



SWANSEA METROPOLITAN UNIVERSITY

PRIFYSGOL FETROPOLITAN ABERTAWE

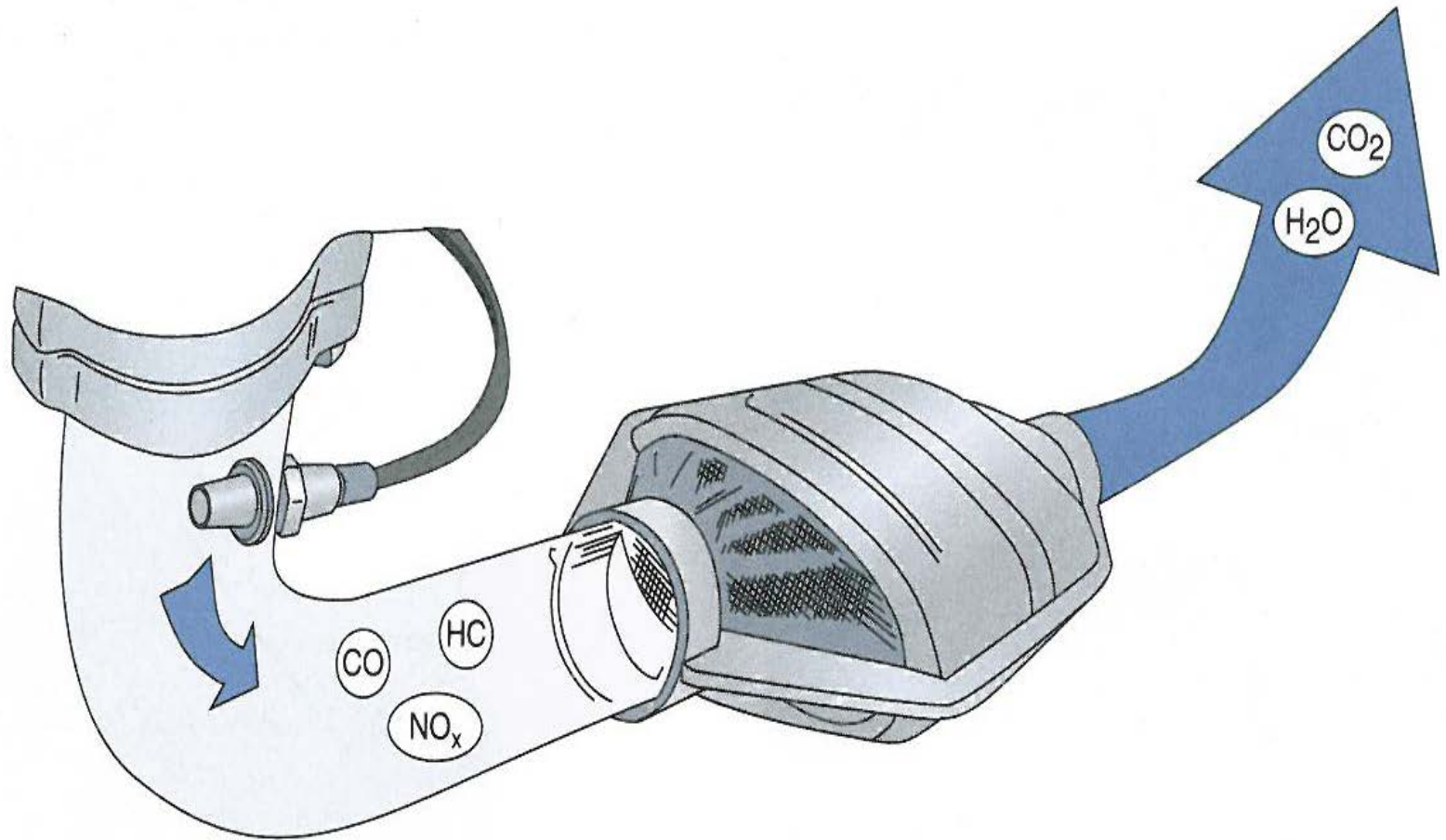
Emissions Control and Diagnostics

Catalytic Converters

Three Way Catalytic Converter



SWANSEA METROPOLITAN UNIVERSITY
PRIFYSGOL FETROPOLITAN ABERTAWE

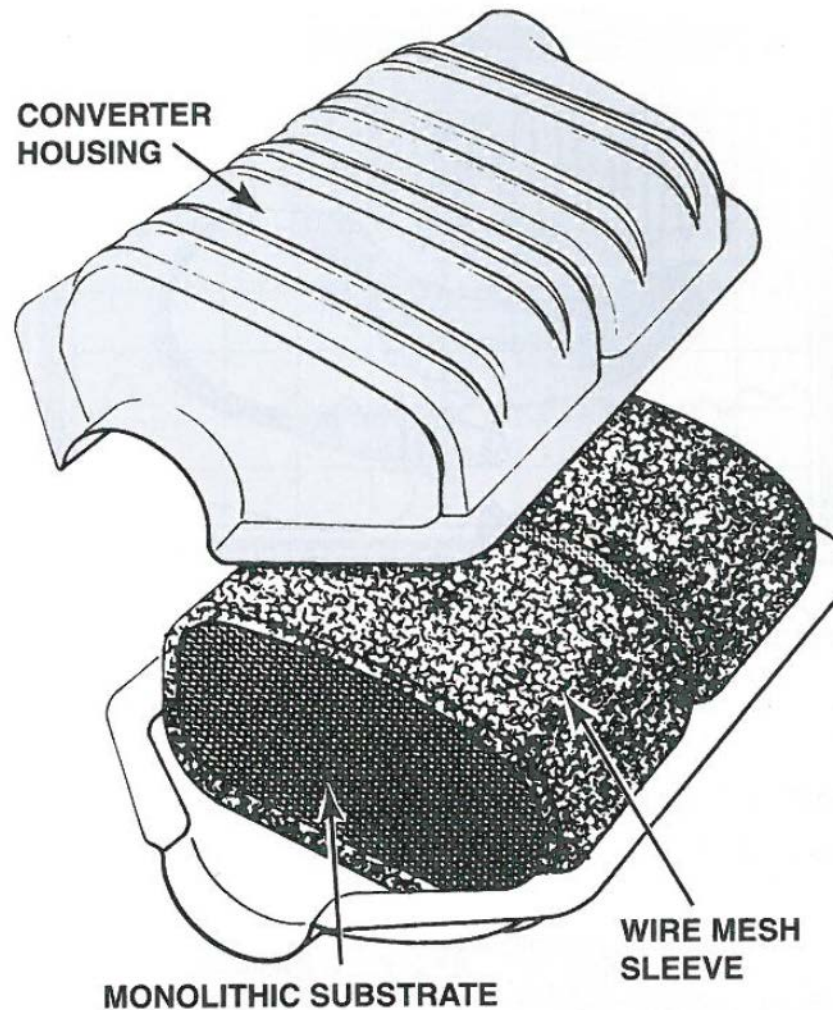


- Are after treatment devices
- Used outside the engine to control emissions
- Positioned between manifold and silencer
 - The nearer the engine the better
 - Needs highest possible exhaust temperature for better operation
- Made out of a ceramic material in a honeycomb shape
- Comprises around 62 square openings per cm²
- Ceramic is coated with a porous aluminium washcoat
 - To make it rough that catalytic materials can adhere to it
 - These are Rhodium, Palladium, Platinum

