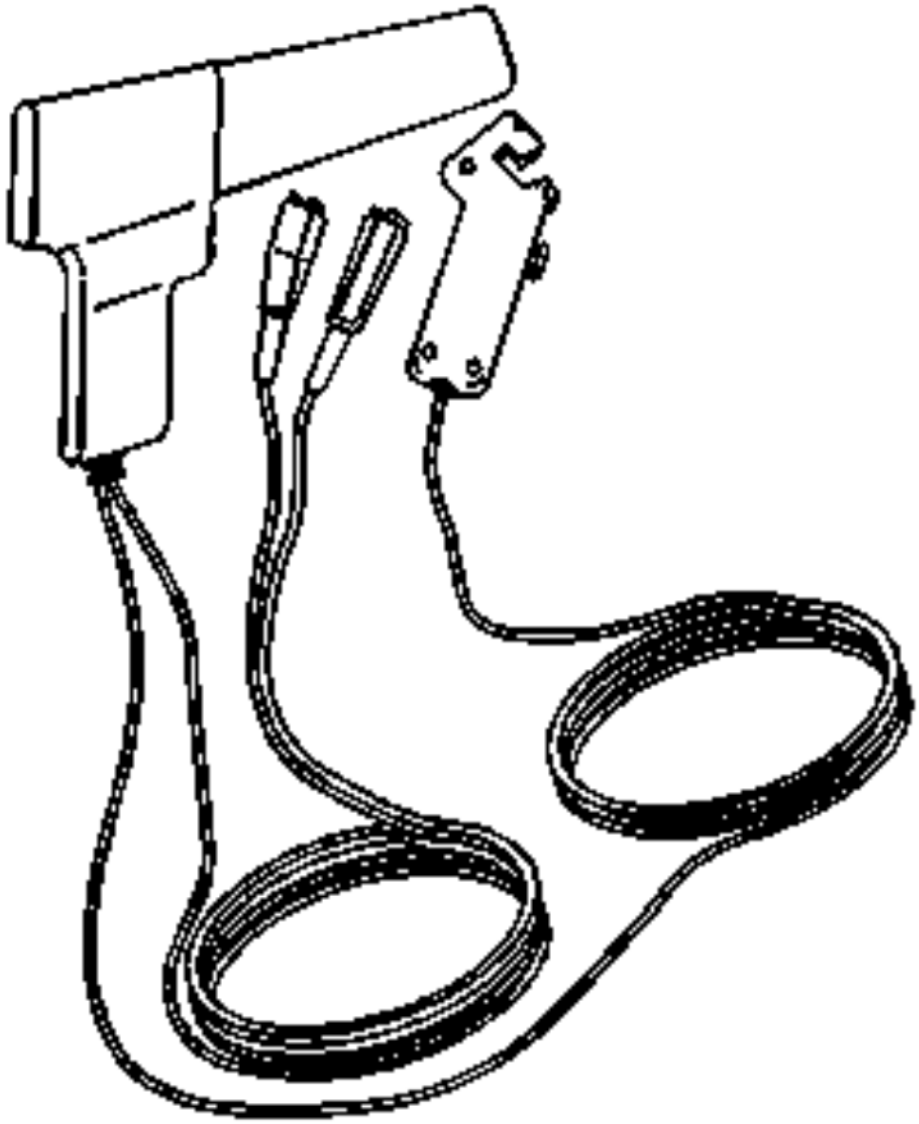
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| Illustration | Tool Number/Description |
| --- | --- |
|  | EL 38792-VS<br>J 38792-VS<br>Vibrate Software |

