IDENTIFYING EMISSIONS PROBLEMS ON COMPUTERIZED VEHICLES

STUDENT STUDY GUIDE

ADEQ
Arizona Department
of Environmental Quality

ADEQ Arizona Department of Environmental Quality

Improvement of air quality is the goal of Arizona's Emission Testing program

Phoenix and Tucson experience serious air pollution problems

The automobile is the largest contributor to Arizona's pollution problem in the larger metropolitan areas.

Area "A" Phoenix (Maricopa County)

Area "B" Tucson (Pima County)

Arizona's Emissions Testing Program checks for

- three primary pollutant gases
  - Hydrocarbons (HC)
  - Carbon Monoxide (CO)
  - Oxides of Nitrogen (NO_x)

    (In Pima County - NO_x is not currently measured)

These gases are invisible and cannot be detected by simple observation.

Special testing devices need to be used

- Infra Red exhaust gas analyzer (I/R Analyzer)
- Constant Volume Sampling (CVS) System

Can also serve as diagnostic tools for troubleshooting problems with CERTAIN vehicles that fail an emissions inspection

Hydrocarbons (HC)

generally measured in "parts per million" or "ppm"

- Too much UNBURNED OR RAW fuel in the exhaust
  - As more unburned fuel is left after combustion, the level of HC in the exhaust increases/go up ⇧

Causes of high HC

- **Combustion failing to occur in one or more cylinders**

  fouled spark plugs

  disconnected or shorted ignition wires

NOTE: on a computerized/OBD vehicle, this will cause an increase in both HC & CO

- **Combustion occurring at the wrong time**

  improper ignition timing adjustment (such as over-advanced timing or improper vacuum advance)

- **Combustion is not being properly contained**

  mechanical failures such as a burnt valve

  Vehicle may display blue-grey smoke out the tail pipe

- **Combustion is not hot enough**

  engine running too rich

- **Combustion is weak**

  due to worn cam lobes on one or more cylinder the normal amount of air/fuel mixture is not being drawn into the cylinders

- **Lean Air/Fuel Mixture**

  Too much air, not enough fuel-causing a periodic misfire

- ***Rich Air/Fuel Mixture***

  Too much fuel not enough air-causing left over Hydrocarbons

Carbon Monoxide (CO)

generally measured in percentage (%)

- Results from fuel that is only partially burned during combustion

- CO is formed in the cylinders when not enough oxygen is present to burn all of the fuel during combustion

Causes of high CO

- **Rich Air/Fuel Mixture**
  - *internal carburetor problems*
  - *improper carburetor adjustments*
  - *other fuel delivery system malfunctions*
- ***Restriction of the air intake***
  - *clogged air filter*
  - *other airway obstructions*

- **Enrichment effects**

  insufficient crankcase ventilation
  oil diluted with fuel

- ***Canister purge system***

  blocked or other malfunction

Two important points in diagnosing HC or CO emissions failures

- HIGH HC READINGS INDICATE UNBURNED FUEL
- HIGH CO READINGS INDICATE PARTIALLY BURNED FUEL

Oxides of Nitrogen (NO_x)

- Air is made up of both nitrogen and oxygen, when heated above 2500° F they unite and form "Oxides of Nitrogen"

- Generally, Excessive NO_x emissions are caused by:
  - a lean air/fuel mixture
  - high compression ratios
  - high combustion temperatures

HC/CO Basics Self-Check

1. _____, _____ & _____
   are the three primary pollutants in a vehicle's exhaust.

   HC Hydrocarbons

   CO Carbon Monoxide

   NOx Oxides of Nitrogen

2. Fuel that partially burns during combustion is responsible for causing what type of emissions?

   A. CO_2

   B. CO

   C. HC

   D. NO_x

3. TRUE OR FALSE – Hydrocarbons are the result of unburned fuel left after combustion.

   TRUE

4. Causes of excessive or high HC readings

A. Combustion failing to occur in one or more cylinder

B. Combustion not being properly contained

C. Enrichment effects

D. Both A and B above

5. True or False Regardless of the actual problem, excessive CO readings are caused by not enough oxygen (or too much fuel) present during combustion, resulting in partially burned fuel in the exhaust.

   TRUE

6. Causes of excessive or high CO readings:

   A. Canister purge system

   B Enrichment effects

   C. Lean air/fuel mixture

   D. Both A and B above

7. You see blue-grey exhaust smoke coming from the tail-pipe of a vehicle being emissions tested. The I/R analyzer indicates high HC readings. Which is most likely the cause of the problem?

A. Lean air/fuel mixture

B. Mechanical/compression

C. Crankcase dilution

D. Leaking Injector

8. Which of the conditions listed below will most likely cause an engine misfire?

A. Faulty ignition components

B. PCV valve stuck in the low flow position

C. Faulty evaporative canister

D. Rich air/fuel mixture

9. A fouled or missing spark plug on an OBD vehicle will cause an increase in what type of tailpipe emissions?

A. HC

B. CO

C. NO_x

D. HC & CO

EMISSIONS *REDUCTION DEVICES*

ADEQ Arizona Department of Environmental Quality

Catalytic Converters

The catalytic converter serves as a "trimmer" to reduce already low emissions to near zero

Common types:

1. Single-bed, Two-way- mid to late 1970's; are materials are contained in a single chamber burns (oxidizes) only HC and CO

2. Single-bed, Three-way-late 1970's to present; all catalytic materials are in a single chamber burns (oxidizes) HC, CO & reduces NO_x

3. Dual-bed, Three-way- late 1970's to present; separate reducing chamber for breaking down NOx; separate oxidizing chamber for HC and CO

The amount of oxygen present in the exhaust has a significant effect on the three way CAT's ability to reduce NOx and oxidize HC and CO at the same time.

The next slide is an actual I/M 240 emissions test done on a 1981 Chevrolet vehicle

After the test; the vehicle was diagnosed as having a bad valve.

