ASE 1 - Engine Repair

Module 7

General Engine Diagnosis
Acknowledgements

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<table>
<thead>
<tr>
<th>Lesson</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Static Compression Test</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>Static Compression Test</td>
<td>46</td>
</tr>
<tr>
<td>5</td>
<td>Running Compression Test</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>How to Perform a Running Compression Test</td>
<td>48</td>
</tr>
<tr>
<td>6</td>
<td>Cylinder Leakage Test</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Cylinder Leakage Test - Testing Procedure</td>
<td>50</td>
</tr>
<tr>
<td>7</td>
<td>Restricted Exhaust Test</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>Restricted Exhaust Diagnostic Chart</td>
<td>53</td>
</tr>
<tr>
<td>8</td>
<td>Vacuum Test</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Vacuum Test Diagnosis Chart</td>
<td>57</td>
</tr>
<tr>
<td>9</td>
<td>Oil Pressure Test</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>Engine Oil Functions</td>
<td>58</td>
</tr>
<tr>
<td>10</td>
<td>Engine Speed-Related Vibrations</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>Isolating Vibrations</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>Exercise 7-1</td>
<td>66</td>
</tr>
</tbody>
</table>
Introduction

After completing this unit, the technician will demonstrate an understanding of general engine diagnosis. The technician will also demonstrate the skills required to troubleshoot general engine diagnosis and general engine customer concerns.

Objectives

NATEF Area A1
A. General Engine Diagnosis; Removal and Reinstallation (R & R)
   1. Identify and interpret engine concern; determine necessary action.
   2. Research applicable vehicle and service information, such as internal engine operation, vehicle service history, service precautions, and technical service bulletins.
   3. Locate and interpret vehicle and major component identification numbers (VIN, vehicle certification labels, and calibration decals).
   4. Inspect engine assembly for fuel, oil, coolant, and other leaks; determine necessary action.
   5. Diagnose engine noises and vibrations; determine necessary action.
   6. Diagnose the cause of excessive oil consumption, unusual engine exhaust color, odor, and sound; determine necessary action.
   7. Perform engine vacuum tests; determine necessary action.
   8. Perform cylinder power balance tests; determine necessary action.
   9. Perform cylinder compression tests; determine necessary action.
  10. Perform cylinder leakage tests; determine necessary action.
Engine Repair

D. Lubrication and Cooling Systems Diagnosis and Repair

1. Perform oil pressure tests; determine necessary action.

STC Tasks:

A. Engine Mechanical Diagnosis and Testing

1. Describe the process for conducting a compression test
2. Describe the process for conducting an engine vacuum test
3. Describe the cylinder leakage test
4. Describe the fluid leak diagnosis process
5. Describe the oil pressure test procedure
6. Describe camshaft timing and related diagnostics
8. Describe engine mechanical diagnostic procedures
9. Verify driver's complaint, perform visual inspection and/or road test vehicle; determine needed action
10. Research applicable vehicle information, such as engine management system operation, vehicle service history, service precautions, and technical service bulletins.
11. Diagnose the cause of unusual engine noise and/or vibration problems; determine needed action
12. Diagnose the cause of unusual exhaust color, odor, and sound
13. Perform engine manifold vacuum or pressure tests
14. Perform cylinder power balance test
15. Perform cylinder cranking compression test
16. Perform cylinder leakage test
18. Verify correct camshaft timing
19. Verify proper engine operating temperature, check coolant level and condition
22. Diagnose the cause of excessive oil consumption
23. Diagnose the cause of excessive coolant consumption
I. Verify customer concerns, make quick checks and perform a system diagnostic check related to engine mechanical system faults.
   1. Describe how to perform a system diagnostic check.

J. Perform engine valve timing component service procedures.
   1. Remove and install the engine valve timing components.

L. Perform engine diagnostic procedures.
   1. Perform engine vacuum gauge diagnostic check.
   2. Perform an engine external oil leak diagnostic check.

O. Perform an engine compression test.
   1. Perform an engine compression test.

R. Perform an engine cylinder leakage test.
   1. Perform an engine cylinder leakage test.
Lesson 1: Oil/Fluid Leak Diagnosis

Introduction

After completing this unit, the technician will demonstrate an understanding of oil leak diagnosis. The technician will also demonstrate the skills required to troubleshoot oil leak diagnosis and address customer concerns.

Objective

Describe the procedures to check for oil leaks and identify possible sources of oil leaks.

Notice:

It is important to correctly identify the source of an oil leak. A power steering fluid leak or spillage can travel across the valley area of the engine and run out the weep hole, which is located at the back of the block. Failure to correctly identify the source of an oil leak can lead to the incorrect or unnecessary replacement of components.

Fluid Leaks

Although oil is one of the main fluids in the engine compartment, there are several other types of fluid that can be mistaken for an oil leak. Many times as fluid migrates through the engine compartment, it will pick up debris and may not be easy to identify.

Engine Compartment Fluids

- Coolant
- Power steering fluid
- A/C PAG oil
- Transmission fluid
- Front axle lube
- Electrolyte
Any of these fluids can migrate from the leak point and travel down the engine. You can repair most fluid leaks by first visually locating the leak, repairing or replacing the component, or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the cause of the leak as well as the leak itself.

To determine if the leaking fluid is engine oil, transmission fluid, power steering fluid, brake fluid, or some other fluid, use the visual inspection method.

**Visual Inspection Method**

1. Bring the vehicle to normal operating temperature.
2. Park the vehicle over a large sheet of paper, or other clean surface.
3. Wait several minutes, and then check for drippings.
4. Identify the type of fluid, and the approximate location of the leak.
5. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.
6. Check for leaks at sealing surfaces, fittings, or from cracked or damaged components.
7. If you cannot locate the leak, do the following:
   a. Completely clean the entire engine and surrounding components.
   b. Operate the vehicle for several miles at normal operation temperature and at varying speeds.
   c. Park the vehicle over a large sheet of paper, or other clean surface.
   d. Wait several minutes, and then check for drippings.
   e. Identify the type of fluid, and the approximate location of the leak.
   f. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.
   g. See possible causes for leaks.

If you still cannot locate the leak, use the powder method or the black light and dye method.
**Powder Method**

1. Completely clean the entire engine and surrounding components.
2. Apply an aerosol-type powder (baby powder, foot powder, etc.) to the suspected area.
3. Operate the vehicle for several miles at normal operation temperature and at varying speeds.
4. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface.
5. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.
6. See possible causes for leaks.

To identify the source of the leak, it's often necessary to use leak dye to identify the leak point and thus the type of fluid.

**Black Light and Dye Method**

1. A dye and light kit is available for finding leaks. Use the J 28428-E or equivalent. Refer to the manufacturer's instructions when using the tool.
2. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.
3. See possible causes for leaks.
Leak Checking Procedure

• The leak dye and black light is one of the best methods for isolating leaks.

• Prior to dye installation, check for presence of dye in engine compartment using black light.

• Dyes for many of the fluids in an engine compartment are all the same color. If they were previously used, there may still be traces, so clean them off to prevent misdiagnosis.

• Next, pour the dye into crankcase and start engine to allow dye to circulate through engine oil passages.

• The engine should run for several minutes to allow the dye to migrate to the leak point.

• Then use black light to search for dye. Use goggles since they enhance the dye.

Figure 7-1, Leak Checking
Notice:
Remember, small leaks may require additional time to become visible. Leak may only occur as the engine cools down.

Important:
Do not get dye on the vehicle finish since it can damage the paint.

Possible Causes for Leaks
Check for the following conditions:
• Higher than recommended fluid levels
• Higher than recommended fluid pressures
• Plugged or malfunctioning fluid filters or pressure bypass valves
• Plugged or malfunctioning engine ventilation system
• Improperly tightened or damaged fasteners
• Cracked or porous components
• Improper sealants or gaskets where required
• Improper sealant or gasket installation
• Damaged or worn gaskets or seals
• Damaged or worn sealing surfaces
Loss of Coolant

1. Check for an incorrect or faulty surge tank cap.
2. Ensure that the cooling system is full.
3. Pressure test the cooling system.
4. While the cooling system is pressurized, inspect for any external coolant leaks.
5. Repair or replace the leaking component(s) as necessary.
6. Check the heater core for leakage.
7. Start the engine and inspect.
8. Check for excessive white smoke from the exhaust and/or rough engine idle.
9. Road test the vehicle and allow the engine to reach full operating temperature.
10. Make sure the engine does not overheat.
11. Remove the oil level indicator stick and inspect.

Important:
Ensure that the cause of the creamy or milky substance is not caused by short drive cycles or a faulty thermostat. Either of these conditions will cause creamy or milky deposits to form in the engine oil because the engine cannot reach full operating temperature in order to dissipate the condensation/moisture.

12. Make sure the engine reached full operating temperature during all of the vehicle drive cycles. The probable cause of the coolant loss is an engine internal coolant leak. If the spark plug electrodes or the porcelain surrounding the spark plug electrodes exhibit signs of coolant, replace the applicable cylinder head(s) or cylinder head gasket(s).
13. Ensure that the cooling system is full. (Refer to Draining and Filling Cooling System).
14. Operate the system in order to verify the repair.
Lesson 2: Engine Mechanical Noises

Introduction
After completing this unit, the technician will be able to apply concepts and procedures to diagnose engine mechanical concerns.

