

Transmitted light process refractometer

For a wide range of applications in the field of chemistry

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 carbon-fiber reinforced PTFE sensors available
- 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 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 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



Sensor PIOX R500-*C



PIOX R721**-****-*A



PIOX R721**-****-*S

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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

θ_i - angle of incidence

n_t - refractive index of prism

θ_t - angle of refraction

Measurement with refractometer PIOX R

Sensor

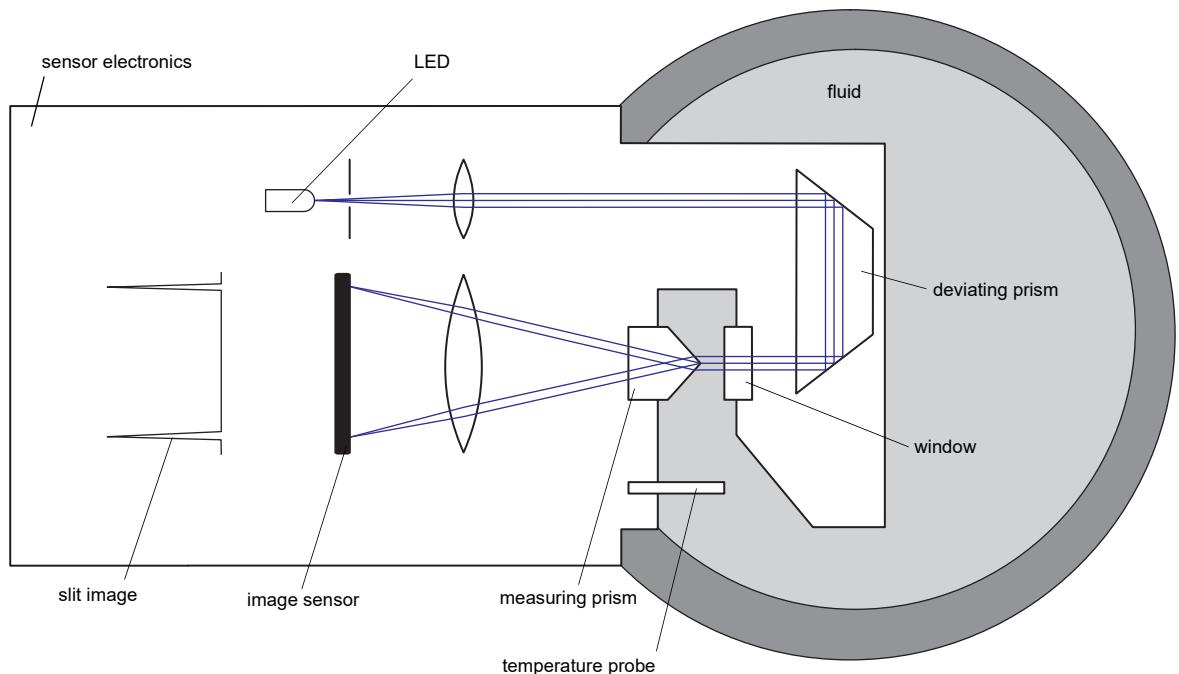
A special LED with a wave length $\lambda = 590$ nm (sodium D line) is used as the light source. The light passes through a slit, is parallelised by a lens and reversed by a deviating prism. Then it enters the fluid through a window in the sensor head. When the light beam re-enters the sensor, it is 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