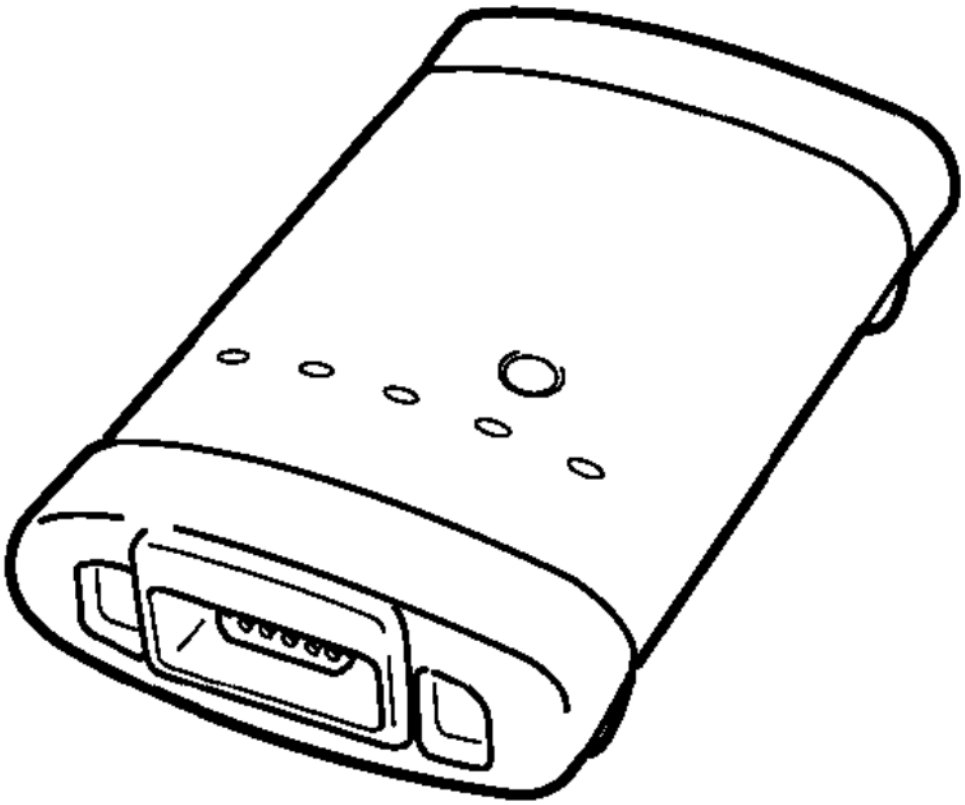
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| Illustration | Tool Number/Description |
| --- | --- |
|  | EL 38792-20<br>J 38792-20<br>20-Foot Timing Light Power Cord Extension |

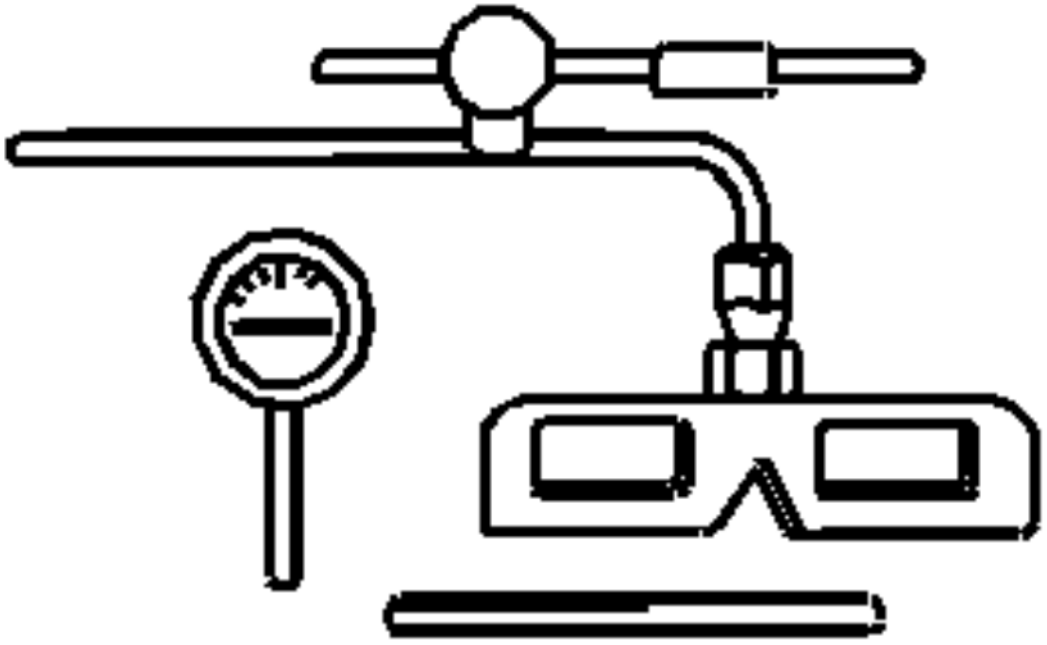
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| Illustration | Tool Number/Description |
| --- | --- |
|  | EL 38792-25<br>J 38792-25<br>Inductive Pickup Timing Light |