Objective
- Identify the primary types of engine mechanical noise.
- Explain what engine noises sound like.
- Explain how engine noise can be affected by load.
- Identify the type of engine faults that can cause the various engine noises.
- Explain how engine noise can cause a misfire DTC.

There are four steps to diagnosing engine noise. You must determine the following conditions:
- Type of noise.
- Determine the exact operating condition under which the noise exists.
- At what rate, and at what location in the engine.
- Compare sounds in other engines to make sure you are not trying to correct a normal condition.

Primary Abnormal Engine Noises
There are two broad categories that the service information uses to classify noise.
- Upper engine or valve train noise: generally associated with tick.
- Lower engine noise: generally associated with knock

In order to make the best use of the service information you must be able to classify an engine noise in one of these two categories.
Upper Engine (Valve Train) Noise

Valve train noise is generally associated with a ticking noise. Although not all valve train noises make the same type of ticking noise, their occurrence will be related to the speed of the camshaft.

Valve train noise is related to engine speed:
- The camshaft drives valve train components.
- The camshaft rotates at half the speed of the crankshaft; therefore, valve train noises will be at 1/2 engine speed.
- Engine speed is based on the crankshaft speed.
- For example, if the engine speed is 600 RPM, the cam speed will be 300 RPM. The valve train noise will occur 5 times per second.

General Sources of Valve Train Noise

- Camshaft(s)
- Lifters/Stationary Hydraulic Lash Adjusters (SHLA)
- Pushrods
- Rocker arms
- Valve components
- Guides
- Carbon build up on valves
- Timing chain
- Balance shaft

Noises related to these items will increase in frequency as the engine RPM increases. For example, as the engine RPM increases they will occur more often, but still at half engine RPM.
Lower Engine Noise

General Sources
Lower engine noise is generally associated with a knocking noise, and occurs once per engine revolution. At 600 RPM, a lower engine noise will occur 10 times per second.

Lower Engine Knocking Sources
• Piston slap
• Main/rod bearing knock
• Piston pin knock
• Flywheel (loose or broken)
• Carbon in the combustion chamber

Noises related to these items will increase in frequency as the engine RPM increases, and are directly related to engine RPM. However, some knock noises will be more pronounced when the cylinder is under pressure during the compression and power strokes. Engine noises can change with engine load or temperature.

How Load Affects Engine Noises
• Engine load can change the intensity of the noise.
• The noise may only occur or be more noticeable under a heavy load.
• For example, a bearing with excessive clearance may not create a noise at idle, but will knock when in gear.

How Temperature Affects Engine Noises
• Some noises may only occur when the engine is either cold or at operating temperature.
• Some clearance-related noises will decrease in intensity when the engine warms-up and the engine components expand, taking up the clearance.
• Lubrication concerns may only appear when the engine is at operating temperature.
• Carbon in the cylinder will generally only cause noise when the engine is cold and it goes away when the engine warms-up.
Top Engine Cleaner

- Used to clean carbon deposits from internal engine components. Does not require engine disassembly.
- Start the engine and allow it to reach operating temp.
- With engine idling, disconnect PCV hose from PCV valve and slowly spray top engine cleaner into hose.
- Raise engine speed to approx. 2000 rpm and when white smoke is coming out of exhaust, shut off engine.
- Let cleaner work for at least 20 minutes.
- Start engine and increase speed to 2000 RPM until exhaust is no longer white. This will remove the cleaner.
- Remember to change oil; cleaner could contaminate it.
- If the noise was result of carbon, this should remove it. If the noise is still present, perform additional diagnostics.

Notice:

There has been a lot of concern about carbon build-up recently and there are bulletins related to this topic. Make sure you check for bulletins before performing service. Most times, the bulletins have procedures that were created as a result of working and testing on vehicles with the concern.

Upper Engine Faults

As with any diagnosis, do the easiest things first. Here are examples of some external engine faults that could create what may sound like an upper engine noise.

The first area is accessories. They can create a variety of noises, but if there is an engine noise, take a few minutes to make sure it’s not related to the accessories.
Figure 7-3, Accessory Drive Belt
Figure 7-4, Generator

Figure 7-5, Power Steering Pump
In addition to the accessory system there are several other areas that should be checked that are external to the engine.

Loose spark plug:
- Changing pressure inside the cylinder pushes and pulls the spark plug against the threads of the cylinder head.
- This causes a metal-to-metal clicking noise.
- A loose spark plug may be caused by damaged threads, requiring thread repair.
- Remember, spark plug threads in aluminum cylinder heads are frequently damaged when removing them with the engine hot.

Exhaust leak:
- Unmuffled exhaust pulses can escape through leaks.
- This can cause a ticking noise.

Internal Components

Primary Areas for Upper Engine Noises
- Upper valve train
- Timing chains

The upper valve train is any component that is being driven by the camshaft or camshafts. To help isolate the source of the noise, use chassis ears or a stethoscope.
Valve Train Noise Isolation

- Use the wooden handle of a hammer and place it on the rocker arms.
- Requires engine to run with valve covers removed. So, make sure oil does not drip on any hot surfaces, and keep body parts and clothing away from moving components.
- Using the wooden handle against the rocker arms removes the clearance in the valve train. If there is noise caused by excessive clearance it should go away when placing tension on rocker arm.
- You’ll have to do this to each rocker arm to determine which valve train component is creating the noise.
- Check both sides of rocker arm. First take the clearance out of valve side then out of the camshaft side.
- If valve train noise goes away or is reduced when handle is placed on valve side, check valve clearance, rocker arm and valve components for damage.
- If noise reduces or goes away when the handle is placed on camshaft side, check rocker arm, pushrod, lifter and camshaft for damage.

Figure 7-6, Valve Train Noise Isolation
Inspections for the Various Components

Checking Valve Clearance

• Start by checking the valve clearance:
  – If there is excessive clearance, determine what is causing it. This may include checking the camshaft lobes.
  – If the clearance is OK, start checking for indications of insufficient lubrication.
  – If the lubrication isn't the cause, check for carbon on the valves and for valve damage.
  – If the valve clearance is incorrect, inspect for several things, starting with the easier checks.

Figure 7-7, Checking Valve Clearance
RockerArm

- Loose and/or worn rocker arm and attachments:
  - Inspect for damage at the arm, stud, nut or bolt.
  - Check the torque to make certain it was torqued to specification.

*Figure 7-8, Rocker Arm Inspection*
Valve Lifter

- Worn or dirty valve lifters or Stationary Hydraulic Lash Adjusters (SHLAs):
  - Inspect for lifter plungers that will not move and debris in the general area of the lifter.
- Bent or damaged push rods:
  - Inspect for damage at the push rod ends.

Inspecting for a Bent Push Rod

- Roll push rod on a flat surface to detect bent condition.
- If it doesn't roll smoothly it's bent.
- A bent push rod is often an indication of a stuck component (like a valve) or an engine over speed condition.
Valve Retainer (Exhaust Only)

- Worn and/or damaged valve retainers:
- Inspect for wear, cracks and metal spalling.

Valve Spring

Inspection points:

- Broken valve springs:
- Inspect for cracks; these can weaken the spring.
- Inspect for damaged retainers, these can mis-position the valve, or in the worst case, allow valve-to-piston contact.

While inspecting components, check for evidence of insufficient lubrication. This can cause components to prematurely wear and create clearance concerns.

Inspection for a lubrication concern:

- Inspect for overheating conditions.
- Discoloration and metal spalling.
- If a lubrication concern is suspected, check oil circuits and oil pump operation.

Valve Guide

Inspection points:

- Inspect for cracks, internal wear and metal scoring.
- Check to see if the valve can be opened by rotating the crankshaft.
- Remember, a stuck valve generally causes damage somewhere else in the valve train. Something has to give.

Overhead Valve

- Rock the valve back and forth to determine if the valve guide or stem is worn.
- To prevent the valve from dropping into the cylinder with the valve spring and retainer removed, apply air pressure to the cylinder. Use the appropriate tools specified in service information.
- Then rock the valve to determine if there is excessive clearance between the valve guide and stem.

If there is a valve or guide concern, most likely the cylinder head will have to be removed for further diagnosis. The only way around this is to use a Boroscope.
Figure 7-11, Overhead Valve Inspections
Valve

Inspection points:

- Worn valve stems:
  - Inspect for cracks, breaks, overheating, pitting and metal spalling.
  - Bent (roll the stem on a flat surface).
- Carbon on the valve can also cause noise.
  - Remember, carbon related noise generally goes away when the engine heats up.
  - If you suspect carbon, use the top engine cleaner before disassembling the engine.

Boroscope Operation

- The tool is basically a small video camera that can be inserted through the spark plug hole or just about any other engine hole for inspections.
- It has a light on the end for illumination.
- An eye piece allows you to see and guide the Boroscope.
- You can see inside the engine without disassembly.

If there is a Boroscope in your shop, this can be a very useful tool to get inside the cylinder and the head for inspections. This tool can be ordered through GM Tool and Equipment.

Figure 7-12, Boroscope
Detonation

• Detonation can also cause an upper engine ticking noise.
• It can cause or be caused by mechanical faults.
• OBD II has been designed to detect misfire conditions like detonation.
• Some detonation concerns could be caused by fuel.

