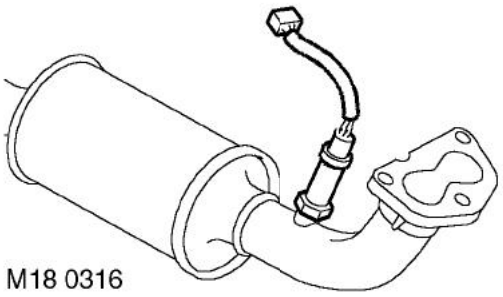
Heated Oxygen Sensors (HO_2S) (C0642)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The market requirement dictates how many HO_2S are fitted to the vehicle.

- 4 sensors are fitted to all NAS and EU-3 vehicles.
- 2 sensors fitted to all UK, European, Australia and Japanese pre EU-3 specification vehicles.
- No sensors fitted to ROW vehicles.

The HO_2S monitor the oxygen content of the exhaust gases. By positioning the sensors one for each bank upstream of the catalytic converter in the exhaust pipe, the ECM can control fuelling on each bank independently of the other. This allows greater control of the air:fuel ratio and maintains optimum catalyst efficiency. On NAS vehicles the ECM also uses two HO_2S positioned downstream of the catalytic converters in the exhaust pipe to monitor catalytic converter efficiency. The ECM is able to achieve this by comparing the values of the upstream HO_2S and the down stream sensor for the same bank. These comparative values form part of the ECM OBD strategy.

The HO_2S uses zirconium contained in a galvanic cell surrounded by a gas permeable ceramic, this produces an output voltage proportional to the ratio difference between the oxygen in the exhaust gases and to the ambient oxygen.

The HO_2S operates at approximately 350 °C (662 °F). To achieve this temperature the HO_2S incorporate a heating element which is controlled by a PWM signal from the ECM. The elements are activated immediately after engine starts and also under low engine load conditions when the exhaust gas temperature is insufficient to maintain the required HO_2S temperature. If the heater fails, the ECM will not allow closed loop fuelling to be implemented until the sensor has achieved the required temperature.

This value equates to an HO_2S output of 450 to 500 mV. A richer mixture can be shown as $\lambda = 0.97$, this pushes the HO_2S output voltage towards 1000 mV. A leaner mixture can be shown as $\lambda = 1.10$, this pushes the HO_2S output voltage towards 100 mV.

From cold start, the ECM runs an open loop fuelling strategy. The ECM keeps this strategy in place until the HO_2S is at a working temperature of 350 °C (662 °F). At this point the ECM starts to receive HO_2S information and it can then switch into closed loop fuelling as part of its adaptive strategy. The maximum working temperature of the tip of the HO_2S is 930 °C (1706 °F), temperatures above this will damage the sensor.

HO_2S age with use, this increases their response time to switch from rich to lean and from lean to rich. This can lead to increased exhaust emissions over a period of time. The switching time of the upstream sensors are monitored by the ECM. If a pre-determined threshold is exceeded, a failure is detected and the MIL illuminated.

☞ **EMISSION CONTROL - V8, DESCRIPTION AND OPERATION, Exhaust Emission Control System.**

Input/Output

The upstream and downstream HO_2S are colour coded to prevent incorrect fitting. The tips of the upstream sensors are physically different to the tips of the downstream sensors.

The HO_2S are colour coded as follows:

- Upstream sensors (both banks) - orange.
- Downstream sensors (both banks) - grey.

The four HO_2S have a direct battery supply to the heater via fuse 2 located in the engine compartment fuse box.

The heater is driven by the ECM providing an earth path for the circuit as follows:
- Upstream LH bank via pin 19 of connector C0635 of the ECM.
- Upstream RH bank via pin 13 of connector C0635 of the ECM.
- Downstream LH bank via pin 7 of connector C0635 of the ECM.
- Downstream RH bank via pin 1 of connector C0635 of the ECM.

The HO_2S output signal is measured by the ECM as follows:
- Upstream LH bank via pin 15 of connector C0635 of the ECM.
- Upstream RH bank via pin 16 of connector C0635 of the ECM.
- Downstream LH bank via pin 17 of connector C0635 of the ECM.
- Downstream RH bank via pin 14 of connector C0635 of the ECM.

The HO_2S earth path for the signal is supplied by the ECM as follows:
- Upstream LH bank via pin 9 of connector C0635 of the ECM.
- Upstream RH bank via pin 10 of connector C0635 of the ECM.
- Downstream LH bank via pin 11 of connector C0635 of the ECM.
- Downstream RH bank via pin 8 of connector C0635 of the ECM.

