Phase 2

Trade of Motor Mechanic

Module 5

Unit 3

Emissions

Produced by

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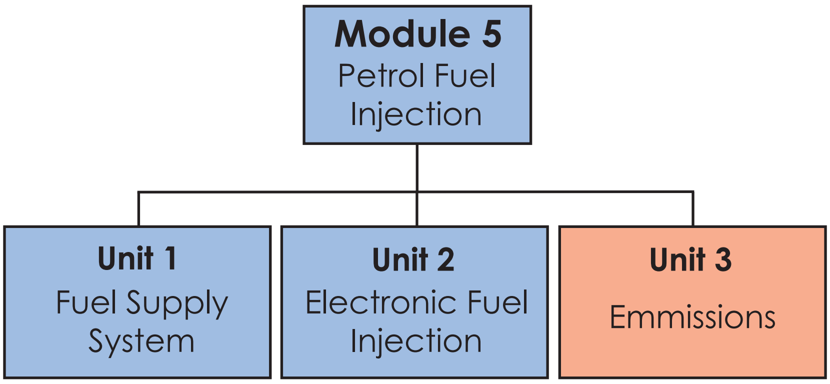
Introduction

There are 3 Units in this Module. Unit 1 focuses on Fuel Supply System, 2 on Electronic Fuel Injection and 3 on Emissions.



Module 5 of this course covers the Petrol Fuel Injection aspect of automotive technology. This is the third unit in module 5 and introduces Emissions.

The term "emission" normally refers to the pollution produced by a vehicle during normal use. Emission control systems are designed to limit the pollution caused by the harmful products of storing and burning fuel.

Related information regarding emissions and Health and safety issues will be covered within this unit.

Unit Objective

By the end of this unit each apprentice will be able to:

- State and apply the health, safety and precautionary procedures applicable to working on vehicle emission systems
- Identify the sources of vehicle emissions
- Describe the principle environmental effects of automotive petrol engine exhaust gas emissions
- Define the terms 'volatility', 'flashpoint' and 'octane rating' as applied to petrol fuel
- Outline the chemical composition of the air/fuel mixture
- Summarise the fundamental principles of the combustion process

- Name the products of the combustion process and their chemical symbols
- State the air/fuel ratios by mass for rich, stoichiometric and lean mixtures and identify the engine operating conditions during which each air/fuel ratio would be present
- State the purpose and describe the fundamental operating principles of the three-way catalytic converter
- State the purpose and outline the structure and fundamental operating principles of the unheated Lambda oxygen sensor
- Distinguish between the terms 'open loop' and 'closed loop' control
- Identify the signal cable of a Lambda sensor
- Use an oscilloscope or voltmeter to observe/display the cycling/voltage levels of a Lambda oxygen sensor at normal operating temperature
- Outline the NCT/DoT VTM requirements applicable to the emissions system
- Carry out an exhaust emission test on fuel injected engines using an exhaust gas analyser and compare gas readings to manufacturer's/NCT/DoT VTM specifications
- Locate and identify the components involved in the evaporative emission control system
- State the function and describe the fundamental principles of operation of the evaporative emission control system
- State the function and describe the principles of operation of the positive crankcase ventilation system
- Outline alternative fuel sources other than petrol fuel

1.0 Health and Safety

Key Learning Points

- Health, safety and precautionary procedures applicable to working on vehicle emission systems (e.g. exhaust fume extraction and hazard from rotating components); personal hazards associated with vehicle exhaust gases, emissions and catalytic converter etc.

1.1 Precautionary procedures

Because of the inability of humans to detect carbon monoxide (CO) by smell/taste and the cumulative effects of CO on the body/blood could lead to carbon monoxide poisoning.

Coming in contact with revolving components e.g. fans, belts etc. could lead to serious injury due to clothing hands, fingers etc. getting caught.

Coming in contact with engine components e.g. exhaust related parts e.g. catalytic converter when the engine is at working temperature could lead to serious burns.

Tests are to be carried out in a ventilated area and the use of appropriate gas extraction equipment which is in good working order.

Instruction is given to insure that all guards are in place before starting engine and appropriate personal protective equipment (PPE) worn e.g. overalls, safety boots etc.

2.0 Sources of Vehicle Emissions

Key Learning Points

- Sources of vehicle emissions (i.e. crankcase blow-by fumes, fuel evaporation and exhaust gases)

2.1 Sources of Emission

The term "emission" normally refers to the pollution produced by a light vehicle during normal use. Emission control systems are designed to limit the pollution caused by the harmful products of storing and burning fuel.

Emissions from petrol driven motor vehicle usually come from 4 sources:

- The fuel tank (fuel evaporation),
- The carburettor or fuel injection system,
- The crankcase
- The exhaust system

The fuel tank and carburettor allow fuel to evaporate and escape to the atmosphere. These are called evaporative emissions.

The crankcase and exhaust system emit pollutants directly from the engine into the atmosphere. They are caused when hydrocarbons, lead compounds and oxygen and nitrogen from the air, are burned in the combustion chamber.

In a compression-ignition engine emissions originate from the engine they escape to the atmosphere from the exhaust and the crankcase breather.

2.2 Regulated Emissions

Air pollutants are classified as either primary or secondary contaminants.

A primary air contaminant such as carbon monoxide gas or particles of unburned fuel is added to the atmosphere as a by-product of burning petrol in an internal combustion engine.

Secondary emissions are emitted as gases and can combine with other airborne

Air contaminants can be divided into gases and particulates.

The primary pollutant gases from vehicles include: carbon monoxide, nitrogen oxides, hydrocarbons and sulphur dioxide. These pollutants can have a damaging effect on the atmosphere and the natural environment.

Particulates often referred to as Particulate Matter or PM, are tiny particles of solid or liquid suspended in the air. They are graded in a size range from 10 nanometres to 100 micrometers in diameter. Particulates of less than 10 micrometers are dangerous to humans because they can be breathed and reach the lungs. Smaller particles also tend to stay airborne longer than larger particles which settle more quickly.

Different countries have recognized the global effects that the continual dispersion of contaminates in the earths atmosphere can have. As a result they have either introduced emission control standards and/or are signatories to international protocols to limit and control global pollution through emissions.

Vehicle manufacturers are required to comply with these standards and are required to ensure that the emissions from the vehicles they produce are strictly limited and have systems incorporated into them that monitor and control such emissions.

Many manufacturers are producing "hybrid" vehicles that use alternative power sources to limit emissions however, even with alternative lower-pollutant fuels; the use of the internal combustion engine is set to remain a key power source for many years.

As a result ever stricter emissions control is at the forefront of vehicle design and construction.