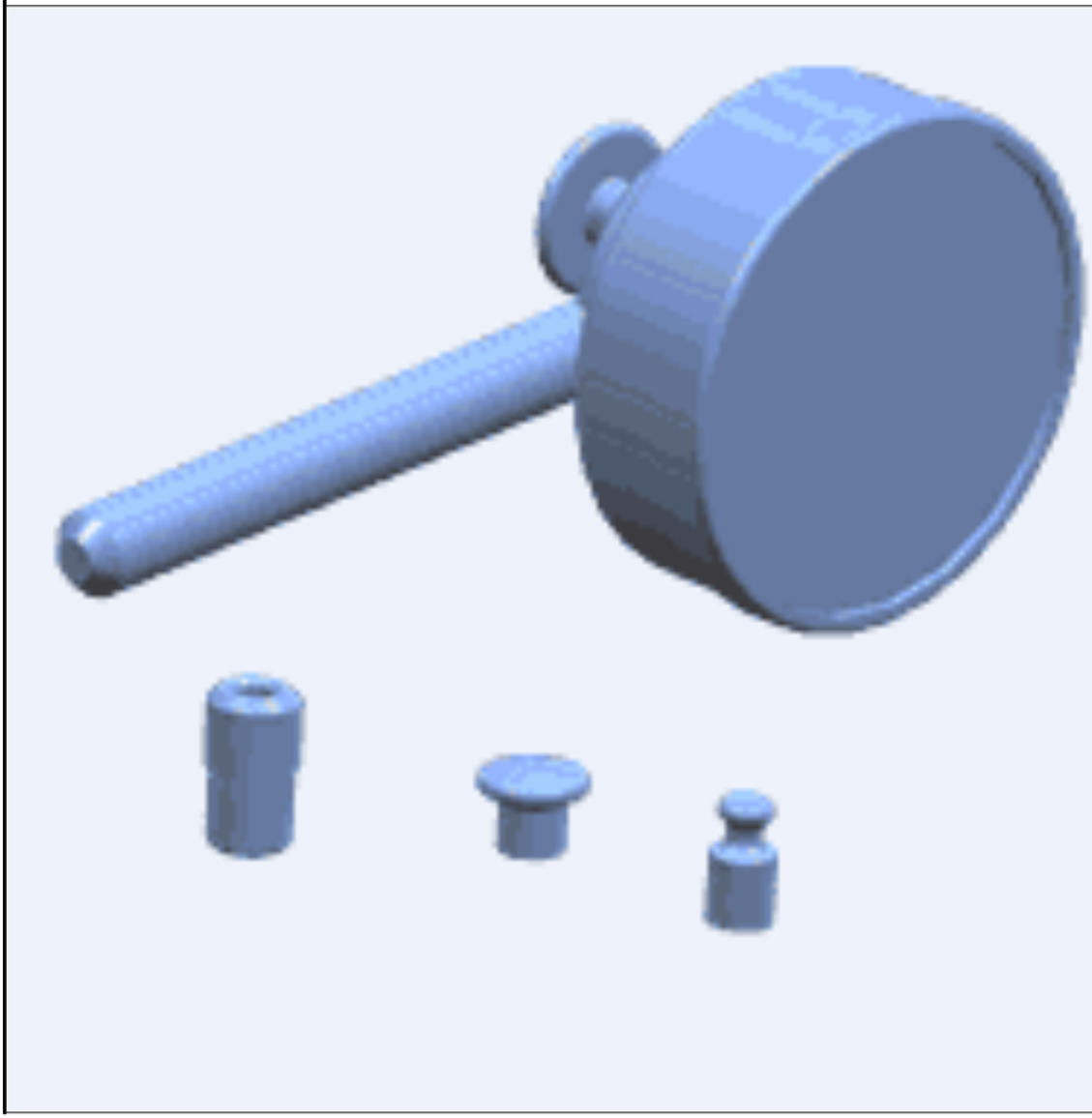
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| Illustration | Tool Number/Description |
| --- | --- |
|  | EL 47955<br>J 2534<br>Multi Diagnostic Interface MDI |