Note the:

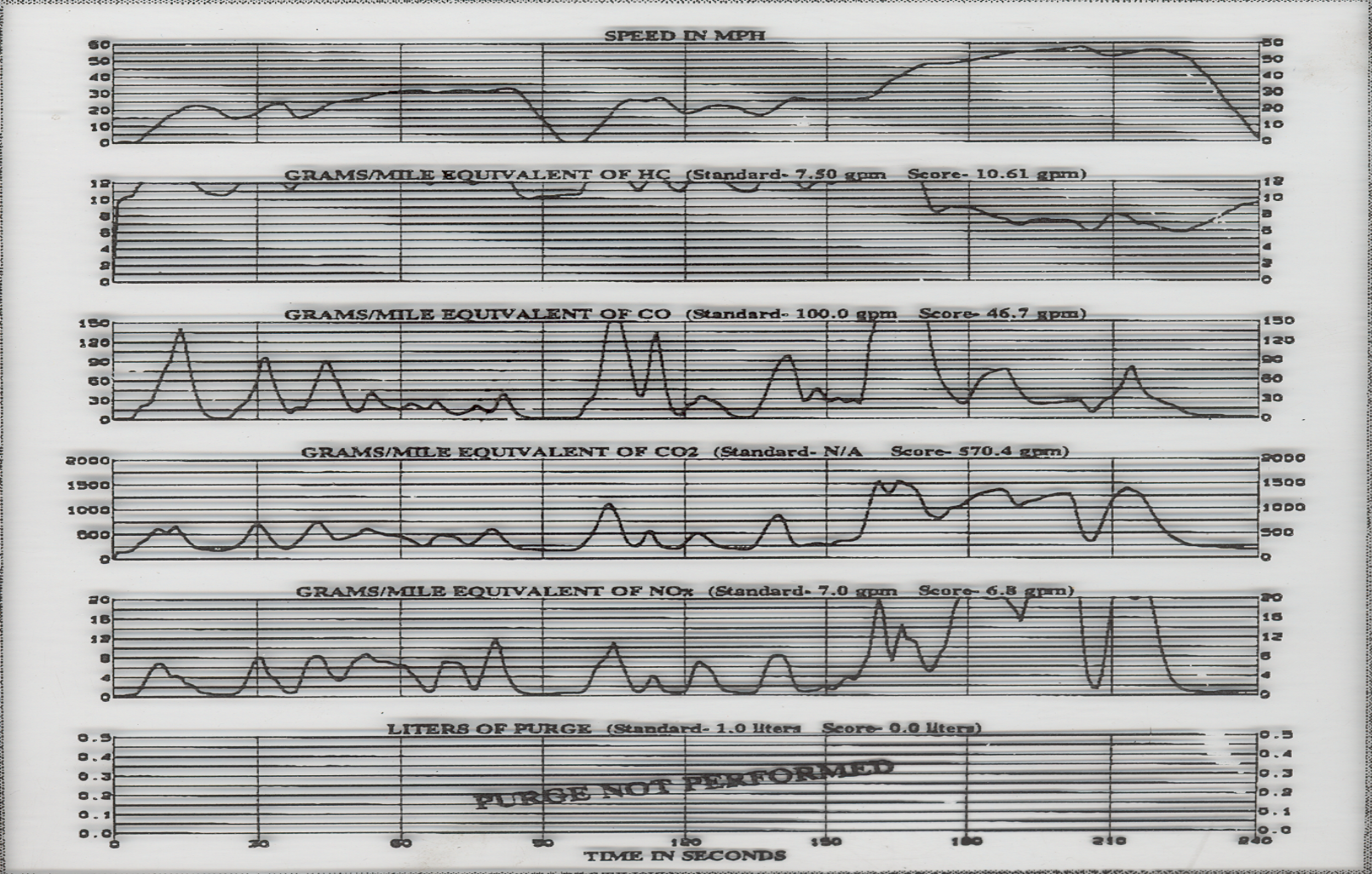
- Date and time of test
- Year of vehicle
- The areas and extent of where the vehicle is failing

ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY

Tag...OS[redacted]
VIN...
Year...1981
Make..CHEVR

Type.....LDT1
Horsepower...17.1
Inertia Wgt...3875

Date....10-04-95
Time....11:11
Station..W04
Lane.....1



ADEQ Arizona Department of Environmental Quality

Look at this next slide of the SAME vehicle at 3:42 pm

- Remember that it had a bad valve at 11:11 am

The ONLY repair done on this vehicle was a new Catalytic Converter installed and driven to break-in.

Note the areas where it was failing in the earlier test.

What are the capabilities of the "Catalytic Converter"?

Tag...QS
VIN...[redacted]
Year...1981
Make..CHEVR

Type.....LDT1
Horsepower...17.1
Inertia Wgt...3875

Date....10-04-95
Time....15:42
Station..W04
Lane.....1

Canister Purge System

- **Purpose**
  - To capture and store fuel vapors emitted from the fuel tank and/or carburetor fuel bowl

if the canister purge system allows stored vapors to flow into the intake manifold at idle, an emission failure and probable poor idle quality will result.

A quick way to check the canister purge system for proper operation is to pinch off the purge hose (or remove it and cap off its entry to manifold vacuum).

If a large change in idle quality or speed is noted, you have found a problem.

Positive Crank Ventilation System (PCV)

- Purpose is to control "blow by" vapors that escape from the cylinders into the crankcase during combustion
  - Two types
    - High flow
    - Low flow

Air Injection Systems
Two types used

- Pulse Type

Reed Valve (Suction)
Relies on negative pressure that occurs in the exhaust system when the exhaust valve closes.

negative pulse creates a momentary low pressure (vacuum) that draws fresh air into the exhaust through a reed valve.

as exhaust pressure increases, the reed valve is forced closed to prevent exhaust flow in the opposite direction

- Pump Type
  - Uses a low pressure high volume pump to supply air to the exhaust

    driven by an accessory drive belt

    late model vehicles are using an electric motor-driven pump that is activated by the vehicle's computer

    Properly directing the air requires a control mechanism

    diverter valve

    bypass valve

    anti-backfire valve

This valve is used to direct air to the appropriate place It is usually controlled by a vacuum signal

In most cases exhaust was diverted from the exhaust to atmosphere during deceleration to prevent exhaust backfire

Other systems prevent air from being injected into the exhaust during periods of extended idle

With feedback systems some air injection systems utilize two types of valves. From the pump air is directed to the diverter or bypass valve.

