System overview

Combination Probe KS1D

LAMTEC

Sensors and systems for combustion engineering

www.lamtec.de

LAMTEC Measuring System LT3 with LS2 or KS1D.

The cost-eff ective package for simultaneous CO_e/O_2 measurement.

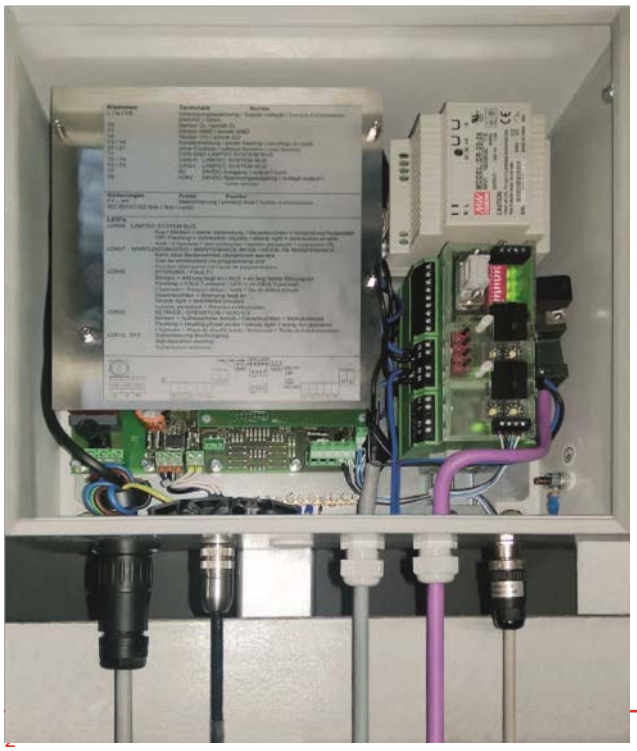
With the LT3 Lambda Transmitter, LAMTEC provides customers with a simple, cost-effective device for the simultaneous measurement of oxygen (O_2) and oxidising gas components (CO_e) or for the pure O_2 measurement.

When used in conjunction with the LAMTEC Combination Probe KS1D, the LAMTEC LT3 Lambda Transmitter is a universal measuring device based on micro-processor technology. This measuring transducer has been specifi cally developed for the simultaneous measurement of O_2 concentration and oxidising components CO_e (CO/H_2) in emissions from combustion systems in the superstoichiom etric range (> 1). The measurement value CO_e e = equivalent - is the sum signal of all oxidisable emissions components. Alternatively, the LAMTEC probe LS2 can be used for pure oxygen measurement (O_2).

The LT3 evaluates the voltage values of two measurement electrodes (U_{O2} and $U_{CO/H2}$). These values are formed of U_{O2} (oxygen characteristic) and the so-called mixed potential (U_{O2} + $U_{CO/H2}$). The formation of the mixed potential takes place very quickly, t_{60}-times below 3 seconds are achieved. Even when the concentration of combustible gases (for example, H_2 or CO) is low, the LT3 displays a signifi cantly higher mixed potential than when measuring O_2 alone. Furthermore, the mixed potential characteristic is much sharper than that for the O_2 measurement, causing the sensor signal's dynamic range to increase quickly, particularly when the content of non-burned fuel begins to rise.

Advantages:

- Direct (in-situ) measurement of oxygen (O_2) and oxidising exhaust gas components (CO/H_2) in the raw gas up to a temperature of 1 200 °C
- O_2 measurement range: 0 to 21 vol.%
- CO_e measurement range: 0 to 10,000 ppm
- Not aff ected by ingress air (CO_e)
- No sample gas conditioning required, measurement directly in the moist fl ue gas
- Response time set to 60 % (T60)
  O_2 < 3 seconds (unfi ltered)
  CO_e < 3 seconds
- Low heating power 20 ... 25 watts depending on the exhaust gas temperature
- Certifi ed fl ame arrestor
- Simple to use – probe connection using plug-in socket
- Low-maintenance
- Approved according to DIN EN 16340



This makes simultaneous CO_e/O_2 measurement using the LAMTEC LT3 distinctly superior to O_2 measurement alone when it comes to sensitivity and speed. The LT3 delivers fi rst-class basic values for the downstream control of air and fuel supply.

