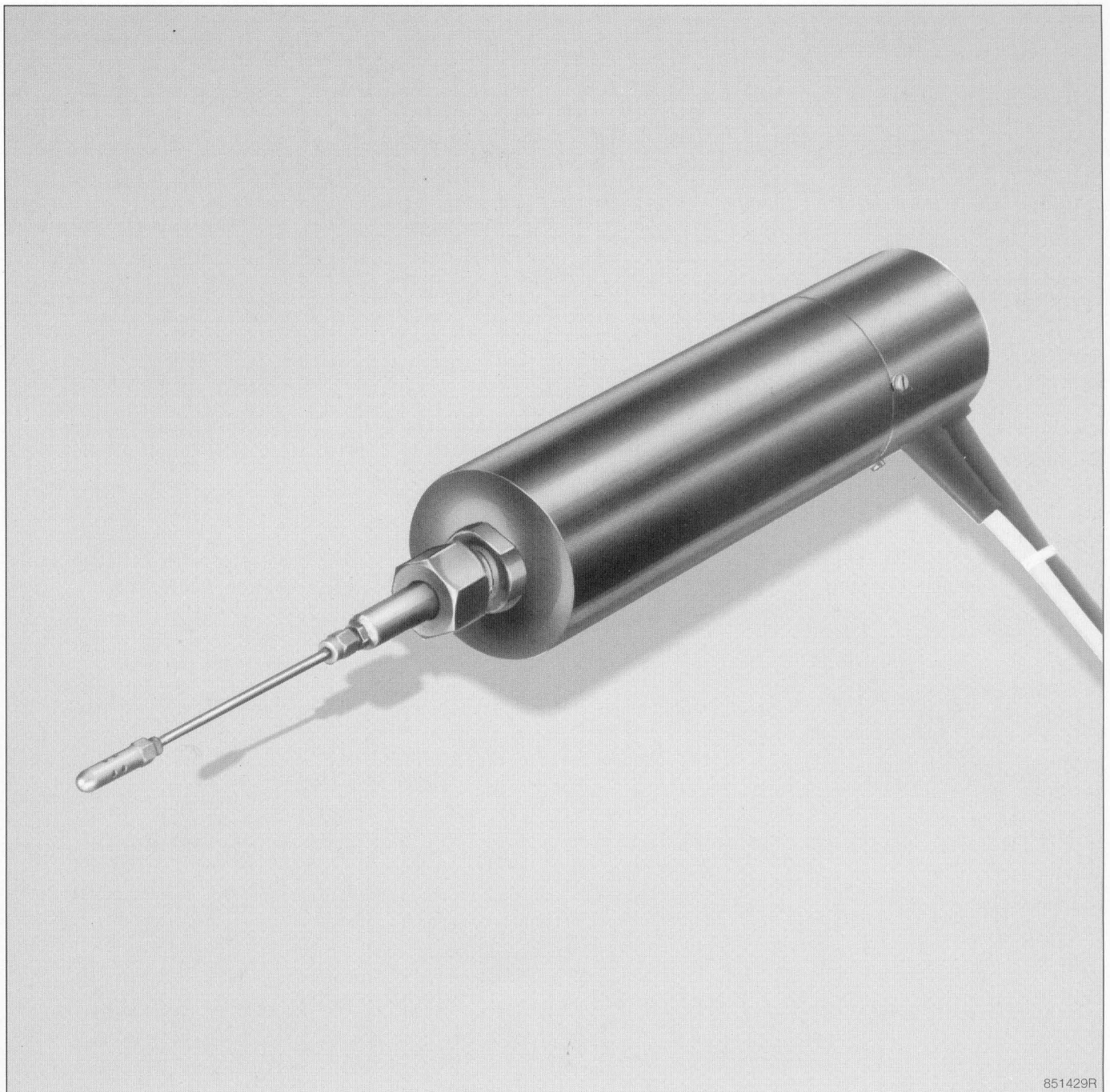


Application
Function
● Technical Data

Lambda Probe LS 1
O₂-Current Mode Sensor
Zirconium Dioxide Cell



851429R

● **Sensor Technology and Systems
for combustion Processes**



Lambda Probe LS 1 "System ABB"

Zirconium dioxide current mode probe for continuous measuring of oxygen concentration in exhaust gases, industrial flue gases and oven atmospheres in the range of $\lambda > 1$ (overstoichiometric range) without special gas conditioning. The LAMTEC Lambda control system is a combination of O₂-probe LS 1,

control unit LR 1 and power supply LP 1 and optimizes combustion processes due to O₂-contents in exhaust gases.