Typically the regulated emissions are:

- Carbon monoxide
- Hydrocarbon
- Nitrogen oxides
- Particulate matter

3.0 Environmental Effects of Exhaust Emissions

Key Learning Points

- Environmental effects of petrol engine exhaust gas emissions; H_2O (water) harmless; CO_2 (carbon dioxide) greenhouse gas, effects on global warming, measurement in grammes per kilometre; CO (carbon monoxide) poisonous; HC (hydrocarbons) particles of unburnt fuel, poisonous; NOX (Oxides of Nitrogen) poisonous

3.1 Exhaust Gases

Hydrocarbons

Petrol, diesel, LP and natural gas are all hydrocarbon compounds.

Hydrocarbon emissions react with other compounds in the atmosphere to produce photo-chemical smog. Hydrocarbons are a major source of motor vehicle emissions.

Smog

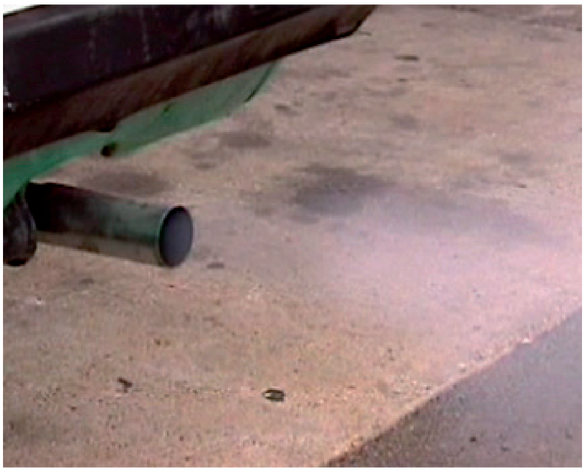
Petrol needs to evaporate easily to burn properly in an internal combustion engine. But this property also means it evaporates easily into the atmosphere at ordinary temperatures and pressures.

When a vehicle is being refuelled hydrocarbon vapours can escape from the filler neck into the atmosphere. When the vehicle is left in the sun its temperature increases and fuel evaporates from the tank .

An evaporation control system is fitted to modern vehicles to collect and store the hydrocarbon vapours from the tank and the fuel system. Then, when conditions are suitable these vapours are then drawn into the intake manifold and burned as part of the combustion process.

Hydrocarbons in Exhaust Gases

Hydrocarbons are also part of the exhaust gases. Chemical symbol (HC) and is measured in particles per million or (P.P.M.).they are very poisonous.



In a 4-stroke petrol engine during valve overlap at top dead centre some intake charge is drawn out of the combustion chamber into the exhaust port. Raw fuel, a mixture of hydrocarbons and air, is released into the atmosphere.

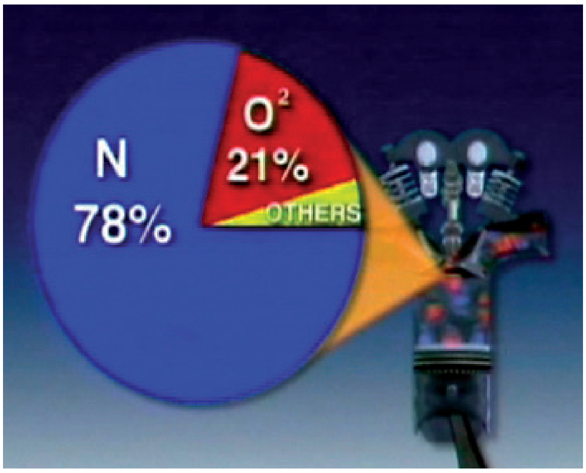
When combustion occurs in the cylinder, the walls, piston and piston rings are slightly cooler than points closer to the burning mixture. Some of the air and fuel molecules come in contact with these cooler parts and they cool down, until their temperature becomes too low for combustion to occur. They are left unburned and when the exhaust port opens they leave the cylinder. Misfiring of the ignition can result in unburned fuel leaving the cylinder when the exhaust port opens.

If an excessively rich air-fuel mixture is used there is too much fuel for the quantity of air. Combustion will be incomplete and any unburned fuel will leave the cylinder through the exhaust port.

If an excessively lean mixture is used, then combustion takes longer and the flame may extinguish before it is complete. When the exhaust port opens, unburned hydrocarbons will be exhausted from the cylinder.

Oxides of Nitrogen

Air that's drawn from the atmosphere into an engine contains almost 80% Nitrogen. Under the high temperatures and pressure of combustion, this nitrogen combines with oxygen to produce oxides of nitrogen. Almost all internal combustion engine exhaust gases contain these chemicals. They are more likely to be produced when high peak temperatures occur during combustion.



The chemical symbol for Oxides of Nitrogen (NOX) occur when the combustion temperature exceeds 1300 degrees Celsius it is measured in grams per mile and produces smog not possible to measure in workshop.

If a lean mixture is used, formation of hydrocarbons and carbon monoxide is reduced, but for oxides of nitrogen, it is increased. This is due to the high temperature and the increase in available oxygen.

Oxides of nitrogen are claimed to be major contributors to photo-chemical smog.

Compression-ignition engines can produce high levels of oxides of nitrogen.

Oxides of nitrogen irritate the eyes, nose and throat. In extreme cases, coughing and lung damage can occur.

Oxygen

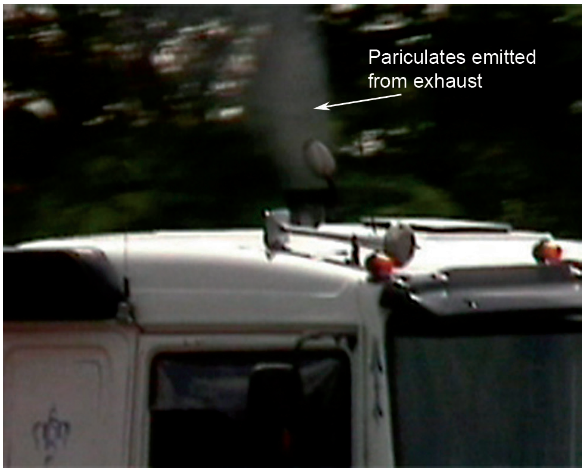
Chemical symbol is O_2. This is the residual oxygen in the exhaust after combustion and is measured as a percentage of the exhaust gases

Water

The chemical symbol is H_2O. This is a water vapour that is emitted from the exhaust system.

Particulates

Particulates from modern engines are usually carbon-based.



Older vehicles may produce lead-based particulates. This is caused by lead compounds used in the fuel to raise its octane rating. In spark ignition engines, particulates are caused by incomplete combustion of rich air-fuel mixtures. In compression-ignition engines, they are caused by a lack of turbulence and lack of oxygen.

