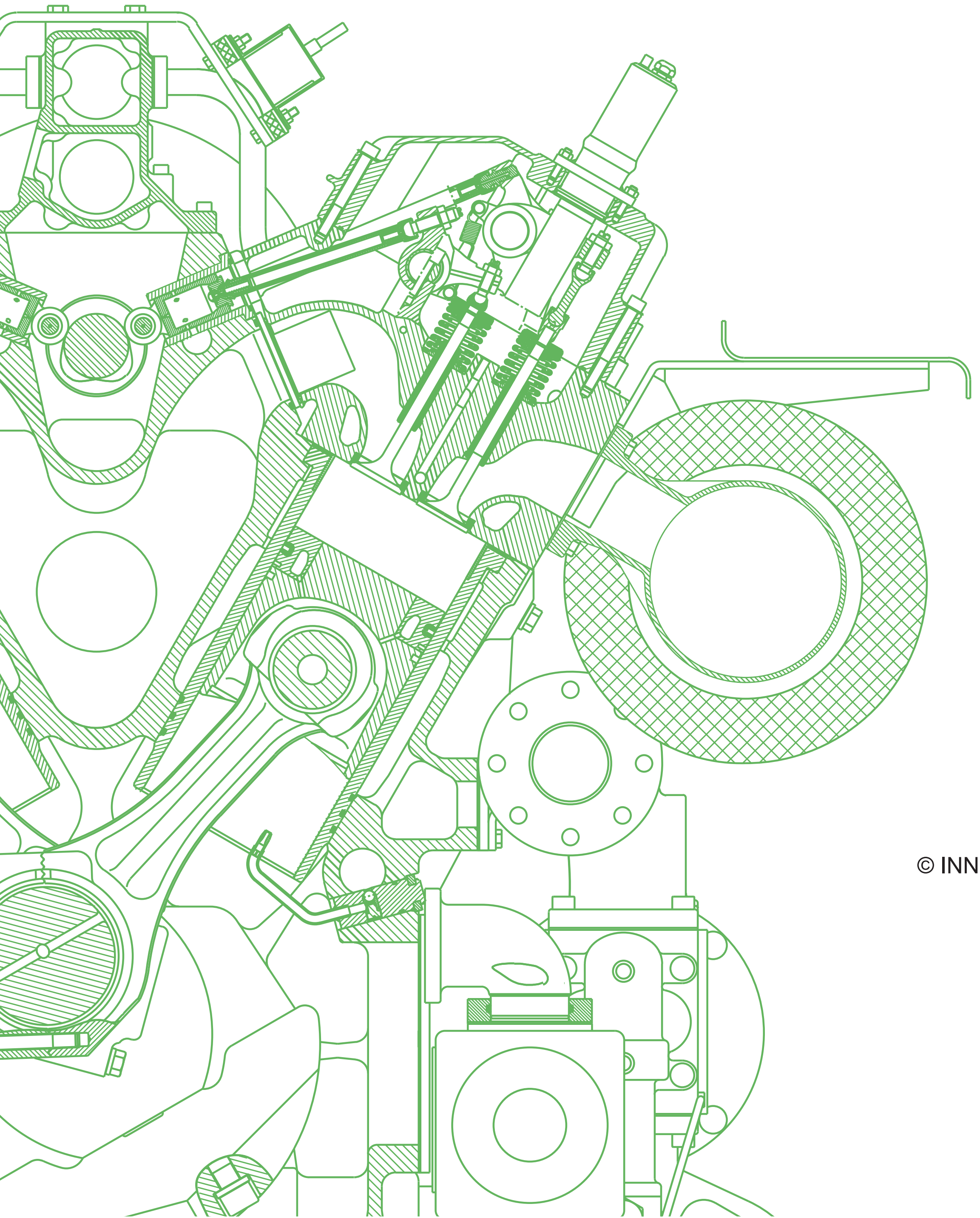
JENBACHER

TA 1531-0003

Technical Instruction

Lambda probe



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1 General

Radical improvements in the exhaust gas cannot be achieved by simply controlling the air-fuel mixture. Substantial reductions in pollutants can only result from mixture control in conjunction with the use of catalytic converters.

