**Introduction**

An organized, systematic procedure is important in any type of diagnosis. It is the most efficient/cost effective way to resolve complaints the first time. NVH complaints are sensed by feeling or hearing and are therefore, very subjective in nature.

A good **systematic diagnostic procedure** is critical to deal with these types of complaints because the symptoms may not clearly point to the condition. Systematic diagnostic procedures will help you successfully resolve NVH conditions as they do with difficult computer and electrical problems.

Elements incorporated in a systematic diagnostic procedure are:

- An organized **process of elimination** which prioritizes activities to quickly isolate the condition
- A thorough **visual inspection** for obvious conditions or clues to help diagnose the condition

**NOTE**

In order to apply these elements to NVH troubleshooting, a solid understanding of the NVH theory in Section 1 is important. Diagnosis applies the theory to isolate the condition. An incorrect diagnosis usually results from a poor diagnostic procedure, a lack of understanding on how the system works or both.

This section of the course will address in detail the first three items of the NVH diagnostic procedure:

- Verify the complaint
- Classify the complaint
- Road test with NVH analyzer

Practice implementing the NVH diagnostic procedure will be accomplished by following **two customer complaint scenarios or case studies**.

- The first scenario is incorporated in this section of the technician handbook.
- The second is part of the worksheet activities.
1. Verify the Customer Complaint
2. Classify the Complaint
3. Road Test
4. Pinpoint Diagnosis
5. Perform the Repair
6. Verify the Complaint has been Resolved
Case Study: Background

In order to help illustrate the concept of NVH diagnosis we will apply the principles outlined above to a customer complaint involving a 4Runner. Each topic in this section will be applied to the scenario and at the end of the section the condition will be resolved.

The details of the diagnostic scenario are contained in the following repair order. They are also included in each procedure and illustration as it applies.
Case Study: Background Continued

Each area of this section includes a worksheet which is based on a customer complaint scenario. Your instructor has created a similar problem in a shop vehicle for you to troubleshoot.

Detailed information and instructions for the worksheets will be provided by your instructor. Upon completion of each worksheet, the complaint should be resolved on the shop vehicles.

Verify the Customer Complaint

Verification of the customer complaint is a key starting point in an NVH diagnostic procedure for two reasons:

- If the complaint can’t be verified, a plan can be implemented that involves satisfying the customer through education or returning the vehicle for service when the complaint can be duplicated.
- It is important that the technician experiences exactly what the customer is complaining about and knows what is involved to satisfy the customer.

There are three courses of action to successfully resolve an NVH complaint:

1. Customer consultation
2. Technician diagnosis and repair
3. Technical assistance for non-serviceable conditions

Starting a diagnostic procedure implies that there is a problem with the vehicle. The service department is then committed to the second or third course of action. If it is discovered after the diagnosis begins that the complaint was not verified, then it is difficult to step back to the first course of action and customer satisfaction is very difficult.

The earlier the appropriate course of action is chosen the more likely a positive service experience will occur.
Customer Interview Sheet

The Interview sheet is a tool designed to solve one of the largest problems identified in NVH service, poor communication. Proper communication helps you educate the customer and ensures an appropriate course of action can be taken.

Research involving unresolved NVH complaints indicates that technicians often start a diagnosis without knowing the exact details of the complaint. This results from a lack of communication with the customer which wastes time or causes a missed diagnosis.

Good communication skills include:

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

A customer, when properly interviewed, can provide a wealth of information to start the diagnosis and process of elimination.

It is important to determine if the person bringing the vehicle in for service is the primary operator of the vehicle. Often, vehicles are brought in for service by someone who has no knowledge of the complaint.

The interview process is designed to help the customer focus on details of the NVH complaint and vehicle conditions when the complaint occurs.

The interview sheet provides a format to communicate these conditions using standard NVH terminology.

Verification of the complaint is also a critical area of diagnosis, when the condition is intermittent or only occurs under specific conditions.

For example:

Noises from suspension components may be much more pronounced at ambient temperatures below 40°F. If these temperature conditions are not present at the time of diagnosis, the technician may not experience the complaint to the same degree as the customer.

The technician needs to experience the condition and be able to duplicate it in order to accurately diagnose it. The more details that are available, the more likely the condition can be found quickly.

An additional benefit of the interview sheet is the documentation of the communication with the customer. It provides a history of the service experience. In the event the complaint can’t be verified, this documentation will provide valuable information in the event of subsequent service visit.
The customer interview sheet is designed to be as **short and concise** as possible. The information collected is divided into the following areas:

- Customer data
- Vehicle data
- NVH data

---

### Interview Sheet for 4Runner

**Fig. 2-3**

---

#### CUSTOMER INTERVIEW SHEET

**INSTRUCTIONS**

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

- **Customer data**
- **Vehicle data**
- **NVH data**

---

**Customer Interview Sheet**

**Continued**

---

#### CUSTOMER DATA

- **Name:** [Name]
- **Address:** [Address]
- **Phone:** [Phone]
- **Email:** [Email]
- **Date:** [Date]

---

#### VEHICLE DATA

- **Make:** [Make]
- **Model:** [Model]
- **Year:** [Year]
- **Color:** [Color]
- **Engine:** [Engine]
- **Transmission:** [Transmission]
- **Mileage:** [Mileage]

---

#### NVH DATA

**Location Indicator**

- **Flow of cooling from the rear of the vehicle**

---

#### OPERATING CONDITION

- **Engine Speed:** [Engine Speed]
- **Vehicle Speed:** [Vehicle Speed]
- **Axle:** [Axle]
- **Coasting:** [Coasting]
- **Driving:** [Driving]
- **Park:** [Park]
- **Neutral:** [Neutral]
- **Clutch:** [Clutch]

---

#### WEATHER CONDITIONS

- **Temperature:** [Temperature]
- **Sun:** [Sun]
- **Rain:** [Rain]
- **Snow:** [Snow]
- **Wind:** [Wind]
- **Other:** [Other]

---

#### ADDITIONAL INFORMATION

- [Additional Information]

---

---

---
Customer and vehicle data are for obvious logistical and administrative purposes. The value of this data becomes clear if future tracking of the customer, the vehicle or an NVH condition is required.

**Customer Interview Sheet**

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

**Communication** is the key objective of the interview sheet and should be done by trained service personnel to provide assistance and clarification. Technician involvement in the interview may be required to allow direct communication and minimize problems created by passing information through a third person.

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

- Noise
- Vibration
- Harshness

The next question determines whether the condition is **constant or intermittent**.

The customer should also be asked if the complaint has developed while operating the vehicle or whether it has been present since the vehicle was new. This information will be useful to the technician in determining which **course of action** to select, either technician diagnosis or technical assistance.
The customer is provided with a list of possible locations with a few details specific to each location.

For example:

If the steering wheel is the location then there are three possible types of steering wheel vibrations:

- Vertical
- Horizontal
- Rotational

Using this information, in conjunction with the classification flow chart (discussed later), will considerably reduce the large list of possible causes of the condition.
The **conditions section** of the interview sheet is designed to collect data for the following subjects:

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

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

Each area has space provided to record information on unique complaints or conditions that fall outside the parameters outlined in the interview sheet.

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

The customers should be aware of the **key role they play in resolving the complaint**.

---

### Vehicle and Operating Conditions

**Fig. 2-6**

<table>
<thead>
<tr>
<th>OPERATING CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>When does the condition occur?</td>
</tr>
<tr>
<td>- Starting</td>
</tr>
<tr>
<td>- Idling</td>
</tr>
<tr>
<td>- Cruise</td>
</tr>
<tr>
<td>- Coasting</td>
</tr>
<tr>
<td>- Other ________</td>
</tr>
<tr>
<td>Vehicle Speed (MPH): 40-60 mph</td>
</tr>
<tr>
<td>Engine Speed (RPM): N/A</td>
</tr>
<tr>
<td>- Cornering Left</td>
</tr>
<tr>
<td>- Cornering Right</td>
</tr>
<tr>
<td>- Acceleration</td>
</tr>
<tr>
<td>- Deceleration</td>
</tr>
<tr>
<td>- Braking</td>
</tr>
<tr>
<td>- Clutch Engagement</td>
</tr>
<tr>
<td>- Other N/A</td>
</tr>
<tr>
<td>Accessories:</td>
</tr>
<tr>
<td>- HVAC</td>
</tr>
<tr>
<td>- 4WD</td>
</tr>
<tr>
<td>- Audio</td>
</tr>
<tr>
<td>- Other N/A</td>
</tr>
<tr>
<td>Engine Temperature:</td>
</tr>
<tr>
<td>- Cold</td>
</tr>
<tr>
<td>- Normal</td>
</tr>
<tr>
<td>- Hot</td>
</tr>
<tr>
<td>Road Conditions:</td>
</tr>
<tr>
<td>- Highway</td>
</tr>
<tr>
<td>- Suburb</td>
</tr>
<tr>
<td>- City</td>
</tr>
<tr>
<td>Road Surface:</td>
</tr>
<tr>
<td>- Asphalt</td>
</tr>
<tr>
<td>- Dirt/Off Road</td>
</tr>
<tr>
<td>- Concrete with Expansion Joints</td>
</tr>
<tr>
<td>- Undulating</td>
</tr>
<tr>
<td>- Other Irregularities</td>
</tr>
<tr>
<td>Explain: N/A</td>
</tr>
</tbody>
</table>