Carbon Monoxide

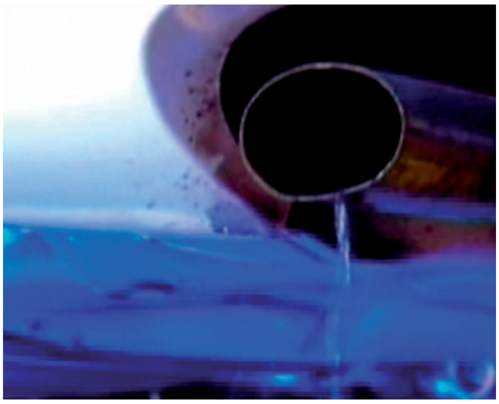
Carbon monoxide, Chemical symbol CO, is an extremely poisonous gas. Inhaling it in a confined space can be lethal and since it is has no odour or colour, it is very dangerous.

CO is formed when there is not enough oxygen present during combustion it is measured as a percentage of the exhaust gas.

It is produced during combustion when there are not enough oxygen molecules around the hydrocarbon molecules. This can be caused by an incorrect air-fuel ratio. In modern vehicles, carbon monoxide emissions have been reduced by better engine designs and by chemically treating the exhaust gas.

Carbon Dioxide

Carbon Dioxide, Chemical symbol CO_2, is produced, with water, when complete combustion of air and fuel occurs. It can reflect the efficiency of the combustion process and is measured as a percentage of the exhaust gas. It is an important diagnostic aid. The chemical make up is one part carbon to two parts oxygen.



It isn't poisonous, but many scientists consider it a serious contributor to global warming (greenhouse gases).Catalytic converters in petrol-engine vehicles convert carbon monoxide to carbon dioxide.

4.0 'Volatility', 'Flashpoint' and 'Octane Rating'

Key Learning Points

- Definition of 'volatility', 'flashpoint' and 'octane rating' as applied to petrol fuel

4.1 Volatility, Flash point, Octane Rating of Petrol

Volatility of a Fuel

The tendency of a product to change from the liquid to that of vapour. This property is of course, very important in petrol. Volatility of a fuel is the measure at which a fuel begins to vaporise. A high volatility of a portion of fuel is necessary for easy starting from cold.

Flash Point

The lowest temperature at which a flash will occur over the surface of a heat oil or solvent. This is usually about 10°C under the fire point.

Octane Rating (Anti-Knock Quality)

Octane rating of petrol is a measure of its resistance to knock or detonate. This antiknock quality varies with fuels so for classification purposes the knock resistance of a fuel is compared to two reference fuels. A high tendency to auto ignite, or low octane rating, is undesirable in a petrol engine.

1. Iso-octane; this is given the number 100 since its anti-knock quality is excellent.
2. Heptane; this has a very poor resistance so the rating is given zero.

Typical Octane Ratings for Unleaded Petrol

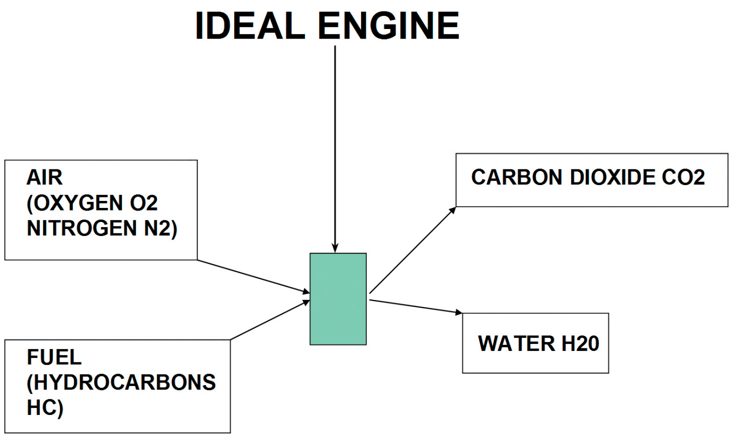
- Premium has a value of 95 RON (research octane number)
- Super plus has a value 98 RON

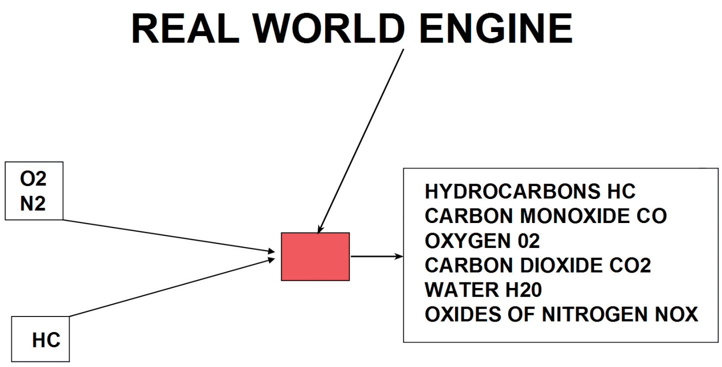
5.0 Chemical Composition of the Air/Fuel Mixture

Key Learning Points

- Chemical composition of the air/fuel mixture

5.1 Chemical Composition of Air/Fuel Mixture



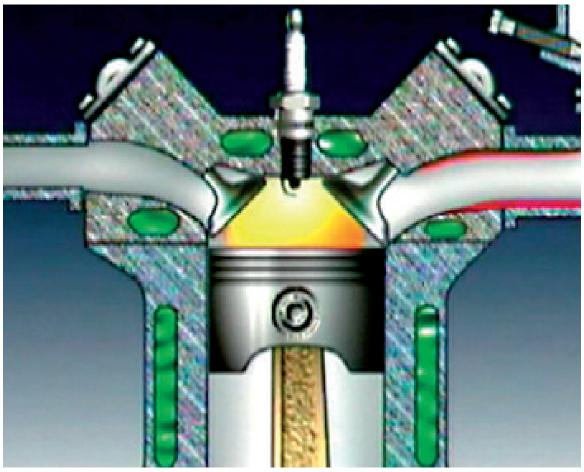


6.0 Principles of the Combustion Process

Key Learning Points

- Fundamental principles of the combustion process (i.e. temperature/pressure relationship, factors affecting complete combustion etc.)

6.1 Combustion Process



Fundamental principles of the combustion process cannot take place unless the following ideal conditions are present.

Ideal compression pressure is reached within the cylinder (engine in good condition), Condition of spark plug and timing accurate, Temperatures at correct value for engine, fuel, air, Amount of fuel correct according to engines requirement, Precise valve timing, That the engine receives the correct amount of air ,Catalytic converter and related parts are operating correctly in the exhaust system.