Converter construction



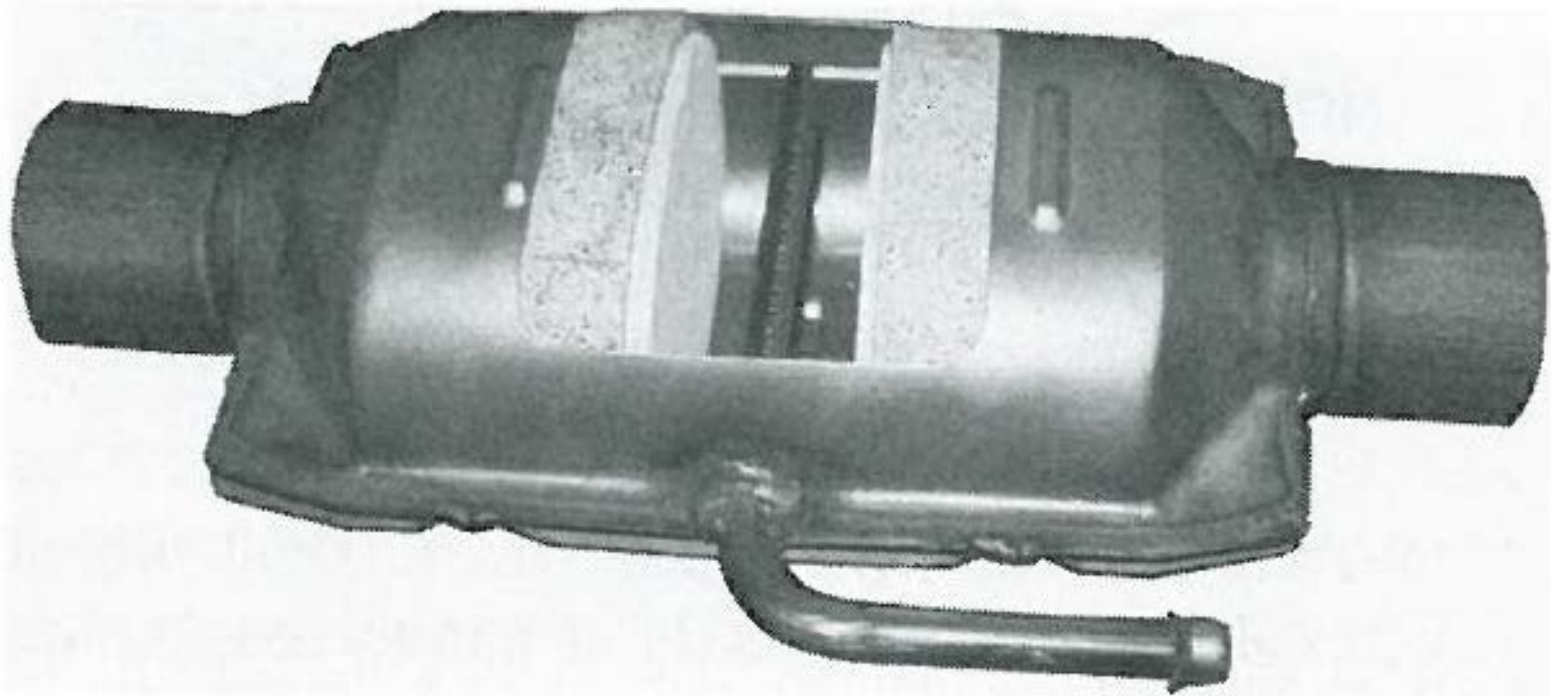
SWANSEA METROPOLITAN UNIVERSITY
PRIFYSGOL FETROPOLITAN ABERTAWE



3 Way Cat

- Three-way catalytic converters TWC converts 3 exhaust emissions – NO_x , HC and CO – into CO_2 and H_2O .
- Oxides of Nitrogen are chemically reduced in the first section of the catalytic converter
 - i.e Nitrogen and Oxygen are separated
- The Hydrocarbons and Carbon Monoxide are oxidised in the second part into Carbon Monoxide and Water
 - Some additional air may be introduced by the SAIR system

Converter with SAIR system



- Most converters now also contain Cerium
 - Cerium can actually store oxygen and release it when required
 - It stores it when the exhaust is lean and as too much oxygen
 - Releases it when the exhaust is too rich and requires additional oxygen for oxidation
- A rich exhaust is required for reduction on NO_x
- A lean exhaust is required to oxidise HC and CO
- What does this mean for the operation of the engine?

- Catalytic converters need to be hot to work correctly
 - Around 260° C for 50% effective
 - Between 480° C and 870° C for fully effective
 - Despite the high temperatures they do not generate any flame or radiant heat as in a burning reaction
- This means that they stay hot well after engine is turned off
 - Heat shields are crucial to avoid fires if in contact with dry leaves/grass
- Should be mounted as close to the manifold as possible as otherwise gases cool too much
 - Usually mounted just after the lambda sensor



- As with all the other emissions systems the operation of catalytic converters is monitored by the ECU
- Usually test takes place when:
 - Closed loop status
 - Intake air temperature over 0° C
 - Engine coolant temperature over 18° C
 - Mass Air Flow sensor input between 15 and 32 g/sec
 - Engine load less than 65% and steady
 - Engine speed lower than 4000 rpm
 - All of the above for at least 4 minutes