For measurement and registration the LAMTEC O₂-Analyzer LU 2, the LAMBDA-Transmitter LT 1 or the O₂-Tester LM 4 are available.

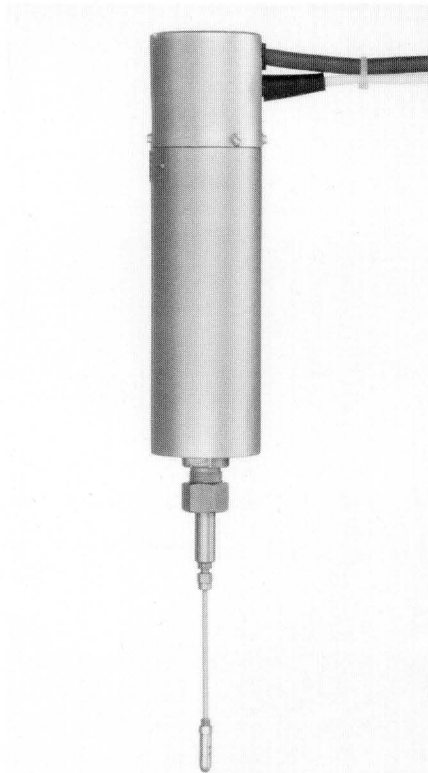
Construction and Operation

The LAMTEC O₂-probe is made basically of a single-end closed solidstate electrolytic tube of zirconium dioxide. Its inner and outer surface consists of porous precious metal layers for electrodes. The zirconium dioxide solid-state electrolyte is doped with yttrium oxide or other rare earths oxides in order to achieve in its crystal lattice O₂-vacancy formations and thereby oxygen ion conductivity which is increasing exponentially with temperature.

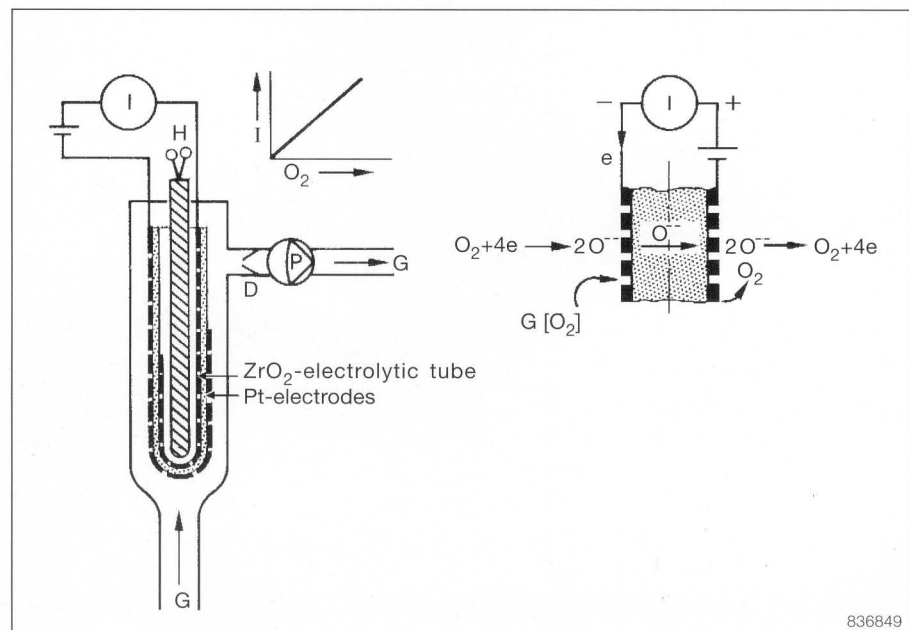
The zirconium dioxide cell is equipped with an internal electric heater and surrounded by a tubing of quartz glass. Between cell and tubing a constant gas flue is sustained by means of a diaphragm pump and a critical nozzle.