Measurement principle

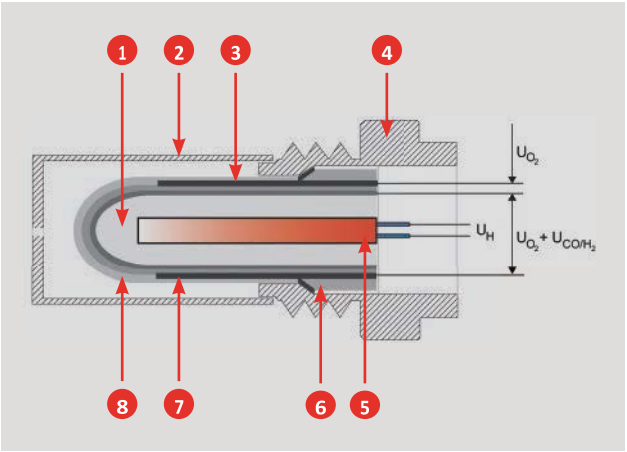
Sensor technology principle for the O_2 electrode:

The LAMTEC KS1D Combination Probe is based on a heated electrochemical measuring cell made from zirconium dioxide ceramic (ZrO_2).

It has 3 electrodes:

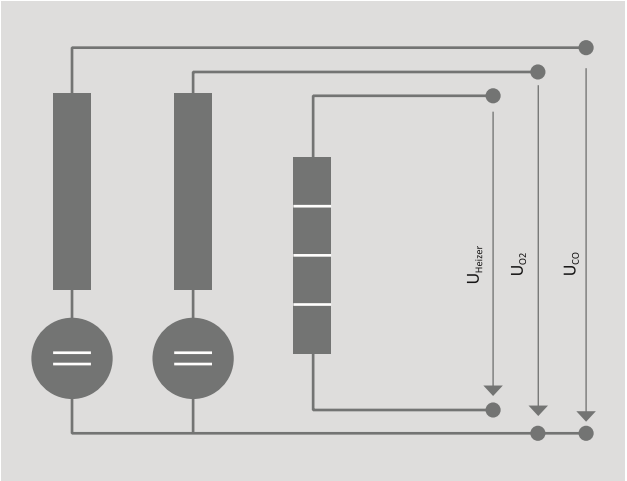
- O_2 electrode (platinum)
- CO_e electrode (platinum/noble metal)
- Reference electrode (platinum)

The probe is a zirconium dioxide ceramic tube that is sealed on one side. It protrudes into the combustion system's emissions channel and divides the reference gas compartment (surrounding area) from the measuring gas compartment (emissions channel) so that no gas can escape. The reference electrode is located on the inner side of the zirconium dioxide ceramic in the reference gas compartment. The two measuring electrodes for O_2 and CO/H_2 are located on the outer side of the ceramic in the measuring gas compartment. An integrated heater warms the probe to a temperature of around 650 °C and controls this temperature. At this temperature, the zirconium dioxide ceramic conducts oxygen ions and the two sensor signal voltages U_{O2} (between the reference and O_2 electrodes) and U_{COe} (between the reference and CO_e electrodes) form accordingly and can be measured.



Design principle for the LAMTEC KS1D Combination Probe.