### WEATHER CONDITIONS

| Temperature: N/A |
| - F |
| - Clear |
| - Rain |
| - Ice/Snow |
| - Wind |
| - Other |

### ADDITIONAL INFORMATION

<table>
<thead>
<tr>
<th>Additional Information</th>
<th>Additional Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional Information</td>
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<td>Additional Information</td>
<td>Additional Information</td>
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<tr>
<td>Additional Information</td>
<td>Additional Information</td>
</tr>
</tbody>
</table>
Summary

At this point in the diagnosis the technician has:

- A completed repair order
- A completed interview sheet
- Verified the complaint
- Chosen one of three course of actions

The technician can now proceed with a plan for customer consultation or NVH diagnosis equipped with a strong background of the complaint.

Case study: Part I

In the 4Runner scenario the customer has filled in the customer and vehicle data sections. This has to be reviewed to make sure that it is completely filled out.

The customer has indicated to the interviewer that he is the primary driver and has experienced the complaint.

The NVH data indicates the following areas have been selected during the interview:

Classify

- Noise other than squeak, rattle or wind noise
- Vibration

They are both constant and started gradually. The vibration is felt in the steering wheel and is rotational. The sound is heard in the rear of the vehicle.

Operating conditions

- 40 - 60 MPH
- Cruise
- Coasting

It is also important to note that the following data has not been selected:

- Since new
- Vehicle condition section
- Road condition section
- Engine RPM
- Weather condition section

The fact that these areas were marked N/A indicates that the condition has developed while in service, engine speed does not effect it and that it is always there once the vehicle speed range is reached.

For the purposes of this scenario the technician has gone for a short ride with the customer and has verified that the complaint does exist as described.

The technician has also chosen the second option, technician diagnosis and repair, based on the information and verification available. The technician agrees that an unacceptable condition does
exist. The customer has indicated that the vehicle has recently developed the condition.
WORKSHEET #1
Verification of the Customer complaint

Diagnostic Description: Verify the Complaint

It is critical for the technician to experience the complaint for it to be successfully resolved. The Customer Interview Sheet is a tool, used by trained NVH service personnel, to collect the details associated with the customer complaint. With the information from the interview the technician can easily duplicate the symptom and gain valuable insight for diagnosis.

Your instructor has created typical NVH conditions in the shop vehicles. The completion of worksheets 1, 2, 4A and 4B will provide practice using the NVH diagnostic procedures and resolve the conditions on these vehicles. Worksheets 3A, 3B and 3C will provide experience using the NVH Analyzer.

NOTE
Your instructor will also act as the customer providing the information necessary to complete the first step, the customer interview (Copy Attached).
Instructions

1. **Conduct** the customer interview with the customer/instructor by asking **all** the questions on the attached sheet.

2. Your instructor will act like a customer and may not understand the question or the terminology used. Be sure to provide **clarification and explanations** as necessary.

   You may need to ask probing questions to determine if the customer understands the questions. They may not easily indicate that they don’t understand.

   The questions asked during this process may prompt the customer to provide additional, valuable information that they may not normally think of as important. You are the NVH expert, not the customer.

   It is important that the interview be conducted and the sheet filled out by personnel trained in NVH service. The customers should **not** be left to fill out the sheet on their own. Trained personnel can provide assistance, as necessary, to ensure high quality information about the complaint.

3. When the interview is complete, **review** all the data collected and **answer** the following questions. If the review or the following questions identify a lack of information, conduct that portion of the interview again.

4. Take a quick **test drive** with the customer to experience the complaint and determine what needs to be done to satisfy the customer.

5. Refer to the **Technician Handbook** for additional information to answer the following questions.

Questions

1. What is the difference between a **test drive** with the customer and a **road test** performed during diagnosis?

2. What is the reason for knowing who is the **primary operator** of the vehicle?
Section 2

Questions (continued)

3. If the person who brings the vehicle in for service is not the primary operator, what is your plan of action?

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Questions (continued)

7. What is the **pitfall** associated with **assuming** the customer **understands the meaning** of NVH terms, such as “harshness”.

8. **When** should the **operating conditions** be determined to maximize a **positive** service experience and why?

9. What information is provided when the interviewer enters **N/A** as an answer?

10. What is the **advantage** to filling in the final details the customer could not answer, during the test drive?

11. What is the **value** of having the interviewer and customer **review and sign** the interview sheet?
Conclusions

1. **List** the information from the interview sheet that is relevant to **resolving** the complaint. Briefly explain each.

   ______________________________________________________

   ______________________________________________________

   ______________________________________________________

   ______________________________________________________

2. From the information gathered at this point, what **test drive techniques** are necessary to **duplicate** the symptoms? Explain.

   ______________________________________________________

   ______________________________________________________

   ______________________________________________________

   ______________________________________________________

3. Based on the information collected from the interview sheet and the test drive, which of the following **course of actions** would you choose and why?
   - Customer Consultation
   - Technician Diagnosis and Repair
   - Technical Assistance for non-serviceable conditions

   ______________________________________________________

   ______________________________________________________

   ______________________________________________________

   ______________________________________________________

4. If **customer consultation** is chosen, what is your **plan of action**? Explain.

   ______________________________________________________

   ______________________________________________________

   ______________________________________________________

   ______________________________________________________
5. What is the **pitfall** associated with **starting** a diagnosis **before** the verification process is complete?
CUSTOMER INTERVIEW SHEET

INSTRUCTIONS
The interview should be conducted and the sheet filled out by personnel trained in NVH diagnosis. Please fill in or check all areas with the appropriate response, enter N/A if it does not apply. The details collected during the interview are critical in successfully resolving the complaint.

CUSTOMER DATA
Name: _______________________________ Date: __________________________
Telephone #: ________________________ RO #: ____________________________

VEHICLE DATA
Model/Year: _________________________ Mileage: _________________________
VIN #: __________________________________________
Is the customer the primary operator of the vehicle?  ○ Yes  ○ No

NVH DATA
What type of condition is the customer experiencing?  ○ Noise  ○ Vibration  ○ Harshness (ride quality)
Is the condition constant?  ○ Constant  ○ Intermittent
When did it start?  ○ While in Service  ○ Since New  ○ Gradually  ○ Suddenly
○ Other __________________________________________

NOISE
Describe the Noise:  ○ Squeak  ○ Rattle  ○ Wind Noise  ○ Other __________
When does the noise seem to be the loudest or most frequent?
________________________________________________________________________
Note here and mark the location of the noise on the illustration (reverse side of this form).
________________________________________________________________________

VIBRATION
Where is it felt:
○ Steering Wheel  ○ Floor  ○ Seat  ○ Instrument Panel
○ Brake Pedal  ○ Console  ○ Accelerator Pedal
○ Shifter  ○ Body  ○ Mirrors  ○ Clutch Pedal
Describe the vibration:
○ Vertical  ○ Horizontal  ○ Rotational
○ Other: ____________________________________________________________

HARSHNESS (Ride Quality)
Where do you experience it? _____________________________________________
When do you experience it? _____________________________________________
Has the vehicle ever been damaged?  ○ Yes  ○ No  If so, please indicate where on the illustration.
Is there any relevant service history?  ○ Yes  ○ No  If so, please describe: __________________________
Has there been any accessory installation?  ○ Yes  ○ No __________________________
Is the vehicle used for towing or to carry any cargo or equipment?  ○ Yes  ○ No ____________
LOCATION INDICATOR

OPERATING CONDITION
When does the condition occur?  ○ Starting  ○ Idling  ○ Cruise  ○ Coasting  ○ Other  ___________
Vehicle Speed (MPH): ___________  Engine Speed (RPM): ___________
  ○ Cornering Left  ○ Cornering Right  ○ Acceleration  ○ Deceleration
  ○ Braking  ○ Clutch Engagement  ○ Other  ___________
Accessories:  ○ HVAC  ○ 4WD  ○ Audio  ○ Other  ___________
Engine Temperature:  ○ Cold  ○ Normal  ○ Hot
Road Conditions:  ○ Highway  ○ Suburb  ○ City
Road Surface:  ○ Asphalt  ○ Dirt/Off Road  ○ Concrete with Expansion Joints
  ○ Undulating  ○ Other Irregularities
Explain: ____________________________________________________________

WEATHER CONDITIONS
Temperature: _______ °F  ○ Clear  ○ Rain  ○ Ice/Snow  ○ Wind
  ○ Other  __________________________________________________________________

ADDITIONAL INFORMATION
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
Classify the Complaint

During diagnosis a technician has to take a large list of possible NVH conditions and, through a process of elimination, find the one that applies to the situation.