Camshafts

A worn or damaged camshaft can cause excessive clearance in the valve train. There are procedures in the service information called "Camshaft and Bearings Cleaning and Inspection" which will lead you through the checks for the camshaft.

Types of inspections:
• Check lobes for wear and signs of lube starvation.
• Increased clearance between the camshaft lobes and lifters can create a clicking noise as camshaft turns.
• Also check bearings and retainers.

Balance Shaft

The balance shaft can cause a detonation/rattle noise that is most noticeable under a slight load.

Inspection points:
• Damaged bearings, broken balance shaft or worn balance shaft sprocket teeth.
Timing Chain

Inspection points related to the timing chain:

Worn or broken timing chain and/or sprocket teeth:
- Check for chain slack, missing teeth, cracks and damaged chain.
- Timing chain contacting cover.
  - A loose timing chain can contact the cover and create a noise.
- If excessively loose, the noise can be similar to a lower engine rod-bearing knock.
- Worn timing chain tensioners, shoes and guides:
  - Look for tensioner that does not move freely and check for wear into components.

Figure 7-13, Timing Chain
Lower Engine Noise

External Malfunctions

Crankshaft Balancer

Inspection points:
Loose or damaged crankshaft balancer:
• Check bolt torque
• May cause low oil pressure on some engines
• Keyway sheering

Inspection points for deterioration:
• Broken balancer can react incorrectly to the power pulses and rattle.

Loose or damaged engine flywheel:
• Inspect for loose bolts to crankshaft and cracks.
• Both can cause a knock noise most noticeable at idle or no load.
• A cracked flywheel can be mistaken for a rod or main bearing noise.
• A damaged flywheel can create a knock noise during engine torque changes on deceleration

Figure 7-14, Flywheel Inspection
Torque Converter

Inspection points:

- Loose torque converter bolts:
  - Inspect for loose or missing bolts or nuts.
  - Check for abnormal elongated holes in the flywheel.
  - Loose bolts will allow the engine power pulses to knock the flywheel against the converter bolts.
  - The noise is most noticeable at idle or no load.

A loose or cracked flywheel will produce an irregular thud or click. To test for a loose or cracked flywheel, operate the vehicle at approximately 20 mph and shut off the engine. If a thud is heard, the flywheel may be loose or damaged. This type of thud is loudest on deceleration.

Loose torque converter-to-flywheel or flywheel-to-crankshaft bolts will sound similar to bearing knock. This condition produces several raps during quick acceleration on a free running engine. Depending on the idle smoothness, when the transaxle is in gear, the noise may or may not appear.

Check the torque converter-to-flywheel and flywheel-to-crankshaft bolts before attempting to investigate any bearing related knock.
Notice:
Be sure the converter-to-flywheel bolts are not too long. Converter bolts that are too long may dimple the torque converter clutch apply surface causing a shudder condition.

Pan Damage
Also check the oil pan for external damage. If the pan is damaged, this could indicate other concerns inside the pan, which could restrict lubrication.

Pan Damage Can Cause:
- Pan contact with the suction screen.
- Pickup tube damage.
- Oil pump damage.
- Engine block damage.

Also check the oil filter. Some aftermarket filters do not have the correct specifications and can restrict flow and allow drain back.

Detonation and Fuel
Fuel can be related to engine noises:
- Wrong grade or contaminated fuel can cause detonation and knock noises.
- Higher octane than needed has also caused carbon concerns since the high-octane fuel is designed to burn slower.
- The benefit of high octane is that it reduces ping in high compression engines.
- However, if the engine is generally operated for only short trips and is not allowed to reach operating temperature, the slow burning fuel can cause carbon build up.
- Since the engine is not given an opportunity to burn off the carbon, it builds up to a point where it can cause noise and must be removed.
Internal Causes of Lower Engine Knock

Piston Malfunctions

Checks that can help isolate piston noises:

Excessive piston-to-cylinder bore clearance:

- This can cause a condition known as piston slap.
- Usually caused by undersized or improperly shaped piston or an oversized bore.
- Most noticeable when the engine is cold, decreases or stops as the engine warms up.

Figure 7-16, Piston-to-Cylinder Bore Clearance Measurement
Excessive piston pin-to-bore clearance:
• Excessive clearance is generally not affected by load.
• Excessive clearance can cause a double knock during idle.
• Piston pins must be centered in the connecting rod pin bore during assembly.

Figure 7-17, Excessive Piston Pin-to-Bore Clearance
Excessive connecting rod bearing clearance:

- Excessive clearance is generally load sensitive; intensity increases with load.
- The metal-to-metal contact caused by loose components will create a knock during power pulses.

In addition to these checks, there are several things you should look for when the knock is related to a piston.

Additional piston component inspections:

- Cracked, burnt or scored pistons.
- Carbon between piston and wall.
  - Generally creates a ticking noise.
  - The noise will usually go away when the engine reaches normal operating temperature.
  - Top engine cleaner used to remove carbon.
- Many pistons must be installed with the mark or dimple on the top of the piston facing the front of the engine.
  - Always follow installation procedures in the service information.

If you suspect that a piston has been installed incorrectly, either disassemble the engine or use a Boroscope.
Crankshaft Bearing Clearance

Characteristics of crankshaft bearing knock:
This knock noise generally cannot be isolated to a particular cylinder. It can vary in intensity or may disappear at times, depending on engine load.
The bearing clearance checking procedure can be used to determine if there is excessive clearance. This procedure is also used for selecting bearings.

![Figure 7-19, Main Bearing Clearance Management](image)

Noise at Startup that Goes Away

- Oil filter
- Damaged/faulty oil filter bypass valve
- Incorrect viscosity oil
- Worn crankshaft thrust bearing
- High valve lifter/SHLA leak down
Remember, piston slap and carbon can also cause a noise at startup that goes away shortly thereafter.

Misfire

There is a difference between a true misfire and a mechanical fault that can cause the PCM to detect a misfire:

- Mechanical faults can produce a misfire DTC.
- A misfire is lack of combustion in the cylinder.
- On most newer engines, the PCM will store a misfire DTC.
Lesson 3: Base Engine Misfire Test

Introduction

After completing this unit, the technician will be able to apply concepts and procedures to diagnose base engine misfires.

Objective

• Identify the cause of an engine misfire.

Base Engine Misfire Procedure

Engine performance diagnosis procedures are covered in Engine Controls and should be consulted for diagnosis of any Driveability, Emissions, or Malfunctioning Indicator Lamp (MIL) concerns. The following diagnosis covers common concerns and possible causes. When the proper diagnosis is made, the concern should be corrected by adjustment, repair or replacement as required. Refer to the appropriate section of the service manual for each specific procedure.

This diagnostic procedure will assist in engine misfire diagnosis due to a mechanical concern such as a faulty camshaft, worn or damaged bearings or bent pushrod. This procedure will not isolate a crossed injector wire, faulty injector or any other driveability component failure that may cause a misfire.

The Powertrain On-Board Diagnostic System checks must be performed first. When using this procedure to make a Base Engine Misfire diagnosis, begin with the preliminary information below and then proceed to the specific category.

Preliminary

1. Perform DTC P0300 before proceeding with Base Engine Misfire Diagnosis information. DTC P0300 will assist in determining which cylinder or cylinders are misfiring.

2. Perform a visual inspection for the following:
   • A loose or improperly installed engine flywheel or crankshaft balancer.
   • Worn, damaged, or misaligned accessory drive system components.

3. Listen to the engine for any abnormal internal engine noises.
4. Inspect the engine for acceptable oil pressure. Refer to Oil Pressure Diagnosis and Testing.

5. Verify if the engine has excessive oil consumption. Refer to Oil Consumption Diagnosis.

6. Verify if the engine has coolant consumption.

7. Perform a compression test on the engine. Refer to Engine Compression Test.

**Intake Manifold Leaks**

An intake manifold that has a vacuum leak may cause a misfire. Inspect for the following:

- Improperly installed or damaged vacuum hoses.
- Loose throttle body.
- Faulty or improperly installed intake manifold and/or gaskets.
- Loose Exhaust Gas Recirculation (EGR) Valve pipe or damaged or missing O-ring seal.
- Cracked or damaged intake manifold; Inspect the areas between the intake runners.
- Improperly installed Manifold Absolute Pressure (MAP) sensor. The sealing grommet of the MAP sensor should not be torn or damaged.
- Improperly installed throttle body or damaged gasket.
- Warped intake manifold.
- Warped or damaged cylinder head sealing surface.
### OBD System Check