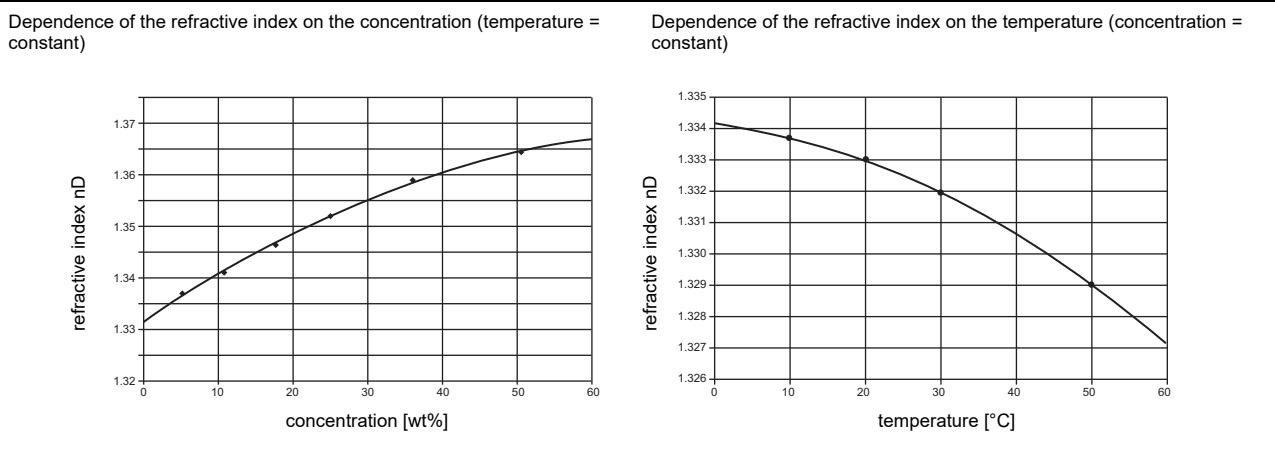
Processing in the transmitter

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.

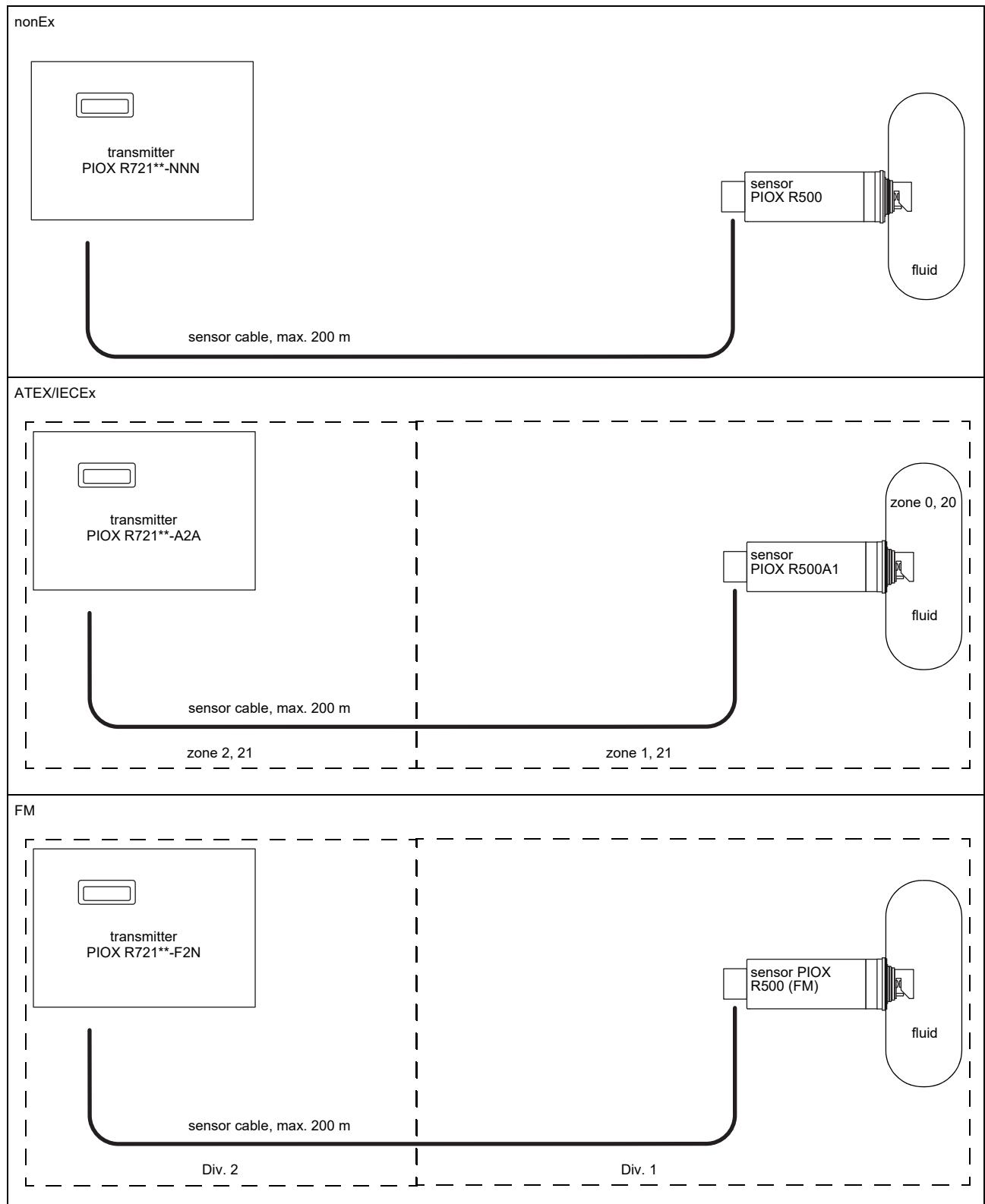
The transmitter can be equipped with electrical inputs, allowing for the input of additional available fluid quantities, e.g. sound speed, density or conductance, and using them for the measurement of three-component mixtures.