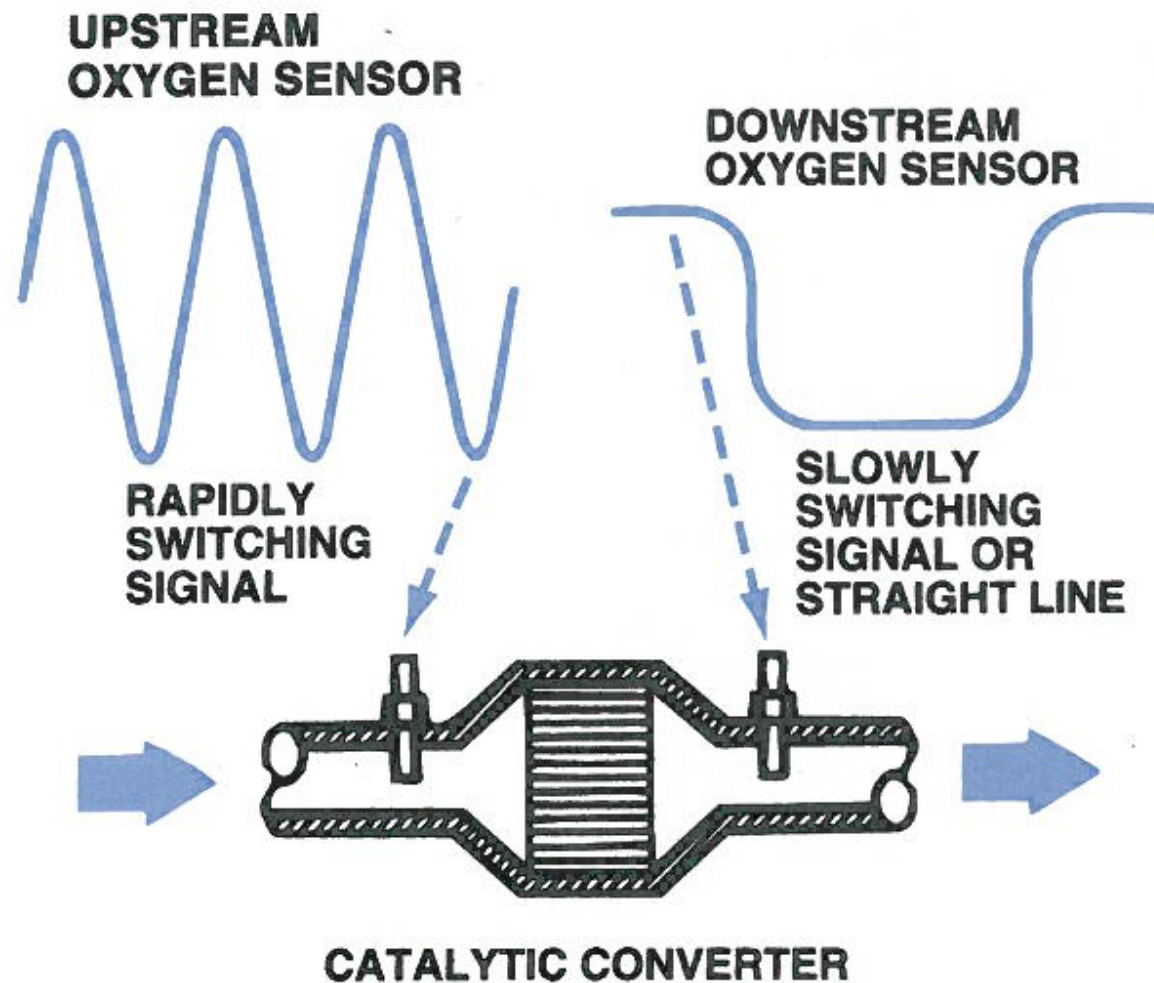


- With OBD-II systems CAT performance is monitored by a heated oxygen sensors (HO2S) positioned before and after the converter.
- With OBD-II catalytic converters are coated with Cerium and therefore have Oxygen Storage Capacity (OSC)
- When the TWC is working correctly the post HO2S is less active than the pre converter one.
- The converter stores and then releases oxygen during its normal operation so the O_2 output is stable
- Whereas before the catalytic the O_2 concentrations vary constantly between lean and rich