This valve either bypasses air to atmosphere or to the air control valve

The Air Control Valve is used to direct air upstream to the exhaust manifold or downstream to the catalytic converter depending on vehicles operating condition

Some manufacturers incorporated both valves into a single valve assembly called an air management valve

During engine warm-up air is directed upstream to promote afterburning in the exhaust manifold

This upstream afterburning reduces the oxygen sensor and catalytic converter warm-up time and allows the vehicle to go into closed loop much quicker

During normal operating condition, air is shifted downstream to the catalytic converter

With oxygen being injected to the rear (oxidation) bed of the catalytic converter HC and CO reduction is improved.

Some computerized feedback engines use the air injection solely to assist in oxygen sensor and catalyst warm-up. Once achieved air is bypassed to the atmosphere or air cleaner.

Exhaust Gas Recirculation System(EGR)

EGR-designed to reduce NO_x emissions created by

- ✓ high compression ratios
- ✓ an increase in cylinder temperature
- ✓ lean air/fuel mixture ratios

The EGR valve will recirculate exhaust into the intake stream, lowering the combustion chamber temperatures.

This procedure will chemically slow and cool the combustion process by several hundred degrees; reducing NO_x formation.

Emissions Reduction Devices Self Check

1. Which emissions control system is designed to temporarily store vapors put out/emitted by the fuel tank and fuel delivery system?

   A. Positive Crankcase Ventilation (PCV) System
   B. Air Injection System
   C. Evaporative Emissions Control system (Canister Purge)
   D. Exhaust Gas Recirculation System

2. The function of the air management system on most computerized vehicle is_____.

   A. To help bring the O_2 sensor to operating temperature rapidly
   B. To direct the air either overboard (atmosphere) or downstream (catalytic converter) after warm-up
   C. To assist the cat to better oxidize both HC and CO
   D. All of the above

3. **Which is the most correct statement about the catalytic converter?**

   A. I/R analyzer readings for CAT and NON-CAT vehicles are nearly the same

   B. It helps emissions by restricting exhaust flow

   C. It acts as a trimmer to reduce already low emissions to near zero

   D. If the vehicle has a catalytic converter, it won't fail an emissions test

4. **<u>True or False</u> The EGR system will reduce NO_x emissions.**

   True

Basic Electronics

ADEQ
Arizona Department
of Environmental Quality

BASIC ELECTRONIC CONCEPTS

- Voltage is measured in "volts“
  - Voltage can be considered a rating on how much "force" is present in the electricity to carry the current
- Current is best described as a measure of electrical flow
  - current is measured in "amperes", or "amps“
- Resistance is best described as opposition to the flow of electricity
  - (Restriction)
    - Measured in ohms (Ω)

- **Alternating Current (A/C)**
  - electricity that cycles
    - changes the direction of flow
    - It is not suitable for use in most electronic applications unless it has been changed, or processed into a form which is more readable by the computer

- **Direct Current (D/C)**
  - does not cycle and flows in only one direction.
    - it is considered stable and is the type of electricity used in most electronic applications.
    - Produced by batteries or from alternating current that has been rectified and filtered into direct current.

- **Reference Voltage**
  - A reference voltage is an electrical signal of predetermined value that is used as a standard when making measurements in an electronic circuit.

- **Diodes**
  - **permits current to flow through it in only one direction**
    - **Used to protect the computer from sudden voltage surges (spikes)**
    - **“one-way valve” (rectifying device on a car alternator**

SELF-CHECK
BASIC ELECTRONICS

1. With the exception of some Ford computerized systems, what should reference voltage be for most computerized systems?

   A. 12 volts

   B. 24 volts

   C. 15 volts

   D. 5 volts

2. The property of an electronic device to oppose/restrict the flow of current through it is called_____.

A. Voltage

B. Resistance

C. Amps

D. Feedback

3. You are using a DVOM that has an audible diode test feature to test a diode. After properly setting your meter and connecting the leads, your DVOM beeps once. You then switch leads (place the red one where the black one was, and vice-versa) and your meter beeps again. What does this indicate?

A. The diode is good

B. The diode is bad

C. Nothing not a valid test

CLOSED LOOP SYSTEM OPERATION

ADEQ
Arizona Department
of Environmental Quality

One of the most common methods to control emissions in computerized vehicles is

"Closed Loop Operation"

- The purpose of the closed loop system is to control engine emissions by regulating the air/fuel mixture & ignition timing, while maintaining satisfactory performance drivability & fuel economy.

Stoichiometric Air/Fuel Ratio

The "ideal" air/fuel mixture

- Consists of 14.7 lbs. of air to 1 lb. of fuel
- 14.7:1 ratio
- Ideally this mixture would burn the fuel mixture completely

*Stoichiometric air/fuel ratio provides low emissions it is NOT necessarily the best ratio for engine power or fuel economy

Richer mixtures (more fuel, less oxygen) 13.9:1 provide more power

Leaner mixtures (more oxygen, less Fuel) 16:1 provides better economy

as the air/fuel mixture moves either richer
Or leaner away from stoichiometric,
Some emissions increase accordingly.

As the air/fuel mixture becomes richer or leaner, the catalytic converter is not as effective at reducing all emissions.

THE COMPUTER

- basic function

  – to control the air/fuel mixture, ignition timing and other engine operations.

Major Computer Elements

– Internal timer

- Once the internal timer runs out (usually 5 seconds to 5 minutes), the computer then starts using sensor information to make engine control decisions.

–Microprocessor

- The microprocessor does all the "work" in the computer.
- It performs all the calculations, makes all the decisions, and handles the communications.
- Analog to digital converters change the signals received from a component into a form the microprocessor can understand.

– Three Part Memory

- The computer's memory consists of three main sections, with each serving a specific purpose.
  - RAM - Random Access Memory
    RAM is a temporary memory, or "scratch pad", that works only while the vehicle's ignition is switched on.
  - ROM - Read Only Memory
    ROM contains a set of permanent instructions that tell the computer what it is capable of doing. These instructions are programmed into ROM by the vehicle's manufacturer and cannot be changed
  - PROM - Programmable Read Only Memory
    PROMS are a type of computer chip that contain special instructions and allow manufacturers to adopt basic computers to specific makes and models of vehicles. Like a ROM, the instructions contained on a PROM are permanent.
  - EPROM & EEPROM's these are the same as a PROM, except that they are erasable. EPROM's and EEPROM's are reprogrammable. A re-flash can be done.