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Important</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Do not perform this diagnostic if there is not a driveability concern, unless another procedure directs you to this diagnostic.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Before you proceed with diagnosis, search for applicable service bulletins.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Unless a diagnostic procedure instructs you, do NOT clear the DTCs.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• If there is a condition with the starting system, refer to <em>A Diagnostic System Check - Engine Electrical</em> in Engine Electrical.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Ensure the battery has a full charge.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Ensure the battery cables are clean and tight.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Ensure the PCM grounds are clean, tight, and in the correct location.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Install a scan tool. Does the scan tool turn ON?</td>
<td>Go to Step 2</td>
<td>Go to Scan Tool Does Not Power Up in Data Link Communications</td>
</tr>
</tbody>
</table>
| 2    | 1. Turn ON the ignition, with the engine OFF.  
2. Attempt to establish communication with the listed control modules. If you are using a Tech 2, obtain the information using the Class 2 Message Monitor feature.  
• PCM  
• VTD  
• IP Cluster  
• EBCM  
• HVAC |     |    |
|      | Does the scan tool communicate with all the listed control modules? | Go to Step 3 | Go to Scan Tool Does Not Communicate with Class 2 Device in Data Link Communications |
| 3    | Attempt to start the engine. Does the engine start and idle? | Go to Step 4 | Go to Engine Cranks but Does Not Run |
| 4    | Select the DTC display function for the following control modules:  
• PCM  
• VTD  
• IP Cluster  
• EBCM  
• HVAC |     |    |
|      | Does the scan tool display any DTCs? | Go to Step 5 | Go to Step 9 |
| 5    | With a scan tool, select Captured Info in order to store the powertrain DTC information. Did you complete the action? | Go to Step 6 | -- |
| 6    | Does the scan tool display DTCs which begin with a “U”? | Go to Scan Tool Does Not Communicate with Class 2 Device in Data Link Communications | Go to Step 7 |
• Steps 1 & 2: Checks ability of scan tool to power up & communicate.
• Step 3: Checks engine start/idle.
• Step 4: Checks for stored DTCs.
• Step 5: Captures stored Powertrain DTC information.
• Step 6: Does scan tool display U-type codes?
• Step 7: Does scan tool display DTC P0601, P0602, P0604 or P0606?
• Step 8: Does scan tool display DTC P0562, P0563, P1637 or P1638?

Figure 7-20, Tech 2 with DTC P0300
## DTC P0300 Engine Misfire Diagnosis Chart

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
<th>Value(s)</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Did you perform the Powertrain On-Board Diagnostic (OBD) System Check?</td>
<td>--</td>
<td>Go to Step 2</td>
<td>Go to A Powertrain On Board Diagnostic (OBD) System Check</td>
</tr>
<tr>
<td></td>
<td><strong>Important</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• If any abnormal engine mechanical noise can be heard, refer to Base Engine Misfire Diagnosis in Engine Mechanical 4.8L, 5.3L, 6.0L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Install the scan tool.</td>
<td>--</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Idle the engine.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Monitor all the Misfire Current counters on the misfire data list using a scan tool. There are a total of 8 counters, one counter per cylinder. Are any of the Misfire Current counters incrementing?</td>
<td></td>
<td>Go to Step 4</td>
<td>Go to Step 3</td>
</tr>
<tr>
<td>4</td>
<td>Is only one misfire counter incrementing?</td>
<td>--</td>
<td>Go to Step 6</td>
<td>Go to Step 5</td>
</tr>
<tr>
<td>6</td>
<td><strong>Important</strong></td>
<td>Before disconnecting the injector harness, refer to Fuel Rail Assembly Replacement. There is a special procedure for disconnecting the fuel injector harness connectors.</td>
<td>--</td>
<td>Go to Step 7</td>
</tr>
<tr>
<td></td>
<td>1. Turn OFF the ignition.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Disconnect the injector that corresponds to the Misfire Current counters that were incrementing.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Connect the injector J 34730-405 test lamp to the injector electrical connector.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Idle the engine. Is the injector test lamp flashing?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Module 7 - General Engine Diagnosis

#### Step 7
- **Action**: Turn OFF the ignition.  
- **Action**: Reconnect the injector harness electrical connector.  
- **Action**: Disconnect the ignition wires from the spark plug that corresponds to the Misfire Current counters that were incrementing. Refer to Spark Plug Wire Harness Replacement in Engine Electrical.  
- **Action**: Install the J 26792 spark tester to a ground.  
- **Action**: Start the engine. Does the spark jump the tester gap and is the spark consistent?  

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
<th>Value(s)</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td>Go to Step 9</td>
</tr>
</tbody>
</table>

#### Step 9
- **Action**: Remove the spark plugs from the cylinder that indicated a misfire. Refer to Spark Plug Replacement in Engine Electrical. Does the spark plug appear to be OK?  

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
<th>Value(s)</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td>Go to Step 10</td>
</tr>
</tbody>
</table>

#### Important
- If the Injector Coil Test Procedure checks to be OK, refer to Base Engine Misfire Diagnosis in Engine Mechanical 4.8L, 5.3L, 6.0L.  

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
<th>Value(s)</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td>Go to Step 15</td>
</tr>
</tbody>
</table>

1. Swap the suspected spark plug with another cylinder that is operating properly. Refer to Spark Plug Replacement in Engine Electrical.  
2. Operate the vehicle under the same conditions that the misfire occurred. Did the misfire move with the spark plug?  

Go to Fuel Injector Coil Test - Engine Coolant Temperature (ECT) Between 10-35 Degrees C (50-95 Degrees F)
Misfire Counter Check (Single)

- Misfire counter for cylinder #3 is increasing, while the other counters are stable.
- Cylinder #3 is misfiring since the counters are increasing.
- Also, we suspect the #1 misfire counter is increasing since it is the next cylinder in the firing order.
- This can often occur, since the non-misfiring cylinder cannot increase the RPM rapidly enough to compensate for the lag created by the previous cylinder.

Figure 7-21, Misfire Counter Check
Test Lamp J 26792 / ST 125 Spark Testing

J 26792/ST 125 Spark Tester results:
- Spark tester showed spark at the cylinder
- The spark plug appeared to be visually OK
- The misfire did not move when we swapped spark plugs
- At Step 6 we will use the injector test lamp
- With ignition OFF, remove the connector for the #3 cylinder and install the test lamp
- For this vehicle, we will use J 34730-405
- Start the engine and see what happens
- At Step 7 we will be using the J 26792/ST 125 to check spark on #3 cylinder
- Now, install J 26792/ST 125 spark tester; make sure it is connected to a good ground
- Start the engine
- It appears OK, so let's move to Step 9 and look at the spark plug
- Spark plugs appear okay
- Let's move to Step 10 and swap the spark plugs

J 26792/ST 125 Spark Tester results:
- Spark tester showed spark at the cylinder
- The spark plug appeared to be visually OK
- The misfire did not move when we swapped spark plugs

Injector Coil Test

A "No" answer at Step 10 sends you to perform the fuel injector coil test.

Results of Injector Coil test:
- The results we have are within specifications
- The chart then directs us to Symptoms
- However, P0300 chart said that if injector coil test procedure checks to be OK, refer to Base Engine Misfire Diagnosis

The results are within specification, so we move on to the base engine misfire.
We performed Steps 1-6 of the Preliminary Checks and no issues were found.

We move on to Step 7, performing a static compression test.
Lesson 4: Static Compression Test

Introduction
After completing this unit, the technician will be able to apply concepts and procedures to diagnose engine mechanical concerns utilizing the static compression test.

Objective
• Identify the condition of the engine's piston rings, valves and head gasket(s).

Static Compression Test
To prepare for an engine compression test:
1. Charge the battery if the battery is not fully charged.
2. Disable the ignition system.
3. Disable the fuel injection system.
4. Remove all the spark plugs.
5. Block the throttle plate wide open.
6. Start with the compression gauge at zero and crank the engine through four compression strokes (four puffs).
7. Make the compression check for each cylinder. Record the reading.
8. If a cylinder has low compression, inject approximately 15 ml (one tablespoon) of engine oil into the combustion chamber through the spark plug hole. Recheck the compression and record the reading.
9. The minimum compression in any one cylinder should not be less than 70 percent of the highest cylinder. No cylinder should read less than 690 kPa (100 psi). For example, if the highest pressure in any one cylinder were 1035 kPa (150 psi), the lowest allowable pressure for any other cylinder would be 725 kPa (105 psi) \((1035 \times 70\% = 725)\) \((150 \times 70\% = 105)\).
• Normal — Compression builds up quickly and evenly to the specified compression for each cylinder.

• Piston Rings Leaking — Compression is low on the first stroke. Compression then builds up with the following strokes but does not reach normal. Compression improves considerably when you add oil.

• Valves Leaking — Compression is low on the first stroke. Compression usually does not build up on the following strokes. Compression does not improve much when you add oil.

• If two adjacent cylinders have lower than normal compression and injecting oil into the cylinders does not increase the compression, the cause may be a head gasket leaking between the cylinders.
Lesson 5: Running Compression Test

Introduction
After completing this unit, the technician will be able to apply concepts and procedures to diagnose engine mechanical concerns utilizing the running compression test.

Objective
Identify the engine's ability to fill and evacuate the cylinder to produce the proper engine output during idle and loaded conditions.

How to Perform a Running Compression Test
1. Start with a normal ("static") compression test. To eliminate rings, valves, holes in pistons, that sort of thing. A normal cylinder balance test is also helpful (so you know which, if any, cylinder is presenting a problem). Engine should be warm.
2. Put all spark plugs but one back in. Ground that plug wire to prevent module damage. Disconnect that injector on a port fuel system.
3. Put your compression tester into the empty hole. The test can be done without a Schrader valve, but most people recommended leaving the valve in the gauge and "burping" the gauge every 5-6 "puffs."
4. Start the engine and take a reading. Write it down.
5. Now snap the throttle for a "snap acceleration" reading. Reading should rise. Write it down.