7.0 Products of the Combustion Process

Key Learning Points

- Products of the combustion process and their chemical symbols

Covered in section 3.0

8.0 Air/Fuel Ratios by Mass for Rich and Lean Mixtures

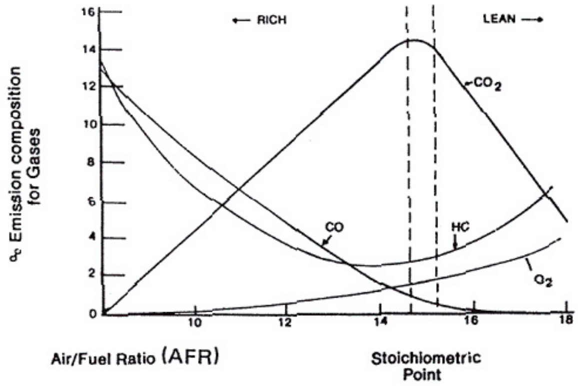
Key Learning Points

- Air/fuel ratios by mass for rich, stoichiometric and lean mixtures
- Engine operating conditions during which each air/fuel ratio would be present

8.1 Air/Fuel Ratio (AFR)

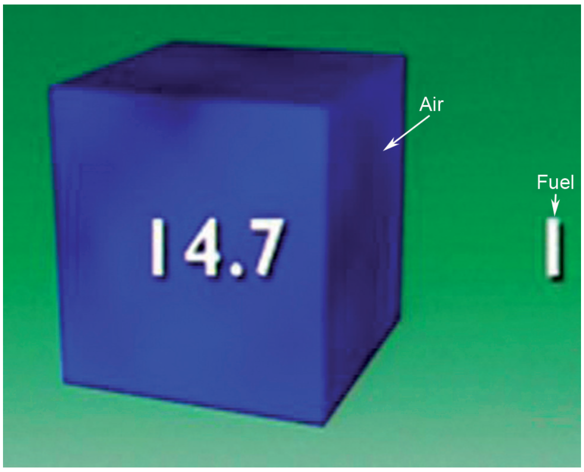
The AFR required to burn the fuel completely is called "Stoichiometric" which is 14.7 to 1 AFR. Our real world engine however still produces some CO and HC emissions but its (CO_2) emissions are at their highest, As shown in graph the most efficient combustion (low HC and CO, high CO_2) in our real world engine occurs at approximately 14.7 to 1 AFR. Note: This point may vary slightly because of the differences in fuel composition. Testing of today's vehicles fitted with catalytic converters and engine management systems has almost eliminated fuel system adjustments. The new computer engine management systems will maintain correct AFR with very little error, but only if the system inputs are operating properly. Carbon dioxide (CO_2) and oxygen (O_2) are the keys to proper diagnosis of today's electronic carburettors and fuel injection systems. It is only by using the four gas methods of analysis that problems can be accurately.

The air fuel ratio for a rich mixture (too much fuel) is less than 14.7 to 1. This would be present when starting from cold, typical value would be 8 to 1. Important to note that the engine management system would be in "open loop". *Covered in chapter 11.0*.



A lean mixture (not enough fuel) is more than 14.7 to 1 and would be present when there is an air leak in the intake system.

8.2 Stoichiometric Point



The oxygen sensor helps the ECM know how much fuel is needed according to the amount of left-over oxygen going through the exhaust pipe. At sea level, the ratio of fuel to air for a perfect (or Stoichiometric) burn is 14.7 parts of air for every one part of fuel. This ratio of 14.7 to 1 is a Lambda of one.

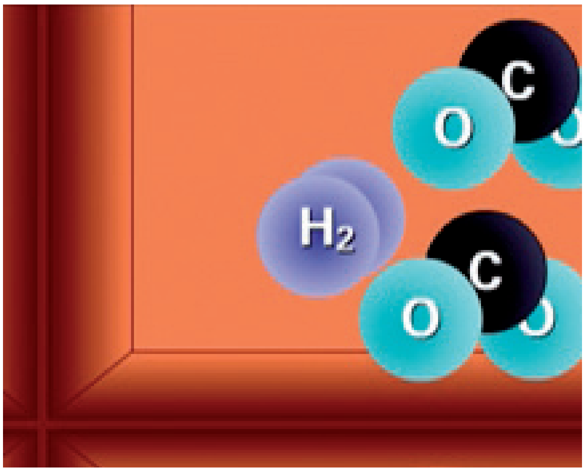
9.0 The Three-Way Catalytic Converter

Key Learning Points

- Purpose of the three-way catalytic converter
- Fundamental operating principles of the three-way catalytic converter

9.1 Catalytic Conversion

Modern petroleum based fuelled vehicles are fitted with three-way catalytic converters. 3-way converters convert hydrocarbons and carbon monoxide to water and carbon dioxide, as well as convert the oxides of nitrogen, nitric oxide and nitrogen dioxide, back into harmless nitrogen and oxygen molecules.



Older catalytic converters converted hydrocarbons and carbon monoxide into water and carbon dioxide, but were not able to convert the oxides of nitrogen.

The term 'three-way' is in relation to the three regulated emissions the converter is designed to reduce: carbon monoxide, hydrocarbons or volatile organic compounds, known as VOCs, produced from evaporated unburned fuel and nitrogen oxides.

The converter uses two different types of catalysts to reduce the pollutants: a reduction catalyst and an oxidation catalyst.

The exhaust gases first pass over the reduction catalyst in the converter. The platinum and rhodium coating helps to reduce the oxides of nitrogen, together known as 'NOX' emissions.

When a nitric oxide or nitrogen dioxide molecule comes into contact with the coating, it strips the nitrogen atom out of the molecule and retains it. This frees up the one or two oxygen atoms in the molecule which combine in pairs to form molecules of oxygen.

The nitrogen atoms bond with other nitrogen atoms that are retained in the catalyst and form molecules of nitrogen. So two molecules of nitric oxide become one molecule each of nitrogen and oxygen, or two molecules of nitrogen dioxide become one molecule of nitrogen and two molecules of oxygen.

The exhaust gases then flow over the oxidation catalyst in the converter. This has the effect of reducing any unburned hydrocarbons and carbon monoxide by oxidizing them over the platinum and palladium coating. This aids the reaction of the carbon monoxide and hydrocarbons with any remaining oxygen in the exhaust gas.

Each carbon monoxide molecule combines with an oxygen molecule to make one less harmful carbon dioxide molecule. Because of strict emission requirements, vehicles with a 3-way catalytic converter have a feedback system, called looping.

The electronic control unit, or ECU, monitors the air-fuel ratio by using an exhaust gas oxygen, or EGO, sensor, also known as a lambda sensor. This sensor tells the engine computer how much oxygen is in the exhaust and uses this information via the ECU to control the fuel injection system.