Symptoms Classification Flow Chart

Fig. 2-8
Once the complaint has been classified, a specific diagnostic approach can be applied which will identify the source. This **eliminates random diagnosis** resulting in wasted time, confusion and frustration.

A further advantage of this organized style of diagnosis is that it allows the technician to **trace the steps**. The point where a decision was made, which led to a wrong, diagnosis can be identified. **Only the necessary procedures** need to be repeated to successfully find the condition.

Classification is done by collecting information about the complaint that is **unique to the condition**. Each step in the process **eliminates possibilities** until there is only one left.

Efficient diagnosis **prioritizes** the procedures that eliminates the largest number of possibilities first. This process will **minimize the number of tests** required and will be less likely to send the technician looking in the wrong direction.

The **four tools** available in the classification process are:

- Customer interview sheet
- Flow chart for classification
- Road test
- NVH Analyzer

With the data collected from the complaint verification and interview sheet, the technician can follow a path through the flow chart by making **yes or no decisions** at each level of the chart.

If a decision **can’t** be clearly made at a specific point in the chart, then a point has been identified where **more information is needed**, and exactly what that information has to include.

Successful completion of the flow chart will provide the technician with a classification for the symptoms which can be associated with **specific characteristics**. These specific characteristics can only be caused by one area on a vehicle and **pinpoint diagnosis** can be focused on that area for the cause and repair (See Section 1 for the specific characteristics).
The recent emphasis placed on NVH in automobiles has brought with it a **new vocabulary**. In addition, **quality communication** from the customer to the technician, has been identified as one of the major areas of concern for successful NVH service.

**Standardized** NVH terminology is very important to ensure that everyone understands the conditions in the same way. The flow chart is a **tool** used by the technician to identify the symptom from the data collected during the interview and the test drive.

When the proper symptom is selected from the list, there are **specific characteristics** associated with the term which are helpful in diagnosis. For example, the **frequency** of the symptom.

**Classification Flow Chart**

![Classification Flow Chart](Fig. 2-9)
Instructions
As indicated in worksheet #1, this worksheet is the second worksheet designed to:

- provide an opportunity to practice the NVH diagnostic procedure
- resolve the condition placed in the shop vehicles.

1. Use the information collected on the customer interview sheet and the test drive (worksheet #1) to answer the questions at each branch of the flow chart. (attached)

2. If you cannot clearly answer the questions on the sheet then you have identified an area that requires more information. Determine if it has to be collected from the customer/instructor or another test drive.

3. Review the characteristics of each symptom on the symptom chart (Section 1 of the student handbook) and answer the following questions.

Questions
1. How many symptoms were identified?

2. List the symptom/s below.

3. Is the symptom/s noise, vibration, harshness or a combination?

4. What are the frequencies associated with the symptom/s?

5. Why will knowing the frequency be helpful during diagnosis?

6. What other things are you familiar with in your daily life which operate at the same frequency? Why is this helpful in diagnosis?

7. Are the symptoms engine speed related, vehicle speed related or both?
Questions (continued)

8. What conditions, listed on the symptom chart (Section 1) are the same as gathered during the interview sheet and the test drive?

What conditions are different?

9. List the possible causes from the symptom chart (Section 1) that are most likely in this case. Explain.

10. What is the vibrating system related to the symptom?

   • Vibrating force: ________________________________
   • Resonance system: ________________________________
   • Transmission system: ________________________________
   • Vibrating body: ________________________________

11. Does the vibrating system from the symptoms chart (Section 1) and the one associated with this case match?

12. Remember, not all cases follow a textbook situation exactly, the chart serves as a guide for most cases.

   What is your plan of action in the event that the case being diagnosed is not exactly the same as the symptoms outlined in the chart?

Conclusions

The information generated with this flow chart will be used with the customer interview sheet, the NVH analyzer, and the road test to classify the complaint and identify the possible source of the vibration or sound. (engine, driveline or wheels)

A successful pinpoint diagnosis can be done with solid background information on the complaint.
CLASSIFICATION FLOW CHART

- Body shake
- Steering flutter
- Steering shimmy
- Accelerator pedal vibration
- Shift lever vibration
- Ride discomfort
- Harshness
- Road noise
- Tire pattern noise
- Body booming noise
- Body beating noise
- Engine noise
- Wind noise
- Transmission gear whine
- Differential gear whine
- Clutch shudder
- Take-off vibration (Acceleration vibration)
- Cranking vibration
- Vibration at idle
- Vibration during braking
- Brake squeal

Driving at high speed
- Seat, steering wheel and floor vibrate vertically and horizontally
- Steering wheel vibrates in direction of rotation

Driving at low or medium speed
- Steering wheel vibrates in direction of rotation
- Accelerator pedal vibration
- Shift lever vibration
- Vibration occurs at bumps and joints in road, and on rough roads

Driving at all speeds
- Shocks and vibrations at bumps and joints in road
- Constant sound regardless of vehicle speed
- Pitch of noise becomes higher as speed increases

Driving at medium or high speed
- Low, heavy sound
- Occurs at certain engine or vehicle speeds only
- Continuous
- Cyclic
- Proportional to E/G rpm
- Proportional to vehicle speed and wind direction
- Related to shift lever position
- Unrelated to shift lever position
- Unrelated to road conditions

Take-off
- At clutch engagement

Starting and accelerating
- Cranking

Stopped
- Idling

Braking
- Related to vibration
- Related to noise
Case study: Part II  After the technician has verified the complaint, the classification flow chart is used to establish that there are two areas or classifications, for the symptoms.

- Steering shimmy
- Body booming

In the first level of the flow chart there are four choices:

- Driving (coasting)
- Take-off
- Standing
- Braking

**Driving** was selected because the symptoms occur between 40 - 60 MPH.

The second level asks if the symptoms are related to vibration or noise. In this case both areas need to be considered because there is a vibration in the steering wheel and a noise from the rear of the 4Runner.

The next level under vibration asks for the speed. The vibration is noticed first at about 40 MPH which is considered to be **medium speed**.

The chart next asks if the steering wheel vibrates in the direction of rotation. The term to describe this symptom is **steering shimmy**.

The next level after noise asks for speed. In this case the noise is most noticeable at speeds **above 50 MPH**. Driving at medium or high speed is the choice that best fits the noise symptom.

Next, you are asked if the noise varies or is unrelated to road condition. **Unrelated** best fits in this case. The customer noted, and the verification indicated, that the noise is always there once the proper speed is reached.

The sound is best described as a **low and heavy sound** as opposed to high clear sound and is related to vehicle speed.

The final question relating to noise asks if it is continuous or cyclic. The noise in the 4Runner scenario is described as being **continuous** which points to a **body booming** classification for the noise.

This may seem to be a complex way to arrive at a description of a symptom. But using this process and the flow chart insures that the proper terms are being used and mean the same thing to everyone involved.

In addition, there are very specific causes associated with each of these classifications which help the technician narrow down the list of possibilities. If the wrong term is used it could lead to a pinpoint diagnosis in the wrong area, wasting time.
Road Test  Diagnostic road testing is done after the complaint has been verified. Customers are helpful in verifying the complaint but do not need to be part of the complete diagnostic process. Unfortunately, some diagnostic procedures do not separate the verification of the complaint from the road test. The road test is designed to help isolate the condition after it has been verified. Data collected from a customer and data collected from a road test are different and serve two different functions.

During the road test, the technician duplicates the complaint under several specific operating conditions. This is done to identify unique characteristics which will help classify the complaint. In addition to duplicating the complaint, the technician should try to change or eliminate the symptom using techniques such as different speeds, RPM, load or other operating conditions.

---

Road Test Procedures

Fig. 2-10

1. Connect NVH Analyzer
2. Engine Run-up
3. Light Acceleration
4. Heavy Acceleration
5. Cruise
6. Coasting
7. Deceleration
8. Turning
9. Brake Torque
10. Jounce
The road test is designed to get the most information in the shortest amount of time. It is also part of a process of elimination reducing a large list of possibilities to the one causing the complaint.