Notice:
Don't use the gas pedal for this snap acceleration. The idea is to manually open then close throttle as fast as possible without speeding up the engine. This forces the engine to take a "gulp" of air.

6. Now, write down your readings for at least the bad cylinder (if there is a single bad cylinder) and maybe 2-3 good ones.
Make a chart like this:

<table>
<thead>
<tr>
<th>CYL</th>
<th>STATIC COMPR</th>
<th>IDLE - RUNNING</th>
<th>COMPR - SNAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyl 1</td>
<td>150</td>
<td>75</td>
<td>125</td>
</tr>
<tr>
<td>Cyl 2</td>
<td>175</td>
<td>80</td>
<td>130</td>
</tr>
<tr>
<td>Cyl 3</td>
<td>160</td>
<td>75</td>
<td>120</td>
</tr>
<tr>
<td>Cyl 4</td>
<td>160</td>
<td>80</td>
<td>125</td>
</tr>
</tbody>
</table>

7. Analysis:
Running compression at idle should be 50-75 psi (about half cranking compression). Snap throttle compression should be about 80% of cranking compression.

Sample 1 - Restricted Exhaust

<table>
<thead>
<tr>
<th>CYL</th>
<th>STATIC COMPR</th>
<th>IDLE - RUNNING</th>
<th>COMPR - SNAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyl 1</td>
<td>150</td>
<td>75</td>
<td>180</td>
</tr>
</tbody>
</table>

If snap measurements are higher than 80% of cranking measurements, look for restricted exhaust on that cylinder - such as worn exhaust cam lobe, or collapsed lifter. Or, if these are all high, look for a clogged catalytic converter.
Lesson 6: Cylinder Leakage Test

Introduction
After completing this unit, the technician will be able to apply concepts and procedures to diagnose engine mechanical concerns utilizing the cylinder leakage test.

Objective
The cylinder leakage test may be used in conjunction with the engine compression test to isolate the cause of leaking cylinders.

Cylinder Leakage Test - Testing Procedure
Tools Required - J 35667-A Cylinder Leakdown Tester

With the use of air pressure, a cylinder leakage test will aid in the diagnosis. Use the cylinder leakage test in conjunction with the engine compression test in order to isolate the cause of leaking cylinders.

Caution:
Before servicing any electrical component, the ignition key must be in the OFF or LOCK position and all electrical loads must be OFF, unless instructed otherwise in these procedures. If a tool or equipment could easily come in contact with a live exposed electrical terminal, also disconnect the negative battery cable. Failure to follow these precautions may cause personal injury and/or damage to the vehicle or its components.
1. Disconnect the negative battery cable.
2. Remove the spark plugs. Refer to Spark Plug Replacement in Engine Controls.
3. Install the J 35667-A
4. Measure each cylinder on the compression stroke, with both valves closed.

Notice:
Hold the crankshaft balancer bolt in order to prevent piston movement.

5. Apply air pressure, using the J 35667-A. Refer to the manufacturer’s instructions.
6. Record the cylinder leakage readings for each cylinder.

Notice:
Normal cylinder leakage is from 12 to 18 percent. Make a note of any cylinder with more leakage than the other cylinders. Any cylinder with 30 percent leakage or more requires service.

7. Inspect the 4 primary areas in order to properly diagnose a leaking cylinder.
8. If air is heard from the intake or exhaust system, perform the following procedure:
   Remove the valve rocker arm cover of the suspect cylinder head. Ensure that both valves are closed. Inspect the cylinder head for a broken valve spring. Remove and inspect the suspect cylinder head. Refer to Cylinder Head Cleaning and Inspection.
9. If air is heard from the crankcase system at the crankcase (oil filler tube), perform the following procedure:
   Remove the piston from the suspect cylinder. Inspect the piston and connecting rod assembly. Refer to Piston, Connecting Rod, and Bearings Cleaning and Inspection. Inspect the engine block. Refer to Engine Block Cleaning and Inspection.
10. If bubbles are found in the radiator, perform the following procedure:
   Remove and inspect both cylinder heads. Refer to Cylinder Head Cleaning and Inspection. Inspect the engine block. Refer to Engine Block Cleaning and Inspection.

11. Remove the J 35667-A.

12. Install the spark plugs. Refer to Spark Plug Replacement in Engine Controls.

13. Connect the negative battery cable. Refer to Battery Negative Cable Disconnect/Connect Procedure in Engine Electrical.

Figure 7-22, Cylinder Leakdown Tester
Lesson 7: Restricted Exhaust Test

Introduction

After completing this unit, the technician will be able to apply concepts and procedures to diagnose engine mechanical concerns utilizing the restricted exhaust test.

Objective

Identify an engine mechanical concern related to a restricted exhaust system.

Restricted Exhaust Diagnostic Chart

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
<th>Value(s)</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Did you verify the customers complaint?</td>
<td>--</td>
<td>Go to Step 2</td>
<td>--</td>
</tr>
<tr>
<td>2</td>
<td>Did you review the exhaust symptoms diagnostic information and perform the necessary inspections?</td>
<td>--</td>
<td>Go to Step 3</td>
<td>Go to Symptoms - Engine Exhaust</td>
</tr>
<tr>
<td>3</td>
<td>Is the vehicle equipped with a 6.6L diesel engine?</td>
<td>--</td>
<td>Go to Diagnostic Aids</td>
<td>Go to Step 4</td>
</tr>
<tr>
<td>4</td>
<td>1. Remove the AIR check valve or the HO2S that is in front of and closest to the catalytic converter. Refer to Heated Oxygen Sensor (HO2S) Replacement Bank 1 Sensor 1 or Heated Oxygen Sensor (HO2S) Replacement Bank 2 Sensor 1 in Engine Controls - 4.3L, Heated Oxygen Sensor (HO2S) Replacement Bank 1 Sensor 1 or Heated Oxygen Sensor (HO2S) Replacement Bank 2 Sensor 1 in Engine Controls - 4.8L, 5.3L, and 6.0L, Heated Oxygen Sensor (HO2S) Replacement Bank 1 Sensor 1 or Heated Oxygen Sensor (HO2S) Replacement Bank 2 Sensor 1 in Engine Controls - 8.1L. 2. Install the J 35314-A/BT-8515/BT-8515A in place of the AIR check valve or HO2S sensor. 3. Start the engine. 4. Increase and monitor the engine speed at 2000 RPM. 5. Observe the exhaust system back pressure reading on the gauge. Does the reading exceed the specified value?</td>
<td>14 kPa (2 psi)</td>
<td>Go to Step 5</td>
<td>Go to Step 8</td>
</tr>
<tr>
<td>Step</td>
<td>Action</td>
<td>Value (s)</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----------</td>
<td>-----</td>
<td>----</td>
</tr>
<tr>
<td>1</td>
<td>Turn the engine off and place the ignition in the lock position.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Remove the J 35314-A/BT-8515/BT-8515A.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Install the J 35314-A/BT-8515/BT-8515A in place of the post HO2S sensor.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Start the engine.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Increase and monitor the engine speed at 2000 RPM.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Observe the exhaust system back pressure reading on the gauge.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Does the reading exceed the specified value?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Go to Step 6  Go to Step 7
Lesson 8: Vacuum Test

Introduction
After completing this unit, the technician will be able to apply concepts and procedures to diagnose engine mechanical concerns utilizing the vacuum test.

Objective
Describe the procedure to check engine vacuum and identify the source(s) of incorrect vacuum readings.

Vacuum Test
The intake stroke of the piston creates a vacuum in the manifold. Vacuum is any pressure lower than the atmospheric pressure. Monitoring the manifold vacuum is a good indicator of the engine's ability to run efficiently. Typical engine vacuum is a steady reading between 15 and 22 inches of mercury with the engine at normal operating temperatures, idle, and in drive.

Vacuum Test Limitations
The amount of vacuum formed in the manifold depends on several things.

- First, the cylinders must be sealed. If a cylinder has high leakage, it will not produce sufficient vacuum to draw in the air/fuel mixture.
- If the manifold is not sealed, vacuum will be lower than normal.
- Vacuum hoses and accessories may leak, causing lower manifold vacuum.
- When the throttle plate is open and atmospheric pressure enters the manifold, vacuum is lower.
- If the engine has higher compression, it will have 1 to 2 inches of mercury higher vacuum.
- For every 1,000 feet of altitude above sea level, vacuum will be lowered by 1 inch of mercury.
- A high lift cam or considerable valve overlap will produce a slightly lower, erratic needle reading on the gauge.
- Vacuum changes with load, so operating accessories when monitoring vacuum will change the readings.
Vacuum Test Results

- A needle that fluctuates or drops between 1 and 2 inches of mercury at idle indicates a burned or leaking valve or a spark plug in one of the cylinders that is not firing.

- An irregular needle drop between 1 and 2 inches of mercury indicates a sticking valve, intermittent spark plug misfire, or rich or lean air/fuel mixture.

- If the vacuum gauge indicates normal at idle speed, but has excessive vibrations at higher RPM, the cause is most likely weak valve springs or valves sticking in their guides.