Catalytic converter monitoring



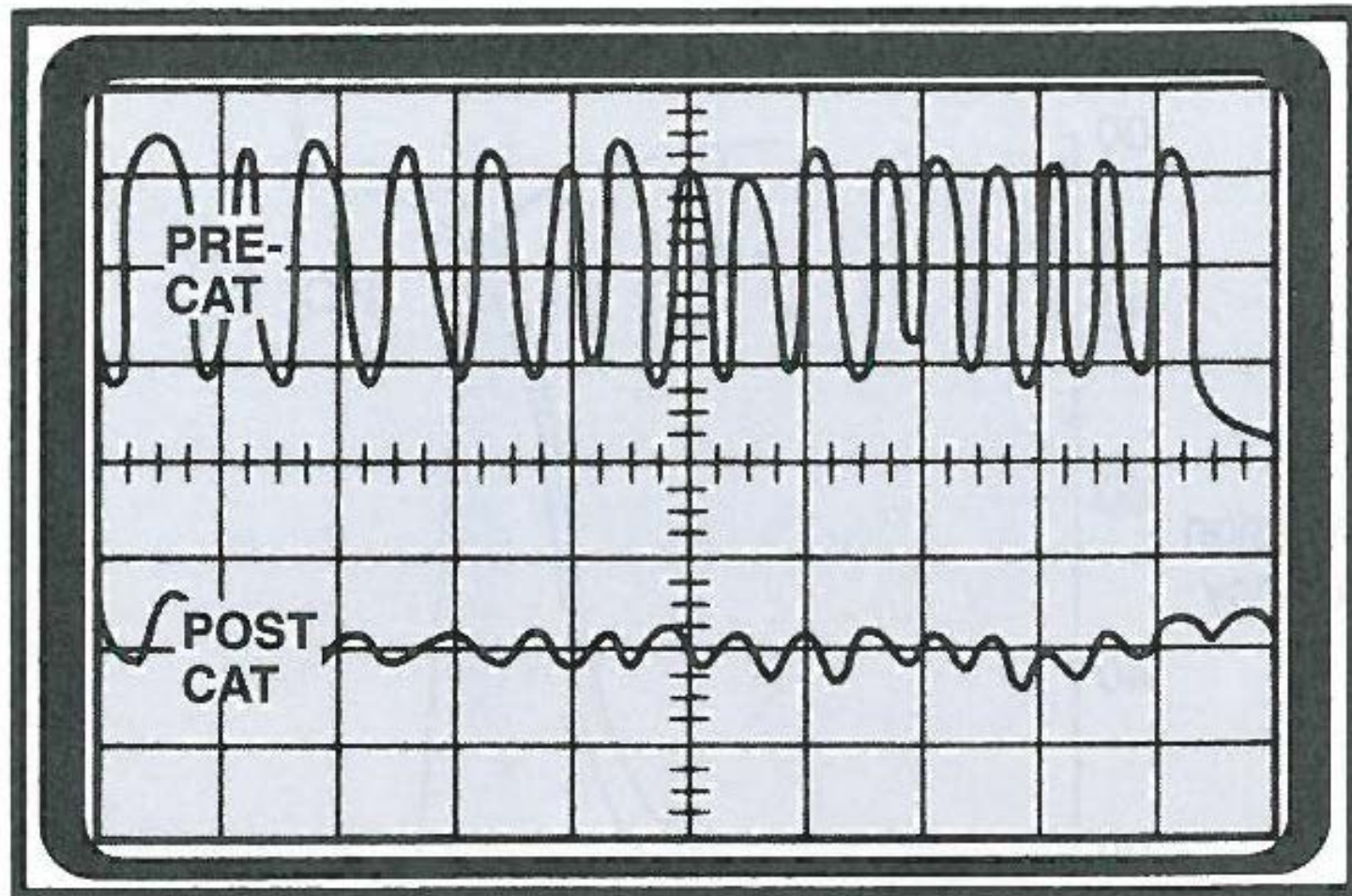
SWANSEA METROPOLITAN UNIVERSITY
PRIFYSGOL FETROPOLITAN ABERTAWE



Catalytic converter monitoring

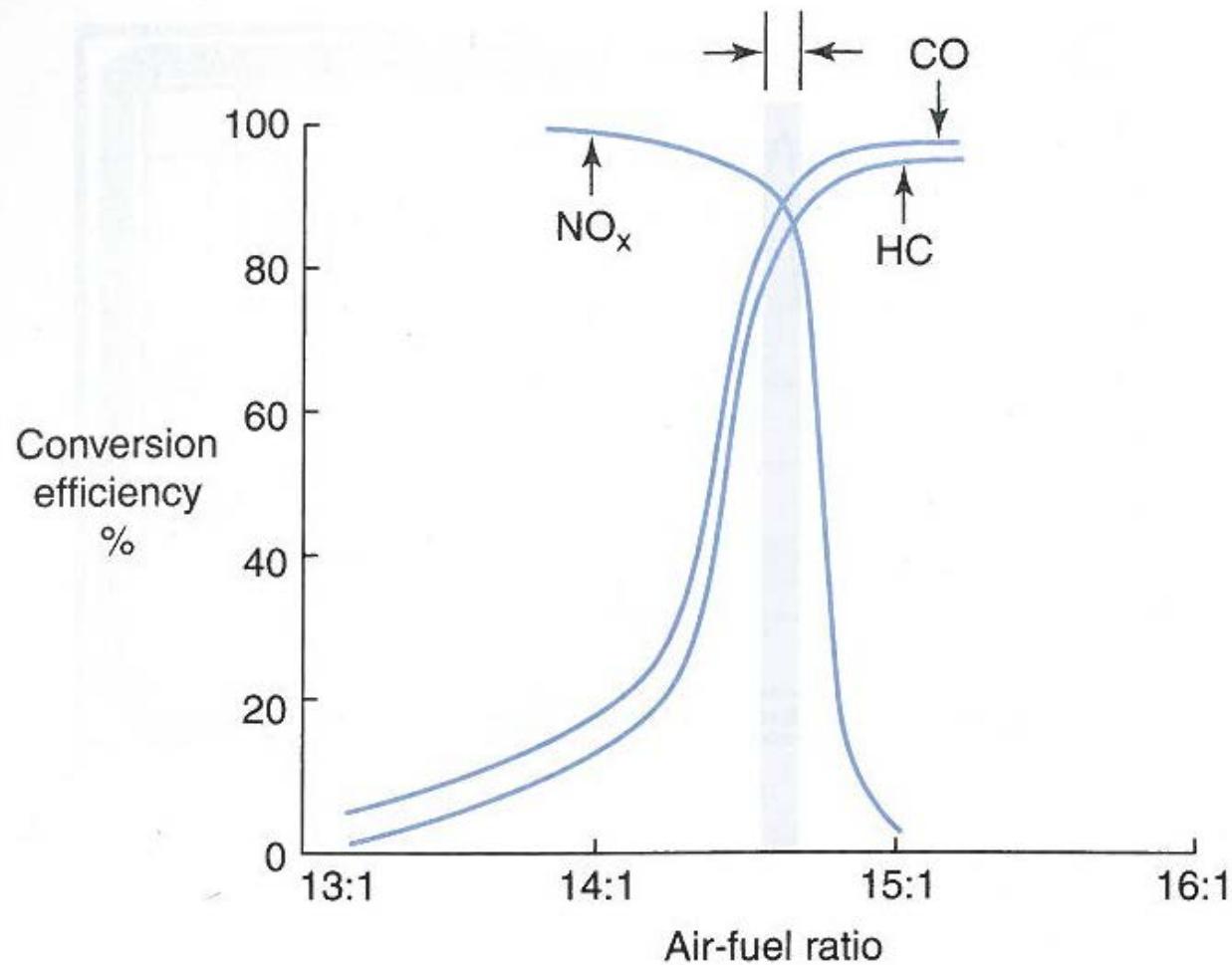


SWANSEA METROPOLITAN UNIVERSITY
PRIFYSGOL FETROPOLITAN ABERTAWE



- Catalytic converters are maintenance free components since they possess no moving parts
- In some countries they are warrantied for 80,000 miles or 8 years
- They can however get damaged and the following may lead to premature failure
 - Contamination : excess oil, antifreeze, sulphur, etc. in the exhaust
 - Excessive temperature: through very lean mixtures or burning of fuel in the exhaust when too rich.
 - Leads to melting the metals and collapse of the monolithic clogging the exhaust
 - Improper air fuel mixtures: lead to either contamination or temperature failure

Catalytic efficiency



- To avoid excessive temperature and vapours reaching the converter:
 - Do not bump start the engine. Use jump leads instead
 - Do not crank the engine for more than 40 seconds
 - Do not turn off ignition with car in motion
 - Do not disconnect spark plug form more than 30 seconds when testing ignition
 - Repair engine problems such as dieseling, misfiring or stumbling from excess fuel as soon as possible

Catalytic converter damage



SWANSEA METROPOLITAN UNIVERSITY
PRIFYSGOL FETROPOLITAN ABERTAWE



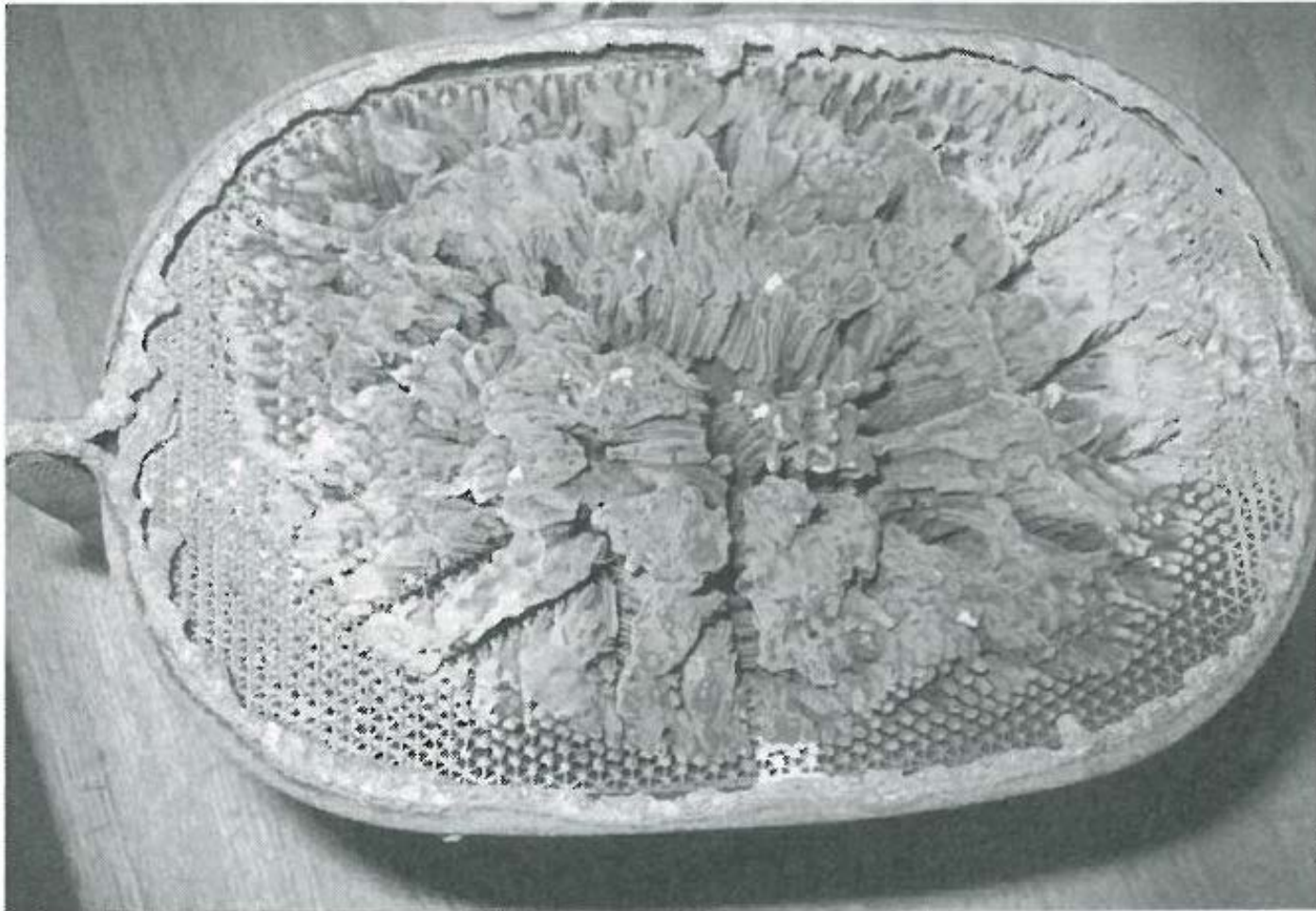


- Tap test
 - Gently tapping the converter with a soft mallet and listen for rattling of the substrate. If it rattles it will need to be replaced.
- Testing back pressure
 - With vacuum gauge: when engine is kept at constant rpm manifold vacuum will drop gradually if there is a restriction in the exhaust
 - With a pressure gauge: at idle the maximum back pressure should be less than 1.5 psi and less than 2.5 psi at 2500 rpm
 - Pressure gauge can be positioned where lambda sensor, EGR valve or AIR check valves are.