The condition of the vehicle must not be modified prior to the road test. A thorough visual inspection may find conditions such as low tire inflation. Properly inflating the tires prior to the road test may modify the vehicle to the point that the symptoms may be effected.

Once the complaint has been verified the road test can be modified specifically to the complaint. Only conditions that apply to the complaint need to be duplicated.

For example:

If the condition occurs at a specific speed then road test parameters that do not apply to that condition do not need to be performed, like engine idle in Neutral or Park.
Collecting, Reading and Analyzing NVH Data

During the road test, the ability to quantify the frequency and the level of the vibration or sound is very useful for diagnosis. It also provides an objective basis for comparison.

Knowing the frequency of the condition will help classify the symptom. The large list of possibilities can be reduced considerably due to the fact that only specific components operate at specific frequencies.

A vibration analyzer, such as the Toyota NVH Analyzer, can measure the level of a specific frequency vibration or sound. This level can be recorded and compared to known good vehicles as well as the complaint vehicle, after the repair has been performed.

If a frequency analyzer is not available, experience with known vibrations is helpful in diagnosis. This approach, however, is very subjective when comparing levels of noise or vibration (See Section 1 for details).
The Diagnostic tool set includes an extensive **Operator’s Manual** with **operating instructions** for each program card. These references provide an excellent resource for the following information:

- Hardware
- Features
- Operating precautions
- Getting started
- Using the RS232 and instrumentation ports

The appendices provide valuable additional information to help the operator get the most out of the Diagnostic Tool Set (See operator’s manual table of contents).

The operating instructions provide details on the NVH Analyzer functionality. When one of the program cards is selected, the instructions will walk the operator through the menu selections and key strokes until the appropriate data is displayed. It will also explain how to move through the different displays, modify the displays and how to pause or snapshot the data. **Interpreting the data is left to the technician.**
Description: The NVH Analyzer Set-up

The NVH Analyzer is designed to be very user friendly, with the minimal menu selections required to select the vehicle and access the data displays.

This worksheet is designed to orient you to the NVH menus and the active keys on the analyzer.
Instructions

1. **Install** the NVH Training Software card.

2. Refer to the NVH section of the Diagnostic Tool Set Operator’s Manual (Sections 1.0 - 3.0) and follow the procedures outlined to familiarize yourself with the operators manual, menu structure, active keys, and functions.
   - 1.0 Getting Ready
   - 2.0 Vehicle and System Selection
   - 3.0 NVH Main Menu

3. Press the **HELP** key frequently to familiarize yourself with the help information available in the software. Use the **EXIT** key to return to the menu or data displays.

4. Perform the **selection procedures** on the following vehicles and note the different selections required to access the NVH data displays.
   - 93 4Runner, 3VZ-E-4WD, AXLE G254, MT 10.5R15
   - 93 Supra
   - 93 Tercel, 4speed MT and AT

5. **Repeat** a vehicle selection from above using the “LAST VEHICLE” selection. Note the menus eliminated using this selection compared to the “NEW VEHICLE” selection.

**NOTE** An auxiliary power source is recommended during this worksheet to avoid interruptions from a dead battery. (Refer to the operators manual section, “Powering the Diagnostic Tester”)

Questions

1. Which key moves **forward** through the menu structure?

2. Which key moves **back** through the menu structure?

3. What are the **two ways** to select “NVH” on the Function Select Menu?

4. What is the **purpose** of selecting the vehicle **specific** year, engine, transmission, etc.?  

5. What effect will the **wrong** vehicle or vehicle parameters selection have on **diagnosis**? How will you know?

6. What is the **advantage** to using the “LAST VEHICLE” selection when possible?
Questions (continued)

7. List the resources available to verify the vehicle axle ratio.

8. Under what conditions would the axle ratio need to be changed? Be specific.


10. Does the tool tell you where to connect the data link cable on the vehicle selected?
    If so, which screen?

11. What is your plan of action if you get the “NVH Signal Conditioner Failure” screen? Explain.

12. What is the printer “Baud Rate” default value? Where did you find the answer?

13. How many unit conversions can be modified?
    List the ones applicable to NVH.

14. What type of information is available through “help”?
Description: The NVH Analyzer Data Displays

The NVH software provides three data displays for NVH diagnosis.

- 2d (2 dimensional)
- Barchart
- 3d (3 dimensional)

These displays are available to analyze the vibrations and noise in a vehicle. They are accessed after the vehicle and function selections are made. (worksheet #3A) In addition to the vehicle vibrations, each display provides information including:

- Vibration indicator arrows
- MPH & RPM
- Time
- Frequency and amplitude

This worksheet is designed to review each of the displays in detail for the information available and the key strokes necessary to manipulate the information.

2d Display

Fig. 2-13
Instructions

1. Install the NVH training software card.

2. Perform the set-up procedures outlined in the NVH section of the operator’s manual (Sections 1.0 - 3.0).
   - 93 Previa, 4wd AT
   - 93 Celica, 5S-FE, convertible
   - 93 Corolla, 4A-FE, DLX

3. Refer to Sections 4.0 - 6.0 for details relating to each of the displays and functions.
   - 4.0 NVH Displays
   - 5.0 Pause Mode
   - 6.0 Data Record

4. Practice manipulating the displays with the active keys to learn the range and function of the data available for diagnosis.

Questions

1. What do the two axises represent on the 2d display?
   - Vertical
   - Horizontal

2. What are the active keys on the 2d display that change the:
   - amplitude
   - frequency (for each direction)
   - source indicator (engine, driveline and wheel)
   - cursor

3. How many ranges or bands are available for:
   - Amplitude
   - Frequency

4. If the time is not correct how is it changed?

5. What is the value of the time indicator on the display or a screen print?
Section 2

Questions (continued)

6. If the “no data” indicator is displayed adjacent to the MPH and RPM indicators, what is your plan of action? Explain.

7. If the vehicle requires a manual gear selection, how is it indicated on the display?

8. What is the key to enter the gear selection display?

9. What is the key required to change the vibration source indicators (selected component)?

10. Why do some vehicles require gear selection while others do not?

11. What is the default gear selection if none is selected?

12. What effect will using the default gear position have in diagnosis?

13. Which active key changes the three NVH Data displays?

14. How many events are displayed on the barchart and 3d display?

15. Which line is the most recent event on both the:
   • barchart
   • 3d display
Questions (continued)

16. On the barchart display, is the total dBg displayed:
   
   A. the sum of the engine, driveline, and wheel dBs
   
   B. or the greatest level of total vibration felt in the vehicle (engine, driveline, and wheel levels are compared to the total)

17. How do you change the **amplitude scale factor** on the barchart display?

   What is the range?

18. What is the function of the **RCV** key?
WORKSHEET #3C
Getting Started with the NVH Analyzer

Description: NVH Data Analysis

NVH data analysis is the key to using the NVH Analyzer in the diagnostic process. The ability to accurately identify the “spikes” associated with the vibration, causing the customer complaint, will contribute to your success and customer satisfaction.

The NVH training simulation software contains pre-recorded vehicles with typical vibration characteristics and customer complaint vibrations. Specific scenarios are selected by choosing one of the following vehicles on the vehicle select screen.

- 93 Truck 3VZ-E 4WD G254 AT STREAM 31
- 93 Truck 3VZ-E 4WD G254 AT STREAM 73
- 93 Truck 3VZ-E 4WD G254 AT STREAM 76
- 93 Camry 5S-FE AT STREAM 35
- 93 Camry 5S-FE AT STREAM 72
- 93 Landcruiser STREAM 30

The NVH data analysis worksheet is designed to utilize the NVH training software to provide practice analyzing vibrations. The software allows this activity to take place in the classroom where everyone can benefit from the same scenarios, discussions and direction from the instructor.

2d Display
Fig. 2-14

![Graph showing vibration analysis](image)
Instructions

1. **Install** the NVH training simulation software and go through the function and **vehicle selection menus**. Use the skills developed in worksheet #3A.

   **NOTE**

   Follow the directions from your instructor in selecting the vehicles. The directions will include details from the **customer interview sheet** and the **symptoms classification flow chart**.

2. **Observe** the data displayed on each of the three displays. Use the skills developed in worksheet #3B to **manipulate** the screens to observe the **clearest view** of the data.

   For example:
   
   Changing the amplitude to a higher scale may eliminate vibrations that are normal. Changing the frequency range may make low frequency wheel vibrations easier to read.

   **NOTE**

   The scenarios were recorded for the length of time required to capture a **representative sample**. The software will display the data in a **continuous loop**. **Watch** the RPM and MPH indicators to determine the beginning of the loop.