- If the vacuum needle has an excessive vibration at idle speed, but steadies at higher RPM, check for worn valve guides.

- If the vacuum gauge needle has an excessive vibration at all RPM, the problem is a leaky head gasket.

- If the needle oscillates slowly, or drifts, between 3 and 9 inches of mercury lower than normal, check for an intake system leak.

- If the vacuum is normal at idle speed, but drops to near zero and rises to lower than normal, the problem is a restriction in the exhaust system.
## Vacuum Test Diagnosis Chart

<table>
<thead>
<tr>
<th>Readings</th>
<th>Possible Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Average, steady readings between 15–22 inches Hg</td>
<td>1. Normal</td>
</tr>
<tr>
<td>(normal readings for a 60° V6 engine may be lower, i.e., 12–16 inches Hg)</td>
<td></td>
</tr>
<tr>
<td>2. Low but steady, between 12 and 15 inches Hg</td>
<td>2. Leakage around piston rings,</td>
</tr>
<tr>
<td></td>
<td>late ignition timing,</td>
</tr>
<tr>
<td></td>
<td>or late valve timing</td>
</tr>
<tr>
<td>3. Needle fluctuates or drops between 1 and 2 inches Hg at idle</td>
<td>3. Burned or leaking valve or spark</td>
</tr>
<tr>
<td></td>
<td>plug in one of the cylinders is not firing</td>
</tr>
<tr>
<td>4. Irregular needle drop between 1 and 2 inches Hg</td>
<td>4. Sticking valve, intermittent spark plug</td>
</tr>
<tr>
<td></td>
<td>misfire, or rich or lean air/fuel mixture</td>
</tr>
<tr>
<td>5. Normal at idle speed, but excessive vibrations at higher rpm</td>
<td>5. Weak valve springs; valves sticking in guides</td>
</tr>
<tr>
<td>6. Excessive vibrations at idle speed, but steadies at higher rpm</td>
<td>6. Worn valve guides</td>
</tr>
<tr>
<td>7. Excessive vibration at all rpm</td>
<td>7. Leaky head gasket</td>
</tr>
<tr>
<td>8. Needle oscillates slowly, or drifts, between 3 and 9 inches Hg lower</td>
<td>8. Intake system leak</td>
</tr>
<tr>
<td>than normal</td>
<td></td>
</tr>
<tr>
<td>9. Normal at idle speed, but drops to near zero and rises to lower</td>
<td>9. Restriction in exhaust system</td>
</tr>
<tr>
<td>than normal</td>
<td></td>
</tr>
</tbody>
</table>
Lesson 9: Oil Pressure Test

Introduction
After completing this unit, the technician will be able to apply concepts and procedures to diagnose engine oil pressure concerns.

Objective
Describe the procedure to check oil pressure and identify the sources of low oil pressure.

Engine Oil Functions
• Provides lubrication to moving parts to prevent damage and overheating.
• Supplies operating pressure to components like valve lifters and the camshaft position actuator on the 4200 engine.
• Cools moving components.
• Provides sealing and cleaning.
Because the oil performs various functions, sufficient flow must be provided by the oil system to make certain that sufficient oil is delivered to engine components.

There are several checks that must be performed to determine if the oil and the oil system are performing the necessary functions.

Initial Engine Oil Checks
Check the level:
• If the level is too low, the lubrication system may not be able to provide sufficient flow.
• If the fluid is too high, it can be an indicator of contamination (fuel, water or coolant).

Check the condition:
• Oil properties degrade over time.
• Combustion gases escaping past the piston rings can contaminate the oil.
Check vehicle oil gauge (if equipped):
• A good initial check of oil is to look at the vehicle oil pressure gauge.
• However, the gauge may not be as sensitive as a mechanical gauge connected directly to the system.

There are two important points that you should remember about engine oil:
• At 6 psi, the oil pressure light turns on.
• Normal oil consumption is 1 quart per 2000 miles.
• During the break-in period, this can be higher.

**Oil Pressure Test**

• Before connecting the gauge, perform a few preliminary inspections:
  – Check for oil pan damage and look for oil leaks.
  – Observe and note abnormal noises.
• Install the gauge and check pressure using service procedures
  – Some applications require special tools
• Compare gauge readings to specifications
  – Check oil pressure cold and hot.

Remember, you can check both the upper end and the lower end for diagnostic purposes.

**Oil Pressure Checking**

• Service procedures generally select pressure tap near oil pump outlet to provide initial pressure produced by pump.
• Tells you if pump is operating within specifications, but not what is happening in other parts of engine.
• If pump is producing insufficient pressure at this tap, look for restrictions or leakage in the lower engine circuit.
• Can also check the pressure further up oil circuit on many engines when valve train is producing noise but oil pressure near the pump is correct
• If there is restriction or leak in the upper valve train circuits, valve train will have insufficient lubrication. Pressure check this portion of the circuit for lower pressure. Closely inspect valve train components for damage.
Oil pressure concerns can be a major cause of engine noises. If the pressure is low at all times, severe engine damage can occur. However, some oil pressure conditions can cause a condition where the engine creates a noise at startup and then goes away shortly after. There is a table in the service information that will help you identify some of the root causes of this condition.

**Oil Pump with Suction Screen**

- Worn oil pump or debris in the pump
  - Creating a restriction or inefficient oil pump operation.
- Loose oil pump-to-engine bolts
- Loose, plugged or damaged oil pump screen.
- Missing or damaged oil pump screen o-ring seal.
- Damage or leak in the oil pump screen suction tube.
  - Allowing air to enter the pump intake

*Figure 7-23, Oil Pressure Checking*
Pressure Regulator Valve

- Malfunctioning oil pump pressure regulator valve
  - Allowing a bypass and low pressure

![Image of Pressure Regulator Valve](image1.jpg)

*Figure 7-24, Pressure Regulator Valve Inspection*

Oil Gallery Plugs

- Missing or incorrectly installed oil gallery plug.
- Cracked, porous or restricted oil galleries.
- These could be external leaks.

![Image of Oil Gallery Plugs](image2.jpg)

*Figure 7-25, Oil Gallery Plugs Inspection*
Lesson 10: Engine Speed-Related Vibrations

Introduction
After completing this unit, the technician will be able to apply concepts and procedures to diagnose engine speed-related vibrations.

Objective
Describe Engine Speed-Related Vibration Firing Frequencies.

Isolating Vibrations
- Duplicate the vibration while the vehicle is on an inspection-type hoist (either a front-end rack or similar hoist that supports the vehicle at curb height).
- While the vibration is present, find the area(s) of the vehicle that are excited or responding to the vibration.
- Look closely for witness marks due to a rubbing component.
- Once an area of the vehicle has been pinpointed, the component should be isolated and the vibration re-evaluated.
- Firing frequency is a term used to describe the pulses that an engine creates as it fires each cylinder.

<table>
<thead>
<tr>
<th></th>
<th>First Order Any Engine</th>
<th>Firing Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RPM</td>
<td>Hz</td>
</tr>
<tr>
<td>Shake</td>
<td>500</td>
<td>8.3</td>
</tr>
<tr>
<td></td>
<td>750</td>
<td>12.5</td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>16.6</td>
</tr>
<tr>
<td></td>
<td>1500</td>
<td>25</td>
</tr>
<tr>
<td>Roughness</td>
<td>2000</td>
<td>33.3</td>
</tr>
<tr>
<td></td>
<td>2500</td>
<td>41.6</td>
</tr>
<tr>
<td>Buzz</td>
<td>3000</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>3500</td>
<td>58.3</td>
</tr>
<tr>
<td></td>
<td>4000</td>
<td>66.6</td>
</tr>
</tbody>
</table>

Figure 7-26, Engine Order Vibration Chart
**Speed-Related Vibrations**

Vibration concerns can be categorized into two groups:

- Vehicle Speed
- Engine RPM

The Slow Acceleration Test is used to identify engine or speed-related concerns.

- The Neutral Coast-Down Test and Downshift Test should be performed to help determine which category the vibration belongs.

The Neutral Coast-Down test is used to identify concerns related to vehicle speed.

- Eliminates the engine and torque converter as a vibration cause.
- Concentrates the repair on the tires and wheels, or on the propshaft and rear (driving) axle based on symptoms.

*Figure 7-27, Speed-Related Vibrations*
Notice:
If the concern is vehicle-speed related only; that it appears at the same mph regardless of the engine speed, the Neutral Run-Up Test and Brake Torque Test probably will not apply.

Notice:
The Neutral Run-Up Test and Brake Torque Test are used for engine speed-related vibrations.

**Engine Speed-Related Vibrations**
The Downshift Test and Neutral Run-Up Test are used to identify engine speed related concerns.

**Brake Torque Test**
Identifies engine-speed-related vibrations not revealed by the Neutral Run-Up Test.
This test also works for vibrations that are sensitive to engine load or torque.

- If the vibration returns at the same rpm, the engine and torque converter are the most probable causes
- In some cases, a vibration may be sensitive to torque or engine load
- These vibrations can be the most difficult to diagnose, and may require additional testing

The Brake Torque Test identifies engine speed-related vibrations, not revealed by the Neutral Run-Up Test.