Most automotive computer systems consist of three main elements:

1. Sensors
   - detect (sense) various engine operating conditions
2. Computer
   - Monitors the input from the sensors
   - Makes decisions
   - Sends commands to adjust engine functions
3. Actuators
   - Perform engine adjustments based on the commands from the computer

Closed Loop vs. Open Loop

- When the computer is using the inputs from the O_2 sensor to control engine functions, the system is operating in "closed loop"

- Before the computer can use the O_2 sensor inputs & attain closed loop operation,

The following four conditions must be met:

1. The computer's internal timer must run out

2. The engine must reach normal operating temperature

    - Coolant temperature sensor is considered the dominant sensor at engine start-up

3. The O_2 sensor must reach operating temperature (about 600° F) & begin sending a varying voltage signal to the computer

4. All other sensors must be sending signals within their normal range.

Operating conditions that affect closed loop:

- **Wide open throttle (WOT)**
  - The computer senses that more power is required and adjusts for a richer air/fuel mixture, the system drops into open loop

- **Semi-closed-loop**
  - the computer automatically shifts to cruise mode operation and adjusts the air/fuel mixture to be lean
  - This increases fuel economy and is one of the reasons that the highway mpg rating are usually higher than the city rating.

ELECTRONIC DEVICES USED AS SENSORS

ADEQ
Arizona Department
of Environmental Quality

Thermistors

- A thermistor functions like a variable resistor
- as temperature changes, a thermistors resistance changes
- manufactured to change resistance at a set rate (10° change in temperature may change resistance by 1000Ω)

- Two types of thermistors

  - Negative temperature co-efficient
    - Decreases in resistance as temperature rises

  - Positive temperature co-efficient
    - Increases in resistance as temperature rises

This change in resistance will cause a corresponding change in circuit current flow.

Thermistors are used as:

- Coolant temperature sensors
- Air charge sensors
- Battery Temperature

Potentiometers

- provide a varying voltage output in response to motion
  - Throttle position sensor
  - EGR position sensor
  - Fuel sender units

Switches

- The voltage used to indicate whether a function is on or off, or if a specific condition does or doesn't exist
  - Provide either a steady voltage or no voltage
  - Can't be used to provide a rate of change

Inductive Pick-ups

- sensitive to movements of magnetic fields
  - as current goes positive (+) the magnetic field expands
  - as current goes negative (-) the magnetic field collapses
- a magnetic field is sensed by a sensor
- When the field is temporarily broken or blocked by an object passing through it, a voltage is sent to the computer
  - Used in electronic ignition systems to control ignition timing by sensing crankshaft position

Piezoelectric Devices

- contain a crystal which responds to specific frequencies, or certain pressures
- When the crystal detects a vibration or pressure change within a preset range, it will produce a voltage signal that is sent to the computer
- Piezoelectric devices are commonly used in:
  - MAP sensor
  - BARO sensor
  - Knock sensor

- They use a piezoresistive diaphragm, spread across two separate chambers. The diaphragm changes resistance as it flexes.
- One chamber is sealed with specific reference pressure
- The other chamber is connected to the pressure being sensed

COMMON ENGINE SENSORS

OXYGEN SENSORS (O_2)

Oxygen Sensors (O_2) sense the amount of oxygen in the exhaust and send a voltage signal back to the computer indicating whether the air/fuel mixture is rich or lean from Stoichiometric (14.7:1 air/fuel mixture ratio)

- a voltage signal from the O_2 sensor
  - varying between .2 - .9 volts [200mv - 900mv]
    - closed loop operation is being used.
  - fixed voltage---the system is operating in open-loop.

- The CTS, MAP or MAF, TPS and IAT sensors are used as the dominant sensors to set air/fuel mixture ratio to as close to 14.7:1 as possible.

- Then the computer will monitor the O_2 sensor and "Trim" the air/fuel mixture ratio to maintain the 14.7:1 under as many driving conditions as possible.

Conditions that affect the output of the oxygen sensor

- Engine coolant
- Excessive oil consumption
- Additives used in sealants
- The wrong fuel additives

The oxygen sensor must reach its operating temperature and begin sending a voltage signal.

As the oxygen content of the exhaust decreases ⇩
(air fuel mixture becomes richer)

output voltage increases ⇧

ZIRCONIA OXYGEN SENSORS

- to sense the amount of oxygen present in the exhaust gas and relay that information to the computer

Its output must vary from .2 to .9 volt for the system to stay in closed loop.

The computer recognizes a specific voltage called "set-point" as the ideal air/fuel mixture ratio (between .45 volts to .5 volts)

- The amount of voltage produced by the O2 sensor increases as the mixture becomes richer.
- As the amount of oxygen in the exhaust increases (as the mixture becomes leaner), the voltage output drops.

TITANIA OXYGEN SENSORS

- Works like a coolant temp sensor. The sensor changes resistance as the air/fuel ratio changes from lean to rich and rich to lean.

AIR/FUEL RATIO SENSOR

- Designed so that at stoichiometric, there is no current flow and the voltage put out by the detection circuit is 3.3 volts. A richer mixture will produce a negative voltage.

COOLANT TEMPERATURE SENSOR (CTS)

- The CTS is the dominant sensor at engine start-up
  - the engine must receive cold enrichment mixtures for starting and cold drive-away performance.

- If the CTS is bad or non-functioning
  - the system may not go into closed loop.

- Factors that affect the output of the CTS:
  - Proper coolant mixture – 50/50 coolant/water mixture
  - Coolant level - sensor must be surrounded by coolant
  - Cooling fan or Fan Clutch operation
  - Thermostat operation (critical)
    - OEM thermostats are highly recommended

- **Faulty CTS emission indications are likely to be:**
  - **High CO readings:**
    - **The engine may not reach operating temperature, causing a cooler combustion and partially burnt fuel to be exhausted, increasing CO.**
  - **High HC readings:**
    - **If the computer does not sense the engine reaching operating temperature, it may keep the air/fuel mixture adjusted for cold enrichment needed at start-up**
    - **This rich mixture causes unburned fuel to be exhausted and increases both HC and CO.**

MANIFOLD ABSOLUTE PRESSURE SENSOR

- MAP sensors are piezoresistive devices and are used to give the computer an indication of engine load depending on throttle opening

- Common MAP sensor problems include:

1. MAP sensor does not hold vacuum.
2. MAP sensor signal out of spec or low.
3. MAP sensor does not receive vacuum.
4. The MAP sensor can shift to a constant high voltage signal, calling for a rich mixture and retarded timing.