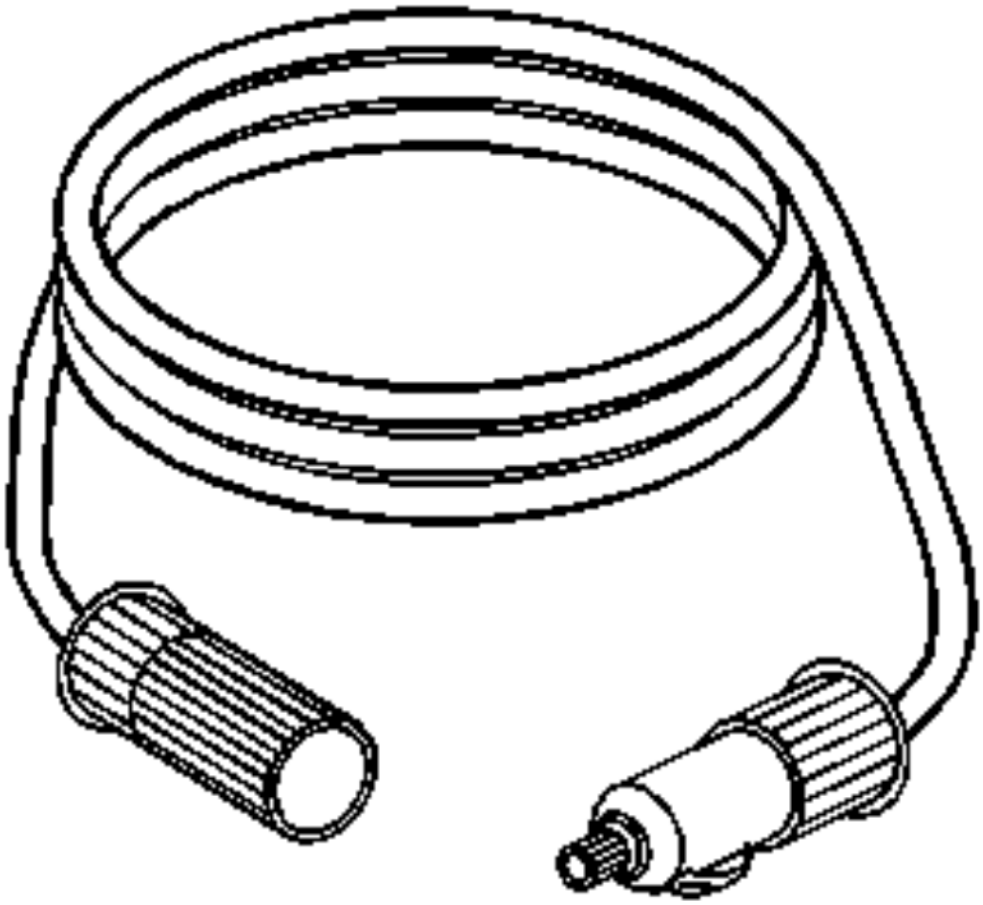
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| Illustration | Tool Number/Description |
| --- | --- |
|  | GE 7872<br>J 7872<br>Magnetic Base Dial Indicator Set |

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| Illustration | Tool Number/Description |
| --- | --- |
|  | GE 8001<br>J 8001<br>Dial Indicator Set |

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| Illustration | Tool Number/Description |
| --- | --- |
|  | J 38792-27<br>6-Foot EVA Power Cord Extension |

Article GUID: A00854554

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