Diagnosing Catalytic Converters



SWANSEA METROPOLITAN UNIVERSITY
PRIFYSGOL FETROPOLITAN ABERTAWE



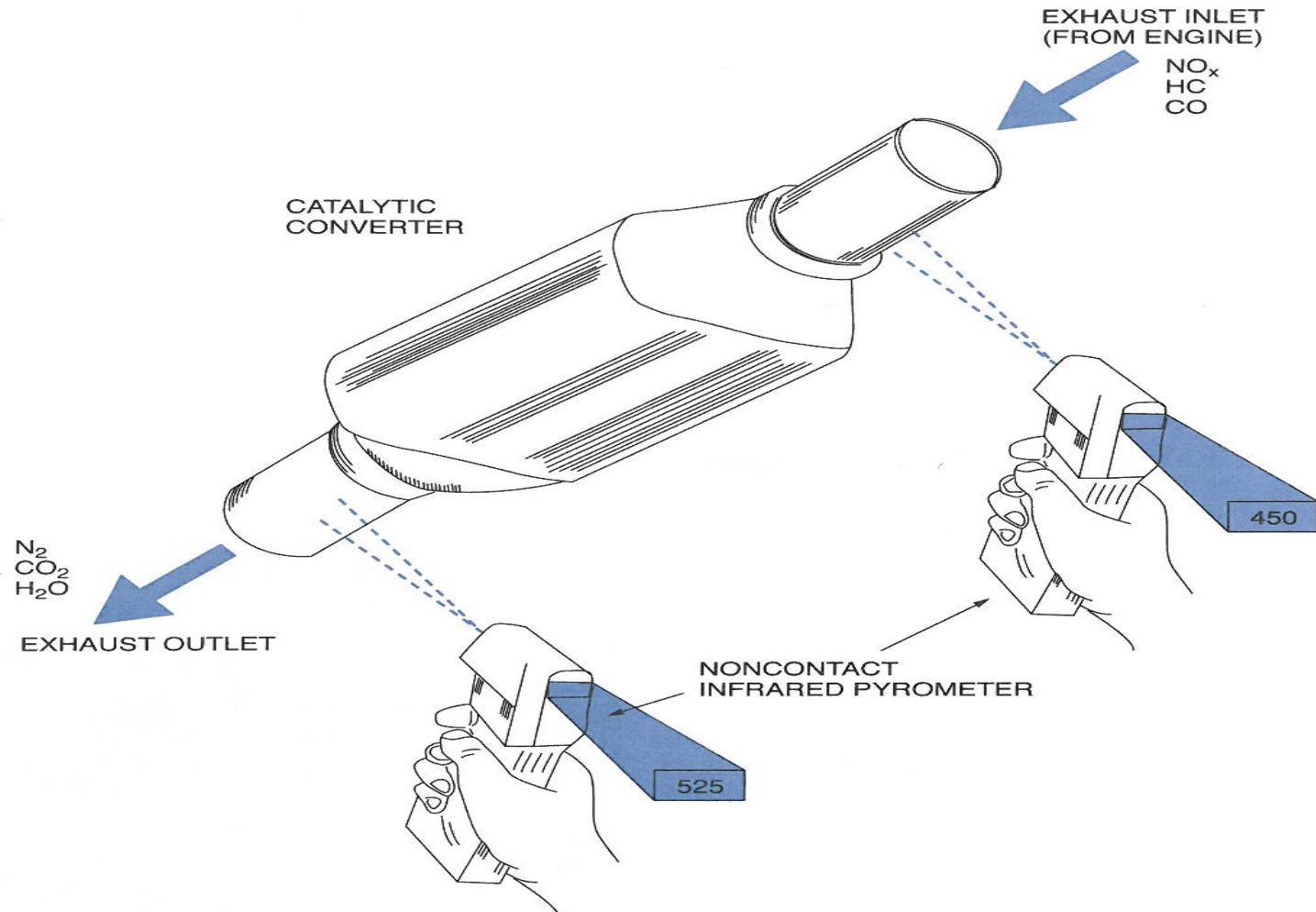


- By temperature rise
 - During the reduction of NO_x and Oxidation of HC and CO, temperature is released. Therefore the temperature of the gases entering and leaving the exhaust will rise
 - To check the good operation of a catalytic converter allow the engine to run at 2500 rpm for two minutes
 - Measure the inlet and outlet converter temperature with an infrared pyrometer
 - The temperature difference should be at least 10%

Diagnosing Catalytic Converters



SWANSEA METROPOLITAN UNIVERSITY
PRIFYSGOL FETROPOLITAN ABERTAWE





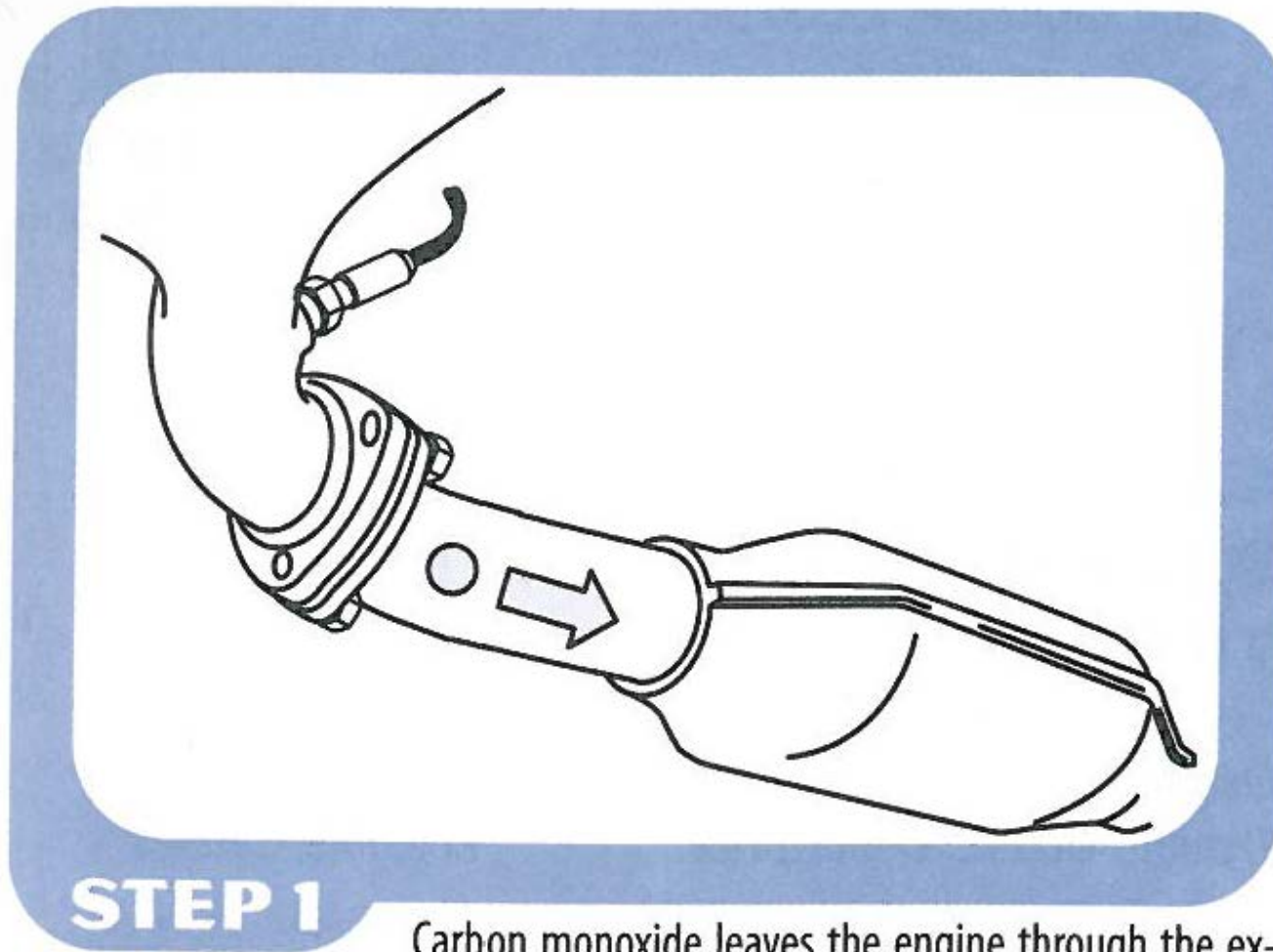
- Using a gas analyser
 - Oxygen level test
 - With engine warm and in closed loop check O_2 and CO levels
 - If O_2 is zero go to snap throttle test
 - If O_2 is greater than zero, check CO level
 - If CO greater than zero, the converter is not working correctly
 - Snap-throttle test
 - With engine warm and in closed loop snap the throttle to WOT and measure O_2
 - The reading should not exceed 1.2%. If it does converter not working
 - If it rises to 1.2% then converter not operating at full efficiency
 - If it remains below 1.2% converter ok