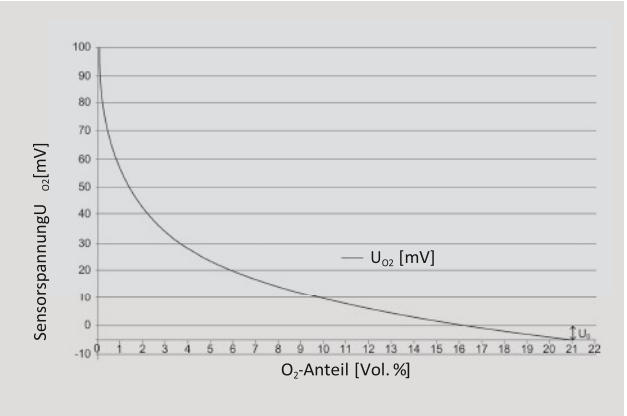
1 Reference electrode **2** Cap with gas inlet **3** O_2 electrode **4** Housing **5** Heater **6** Functional ceramics **7** CO_e electrode **8** Protective coating



Simple equivalent circuit diagram for the KS1D.

The sensor voltage U_{O2} [mV] corresponds to the known Nernst voltage, which is dependent on the sensor temperature T [K] and on the logarithm for the O_2 partial pressure ratio between the reference and measuring chambers, with the constants k = 0.21543 [mV/K] and the sensor-specifi c off set voltage U_0 [mV]. as per the formula: $U_{O2} = U_0 + kT\ln(p_{O2,ref}/p_{O2,meas})$.

U_0 is determined by calibrating the probe with the ambient air: With $p_{O2,ref} = p_{O2,meas} = 0.21$, the last part of the equation becomes zero and the off set voltage is measured $U_0 = U_{O2}$ at 21 vol. % per volume O_2. A typical Nernst O_2 characteristic (U_{O2}) at a typical sensor temperature T = 923° [K] with a typical off set voltage of U_0 = -5 [mV] is shown in "Nernst sensor characteristic Us = f (O_2)".



Nernst sensor characteristic $U_s = f(O_2)$.

Sensor technology principle for the CO_e electrode: The CO_e electrode is identical to the O_2 electrode apart from the fact that the electro-chemical and catalytic properties in the signal materials are diff erent, thus enabling combustible components such as CO, H_2, to be detected.

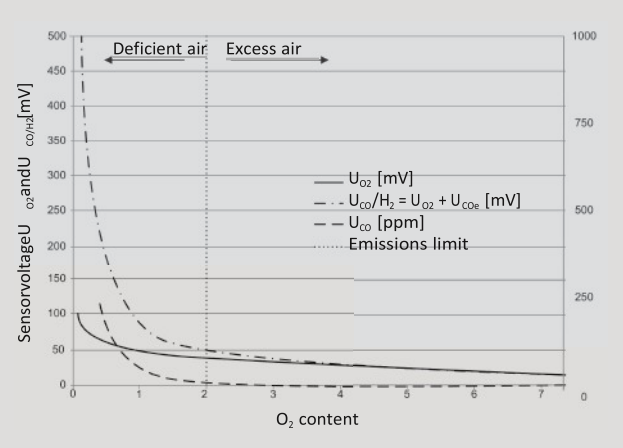
For 'clean' combustion, the Nernst voltage U_{O2} also forms on the CO_e electrode and the characteristics of both electrodes follow an identical path. In the event of incomplete combustion and in the presence of combustible components, a non-Nernst voltage U_{COe} also forms on the CO electrode and the characteristics for both electrodes move apart (see "Typical signal characteristics for the two KS1D sensor voltages").

The total sensor signal $U_{CO/H2}$ on the CO_e electrode is made up of the total of these two voltages: $U_{CO/H2} = U_{O2} + U_{COe}$. If the oxygen content – measured by the O_2 electrode – is deducted from the total sensor signal, the result $U_{COe} = U_{CO/H2} - U_{O2}$ can be used to generate the concentration of combustible components CO_e in ppm. The "Typical signal characteristics" for the two KS1D sensor voltages shows the typical path for CO_e concentrations (dashed line) when O_2 content reduces gradually. When moving into the defi cient air range, the CO_e concentration increases signifi cantly at the so-called emissions limit as a result of the poor/incomplete combustion caused by insuffi cient air for combustion.