MASS AIR FLOW (MAF) SENSORS

Three most common types

- the hot wire type
- grid type
- Karman Vortex type

MAF sensors are not interchangeable and the correct type must be used for the specific engine application.

- There are two types of Karmon Vortex MAF sensors.
  - One measures mass air flow by sensing ultrasonic waveforms
  - the other uses optical vibrations

BAROMETRIC SENSOR (BARO)

- purpose is to provide the computer with an input of the operating altitude of the vehicle

Drivability problems with a faulty BARO sensor may not be noticed until operating conditions change.

For example

a trip to the mountains or a higher altitude - problems like sluggishness, poor throttle response, and excessive knocks or pinging may be noticed.

THROTTLE POSITION SENSOR (TPS)

- purpose is to indicate the angle of the throttle opening to the computer.
- At wide open throttle (WOT), about 85% (or more) of the voltage is returned to the computer.
- Common TPS problem is:
  - Dirty center wiper
    - The transition from idle to WOT should be a smooth increase in signal voltage when monitored with a DVOM.
    - If the transition is not smooth (or jumps in voltage are noticed), then the TPS should be replaced.
    - Symptoms include hesitation on light acceleration, or sudden jerking.

If you are testing a TPS and show 5 volts at idle replace it.

CRANKSHAFT POSITION SENSOR (CPS)

purpose is control ignition timing by monitoring the rotational position of the crankshaft.

- if the signal is weak or incorrect, the following problem may be noticed:
  - Improper ignition timing
    - Excessive knocks and pinging along with hesitation and other drivability problems may result as the computer tries to adjust the ignition timing for the conditions being sensed.
    - Emission indications are likely to be excessive HC

CAMSHAFT POSITION SENSOR (CMP)

purpose is to communicate the position of the camshaft to the control module.

- This information is used to synchronize the pulsing of sequential fuel injectors to match the firing order of the engine

KNOCK SENSOR

- purpose is to send a voltage signal to the computer indicating that engine knock is occurring.

- The Knock Sensor is a piezoelectric type sensor that responds to certain frequencies.

- When the computer receives a signal from the knock sensor it will retard ignition timing in small increments until pre-ignition is reduced or eliminated.

SWITCHES

- used to indicate that a condition is present for which the computer may need to adjust engine operation

- Some of the types of switches used to monitor different conditions include:
  - Park/Neutral Switch
  - Air Conditioning (A/C) Switch
  - Idle Speed Control Switch
  - Transmission Switches
  - EGR Switch

ACTUATORS

- These are the devices that actually make adjustments to engine control systems.

- All actuators have one thing in common; they don't "act" until they are told to do so by the computer.

  - The current flow to the actuator may be regulated by a relay that is controlled by the computer.

  - In some cases, the actuator draws less than .5 amps and is controlled by a power transistor within the computer

Actuator Types

- **Solenoids**

- uses a magnetic field created by a coil of wire to move an iron center core or armature

- commonly connected to valves to control engine functions, such as vacuum, fuel mixture, or EGR. Fuel injectors and relays are other examples of common solenoid devices.

Power Relays

- Relays also have a coil of wire that creates a magnetic field to open or break a set of contacts that control the heavier current flow.
- The most common use of relays in vehicles is the starter
- used to energize current dependent devices, without passing those loads through the ignition system.

Motors

- The motor contains a coil winding, which drives a shaft as it receives direct current or electric pulses.
- The direction the shaft turns is controlled by the polarity (pos or neg) applied to the coil windings, thereby making most motors reversible.
- A motor is commonly used to control the idle speed (and in some cases, the air/fuel mixture) in computerized vehicles

CLOSED LOOP SYSTEM OPERATION SELF - CHECK

1. TRUE or FALSE – The purpose of the closed loop system is to control emissions by regulating ignition timing and air/fuel mixture, while maintaining the acceptable performance/drivability and fuel economy.
   True

2. Inductive pick-ups are commonly used in computerized engine control systems to_____.

   A. Indicate EGR valve position
   B. Detect engine knock
   C. Provide crankshaft position for ignition timing
   D. Indicate coolant Temperature

3. Which sensor on an OBD equipped vehicle has to be heated before it will begin sending a signal to the computer?

   A. Oxygen Sensor (O_2)

   B. Throttle Position Sensor (TPS)

   C. Manifold Absolute Pressure Sensor (MAP)

   D. Thermistor Style Coolant Temperature Sensor (CTS)

4. The device/chip which contains specific instructions for the computer and allows auto manufacturers to use the same computer in different models of vehicles is called_____.

   A. Read Only Memory (ROM)

   B. Random Access Memory (RAM)

   C. Programmable Read Only Memory (PROM)

   D. Keep Alive Memory (KAM)

5. As the oxygen level of the exhaust gas goes down/decreases, the O_2 sensor voltage should_____.

A. go up/increase
B. go down/decrease
C. show no significant change
D. none of the above

6. The "ideal" air/fuel mixture for emissions, referred to as "Stoichiometric "Air/Fuel ratio is approximately _____.

A. 13.5:1 A/F ratio
B. 14.7:1 A/F ratio
C. 15.1:1A/F ratio
D. None of the above

7. You are using a DVOM to monitor a Throttle Position Sensor (TPS). As you slowly open the throttle, you *first* observe a slow steady increase in voltage. As you approach mid-throttle range, the voltage suddenly decreases by almost a full volt. What does this indicate?

A. Normal TPS operation
B. Defective Digital Volt Ohm Meter (DVOM)
C. Defective TPS, repair or replace

8. The components used to perform engine adjustments as commanded by the computer are referred to as_____.

A. Switches
B. Actuators
C. Sensors
D. Diodes

9. While monitoring the output of a known good oxygen sensor with a DVOM. The readings remain fixed at about 0.75 volts. What does this indicate?

