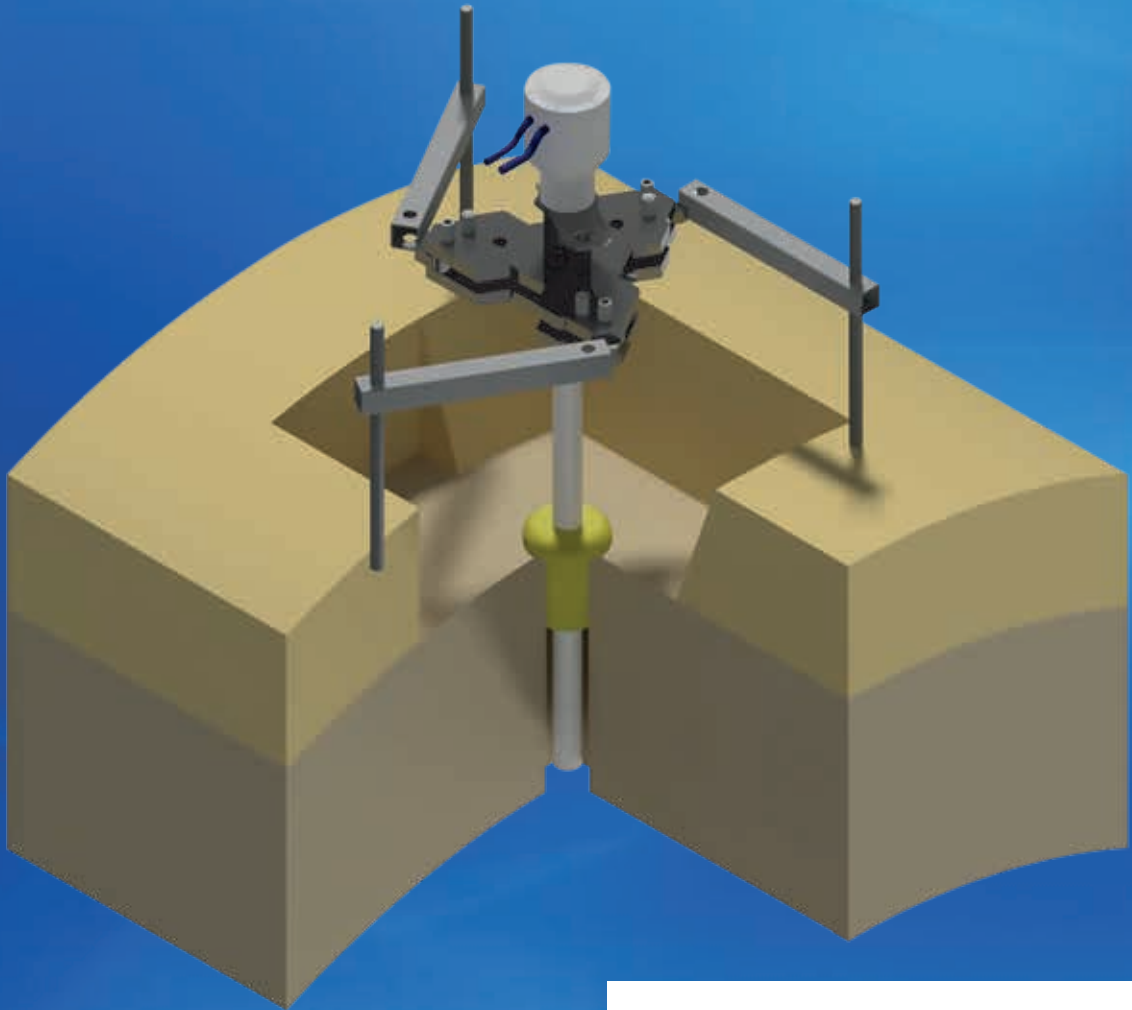


EUROX[®] **MEASUREMENT-** **SYSTEMS**

FURNACE COMBUSTION CONTROL
GLASS CONDITIONING - PREMIX COMBUSTION CONTROL
TIN BATH MONITORING

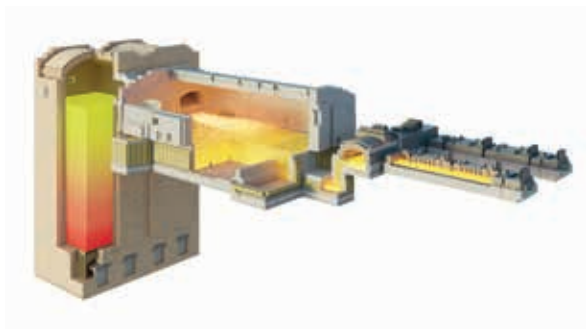


euRox

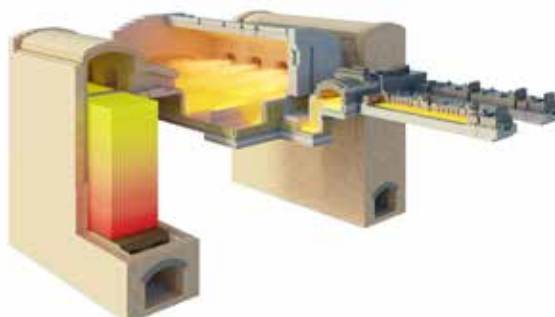
AN INNOVATIVE PRODUCT LINE OF
HORN[®] GLASS INDUSTRIES AG

EUROX® PRODUCTS SUMMARY

DIRECTLY INSERTED OXYGEN SENSORS



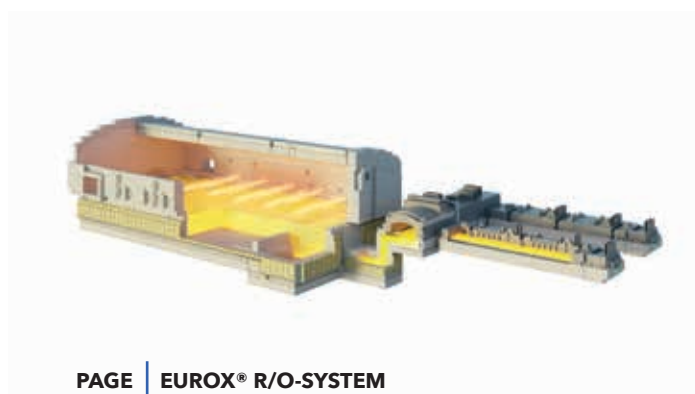
PAGE | **EUROX® REG-EFF-SYSTEM**
3 - 10 | For End fired furnaces



PAGE | **EUROX® REG-CFF-SYSTEM**
3 - 10 | For Cross fired furnaces

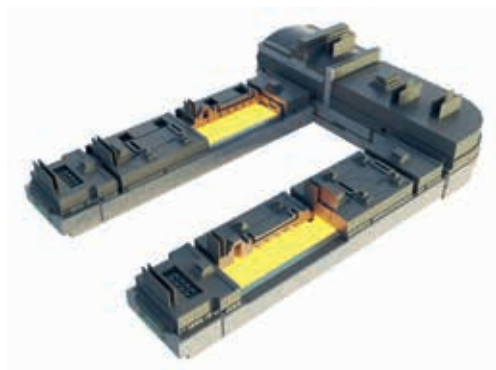


PAGE | **EUROX® R/O-SYSTEM**
3 - 10 | For Recuperative furnaces

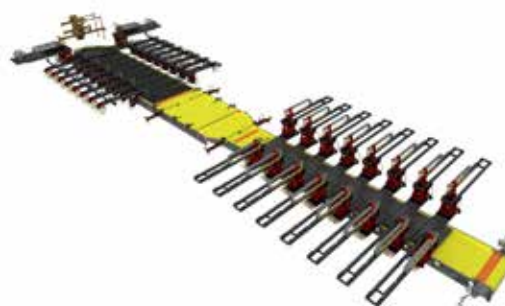


PAGE | **EUROX® R/O-SYSTEM**
3 - 10 | For Oxy-fuel furnaces

HEATED SENSORS FOR EXTRACTIVE MEASUREMENTS



PAGE | **EUROX® FH-SYSTEM**
11 - 13 | For forehearth and working end



PAGE | **EUROX® TB-SYSTEM**
11, 14 - 17 | For Tin baths

DIRECTLY INSERTED OXYGEN SENSORS FOR INCREASED FURNACE EFFICIENCY

OXYGEN SENSOR EXHAUST SYSTEM



Oxygen sensor
Type REG / Type R/O

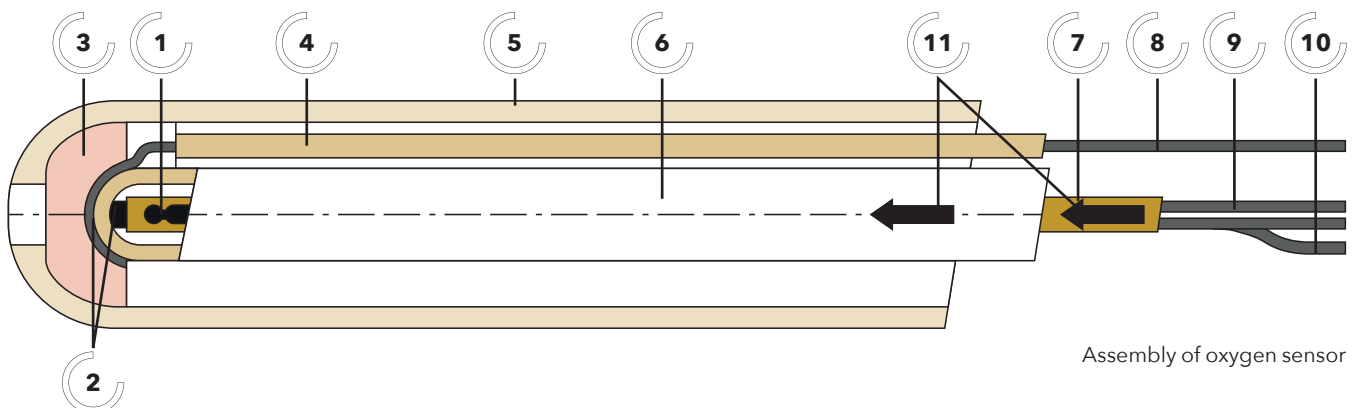
OPERATING PRINCIPLE

- Measuring oxygen content in flue gas with zirconium oxide measuring cell against reference air from reference unit
- Integrated thermocouple for measuring the cell temperature
- Inner and outer protection tube consisting of aluminium oxide for maximum protection
- Active ceramic diffusion block for protection of the inner components