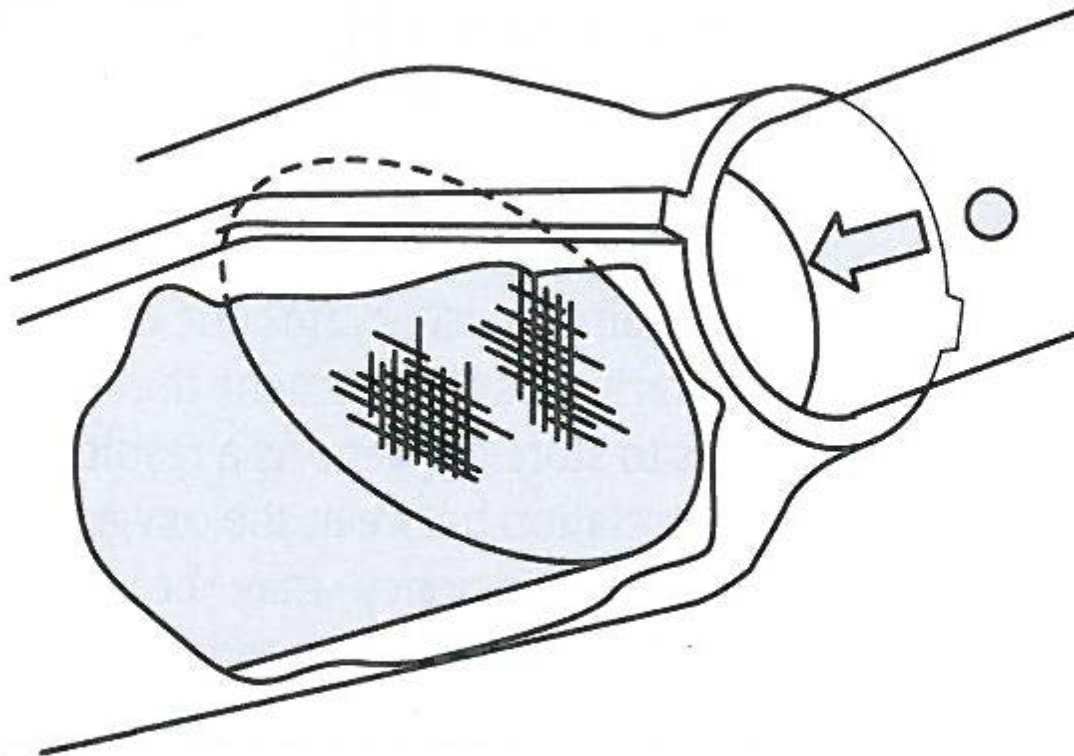
SWANSEA METROPOLITAN UNIVERSITY

PRIFYSGOL FETROPOLITAN ABERTAWE

Catalytic converter operation in detail

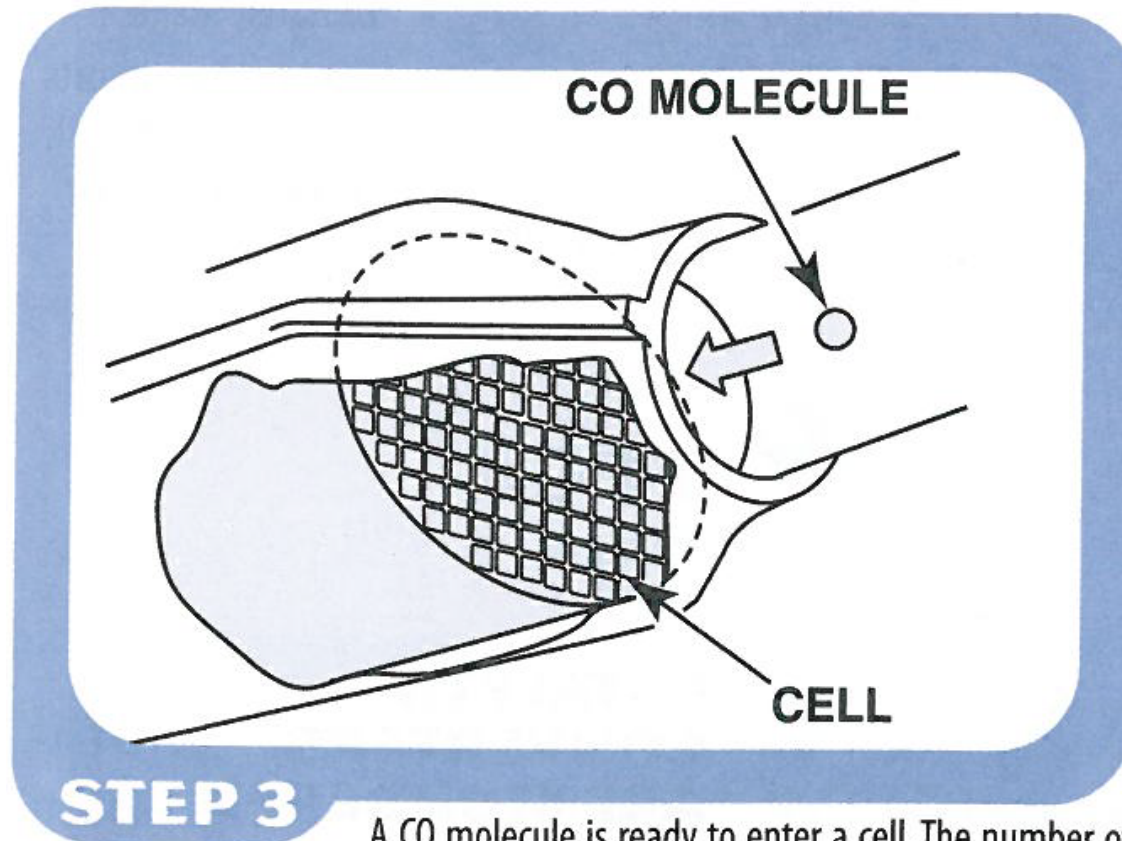


Carbon monoxide leaves the engine through the exhaust valve on the exhaust stroke.

