8. SENZORI KONCENTRACIJE

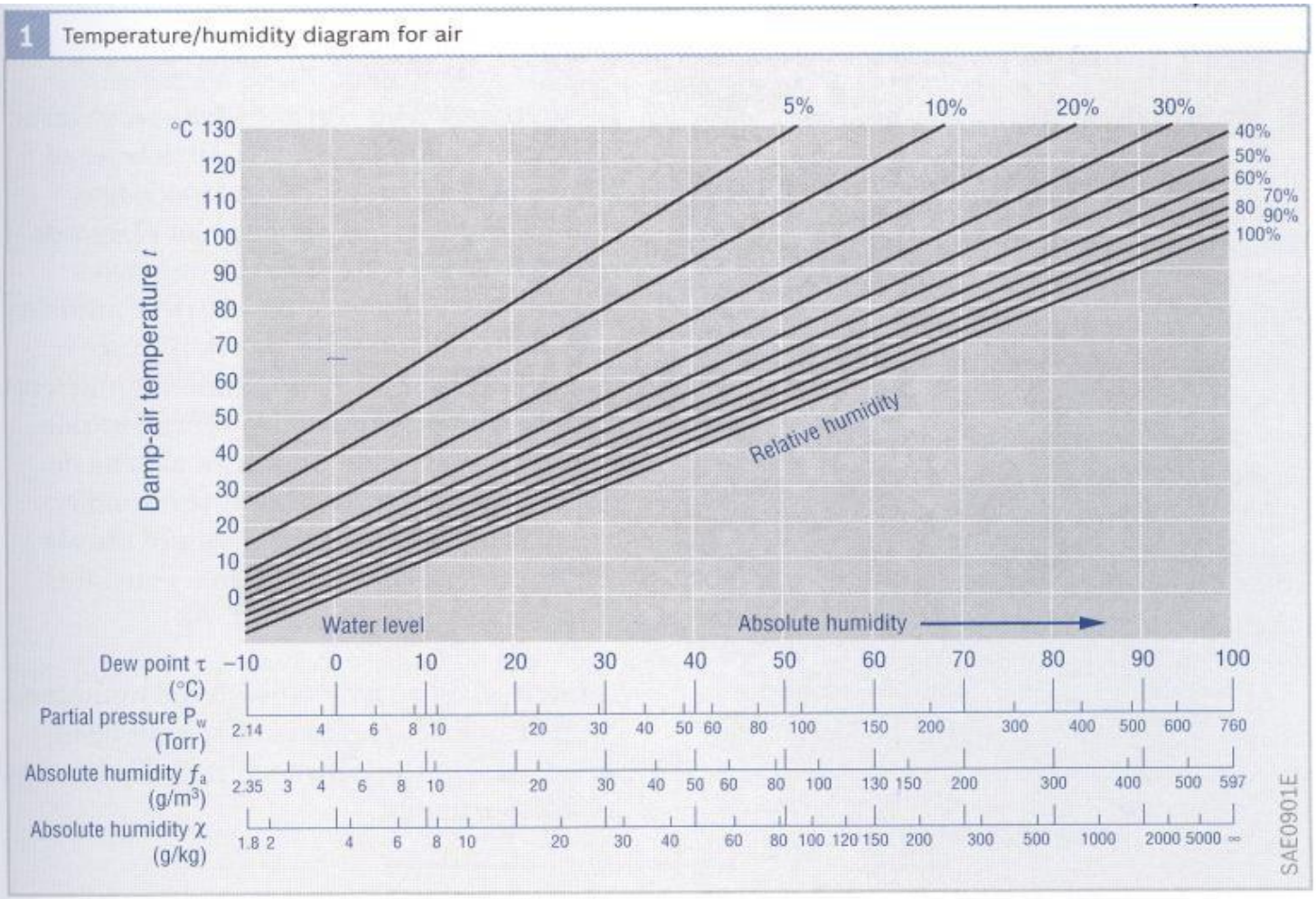
8.1. Merne promenljive i merni principi

- Koncentracija određenih hemijskih elemenata ili jedinjenja (supstanci) u fluidu (gasu) definiše masu ili procentualni udeo te supstance u hemijskom sastavu gasa.
- U idealnom slučaju, senzor koncentracije određene supstnce treba da bude osetljiv samo na prisustvo te supstancu u hemijskom sastavu gasa, što je u praksi retko ostvarivo, jer je teško isključiti uticaje ostalih komponenti.
- Senzori koncentracije su po pravilu direktno izloženi kontaminiranom uticaju štetnih supstanci tokom eksploatacije senzora, što utiče na njihovu pouzdanost (senzor viška kiseonika u izduvnim gasovima -lambda sonda, može postati potpuno neupotrebljiv usled prisutnosti olova u izduvnim gasovima iz goriva).
- U motornim vozilima, potrebno je meriti sledeće promenljive:
  - sadržaj kiseonika u izduvnim gasovima (zatvorena petlja kontrole sagorevanja, nadzor katalitičkog konvertora),
  - sadržaj ugljenmonoksida i azotnih oksida kao i vlažnost vazduha u vozilu (kvalitet vazduha, sprečavanje zamagljivanja stakala),
  - vlažnost vazduha u pneumatskim kočnim sistemima (nadzor prečistača vazduha),
  - vlažnost i temperaturu spoljnjeg vazduha (upozorenje na crni led).

1 Gas-analysis processes (without particular attention being paid to the moisture-measurement process)
(X) = for automotive applications

Physical process	Physical-chemical process		Chemical process
Thermal conductivity	Heat of reaction		Selective absorption
Magnetic processes	Heat of absorption		Selective absorption with prior chemical conversion
Radiation absorption	Characteristic color reaction		
Gas chromatography	Electrolytic conductivity	X	
Radioactive processes	Electrochemical processes	X	

1 Temperature/humidity diagram for air

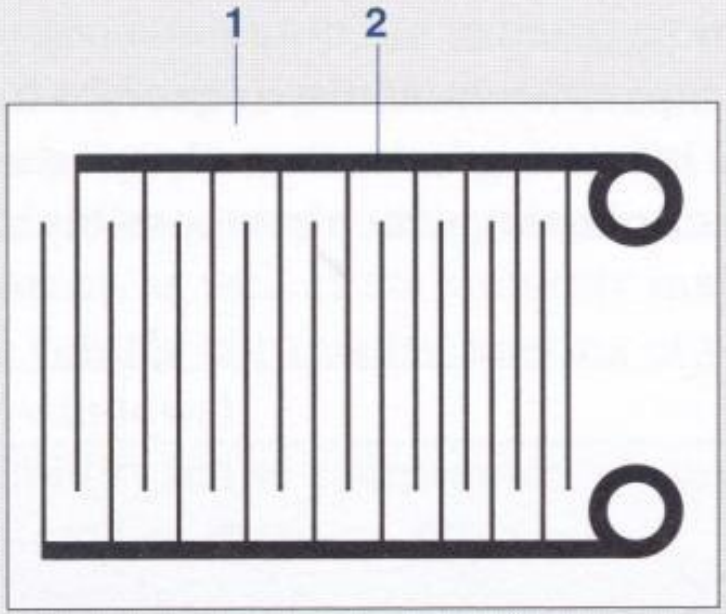


2 Humidity-measurement procedures. X = technologically important

Processes	Serial no.		Measuring device	Measuring method
Saturation processes	1	X	Dew point hygrometer	Direct methods (measurement of absolute humidity)
	2	X	LiCl dew point hygrometer	
Evaporation processes	3	X	Psychrometer	
Absorption processes	4		Volume hygrometer	
	5	X	Electrolysis hygrometer	
	6		Condensate volume hygrometer	
Energetic processes	7	X	Infrared hygrometer	
	8		Microwave hygrometer	
	9		Electrical-discharge hygrometer	
	10		Diffusion hygrometer	
Hygroscopic processes	11	X	Electrical conductive-foil hygrometer	Indirect methods (measurement of relative humidity)
	12			
	13	X	Capacitor hygrometer	
	14	X	Hair hygrometer	
	15		Bimetal strip hygrometer	
	16		Color hygrometer	
	17		Quartz hygrometer	
			Gravimetric hygrometer	

- Novije elektronske upravljačke jedinice klima sistema koje nadziru kvalitet vazduha u kabini vozila takođe imaju i senzor vlage, čiji se signal koristi zajedno sa signalima unutrašnje temperature na različitm mestima u kabini vozila, a u cilju sprečavanja zamagljivanja stakala vozila.

2 Capacitive sensor wafer with comb electrodes



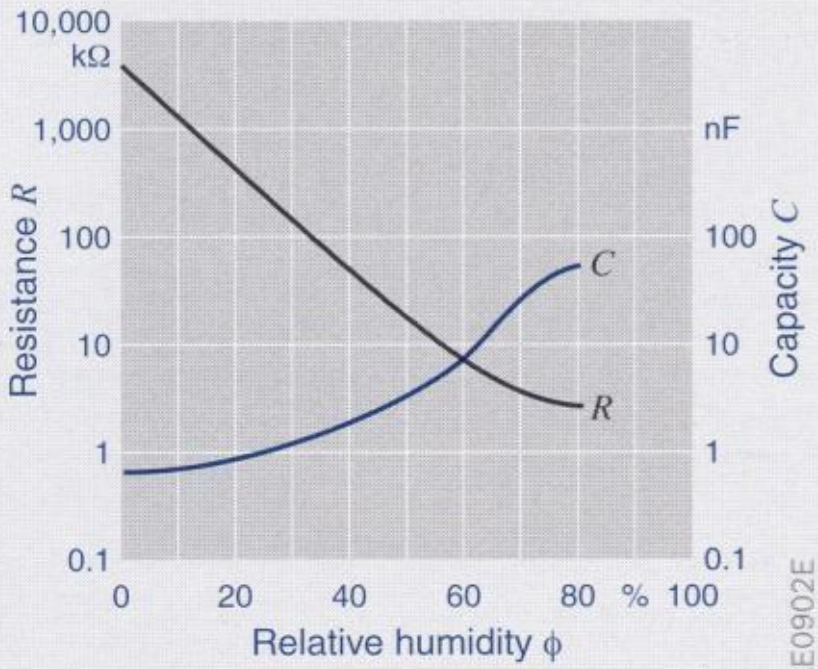
SAE0903Y

Fig. 2

1 Plastic wafer

2 Comb-like, embossed gold-foil electrodes

3 Resistive and capacitive humidity sensors (typical characteristic curve)



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- Pored otpornih senzora često se koriste i kapacitivni senzori za određivanje relativne vlažnosti.
- Senzor je konstruisan u tehnici tankog filma kao polimer sa metalnom zaštitom na obe strane.