WHY USE DIRECTLY INSERTED OXYGEN SENSOR IN A FURNACE?

To obtain information about ways to improve combustion in the furnace:

- Optimising the combustion to reduce emission like NO_x and CO and to save energy ($\lambda=1.0$ to 1.1)
- Detecting fluctuations in heating value to react and adjust air/fuel ratio



Assembly of oxygen sensor

1. Thermocouple embedded with a special cement
2. Pressed-on solid electrodes
3. Active ceramic diffusion block
4. Insulating tube
5. External protection tube
6. ZrO₂ tube

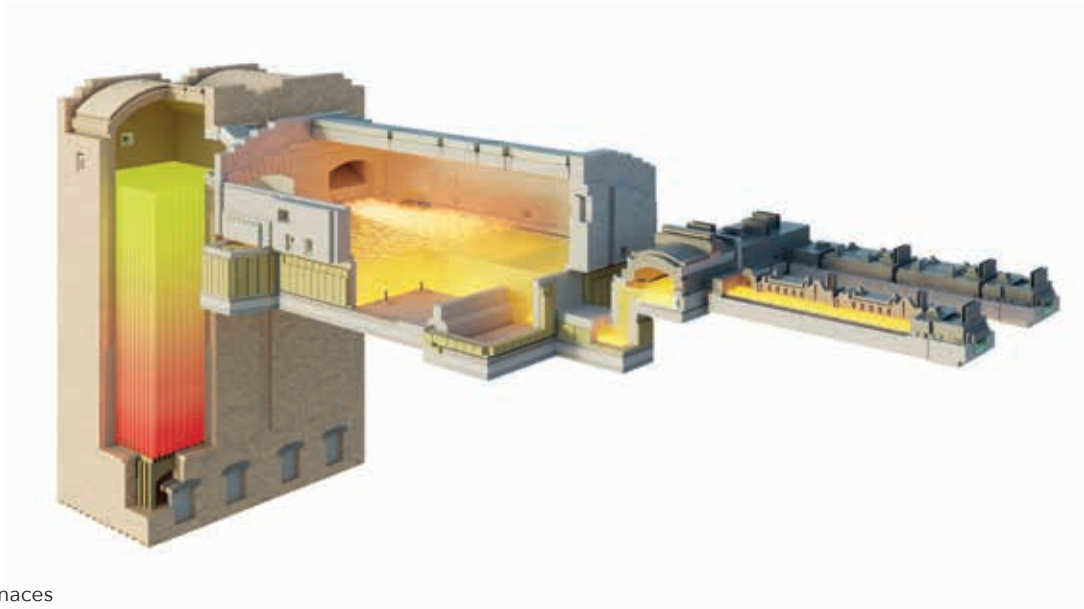
7. Capillary tube for inside electrode, thermocouple and reference air
8. Platinum wire outside electrode
9. Platinum wire inside electrode
10. Thermocouple
11. Compressing forces for electrode attachments

EUROX® REG-SYSTEM

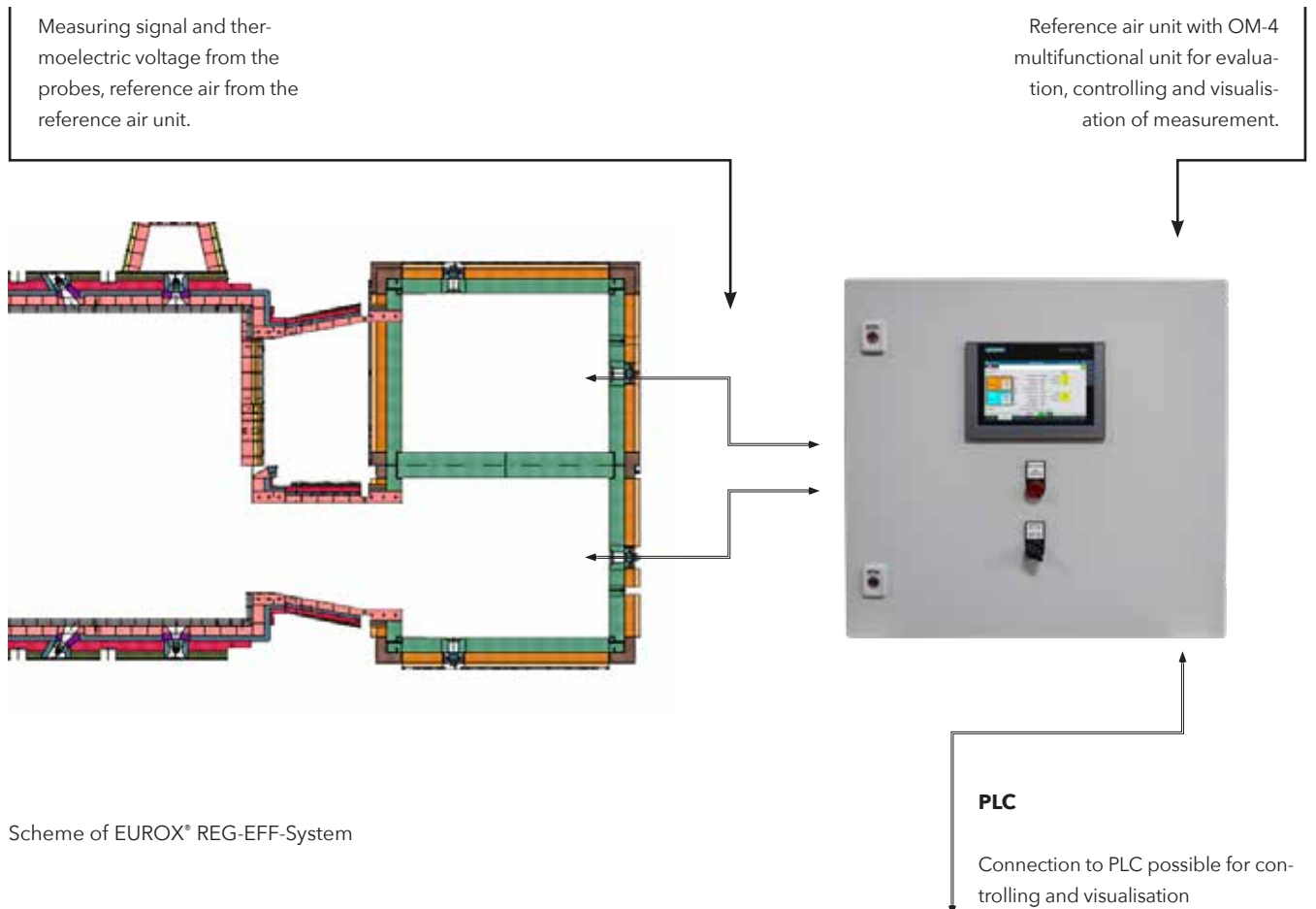
- Proven positioning in regenerative furnaces
- Shortest reaction time because of adapted construction

- For end fired furnaces with two sensors as well as for cross-fired furnaces with more sensors

