5.1 Catalytic converter

Catalytic converters are chemical substances that affect a chemical reaction without changing themselves.
The catalytic converter is used in automobiles to clean exhaust gases:

- Nitrogen oxides (NOx) are reduced to carbon dioxides (CO2) and nitrogen (N2).
- Carbon monoxide (CO) is oxidised to carbon dioxide (CO2).
- Hydrocarbons (HC) are oxidised to carbon dioxide (CO2) and water (H2O).

It is therefore one of the most important components of emissions control.
The state of current technology for petrol engines is the “regulated” catalytic converter.
Here a controlled fuel/air mixture, whose mix ratio fluctuates by lambda (λ) = 1, is supplied to the engine.
The volume control is handled by the engine control unit.
A lambda probe upstream from the converter measures the residual oxygen in the exhaust gas.
A corresponding voltage signal serves as a control value for the engine control unit.
The converter will reach its full functionality at temperatures between 350 and 750° C.
Leaded fuel and temperatures above 1000° C can destroy a converter.
Because the catalytic converter has a great influence on emissions control, it is monitored in OBD.

5.1.1 Monitoring

The catalytic converter is monitored for efficiency and ageing. To monitor the state of the converter, the residual oxygen in the exhaust gas is measured by a second lambda probe downstream from the converter. This probe is also referred to as the “secondary, monitor, or post-cat probe”.
Here the voltage signal of the lambda probe upstream from the catalytic converter (“control probe”) is compared with the signal from the post-cat.
The control probe signal fluctuates extremely (large controller transient oscillations). These fluctuations are caused by the different residual oxygen content in the exhaust gas as a result of the lambda control (rich/lean).
A functioning catalytic converter accumulates large quantities of oxygen.
This causes the measurable oxygen content downstream from the converter to fluctuate only slightly.
As a result, the voltage signal is relatively constant. The controller transient oscillations of the post-cat probe are low.

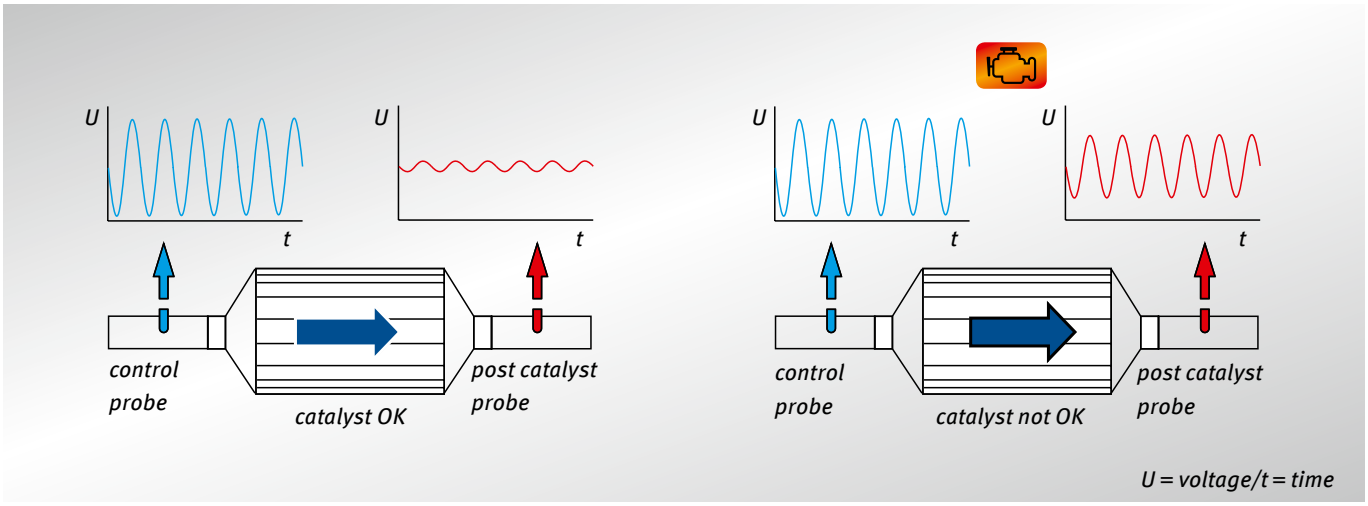

Fig. 45: monitoring the efficiency of the catalytic converter

Evaluation:
small controller transient oscillations of the post-cat probe = catalytic converter effective
large controller transient oscillations of the post-cat probe = catalytic converter ineffective
When a catalytic converter is defective, both probe signals will be almost identical.

Monitoring conditions

- The vehicle is operating at speeds between 5 and 80 km/h.
- The engine has reached operating temperature.
- The catalytic converter has reached temperatures between 350 and 650° C.
- The engine speed and the accelerator pedal position are basically constant.

The catalytic converter will be detected as faulty if 150% of the pollution limit is exceeded.

Possible fault codes

P0420	catalyst system (bank 1)	efficiency below threshold
P0421	warm up catalyst (bank 1)	efficiency below threshold
P0422	main catalyst (bank 1)	efficiency below threshold
P0423	heated catalyst (bank 1)	efficiency below threshold
P0424	heated catalyst (bank 1)	temperature below threshold
P0425	catalyst temperature sensor (bank 1)	malfunction
P0426	catalyst temperature sensor (bank 1)	range/performance
P0427	catalyst temperature sensor (bank 1)	low input
P0428	catalyst temperature sensor (bank 1)	high input
P0429	catalyst heater control circuit (bank 1)	malfunction
P0430	catalyst system (bank 2)	efficiency below threshold
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P0439	catalyst heater control circuit (bank 2)	malfunction

Diagnostic instructions

Error	Causes
insufficient effect caused by deposits on the catalytic effective surface	• leaded fuel has “contaminated” the converter, i.e., the active surface is plugged • oil deposit in the active surface • premature ageing due to high temperatures • In these cases the catalytic effect is reduced.
lack of power (caused by increased exhaust gas back pressure) uneven running is detected (caused by increased exhaust gas back pressure)	• the monolith is broken due to excessive mechanical pressure (there will be noises if the converter is moved/shaken) • the monolith had melted down or is partially melted due to very high temperatures • the monolith has been destroyed by a “water hammer” In these cases the catalytic converter may be so damaged that the free area is no longer sufficient. The exhaust gas back pressure increases, power decreases noticeably. For the error diagnosis: check whether the back pressure in the exhaust gas system has increased. For the test, remove the pre-cat probe and measure the pressure there with a precision manometer. The exhaust gas back pressure is usually about 0.2 bar.