The HO_2S voltage is difficult to measure using a multimeter, the output can be monitored using TestBook. A rich mixture would read 500 to 1000 mV, a weak mixture would read 100 mV to 500 mV, the reading should switch from rich to weak. The open loop default voltage is 450 mV, this is used by the ECM to set the air/ fuel ratio until the tip of the HO_2S reaches operating temperature.

The HO_2S can fail the following ways or supply incorrect signal:
- Sensor open circuit.
- Short circuit to vehicle supply.
- Short circuit to vehicle earth.
- Sensor disconnected.
- Stoichiometric ratio outside the correct operating band.
- Contamination from leaded fuel.
- Air leak into the exhaust system.
- Wiring loom damage.
- Sensors fitted incorrectly or cross wired.

In the event of a HO_2S signal failure any of the following symptoms may be observed:
- Default to open loop fuelling on defective bank.
- If the sensors are crossed over (LH bank to RH bank), the engine will run normally after initial start up, but performance will become progressively worse as the sensors go towards maximum rich for one bank of cylinders and maximum lean for the other. The ECM will eventually default into open loop fuelling.
- High CO reading.
- Excess emissions.
- Strong hydrogen sulphide (H_2S) smell until the ECM defaults to open loop fuelling. .
- MIL illuminated (NAS market only).

A number of diagnostic tests are performed by the ECM with regards to the HO_2sensors:
- HO_2 sensor and system diagnostics
- HO_2 sensor heater diagnostics
- HO_2 sensor switching period (ageing) diagnostics
- Rear HO_2 sensor adaption diagnostic (NAS only)
- Catalyst monitoring diagnostic

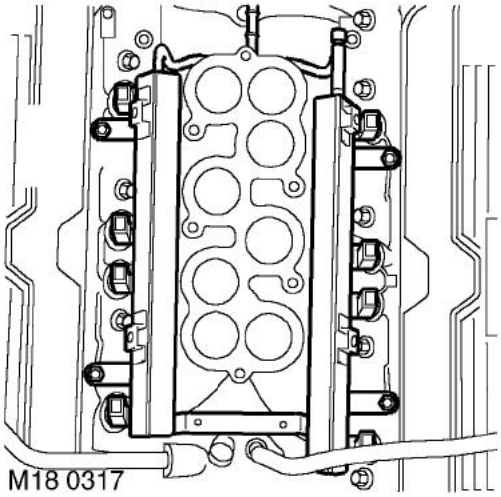
For further details of the heated oxygen sensors and exhaust emission control, refer to the V8 Emission Control section of this manual.

☞ **EMISSION CONTROL - V8, DESCRIPTION AND OPERATION, Exhaust Emission Control System.**

Should a malfunction of the component occur the following fault codes may be evident and can be retrieved by TestBook:

P Code	J2012 Description	Land Rover Description
P1129	O_2 sensors swapped bank to bank (sensor 1)	Front sensors transposed
P0130	O_2 sensor circuit malfunction (bank 1, sensor 1)	Front sensor LH bank stoichiometric ratio outside operating band
P0132	O_2 sensor circuit high voltage (bank 1, sensor 1)	Front sensor LH bank short circuit to battery supply
P0134	O_2 sensor circuit no activity detected (bank 1, sensor 1)	Front sensor LH bank open circuit
P0150	O_2 sensor circuit malfunction (bank 2, sensor 1)	Front sensor RH bank stoichiometric ratio outside operating band
P0152	O_2 sensor circuit high voltage (bank 2, sensor 1)	Front sensor RH bank short circuit to battery supply
P0154	O_2 sensor circuit no activity detected (bank 2, sensor 1)	Front sensor RH bank open circuit
P0136	O_2 sensor circuit malfunction (bank 1, sensor 2)	Rear sensor LH bank stoichiometric ratio outside operating band (NAS only)
P0137	O_2 sensor circuit low voltage (bank 1, sensor 2)	Rear sensor LH bank short circuit to earth (NAS only)
P0138	O_2 sensor circuit high voltage (bank 1, sensor 2)	Rear sensor LH bank short circuit to battery supply (NAS only)
P0140	O_2 sensor circuit no activity detected (bank 1, sensor 2)	Rear sensor LH bank open circuit (NAS only)
P0156	O_2 sensor circuit malfunction (bank 2, sensor 2)	Rear sensor RH bank stoichiometric ratio outside operating band (NAS only)
P0157	O_2 sensor circuit low voltage (bank 2, sensor 2)	Rear sensor RH bank short circuit to earth (NAS only)
P0158	O_2 sensor circuit high voltage (bank 2, sensor 2)	Rear sensor RH bank short circuit to battery voltage (NAS only)
P0160	O_2 sensor circuit no activity detected (bank 2, sensor 2)	Rear sensor RH bank open circuit (NAS only)
P0133	O_2 sensor circuit slow response (bank 1, sensor 1)	Front sensor aged - period time too long/too short LH bank
P0153	O_2 sensor circuit slow response (bank 2, sensor 1)	Front sensor aged - period time too long/too short RH bank
P1170	Downstream fuel trim malfunction (bank 1)	Front sensor aged - rear HO_2S adaption too lean/too rich LH bank (NAS and EU-3 only)
P1173	Downstream fuel trim malfunction (bank 2)	Front sensor aged - rear HO_2S adaption too lean/too rich RH bank (NAS and EU-3 only)
P0135	O_2 sensor heater circuit malfunction (bank 1, sensor 1)	Front sensor heater LH bank - short/open circuit
P0141	O_2 sensor heater circuit malfunction (bank 1, sensor 2)	Rear sensor heater LH bank - short/open circuit (NAS and EU-3 only)
P0155	O_2 sensor heater circuit malfunction (bank 2, sensor 1)	Front sensor heater RH bank - short/open circuit
P0161	O_2 sensor heater circuit malfunction (bank 2, sensor 2)	Rear sensor heater RH bank - short/open circuit (NAS and EU-3 only)
P0420	-	Catalyst efficiency deteriorated - LH bank (NAS and EU-3 only)
P0430	-	Catalyst efficiency deteriorated - RH bank (NAS and EU-3 only)

Fuel injectors



The fuel injectors are located beneath the air inlet manifold. They utilise an electrical solenoid to lift the injector needle off its seat to allow fuel injection to take place. The fuel injectors provide excellent fuel atomisation in the lower portion of the inlet manifold, the air/fuel mixture can then be drawn into the cylinders to give good combustion characteristics and therefore excellent driveability.

There are eight fuel injectors one per cylinder that the ECM operates sequentially. All the injectors are fed from a common fuel rail as part of the returnless fuel system. Fuel pressure is maintained at a constant 3.5 bar (52 lbf.in^2) by a regulator that is integral with the fuel pump.

☞ **FUEL DELIVERY SYSTEM - V8, DESCRIPTION AND OPERATION, Description.**

Input/Output

All eight fuel injectors are supplied with battery voltage via fuse number 1 located in engine compartment fuse box. The ECM controls the individual earth path for each injector via its own pin at connector C0636 of the ECM multiplug. This facility allows the ECM to control the fuel injectors so that sequential fuel injection can take place.

Typical hot engine injector pulse width values:

- Idle = 2.5 ms.
- Peak torque (3000 rev/min) = 7 ms The ECM controls injector earth as follows:
- Cylinder No 1 - pin 41 of connector C0636 of the ECM multiplug.
- Cylinder No 2 - pin 1 of connector C0636 of the ECM multiplug.
- Cylinder No 3 - pin 27 of connector C0636 of the ECM multiplug.
- Cylinder No 4 - pin 40 of connector C0636 of the ECM multiplug.
- Cylinder No 5 - pin 2 of connector C0636 of the ECM multiplug.
- Cylinder No 6 - pin 15 of connector C0636 of the ECM multiplug.
- Cylinder No 7 - pin 14 of connector C0636 of the ECM multiplug.
- Cylinder No 8 - pin 28 of connector C0636 of the ECM multiplug.

Individual injectors can be measured for resistance using a multimeter. An acceptable injector resistance is as follows:

- 14.5 ±0.7 ohms at 20 °C (68 °F).

The fuel injectors can fail in the following ways or supply incorrect signal:

- Injector actuator open circuit.
- Short circuit to vehicle supply.
- Short circuit to vehicle earth.
- Blocked injector.
- Restricted injector.
- Low fuel pressure.

In the event of fuel injector signal failure any of the following symptoms may be observed:

- Rough running.
- Difficult starting.
- Engine misfire.
- Possible catalyst damage.
- High emissions.
- Adaptive fuelling disabled.
- Adaptive idle speed control disabled.

