Transmitted light process refractometer

For a wide range of applications in the field of hygiene

Features

- Unique transmitted light refractometer for process analysis
- High accuracy and drift-free due to difference measurement
- No minimum flow velocity required for reliable measurement
- Immune to pressure and temperature fluctuations
- Integrated fluid temperature measurement
- Sapphire optics with high chemical resistance and mechanical durability
- Optical system insensitive to deposits
- Internal self-diagnosis and detection of errors
- Stainless steel and no dead space sensors for one-sided pipe access
- Use in explosive atmospheres feasible
- Sensor calibration microcontroller-controlled and independent of the transmitter
- Digital data transmission between transmitter and sensor
- Configurable data logger
- Remote parameterizing via USB/LAN
- Support of numerous fieldbus systems
- Process connections Varivent and Tri-Clamp are compatible for a wide range of pipe and vessel dimensions
- Library for approx. 50 typical analysis applications available, customized fluid data sets can also be provided
- Typical analysis outputs like Brix, M%, Vol%, g/l, operating density, laboratory density selectable
- Analysis of multi-component mixtures possible using additional measurement parameter, e.g. density, conductance, sound speed
## Measurement principle
Refractive index
Measurement with refractometer PIOX R.

## Measuring setup
Transmitter
Technical data
Dimensions
2” pipe mounting kit
Storage
Terminal assignment

## Sensor
Technical data
Dimensions
Sensor mounting positions
Connection
Sensor order code
**Measurement principle**

**Refractive index**

The refractive index $n$ of a solution is determined using transmitted light refractometry. A light beam propagates through the solution and is refracted at the interface of a prism. The angle of refraction is measured by a detector. The refractive index $n$ of the solution is calculated from the angle of refraction using Snell's law of refraction:

$$n_i \cdot \sin \theta_i = n_t \cdot \sin \theta_t$$

where

- $n_i$ - refractive index of fluid
- $\theta_i$ - angle of incidence
- $n_t$ - refractive index of prism
- $\theta_t$ - angle of refraction

**Measurement with refractometer PIOX R**

**Sensor**

A special LED with a wavelength $\lambda = 590$ nm (sodium D line) is used as the light source. The light passes through a slit, is parallelised by a lens and reversed by a deviating prism. Then it enters the fluid through a window in the sensor head. When the light beam re-enters the sensor, it is split at the apex of a measuring prism and refracted at its lateral surfaces. The two resulting measuring beams are focused by a lens, generating sharp slit images on the image sensor.

The angle of refraction is determined from the difference between the two images of the slit. The zero point is calculated continuously in order to compensate for the influences of the process pressure and temperature.

The refractive index $n_D$ is calculated from the angle of refraction between the measuring prism and the fluid. Furthermore, the following values can be measured:

- fluid temperature measured by the integrated temperature probe Pt1000
- diagnostic values (e.g., gain, amplitude, quality, symmetry) resulting from extended signal processing
- sensor humidity and temperature
Processing in the transmitter
The transmitter calculates application-specific analysis quantity such as M%, Vol%, g/l, nDT (temperature-compensated refractive index), operating density, laboratory density, Brix value either with standardised fluid data sets from the library or with customised ones.

The transmitter can be equipped with electrical inputs, allowing for the input of additional available fluid quantities, e.g. sound speed, density or conductance, and using them for the measurement of three-component mixtures.

Dependence on temperature and concentration
As well as the density, the refractive index of a fluid depends on the temperature and concentration. In the majority of aqueous solutions, the refractive index increases with rising concentration (temperature = constant) and decreases with rising temperature (concentration = constant).
Measuring setup

**nonEx**

- Transmitter: PIOX R721**-NNN**
- Sensor: PIOX R500
- Sensor cable, max. 200 m

**ATEX/IECEEx**

- Transmitter: PIOX R721**-A2A**
- Sensor: PIOX R500 (FM)
- Sensor cable, max. 200 m
- Zone: 2, 21
- Zone 0, 20

**FM**

- Transmitter: PIOX R721**-F2N**
- Sensor: PIOX R500 (FM)
- Sensor cable, max. 200 m
- Div. 2
- Div. 1
## Transmitter Technical data

<table>
<thead>
<tr>
<th></th>
<th>PIOC R721**-NNN**-1A</th>
<th>PIOC R721**-NNN**-1S</th>
<th>PIOC R721**-A2A**-1S</th>
<th>PIOC R721**-F2N**-1S</th>
</tr>
</thead>
</table>

### design
- **standard field device**
- **field device with stainless steel housing**
- **field device with stainless steel housing zone 2**
- **field device with stainless steel housing FM Class I Div. 2**

### power supply
- 100...230 V/50...60 Hz or 20...32 V DC
- 20...32 V DC
- 20...32 V DC

### power consumption
- W < 15
- 1

### number of measuring channels
- 1

### damping
- s 0...100 (adjustable)
- 1

### response time
- s

### housing material
- aluminum, powder coated
- stainless steel 316L (1.4404)

### degree of protection
- IP66
- IP66
- IP66
- IP65

### dimensions
- mm

### weight
- kg 5.4
- 5.1

### fixation
- wall mounting, optional: 2“ pipe mounting

### ambient temperature
- °C -40...+60 (< -20 without operation of the display)
- -40...+60 (< -20 without operation of the display)
- -20...+60