The ECU can increase or decrease the amount of oxygen in the exhaust by adjusting the air-to-fuel ratio. The system ensures that the engine runs at close to the Stoichiometric point in normal driving conditions. It also ensures that there is always sufficient oxygen in the exhaust system to allow the oxidization catalyst to deal with unburned hydrocarbons and carbon monoxide.

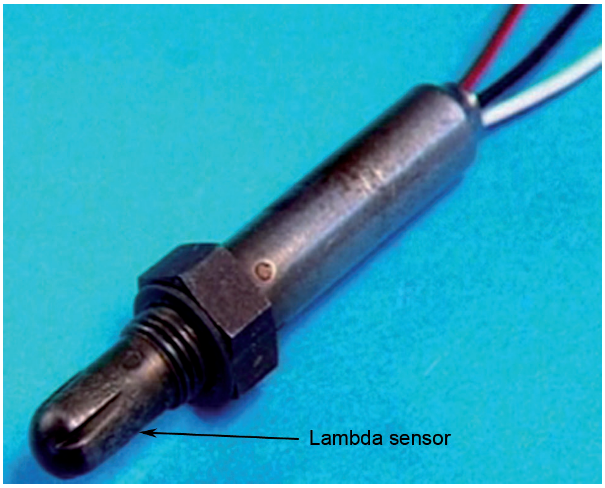
10.0 Unheated Lambda Oxygen Sensor

Key Learning Points

- Composition of the exhaust gases within the catalytic converter operating range (Lambda 'window')
- Purpose, structure and fundamental operating principles of the unheated Lambda oxygen sensor (including relationship with catalytic converter, voltage generation, operating temperature etc.)

10.1 Lambda Sensor and Testing

Exhaust gas oxygen sensor



The oxygen sensor, also called a lambda sensor, is mounted in the exhaust manifold, or the engine pipe. There is no heater element in an unheated Lambda oxygen sensor, Therefore it relies on engine exhaust gases to bring the sensor up to its operating temperature of approximately 350°c. When the sensor reaches its operating temperature it operates the same as an electrically heated sensor. Its sensing portion is exposed to the stream of exhaust gas. It detects left-over oxygen in the exhaust gas and sends the data to the control unit.

The control unit uses it to fine-tune the pulse it sends to the fuel injectors.

The sensor consists of a tube, closed at one end and made of Zirconium ceramic, or Titanium ceramic. Its inner and outer surfaces are coated with platinum. The outer closed end is covered by a louvered metal shroud that protects it from breakage but still lets the exhaust gas contact the tube. Its inner surface is in contact with the air. A wire contacts the inner surface of the tube through a spring and an electrode bush. This provides the electrical link to the control unit.

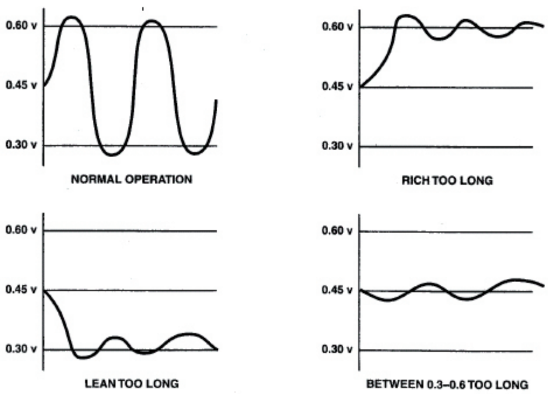
The inner and outer surfaces of the ceramic tube are coated with porous platinum. The side facing the exhaust gas has a highly porous ceramic layer on top of the platinum, which lets oxygen through. The ceramic tube with its platinum electrodes is now a porous, solid electrolyte. At temperatures around 350°c it becomes a conductor. One side detects the level of oxygen in the exhaust gas. The other detects its level in ordinary air. If the levels are different, a voltage is generated between the 2 sides.

Note: When lambda equals 1, complete combustion

Higher than 1, indicates excess air

Lower than 1, indicates insufficient air

Here is a few of the typical voltages measured using an oscilloscope and what they represent.



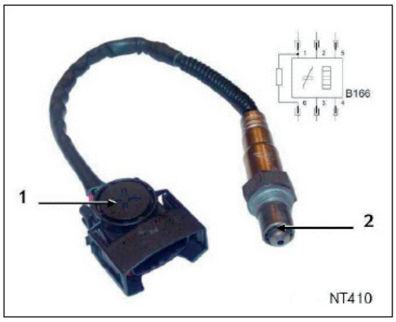
O2S Voltages

The control unit compares this voltage to a pre-set level. Below the level indicates a lean mixture, above it means a rich mixture. The control unit may then adjust the pulse to the injectors, to maintain correct mixture. This fine tuning is needed for the catalytic converter to function properly.

An oxygen sensor has to be at operating temperature to monitor exhaust gases. Some sensors have a built-in heating element powered by the vehicle's electrical system. It helps them reach operating temperatures quickly and therefore monitor exhaust gases.

Wide Band Oxygen Sensor

This sensor operates on the same principle but on a wider operating band (0.7-2.5 lambda compared to 0.8-1.7 on conventional sensor).



1. Resistor housing
2. Sensor housing

Advantages of wide band oxygen sensor:

- The sensor provides a lambda proportional signal also with lean mixtures
- The sensor is so quick it can make separate cylinder combustions visible
- The sensor is more accurate
- The sensor requires less power
- The sensor has a rapid operation readiness after (cold) starts

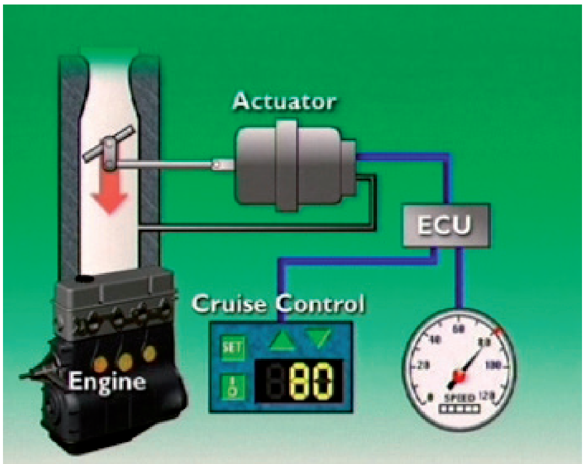
11.0 'Open Loop' and 'Closed Loop' Control

Key Learning Points

- Distinction between the terms 'open loop' and 'closed loop' control

11.1 Closed Loop/Open Loop

A closed loop is usually part of what is called a feedback system. A feedback system collects information on how a system is operating then feeds that information back to affect how the system is working. They can be very simple and very sophisticated.