**Neutral Run-Up Test**
Identifies engine speed-related vibrations.
Use this test whenever customer expresses a concern about vibration at idle, or as a follow-up to Downshift Test.
Brake Torque Test

Identifies engine-speed-related vibrations not revealed by the Neutral Run-Up Test.

This test also works for vibrations that are sensitive to engine load or torque.

---

*Figure 7-28, Engine Speed-Related Vibrations*

Do not accelerate against the brakes for longer than 15 seconds.

Care should be taken not to overheat the engine or transmission.

Depending on the vehicle design, the engine will only rev to a certain point under these conditions.

Also, care should be taken during diagnosis because some disturbances may be created during brake torque that normally does NOT exist.
Exercise 7-1

Read each question carefully and choose the correct response.

1. A compression test is performed on an engine. Technician A states that the lowest cylinder should NOT be less than 70% of the highest reading. Technician B states that you should consult service information for the correct pressure specifications. Which technician is correct? (3)
   a. Technician A
   b. Technician B
   c. Both technicians are correct
   d. Neither technician is correct.

2. For a properly running engine, a good vacuum reading should be ______________.
   a. 10-14 inches of mercury
   b. Steady needle, 17-20 inches of water
   c. Steady needle, 17-20 inches of mercury
   d. Fluctuating gauge between 15-17 inches of water

3. A diagram shows a vacuum hose connected to “ported vacuum.” This means the hose should be connected ______________.
   a. To the vacuum reservoir tank
   b. To the intake manifold
   c. Below the throttle plate
   d. Above the throttle plate

4. All of the following engine mechanical conditions can be diagnosed with a leakage test EXCEPT:
   a. Burned exhaust valve
   b. Cracked or warped head
   c. Worn cam lobes
   d. Worn piston rings
5. During a cylinder leakage test you find air coming out around the cylinder head valve cover. All of the following could be the cause EXCEPT:
   a. Blown head gasket
   b. Cracked block
   c. Warped head
   d. Worn piston rings

6. A leakage test on cylinder 3 shows air coming from cylinder 5, and vice versa. These results mean which of the following?
   a. Leakage head gasket
   b. Hole in piston 3
   c. Leaky exhaust valve
   d. Leaky intake valve

7. A customer is concerned because oil is leaking from the middle of their vehicle engine compartment. The source of the leak cannot be determined visually. How should the source of the leak be pinpointed?
   a. Overfill all the fluids
   b. Inspect seals
   c. Replace all the seals
   d. Use fluorescent dye

8. Which of the following devices is used with dye to help find leaks?
   a. Fluorescent light
   b. Infrared camera
   c. Ultraviolet light
   d. Neon light

9. When using the black light and dye method to perform oil leak detection, the dye will appear _______ under the light.
   a. Red
   b. Yellow
   c. Blue
   d. Black
10. The purpose of the oil pump is to ______________.
   a. clean the oil
   b. cool the oil
   c. pressurize the oil
   d. control oil pressure

11. Which of the following is NOT a cause of low or no oil pressure?
   a. Improper oil viscosity
   b. Low oil level
   c. Low cylinder compression
   d. Slow idle speed

12. Which of the following can NOT be the cause of low engine oil pressure?
   a. Loose crankshaft balancer bolt
   b. Loose oil pump mounting bolts
   c. Missing pickup o-ring
   d. Broken valve lifters

13. On a V-type engine with dual overhead cams, compression is found to be low on all cylinders in one bank only. The most likely cause would be ______________.
   a. jumped timing chain
   b. incorrect ignition timing
   c. leaking head gasket
   d. broken crank gear

14. If camshaft timing were incorrect, all of the following might be the result EXCEPT __________.
   a. no start
   b. lack of power
   c. possible damage to valves or pistons (depending on the application)
   d. worn camshaft lobes
15. When verifying camshaft timing, the timing marks should be at which of the following positions?
   a. All at 12 o’clock
   b. Pointing at each other
   c. Lined up according to service information
   d. Ignored, as they are only for use in ignition timing

16. Valve train noises occur at ______ speed of the engine.
   a. 1/4
   b. 1/2
   c. 3/4
   d. the same

17. When checking the Camshaft position actuator movement, approximately how much movement should there be?
   a. 5-8 mm
   b. 10-11 mm
   c. 14-15 mm
   d. 17-18 mm

18. A customer brings in a 1996 Oldsmobile Aurora with a 4.0L V8. The customer is concerned because oil is leaking from the middle of the engine compartment. Which of the following processes should be used to solve the concern?
   a. System verification process
   b. Strategy-based diagnostics
   c. Testing based diagnostics
   d. Strategy verification process

19. A customer brings in a 1996 Oldsmobile Aurora with a 4.0L V8. The customer is concerned because oil is leaking from the middle of the engine compartment. Which of the following is the first step?
   a. Check bulletins
   b. Verify the customer concern
   c. Check vehicle history
   d. Start OBD system check
20. A customer brings in a vehicle with an intermittent misfire concern. The MIL is illuminated. Which of the following is the first step in diagnosing this concern using a strategy based diagnostic process?

a. Verify concern
b. Check service diagnostics
c. Verify bulletins
d. Conduct preliminary checks

21. A customer brings in a 1999 Cadillac Eldorado with a 4.6L V8 VIN Y ROP Code LD8, concerned because it misfires at all times. The MIL is illuminated. All of the following are quick checks EXCEPT:

a. Checking for loose or missing plug wire
b. Looking for damaged coil
c. Listening for engine noises
d. Checking for vehicle history

22. After performing an engine vacuum and a compression test, the test results are reviewed and oil is added to cylinders 3 and 5. If the compression remains the same, which of the following tests is performed next?

a. Compression test
b. Cylinder leakage test
c. Fuel pressure test
d. Oil pressure test

23. A compression test shows that one cylinder is too low. A cylinder leakage test shows that there is too much leakage. During the test, air could be heard coming from the tailpipe. Which of the following could be the cause?

a. Broken piston ring
b. Blown head gasket
c. Leaking exhaust gasket
d. Leaking exhaust valve
24. An irregular thud or click loudest on deceleration is most likely related to the ____________.
   a. main bearings  
   b. flywheel  
   c. valve train  
   d. harmonic balancer

25. In engine noise diagnosis, noises synchronized to one-half the engine speed are normally associated with the ____________.
   a. main bearings  
   b. connecting rod bearings  
   c. pistons  
   d. valve train

26. A high frequency light-knocking sound occurring at the same intensity regardless of engine load is related to the ________________.
   a. flywheel  
   b. connecting rod bearings  
   c. main bearings  
   d. timing chain and sprocket

27. Top engine cleaner is the recommended GM cleaner for which of the following conditions:
   a. Leaking oil seals  
   b. Carbon build up  
   c. Coolant system leaks  
   d. Defective head gasket

28. When removing carbon build up, the top engine cleaner should be allowed to work inside the engine for at least ________ minutes, before starting the engine to remove the cleaner:
   a. 5  
   b. 10  
   c. 15  
   d. 20
29. The injector test lamp tests which of the following:
   a. The mechanical side of the injector
   b. The fuel pump
   c. The PCM and harness
   d. The fuel pressure regulator

30. A customer is concerned about a knocking noise in the front of their vehicle on start up. The first step of the SBD process is __________.
   a. verify the concern
   b. preliminary checks
   c. check vehicle history
   d. check bulletins

31. In reference to low or no oil pressure, Technician A says that it could be caused by worn main bearings. Technician B says that worn rings will cause the same. Which technician is correct?
   a. Technician A
   b. Technician B
   c. Both technicians are correct
   d. Neither technician is correct

32. During which of the following engine operating conditions will carbon build up cause a noise concern?
   a. Cold engine operation
   b. Engine overheating condition
   c. Normal operating conditions
   d. All engine operating conditions

33. Which of the following noises would usually be associated with a balance shaft concern?
   a. Rattle noise
   b. Whine
   c. Knock
   d. Growl
34. A damaged flywheel will usually create a knocking noise during which of the following conditions:
   a. acceleration
   b. deceleration
   c. idle
   d. part throttle cruise

35. Which of the following is a cause of low oil pressure?
   a. Too much oil
   b. Broken piston oil ring
   c. Plugged oil pump pickup screen
   d. Oil pan leak

36. A technician is measuring engine vacuum on an engine. The readings are 20 inches of vacuum at idle and 10 inches of vacuum at 2000 RPM. This would indicate ______________.
   a. late valve timing
   b. restricted exhaust
   c. restriction in air intake system
   d. a vacuum leak at the intake manifold

37. A plugged catalytic converter will cause a vacuum gauge to ________.
   a. read a steady 16 inches at idle
   b. fluctuate between 16 and 21 inches at idle
   c. read a steady 25 inches at idle
   d. read a gradual loss of vacuum

38. When checking engine vacuum, idle has 15 inches and when increasing RPM’s, vacuum steadily drops off and engine stalls. This means the _____________.
   a. catalytic converter is restricted
   b. muffler has been replaced with test pipe
   c. vacuum reading is normal
   d. engine timing is retarded
39. A vacuum test shows low, but steady vacuum. Which of the following is the least likely cause?
   a. Weak valve springs
   b. Leakage around piston rings
   c. Late ignition timing
   d. Vacuum leak

