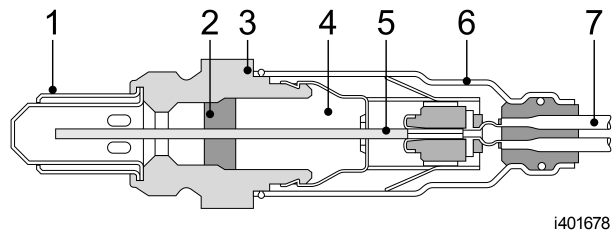
Sensor, lambda (F834)



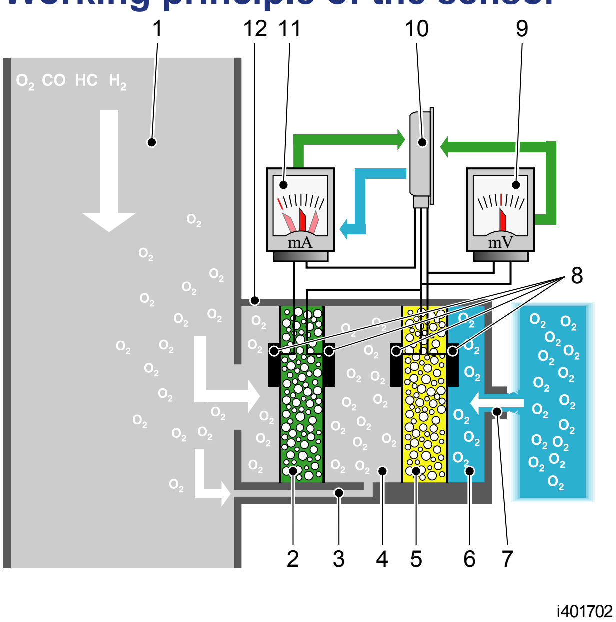
1. Guard tube
2. Ceramic seal assembly
3. Sensor housing
4. Ceramic support tube
5. Planar sensor element
6. Protective cap
7. Connection cable

The lambda sensor is located in the exhaust pipe. The function of the lambda sensor is to measure the oxygen residue in the exhaust gas, compared with the ambient air. The amount of oxygen in the exhaust gas is directly related to the air/fuel mixture in the combustion chamber. Thus a lambda sensor can determine the current air/fuel ratio in the combustion chamber. This is the ratio between the mass of air and the mass of fuel in the fuel-air mixture at any given moment.

When all the fuel is combined with all the free oxygen, the air/fuel mixture is chemically balanced; this air/fuel ratio is called the stoichiometric mixture. The air/fuel ratio is an important measurement for antipollution and performance tuning purposes. Lambda (λ) is an alternative method of representing the air/fuel ratio. It is the ratio of actual air/fuel ratio to stoichiometry for a given mixture. For a stoichiometric mixture, Lambda (λ) = 1. When the engine runs on a rich mixture, lambda is less than 1. When the engine runs on a lean mixture, lambda is greater than 1.

The Lambda sensor used is a "wideband sensor," meaning the sensor can measure over a wide lambda range. The sensor only works at temperatures up to 600°C. An electric heater element is used to warm the ceramic material after cold starts and when the engine is operating at low load factors. The heater element ensures low and stable emissions due to the consistent maintenance of optimal operating temperatures. The sensor is located downstream of the butterfly valve in order to protect the sensor against too high pressures.