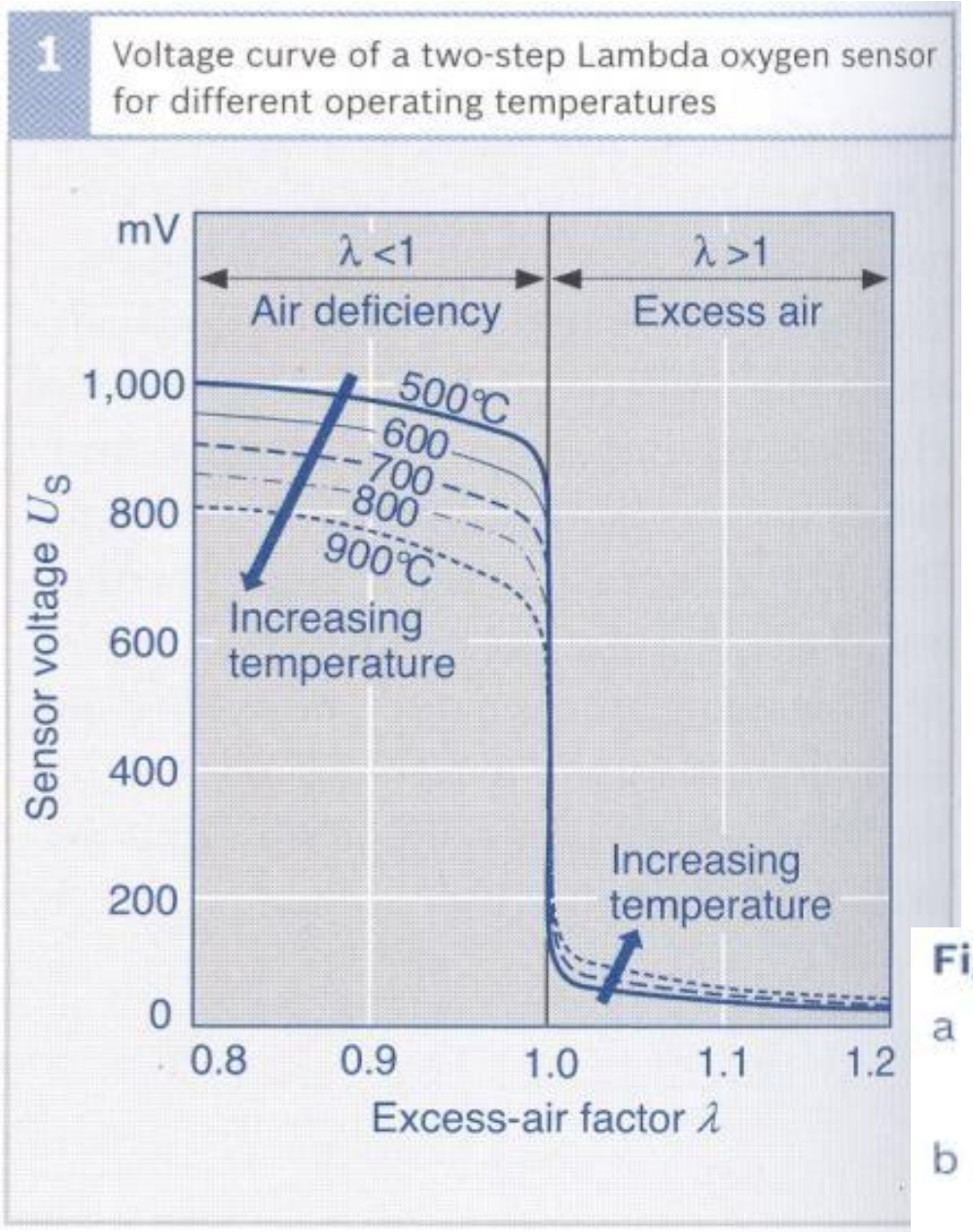
8.2. Senzor koncentracije kiseonika (lambda senzor)

- Elektronska upravljačka jedinica za upravljanje radom motora vrši proračun (određuje) potrebnu količinu ubrizganog goriva, između ostalog i prema sadržaju kiseonika u izduvnim gasovima, određenog pomoću lambda senzora, a u cilju ostvarenja sastava smeše vazduha i goriva kako bi se postigla stehiometrijska smeše (λ=1).
- Galvanski napon (Nernstov napon) lambda sonde je:

$$U_S = \frac{R\,T}{4F} ln \frac{p^{v}_{O_2}}{p^{ig}_{O_2}}$$

gde je:

p^{v}_{O2} - parcijalni pritisci kiseonika u vazduhu
p^{ig}_{O2} - parcijalni pritisci kiseonika u izduvnom gasu
R – gasna konstanta
T – apsolutna temperatura
F - Faradejeva konstanta

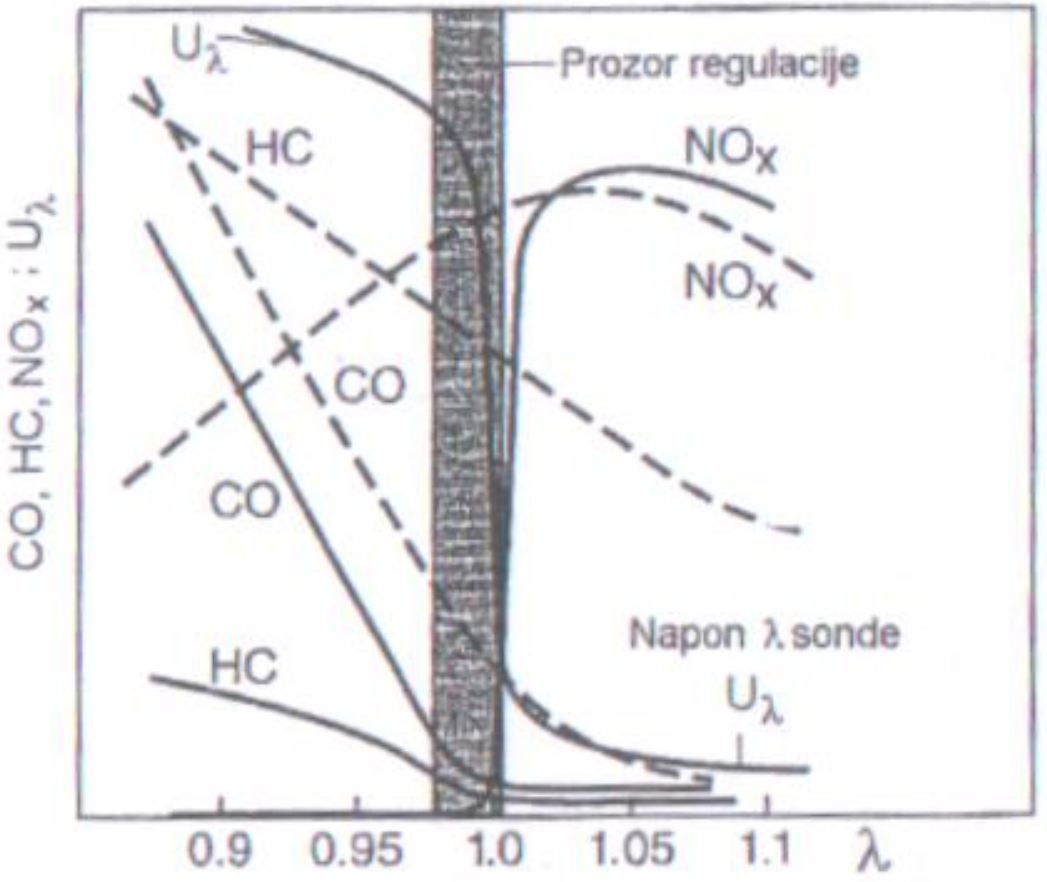


- Izlazna karakteristika dvostepene lambda sonde specifična je po tome što se napon naglo menja pri λ=1.
- Ovaj senzor kiseonika, često predstavljen kao Nernstova ćelija, može da radi na principu pumpe,
- Kada se napon dovede na njega, ćelija transportuje jone kiseonika u smeru manjeg napona, što predstavlja osnovni princip rada LSU širokopojasne lambda sonde.