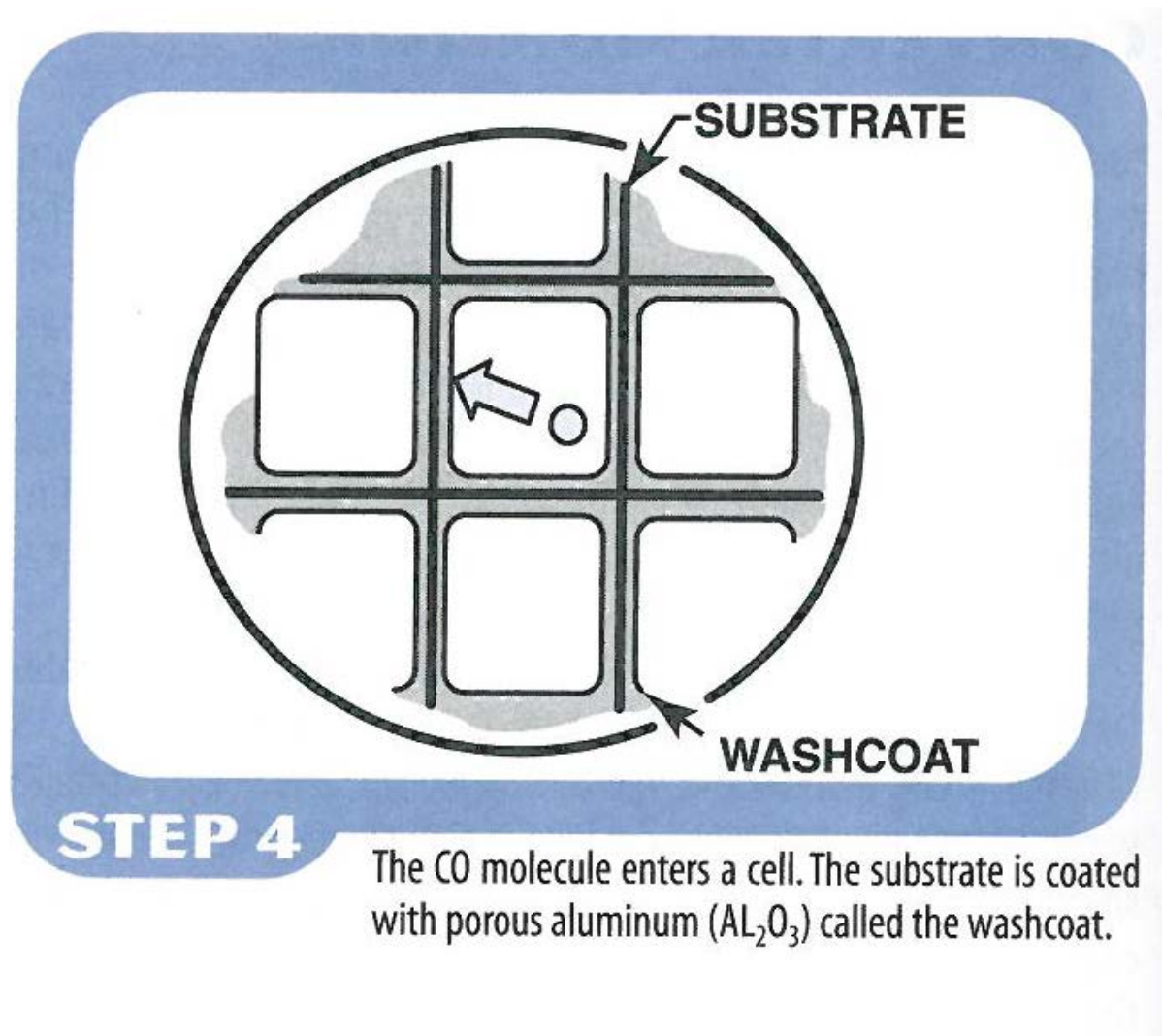


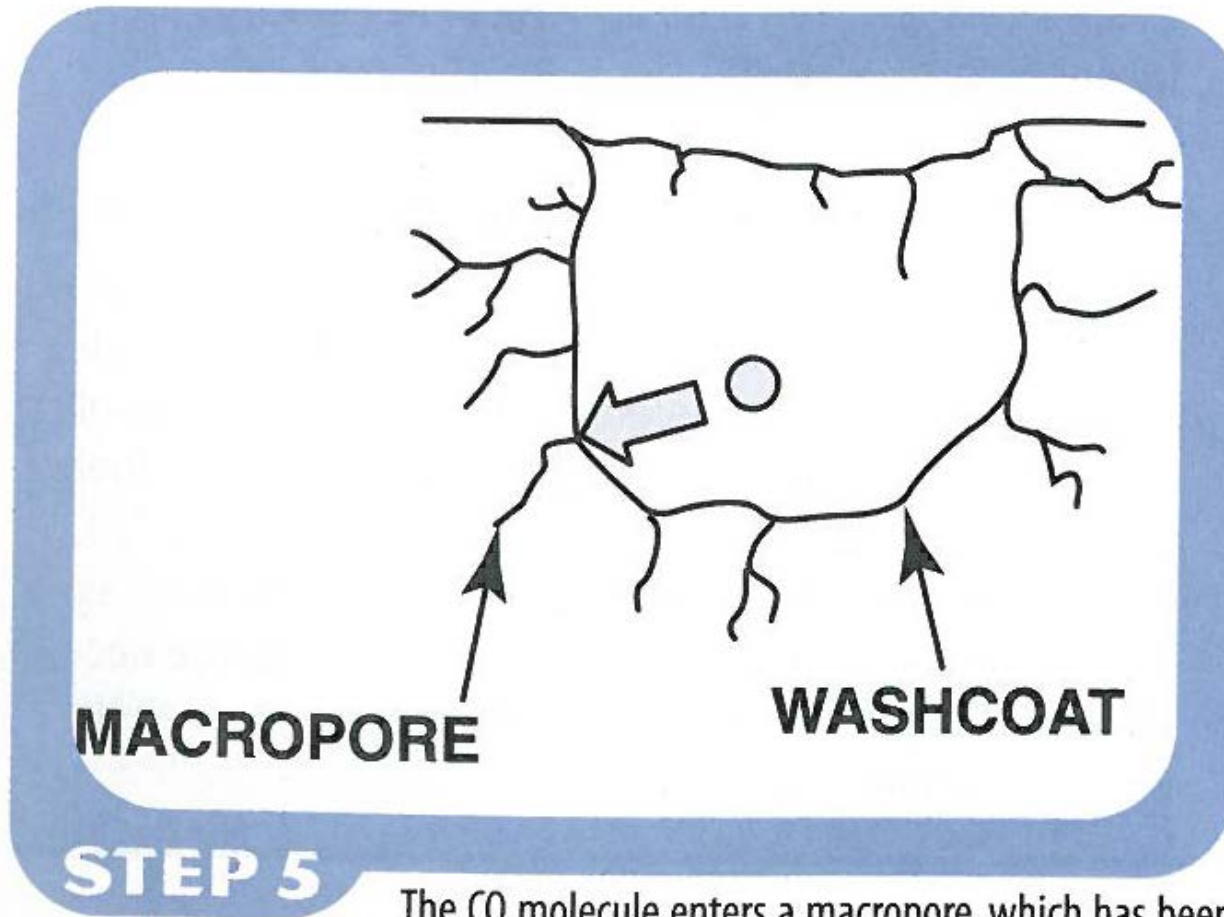
STEP 2

The CO molecule is starting to enter the converter.