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



Transmitter

Technical data

	PIOX R721**-NNN**-1A	PIOX R721**-NNN**-1S	PIOX R721**-A2A**-1S	PIOX R721**-F2N**-1S
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
transmitter				
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			
number of measuring channels	1			
damping s	0...100 (adjustable)			
response time s	1			
housing material	aluminum, powder coated	stainless steel 316L (1.4404)		
degree of protection	IP66	IP66	IP66	IP65
dimensions mm	see dimensional drawing			
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)	-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				
marking	-	-	R721RI-A2A1S: II(1)3G CE 0637 Ex I(M1) II(1)2D Ex ec nC ic [ia Ga] IIC T4 Gc [Ex ia Ma] I Ex tb [ia Da] IIIC T120 °C Db Ta -40...+60 °C	-
certification	-	-	IBExU06ATEX1075 X, IECEx IBE 10.0003X	-
intrinsic safety parameters	-	-	U _m = 120 V	-
• FM				
marking	-	-	-	R721RI-F201S: Cl. I,II,III/Div. 2/ GP. A,B,C,D,F,G T5 -20 °C to +60 °C
measuring functions				
physical quantities	see table below			
diagnostic functions	signal amplitude, sensor humidity, sensor temperature			
communication interfaces				
service interfaces	measured value transmission, parametrisation of the transmitter: • USB ¹ • LAN ¹			
process interfaces	max. 1 option: • Modbus RTU • HART • Modbus TCP			
accessories				
data transmission kit	USB cable			
software	• 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)