### display
- 128 x 64 dots, backlight

### menu language
- English, German, French, Spanish, Dutch, Russian, Polish

### explosion protection
- **ATEX/IECEx**
- R721RI-A2A1S: IIC T4 Gc
- Ex ec nC ic [ia Ga] II2D T4 Gc
- IECEx 10.0003X

### intrinsic safety
- parameters
- U_m = 120 V

### measuring functions
- physical quantities
- diagnostic functions

### communication interfaces
- service interfaces
- process interfaces
- max. 1 option:
  - Modbus RTU
  - HART
  - Modbus TCP

### accessories
- data transmission kit
- software
- USB cable
- FluxDiagReader: reading of measured values and parameters, graphical representation
- FluxDiag (optional): reading of measurement data, graphical representation, report generation, parametrisation of the transmitter

### data logger
- loggable values
- all physical quantities, totalised physical quantities and diagnostic values
- capacity
- max. 800 000 measured values

---

1 outside the explosive atmosphere (housing cover open)
Physical quantities

The available physical quantities depend on the fluid data set in the transmitter.

<table>
<thead>
<tr>
<th>fluid data set</th>
<th>physical quantities</th>
<th>remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>no fluid data set</td>
<td>refractive index, fluid temperature, °Brix, wt% (saccharose)</td>
<td></td>
</tr>
<tr>
<td>SSF</td>
<td>refractive index, fluid temperature, °Brix, wt% (saccharose), concentration</td>
<td>application-specific fluid data set from FLEXIM database</td>
</tr>
<tr>
<td>SCF</td>
<td>refractive index, fluid temperature, °Brix, wt% (saccharose), further customised physical quantities</td>
<td>data set developed by FLEXIM in cooperation with the customer</td>
</tr>
</tbody>
</table>
Dimensions

R721**-*****-A

- Dimensions in mm:
  - Width: 320 mm
  - Height: 255 mm
  - Depth: 94 mm

- Wall mount:
  - 9 x 5 in mm
  - ø6.2

- Thread: 6x M20 x 1.5

R721**-*****-S

- Dimensions in mm:
  - Width: 255 mm
  - Height: 190.2 mm
  - Depth: 93 mm

- Wall mount:
  - 9 x 5 in mm
  - ø6.2

- Fixing holes for wall mounting:
  - 240

- Cable gland: M20 with flat gasket and counter nut
  - 4x opening for cable gland M20 with flat gasket and counter nut

in mm
2" pipe mounting kit

**Storage**
- do not store outdoors
- store within the original package
- store in a dry and dust-free place
- protect against sunlight
- keep all openings closed
- storing temperature: -20...+60 °C
Terminal assignment

**power supply**

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Connection (AC)</th>
<th>Connection (DC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE</td>
<td>protective conductor</td>
<td>protective conductor</td>
</tr>
<tr>
<td>N(-)</td>
<td>neutral conductor</td>
<td>-</td>
</tr>
<tr>
<td>L(*)</td>
<td>outer conductor</td>
<td>+</td>
</tr>
</tbody>
</table>

**transducers**

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Transducer cable</th>
</tr>
</thead>
<tbody>
<tr>
<td>V+</td>
<td>yellow</td>
</tr>
<tr>
<td>V-</td>
<td>green</td>
</tr>
<tr>
<td>A+</td>
<td>brown</td>
</tr>
<tr>
<td>B-</td>
<td>white</td>
</tr>
</tbody>
</table>

**outputs**

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Connection</th>
<th>Terminal</th>
<th>Connection</th>
<th>Communication Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1+...P4+</td>
<td>current output, voltage output</td>
<td>A+</td>
<td>signal +</td>
<td>* Modbus RTU¹</td>
</tr>
<tr>
<td>P1-...P4-</td>
<td></td>
<td>B-</td>
<td>signal -</td>
<td>* HART¹</td>
</tr>
<tr>
<td>P5a...P7a</td>
<td>digital output</td>
<td>S</td>
<td>shield</td>
<td></td>
</tr>
<tr>
<td>P5b...P7b</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**analog inputs**

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Temperature probe</th>
<th>Passive sensor</th>
<th>Active sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1a...T4a</td>
<td>not connected</td>
<td>not connected</td>
<td></td>
</tr>
<tr>
<td>T1A...T4A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1b...T4b</td>
<td>+</td>
<td>not connected</td>
<td></td>
</tr>
<tr>
<td>T1B...T4B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S1, S3</td>
<td>not connected</td>
<td>not connected</td>
<td></td>
</tr>
</tbody>
</table>

¹ cable (by customer): e.g. flexible wires, with insulated wire ferrules, wire cross-section: 0.25...2.5 mm²

² The number, type and terminal assignment are customised.
## Technical specification