The oxygen concentration in the flue is determined by applying a DC voltage of 0,4 to 1,0 V at operating

temperature ($T \geq 650^\circ \text{C}$) to the zirconium dioxide cell and measuring with a milliammeter the oxygen ion current flowing through the solid-state electrolyte. The total amount of oxygen in the probe gas is ionized by the DC voltage applied to the negative outer electrode. The negative oxygen ions are transferred to the positive inner electrode and discharged to molecular oxygen. The ion current, measured as sensor current, depends linearly on the oxygen-concentration and the amount of probe gas per time unit. The diaphragm pump keeps the probe gas flow constant by means of a critical nozzle. Therewith the oxygen concentration is directly proportional to the ion current. The proportionality factor and the through put rate of the critical nozzle can be determined by calibration with a gas of a known oxygen concentration (e.g. air with 20,96 % of O₂). The charac-



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Figure: Principle and function of the LAMTEC O₂-probe

- I = Oxygen content-dependent current
- H = Electric heater
- G = Flue gas
- D = Critical nozzle
- P = Diaphragm pump

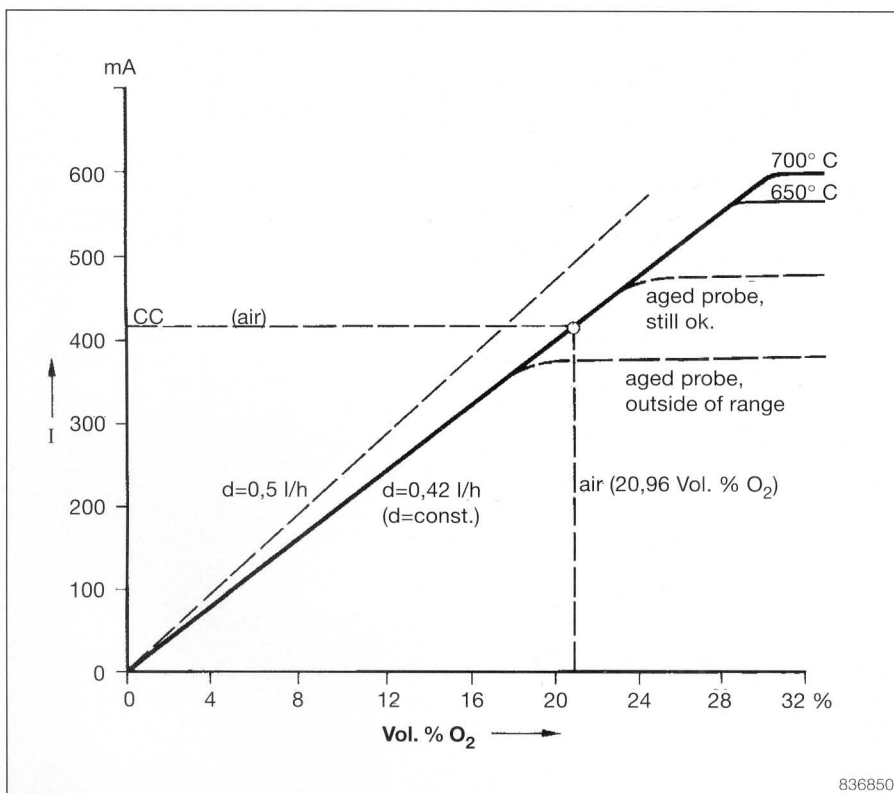


Figure: Characteristic and calibration diagram of the oxygen probe depicting the influence of temperature and aging as well as gas flow on the characteristic line.

- I = Oxygen content-dependent current
- CC = Calibration current (air equivalent; $I_{Air} \sim 21 \text{ Vol. \% O}_2$)
- d = Probe-gas-flow constant

teristic of probe current versus O_2 -concentration varies also slightly as shown in the calibration diagram. To measure the oxygen the knowledge of the flow rate and/or the factor of proportionality is not required. It is sufficient to correlate the known oxygen concentration of air (20,96 %) to the measured probe current and to draw a line through 21 % to zero point. This means in praxis that the calibration of the O_2 -measuring system is done by scaling the gain-factor from the analog input amplifier which scales the measured air value to 20,96 respectively to 21 Vol. % of the indicating instrument's linear oxygen scale, in order to get a linear response over the whole range.