EUROX® REG-EFF-SYSTEM

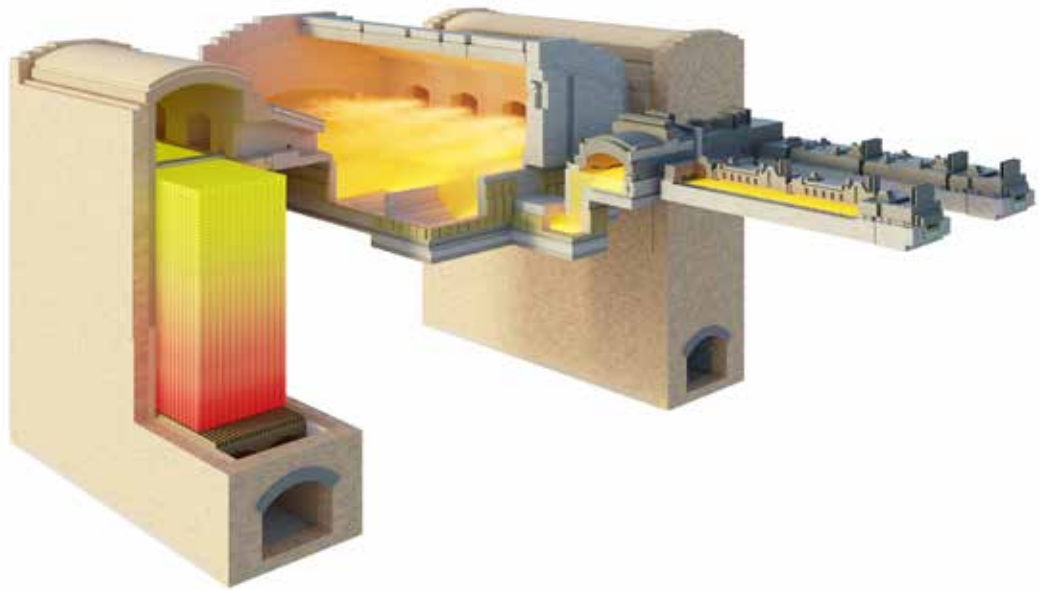


End fired furnaces

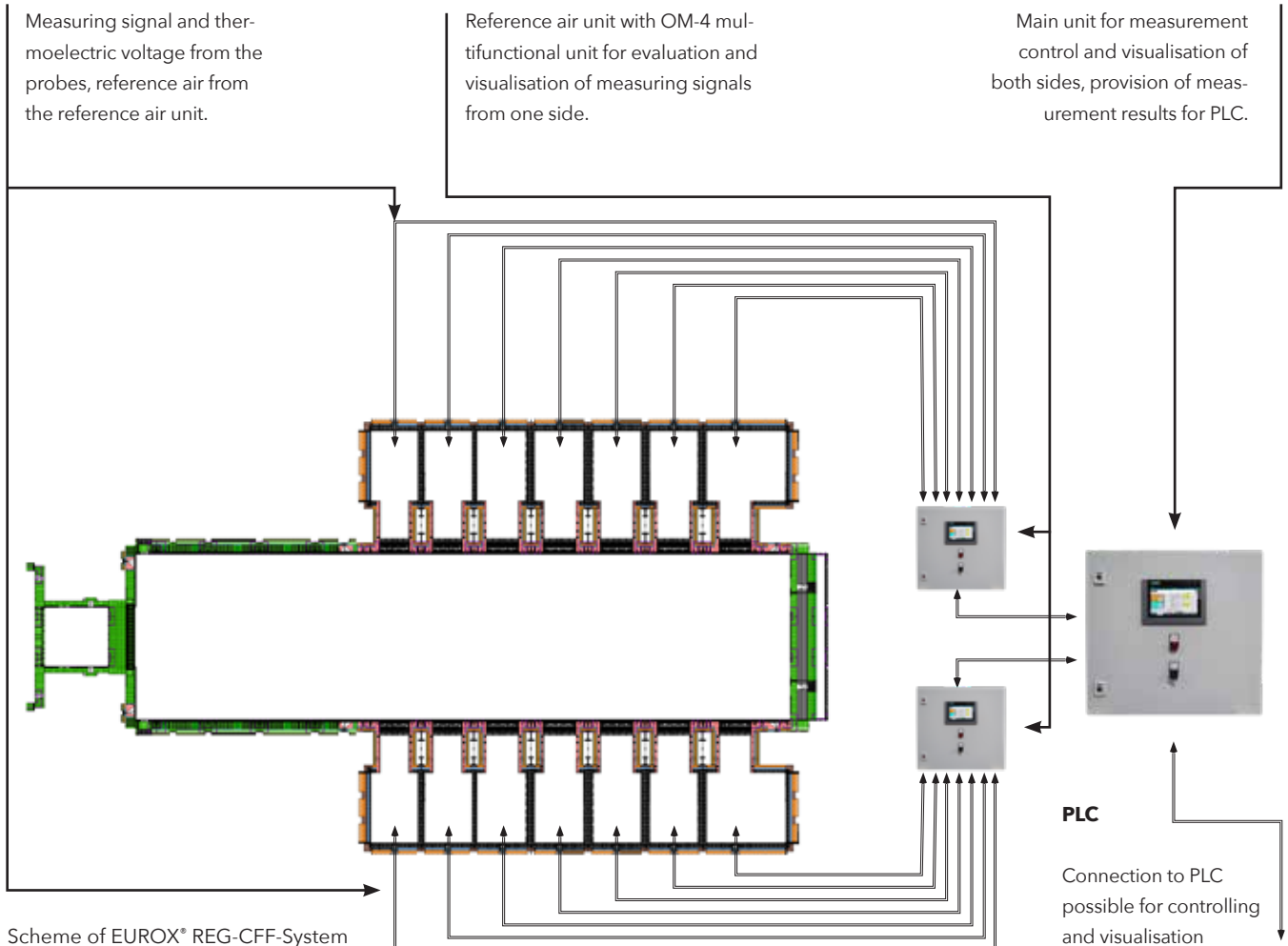


Scheme of EUROX® REG-EFF-System

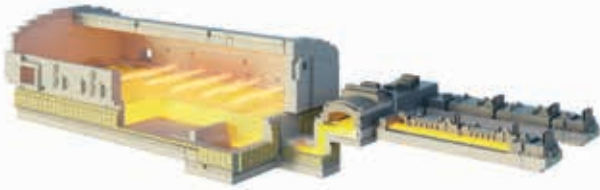
EUROX® REG-CFF-SYSTEM



Cross fired furnaces



EUROX® R/O-SYSTEM



Oxy-fuel furnaces

EUROX® R/O-SYSTEM FOR RECUPERATIVE AND OXY-FUEL FURNACES

- Can be installed horizontally and vertically
- Maximum protection of the measuring cell through adapted construction

EUROX® R/O-SYSTEM



Recuperative furnaces

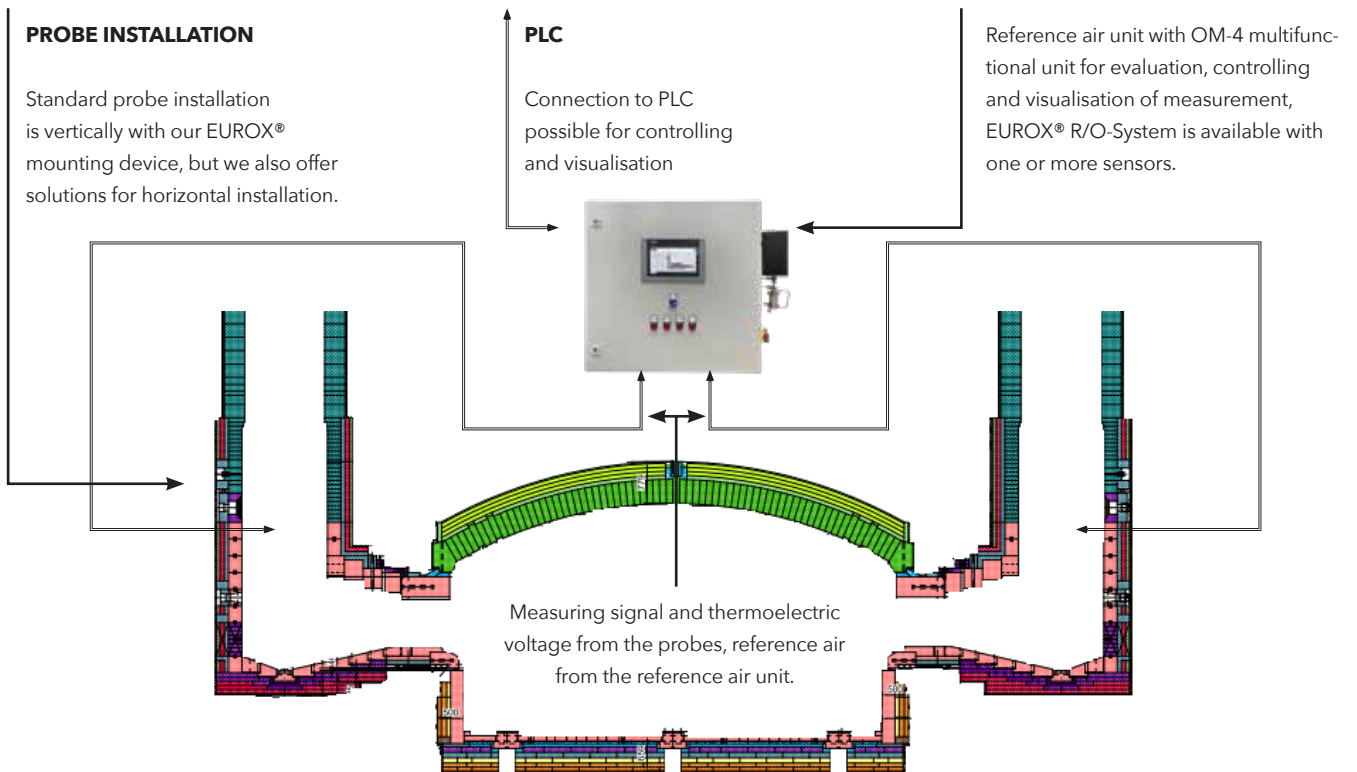
PROBE INSTALLATION

Standard probe installation is vertically with our EUROX® mounting device, but we also offer solutions for horizontal installation.

