Some combustion processes, e.g. process heaters, steam boilers or heating furnaces the air required to achieve optimal system efficiency can easily fluctuate. And the economic optimum of the process fluctuates within a relatively narrow range. Both elevated NOx or SOx emission due to an excess supply of air (excess O2) as well as energy loss within the system due to incomplete combustion (lack of O2) require measuring the oxygen level in the flue gas of the combustion process. Sampling near the combustion chamber is therefore just as vital as using a rapid response sensor to allow for responding to changes in the combustion gas temperature and/or other variables in the combustion process promptly. The BA 2000 was developed specifically for this application.

### Oxygen Flue Gas Analyzer BA 2000

- Fast response time
- Tool-less filter change
- Easy handling
- Flue gas temperatures up to 1600 °C (2912 °F)
- Durable ZrO2 measuring cell
- Display includes O2
- 4-20 mA output signal
- Ambient temperature -20 to +70 °C (-4 to 158 °F)
- No reference gas required
- No test gas required
- No gas conditioning required
- Calibration with instrument air
**Description**

The injector built into the filter housing constantly supplies the ZrO$_2$ sensor with fresh process gas. The self-regulating probe part is heated to 180 °C (356 °F) to prevent condensation. The ZrO$_2$ sensor in the BA 2000 provides accurate, extremely fast measurements.

No reference gas needed for operation. The sensor’s 1-point calibration uses instrument air also needed to operate the injector. If necessary, 2-point calibration may also be performed. The test gas additionally needed for calibration in this case should ideally correspond with the O$_2$ concentration of the sample gas.

A filter built into the probe protects the measuring cell from dust exposure. The filter can be changed in seconds without tools by simply turning the handle 90°.

The filter elements are available in ceramic, sintered or star-pleated stainless steel.

Together with the filters listed, the BA 2000 can be used for gases with a dust load of up to approx. 2 g/m$^3$.

The BA 2000 will provide all the information required for safe operation. The controller features a display with key pad for entering commands, alarm output, calibration function and 4 - 20 mA output signal.

**$t_{90}$ times depending on volume flow and pressure**

![Graphs showing $t_{90}$ times for different volume flows and pressures.]

**Oxygen measurement principle with ZrO$_2$ cells**

The NERNST equation serves as the basis for determining the oxygen concentration in gases by zirconium dioxide measuring cell.

\[
U = \frac{RT}{4F} \ln \left( \frac{P_{O_2, \, \text{air}}}{P_{O_2, \, \text{sample gas}}} \right)
\]

- $U$: Cell voltage in V
- $R$: Universal gas constant, $R = 8.31447 \text{ J/(mol K)}$
- $T$: Measuring temperature in K
- $F$: Faraday-constant, $F = 96485.34 \text{ C/mol}$
- $P_{O_2, \, \text{air}}$: Partial pressure of oxygen at the reference electrode in dry air in Pa
- $P_{O_2, \, \text{Sample gas}}$: Partial pressure of oxygen at the reference electrode in dry air in Pa

The conductivity of the oxide ions of zirconium oxide increases exponentially with the temperature and reaches adequate values above 600 °C (1112 °F).

Provided the total pressures of the gases are about equal on both electrodes (in this case volume concentrations can be used in place of partial pressures), after adding the numeric values for the constants in equation (I) results in the following equation for the oxygen concentration.

\[
\phi_{O_2} = 20.9 \cdot e^{-\left(46.42 \cdot \frac{U}{T}\right)}
\]

- $\phi_{O_2}$: Oxygen concentration in sample gas in Vol.-%
- $U$: Potential difference in mV
- $T$: Measuring temperature in K
- 20.9: Oxygen concentration in dry air in Vol.-%

The BA 2000 uses a potentiometric cell. The reference and the sample gas electrode are located in two different gas chambers with different oxygen partial pressure. The two chambers are separated by the gas-tight ZrO$_2$ tube. The electrodes generate e.m.f. (electromotive force) proportional to the partial pressure difference of the oxygen. The NERNST equation applies.
BA 2000 Technical Data