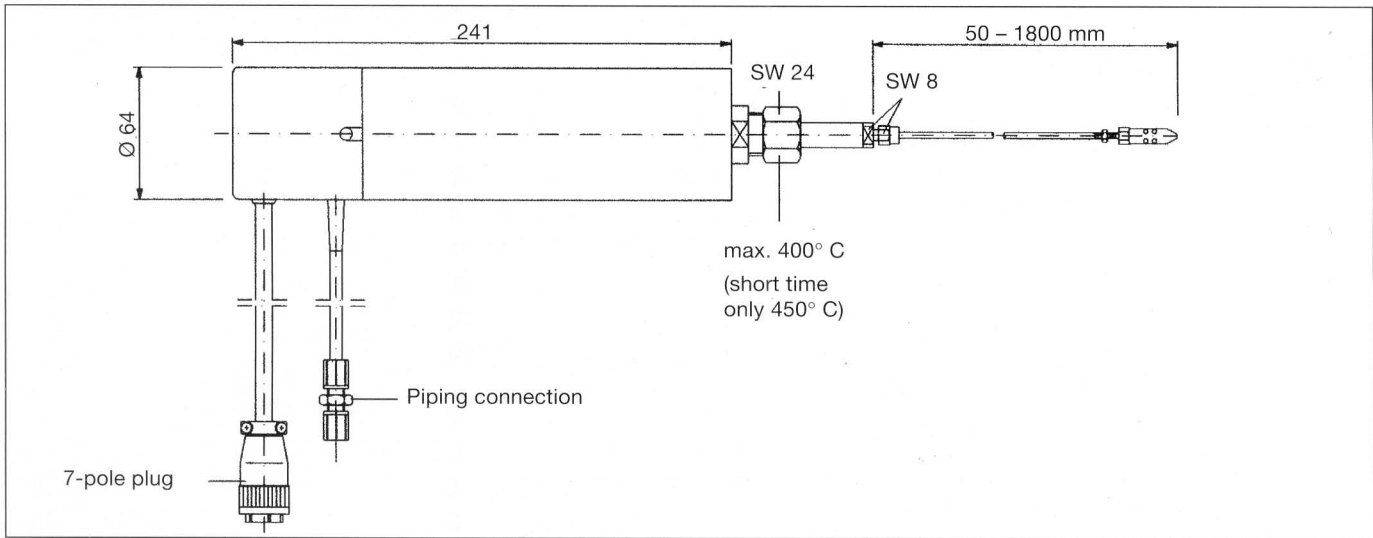
The linear characteristic of the probe-provided the cell construction and voltage are applicable – only depends on the gas flow which determines the slope of straight calibration line (see diagram).

The sensor temperature has no influence on the probe current in the linear range, but it rules the inner impedance and so limits the saturation current, in other words, the measuring range of oxygen concentration.

In so far the sensor temperature has not to be controlled, but only kept above a critical level, depending on the required measuring range.

For example: A measuring range up to 21 % O_2 requires a minimum temperature of about 650° C. The