		PIOX R721**-NNN**-1A	PIOX R721**-NNN**-1S	PIOX R721**-A2A**-1S	PIOX R721**-F2N**-1S	
outputs						
		The outputs are galvanically isolated from the transmitter.				
number		on request				
• switchable current output						
		All switchable current outputs are jointly switched to active or passive.				
range	mA	4...20 (3.2...22)				
accuracy		0.04 % MV \pm 3 μ A				
active output		$R_{ext} < 250 \Omega$				
passive output		$U_{ext} = 8...30$ V, depending on R_{ext} ($R_{ext} < 1$ k Ω at 30 V)				
• voltage output						
range	V	0...1 or 0...10				
accuracy		0...1 V: 0.1 % MV \pm 1 mV 0...10 V: 0.1 % MV \pm 10 mV				
internal resistance		$R_{int} = 500 \Omega$				
• digital output						
functions		<ul style="list-style-type: none"> • frequency output • binary output • pulse output 				
number		3				
		5...30 V/ < 100 mA				
frequency output						
• range	kHz	0...5				
binary output						
• binary output as alarm output		limit, change of flow direction or error				
pulse output						
• pulse value	units	0.01...1000				
• pulse width	ms	0.05...1000				
inputs						
		The inputs are galvanically isolated from the transmitter.				
number		max. 4, on request				
• temperature input						
type		Pt100/Pt1000				
connection		4-wire				
range	°C	-150...+560				
resolution	K	0.01				
accuracy		± 0.01 % MV ± 0.03 K				
• current input						
accuracy		0.1 % MV ± 10 μ A				
active input		$I_{int} = 24$ V, $R_{int} = 50 \Omega$, $P_{int} < 0.5$ W, not short-circuit proof				
• range	mA	0...20				
passive input		$R_{int} = 50 \Omega$, $P_{int} < 0.3$ W				
• range	mA	-20...+20				
• voltage input						
range	V	0...1				
accuracy		0.1 % MV ± 1 mV				
internal resistance		$R_{int} = 1$ M Ω				

¹ outside the explosive atmosphere (housing cover open)