3. Select each of the three source indicators and **identify the spikes** above each arrow on the 2d and 3d displays.

4. **Compare** what is indicated on the 2d and 3d displays to the data indicated on the barchart display.

5. When you have **identified** the spike that is associated with the symptom perform a **save and screen print** of all the displays. Attach to the sheet provided.

6. **Formulate a plan** for a thorough **road test** that you would perform to determine if your conclusions are correct. Base the plan on the information from:

   - the customer interview sheet
   - the symptoms classification flow chart
   - the data viewed in the scenario

   Place your answer in the space provided on the attached sheet.

   **NOTE**

   The ability to **anticipate** what spikes you should find is very helpful in diagnosis. It makes it easier and more efficient to plan the display manipulations and the road test.

7. **Answer** the questions as you review the scenarios and place your answers for 1-10 on the **chart** (attached).

Questions

1. Based on the information from the customer interview and the symptom classification, indicate what **type of vibration** you expect to see on the display prior to reviewing the NVH data.

   - engine 1st order 2nd order 3rd order 4th order
   - driveline 1st order 2nd order 3rd order 4th order
   - wheels 1st order 2nd order 3rd order 4th order
Questions (continued)

2. Observing the spikes in question, what frequency range would best display the spikes? Explain.

3. While viewing data on the 2d display, are there any spikes shown at frequencies greater than 125 Hz?

4. What amplitude range will clearly display the larger spikes and eliminate the normal vibrations?

5. Which scenarios indicate an overlap condition?

6. Which indicators are overlapping?

7. What would your plan of action be for a road test to determine which source was causing the spike? Be specific.

8. Which source shows the greatest level of energy on the barchart display?

9. After reviewing the displays which are the vibrations of concern?

10. What are your conclusions and plan of action from the symptom information and NVH data on this vehicle?
Conclusion

1. Why were the three sources of vibration (engine, driveline and wheel) selected for indication by the NVH Analyzer?

2. When is a comparison of amplitude level from vehicle to vehicle of little value?

3. What is the value of recording the amplitude level of the vibration causing the complaint before the repair?

4. How do you obtain the exact frequency and amplitude of any spike displayed?

5. What is your plan if you find a significantly large spike that is not over an arrow?

6. What type of vibrations and sounds are the technician expected to repair? Give examples.

   Explain.

7. What type of vibrations and sounds are beyond the scope of the technician? Give examples.

   Explain.
Questions (continued)

8. What is the value of the **diagnostic procedures** and the **NVH Analyzer** when dealing with vibrations that require assistance?

9. **List** the information necessary prior to calling for assistance.

10. On the Stored Data Blocks screen which is the **most current** stored data and where is the **default** position of the cursor?

11. **How many** data blocks can be stored?

   What are the **active keys** required to store data?

12. What happens if you hit **ENTER** to save **paused** data and the all the **blocks are full**?

13. **When** do you get the “Review Old Data” screen?

   Under what **conditions** does it appear?

14. What are the **two ways** to delete data saved?

15. What is missing when analyzing data on the training software compared to analyzing data during the Road Test?
### QUESTION 1. ANTICIPATED VIBRATION SOURCE/ORDER 2. BEST FREQUENCY RANGE 3. “SPIKES” ABOVE 125 Hz YES/NO 4. BEST AMPLITUDE RANGE

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### SYMPTOM 1

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WORKSHEET #3D
Dynamic NVH Data Analysis

Diagnostic Description: Dynamic NVH Data Analysis

The NVH training software used in worksheets #3A, #3B, and #3C provide excellent classroom training to introduce and develop basic skills with the NVH Analyzer.

This worksheet is designed to add the dynamic element of sensing the vibration or noise while analyzing the NVH data. Sensing the symptom while viewing the data develops the relationship between the vibration or noise and the spikes. The ability to make this relationship is key to duplicating and manipulating the symptom which will make diagnosis easier.

Instructions

1. Install the NVH/BREAK-OUT BOX Program Card.

2. Connect the Data Link Cable and the Accelerometer to the vehicle set up in the shop, using the Operator’s Manual.

3. Review the information from the Customer Interview Sheet and the Classification Flow Chart for the vehicle selected.

4. Use the skills gained in worksheet #3C to anticipate and develop a plan to analyze the data.

5. With the help of the instructor confirm the customer complaint in the vehicle set up in the shop.

6. Analyze the data while duplicating and manipulating the symptom, save and print a representative sample of each display. Attach to the sheet provided.

7. Based on the complaint information and the NVH data analysis, develop a plan for a pinpoint diagnosis.

8. Remove the “bug” and retest the vehicle to confirm the “repair”. Attach a screen print to sheet provided.

Questions

1. What are your conclusions from the NVH data analysis for developing a pinpoint diagnosis plan?

2. List the advantages of being able to sense the vibration or noise while analyzing the NVH data.
Questions (continued)

3. How does sensing the symptoms make the diagnosis more efficient than simply viewing the data in worksheet #3C?

4. After the “bugs” were identified would you have come to the same conclusions or a pinpoint diagnostic plan in question #1? Explain.
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<td>ATTACH SCREEN PRINT HERE</td>
</tr>
<tr>
<td></td>
<td>COMMENTS</td>
<td></td>
</tr>
</tbody>
</table>
Learning to associate the NVH data with vehicle vibrations takes practice and an understanding of how the different displays provide information. It is also helpful to understand how the displays can be compared to one another to isolate the data that relates to the complaint.
The road test techniques are also valuable when using an NVH analyzer while trying to isolate a complaint. Duplicating and controlling the symptoms during a road test can help identify specific data that responds in the same way as the symptom.

For safety reasons, the pause and save (F0 F6) features are helpful to store and review the data after the road test. It is very difficult to safely operate the vehicle and analyze data at the same time. A second person to operate the vehicle is also useful during a road test, especially if the vibration is intermittent.

For example:

The 2d display (which is a two dimensional display that plots the vibrations according to frequency and amplitude) is useful during the test drive of an engine vibration. The driver can shift the vehicle into neutral and coast while the technician watches or records the vibrations. The spikes on the display that are related to the engine should go away while the spikes that are related to the driveline or wheels should remain.

The barchart display is a three dimensional display that shows eleven samples of data, plotting the amount of energy of the vibrations in the three source groups:

- Engine
- Driveline
- Wheels and tires

The barchart display makes an excellent starting point for diagnosis. It is very helpful to determine where the most amount of energy is generated or how the energy is distributed.

A technician can decide which of the above areas to focus on when moving to the 2d or the 3d displays for more specific analysis of the vibrations.

For example:

While test driving a vehicle, the barchart display may show the majority of the energy in the area of the driveline. The technician can now switch to the 2d display (F1), select the driveline indicators (F3), and look for large spikes that fall above the driveline arrows. Large spikes would indicate vibrations that would generate the high energy levels on the bar chart display.
A large spike above a **driveline arrow** would confirm a driveline condition. The amplitude level can be **documented** for future reference. A technician can now focus the diagnosis in the driveline area.

The NVH Analyzer is designed to do the math required to associate a specific frequency vibration with one of the three groups listed above. It displays this by providing the terms “engine”, “driveline” or “wheels” on the display and arrows for various order vibrations. These arrows are placed below the display pointing to the associated frequencies. A “^” is used to depict the CV joint frequency when checking driveline vibrations.

### 2d Display Indicators

![Diagram](image_url)

- **ENGINE**
- **DRIVELINE**
- **WHEELS**
When using the NVH Analyzer it is very important that the **vehicle parameters** be verified for the vehicle being tested. Every effort has been made to provide an accurate data base but there are many variables and combinations involved with our vehicles.

### Vehicle Parameters Menu

![Vehicle Parameters Menu](image)

### Sticker on “B” Pillar

![Sticker on “B” Pillar](image)
It is possible to have a unique situation that requires research in the Repair Manuals, parts fiche, TSBs and NCFs to collect the specifications necessary to modify the data base.

When the data base is accurate, the arrows will properly line up with engine, driveline and wheel vibrations.

An LED will light and “overlap” will flash when there is a possible overlap situation. This indicates that more than one source needs to be considered for a vibration displayed on the screen. The arrow will also flash indicating which spike could be caused by more than one source.

For example:

When a vehicle is operating in fourth gear on a manual transmission it is possible for the gear ratio to be 1:1. The engine speed and the driveline speed are the same in this case, therefore an overlap could occur with a vibration generated by either area.

In this case an LED will light warning the technician of the overlap condition. The technician would view the other two groups (\( \frac{3}{3} \)) to identify the overlap. This is done by finding the spike that has an arrow pointing to it in more than one area (engine, driveline, wheels).