   A. Normal exhaust condition
   B. Rich exhaust condition
   C. Lean exhaust condition

10. The part of the computer's memory which temporarily stores information is called

   A. Random Access Memory (RAM)
   B. Programmable Read Only Memory (PROM)
   C. Central Processing Unit (CPU)
   D. Read Only Memory (ROM)

11. When the computer receives a signal from the knock sensor, it is likely to respond by sending a command to_____.

A. Retard ignition timing

B. Advance ignition timing

C. Adjust base timing

D. To make Air/Fuel mixture richer

12. The computer is able to adjust the engine for operation at different altitudes by monitoring which sensor?

A. Coolant Temperature Sensor (CTS)

B. Air Conditioning Sensor (ACS)

C. Oxygen Sensor (O_2)

D. Barometric Pressure Sensor (BARO)

13. Which sensor is monitored by the computer as the dominate sensor at engine start-up most computerized automotive systems?

A. Throttle Position Sensor (TPS)

B. Manifold Absolute Pressure Sensor (MAP)

C. Coolant Temperature Sensor (CTS)

D. Oxygen Sensor (O_2)

14. What factors can most likely affect Coolant Temperature Sensor (CTS) output?

A. Potentiometer positioning

B. Thermostat operation

C. Engine load

D. None of the above

15. On computerized systems the MAP tells the computer____.

A. To change dwell on the mixture control
B. About engine load
C. When to advance or retard timing
D. About engine temperature

16. You are monitoring the output of a known good oxygen sensor with a DVOM. The output voltage seems to fluctuate between about 0.2 volts and 0.9 volts. From this, you can conclude that_____.

A. The system is operating in open loop
B. The vehicle has an emissions problem
C. The system is operating in closed loop

ON-BOARD DIAGNOSTICS

ADEQ
Arizona Department
of Environmental Quality

- The OBD system uses
  - Diagnostic Trouble Codes (DTC)
    - To help techs isolate a problem
  - Malfunction Indicator Light (MIL)
    - To alert the driver that there is an emissions system problem

OBD II

- **All light duty vehicles beginning with the 1996 model year are required to have OBDII diagnostic systems.**

- ***The purpose of OBD-II was to make sure every new vehicle's emission system works properly for the lifetime of the vehicle.***

- **Every OBDII diagnostic system must be capable of:**
  - Identifying failure or malfunction of emissions components which would result in the vehicle's failure to comply with federal emissions standards
  - Alerting the vehicle operator of the need to maintain and/or repair emissions-related components and/or systems.
  - Storing trouble codes and providing access to vehicle on-board information.

- OBD II monitors the performance of emission systems and components as well as electrical failures

- The MIL will be activated/illuminated and a DTC will be set by the system, if it detects an emissions system failure on TWO consecutive drive cycles.

- The MIL will be turned OFF by the OBD II system when it detects THREE consecutive trips without the problem re-occurring.

Two types of Readiness Monitors
Continuous

- Misfire
- Fuel trim/fuel delivery system
- Comprehensive components (sensors & actuators)

These are continuously checked by the OBDII system and are NOT to be considered in the readiness monitor determination

Two types of Readiness Monitors

Non-continuous

- Comprehensive component monitoring (emissions related inputs and outputs
- 0_2 sensor system
- 0_2 sensor heater system
- Catalytic converter efficiency
- Heated catalyst monitoring
- Evaporative emissions control system
- EGR system
- Secondary Air Injection

These monitors are to be considered in the readiness monitor determination

OBDII systems include an emission monitor.

Before any of the vehicles emissions rise more that 1.5 times the Federal Test Procedure cut-points/new car standard, the system turns on the MIL "ON"

After repairs and/or battery service, replacement or disconnection; it is recommended that the vehicle be driven through the drive cycles;

then rechecked to ensure monitor readiness before returning for a retest

In 1998, CARB and SAE developed a new set of standards for vehicle control systems requiring a common:

- set of terms and definitions
- set of diagnostic trouble codes and definitions
- diagnostic connector and connector location
- diagnostic tool
- set of diagnostic test modes
- way for technicians to get service information
- SAE recommended serial data communication system
- international serial data communication system

All manufacturers are required to:

- use the same diagnostic link connector (DLC)
- each DLC must be wired the same way
- use the same type of software packages

This means one scan tool should be able to provide information on every vehicle that comes through the shop.

- All OBDII connectors must be compatible with one generic scan tool
- Manufacturer's are required to make their OBDII-DLC's work with one generic scan tool.

The standards also provides minimum requirements that the generic scan tool protocol must meet for the manufacturer to claim that it is OBDII compatible.

Among these requirements is the retrieval of:

- Diagnostic Trouble Codes
- Sensor Parameter value
- Freeze Frame Data

The generic scan tool protocol may also read serial data & perform diagnostic test modes, OBDII standard J1979 requires certain serial data be available to the scan tool & that certain diagnostic capabilities be part of the on-board computer design.

- Standard test modes include:

  - Diagnostic test modes
  - Diagnostic test results
  - Retrieving trouble codes
  - Clearing trouble codes

- One of the features of OBDII are "TRIPS".
  - During a trip, the computer performs a specific series of tests and monitors while you drive the vehicle through a specific series of conditions.

- These driving conditions are called an OBDII "DRIVE CYCLE"

- OBDII systems provide "ADAPTIVE LEARNING"
  - OBDII systems sense specific conditions during a drive cycle, & adjust to compensate for those conditions.

ECT Sensor Diagnostics

The computer provides a 5 volt reference voltage signal to the sensor. The sensor provides high resistance when the engine is cold. The computer measures this resistance as a high voltage drop across the sensor.

The OBDII system requires that the sensor be monitored for performance deterioration.

diagnostics includes several tests.

- ECT sensor voltage out of range
- ECT sensor input failed to enable closed-loop
  - Also tests for intermittent circuit activity.

The computer monitors temperature readings from the ECT in 100 millisecond intervals. For a fixed period of time, the diagnostic counts the number of ECT sensor readings outside of the sensor's expected range.

If the number of ECT sensor readings in the high or low range exceeds a calibrated threshold, the sensor shows a high or low fail.