### PIOX R721/R500

#### Sensor

### Technical data

<table>
<thead>
<tr>
<th></th>
<th>R500</th>
<th>R500A1</th>
<th>R500 (FM)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>process parameters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>fluid</strong></td>
<td>all liquids with a turbidity &lt; 10 000 FAU</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>fluid temperature</strong></td>
<td>-20...+150</td>
<td>-20...+130</td>
<td></td>
</tr>
<tr>
<td>(depending on ambient temperature)</td>
<td>(150 °C at an ambient temperature of 20 °C)</td>
<td>(150 °C at an ambient temperature of 20 °C)</td>
<td></td>
</tr>
<tr>
<td><strong>fluid pressure</strong></td>
<td>PN 10</td>
<td></td>
<td>150 psi</td>
</tr>
<tr>
<td><strong>measurement</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>measurement principle</strong></td>
<td>transmitt light refractometry</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>measuring range</strong></td>
<td>nD: 1.3...1.7</td>
<td>nD: 0.000 2</td>
<td>nD: 0.000 02</td>
</tr>
<tr>
<td><strong>accuracy (absolute)</strong></td>
<td>°Brix: 0...100</td>
<td>(corresponds to 0.1°Brix, typically 0.1 wt%)</td>
<td>(corresponds to 0.01 °Brix, typically 0.01 wt%)</td>
</tr>
<tr>
<td><strong>resolution (display)</strong></td>
<td>nD: 0.000 001</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>material</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>housing</strong></td>
<td>stainless steel 304 (1.4301)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>wetted parts</strong></td>
<td>stainless steel 316L (1.4404)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>gaskets</strong></td>
<td>EPDM</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>prism</strong></td>
<td>sapphire, nD = 1.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>degree of protection</strong></td>
<td>IP54, wetted parts: IP67</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>flange</strong></td>
<td>for Varivent (N) or Tri-Clamp 3&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>dimensions</strong></td>
<td>see dimensional drawing</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>weight</strong></td>
<td>kg</td>
<td></td>
<td>min. 2</td>
</tr>
<tr>
<td><strong>ambient temperature</strong></td>
<td>°C</td>
<td></td>
<td>-40...+70</td>
</tr>
<tr>
<td><strong>explosion protection</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ATEX/IECEx</strong></td>
<td></td>
<td>IBExU06ATEX1075 X,</td>
<td></td>
</tr>
<tr>
<td><strong>FM</strong></td>
<td></td>
<td>IECEx IBE 10.0003X</td>
<td></td>
</tr>
<tr>
<td><strong>temperature probe</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>type</strong></td>
<td>PT1000</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>resolution</strong></td>
<td>K</td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td><strong>accuracy at 20 °C</strong></td>
<td>K</td>
<td></td>
<td>0.15</td>
</tr>
<tr>
<td><strong>response time</strong></td>
<td>s</td>
<td></td>
<td>5</td>
</tr>
</tbody>
</table>
Dimensions

R500-MH, Varivent connection

R500-MH, Tri-Clamp connection

Sensor mounting positions

The pipe always has to be completely filled. The preferred flow direction is upward, in exceptional cases downward.
Connection

Terminal assignment

<table>
<thead>
<tr>
<th>terminal</th>
<th>connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>yellow</td>
</tr>
<tr>
<td>-</td>
<td>green</td>
</tr>
<tr>
<td>X+</td>
<td>brown</td>
</tr>
<tr>
<td>B-</td>
<td>white</td>
</tr>
<tr>
<td>S</td>
<td>shield</td>
</tr>
</tbody>
</table>

equipotential bonding terminal on housing cover

Sensor cable

<table>
<thead>
<tr>
<th></th>
<th>R500</th>
<th>R500A1</th>
</tr>
</thead>
<tbody>
<tr>
<td>item number</td>
<td>TR10126</td>
<td>TR10125</td>
</tr>
<tr>
<td>type</td>
<td>LIYCY 2 x 2 x 0.75 grey</td>
<td>EB CY 2x2x0.75</td>
</tr>
<tr>
<td>length m</td>
<td>max. 200</td>
<td>max. 200</td>
</tr>
<tr>
<td>weight kg/m</td>
<td>approx. 0.106</td>
<td>approx. 0.106</td>
</tr>
<tr>
<td>ambient temperature °C</td>
<td>-40...+80</td>
<td>-40...+80</td>
</tr>
<tr>
<td>properties</td>
<td>flame retardant according to IEC 60332-1-2</td>
<td>flame retardant according to IEC 60332-1-2</td>
</tr>
<tr>
<td>cable jacket</td>
<td>PVC</td>
<td>PVC</td>
</tr>
<tr>
<td>outer diameter mm</td>
<td>8.5</td>
<td>8.7</td>
</tr>
<tr>
<td>colour</td>
<td>grey</td>
<td>blue</td>
</tr>
<tr>
<td>shield</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>measurement principle</td>
<td>type</td>
<td>type of construction</td>
</tr>
<tr>
<td>------------------------</td>
<td>------</td>
<td>----------------------</td>
</tr>
<tr>
<td>R</td>
<td>500</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

1 process connection by customer