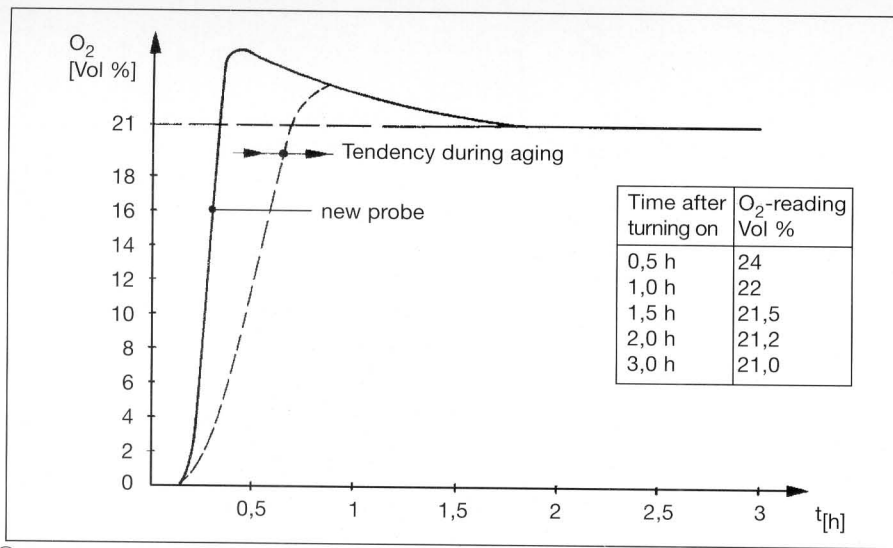
shown static characteristic of the probe $I = f(O_2)$ demonstrates, that the accuracy of measurement is remarkably constant regardless of temperature or the O_2 concentration. If considerable variations of the temperature of the critical nozzle are avoided and a current proportional voltage is applied to the sensor, an accuracy of $\pm 0.1 \text{ Vol. \% O}_2$ will be obtained. Aging of the sensor does not affect the accuracy, yet limits the range of measurement. For the possibility of calibrating air, the saturation must be kept above an equivalent current of 21 Vol. % O_2 .



Specifications

Sensor element:	Zirconium dioxide
Operation principle:	Current-mode probe Probe current = lin. f (O_2 -contents)
Probe current for 21 Vol. % O_2 :	300 to 600 mA
Operating temperature of sensor:	750 to 850° C
Warm-up time:	30 min. to peak current for 21 % O_2 180 min. to thermal equilibrium
Probe current response time:	$t_{90} < 15$ s using standard intake tube, length 450 mm lang
Probe gas flow:	0,3 to 0,6 l/h; constant by critical nozzle
Measuring range:	0 - 21 Vol. % O_2 after calibration with air
Accuracy:	$\pm 0,1$ Vol. % O_2 after calibration
Temperature sensitivity:	1 % of true value/10° K case temperature variation
Pressure sensitivity:	1,3 % of true value/10 mbar variation
Zero point drift:	None
Cross sensitivity:	None with H_2O , CO_2 , SO_2 , HCL CO as well as other combustibles is oxydized catalytically
Materials	
Intake tube:	Standard: 2.4851 (Alloy 601) for flue gas temperature up to max. 900° C Ceramic $Al_2 O_3$ for flue gas temperature up to max. 1700° C
Casing:	Die cast Al Si 12, resp. Al 99,5 (cap)
Vacuum hose:	Teflon, 4 x 1 mm, length 300 mm
Electrical connection:	7 Kapton isolated stranded leads in teflon hose with 7-pole locking plug, length 300 mm and extension cables for 2, 5, 10 m, shielded
Weight:	approx. ca. 1,3 kg
Mounting position:	Any, but hose downward
Protection grade:	IP 42 (DIN, IEC, NF,)
Energy requirements:	Heater: 26 ... 31 V_{RMS} 3 A_{RMS} Measuring voltage: 0,4 ... 1 V DC current-controlled Measuring current: < 1 A DC Vacuum: $\geq 0,6$ bar absolute at 0,5 l/h
Ambient temperature range	
during operation:	+ 5° C to + 100° C
during transport and in storage:	- 25° C to + 60° C

Warming-up behavior of probe with heater voltage of 26 V AC.



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Probe types:

Probe types with 300 mm connection cable, without flue-gas-intake (MEV)

Order No.:	designation/type
6 50 R 0001	Lambda probe LS 1
6 50 R 0004	Lambda probe LS 1 for aggressive flue gas
6 50 R 0031	Lambda probe LS 1 gastight version (flange mounted)
6 50 R 0034	Lambda probe LS 1 gastight version (flange mounted) for aggressive flue gas

Accessories:

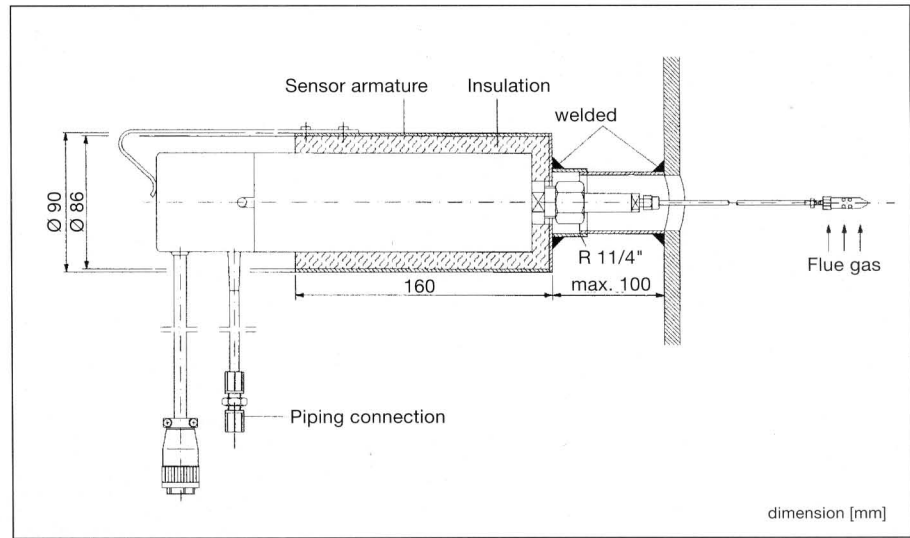
Order No.:	designation/type
6 55 R 0090	Flue-gas-intake (MEV), length 50 mm
6 55 R 0026	Flue-gas-intake (MEV), length 350 mm
6 55 R 0022	Flue-gas-intake (MEV), length 450 mm
6 55 R 0027	Flue-gas-intake (MEV), length 1000 mm
6 55 R 0123	Flue-gas-intake (MEV), length 1400 mm
6 55 R 0023	Flue-gas-intake (MEV), length on request
6 55 R 0025	Ceramic flue-gas-intake (MEV), length 450 mm
6 55 R 0024	Ceramic flue-gas-intake (MEV), length 1000 mm
6 55 R 0010	Extension cable for Lambda probe LS 1, length 2 m, shielded
6 55 R 0011	Extension cable for Lambda probe LS 1, length 5 m, shielded
6 55 R 0012	Extension cable for Lambda probe LS 1, length 10 m, shielded
6 55 R 0013	Lambda probe terminal box with flue gas – and calibration gas pump
6 55 R 0014	Lambda probe terminal box with flue gas pump
6 55 R 0015	Lambda probe terminal box IP 65
6 55 R 0113	Lambda probe terminal box R0013, incl. power supply for flue-gas-intake (MEV) heating
6 55 R 0032	Probe mounting armature, R 1 1/4 inch piping version, material steel, with insulation-form
6 55 R 0035	Probe mounting armature for connection to MEV (on site) with 3-way-cock, mat. 1.4571 (V4A)
6 55 R 0037	Probe mounting armature, gastight, version for calibration, material 1.4571 (V4A)
6 55 R 0041	Probe mounting armature, R 1 1/4 inch piping version, material steel zinc coated
6 55 R 0042	Probe mounting armature, gastight, flange mounting version, material steel zinc coated
6 55 R 0083	Probe mounting armature, gastight submerged version for calibration, material 1.4571 (V4A)
6 55 R 0087	Transmitter protection housing (material: GFK) with electrically heating, field mounting
6 55 R 0055	Protection cage insulated, mounting type
6 55 R 0056	Insulation 230 mm for SEA 655 R 0037 and LS 1 650 R 0031
6 55 R 0057	Insulation 330 mm for SEA 655 R 0037 und LS 1 650 R 0034
6 55 R 0058	Insulation 230 mm for SEA 655 R 0039/R 0042 und LS 1 650 R 0031
6 55 R 0053	Insulation 230 mm for SEA 655 R 0083 und LS 1 650 R 0031/R 0034
6 55 R 0154	Insulation 230 mm for SEA 655 R 0032 und LS 1 650 R 0001/R 0004