Fig. 1

a Rich mixture (air deficiency)

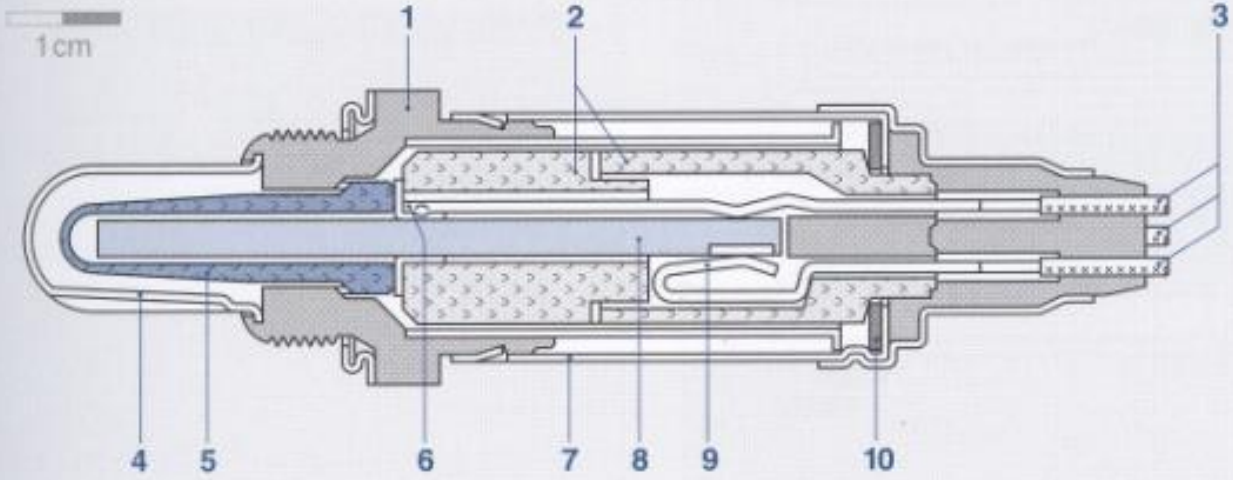
b Lean mixture (excess air)



Sl.1.117-Efikasnost 3-komp. katalizatora u funkciji sastava smeše.
— — — pre 3-komp. katalizatora
——— posle 3-komp. katalizatora

2 LSH25 heated finger-type Lambda oxygen sensor (view and section)

UMK1450Y



UMK0143Y

Fig. 2

1 Sensor housing
2 Ceramic support tube
3 Connecting cable
4 Protective tube with slots
5 Active sensor ceramic
6 Contact element
7 Protective sleeve
8 Heater element
9 Clamp-type connections for the heater element
10 Disk spring

3 Configuration of a finger-type Lambda oxygen sensor in the exhaust pipe

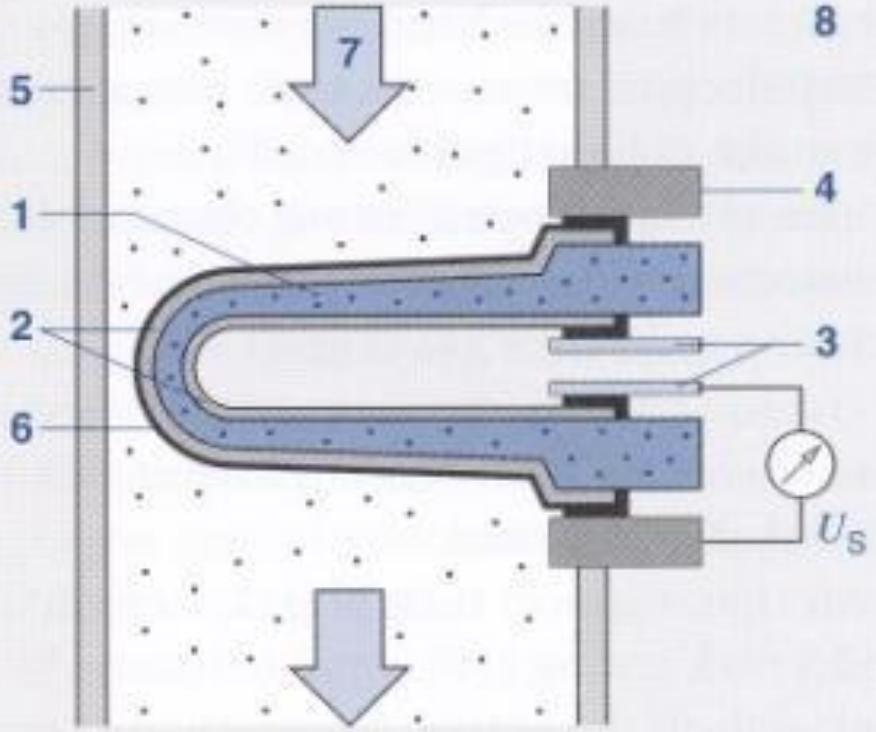


Fig. 3

1 Sensor ceramic element
2 Electrodes
3 Contacts
4 Housing contact
5 Exhaust pipe
6 Ceramic protective layer (porous)
7 Exhaust gas
8 Outside air
U_S Sensor voltage

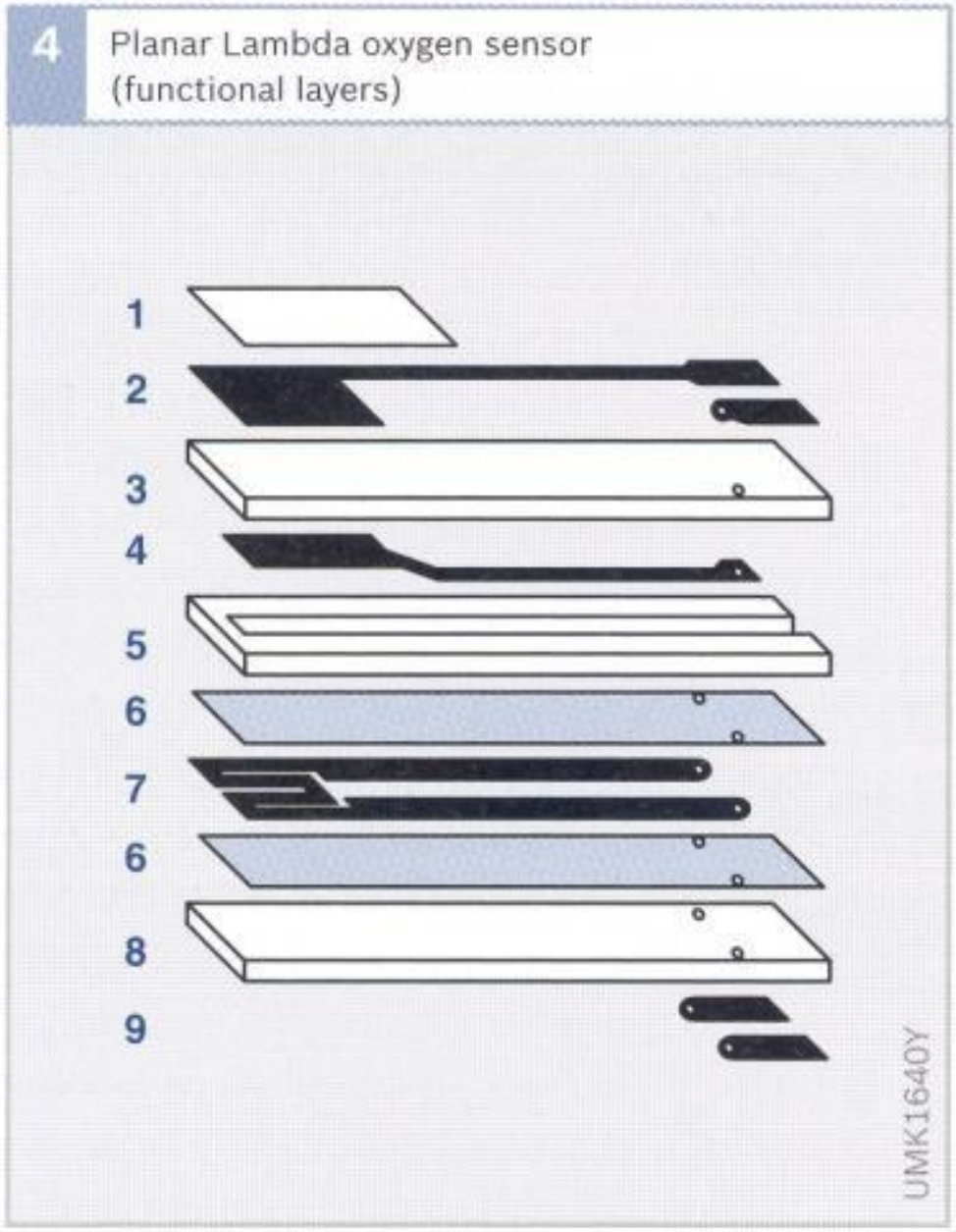


Fig. 4

1 Porous protective layer
2 Outer electrode
3 Sensor foil
4 Inner electrode
5 Reference-air-channel foil
6 Insulation layer
7 Heater
8 Heater foil
9 Connection contacts