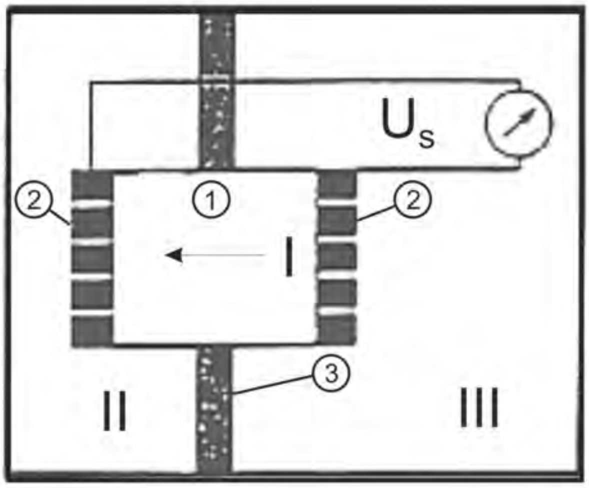
The lambda probe is an essential component in mixture control. It sends a signal about the instantaneous exhaust gas composition to the controller, which then corrects the fuel quantity accordingly. The signal from the lambda probe is stable and not susceptible to interference.

2 Measuring principle

The lambda probe operates on the principle of the galvanic oxygen concentration cell with a solid electrolyte. The solid non-gas-permeable electrolyte is an oxide mixture of zirconium oxide and yttrium oxide.

The oxide mixture is an almost pure oxygen ion conductor over a wide temperature range. The oxygen conductivity arises as a result of substitution in the crystal lattice of the zirconium ions with a valency of four by yttrium ions with a valency of three. Oxygen vacancies remain unoccupied during this due to electrical neutrality. The oxygen ions are transported through these vacancies in the lattice. The magnitude of the electrical conductivity is determined mainly by the composition of the oxide mixture and the temperature. If the solid electrolyte is in contact on both sides with porous electrodes and if a higher oxygen concentration is applied on one side than the other, an electrical voltage is obtained at the electrodes. This property is used in the lambda probe to measure the oxygen concentration in the exhaust gas at an appropriately high temperature of the solid electrolyte.

① Solid electrolyte
② Porous electrodes
③ Separating wall (exhaust pipe)
U_p Probe voltage
I Oxygen ion conductor
II Exhaust gas (with low oxygen content)
III Air (with high oxygen content)



3 Design

The ceramic part of the lambda probe (solid electrolyte) is in the shape of a tube closed at one end. The surface of the probe ceramic body is coated with a microporous platinum layer, which not only has a major effect on the probe characteristics due to its catalytic effect, but also acts as a contact.

The exhaust-side of the probe ceramic body is coated with a firmly-adhering highly porous ceramic layer over the platinum layer. This protective layer prevents deposits in the exhaust gas from exercising any erosive effect on the catalytically-active platinum layer. This gives the probe a high degree of long-term stability.

4 Method of operation

The lambda probe, particularly the unheated version, is installed in the engine exhaust pipe at a location where the necessary temperature for the probe to operate prevails over the entire operating range of the engine.

The probe projects into the exhaust gas flow and is designed so that one electrode side is immersed in exhaust gas while the other electrode side is in contact with the external air (atmosphere).

The exhaust gases from an Otto engine still contain a residual oxygen content, even if there is an excess of fuel in the mixture (approximately 0.1 to 0.3 % oxygen by volume at lambda = 0.95), which is measured by the lambda probe.

The use of porous platinum electrodes means that complete reaction of the residual oxygen takes place at the electrode surface with the carbon monoxide, hydrocarbons and water contained in the exhaust gas. The catalytic effect of the exhaust-gas side electrode surface results in a jump in the probe voltage in the region of the stoichiometric composition of the fuel-air mixture (lambda = 1).