Working principle of the sensor



1. Exhaust gas
2. Pump cell
3. Incision
4. Diffusion chamber

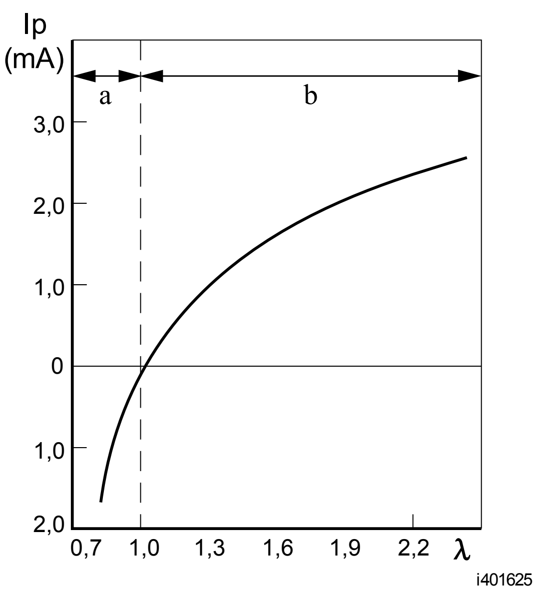
5. Nernst cell
6. Reference chamber
7. Opening
8. Electrodes
9. Nernst cell voltage
10. Electronic unit, PMCI-2
11. Pump cell current
12. Lambda sensor housing

The wideband sensor consists of two different measuring cells, integrated in a common housing: a pump cell (2) and a Nernst cell (5). The exhaust gas contains several combustion gases, under which there is residual oxygen. The exhaust gas (1) enters the diffusion chamber (4) through a very small incision (3). The diffusion chamber (4) is the actual measuring chamber of the sensor. It is shared by both the Nernst cell (5) and the pump cell (2).

The Nernst cell (5) consists of two electrodes (8) consisting of layers of zirconium dioxide. One electrode is placed in the reference chamber (6) and the other is located in the diffusion chamber (4). The reference chamber (6) is connected to the ambient air via an opening (7). The pump cell (6) also has two electrodes (8). One electrode is located in the diffusion chamber (4), while the other is located in the exhaust gas stream.

The difference of oxygen in the reference chamber (6) and the diffusion chamber (4) results in an electrical potential difference (the Nernst principle) over the electrodes (8) of the Nernst cell (5). This potential difference is transferred to the electronic unit (10) as an output voltage. The output voltage changes with the quantity of oxygen in the diffusion chamber (4). A voltage of 450 mV corresponds to a stoichiometric air/fuel ratio (λ = 1).

The PMCI-2 electronic unit (D365) tries to maintain a consistently stoichiometric air/fuel ratio in the diffusion chamber by activating the pump cell. The pump cell pumps oxygen ions into and/or out of the diffusion chamber. The current necessary to reach the correct amount of oxygen in the diffusion chamber represents the air/fuel ratio of the exhaust gas.

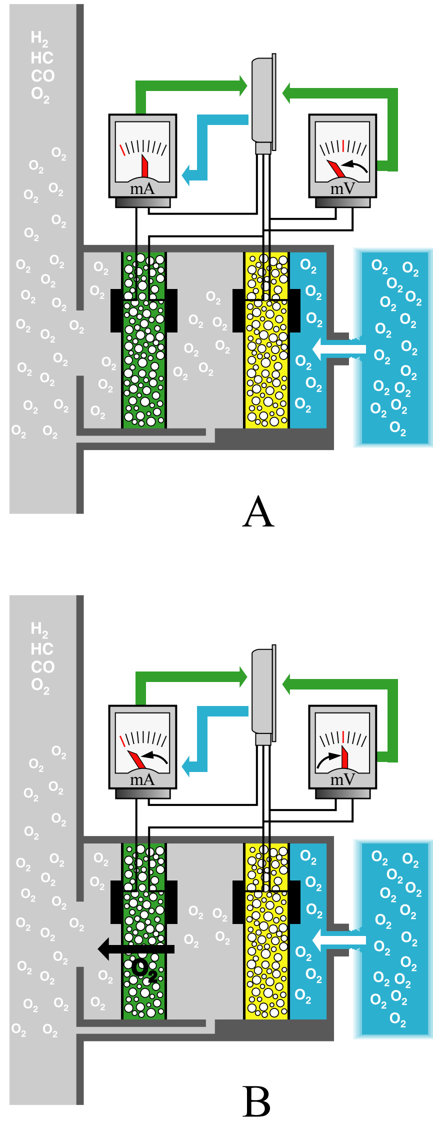


λ	Excess air factor (Lambda)
Ip	Pump cell current
a.	rich mixture
b.	lean mixture

Lean mixture

As the mixture becomes leaner (A), the oxygen ratio in the exhaust gas increases. If the pump cell current is unchanged, more oxygen is pumped into the diffusion chamber by the pump cell than can escape via the diffusion canal. As a result, the oxygen ratio changes compared with the ambient air, and the output voltage of the Nernst cell decreases.