PLC

Connection to PLC possible for controlling and visualisation

Reference air unit with OM-4 multifunctional unit for evaluation, controlling and visualisation of measurement, EUROX® R/O-System is available with one or more sensors.



FEATURES

- Protection of measuring cell through diffusion block
- Lifetime up to six years depending on conditions
- Available as a stand-alone and add-on system on HORN SCADA systems
- Every sensor is inspected in our laboratory beforehand
- Stable structure due to optimised design
- Operating temperatures up to 1500°C/2730°F
- Fast installation
- Can be offered as purchase offer or rental- and service

COMPONENTS OF THE HOLDING AND MOUNTING DEVICE

1. Holding and mounting device
2. Lower part of the support rod
3. Upper part of the support rod
4. Support bracket
5. Splint

MOUNTING DEVICE

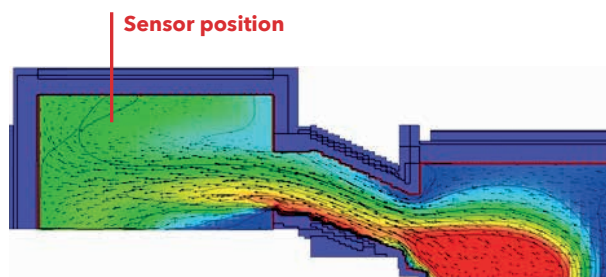
- Easy, safe and quick installation
- Adjustable positioning of sensor
- Often proven in harsh conditions

Illustrated is the standard mounting device. Special types are also available. Please contact EUROX® specialists for more information.

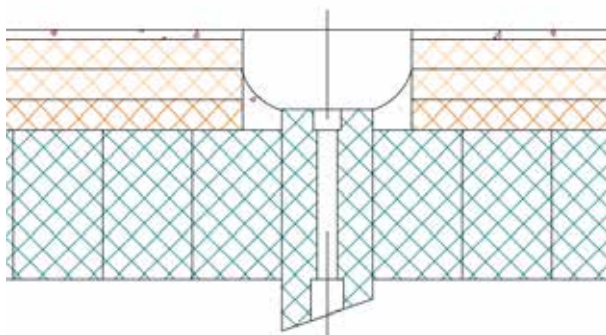
After installation of the sensor with the EUROX® mounting device the measuring cell is in a defined position to ensure optimal measuring results and a maximum lifetime.

SENSOR POSITION

Proven positioning of the sensor in the flue gas stream through modelling and tests to be sure the sensor position gives an average oxygen content of the whole flue gas stream.



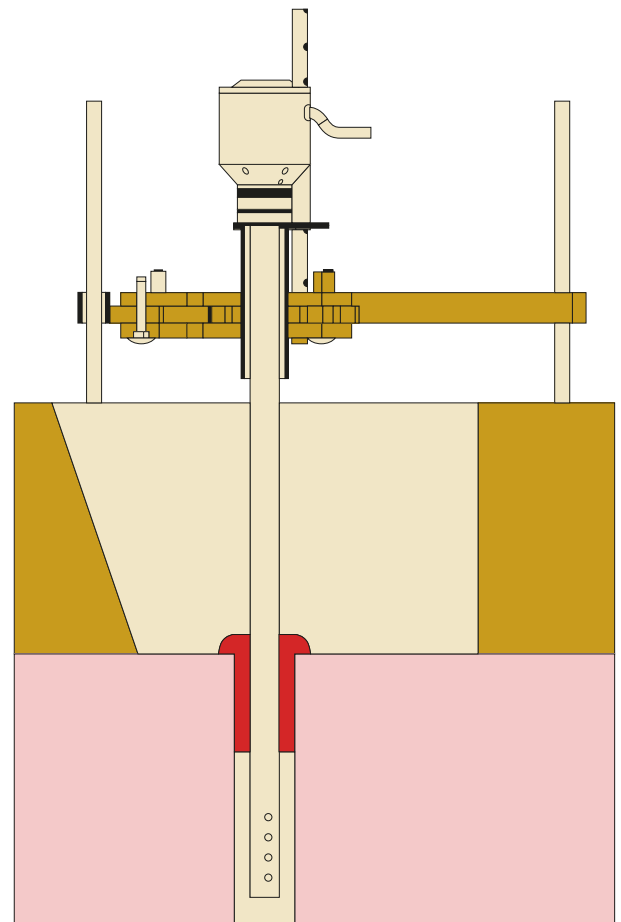
Modelled oxygen distribution in flue gas stream



Oxygen sensor mounting block



Mounting device



Installation scheme of Sensor Type REG

OXYGEN SENSOR MOUNTING BLOCK

- For a deeper and simultaneously protected position of the sensor
- Due to the shape of the block and the lower position of the sensor, a more accurate measurement result is obtained
- The shape of the block was determined in different modellings

TECHNICAL ASPECTS OF TYPE REG / R/O SENSORS

The type REG / R/O sensors consist of monolithic zirconium tube and inner and outer electrodes made of chemical resistant platinum alloy, no platinum paste is used.

The zirconium tube is protected by two protection tubes which are adapted to the application.

The output of the sensors is a cell voltage and a thermo-electric voltage which can be processed by the Nernst equation.

Supplied installation material:

- 25 m copper pipe per sensor

- 25 m silicone cable per sensor
- Installation material
- Connection box between the sensor and the reference air unit

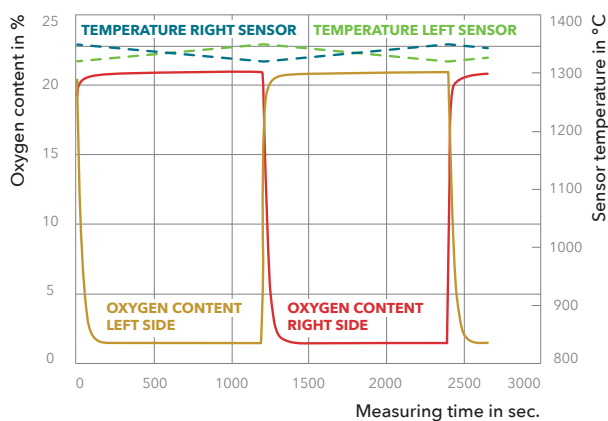
Dimensions:

- Sensor length: 800 mm
- Diameter of outer protection tube: 32 mm

The cell temperature is measured with an integrated thermocouple type B.

MEASURING WITH EUROX® REG / R/O-SYSTEM

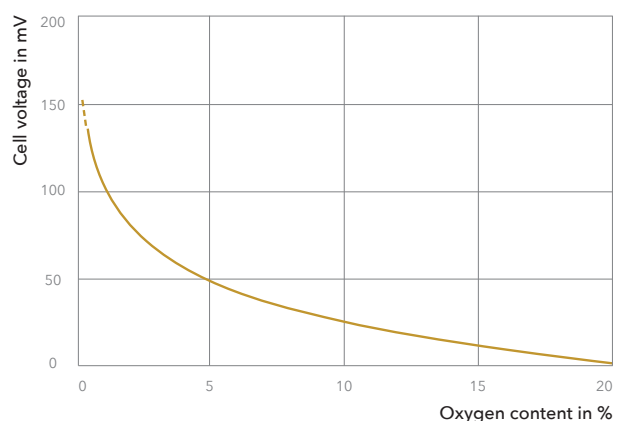
MEASURED OXYGEN TREND



Measuring trend of EUROX® REG-EFF-System

EUROX® sensors show a fast and reliable response, as well as reproducible measuring results over a long lifetime. With the EUROX® mounting device the sensor temperature and the reaction speed can be influenced by the installation depth of the sensor. So there is an optimum between the performance and lifespan of the sensor.

CELL VOLTAGE - 20.9 % O₂ IN REFERENCE AIR AND 1300 °C



Cell voltage depending on oxygen content

By a defined excess air of 10 % an oxygen content of 1.5 up to 2 % in the exhaust air is expected. The Nernst-Behavior shows a great change of the measured cell voltage by small changes in the oxygen content.

The EUROX® System Type REG and Type R/O are optimised to be reliable and precise - even in near stoichiometric conditions.