In this example, the technician could select a different gear or step on the clutch to make the engine and driveline RPM different. This would isolate the vibration to a specific source.
The 3d display provides a three dimensional (3d) view of the vibrations in a vehicle by displaying 11 spectral lines (2d) which provides a brief history of the vibrations. Each of the eleven lines is the same as one 2d line, showing frequency and amplitude. By stacking them, a technician can easily observe changes in the spikes as the symptom changes.

This is helpful when road testing a vehicle with a difficult condition to diagnosis. When the technician modifies the operating conditions of the vehicle, while trying to control the symptoms, the 3d display will show changes in the spike related to the complaint. Observing which spike changes as the symptom changes can identify the area causing the condition by looking at the arrow associated with that spike.
“VIBRATION” function

Continued

For example:

If you watch the normal engine firing vibrations on the 3d display, you will note a variation in the amplitude of the vibration due to power fluctuations of the engine. The power fluctuations are caused by changes in the air/fuel ratio in a normal feedback system.

Each of the displays can be changed to customize the parameters and focus in on a sample. These features allow the technician to eliminate data that is not applicable and provide a clearer view of the data that is relevant to the condition.

The parameters can be changed in the following way:

- Frequency band width (F2) forward & (F2) backward
- Floor and ceiling level of the amplitude scale ( )
- Engine, driveline and wheel indicators (F3)

**Frequency band width** is adjustable to the following four ranges using the F2 key:

- 0 - 500 Hz
- 0 - 250 Hz
- 0 - 125 Hz
- 0 - 62.5 Hz

The frequency band width **defaults to the 125 Hz scale** when the display is first selected from the vehicle parameters menu. Once in the display, if a different scale is selected, then it remains at that level as other displays are selected.

The scale selected is shown in **two places** on the 2d and 3d display as shown in fig. 2-21 and in the **upper right corner** of the barchart display.

The advantage of starting with the 125 Hz scale is that it gives a **clear view** of the spikes most likely generated by a vehicle. Once a spike or range has been identified, the appropriate band width can be selected using the F2 key. If the default is set at a smaller frequency band then a spike outside that range may be overlooked. A quick check of the 500 Hz scale will reveal any spikes that may appear above the default setting.

If there is an indicator arrow outside the frequency band selected, there will be a **flashing LED and frequency indicator** to warn the technician to check a larger frequency range for possible spikes.
The floor and ceiling level of the amplitude scale is adjustable from the default position of 10 to 30 dBG range with the \(\equiv\) keys. The following ranges are available:

- 0 - 20 dBG
- 10 - 30 dBG
- 20 - 40 dBG
- 30 - 50 dBG
- 40 - 60 dBG

The advantage of moving the amplitude window is to drop out of view spikes that are normal in a particular vehicle, leaving the larger amplitude spikes for analysis. The display becomes less confusing and easier to interpret.

**Default Settings for Frequency and Amplitude**

Fig. 2-21

---

**Amplitude**

2d

**Frequency**

BARCHART

3d

**Amplitude**

60 dB

**Frequency**

Engine
Additional display features include:
- RPM and MPH display
- Time display
- Cursor w/Hz and dBg (🕒زواره‌ی‌های‌ه‌ا۱۲۴)
- “NO data” indicator for RPM/MPH

The RPM and MPH are displayed in the upper left corner of the screen. This data is collected from the data link connected to a diagnostic connector identified in the vehicle parameter screen.

Many NVH complaints are related to RPM or vehicle speed. The display makes it convenient to monitor RPM and MPH from the check connector or data stream without additional test equipment.

There are two ways the tool obtains the data for RPM and MPH. The first is from the data stream on late model vehicles and the second is from the IG- signal on non-data stream vehicles. The tool is able to determine where to get the information when the vehicle is selected by the technician. The vehicles parameters screen has a line indicating the connector that has to be used. In addition, an asterisk is displayed next to the MPH indicator when gear selection is required by the user.

The tool is not able to determine the gear selection when using IG-. The technician needs to press F8 and select the gear manually for the driveline and wheel indicators to be accurate.
The default position for the gear selection is **the highest transmission gear available** and will be accurate when driving in that gear if a selection was not made.

Other differences between using the data stream and IG- include:

- The resolution of RPM on IG- is an actual reading, on the data stream it changes in 25 RPM increments.
- On IG- vehicles when the RPM is below 1600 the MPH reads 0.

RPM and MPH will be displayed if:

- The vehicle is equipped with functioning IG- in the under hood DLC1 (check connector)
- Data stream is available from the DLC1 (check connector), DLC2 (TDCL), or DLC3 (OBD2 connector)
- All connections are complete from the check connector to the NVH Analyzer
- The NVH Analyzer is functioning properly

**“NO data”** indicator for RPM/MPH is a feature that appears to let the technician know that there is no communication through the data link.

When a vehicle has both IG- and a data stream, the data stream should be used for accuracy. Check for a DLC2 (TDCL) or DLC3 connector and use it if available.

When using DLC2 (TDCL), the NVH Analyzer must be connected to the cigarette lighter for power. There is no B+ terminal in the DLC2 connector.

The **time** display provides the screen print with a **time stamp** which helps differentiate and sequence multiple printouts. It helps eliminate questions as to whether a printout applies to a specific vehicle or road test event.

A **cursor** is available with the use of the **< >** keys which allows the technician to find the exact frequency and amplitude of a particular spike. This is done by placing the cursor directly over the spike and reading the frequency and amplitude above the display. The indicators move with the cursor.

The cursor moves in **equal increments with each stroke** of the key or **progressively faster if the key is held**. If the end of the display is reached then the cursor automatically appears at the **opposite end** of the display.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Increment</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>4 Hz</td>
</tr>
<tr>
<td>250</td>
<td>2 Hz</td>
</tr>
<tr>
<td>125</td>
<td>1 Hz</td>
</tr>
<tr>
<td>62.5</td>
<td>.5 Hz</td>
</tr>
</tbody>
</table>
The noise selection from the main menu will function the same as the vibration selection. The menus for vehicle setup are the same and the noise function uses the same diagnostic displays. The exception is in the parameters for amplitude.

- dB is used instead of dBg
- The floor and ceiling level default is **65 to 85 dB**
- The following ranges are available:

  - 45 - 75 dB
  - 65 - 85 dB
  - 75 - 95 dB
  - 85 - 105 dB
  - 95 - 115 dB

A microphone is used instead of an accelerometer as an input for sound. The microphone is non-directional and cannot be used to find the location of a noise.

Noise function operates the same as the vibration function because a noise is also a vibration. The same skills used to isolate a vibration are also used with noise.

It is important to understand that noise can also be generated by:

- Rattles
- Squeaks
- Wind

These are in addition to noises that can be generated by the three component groups indicated by the arrows on the displays:

- Engine
- Driveline
- Wheels and tires

Rattles, squeaks and wind noise will be discussed in the last part of Section 4 and in the Wind and Interior Noise program. The techniques used to diagnose these areas are different than noises related to the three major sources that the NVH Analyzer is able to display.

Rattles are usually low frequency, low amplitude and intermittent making them difficult to identify on a vibration analyzer.

Squeaks and wind noise are usually high frequency above the 500 Hz limit of the NVH Analyzer.

Other noises of significant amplitude, which are within the NVH Analyzer frequency limits, can be displayed on either the vibration or the noise selection.
The classification process discussed earlier is very helpful in identifying the frequency range of a noise to determine which diagnostic technique is most appropriate:

- For frequency ranges below 500 Hz, the NVH Analyzer can identify one of the three sources of vibration: engine, driveline, wheels.
- For frequencies above 500 Hz, a pinpoint diagnosis for rattles, squeaks or wind noise should be used.

The ability to control the noise, through test driving techniques, can produce a relationship between the noise and the spike displayed on the NVH Analyzer.

For example:

If a noise appears at a specific speed or operating condition then the technician needs to become familiar with the data displayed when there is no noise. When the noise appears then the spike that was not there before should be identified. If the spike appears above a pointer associated with a component group then diagnosis should be directed in that area.

If the frequency of a vibration or noise spike is not associated with an arrow, then the frequency should be multiplied by 60 to find the RPM. The components operating at that RPM can be considered for diagnosis.

The skills developed in using the NVH Analyzer are now applied in the next area of diagnosis, the road test.

Install NVH Analyzer to monitor and record NVH and vehicle data (See NVH Analyzer operating and instruction manual for details).

A tachometer is recommended if a NVH Analyzer is not available and the vehicle is not equipped with a tach. MPH can be noted from the speedometer.

A road test course should be selected that allows for safe operating conditions that will duplicate the customer’s complaint. Frequent use of the same course will allow the technician to develop experience in predicting what normal vibrations can be expected during different aspects of the road test.