40. For most engines, normal engine vacuum at idle should be _______ inches Hg.
   a. 25-29
   b. 15-22
   c. 7-12
   d. 5-7

41. When performing an engine vacuum test, the test shows the needle fluctuating between 12 and 17 inches Hg. Which of the following tests should be performed next?
   a. Compression test
   b. Engine vacuum test
   c. Fuel pressure test
   d. Leakage test

42. For every _______ feet of altitude above sea level, vacuum will be lowered by 1 in-Hg.
   a. 500
   b. 1,000
   c. 5,000
   d. 10,000

43. While doing a cylinder leakage test, the technician finds air escaping out the dipstick tube. The most likely cause would be ____________.
   a. worn piston rings
   b. burned intake valve
   c. blown head gasket
   d. burned exhaust valve
44. A car runs rough and backfires through the throttle body. Compression is checked and one cylinder is low. The most likely cause of the problem is a/an:
   a. faulty intake valve
   b. burned exhaust valve
   c. EGR valve failure
   d. blown head gasket

45. During a compression test, you get a reading of 80 PSI dry and 140 PSI wet on the #4 cylinder. All other cylinders are about 145 PSI wet and dry. Which of these readings most likely indicate a/an:
   a. blown head gasket between cylinder #3 and cylinder #4
   b. bad intake valve on cylinder #4
   c. bad exhaust valve on cylinder #4
   d. worn piston ring on cylinder #4

46. During an engine compression test, how many compression strokes are needed to obtain an accurate reading on the gauge?
   a. Four
   b. Three
   c. Two
   d. One

47. An engine compression test indicates compression is low on the first stroke, and does NOT build up, even with the addition of oil. Which of the following parts could be the cause of this concern?
   a. Valve stem seals
   b. Piston rings
   c. Valves
   d. Intake manifold
48. An engine compression test indicates compression is low on the first stroke, but builds with successive strokes, especially when oil is added. Which of the following parts is most likely the cause of this concern?
   a. Valve stem seals
   b. Piston rings
   c. Valves
   d. Head gasket

49. When performing an engine compression test, if the compression is low on the first stroke, does NOT build on successive strokes, and does NOT increase with oil added, the most likely problem is/are the:
   a. Valves
   b. Piston rings
   c. Intake manifold
   d. Valve stem seals

50. During a cylinder leakage test, you notice air escaping past the throttle plate. This means there is a leak at the __________.
   a. Piston rings
   b. Intake valve
   c. Intake manifold gasket
   d. Head gasket

51. During the leakage test, listen for air leakage in all of the following locations EXCEPT the:
   a. Throttle body
   b. Tailpipe
   c. Crankcase or valve cover
   d. Transmission
52. Which of the following is the MOST likely symptom of a leaky valve when performing a cylinder leak down test?
   a. Hissing in crankcase
   b. Bubbles in radiator
   c. Hissing in intake or exhaust
   d. Hissing at the spark plug hole

53. When doing a compression test, all cylinders are found to be low. Which of the following would be the most likely cause?
   a. Advanced ignition timing
   b. Burned intake valves
   c. Late valve timing
   d. Carbon build up in the cylinder

54. A leak in the hose on the bottom radiator tank to the water pump will allow coolant to leak and:
   a. Air to enter
   b. The thermostat to fail
   c. Increase pressure in cap
   d. The hose to fail

55. Technician A says that too high an oil level could cause seepage and foaming. Technician B says it could cause low crankcase pressure. Which technician is correct?
   a. Technician A
   b. Technician B
   c. Both technicians are correct
   d. Neither technician is correct

56. A common cause for excessive oil burning is a/an ____________.
   a. stuck piston rings
   b. leaking crankshaft seal
   c. clogged engine air cleaner
   d. external leak
57. You are performing a cylinder leakage test. Bubbles in the radiator would indicate ________________.
   a. defective piston rings
   b. burned intake valve
   c. a leaking intake manifold gasket
   d. a blown head gasket

58. The primary cause of an overheating problem is ________________.
   a. thermostats
   b. loss of coolant
   c. defective water pumps
   d. incorrect coolant mixture

59. When using an outside micrometer with a Vernier scale, the most precise measurement is obtained from the Vernier. To read the scale, identify the Vernier number that is most perfectly ________________.
   a. aligned with any scale mark on the barrel
   b. aligned with the Vernier pointer on the thimble
   c. aligned with any scale mark on the thimble
   d. between any two scale marks on the thimble

60. Which of the following must be reset on the torque angle meter before tightening each fastener?
   a. Angle zero pad
   b. Reset angle pad
   c. Operate/set alarm pad
   d. Torque/angle pad

61. Which of the following tools is used to measure crankshaft endplay?
   a. Torque angle meter
   b. Dial indicator
   c. Micrometer
   d. Telescoping gauge
62. One of the reasons that piston rings wear a deeper groove at the top of the cylinder than at the bottom is that the ______________.
   a. connecting rod angle is greater
   b. combustion pressure is higher at the top
   c. heat softens the upper wall
   d. cooling system is less effective there

63. The thrust surfaces of a cylinder are ______________ to the piston pin.
   a. parallel
   b. vertical
   c. horizontal
   d. perpendicular

64. When removing valve springs, which of the following should be done to prevent the valve from dropping into the cylinder?
   a. Grasp valve with valve stem key
   b. Compress valve locks using valve lock compressor
   c. Insert valve stem retaining pin
   d. Apply air pressure to the cylinder

65. Which of the following is a thread-locking compound and is applied to the insert OD threads?
   a. General Motors P/N 1052864
   b. Loctite® 277
   c. General Motors Cleaner P/N 12346139
   d. WD-40®

66. Engine blocks may be distorted if head bolts are tightened without the use of a __________ wrench.
   a. box
   b. rachet
   c. socket
   d. torque
67. With the camshaft and crankshaft gears aligned correctly, the piston on Number 1 cylinder is located ______________.
   a. on valve overlap
   b. BDC on exhaust stroke
   c. TDC on compression stroke
   d. BDC on power stroke

68. Push rods should be checked for ______________.
   a. straightness
   b. adjustment
   c. clearance
   d. rotatability

69. Excessive valve guide clearance can be corrected by all of the following EXCEPT ______________.
   a. by knurlizing
   b. with valve guide installation
   c. with an oversized valve stem
   d. with an undersized valve stem

70. The crankshaft is held in the engine block by the ______________.
   a. rod caps
   b. main bearing caps
   c. main bearing journals
   d. harmonic balance

71. Two types of rear main-bearing oil seal materials are ______________.
   a. neoprene and leather
   b. neoprene and rope
   c. #2 Permatex and RTV
   d. rubber and anaerobic
72. In which groove(s) is the oil ring located?
   a. Bottom
   b. Middle
   c. Top
   d. All grooves

73. Which one of the following cleaning methods uses live microbes to clean components?
   a. Bio-remediating
   b. Sand blasting
   c. Acid bath
   d. Sonic vibration

74. If a bio-remediating aqueous parts washer is NOT used for more than two weeks, it may be necessary to change the filter pad in order to ________.
   a. provide a fresh supply of microbes
   b. remove excess oil and grease
   c. provide fresh supply of rust inhibitor
   d. prevent sediment from clogging the circulating pump

75. An engine failure has caused metal contamination of the oil. Which of the following must be replaced?
   a. Regulating valve
   b. Oil cooler
   c. Relief valve
   d. Nothing needs to be replaced

76. The proper way to clean a cylinder head is to use ________.
   a. aluminum oxide disks
   b. solvent
   c. a plastic scraper
   d. air pressure
77. A common difficulty when diagnosing a problem reported by a customer is the ____________.
   a. customer’s misconception of results to be expected from the services to be performed
   b. communication of the malfunction from the customer to the service manager
   c. customer’s insistence for the use of nonfactory replacement parts
   d. service manager’s inability to quickly recognize the malfunction

78. The engine vacuum reading is low but steady. Which of the following is the most likely cause of this problem?
   a. A sticky valve
   b. Leaky fuel injectors
   c. Retarded timing
   d. Fouled spark plugs

79. A technician is measuring engine vacuum. The needle is normal at idle but fluctuates rapidly as engine speed is increased. This would indicate _____________.
   a. improper valve timing
   b. blown head gasket
   c. weak valve spring
   d. burned or warped valve

80. When doing a vacuum test on an engine, the needle occasionally makes a sharp, fast drop. This would be caused by a/an ___________.
   a. improper valve timing
   b. vacuum leak
   c. weak valve spring
   d. sticking valve
82. Which of the following will assist in determining which cylinders are misfiring?
   a. DTC P0201 - P0208
   b. DTC P0301 - P0308
   c. DTC P0401 - P0408
   d. DTC P0501 - P0508

83. When cleaning the external battery case terminals, use __________.
   a. a solution of water and baking powder
   b. clean mineral spirits
   c. a solution of water and baking soda
   d. clean water

84. When replacing electrical components, _____________.
   a. disconnect the battery ground cable
   b. disable the ignition system
   c. use only insulated wrenches
   d. isolate the alternator to prevent damage

85. All of the following will clear DTCs EXCEPT _____________.
   a. disconnect the battery
   b. Tech 2
   c. grounding the Data Link Connector (DLC)
   d. 40 consecutive warm-up cycles