REFERENCE AIR SUPPLIES FOR CORRECT SENSOR OPERATION



Reference air unit inside

FEATURES

- **Stable and long-term dosage of reference air for high accuracy and highest lifespans of the measurement system**
- **Easy monitoring of the functions by the customer on-site**
- **Low maintenance**
- **Available as stand-alone solution and add-on-solution**
- **Siemens-based multifunctional unit OM-4 is included in stand-alone version.**

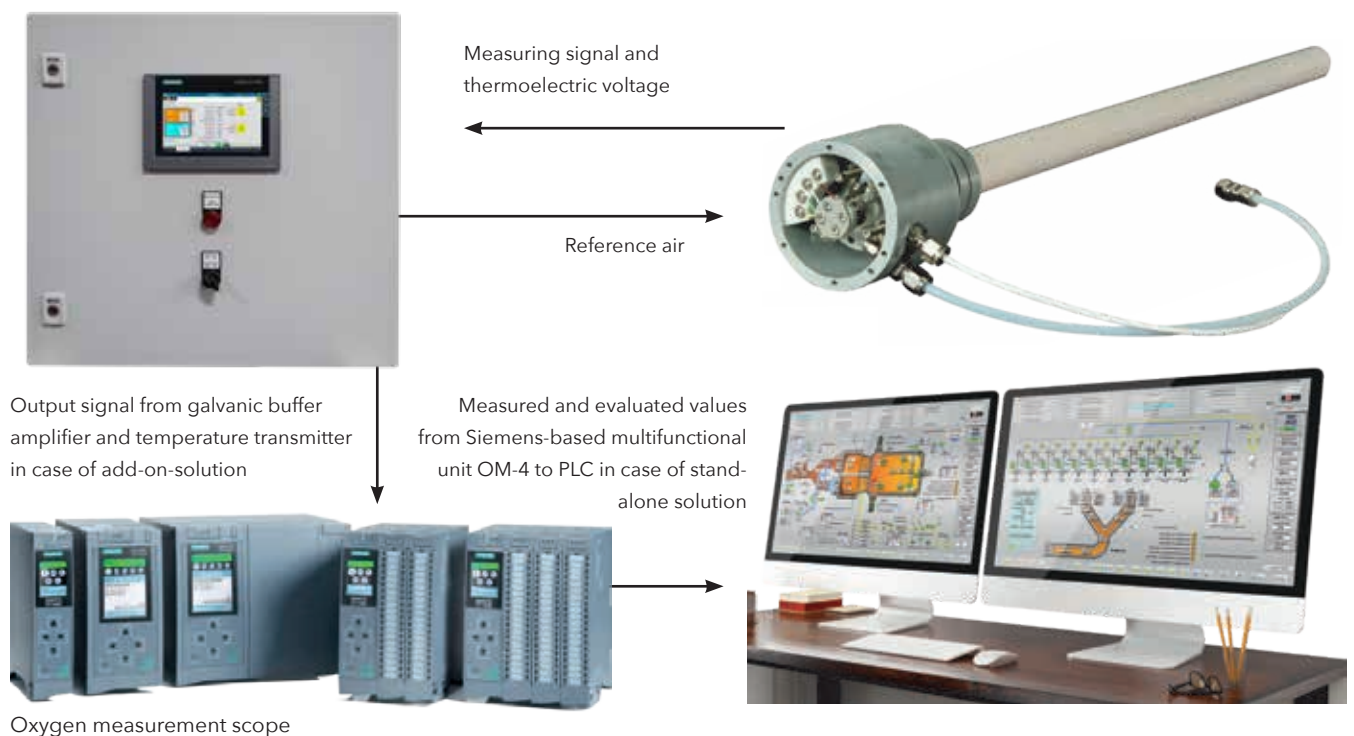
ADD-ON-SOLUTION FOR HORN SCADA SYSTEM ONLY

- Reference unit directly connected to the control cabinet, where the oxygen content read by the sensors is evaluated and visualised with the PLC software
- Visualisation of the measuring signals in the HORN SCADA system
- No Siemens-based multifunctional unit OM-4 is included, data transmission via galvanic buffer amplifier and temperature transmitter

STAND-ALONE-SOLUTION FOR THIRD-PARTY PLC-SYSTEMS

- Siemens based control- and evaluation unit OM-4 for oxygen measurement on-site
- Option 1: Visualisation and controlling unit installed in reference unit
- Option 2: Visualisation and controlling unit installed in customer cabinet
- Optional connection to the control cabinet to visualise measurements and control air/fuel ratio at customer's PLC

SCOPE OF OXYGEN MEASUREMENT WITH EUROX® SYSTEM



TECHNICAL ASPECTS OF REFERENCE AIR SUPPLY

- Power supply: 230 VAC/50Hz
- Designed for long lifetime
- Double diaphragm pumps and pressure control valve with one manometer
- Flow meter for stable reference air supply for each sensor
- Two filters (99,99% />1µm and an activated carbon filter) to remove oil mist from the air
- Alarm switch for operating pressure
- For calculation of oxygen content in measured gas 20.9% oxygen in reference air is used
- Controlling of measurement is done via Siemens-based multifunctional unit OM-4 or via PLC

Stand-alone-solution for third-party PLC-systems

- Connection terminals are provided, cables for PLC connection not included
- No galvanic buffer amplifier and temperature transmitter required
- Visualisation part of multifunctional unit OM-4 is required

Add-on-solution for HORN SCADA system only

- Galvanic buffer amplifier and temperature transmitter with 4 – 20 mA output signal
- Add-on-solution means that it is an add-on to a HORN system
- Output signal from galvanic buffer amplifier and temperature transmitter



Visualisation of system type REG-EFF

MEASUREMENT VISUALISATION

Depending on the application and the number of sensors the visualisation is adapted to a regenerative, recuperative or oxy-fuel furnace with one or more sensors. All relevant and evaluated values are visualised.

MEASUREMENT EVALUATION

Depending on the application, different values and alignments can be presented:

SENSOR TEMPERATURE IN °C, CELL VOLTAGE IN mV

- Standard values of the measurement
- Output from sensor

LAMBDA

- Lambda value of the actual combustion condition

CO IN PPM

- CO concentration based on combustion

O₂ TREND VALUE IN %

- Theoretical value after complete settling of the measurement at the end of the firing time

SELF-CHECK MODULE

- Various internal checks and monitored values to prevent malfunctions of the measuring system

MEASURED OXYGEN CONTENT IN %

- Actual measured oxygen content, based on Nernst equation
- Basis for measurement evaluation

RATIO REAL

- Real air/fuel gas ratio, including false air

FALSE AIR IN %

- False air in furnace
- Input from PLC needed

FLUSHING OBSERVATION

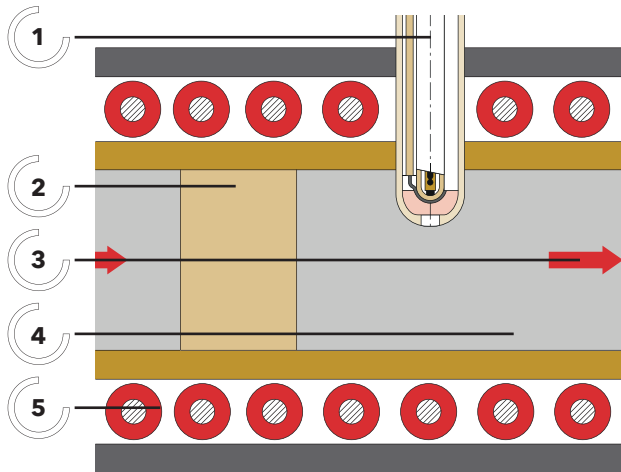
- Monitoring of the reversing process to detect any malfunctions

MEMORY MODULE

- Internal memory that gives the measurement a memory to detect long-term trends or drifts and to compare the current readings with values from the past

HEATED OXYGEN SENSORS FOR EXTRACTIVE MEASUREMENTS

MEASURING PRINCIPLE



Working principle of heated oxygen sensor

1. Oxygen sensor
2. Catalytic mass
3. Flow direction of the gas to be examined
4. Measurement chamber
5. Heating coil

WORKING PRINCIPLE

- The gas to be investigated is heated and catalytically decomposed.
- The heated oxygen sensor measures the oxygen content after reaction at equilibrium and provides information about the gas to be examined.
- Several sampling points can be monitored with just one sensor.

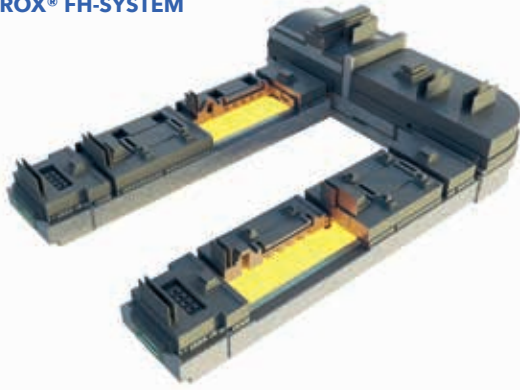
FEATURES OF EUROX® FH- / TB-SYSTEM

- Stable structure and low maintenance even in harsh conditions
- Lifespan up to six years depending on conditions
- Quick response and high precision also in near-stoichiometric conditions
- Up to 12 sampling points can be inspected with just one sensor. However, the recommendation for the maximum number of measuring points in the tin bath is six.
- Fast installation
- Every sensor is inspected and calibrated before shipment in our laboratory
- Can be offered as purchase offer or rental- and service

TECHNICAL ASPECTS OF EUROX® FH- / TB-SYSTEM

- 1000°C working temperature for a complete catalytic transformation
- Galvanic buffer amplifier with 4 - 20 mA output signal
- Alarm signals for temperature and pressure
- Measuring gas extraction with flowmeter
- Power supply: 230 VAC/ 50Hz
- According to DIN EN 61439
- Pump capacity for extraction of measuring gas: 10 to 40 l/h
- Integrated flame trap
- Visualisation, evaluation and controlling is done via Siemens-based multifunctional unit OM-4