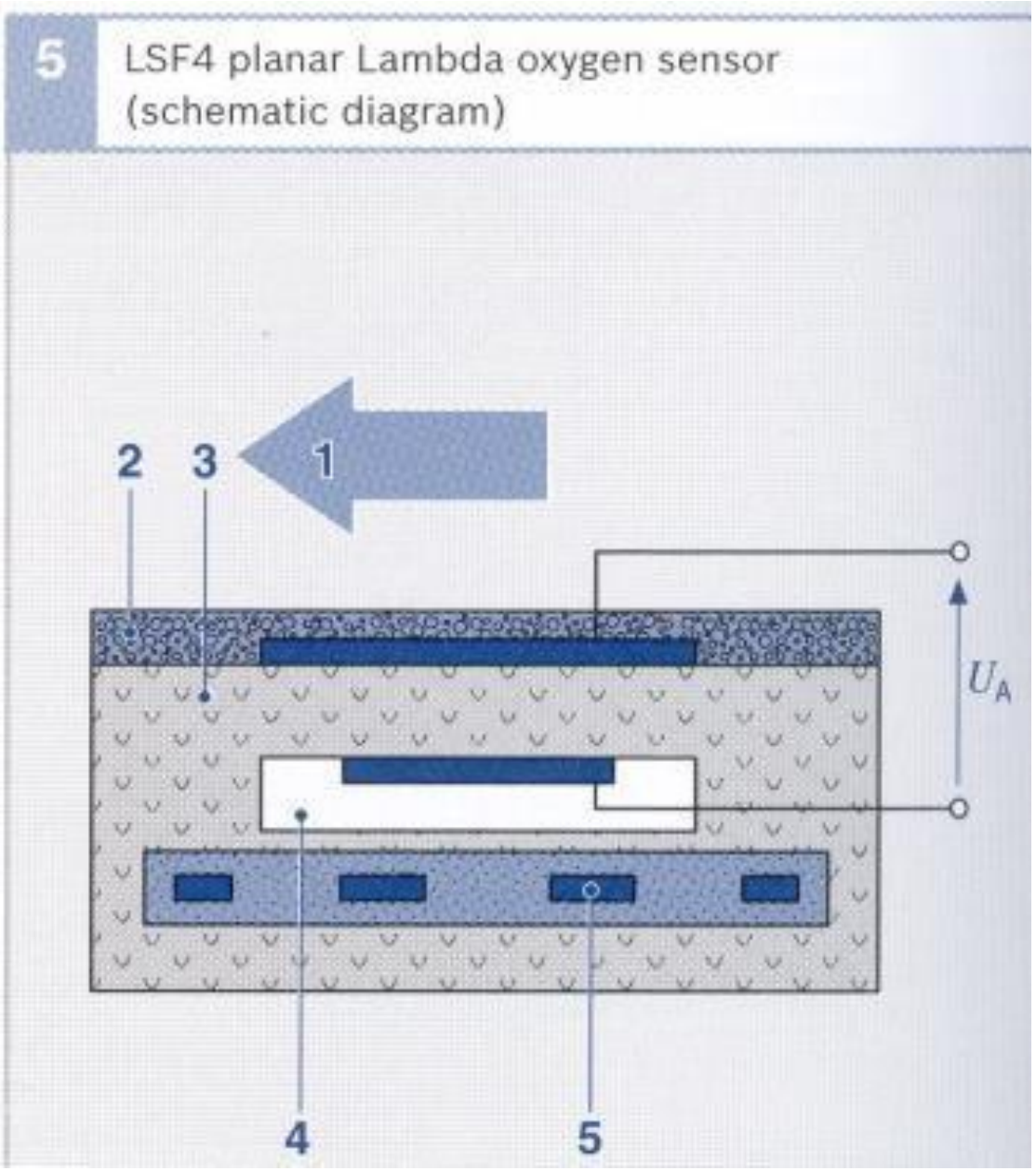


Fig. 5

1 Exhaust gas
2 Porous ceramic protective layer
3 Measuring cell with microporous noble-metal layer
4 Reference-air channel
5 Heater
U_A Output voltage

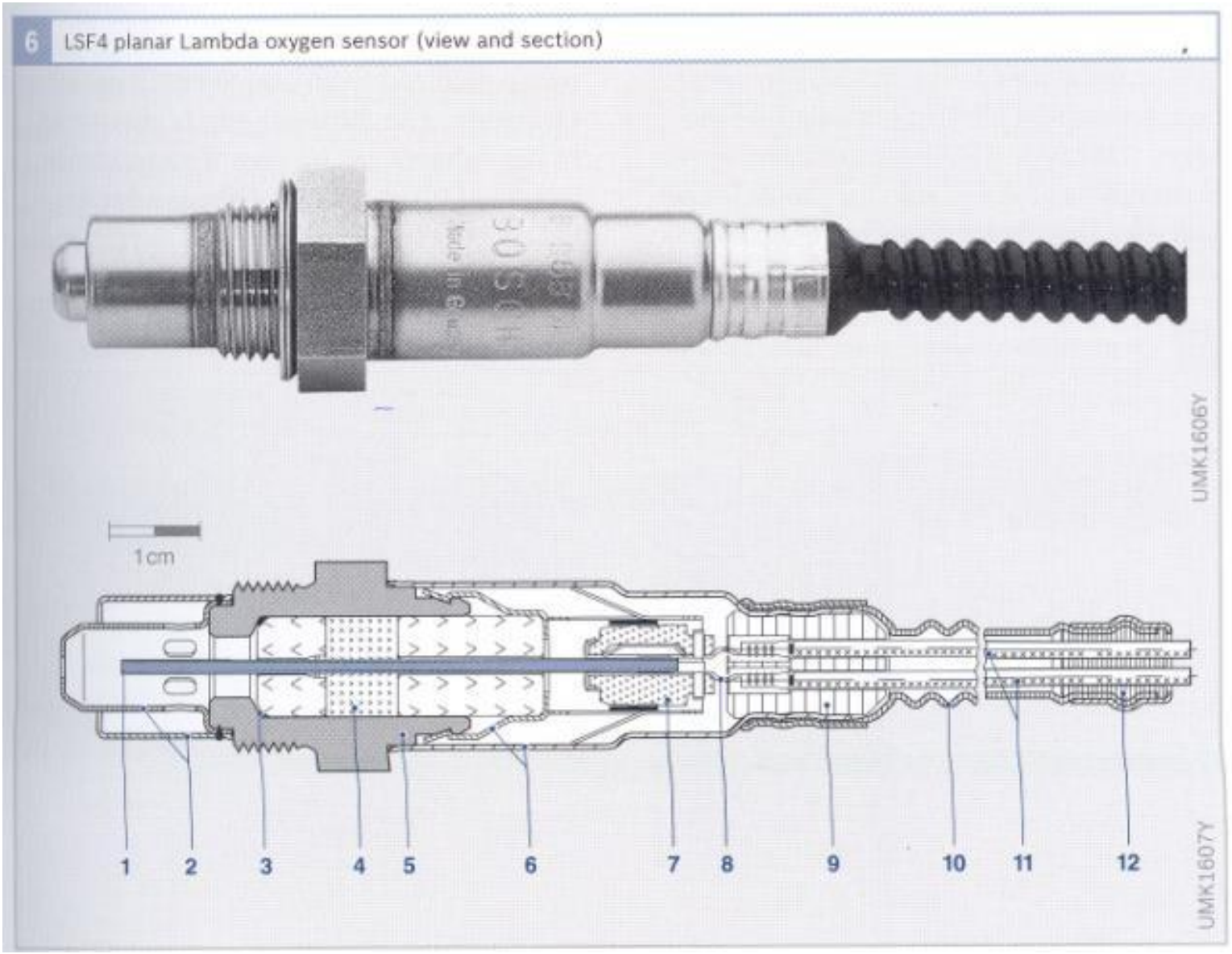


Fig. 6

1 Planar measuring cell
2 Double protective tube
3 Sealing ring
4 Seal packing
5 Sensor housing
6 Protective sleeve
7 Contact holder
8 Contact clip
9 PTFE grommet
10 PTFE shaped sleeve
11 Five connection cables
12 Seal