Sampling tube length: 0.5...2 m (1.6...6.6 ft)
Voltage: 115 or 230 V, 50/60 Hz
Probe heat output: 400 W
Measuring range: 0.1 to 21 Vol.-% O₂
Output signal: 4-20 mA = 0-21 Vol.-% O₂ (scalable 0-2.5/0-5/0-10/0-15)
Accuracy: relative error < 5 %
Sensor Tₚ time: < 15 sec
Alarm Sensor: Upper and lower limit of nominal value for heating (fixed)
Upper and lower limit of O₂ concentration (adjustable)
Probe alarm: Insufficient temperature
Ambient temperature: -20 ... +70 °C (-4 ... 158 °F)
Process temperature: up to 1600 °C (2912 °F), depending on sampling tube
Probe operating temperature: max. 200 °C (392 °F)
Probe material: 1.4571
Test gas 1-point calibration: Instrument air 20.9 Vol.-% O₂
Test gases 2-point calibration: Instrument air 20.9 Vol.-% O₂ and
test gas 0.1 to 15 Vol.-% O₂

Ordering instructions

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<tr>
<th>Item no.</th>
<th>Description</th>
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<tbody>
<tr>
<td>55200099</td>
<td>BA 2000, 230 V 50/60Hz</td>
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<tr>
<td>55201099</td>
<td>BA 2000-MF, 230 V 50/60Hz</td>
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<tr>
<td>55202099</td>
<td>BA 2000-SE, 230 V 50/60Hz</td>
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<td>BA 2000, 115 V 50/60Hz</td>
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<tr>
<td>55201098</td>
<td>BA 2000-MF, 115 V 50/60Hz</td>
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<td>55202098</td>
<td>BA 2000-SE, 115 V 50/60Hz</td>
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<td>5520098I</td>
<td>BA 2000I, 115 V 50/60Hz, US sized</td>
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<tr>
<td>55202099I</td>
<td>BA 2000I-SE, 230 V 50/60Hz, US sized</td>
</tr>
</tbody>
</table>

MF = separate sample gas recovery
SE = separated electronics up to approx. 15 m (49.2 ft)

Adapter flanges

<table>
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<tr>
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<th>Description</th>
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<tbody>
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<td>55200001</td>
<td>Adapter flange DN65 PN6 to Servomex</td>
</tr>
<tr>
<td>55200002</td>
<td>Adapter flange DN65 PN6 to Thermox</td>
</tr>
<tr>
<td>5520001</td>
<td>Adapter flange DN3-150 to Servomex</td>
</tr>
<tr>
<td>5520002I</td>
<td>Adapter flange DN3-150 to Thermox</td>
</tr>
</tbody>
</table>
We reserve the right to amend specification.

Untertemperaturalarm Sonda/Iox temperature alarm probe

Steckverbindung/connector 3-pins • PE
Klemmbereich/clamping range 9,4-10mm

Alarm D2-kort oder Temperatur/ alarm D2-value on temperature M16x1,5
Klemmbereich/clamping range 9,4-10mm

Filter/Filter Zubehör/accessories
Isolation/Insulation

Art.Nr. 55200098 55200099 55200098 552000991

Umgebungstemperatur/ ambient temperature
-20 bis/ up to +70°C

Werkstoff/Material: flansch/flange head 1.4571/SS216 Ti

Betriebstemperatur/operating temp. probe
max 200°C / 392°F

Betriebsspannung/power supply 230VAC 115YAC 230VAC 115YAC

Untertemperaturalarm/low temperature alarm
max Schaltstrom/max current

Messbereich/measuring range
Aussangs/signal skeller/signal output scalable

\[ A = 0,1 \text{ } 20,9 \text{ } \text{Kpl} < 2 \text{ } \text{Q2} \]

\[
\begin{array}{|c|c|}
\hline
\text{Flansch/ flange} & \text{DN3“-150} \\
A & \phi 160 \\
B & \phi 130 \\
C & \phi 114 \\
D & 130 \\
E & 278 \\
F & \phi 1/4 \\
\hline
\end{array}
\]