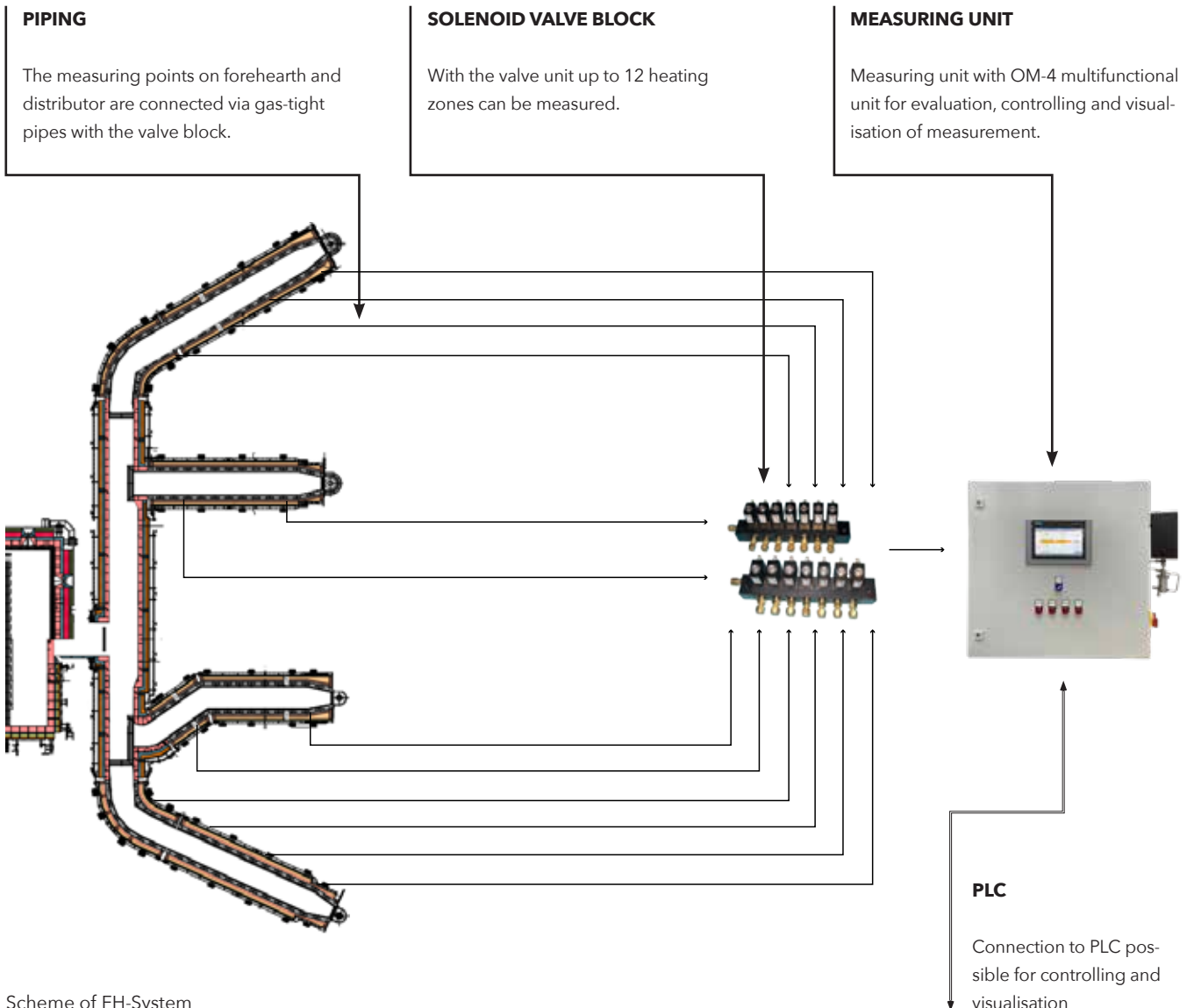
EUROX® FH-SYSTEM



Glass conditioning system - distributor and forehearths

WHY USE AN OXYGEN-SENSOR ON A GLASS CONDITIONING SYSTEM?

The atmosphere in distributor and forehearth has strong influence on the redox state of the glass. There are numerous factors influencing the atmosphere, such as air leakage from various openings or leaks. However the setting and stability of the fuel gas / air mixture for zone heating has an important influence, but there are a lot of influences which affect the combustion condition defined by the mixing ratio. To attain a constant combustion condition for a stable glass quality despite fluctuating heating values, changing oxygen concentration in ambivalent air or other influences, it is recommendable to examine the fuel gas / air mixture.

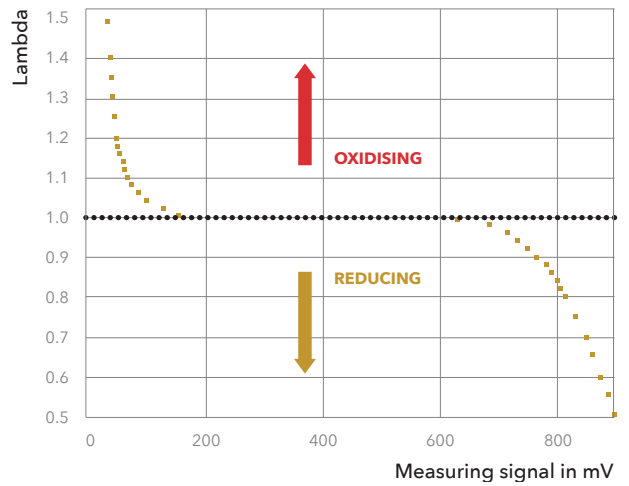


EUROX® FH-SYSTEM FOR FOREHEARTH AND WORKING END

Air/gas-premixes for all monitored zones are analysed. Results can either be visualised or the gas/air-ratio can be controlled, with additional HORN equipment, so a stable combustion condition in all monitored zones can be reached.

Lambda is calibrated from 0.5 to 1.5. In this range the oxygen content in the premixed gas is calculated.

Calibration on air is not necessary.



Calibration curve of EUROX® FH-System - premixed gas measurements at glass conditioning systems.

Every sensor is calibrated with a fuel gas / air mixture to check its functionality but also to obtain an even higher degree of measurement accuracy. For each sensor its respective calibration curve is stored in the program.



Visualisation of FH-System

SENSOR TEMPERATURE IN °C, CELL VOLTAGE IN mV

- Standard values of the measurement
- Output from sensor

O₂ CONTENT IN PREMIXED GAS IN %

- Calculated oxygen content in the premixed gas before firing

MEMORY MODULE

- Internal memory that gives the measurement a memory to detect long-term trends or drifts and to compare the current readings with values from the past

MEASUREMENT VISUALISATION

Depending on the number of heating zones the visualisation is adapted.

All relevant and evaluated values are visualised.

MEASUREMENT EVALUATION

Depending on the application, different values and alignments can be presented:

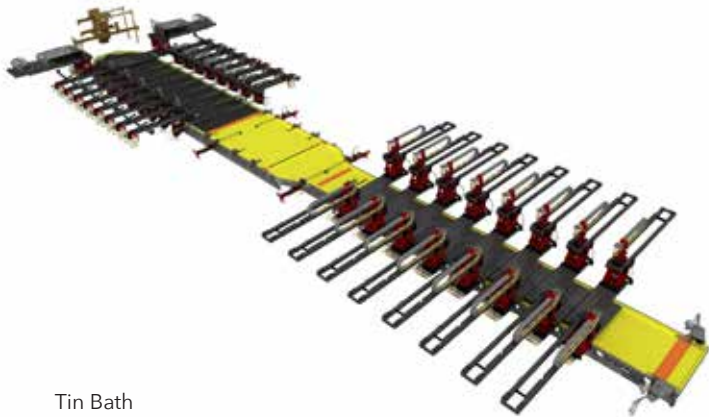
LAMBDA

- Lambda value of the actual combustion condition when firing the premixed gas

SELF-CHECK MODULE

- Various internal checks and monitored values to prevent malfunctions of the measuring system