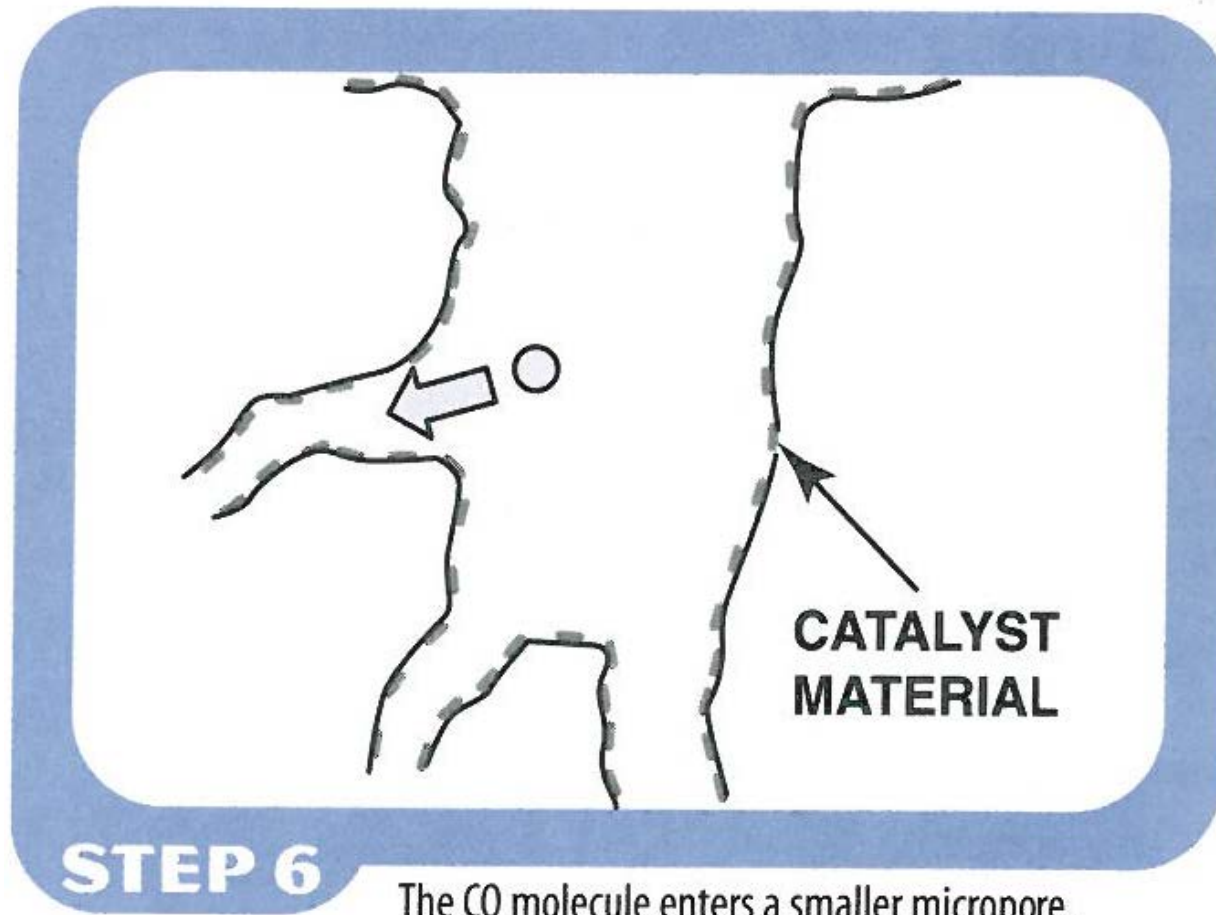


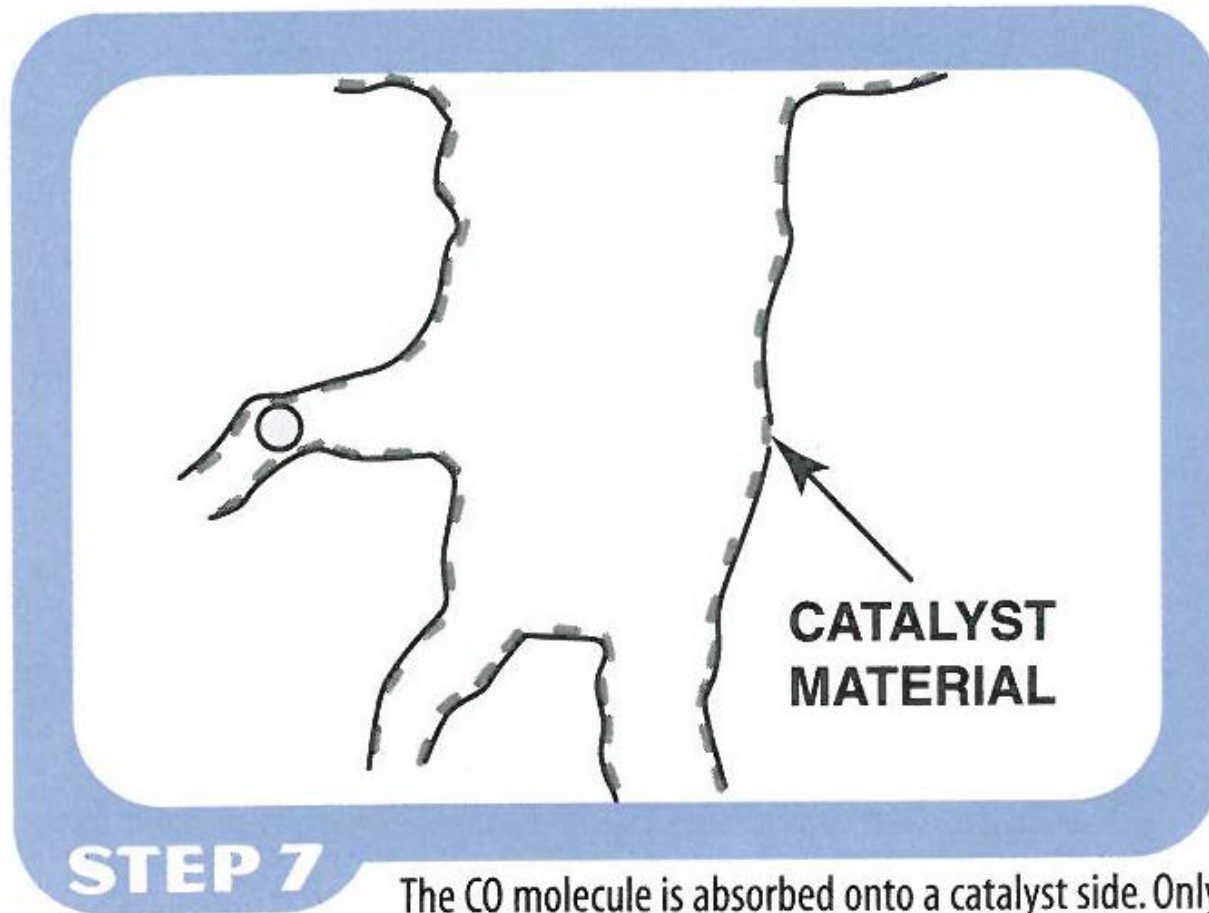
A CO molecule is ready to enter a cell. The number of cells ranges from 300 to 900 per square in. The substrate is cordierite (Mg, AL, Si) or foil-backed metal and is 0.002–0.006 in. (15 mm) thick wall.





The CO molecule enters a macropore, which has been created in the porous washcoat.





The CO molecule is absorbed onto a catalyst side. Only a few grams of catalyst material are applied to the washcoat.