Known good vehicles should be analyzed on this course for comparison with complaint vehicles. This will be most helpful when looking for spikes, related to complaints, on a NVH Analyzer display.
Engine Run-up Test  
After installing the NVH Analyzer, use the engine run-up test to determine if the complaint is related to engine speed or vehicle speed.

With the information from the interview sheet, and the complaint verification, try to duplicate the symptom by creating the same vehicle and operating conditions described by the customer.

Start at idle, cold or hot, (if applicable) then increase the engine RPM with the transmission in Park or Neutral.

If the symptoms occur, record the vibration to capture the engine RPM, frequency and amplitude of the complaint for future reference. Further road test procedures are not necessary.

If a vibration occurs, but does not directly relate to an engine vibration indicator, then an accessory such as power steering, A/C, or water pump should be considered.

These components operate at different speeds/frequencies relative to the pulley diameter. Using the calculations outlined in Section 1 and a photo tach, you can identify the accessory that is related to a spike on the NVH display.

**Shifting the vehicle into neutral** when the symptoms occur will also help confirm if the complaint is engine or vehicle speed related. If the vibration goes away as the engine RPM goes to idle, further diagnosis in the engine area is required.

Brake Torque Test  
Some engine related vibrations may be sensitive to load. Block the wheels, set the brakes and raise the engine RPM with the transmission in drive. This will apply a load on the vehicle which may cause components to move and vibrate, that would not under normal operating conditions. Use the 3d screen to easily recognize unusual or different vibration.

For example:
- motor mounts
- exhaust system contact
- engine misfire

**CAUTION**  
Use care not to overheat the engine or transmission.

Light Acceleration Test  
If the above tests do not duplicate the complaint then perform the light acceleration test. Accelerate on a smooth, level surface until the symptoms are present. Record the vibration at the point when it is most noticeable.

Note if the vibration changes or disappears when cruise is maintained, after acceleration. If it occurs perform a heavy acceleration to see if the condition can be exaggerated.
Some conditions require the vehicle to be under load, for example, a propeller shaft vibration. Heavy acceleration and/or a road test course that includes a hill will be helpful to provide the load required to duplicate the complaint.

For example:

Loading and unloading a driveline is very helpful in isolating a propeller shaft condition, especially when there is an overlap indicated on the NVH Analyzer for driveline and wheels. As the driveline loading changes a propeller shaft vibration will change. A condition in the wheel area will tend to stay constant.

An overlap indication is indicated on the NVH Analyzer with the word “overlap” displayed on the screen and an LED light below the screen. When this occurs, the technician should change the vehicle condition to eliminate the overlap and observe the spikes that remain.

Some engine related vibrations, transmitted through the exhaust, are also more noticeable under load than during an engine run-up test.

Cruise is often the most common operating condition of a complaint. It is much easier to “tune” into a particular symptom when it is continuous.

In addition to constant vibrations, beating vibrations that come and go need to be observed during cruise over a longer period of time. A noticeable beat may occur in 4-6 second cycles.

Although the customer may indicate that the vibration occurs at a particular speed, the road test should include several cruise speeds, (i.e. 35, 45, 55 MPH). The speed the customer mentions may be the most common operating speed and not the speed that produces the greatest amplitude.

For example:

Tire vibrations are often most noticeable when they resonate with the suspension or steering system between 40 and 55 MPH. Driveline vibrations are often more noticeable at speeds above 50 MPH.

A road test should also include some rough road to induce energy into the suspension that may produce vibrations or shimmy in the steering wheel.

For example:

A leaking front strut will cause a suspension and steering system to resonate on a rough road.

Rough road conditions may also produce noises such as squeaks or rattles that are not as noticeable on a smooth road.
Coasting  The advantage of coasting is that it **eliminates engine vibrations** and **load**. The vehicle environment may become quieter making it easier to notice noises that are **masked** by other sounds.

Deceleration  Deceleration is similar to coasting with the **addition** of **load** caused by engine compression. The load is a different force than load applied during acceleration. This will cause components to react differently under these conditions, producing a larger level vibration.

Turning  CV joint symptoms often appear in a turn when the joint angle increases. In many cases, the NVH Analyzer will show an overlap with a third order wheel vibration. Putting a load on the CV joint may **increase the level of the vibration**, while the third order wheel level would remain the same.

Turns are also helpful in identifying vibrations from components **which contact the body**. **Worn suspension parts** may shift with a side load.

The customer interview sheet can be very helpful to identify the need for this type of test.

Jounce Test  A technician may be able to reproduce a noise by simply **bouncing the vehicle up and down**. It should be done at each quarter of the vehicle while observing components and listening for sounds. A second person is helpful during this test.
Additional Road Test Considerations  When the symptom is at its most noticeable level, the technician can try to control or modify the symptoms to help isolate the source. The following chart is a list of additional items to keep in mind while trying to diagnose a complaint. You may add items as you gain experience with NVH diagnosis:

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles w/o locking torque converters</td>
<td>A few of our vehicles do not have locking torque converters. The NVH Analyzer calculates MPH using RPM and the gear ratio database. In these cases it is important to make sure the vehicle is not under load and that stable cruise has been established for accurate driveline and wheel arrow indicators.</td>
</tr>
<tr>
<td>Brake application</td>
<td>Lightly applying the brake at cruise may produce a vibration at wheel speed frequency. Pedal feel is important during this procedure. Lightly applying the parking braking will do the same as the above but only to the rear wheels. This can be helpful in isolating a front or rear brake condition. Caution: Use care not to overheat the brakes in this procedure. Damage and additional vibration may result.</td>
</tr>
<tr>
<td>4x4 vehicles</td>
<td>4x4 vehicles have additional driveline components that may be engaged, disengaged or removed to determine which group is contributing to the complaint,</td>
</tr>
<tr>
<td>Accessories</td>
<td>Turning accessories on and off may also have an impact on the symptoms. They may cause a belt to resonate or slip. This test may also effect an accessory condition caused by a worn bearing, mounting or slipping A/C clutch.</td>
</tr>
<tr>
<td>Electric cooling fans</td>
<td>Cooling fans often require a specific temperature level to engage. A fan imbalance or runout condition may only be identified when the fan engages at that temperature.</td>
</tr>
<tr>
<td>Power steering</td>
<td>Symptoms relating to power steering may be temperature related. These conditions may only be present with the system under load. For example: a vibrating high pressure hose caused by incorrect mounting or routing.</td>
</tr>
</tbody>
</table>
Alternative Diagnostic Methods

Although the road test or a dynamometer is ideal, and sometimes the only way to duplicate a customer complaint, the use of a lift or safety stands can also be helpful for diagnosis.

In order for this technique to be safe and effective, the following details must be considered:

- **Verification** of the customer complaint is very important to determine when diagnosis without a road test will produce the symptoms. Not all complaints can be duplicated without setting up the same vehicle and operating conditions. For example, the ability to apply a load to a system.

- To duplicate many driveline and suspension complaints the vehicle has to be raised maintaining the correct operating angles.

New vibrations may occur on a lift that do not exist on the road. This is due to the change in loading of the suspension and possible interaction of the vehicle with the lift. The lift is now carrying the weight of the vehicle not the tires and wheel bearings.

**Balance is critical** in safely operating a vehicle in a shop. Normal vibrations may cause a vehicle to move out of position or fall.

- Operating one drive wheel while the other is stationary is a technique used to isolate a symptom. The front wheels on a FR vehicle or the rear wheels on a FF vehicle cannot simulate operating movement and will not contribute to the vibrations in a vehicle. This can be helpful if the vibration complaint that was verified goes away.

It is important to remember that the wheel will rotate at twice the speed indicated on the speedometer, due to the differential.

For example:

If the speedometer is indicating 40 MPH and one drive wheel is stationary while the other is turning, then the turning wheel is rotating at 80 MPH.

If the stationary wheel is on the ground the vehicle could move causing severe damage. This is especially true in vehicles with limited slip differentials.

**Traction Control** must be turned off on vehicles so equipped. Due to the differential in wheel speed the system will activate.

The advantages of this type of diagnosis include:

- The ability to perform a good visual inspection while the vehicle is operating. For example, observing runout of a wheel or tire.

- The ability to use tools such as a stethoscope or a screw driver to amplify a vibration on specific components.
Diagnostic Description: **Road Test with the NVH Analyzer Vibration Function**

The road test is a **diagnostic procedure** designed to **duplicate** and **manipulate** the symptoms in order to gain as much **additional knowledge** as possible. This knowledge will help identify the source of the symptom by a **process of elimination**.

This worksheet is the **third** in the series of worksheets that is used to diagnose the conditions placed in the **shop vehicles** by your instructor.