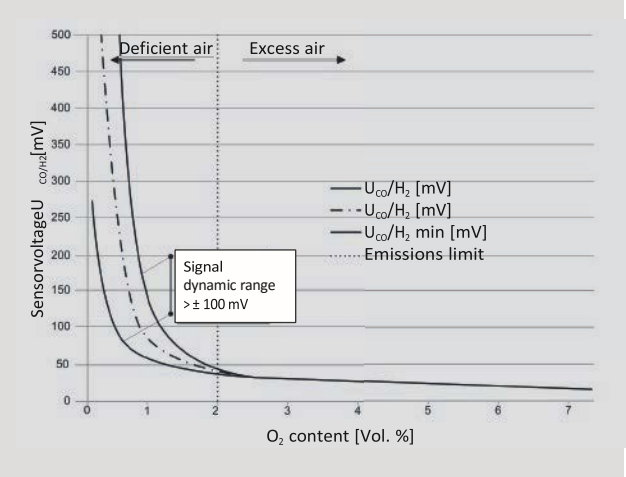
The resulting signal characteristics U_{O2} (continuous line) and $U_{CO/H2}$ (dotted dashed line) for the KS1D are also shown. In the excess air range with clean CO_e free combustion, the two sensor signals U_{O2} and $U_{CO/H2}$ are identical to one another and show the current oxygen content in the exhaust gas channel in accordance with the Nernst principle.

Close to the emissions limit, the sensor signal for the CO_e electrode $U_{CO/H2}$ increases at a disproportionate rate due to the additional non-Nernst CO_e signal.

The typical signal characteristics for the two KS1D sensor voltages U_{O2} and $U_{CO/H2}$ in relation to the O_2 content in the emissions channel. The typical characteristic of combustible components CO_e is also shown.



Typical signal characteristics for the two KS1D sensor voltages.

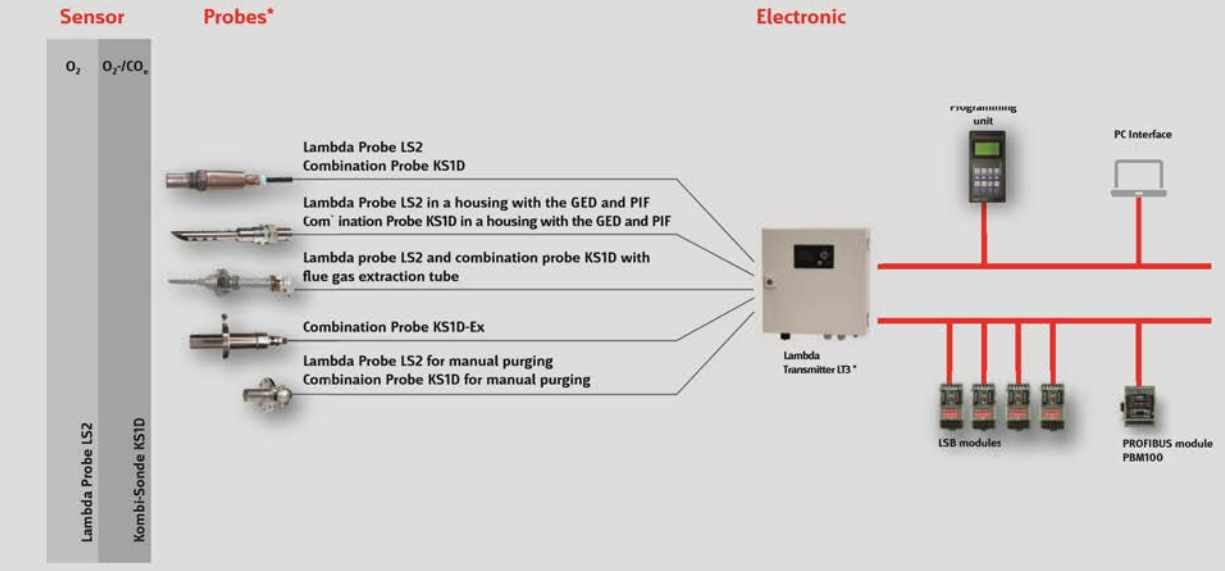


Dynamic range of the CO_e electrode signal U_{CO}/H_2 in the deficient air range.