The ECM performs three types of fuel injector diagnostic check:

- Output short circuit to earth
- Output short circuit to battery voltage
- Output open circuit

Should a malfunction of the component occur the following fault codes may be evident and can be retrieved by TestBook:

P Code	J2012 Description	Land Rover Description
P0201	Injection circuit malfunction - cylinder 1	Injector 1 open circuit
P0261	Cylinder 1 injector circuit low	Injector 1 short circuit to earth
P0262	Cylinder 1 injector circuit high	Injector 1 short circuit to battery supply
P0301	Cylinder 1 misfire detected	Injector 1 excess emissions/catalyst damaging level of misfire
P0202	Injection circuit malfunction - cylinder 2	Injector 2 open circuit
P0264	Cylinder 2 injector circuit low	Injector 2 short circuit to earth
P0265	Cylinder 2 injector circuit high	Injector 2 short circuit to battery supply
P0302	Cylinder 2 misfire detected	Injector 2 excess emissions/catalyst damaging level of misfire
P0203	Injection circuit malfunction - cylinder 3	Injector 3 open circuit
P0267	Cylinder 3 injector circuit low	Injector 3 short circuit to earth
P0268	Cylinder 3 injector circuit high	Injector 3 short circuit to battery supply
P0303	Cylinder 3 misfire detected	Injector 3 excess emissions/catalyst damaging level of misfire
P0204	Injection circuit malfunction - cylinder 4	Injector 4 open circuit
P0270	Cylinder 4 injector circuit low	Injector 4 short circuit to earth
P0271	Cylinder 4 injector circuit high	Injector 4 short circuit to battery supply
P0304	Cylinder 4 misfire detected	Injector 4 excess emissions/catalyst damaging level of misfire
P0205	Injection circuit malfunction - cylinder 5	Injector 5 open circuit
P0273	Cylinder 5 injector circuit low	Injector 5 short circuit to earth
P0274	Cylinder 5 injector circuit high	Injector 5 short circuit to battery supply
P0305	Cylinder 5 misfire detected	Injector 5 excess emissions/catalyst damaging level of misfire
P0206	Injection circuit malfunction - cylinder 6	Injector 6 open circuit
P0276	Cylinder 6 injector circuit low	Injector 6 short circuit to earth
P0277	Cylinder 6 injector circuit high	Injector 6 short circuit to battery supply
P0306	Cylinder 6 misfire detected	Injector 6 excess emissions/catalyst damaging level of misfire
P0207	Injection circuit malfunction - cylinder 7	Injector 7 open circuit
P0279	Cylinder 7 injector circuit low	Injector 7 short circuit to earth
P0280	Cylinder 7 injector circuit high	Injector 7 short circuit to battery supply
P0307	Cylinder 7 misfire detected	Injector 7 excess emissions/catalyst damaging level of misfire
P0208	Injection circuit malfunction - cylinder 8	Injector 8 open circuit
P0282	Cylinder 8 injector circuit low	Injector 8 short circuit to earth
P0283	Cylinder 8 injector circuit high	Injector 8 short circuit to battery supply

P Code	J2012 Description	Land Rover Description
P0308	Cylinder 8 misfire detected	Injector 8 excess emissions/catalyst damaging level of misfire
P0171	System too lean (bank 1)	Multiplication injector adaptive fuelling - lean limit exceeded LH bank
P0172	System too rich (bank 1)	Multiplication injector adaptive fuelling - rich limit exceeded LH bank
P0174	System too lean (bank 2)	Multiplication injector adaptive fuelling - lean limit exceeded RH bank
P0175	System too rich (bank 2)	Multiplication injector adaptive fuelling - rich limit exceeded RH bank
P1171	System too lean (bank 1)	Additive injector adaptive fuelling - lean limit exceeded LH bank
P1172	System too rich (bank1)	Additive injector adaptive fuelling - rich limit exceeded LH bank
P1174	System too lean (bank 2)	Additive injector adaptive fuelling - lean limit exceeded RH bank
P1175	System too rich (bank 2)	Additive injector adaptive fuelling - rich limit exceeded RH bank
P0300	Random/multiple cylinder excess emissions detected	Excess emissions detected on more than one cylinder
P1300	Random/multiple cylinder misfire detected	Catalyst damaging level of misfire on more than one cylinder
P1319		Misfire detected with low fuel level