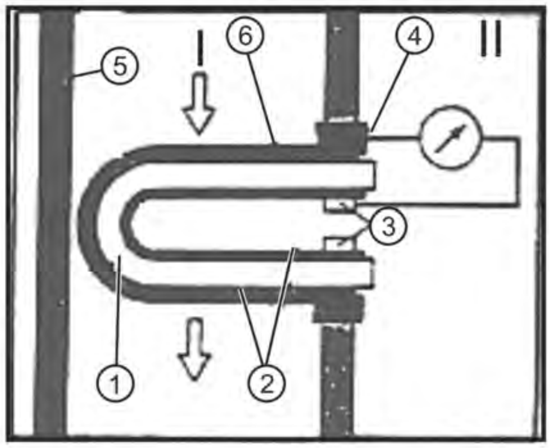
The probe voltage and the internal resistance of the probe vary as a function of the temperature. Reliable control operation is possible at exhaust temperatures above 350 °C (unheated probe) or 200 °C (heated probe).

5 Installation instructions

The lambda probe is installed at a location in the exhaust pipe that exhibits a representative composition of the exhaust gas from all the cylinders at a sufficiently high prevailing temperature (350 °C min. for an unheated probe, and 200 °C min. for a heated probe).

Overheating of the connection, particularly after the engine has been shut down, must be prevented.

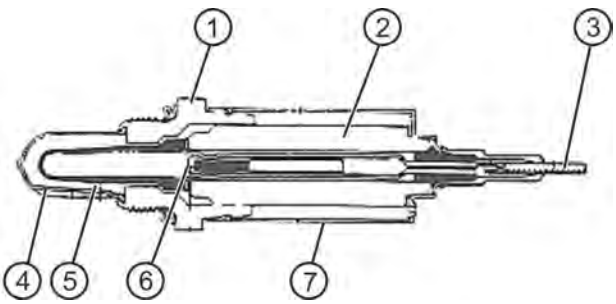
① Probe ceramic body
② Electrodes
③ Contact
④ Housing contact
⑤ Exhaust pipe
⑥ Protective ceramic layer (porous)
I Exhaust gas
II Air



6 Unheated lambda probe

The active probe ceramic body is held in the probe housing by a ceramic support tube and cup spring. Electrical contact is provided by a contact piece between the support tube and the active probe ceramic body, and by a metallic joint ring between the probe ceramic body and the probe housing. A metallic protective sheath caulked to the probe housing is fitted over the connection side of the probe. The protective sheath has small openings to equalise the pressure in the probe interior and acts as a backing support for the cup spring. The connecting cable is crimped on the contact part that is led out, and protected against moisture and mechanical damage by a temperature-resistant PTFE cap. The exhaust gas side is fitted with a protective tube with a special geometry to keep combustion residues in the exhaust gas away from the probe ceramic body. Slots are let into the protective tube to prevent any direct contact between the exhaust gases and the ceramic body. As well as provided mechanical protection, this effectively mitigates the temperature shock that occurs when changing from one operating condition to another. The temperature at the connection side of the probe ceramic body can reach 300 ... 500 °C.

① Probe housing
② Ceramic support tube
③ Connecting cable
④ Protective tube with slots
⑤ Active probe ceramic body
⑥ Contact piece
⑦ Protective sleeve



7 Heated lambda probe

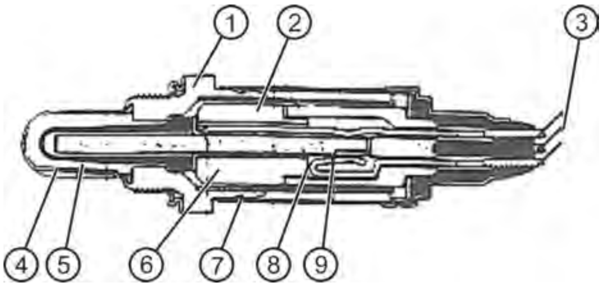
The design principle of the heated probe is largely identical to that of the unheated probe.

The active probe ceramic body (ZrO_2) is heated from inside by a ceramic heating element, so that the temperature of the probe ceramic body remains above the operating limit of 350 °C regardless of the exhaust gas temperature. The ceramic heating element has a PTC characteristic, which results in fast heating and a reduced power requirement with hot exhaust gas (approx. 12 W at an exhaust gas temperature of 350 °C).

The heating element connections are completely separate from those of the signal line (R ≥ 30 M Ω).