**Road Test Procedures**

Fig. 2-23

1. Connect NVH Analyzer
2. Engine Run-up
3. Light Acceleration
4. Heavy Acceleration
5. Cruise
6. Coasting
7. Deceleration
8. Turning
9. Brake Torque
10. Jounce
Instructions

1. The technician should use all the information collected during the Verification of the complaint (worksheet #1) and the Classification Flow Chart (worksheet #2) to establish a road test plan that is most likely to duplicate the symptom/s. The symptom/s can then be manipulated and measured with the NVH Analyzer. (Refer to Section 2 of the technician handbook.)

2. Consider the possible sources of the complaint from the information in step #1 and develop a strategy for analyzing the NVH data during the road test.

3. Connect the NVH Analyzer to the vehicle, perform the road test and save the data relating to the symptoms.

4. Take notes regarding the road test procedures and results for review with the saved data.

   For example:

   Note if the symptom was most noticeable in a left turn on a hill. The analyzer will display MPH and RPM but cannot tell you the additional information about the road test that you may have performed to duplicate the symptom. With several possible saved samples you may become confused without good notes.

5. Review the data saved on all the displays using the skills developed during NVH data analysis worksheets #3A, #3B & #3C.

6. Identify the spikes on the 2d and 3d displays that are associated with the symptoms and compare the conclusions with the data on the barchart display.

7. Determine the source of the symptoms, including the order, that will be the focus for the pinpoint diagnosis.

8. Print the screens and attach with the space provided to support your conclusions.

9. Add the notes from the road test that will help identify the source of the complaint and the pinpoint diagnosis area.

10. Compare your results with the plan you formulated in step #1 and #2.

11. Remove the “bugs”, retest and compare your results. Attach screen print to the space provided.

Questions

1. List the road test procedures you plan to use to measure and duplicate the complaint.

2. What is the advantage of making the road test plan prior to performing the test?

3. What page in Section 2 did you find the details of the road test?

4. Outline the strategy you plan to use to analyze the NVH data during the road test.
Section 2

5. \textbf{Where} did you connect the \textbf{data link cable} to the vehicle?

6. How did you determine this \textbf{location}?

7. \textbf{Where} did you locate the \textbf{accelerometer} and why?

8. List \textbf{two} items that are important to consider when \textbf{positioning} the accelerometer. Explain each.

9. \textbf{How many people} should be involved in a road test and why?

10. \textbf{How many events} should be saved and why?

11. What are \textbf{two} advantages of taking the \textbf{printer} along for the road test, if available?

12. \textbf{How many large spikes} are displayed on the 2d display?
13. **Record** the frequency and amplitude of the **significant** spikes on the chart below.

<table>
<thead>
<tr>
<th></th>
<th>FIRST ORDER Freq/Ampl</th>
<th>SECOND ORDER Freq/Ampl</th>
<th>THIRD ORDER Freq/Ampl</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGINE</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>DRIVELINE</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>WHEELS</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
</tbody>
</table>

14. What is the **incremental movements** of the cursor on the:
   - 62.5 Hz scale ______________________
   - 125 Hz scale ______________________
   - 250 Hz scale ______________________
   - 500 Hz scale ______________________

15. What happens to the **cursor** if you **hold** your finger on the key?

16. On the **barchart** display which component sources indicate a large level of vibration/energy?

17. **Manipulating** the vibration during the road test can be seen **best** on which display? Explain.

18. Which display would show a **beating symptom** the best? Explain.

19. What is the **next display** you would look at once a beating symptom has been observed in question 18? Explain?

20. Which vibration **changes** frequency when **different gears** are selected with a **constant vehicle speed**?

21. What are the advantages of the **time indicator**? Explain.
Conclusion

1. Based on the information used to set up the road test and the data from the NVH Analyzer, what is your plan of action for the pinpoint diagnosis?

2. Did you notice an improvement in the vehicle condition after the “bugs” were removed?

3. Did the NVH Analyzer indicate an improvement? How much?

4. Upon discovering the “bugs” was your plan for pinpoint diagnosis on track? Explain.
<table>
<thead>
<tr>
<th>2D</th>
<th>BARCHART</th>
<th>3D</th>
</tr>
</thead>
<tbody>
<tr>
<td>BEFORE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATTACH SCREEN PRINT HERE</td>
<td>ATTACH SCREEN PRINT HERE</td>
<td>ATTACH SCREEN PRINT HERE</td>
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<tr>
<td>AFTER</td>
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<td>ATTACH SCREEN PRINT HERE</td>
<td>ATTACH SCREEN PRINT HERE</td>
<td>ATTACH SCREEN PRINT HERE</td>
</tr>
<tr>
<td>COMMENTS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Diagnostic Description: **Road Test with the NVH Analyzer Microphone Function**

The microphone (optional) is added to the Toyota Diagnostic Tool Set to assist in diagnosing noise complaints. It uses the same menus, displays and key strokes as the vibration function.

This worksheet is designed to demonstrate the **functions** of the noise analyzer with the microphone.

**Road Test Procedures**

Fig. 2-24

1. Connect NVH Analyzer
2. Engine Run-up
3. Light Acceleration
4. Heavy Acceleration
5. Cruise
6. Coastling
7. Deceleration
8. Turning
9. Brake Torque
10. Jounce
Instructions
1. On the same vehicle you diagnosed in worksheet #4A, connect the NVH Analyzer with the microphone and select the NOISE function on the NVH MAIN MENU.

2. Road test the vehicle duplicating the symptom and review the data on all the displays.

3. Move the microphone around the vehicle and note any changes.

4. Save representative displays that provide the clearest view of the spikes associated with the complaint.

5. Print each display and compare them to the print outs captured in worksheet #4A. Attach screen print to the space provided.

Questions
1. Are there any differences in the menu structures, key strokes or displays? Please list.

2. What frequency ranges are available for diagnosis?

3. How is the amplitude measured?

   What are the ranges?

4. When the microphone was moved around the vehicle did you note any significant change?

5. What conclusions can you draw about the use of the microphone in finding the location of a noise?

6. Where is the best location for the microphone for noise diagnosis?

7. What types of noises can be diagnosed with the microphone? Explain.
Section 2

8. What type of noises cannot be diagnosed with the microphone? Explain.

9. How would you resolve noise complaints that are not diagnosed with the NVH Analyzer?
   Where do you get the information?

10. What are the similarities between the microphone and the accelerometer for diagnosis?

11. What principle in Section 1 of the text explains the phenomenon in question 10?
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<th>BARCHART</th>
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Summary

At this point in the diagnosis, the technician has used the following to classify the complaint:

- Interview sheet
- Flow chart
- Road test with NVH Analyzer

The classification process has reduced a large list of possible symptoms to just a few which fit the complaint.

The technician can now use the specific characteristics associated with the symptom to perform the pinpoint diagnosis, which will be the subject of the next section. (See Section 1 details on the characteristics associated with a specific classification)

Case Study: Part III

The interview sheet was used to choose the following road test from the procedures outlined on the road test reference card:

- 40 - 60 MPH
- Cruise

The NVH Analyzer “Vibration Selection” was used during the road test to capture the data. The technician selected the vibration function because the complaint was described as a vibration and a noise. We know that a noise is also a vibration which can be displayed on the tool. (Section 1)

The displays shown were selected based on the information gathered during the verification of the complaint.

- Barchart display shows the largest amount of energy divided between the wheel and driveline areas, with very little energy visible in the engine area.

- 2d display shows two large spikes in the 125 Hz frequency range.
  - The default frequency band (125 Hz) clearly displays the two spikes in question
  - The default amplitude window eliminates spikes that may normally appear in a 4Runner
  - The cursor is moved over the spikes in question to display the exact frequency and amplitude
  - The F3 key is toggled to see if the engine, driveline or wheel arrows line up with the spikes
  - Two displays are captured and printed for future reference, because at 55 MPH the 12 Hz frequency spike lines up with the wheel arrow and the 54 Hz frequency spike line up with the driveline arrow. This information supports the data shown on the barchart display.
Case Study: Part III  Continued

The 3d display is consulted during the road test to follow the movement of the largest spikes while the operator alters the symptoms observed between 40 and 60 MPH. We verify that the spikes in question are vehicle speed sensitive versus engine speed sensitive. When the driver shifts the vehicle to neutral, at the point when the symptoms are most noticeable, the spikes remained.

4Runner Scenario

Fig. 2-25

The data indicates that there are two possible conditions contributing to the complaint. One in the area of wheels and the other in the area of driveline.

The road test eliminated the engine as a source of the complaint and maximized the symptoms for measuring.

The next section will deal with the pinpoint diagnosis of the steering shimmy and the body booming in the driveline and wheel areas.