1 Planar wide-band Lambda oxygen sensor (schematic design of the measuring cell and installation in the exhaust pipe)

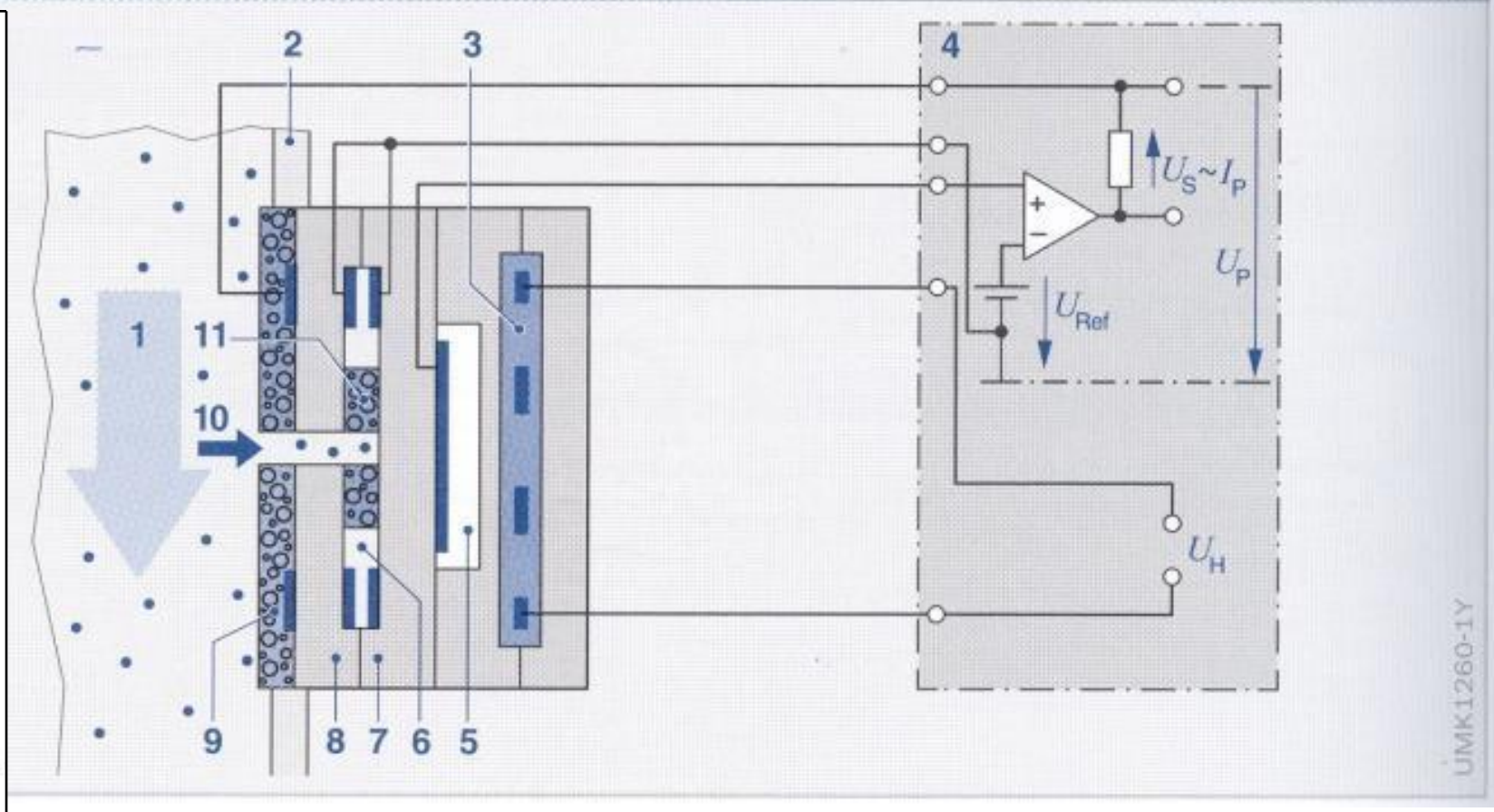


Fig. 1

1 Exhaust gas
2 Exhaust pipe
3 Heater
4 Control electronics
5 Reference cell with reference-air channel
6 Diffusion gap
7 Nernst concentration cell with Nernst measuring electrode (on the diffusion-gap side) and reference electrodes (on the reference-cell side)
8 Oxygen-pump cell with pump electrode
9 Porous protective layer
10 Gas-access passage
11 Porous diffusion barrier

I_P Pump current
U_P Pump voltage
U_H Heating voltage
U_{Ref} Reference voltage (450 mV, corresponds to $\lambda = 1$)
U_S Sensor voltage

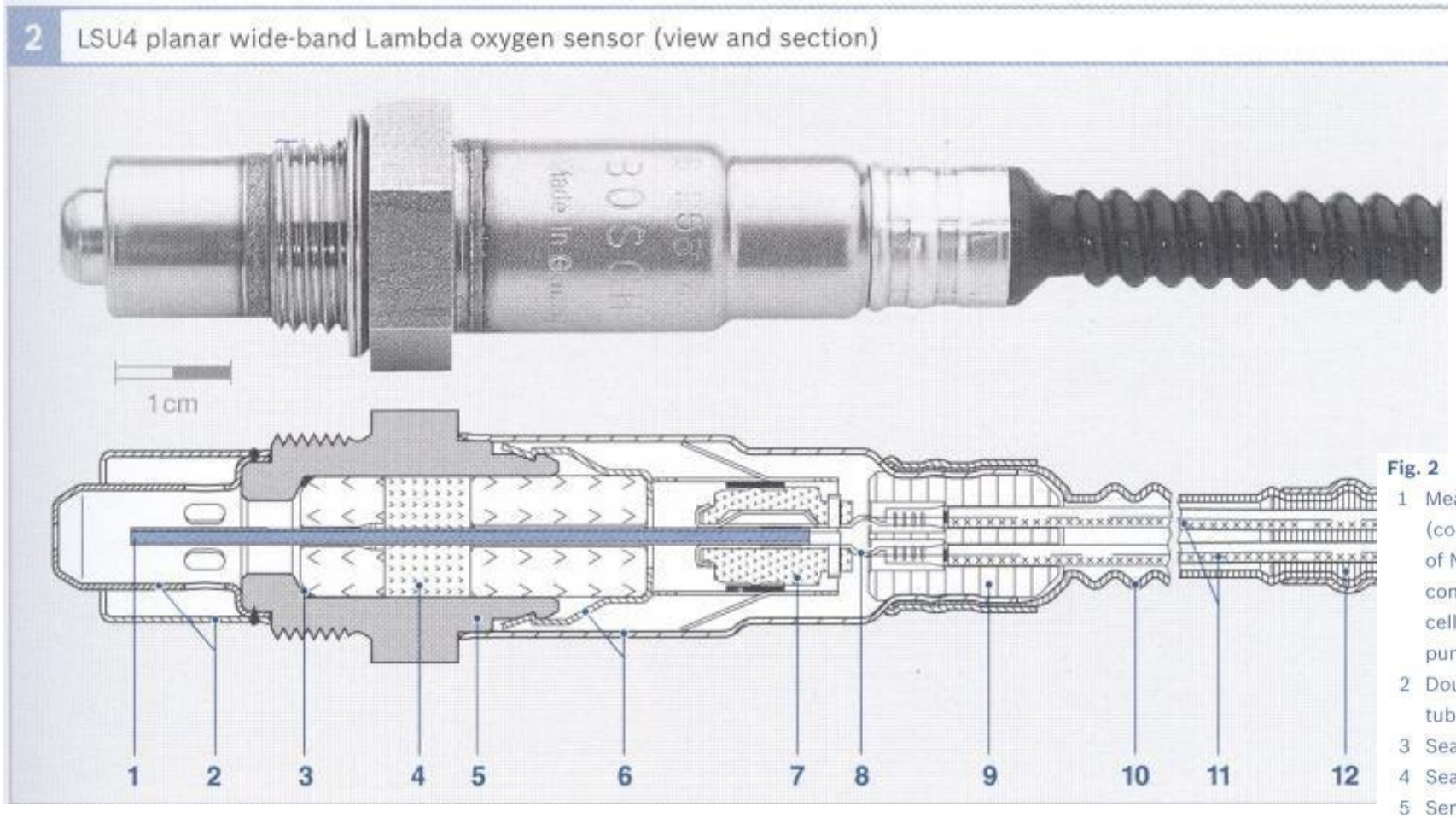
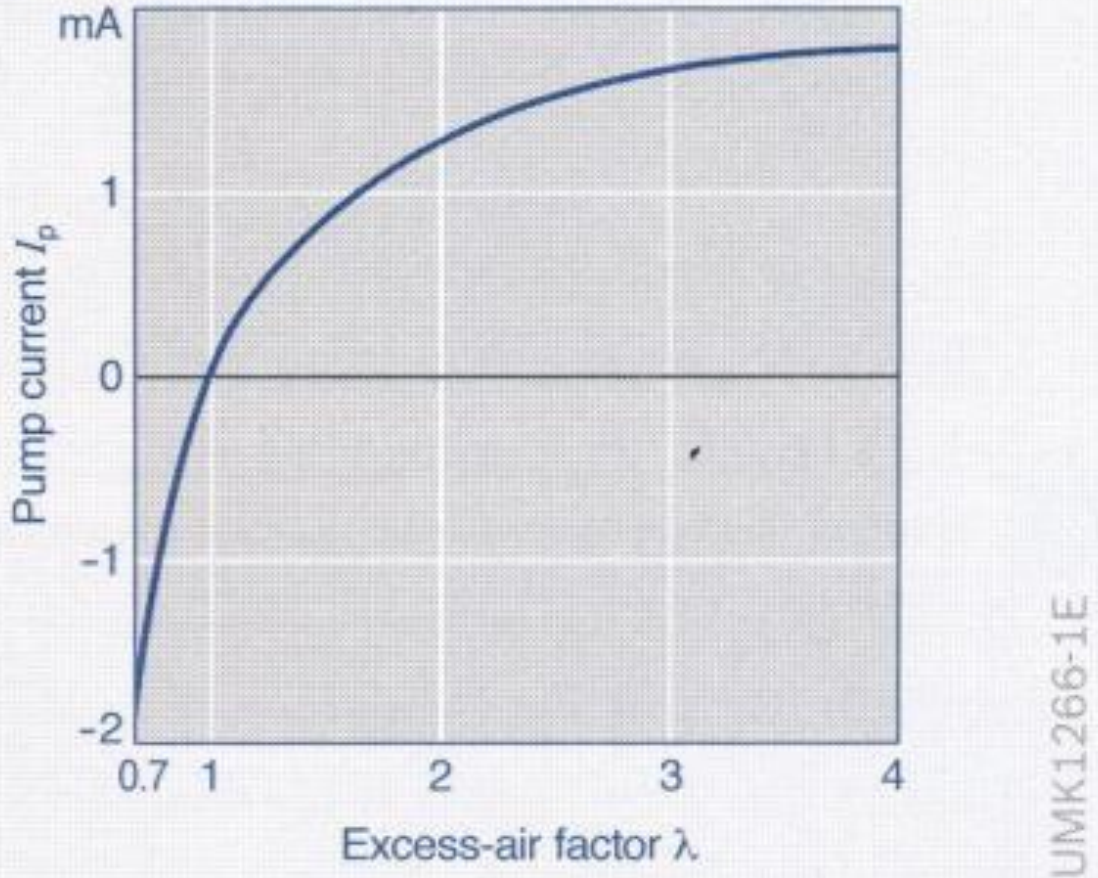