In this example the vehicle has a cruise control unit to help it maintain a set speed. When it falls below it a computer sends a signal that moves the throttle linkage and increases the fuel reaching the engine and speed. It has the opposite effect when the vehicle exceeds the set speed. A cruise control unit that continually monitors the system is called a closed loop system.

A *closed loop* system in an engine exhaust system can monitor the amount of oxygen in exhaust gases to maintain a constant air-fuel ratio.

Open loop is present when the engine starts from cold and the oxygen sensor has not reached ideal operating temperature. The engine control unit is not monitoring the exhaust system at this time and the exhaust emissions are un-regulated.

12.0 Lambda Sensor Cable Identification

Key Learning Points

- Identification of Lambda sensor signal cable

Practical Task

As vehicle manufactures may vary depending on the type of sensor used Please refer to your instructor for additional information, which is available from the automotive technical manuals.

13.0 Lambda Oxygen Sensor Signal Patterns

Key Learning Points

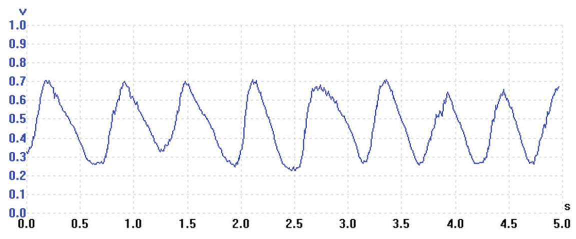
- Use of an oscilloscope or voltmeter to observe the cycling/voltage levels of a Lambda oxygen sensor at normal operating temperature for comparison with manufacturer's specifications

Practical Task

Please refer to your instructor for additional information, which is available from the automotive technical manuals.

13.1 Typical Lambda Sensor Oscilloscope Displays

Note: Different patterns depending on sensor composition.



Zirconium type

14.0 NCT/DoT VTM Requirements

Key Learning Points

- NCT/DoT VTM requirements applicable to the emissions system

14.1 NCT Requirements

Please refer to item no 3 of the (2004) NCT manual for the relevant specifications.

15.0 Exhaust Emission Testing and Comparison of Gas Readings

Key Learning Points

- Exhaust gas emissions test; appropriate location for the test, i.e. ventilated work area, exhaust gas extraction equipment in operation, dangers of carbon monoxide poisoning, inability of humans to detect CO by smell/taste, cumulative effects of CO on the body/blood. Engine/catalytic converter at working temperature, manufacturer's recommended r.p.m., recording and comparison of CO and HC levels to manufacturer's specifications. Basic analysis of Lambda figure
- Use of manufacturer's/NCT/DoT VTM data to evaluate gas Readings
- Use of data manuals/manufacturer's manuals/NCT/DoT VTM manual

15.1 Appropriate Health and Safety

Appropriate location for the test, i.e. ventilated work area and exhaust gas extraction equipment in operation. Instruction is given to insure that all appropriate personal protective equipment (PPE) worn e.g. overalls, safety boots etc.

Practical Task

This is a practical task. Please refer to your instructor for additional information, which is available from the automotive technical manuals.

16.0 Components in the Evaporative Emission Control System

Key Learning Points

- Location and identification of the components involved in the evaporative emission control system (including vapour lines, charcoal canister, canister purge solenoid)

Practical Task

This is a practical task. Please refer to your instructor for additional information, which is available from the automotive technical manuals.

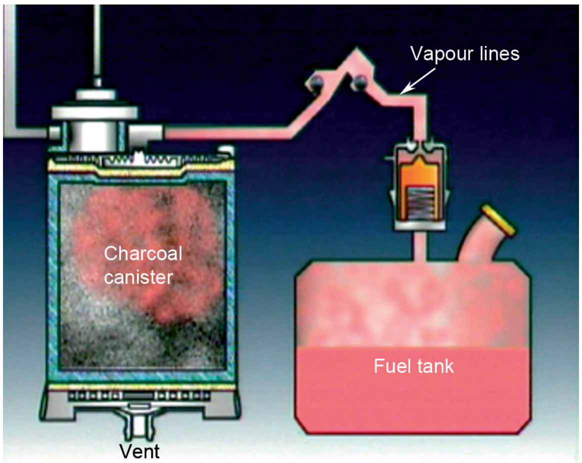
17.0 The Evaporative Emission Control System

Key Learning Points

- Function and fundamental principles of operation of the evaporative emission control system

17.1 Evaporation Emission Control

Early vehicles vented the fuel tank through the filler cap into the atmosphere. Some of the fuel in the tank would vaporise. Some vapours escaped from the filler cap, some from the carburettor.



Non-vented filler caps are designed to stop the exit of vapours. A vacuum relief valve can relieve low pressure in the tank when the temperature drops. This will also stop the tank from collapsing if its internal pressure falls below atmospheric pressure.

The fuel cap may also incorporate a pressure relief valve. If the tank's internal pressure exceeds the set value of the relief valve, it can stop the tank from rupturing. Some modern caps have no valves at all and are completely sealed to stop the entry of air and water, as well as the emission of fuel vapour.

Modern tanks also contain an expansion volume either directly in the shape of the tank or in a separate chamber connected to the fuel tank by tubing.

A liquid vapour-separator may be connected to the tank by a number of tubes. This separator allows liquid fuel to separate from the vapours and return to the tank.

A vapour line is connected to the vapour space in the tank, or the liquid vapour separator. It carries fuel vapours from the tank to a storage volume. This vapour line can incorporate check valves. If the vehicle is tilted too far from the horizontal, they stop liquid fuel entering the storage volume.

A storage device is used to store the fuel vapours. The fuel tank breathes through this storage device. Some vehicles use the engine crankcase.

When the temperature of the fuel in the tank increases, fuel vapours are forced along the vent line, past a liquid check valve and into the crankcase.

When the engine starts, the Positive Crankcase Ventilation system flushes vapours out of the crankcase and into the intake manifold where it joins with the inlet air-fuel mixture. Once in the inlet manifold, the vapours are drawn into the engine where combustion can convert them into carbon dioxide and water vapour.