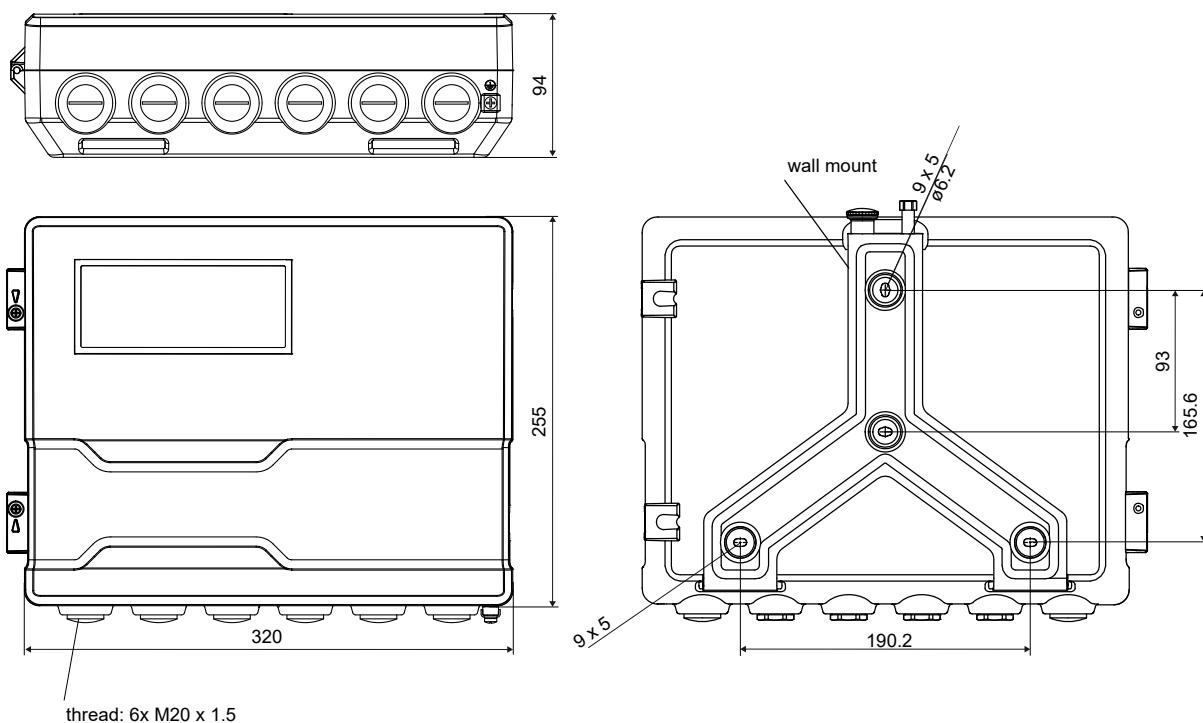
Physical quantities

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

fluid data set		physical quantities	remark
	no fluid data set	refractive index, fluid temperature, °Brix	
SSF	standard fluid data set	refractive index, fluid temperature, °Brix, concentration	application-specific fluid data set from FLEXIM database
SCF	customised fluid data set	refractive index, fluid temperature, °Brix, further customised physical quantities	data set developed by FLEXIM in cooperation with the customer

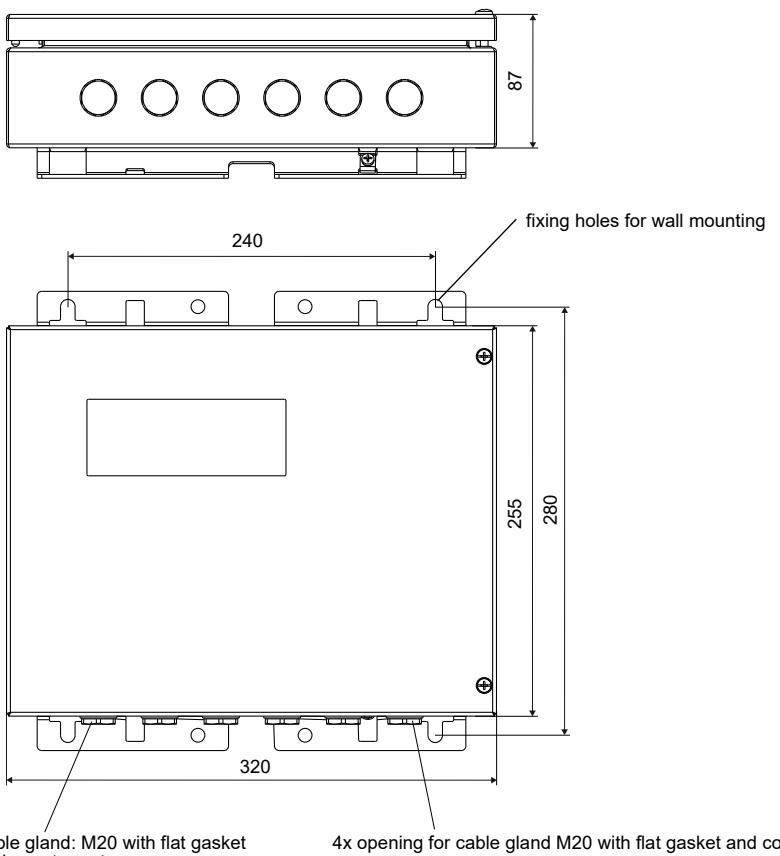
Dimensions

R721**-****-*A



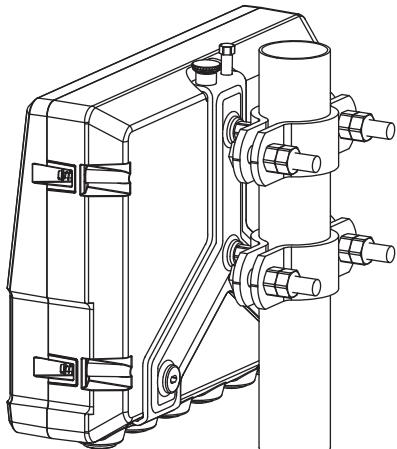
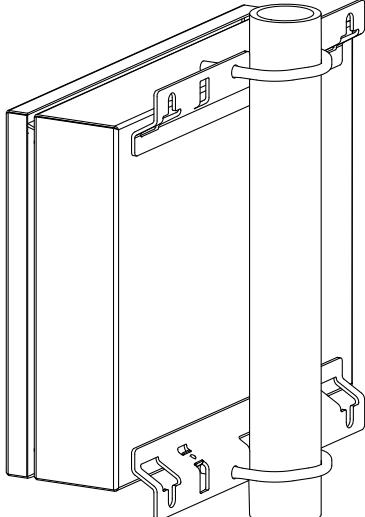
in mm