In addition to the absolute sensor signals $U_{CO/H2}$ and U_{O2}, the relative change to the sensor signals after time dU_{O2}/dt and $dU_{CO/H2}/dt$ and, in particular, the signal dynamic range for the CO_e electrode can also be used to determine the emissions limit (see “Dynamic range of the CO_e electrode signal $U_{CO/H2}$ in the incomplete combustion range”).

System overview.
Basic system.

Various probe designs.



* Only one probe possible for each LT3.

Functions in the LT3 with LS2 | KS1D.

LT3 with user interface.

LT3 with an integrated programming unit.

LT3 connections on the underside.

The LAMTEC LT3 Lambda Transmitter is available in three diff erent designs: with and without a user interface or programming unit. The user interface (UI) is attached to

the front door and is equipped with the following functions:

- Password entry
- Readings for O_2 and CO_e measuring values
- Information on the probe, fuel, warnings, faults, soft ware version, CRC and serial number
- Calibration of measurements
- Settings for maintenance, fi lter time, analogue output, replacing probes, display. All other functions and parameter settings can also be carried out using the integrated programming unit

The LT3 Ex

The following connections are located on the underside of the device:

- Power supply
- KS1D probe connector (probe signal/probe heater)
- External LSB connector for the PC (use of LAMTEC remote soft ware)
- Cable bushing for connecting to the LAMTEC SYSTEM BUS
- Cable bushing for connecting to LSB modules

Lambda Transmitter LT3 Ex

The LT3-Ex lambda transmitter is used in conjunction with an Ex probe, a measuring system for the continuous measurement of the concentration of O_2 and oxidizing components (CO/H_2). The LT3 Ex is used in potentially explosive areas.

Applications:

- Natural gas, heating oil (extra light).

Lambda Probe LS2 in HT design
Combination Probe KS1D in HT design

Properties:

- High exhaust gas temperatures up to 1400°C
- T-adapter to protect the probe

Applications:

- Dusty and other special fuels

Properties:

- Measurements are taken directly in the moist fl ue gas up to 1,200 °C
- Option for semi-automatic calibration during operation with test gas

Lambda Probe LS2 in standard housing
Combination Probe KS1D in standard housing

Properties:

- Measurements are taken directly in the moist fl ue gas up to 300 °C
- Protection rating IP42, the probe must be protected against water, snow, etc., if installed outside

Probes.

In-situ LAMTEC probes support both O_2 measurement (LS2 Lambda Probe) and simultaneous measurement (KS1D Combination Probe) of O_2 concentration and combustible oxidising gas components (CO/H_2), displayed as CO_e (CO equivalent).

Lambda Probe LS2
Combination Probe KS1D

Properties:

- Measurements are taken directly in the moist flue gas up to 300 °C
- Protection rating IP42, the probe must be protected against water, snow, etc., if installed outside

Applications:

- Natural gas, heating oil (extra light).

- IP65 protection rating

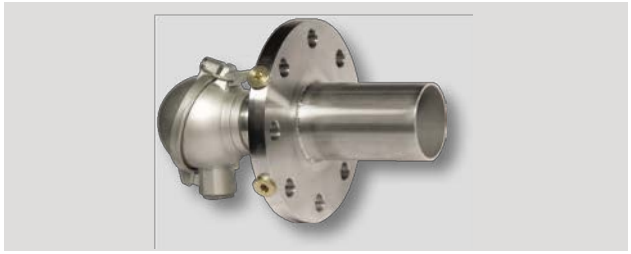
Properties:

- Measurements are taken directly in the moist fl ue gas up to 1,200 °C
- Option for semi-automatic calibration during operation with test gas
- IP65 protection rating

Applications:

- Natural gas, heating oil EL, HFO, special gases

Lambda Probe LS2 and Combination Probe KS1D with fl ue gas extraction tube and T-adapter
Lambda Probe LS2 for manual purging Combination Probe KS1D for manual purging