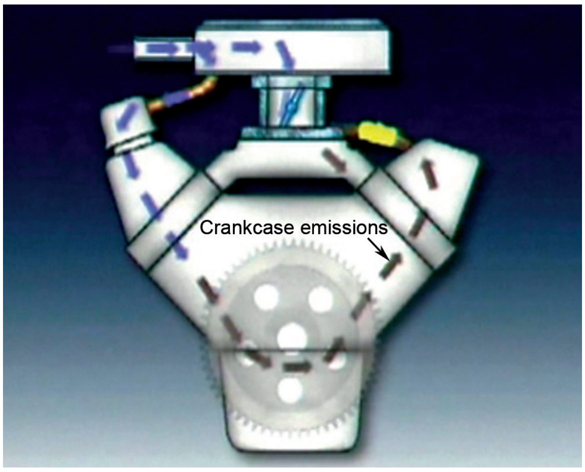
18.0 The Positive Crankcase Ventilation System

Key Learning Points

- Function and principles of operation of the positive crankcase ventilation (PCV) system (including its effect on vehicle emissions)

18.1 Crankcase Emission Control

While the engine is running, some gases from combustion leak between the piston rings and the cylinder walls, down into the crankcase.



This leakage is called blow-by. Unburned fuel and water from condensation, also finds their way into the crankcase and sump. When the engine reaches its full operating temperature, the water and fuel evaporate. To prevent pressure build-up, the crankcase must be ventilated.

In older vehicles, crankcase vapours were vented directly to the atmosphere through a breather tube, or road-draught tube. It was shaped to help draw the vapours from the crankcase, as the vehicle was being driven.

Modern vehicles are required to direct crankcase breather gases and vapours back into the inlet system to be burned.

A common method of doing this is called positive crankcase ventilation or PCV.

A valve called a PCV valve regulates gas flow between the crankcase and the inlet manifold. It is controlled by the pressure in the manifold. With the engine off, the valve is closed and air cannot enter the inlet manifold. This allows the engine to start.

At idle, low pressure in the manifold draws the valve to the other end of the body. This lets a small, measured amount of vapour pass the valve.

At wider throttle openings, the valve plunger position allows maximum flow through the body, which gives maximum crankcase ventilation.

The system is designed to remove more air than just blow-by so there's a fresh air intake, usually at the air cleaner, to direct filtered air to the crankcase. This intake is usually as far as possible from the PCV valve.

Wide throttle openings produce maximum blow-by. Gases that can't be handled through the vacuum system are directed back through the inlet connection to the air cleaner, where they join the intake air and are drawn into the cylinders for burning.

19.0 Alternative Fuel Sources Other Than Petrol Fuel

Key Learning Points

- Alternative fuel sources; Compressed Natural Gas (CNG), Liquefied Petroleum Gas (LPG), limitations of use, e.g. presently unsuitable for use in direct injection petrol engines. Fuel cell technology etc.

19.1 Alternative Fuels

Alternative fuel sources are used as a way of reducing the operating cost of vehicles, or to reduce pollution from vehicle emissions, or both.

Some alternative fuels can be mixed with petrol as a fuel additive to reduce the total amount of petrol used; others are a complete fuel alternative which may require some modifications to the vehicle.

Ethanol is usually derived from an organic process such as the fermentation of sugar cane and is therefore referred to as a bio-fuel. It is normally used in the ratio of 9:1 or 9 parts petrol to 1 part ethanol and is primarily used to reduce the negative emission effects of petrol.

Methanol is produced from wood or other organic materials. Its calorific value, or burn rate, is not as high as that of petrol fuel and cannot be used in conventional vehicles without significant modifications.

Liquefied Petroleum Gas or LPG is petroleum derived colourless gas and has been used for many years to power specially modified petrol engine vehicles. It is the third most common fuel and emits much fewer harmful emissions than petrol. It is generally cheaper than petrol and is non-toxic and non-poisonous with a very small flammability range. It is popular with high-mileage applications such as taxis, where the cost of vehicle modification can be recouped over time more easily through lower fuel costs. Note: this fuel is presently unsuitable for use in direct injection petrol engines

Compressed Natural Gas or CNG is being used as an alternative fuel in vehicles such as light-duty passenger vehicles, delivery trucks and buses. CNG powered vehicles use natural gas stored in cylinders at pressures of 140 to 240 Bar.

Liquefied Natural Gas or LNG is being used in heavy-duty diesel powered vehicles such as long-haul trucks, delivery trucks and buses. LNG is almost pure methane and has an energy storage density much closer to petrol than CNG, but for the gas to become a more compact and easily stored liquid it has to be cooled to an extremely low temperature minus 164 degrees Celsius. The need to keep the liquid very cold at all times limits the more widespread use of LNG.

Natural gas, whether liquefied or compressed, is less expensive than diesel and natural gas vehicles are substantially cleaner than comparable diesel vehicles.

19.2 Fuel Cells

Fuel cell technology has been used for a number of years in the space industry. Recent improvements in technology and the need to seek alternative fuel technologies for the automotive industry have seen a number of manufacturers develop fuel cell technology for use in automobiles. In a vehicle powered by a fuel cell, the electrical motor is powered by electricity generated by the fuel cell.

A fuel cell is an electro chemical device that combines hydrogen and oxygen to produce water and in the process it produces electricity and heat. Fuel cells operate without combustion so they are virtually pollution free.

Another electro chemical device you are already familiar with is the vehicle battery. In a battery all the chemicals are stored inside and it converts those chemical into electricity. This means the battery eventually becomes discharged until you recharge it.

In a fuel cell, the chemicals oxygen and hydrogen constantly flow through the cell, like fuel through an engine, so it continues to produce electricity as long as fuel is available.

Self Assessment

Q1: In terms of catalytic conversion of undesirable emissions from a spark ignition engine, the stoichiometric point is also known as: (Tick one box only)

❑ 1. The operating window

❑ 2. The efficiency point

❑ 3. The looping point

❑ 4. The drop point

Q2: The chemically correct air-fuel ratio, by mass, for complete petrol combustion is approximately: (Tick one box only)

❑ 1. 18:1

❑ 2. 14.7:1

❑ 3. 12:1

❑ 4. 9:1

Q3: Closed loop control is used to maintain: (Tick one box only)

❑ 1. A constant fuel pressure

❑ 2. Coolant temperature within close limits

❑ 3. The air-fuel ratio within close limits

❑ 4. A constant fuel flow

Q4: Petrol and diesel fuels contain sulphur as part of their chemical make up. When combined with water vapour formed during the combustion process, sulphuric acid is produced. What is the common environmental hazards a consequence of this process known as? (Tick one box only)

❑ 1. 'Heavy rain'

❑ 2. 'Acid rain'

❑ 3. 'Cyclonic rain'

Q5: Can any generic scan tool access most OBDII data? (Tick one box only)

- ❑ 1. Yes, provided that the scan tool is loaded with the correct hardware
- ❑ 2. Yes, provided that the scan tool is connected in line with the system
- ❑ 3. Yes, provided that the scan tool is loaded with the correct software and connected to the vehicle with the appropriate adapter
- ❑ 4. No, only manufacturer's scan tools can read manufacturer's data