The diagnostic for closed-loop enable monitors the engine run time required for the ECT sensor to reach the closed-loop enable threshold.

This diagnostic is to identify an ECT sensor reading that is delaying or preventing closed-loop operation, yet has not failed out of range.

Heated Oxygen Sensor Monitor

- The fuel control heated oxygen sensors provide the computer with exhaust stream oxygen content information
  - The O_2 sensor monitor is designed to monitor the upstream heated oxygen sensor (s)
  - Monitor looks for these conditions:
    - Heater performance (time it takes to reach operating temperature on a cold engine)
    - Heated Oxygen Sensor slow response time
    - Inactive signal (Voltage steady at bias of around 450mv)
    - Heated Oxygen Sensor signal fixed high
    - Heated Oxygen Sensor signal fixed low

- **Possible causes of Oxygen Sensor Heater Monitor codes:**
  - Open heater element (s)
  - Faulty heated Oxygen sensor
  - Backed-out terminals, damaged connectors or wiring

- **During a drive cycle the OBDII system monitors the oxygen sensor**
  - after warm-up
  - during a steady speed cruise between 20 & 45 MPH for about 20 seconds

Catalyst Efficiency

- OBDII monitors catalytic converter efficiency by checking two oxygen sensors
  - one before the converter and one after
- The system compares the oxygen levels coming in and going out of the converter
  - The sensor before the converter should be switching back and forth within its full voltage range
  - The sensor after the converter should not have an equal switching rate to the oxygen sensor before the converter

When the computer sees that both oxygen sensor readings are similar, it sets a code that the catalyst efficiency may be reduced.

Inputs from various sensors are required to allow the Catalyst Monitor to run:

- Crankshaft Position Sensor (CKP)
- Engine Coolant Temperature Sensor (ECT)
- Intake Air Temperature (IAT)
- Throttle Position Sensor (TPS)
- Vehicle Speed Sensor (VSS)

- Also a specific amount of time had to have expired since engine start-up, and closed-loop operation must be enabled
- *The slower the switching frequency of the downstream HO_2S oxygen sensor the more efficient the converter*
- During the drive cycle the OBDII system Monitors the oxygen levels in the exhaust before and after the catalytic converter, to determine its oxygen storage capabilities.
- This test requires a Steady speed cruise, between 40 & 60 MPH, for a little over a minute.

EVAP System Monitor

- **Designed to test for correct operation of the Evaporative Emissions System by checking the operation of its components & its ability to flow fuel vapors (HC) to the engine**
  - Detects leaks equal to or greater than the mfg set level by performing a vacuum check of the complete Evap System
  - **Possible fault causes:**
    - Vacuum hoses cracked, leaking, cut, or disconnected
    - Plugged hoses from the solenoid to canister or throttle body
    - Plastic connector to Evap Canister Purge Solenoid cracked
    - Connectors or wiring damage
    - Evap Canister Purge Solenoid fault or computer defective
    - Faulty fuel cap

EGR System Monitor

- Designed to test the integrity and flow features of the EGR system
  - Checks for abnormally high or low flow-rates and sets a code if it detects an EGR system component fault, or a change in EGR flow rate that could result in the vehicles emissions exceeding 1.5 times the new car standard

EGR System Monitor

Possible causes:

- Opened or blocked vacuum supply (hoses) to the EGR valve
- Blocked exhaust transfer tubes to the intake manifold
- Blocked backpressure tube to the transducer
- Failed EGR valve or EGR transducer
- Backed-out or damaged connector terminals

During the drive cycle the OBDII system monitors the EGR system operation during a series of idles and accelerations

Misfire Monitor

- Designed to monitor engine misfires & identify the specific cylinder in which a misfire occurred
- Inputs from the following are needed for the monitor to work:
  - Crankshaft Position Sensor
  - Engine Coolant Temperature Sensor
  - Mass Air Flow Sensor

  - Possible causes of misfire monitor faults:
    - Engine mechanical faults, restricted exhaust
    - Fuel pump faults or a plugged or restricted fuel filter
    - EGR or EVAP system faults
    - Dirty or faulty fuel injectors, damaged injector connectors
    - Vehicle low or out of fuel
    - Intake system restriction
    - PCM power or ground circuit faults, a faulty PCM
    - Ignition defects
    - Fouled or malfunctioning spark plugs or bad plug wires

Fuel System Monitor

- Designed to measure the average of short term & long term fuel trim
- Fuel trim diagnostic compares the average values of short term & long term fuel trim value to rich & lean tolerances
  - Both values are within range the fuel system passes the monitor test
- If the oxygen sensor used for air/fuel control indicates a rich exhaust condition, the computer moves short term fuel trim to a negative range to correct the rich condition

- If after a calibrated period of time the short term fuel trim is still correcting for the rich condition, the computer learns this and changes long term fuel trim into the negative range to correct the condition, allowing short term fuel trim to return to a value of 0%.

- **Possible causes of fuel system monitor faults:**
  - Incoming air temperature sensor faults
  - MAP sensor faults
  - O_2 sensor or computer faults
  - EGR faults
  - Fuel or ignition system faults
  - Worn engine parts
  - A defective catalytic converter

During the drive cycle the OBDII system begins performing misfire, comprehensive component and fuel system monitoring and it can end any time during the trip.

Secondary Air Monitor

- Vehicles that are equipped with secondary air injection pumps must be monitored for the presence of air flow in the exhaust, and functional monitoring of the air pump and related valves
  - The monitor tests the HO_2S1 voltage after start-up and before closed-loop operation
    - Monitor will indicate a pass if the HO_2S1 voltage indicates a lean condition before it goes into closed-loop operation
  - If this fails an active test is started. The air pump is turned on when the fuel system is in closed loop operations.
    - Monitor will indicate pass/fail based on the HO_2S1 and short term fuel trim values. A low HO_2S1 voltage signal and increased short trim fuel values indicates the air system is operational

MAP Diagnostics

- The MAP sensor measures changes in intake manifold pressure.
  - MAP sensor readings are shown in both kilopascals (kPa) and voltage.
- Intake manifold pressure changes are a result of engine load and speed changes.
  - To measure these changes the MAP sensor varies resistance.
    - The computer sends out a 5-volt reference voltage and then decreases the voltage according to the pressure in the intake manifold.