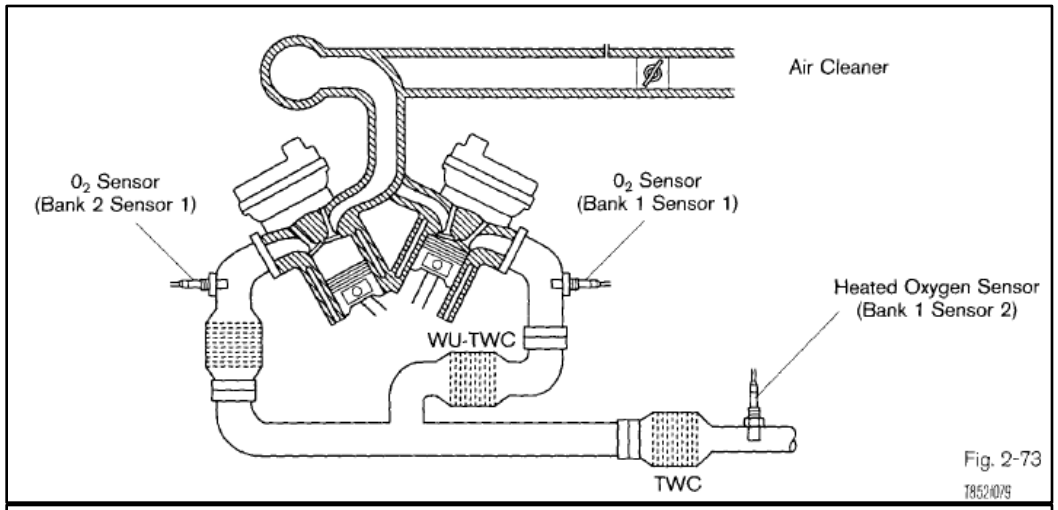
Fig. 2

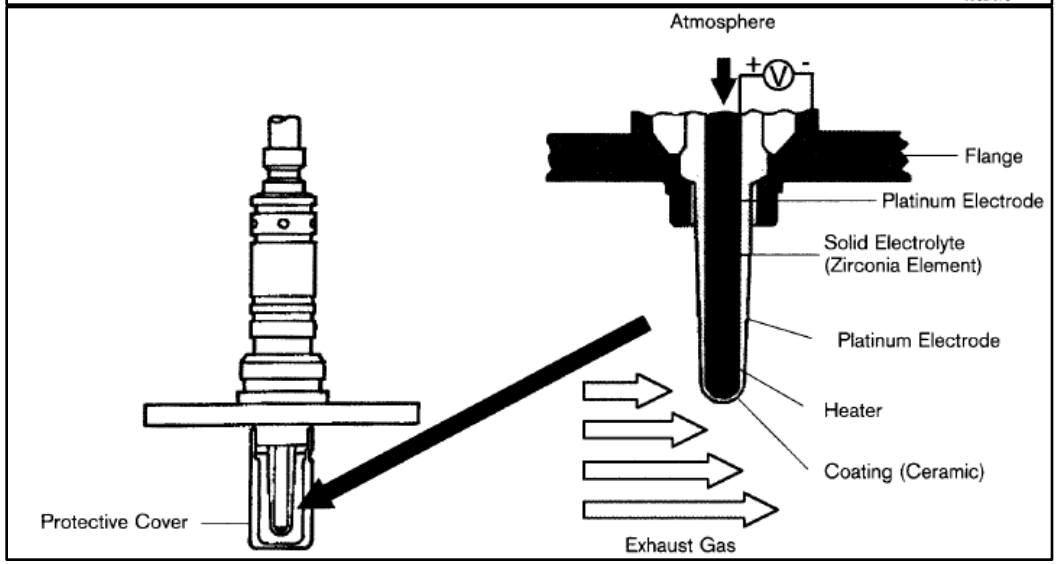
1 Measuring cell (combination of Nernst concentration cell and oxygen-pump cell)
2 Double protective tube
3 Sealing ring
4 Seal packing
5 Sensor housing
6 Protective sleeve
7 Contact holder
8 Contact clip
9 PTFE grommet
10 PTFE shaped sleeve
11 Five connecting cables
12 Seal

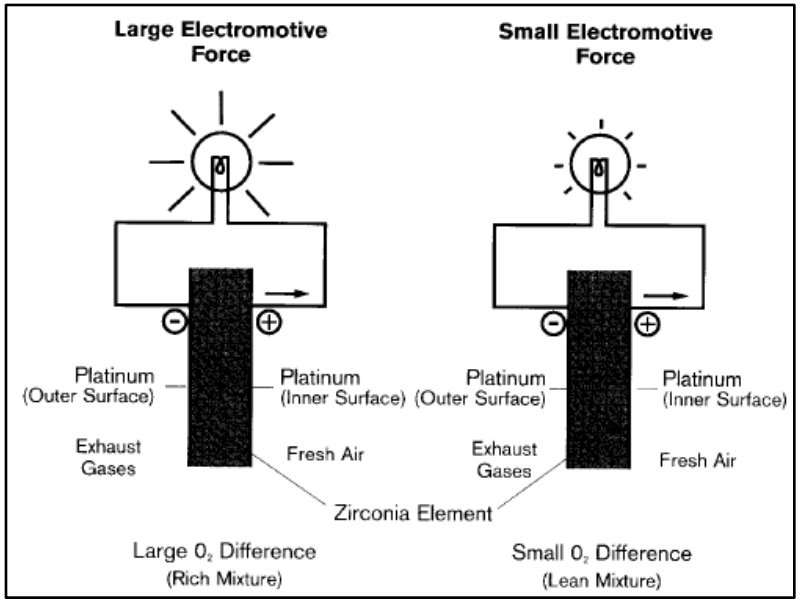
3 Pump current I_P of a wide-band Lambda oxygen sensor as a function of the excess-air factor λ of the exhaust gas