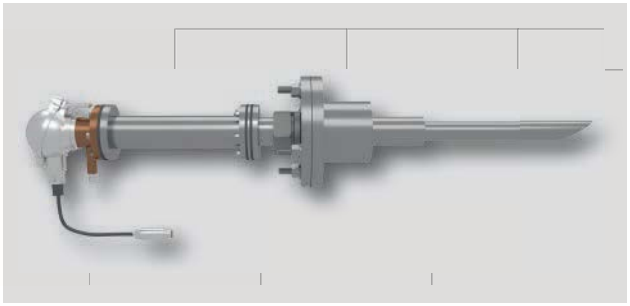
Properties:

- Measurements are taken directly in the moist fl ue gas up to 600 °C
- Includes fi tting for manual purging
- IP65 protection rating

Applications:

- Natural gas, heating oil (extra-light), coal, particle-laden fuel emissions (available with optional de-dusting cleaning).

Lambda probe LS2 and Combination Probe KS1D with flue gas extraction tube



Applications:

- Measurement of very high exhaust gas temperatures. Fuels: Natural gas, domestic fuel (extra-light), heating oil (heavy), coal, biomass, non-standard fuels

Combination Probe KS1D-Ex

Properties:

- Measurement directly in the moist fl ue gas up to 1,200 °C
- Option for semi-automatic calibration during operation with test gas
- IP65 protection rating
- Atex: Ex 2 IIG - Ex dIIC T4 (-20 to +60 °C).

Applications:

- Natural gas, heating oil (extra-light), heating oil (heavy), coal, non-standard fuels

Optional components.

LSB modules

The LSB modules are universally-compatible input and output modules that can be controlled via the LAMTEC SYSTEM BUS. For this to occur, the module is confi gured by an adjustable address. The relay outputs are activated manually using switches.

- *Analogue outputs:*

There are two diff erent modules outputs:

- Power module with 4 analogue output 20 mA
- Voltage module with 4 analogue outpu 10 VDC

Digital outputs:

The digital LSB module is equipped with 4 outputs.

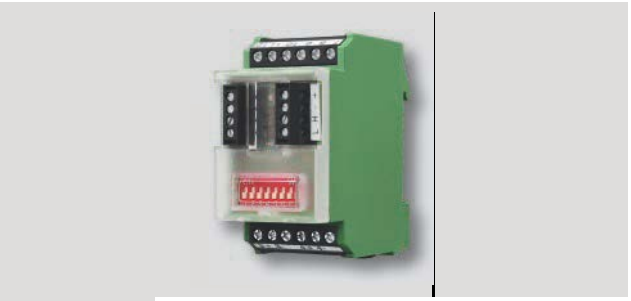
- Two PT100 temperature inputs to record the fl ue gas temperature and air intake temperature
- Two analogue outputs 0/4 to 20 mA to emit the fl ue gas temperature and its effi ciency
- Power supply 24 VDC / 50 mA

The digital LSB module is equipped with 4 inputs. Use of a strapping plug means that two modules can be wired quickly and increases the number of inputs to 8.

LSB module for calculating combustion effi ciency:

The effi ciency module has the following properties:

Digital inputs:



Communication via PROFIBUS:

The Fieldbus modules are connected via the LSB. With regard to integration into a parent process and building management system, PROFIBUS communication off ers many advantages.

- Either installed straight onto the LT3 or externally, e.g. on the switch board
- Fast and precise transmission of processor values
- Direct reading of inputs and outputs
- Remote diagnosis through a readout of the fault history.