R721**-****-*S



in mm

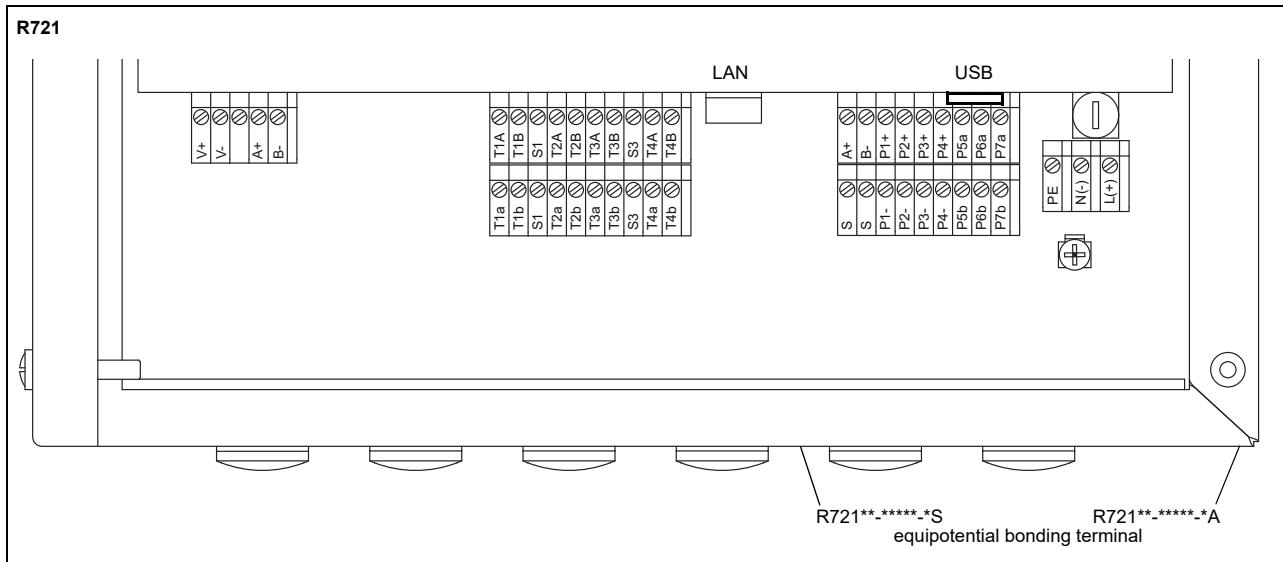
2" pipe mounting kit

*72***-****-*A		item number: 721037-4
*72***-****-*S		item number: 721110-4

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 supply¹

terminal	connection (AC)	connection (DC)
PE	protective conductor	protective conductor
N(-)	neutral conductor	-
L(+)	outer conductor	+

transducers

terminal	transducer cable
V+	yellow
V-	green
A+	brown
B-	white

outputs^{1, 2}

terminal	connection	terminal	connection	communication interface
P1+...P4+	current output, voltage output	A+	signal +	• Modbus RTU ¹ • HART ¹
P1-...P4-		B-	signal -	
P5a...P7a P5b...P7b	digital output	S	shield	

	USB	type B Hi-Speed USB 2.0 Device	• service (FluxDiag/ FluxDiagReader)
	LAN	RJ45 10/100 Mbps Ethernet	• service (FluxDiag/ FluxDiagReader) • Modbus TCP

analog inputs^{1, 2}

terminal	temperature probe	passive sensor	active sensor
T1a...T4a		not connected	not connected
T1A...T4A		-	+
T1b...T4b		+	not connected
T1B...T4B'		not connected	-
S1, S3		not connected	not connected

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.