- The MAP signal is used to measure
  - barometric pressure
  - Changes in linear Exhaust Gas Recirculation (EGR) flow
  - Changes in manifold pressure during certain diagnostic testing.
- MAP sensor Monitoring Diagnostics will monitor for voltages outside of its normal calibrated range.
  - The computer also measures actual MAP output to calculated values to determine sensor performance failure.
    - The calculated values are based on Throttle Position and various engine load factors.

OBDII Emissions Inspection

The test consists of:

verifying the operation of the malfunction indicator lamp (MIL)

confirming that the appropriate readiness monitors are set

visually inspecting the diagnostic link connector (DLC)

determining if the MIL is commanded "ON" recording DTC's.

The process is as follows:

1. The vehicle's ignition is turned to "Key On Engine Off" (KOEO) and the MIL is observed; the MIL must be lit.

   This portion of the test verifies MIL operation and is commonly known as the "bulb check"
   On = pass
   Off = fail

2. The DLC is located and inspected for tampering (missing, loose, or damaged).
   If the DLC is tampered (missing, loose, or damaged), the vehicle fails the inspection.

3. The vehicle's DLC is connected to the scan tool. The vehicle's ignition is turned "Key On Engine Running" (KOER) and the MIL is observed. The MIL should light and then go out during this phase.
   If the MIL stays on; the vehicle fails.
   If the MIL goes off the vehicle passes.

4. **The scan tool used must be in the generic OBD mode, and the following is then determined:**

   Readiness Monitor Status:

   1996 through 2000 model year vehicles are allowed two or fewer unset readiness monitors for a valid test.

   2001 and newer model year vehicles are allowed one or less unset readiness monitors for a valid test.

   If monitor requirements are not met, the vehicle must be driven through a drive cycle until required monitors are set.

   The MIL status is then checked to determine if the vehicle's computer is commanding the MIL to be on or off.

   MIL commanded off = pass

   MIL commanded on = fail

5. **The functional gas cap test is performed.**

Self Check
On-Board Diagnostics - OBDII

1. TRUE or FALSE - The slower the switching frequency of the downstream oxygen sensor the more efficient the catalytic converter

   TRUE

2. All light-duty vehicles beginning with what model year are required to have OBDII diagnostic systems

   A. 1995
   B. 1996
   C. 1997
   D. 2000

3. The scan tool used to perform or duplicate the official Arizona OBD test must be set to_____.

   A. Generic Mode
   B. It really doesn't matter what the setting is
   C. Manufacturer specific mode
   D. None of the above

4. The purpose of OBDII was to make sure every new vehicle's emission system___.

A. Tells technicians when to replace emissions components
B. Operates properly for the lifetime of the vehicle
C. Shuts the engine off when a problem occurs
D. None of the above

5. The oxygen sensor monitor is designed to monitor the heated upstream oxygen sensor(s). The monitor not only looks for a heated oxygen sensor signal fixed high or low but also for_____

A. Heated oxygen sensor slow response
B. Heater performance (time to reach operating temperature on a cold engine)
C. Inactive signal (voltage steady at bias of around 450mv
D. All of the above

6. The OBD system uses Diagnostic Trouble Codes (DTC's) to_____.

A. Help the techs isolate a problem

B. Tell the techs what component to replace

C. Annoy the vehicle owner by turning the light on

D. None of the above

7. One of the features of OBD II is a “TRIP”. During a trip, the computer performs a specific series of test and monitors while driving the vehicle through a specific series of conditions. These driving conditions are referred to as_____.

A. OBD II Data Stream Cycle

B. Emissions System Test Cycle

C. OBD II Drive Cycle

D. Get It Ready Cycle

8. On an OBD II Catalytic Converter system, the MIL is activated when a fault is detected on_____ consecutive drive cycles.

A. 4

B. 2

C. 1

D. 3

9. The Malfunction Indicator Light (MIL) is lit and a Diagnostic Trouble Code (DTC) is stored, when one or more of the vehicles emissions systems signals increases more than_____.

A. One and one half (1.5) times the new car standard f or the vehicle being tested

B. Two (2) times the new car standard for the vehicle being tested

C. Four (4) times the new car standard for the vehicle being tested

D. One half (0.5) times the new car standard for the vehicle being tested

10. The purpose of the OBD II evaporative system monitor is to_____.

A. Test the integrity of the system components.
B. To detect a leak in the system.
C. Both A and B
D. None of the above

11. Possible causes of an EGR System Monitor Fault are____.

A. Blocked exhaust transfer tubes to the intake manifold
B. Failed EGR valve or EGR transducer
C. Open or blocked vacuum supply (hoses) to the EGR valve
D. All of the above

12. The Catalyst Efficiency Monitor measures the amount of _____ before and after the catalyst to determine catalyst efficiency.

A. Hydrocarbons (HC)
B. Oxygen (O_2)
C. Carbon Monoxide (CO)
D. Carbon Dioxide (CO_2)

13. Which of the conditions listed below will most likely cause an engine misfire, or a misfire DTC to be set?

A. Faulty ignition components
B. PCV valve stuck in the low flow position
C. Faulty evaporative canister
D. Rich air/fuel mixture

14. 2001 and newer model year vehicles are allowed _____ or less unset readiness monitors for a valid test.

A. Three

B. One

C. Two

D. Zero

15. If the oxygen sensor used for air/fuel mixture control (HO_2S1) indicates a rich exhaust condition, the computer responds by moving_____.

A. Short Term Fuel Trim to a negative range first, and if the problem persist then Long Term Fuel Trim is moved to a negative range

B. Long Term Fuel Trim to a positive range

C. Short Term Fuel Trim to a positive range

D. Short Term Fuel Trim to a positive range first, and if the problem persist then Long Term Fuel Trim to a positive range

myDEQ
Arizona Department of Environmental Quality

CERTIFICATION | FLEET STATION HANDBOOK TRAINING

Certificate of Completion

Congratulations on completing this online coarse, you will need to show proof of completion when you take your test.

Please select your desired testing location to obtain a copy of your Certificate of Completion:

Phoenix Testing Center | Download Certificate >

Tucson Testing Center | Download Certificate >