EUROX® TB-SYSTEM



Tin Bath

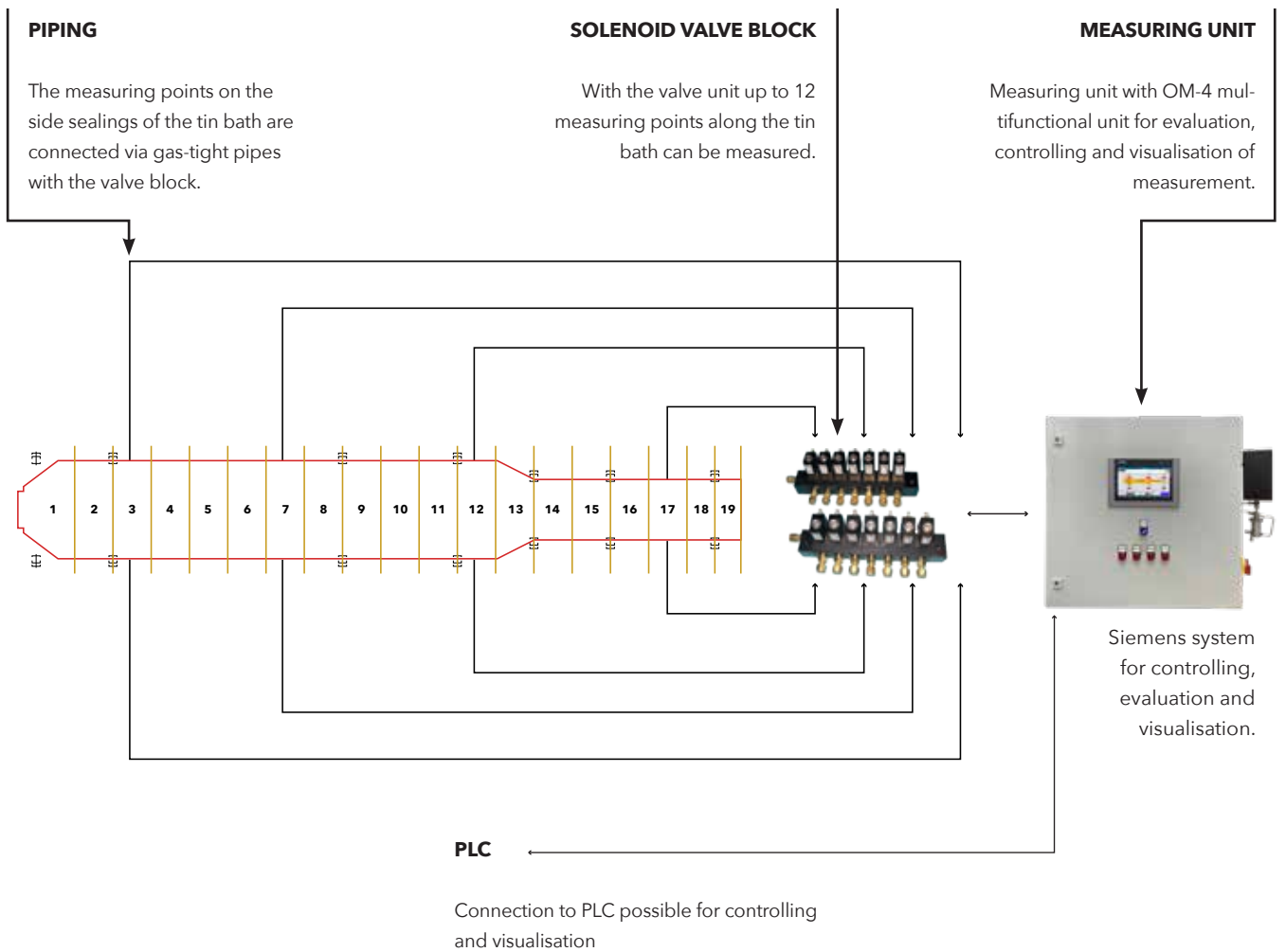
WHY SHOULD YOU USE AN OXYGEN SENSOR IN YOUR TIN BATH?

Oxygen enters the tin bath through leaks but also with the glass. Too much oxygen leads to a high degree of oxidation of the liquid tin and thus to glass defects.

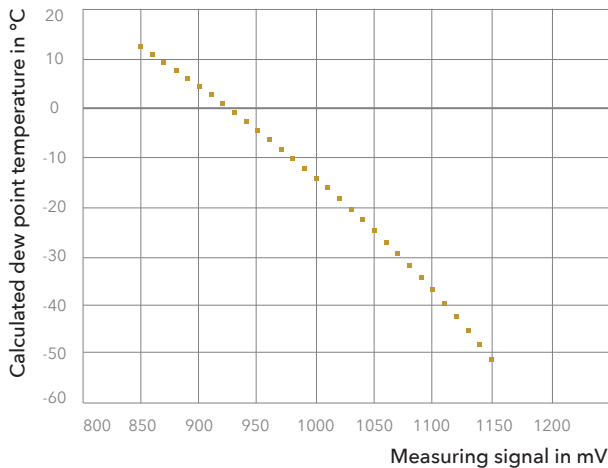
An inert gas atmosphere protects the liquid tin from oxidation but a high degree of protection increases operating costs.

Continuous monitoring of the tin bath atmosphere enables safe operation of the tin bath and timely detection of malfunctions.

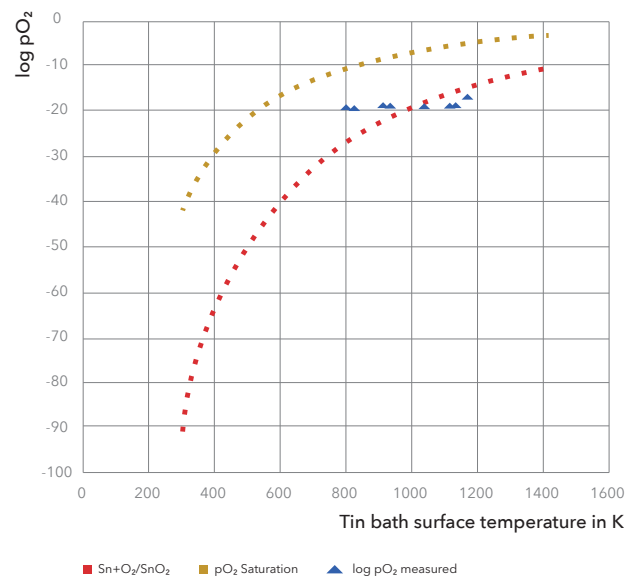
Because of historical reasons the dew point of the atmosphere is detected in the tin bath. This is an indirect indication of the oxygen content in the atmosphere.



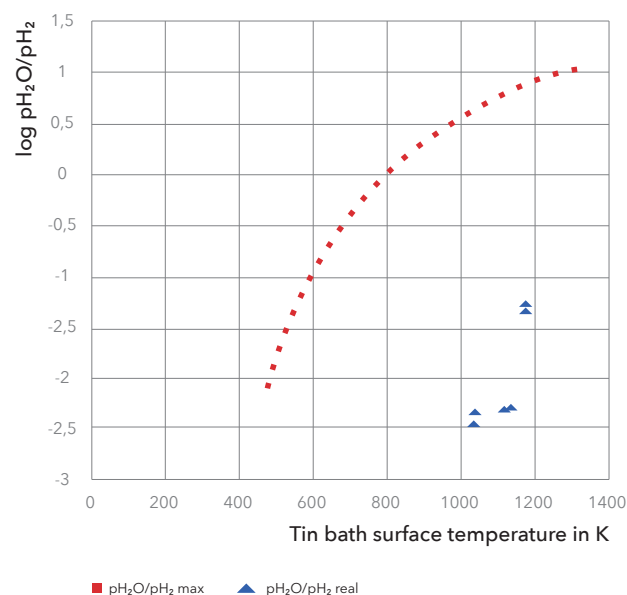
Scheme of TB-System



Relationship between measuring signal and dew point temperature



Comparison of equilibrium lines and real measured oxygen partial pressures



Maximum and real determined water content related to hydrogen content

EUROX® TB-SYSTEM FOR TIN BATHS

Measuring points are located at selected points along the whole tin bath, so the condition of the tin bath can be analysed over its entire length.

The EUROX® measuring system describes the condition of the tin bath on the basis of several characteristic values.

DEW POINT TEMPERATURE IN TIN BATH ATMOSPHERE

Based on the hydrogen - oxygen / water equilibrium the dew point temperature is determined.

Determination is also based on empirical data. Each sensor is calibrated by a defined test.

OXIDATION - STATE

The oxygen partial pressure in the tin bath atmosphere is measured and related to temperature dependent tin/tin oxide equilibrium curves. This indicates the degree of oxidation of the tin bath surface.

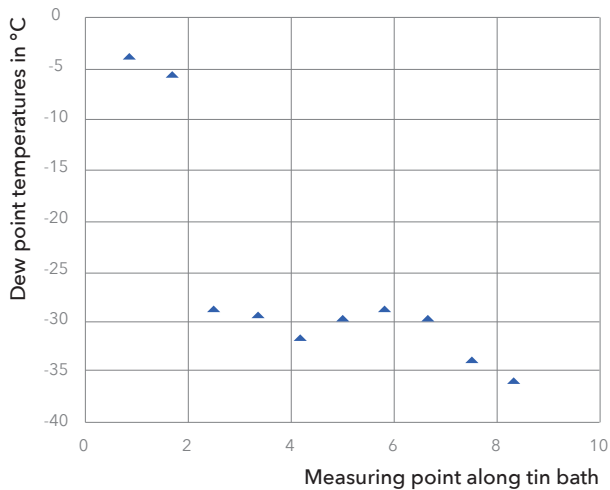
The oxidation - state is defined as 1 on the tetravalent tin / tin oxide equilibrium curve. When the measured oxygen partial pressure is higher than the tetravalent equilibrium curve, then also the oxidation state is higher than 1.

HYDRO - STATE

Hydrogen in the atmosphere does not only reduce the oxygen in the atmosphere, it can also reduce tin oxide to tin and water. The quotient water to hydrogen is a measure of the potential of this reaction.

The water content in the atmosphere can be calculated and related to the H₂ content. So the Hydro - State is defined.

This indicates a reasonable range of the H₂ content, but also gives an indication about the water content in the tin bath and thus also about the dissolved water content in the liquid tin. If the measured quotient is equal to the temperature dependent maximum, the state is by definition equal to one. If it is less, then it is less than 1.