To keep the Nernst cell voltage at 450 mV, the oxygen ratio in the diffusion chamber must be decreased by the pump cell (B). The pump cell must pump enough oxygen out of the diffusion chamber to recondition 450 mV. The PMCI-2 electronic control unit determines the lambda value out of the pump cell current.



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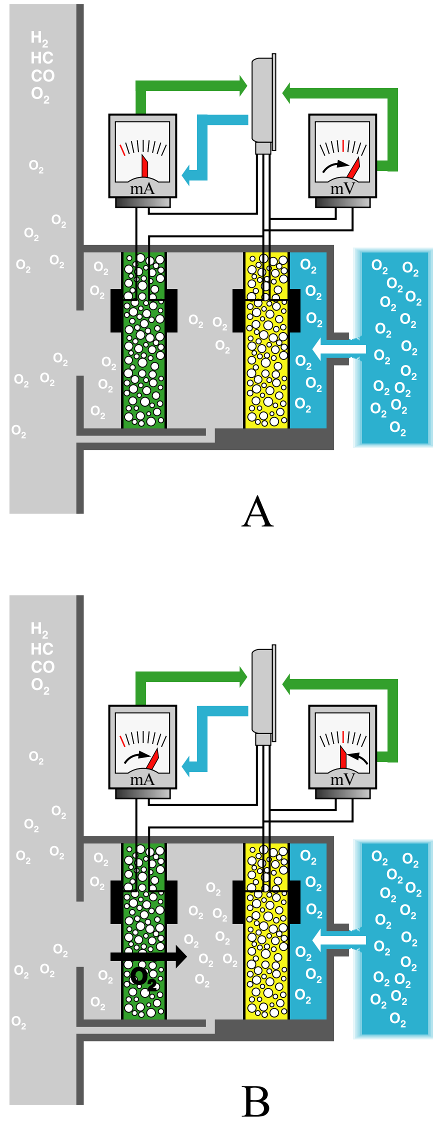
Rich mixture

As the mixture becomes richer (A), the oxygen ratio in the exhaust gas decreases. If the pump cell current is unchanged, more oxygen can escape via the diffusion canal than is pumped into the diffusion chamber pump. As a result, the oxygen ratio changes compared with the ambient air, and the output voltage of the Nernst cell increases.

In order to keep the Nernst cell voltage at 450 mV, the oxygen ratio in the diffusion chamber must be increased by the pump cell (B). The pump cell must pump less oxygen out of the diffusion chamber to recondition 450 mV. The PMCI-2 electronic control unit determines the lambda value out of the pump cell current.



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Effect of output signal on the system

- Used to compare the air/fuel ratio calculated by the ECU with the measured air/fuel ratio calculated by the lambda sensor, and correct it if necessary.
- Limiting smoke output, where the measured exhaust gas oxygen is compared with a target value for smoke limitation.
- Oxygen sensor feedback is also used to determine whether the target exhaust gas recirculation is being achieved.
- Information for regeneration of the DPF (Diesel Particulate Filter).
- Sensor signal used for calculation of NOx in exhaust gas.

Compensation during lifetime

The lambda sensor output changes over time and to compensate for this, when the engine is in overrun conditions, a comparison is made between the measured oxygen concentration of the exhaust gas and the expected output of the sensor if it were sensing fresh air. Any difference is applied as a learned correction value.

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