Unlike the unheated probe, the heated probe has a protective tube with reduced apertures. One effect of this is to prevent the probe ceramic body from cooling down with cold exhaust gas (3 slots).

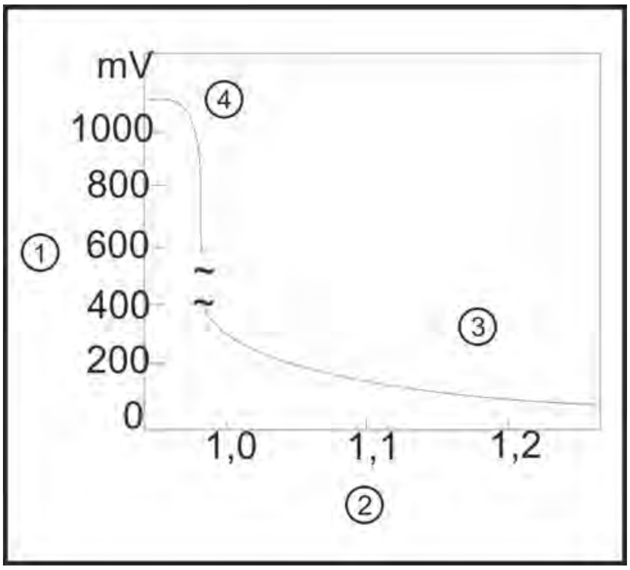
① Probe housing
② Ceramic support tube
③ Connecting cable
④ Protective tube
⑤ Active probe ceramic body
⑥ Contact piece
⑦ Protective sleeve
⑧ Heating element
⑨ Heating element connection terminals



8 Lean lambda probe

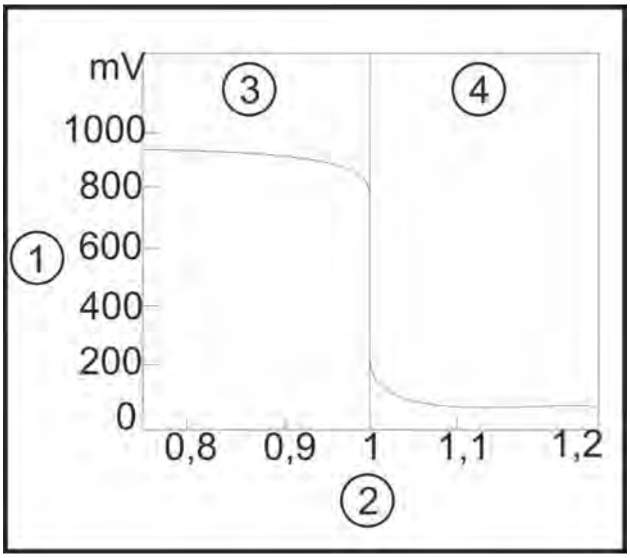
The design of the lean lambda heated probe is largely identical to that of the unheated probe. The operation of the lean lambda probe is based on the same principle of physics as the lambda = 1 probe, but the probe also exploits the stabilised lambda curve in the range from lambda > 1.0 to lambda = 1.5 (lambda = 2.0 for special applications).

Use of a more powerful heating element (approx. 18 W instead of 12 W) and an additional earth lead stabilises the output voltage (10 ... 60 mV at lambda = 1.5 ... 1.05) even without temperature control. Depending on the exhaust gas temperature and velocity, the influence of temperature can be reduced by a special design of the protective tube.



①	Probe voltage U_p
②	Lambda air ratio
③	Lean regulation
④	Lambda control = 1

9 Voltage curve of the lambda probe at an exhaust gas temperature of 600 °C



①	Probe voltage U_p
②	Lambda air ratio
③	Rich mixture (lack of air)
④	Lean mixture (excess air)

10 Revision code

Revision history

Index	Date	Description / Revision summary	Expert *Auditor*
2	15.04.2019	GE durch INNIO ersetzt / GE replaced by INNIO	**Opoku** *Pichler R.*
1	19.08.2014	Umstellung auf CMS / Change to **C**ontent **M**anagement **S**ystem ersetzt / replaced Index: **a**	**Kecht** *Hillen*