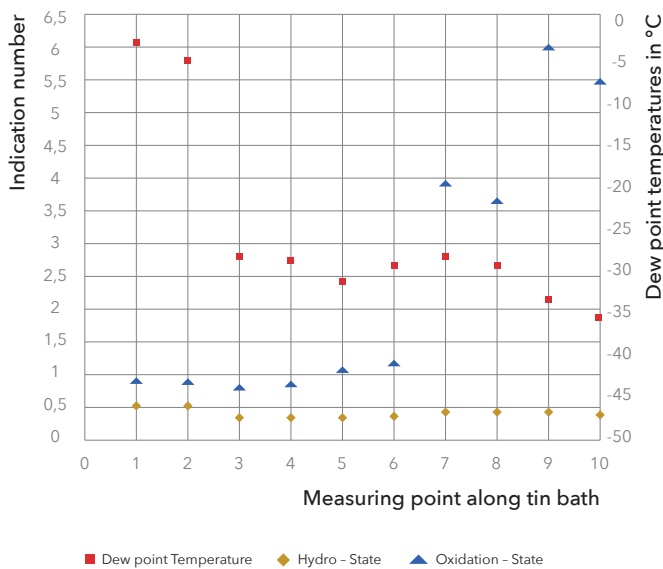


Real measured dew point temperatures in tin bath

REAL MEASURED DEW POINT TEMPERATURES ALONG A TIN BATH

The calculated dew point temperatures along the tin bath in this example were confirmed by comparative measurements.

At measuring point 1 and 2, which correspond to measuring points at the glass entry into the tin bath, higher dew point temperatures were determined than in the rest of the tin bath. A leak in the tin bath was discovered there.



Comparison of all indication numbers of EUROX® TB-System

INDICATOR NUMBERS OF TIN BATH MONITORING

All three characteristic values are compared according to their measurement location. If the dew point at the beginning of the tin bath indicates an air ingress, the oxidation - state shows that no significant oxidation of the tin bath takes place due to the high temperature in this area.

At the other end of the tin bath, however, the degree of oxidation is increased, which is mainly due to the low temperature.

However, the fact that the hydro-state is far below 1 in the entire tin bath shows that the protection of the liquid tin is given and could even be reduced somewhat, which would have a positive effect on the operating costs.



Visualisation of TB-System

SENSOR TEMPERATURE IN °C, CELL VOLTAGE IN mV

- Standard values of the measurement
- Output from sensor

OXIDATION - STATE

- Indication number for the amount of oxygen in the tin bath atmosphere
- Gives an indication of the degree of oxidation of the tin

SELF-CHECK MODULE

- Various internal checks and monitored values to prevent malfunctions of the measuring system

MEASUREMENT VISUALISATION

Depending on the amount of measuring points along the tin bath the visualisation is adapted.

All relevant and evaluated values are visualised.

MEASUREMENT EVALUATION

Depending on the application, different values and alignments can be presented:

DEW POINT TEMPERATURE

- Calculated dew point temperature of each measuring point along the tin bath

HYDRO - STATE

- Indication number for the reduction of tin oxide by hydrogen
- Gives an indication of the correct amount of H₂ in the atmosphere

MEMORY MODULE

- Internal memory that gives the measurement a memory to detect long-term trends or drifts and to compare the current readings with values from the past

PORTABLE EUROX® MEASUREMENT SYSTEMS FOR EXTRACTIVE MEASUREMENTS

FOR PREMIXED GAS MEASUREMENTS AT GLASS CONDITIONING SYSTEMS AND TIN BATH MONITORING AT FLOAT GLASS PLANTS

FEATURES OF PORTABLE EUROX® MEASURING SYSTEM

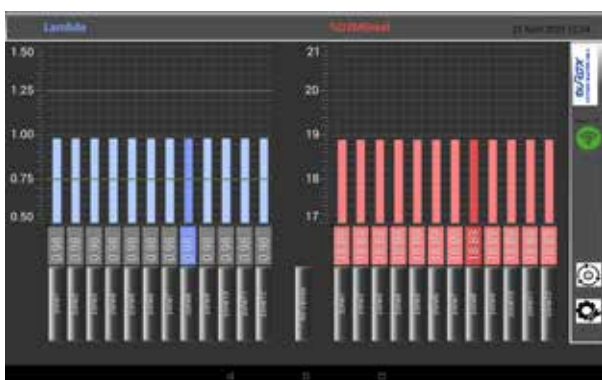
- "Plug and play"
- Six sampling points can be inspected
- Easy and quick setting of gas mixing station for premixed gas measurements in glass conditioning systems
- Flexible measurements in tin bath
- Visualisation, measurement control and data storage via integrated OM-4 multifunctional unit
- Additional visualisation via convertible notebook or any mobile device which can be connected via integrated WiFi interface
- The portable EUROX® measuring system for extractive measurements can be offered as purchase offer or rental- and service



Portable measurement system

MEASUREMENT VISUALISATION

- Depending on the application all relevant values are visualised
- Switching between the sampling points via convertible notebook or any mobile device is possible
- Storage function for measured values
- Using mobile devices enables a mobile visualisation of all investigated points



Visualisation of portable measurement system

TECHNICAL ASPECTS OF THE PORTABLE EUROX® MEASURING SYSTEM

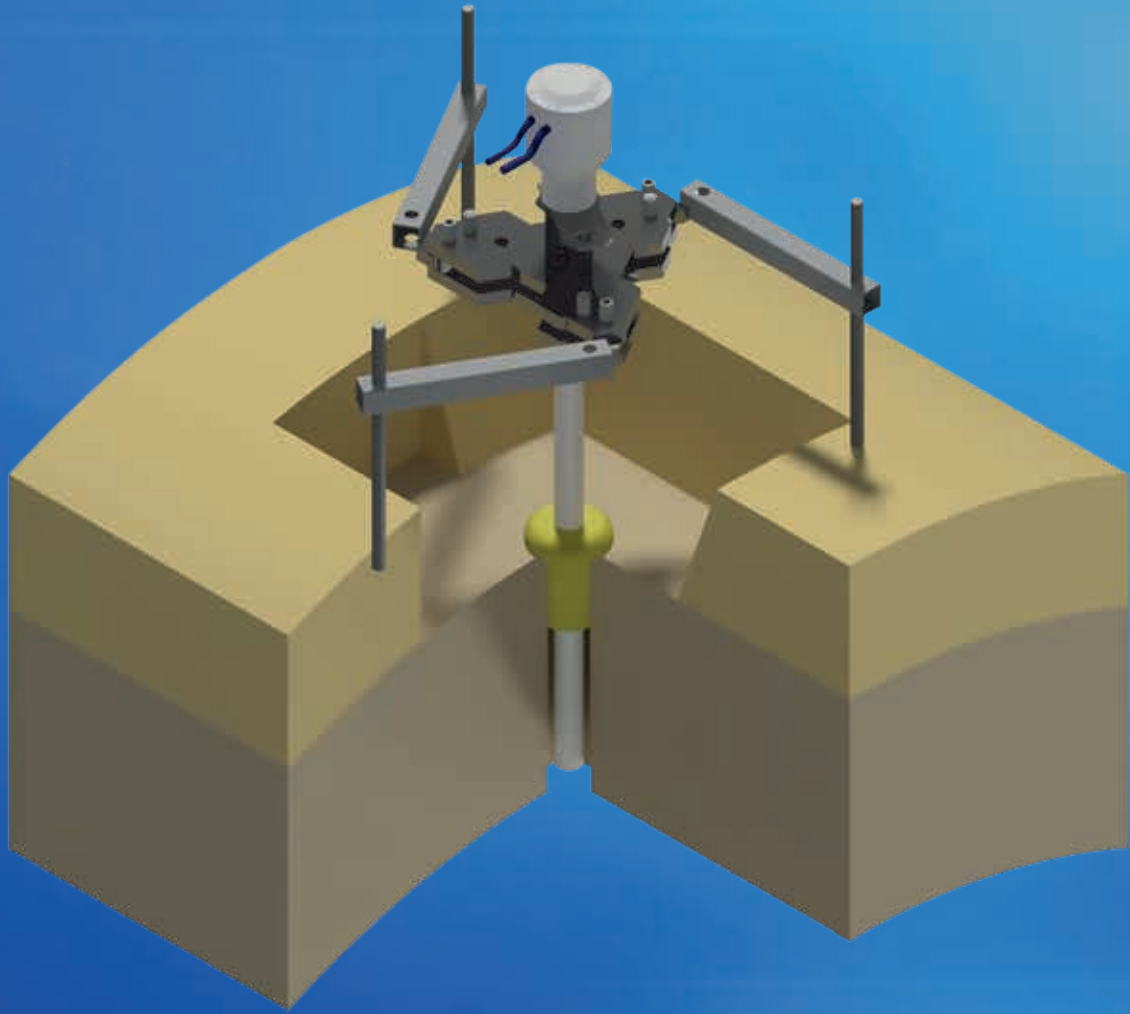
Solenoid valve unit with 6 valves, Siemens-based multifunctional unit OM-4 with WiFi-interface and heated oxygen sensor with related equipment included in one portable box.

Convertible notebook and connection tube for gas extraction included in scope of delivery.

Standard power supply: 230 VAC/50Hz.

REFERENCES





euRoX

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