Programming unit

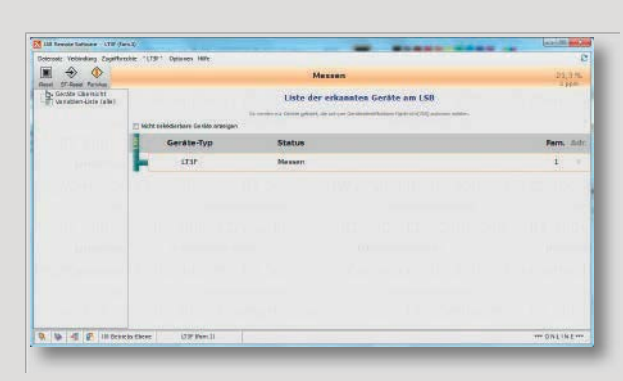
If the device is supplied without a user interface or if you simply require an additional control solution, you can also operate the device using a hand-held programming unit. The hand-held programming unit can be connected

to the LT3 Lambda Transmitter via the LAMTEC SYSTEM BUS.

PROFIBUS PBM100.

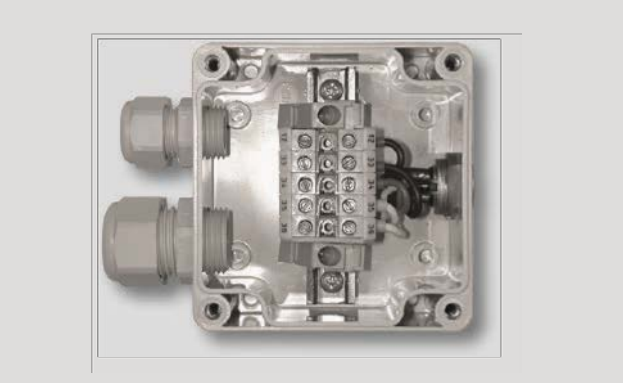
LSB Remote Software

The LSB USB module PC interface makes working with the LT3 Lambda Transmitter even easier: The device can be operated remotely using a laptop. Set configurations and curve data can be archived – this backs up data so that it can be re-imported in the event of an emergency, enabling the device to be ready for operation again in just a few min utes. Using the LSB Remote Software enables users to retrieve and monitor data from the LAMTEC Lambda Transmitter from their offi ce without needing to be on site.



PCB probe connection box

The LAMTEC PCB probe connection box has been designed to bridge longer distances between the LT3 and the probe without need for an extension ca ble (> 2 metre). Here, the probe connection jack and the blank cover replace the standard screwed cable gland. The PCB contains a terminal strip to allow customers to use their own cabling to connect to the LT3 analyser.



Purging unit for the KS1D Combination Probe.

Connections for the purging unit.

Purging unit for the KS1D Combination Probe Users whose applications require a purging device can benefi t from the LAMTEC cleaning unit. The unit is integrated in a separate wall-mounted housing. It is controlled via the LT3 or directly using the process control system.

Inputs.

Outputs.

Lambda Transmitter LT3

Power supply
230 VDC

LSB module Analogue outputs

LSB module Digital inputs

LSB module Digital outputs

LSB module for calculating combustion effi ciency:

Communication via PROFIBUS

1 0_2 measurement value

2 $C0_e$ measurement value

3 Not assigned

4 Not assigned

1 Fault

2 Warning

3 Limit value 1

4 Limit value 1

1 Resolve offset calibration

2 Reset fault

3 Changeover to CO_e curve fuel 1

4 Deactivation of limit value 1 to 4

5 Reset limit value 1 to 4

6 Changeover to CO_e curve fuel 3

7 Changeover to CO_e curve fuel 4

8 Deactivation for calibration

gas temperature

4 Effi ciency

1, 2 CO_e actual value

3, 4 C O_e actual value

status

5, 6 O_2 actual value

7, 8 CO sensor voltage

rough

9, 10 O_2 sensor voltage

1 Recording for flue gas temperature

rough

11, 12 P robe voltage U_{COe}

2 Recording for ambient temperature

13, 14 L T3 status

15, 16 W arning value 1

17, 18 W arning value 2

1, 2 Fault/ warning reset

19, 20 Fault value 1 21, 22 Fault value 2

3 ID of the digital module 1 to 16

4 Coding for setting digital outputs

Notes.

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