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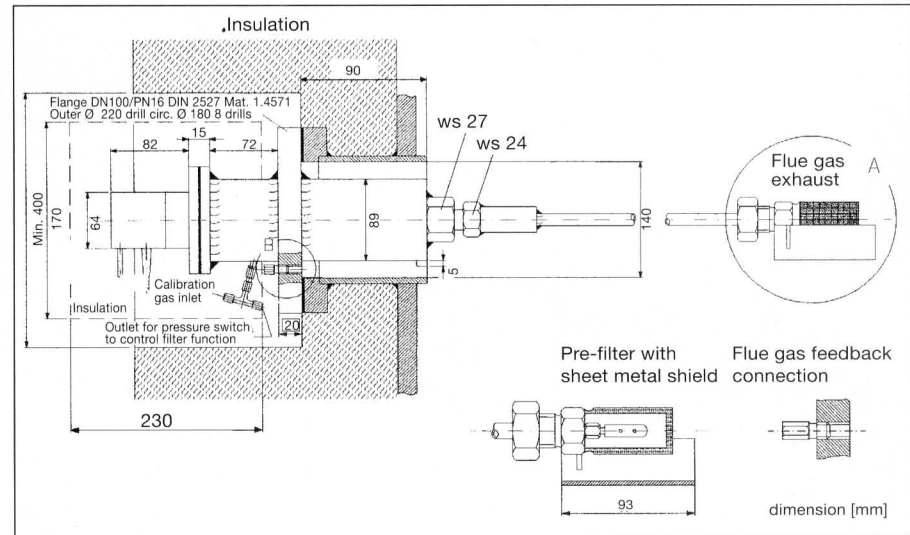
Attention:

The probe extension cable and the flue-gas-intake (MEV) must be ordered separately. Since March '96 the LS 1 Lambda probe will be delivered just only with a 300 mm connection cable and without the flue-gas-intake.

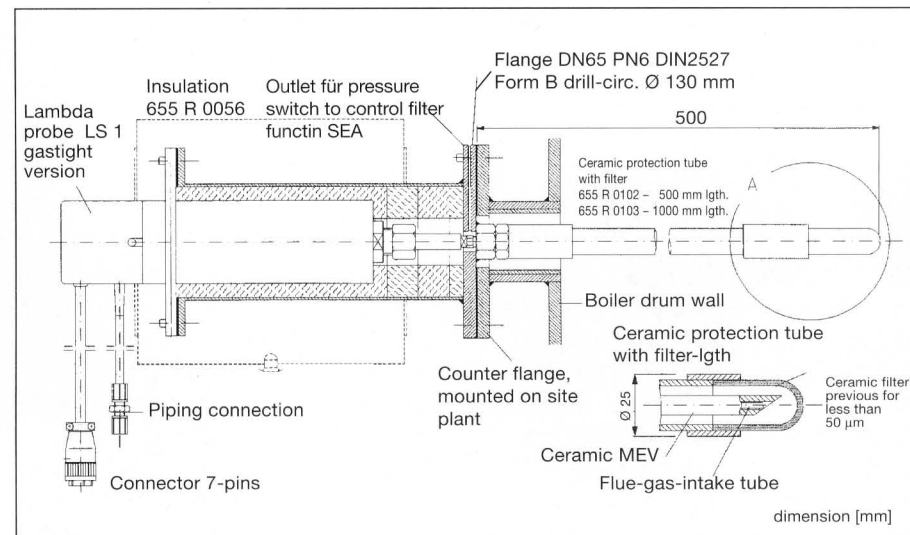
Lambda probe LS 1 650 R 0001
with flue-gas-intake (MEV, 350 mm
length) 655 R 0026 mounted with
probe mounting armature (SEA)
655 R 0032



Lambda probe LS 1, gastight
version 650 R 0031 with flue-gas-
intake (MEV) mounted with probe
mounting armature
(SEA) 655 R 0083 and
insulation device 655 R 0053



Lambda probe LS 1, gastight
version 650 R 0031 with ceramic
flue-gas-intake, (MEV) 655 R 0025
mounted with probe mounting
armature (SEA) 655 R 0037 with
ceramic protection tube 655 R
0102 and insulation 655 R 0056.



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