Q6: Which OBD standard operates under a standard set by the Society of Automotive Engineers? (Tick one box only)

- ❑ 1. OBDI
- ❑ 2. OBDII
- ❑ 3. Both
- ❑ 4. Neither

Q7: In a basic EFI system the stoichiometric ratio of 14.7:1 is maintained under all engine operating conditions: (Tick one box only)

- ❑ 1. True
- ❑ 2. False

Q8: An OBDII "Continuous" system check is where major emission causing faults, such as Engine Misfire and incorrect Air/fuel mix, are continually monitored. (Tick one box only)

- ❑ 1. True
- ❑ 2. False

Q9: Hydrocarbons are a major atmospheric pollutant. Under what conditions could hydrocarbons escape into the atmosphere, when a vehicle is being refuelled? (Tick one box only)

- ❑ 1. In cold weather the fuel can evaporate out of the tank outlet feed pipe during fuel transfer
- ❑ 2. In cold weather the fuel can evaporate out of the tank filler point during fuel transfer
- ❑ 3. In hot weather the fuel can evaporate out of the tank outlet feed pipe during fuel transfer
- ❑ 4. In hot weather the fuel can evaporate out of the tank filler point during fuel transfer

Q10: What does the term "activated" charcoal mean? (Tick one box only)

- ❑ 1. That the charcoal material is non-porous, has a large surface area and can store large quantities of fuel vapour
- ❑ 2. That the charcoal material is porous, has a large surface area and can store large quantities of fuel vapour
- ❑ 3. That the charcoal material is porous, has a large surface area and can store small quantities of fuel vapour

Q11: Exhaust gas recirculation valves bleed exhaust gas into the inlet air-fuel mixture: (Tick one box only)

- ❑ 1. To limit combustion temperatures
- ❑ 2. To reduce exhaust back-pressure
- ❑ 3. To burn unused fuel
- ❑ 4. At all engine speeds

Q12: Technician A says a catalytic converter requires yearly maintenance. Technician B says a catalytic converter requires no maintenance under normal operating conditions. Who is correct? (Tick one box only)

- ❑ 1. Technician A
- ❑ 2. Technician B
- ❑ 3. Both Technician A and Technician B
- ❑ 4. Neither Technician A or B

Q13: The catalyst material in a catalytic converter is used to: (Tick one box only)

- ❑ 1. Control the flow of gases through the converter
- ❑ 2. Reduce exhaust temperatures
- ❑ 3. Promote a chemical reaction to reduce toxic emissions
- ❑ 4. Trap the harmful emissions

Q14: An EGR valve may be used to control: (Tick one box only)

- ❑ 1. Unburned hydrocarbons
- ❑ 2. Carbon dioxide
- ❑ 3. Carbon monoxide
- ❑ 4. Oxides of nitrogen

Q15: Technician A says leaner air/fuel ratios reduce hydrocarbon emissions but increase NOx. Technician B says that additional pollution controls are used to reduce NOx. Who is correct? (Tick one box only)

- ❑ 1. Technician A
- ❑ 2. Technician B
- ❑ 3. Both Technician A and Technician B
- ❑ 4. Neither Technician A or B

Q16: By volume, how much air is needed to consume 1 litre of petrol? (Tick one box only)

- ❑ 1. 11 litres
- ❑ 2. 110 litres
- ❑ 3. 1,100 litres
- ❑ 4. 11,000 litres
- ❑ 5. 110,000 litres

Q17: During combustion, what causes carbon monoxide? (Tick one box only)

- ❑ 1. Untreated exhaust gases
- ❑ 2. Incomplete combustion of fuel
- ❑ 3. Overheated fuel
- ❑ 4. A highly combustible air-fuel mixture

Q18: Under vehicle acceleration conditions the fuel mixture is: (Tick one box only)

- ❑ 1. Leaner than the stoichiometric ratio of 14.7:1
- ❑ 2. Richer than the stoichiometric ratio of 14.7:1
- ❑ 3. The same as the stoichiometric ratio of 14.7:1

Suggested Exercises

- Use an electronic data facility to procure manufacturer's appropriate data for use with practical exercises
- Use an oscilloscope or voltmeter to observe/display the cycling activity of a Lambda oxygen sensor at normal operating temperature
- Carry out an exhaust emission test on fuel injected engines using an exhaust gas analyser and compare gas readings to manufacturer's/NCT/DoT VTM specifications
- Locate and identify the components involved in the evaporative emission control system

Training Resources

- Fuel injected vehicles/training units
- Oscilloscopes, data manuals, manufacturer's manuals, NCT/DoT VTM manuals, video/multimedia resources
- Exhaust gas analysers, multimeters
- Selection of emission-related components including Lambda oxygen sensors, positive crankcase ventilation components, sectioned catalytic converters, evaporative emission system components
- Appropriate petrol storage containers
- Fire extinguishers

Suggested Further Reading

- Advanced Automotive Diagnosis. Tom Denton. ISBN 0340741236
- Automobile Electrical and Electronic Systems (3rd Edition). Tom Denton. ISBN 0750662190
- Automotive Mechanics (10th Edition). William H. Crouse and Donald L. Anglin. ISBN 0028009436
- Bosch Automotive Electrics Automotive Electronics: Systems and Components (4th Edition). Robert Bosch. ISBN 0837610508
- Bosch Automotive Handbook (6th Edition). Robert Bosch. ISBN 1860584748
- Bosch Automotive Technology Technical Instruction booklet series (numerous titles)
- Hillier's Fundamentals of Motor Vehicle Technology: Book One (5th Edition). V.A.W. Hillier and Peter Coombes. ISBN 0748780823
- Hillier's Fundamentals of Motor Vehicle Technology: Book Two (5th Edition). V.A.W. Hillier and Peter Coombes. ISBN 0748780998
- Modern Automotive Technology. James E. Duffy. ISBN 1566376106
- Motor Vehicle Craft Studies - Principles. F.K. Sully. ISBN 040800133X
- National Car Test (NCT) Manual (Department of Transport, Vehicle Testers Manual - DoT VTM). Department of Transport
- Transmission, Chassis and Related Systems (Vehicle Maintenance and Repair Series: Level 3) (3rd Edition) John Whipp and Roy Brooks. ISBN 186152806X
- Vehicle and Engine Technology (2nd Edition). Heinz Heisler. ISBN 0340691867
- http://www.cdxglobal.com/
- http://auto.howstuffworks.com/
- http://www.autoshop101.com/
- http://www.cdxetextbook.com/
- Automotive Encyclopedia and Text Book Resource (CD version of e-textbook), Available from your instructor.

Notes

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