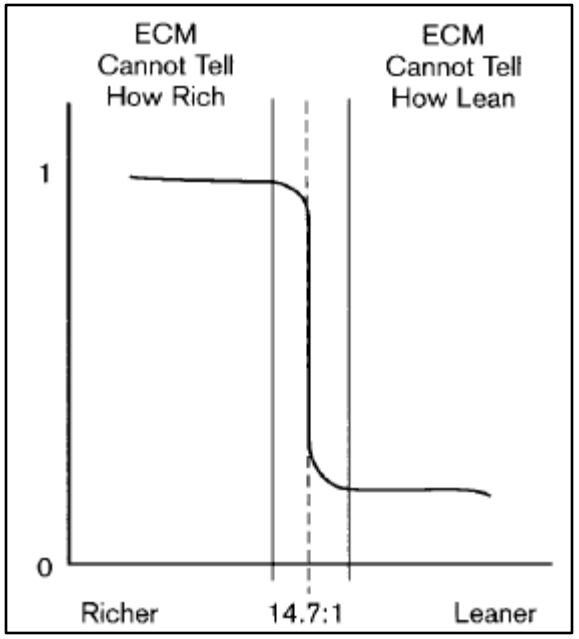


SENZORI I AKTUATORI



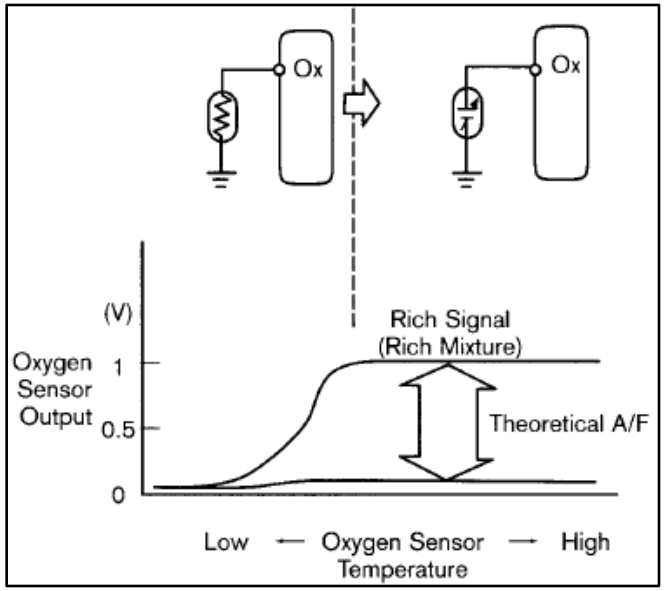


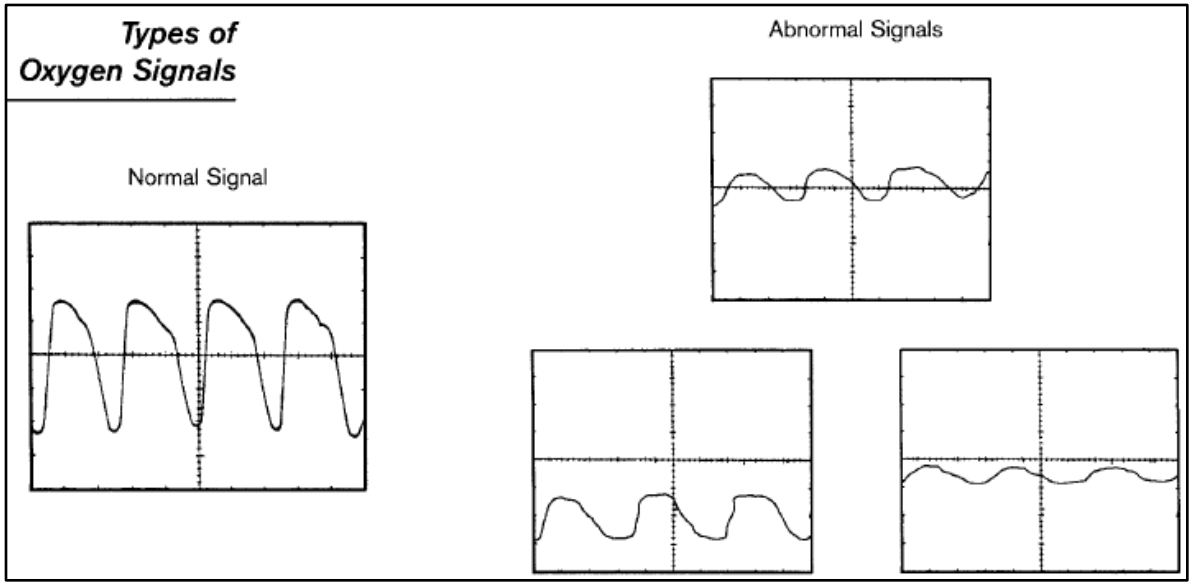


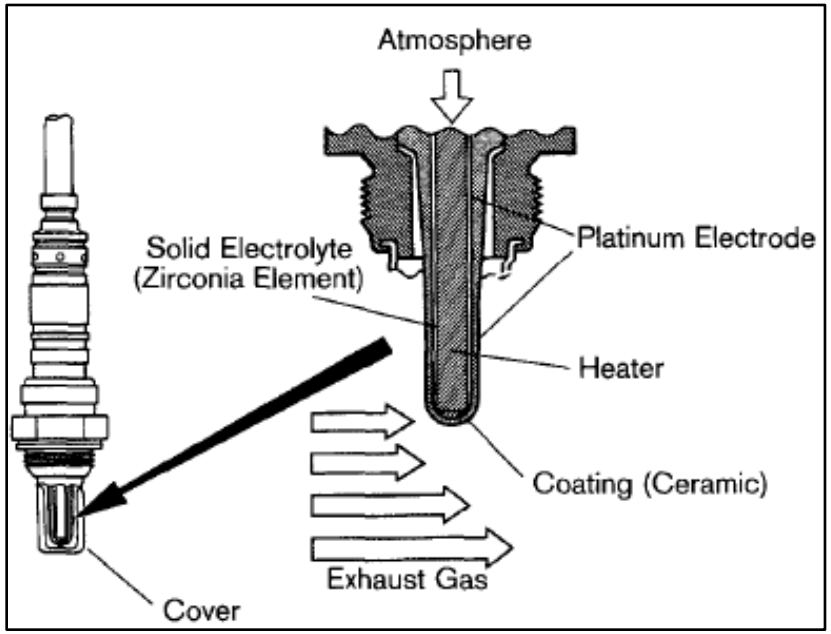


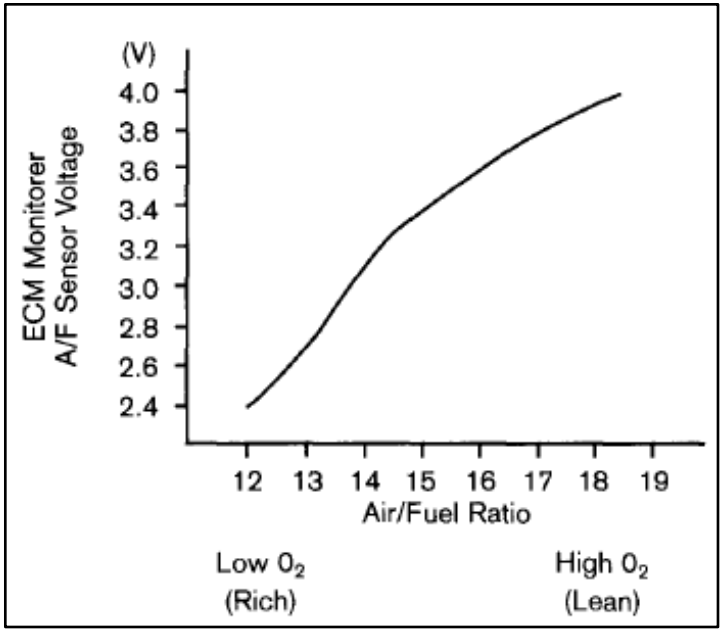
Exhaust Oxygen Content	Oxygen Sensor Output	Air/Fuel Ratio Judged To Be
Low →	High, Above 0.45 volts →	Rich
High →	Low, Below 0.45 volts →	Lean

SENZORI I AKTUATORI

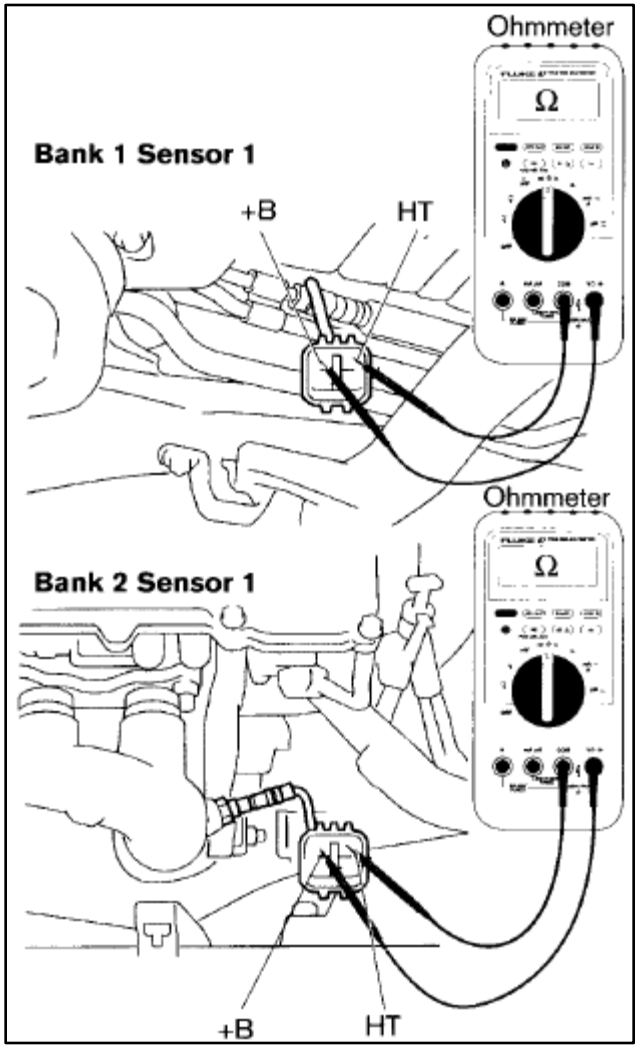


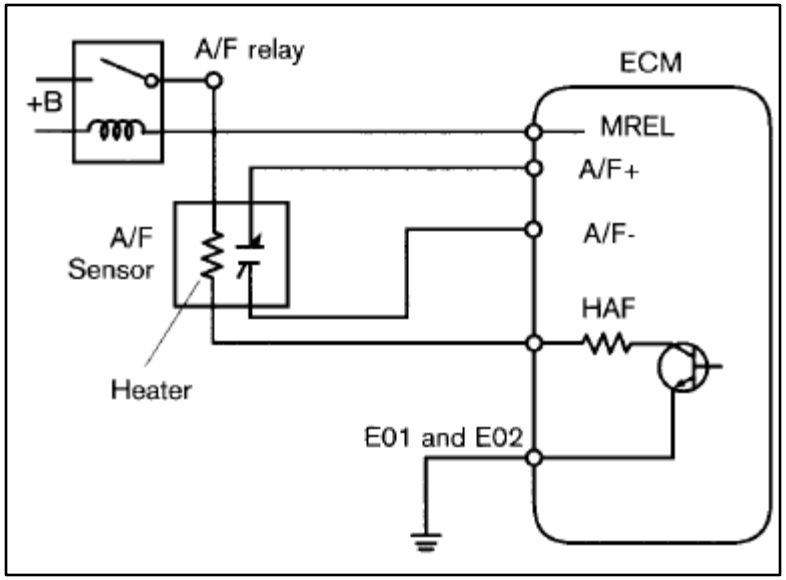


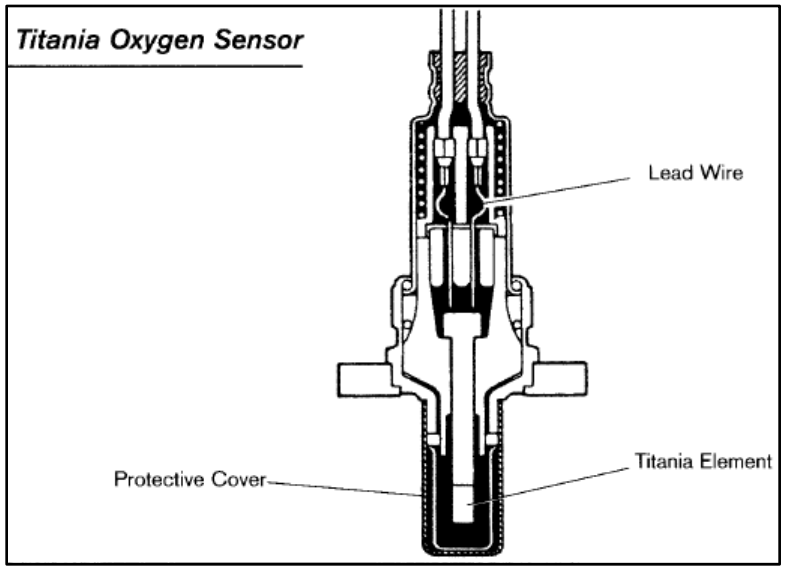


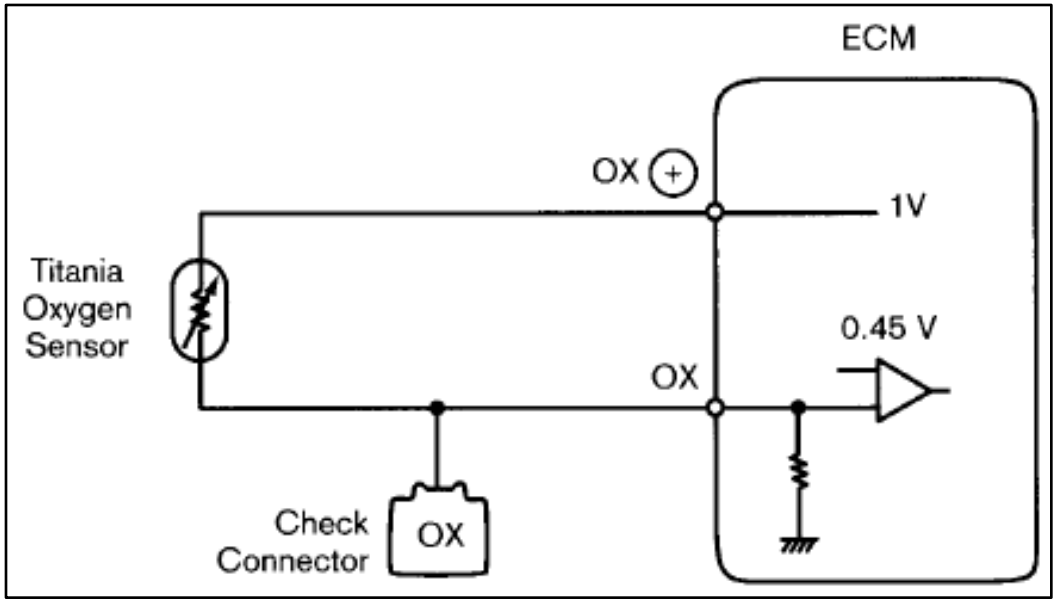


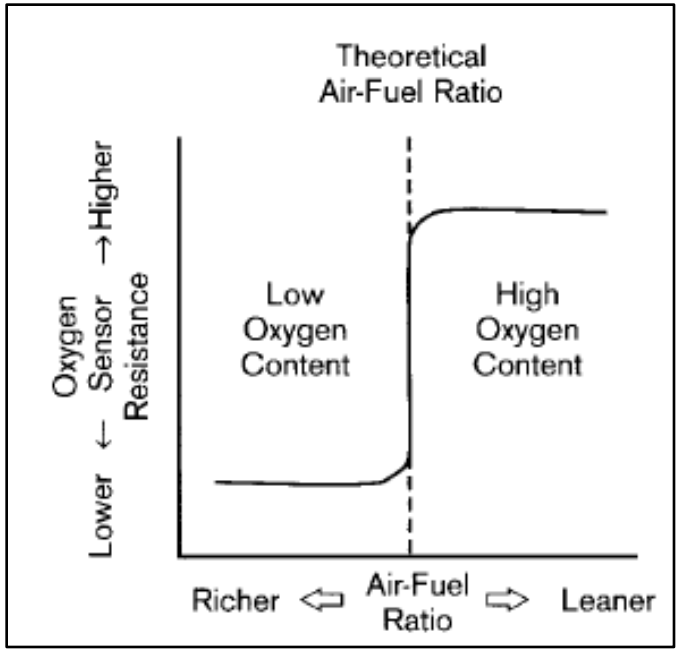
Ispitivanje senzora






Titania Oxygen Sensor
Lead Wire
Protective Cover
Titania Element


ECM
OX
1V
Titania
Oxygen
Sensor
0.45 V
OX
Check
Connector
OX


Theoretical
Air-Fuel Ratio
Oxygen Sensor Resistance
Higher
Lower
Low
Oxygen
Content
High
Oxygen
Content
Richer
Air-Fuel
Ratio
Leaner

Lambda oxygen sensor, type LSM 11

Measurement of oxygen content

U_s Sensor voltage
U_H Heater voltage
ϑ_a Exhaust-gas temperature
λ Excess-air factor
O_2 Oxygen concentration in %

Technical data

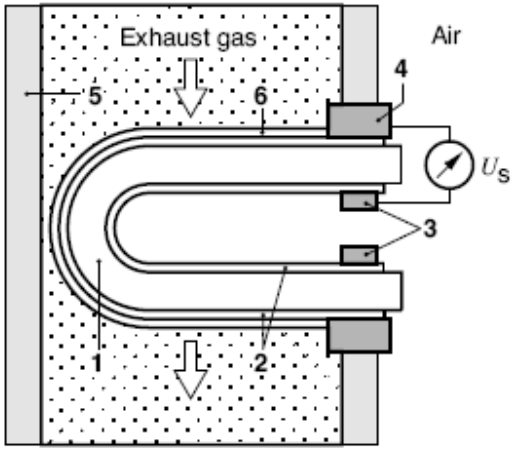
Usage conditions

Passive temperature range (storage temperature range)	-40 ... 100 °C
Sustained exhaust-gas temperature with heating on	+ 150 °C ...+ 600 °C
Maximum permissible exhaust-gas temperature with heating on (200 h cumulative)	+ 800 °C
Operating temperature at hexagon end of sensor housing	≤ 500 °C
Operating temperature at cable gland	≤ 200 °C
Operating temperature at connecting cable	≤ 150 °C
Operating temperature at connector	≤ 120 °C
Temperature gradient on front side of sensor ceramic element	≤ 100 K/s
Temperature gradient at hexagon end of sensor housing	≤ 150 K/s
Permissible vibration at hexagon end - stochastic vibration - max. acceleration	≤ 800 m/s²
Permissible vibration at hexagon end - sinusoidal vibration - amplitude	≤ 0,3 mm
Permissible vibration at hexagon end - sinusoidal vibration - acceleration	≤ 300 m/s²
Max. load current	± 20 µA

Heating element

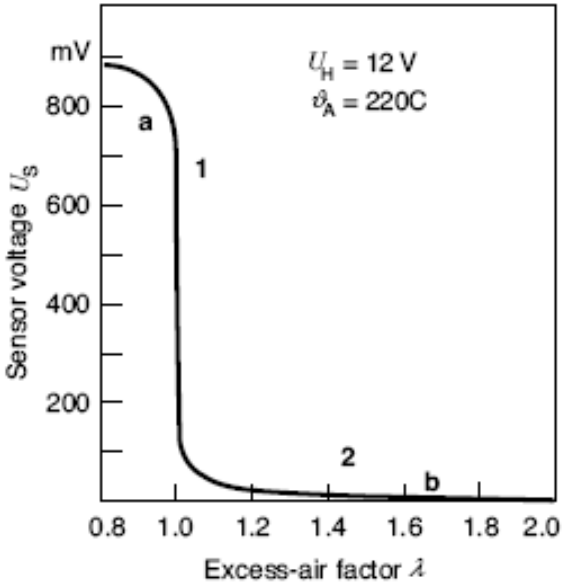
Rated supply voltage (preferably AC voltage) U_N	12 V_{eff}
Operating voltage U_V	12 ... 13 V
Heat output for ϑ_{Gas} = 350 °C and exhaust-gas flow velocity of ≈ 0.7 m/s at 12 V heating voltage in steady state	≈ 16 W
Heating current at 12 V in steady state	≈ 1,25 A
Insulation resistance between heating and sensor connection	> 30 MΩ

Lambda oxygen sensor in exhaust pipe (block diagram)



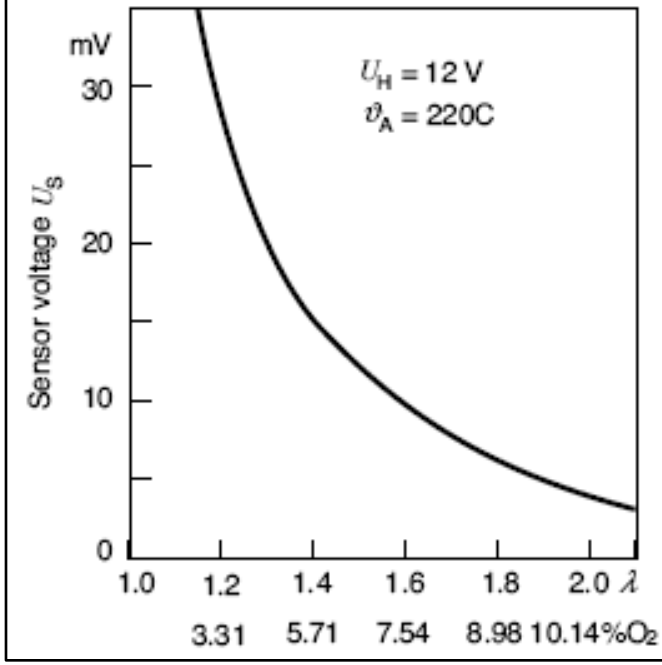
1 Sensor ceramic, 2 Electrodes, 3 Contact, 4 Housing contacts, 5 Exhaust pipe, 6 Ceramic protective layer (porous)

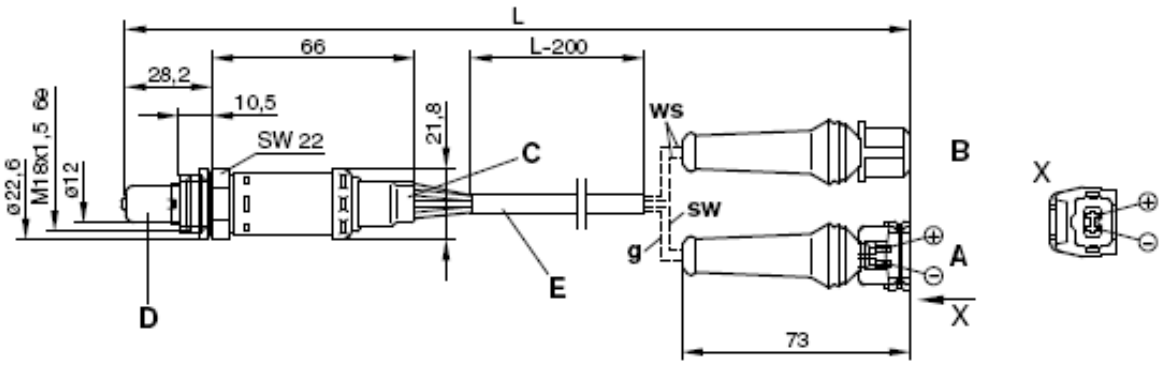
Characteristic curve for full range



1 Control λ = 1; 2 Lean control
a Rich mixture, b Lean mixture.

Characteristic curve for pro-pane-gas operation (lean range)





A	Signal voltage
B	Heating voltage
C	Cable grommet and seals
D	Conduit
E	Sheath
ws	White
sw	Black
g	Grey
L	Total length

0 258 104 002