Sensor

Technical data

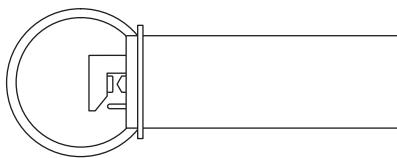
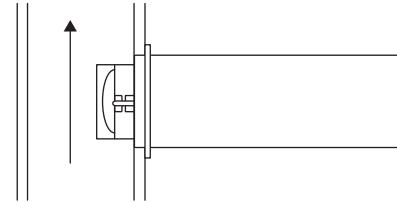
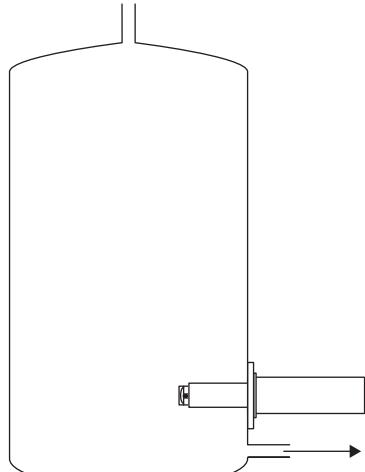
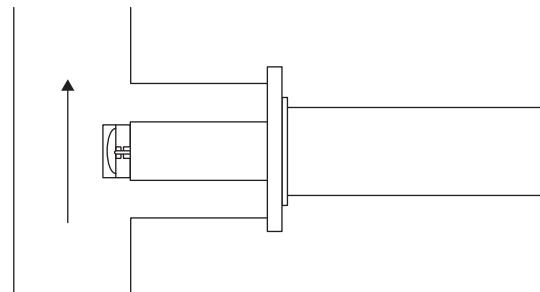
	R500	R500A1	R500 (FM)	R500	R500A1	R500 (FM)									
order code	RS1-R500-*CS4KR-NN	RS1-R500-*CS4KR-A1	RS1-R500-*CS4KR-F1	RS1-R500-*CTFKR-NN	RS1-R500-*CTFKR-A1	RS1-R500-*CTFKR-F1									
process parameters															
fluid	all liquids with a turbidity < 10 000 FAU			all liquids with a turbidity < 10 000 FAU											
fluid temperature (depending on ambient temperature)	°C -20...+150 (150 °C at an ambient temperature of 20 °C)	-20...+130		-20...+120											
fluid pressure	PN 10, PN 16, PN 40 (on request, depending on process connection)		150 psi, 300 psi	PN 10	150 psi										
measurement															
measurement principle	transmitted light refractometry			transmitted light refractometry											
measuring range	nD: 1.3...1.7			nD: 1.3...1.7											
accuracy (absolute)	nD: 0.000 2 (typically 0.1 wt%) ¹			nD: 0.000 2 (typically 0.1 wt%) ¹											
repeatability	nD: 0.000 02 (typically 0.01 wt%)			nD: 0.000 02 (typically 0.01 wt%)											
resolution (display)	nD: 0.000 001			nD: 0.000 001											
material															
housing	stainless steel 304 (1.4301)			stainless steel 304 (1.4301), epoxy-powder coated											
wetted parts	stainless steel 316Ti (1.4571) (others on request)			PTFE/carbon 25 %											
gaskets	FFKM			FFKM											
prism	sapphire, nD ≈ 1.76			sapphire, nD ≈ 1.76											
degree of protection	IP54, wetted parts: IP67			IP54, wetted parts: IP67											
flange	depending on type of construction (see sensor order code)			depending on type of construction (see sensor order code)											
dimensions	see dimensional drawing			see dimensional drawing											
weight	kg	min. 2													
ambient temperature	°C	-40...+70													
explosion protection															
• ATEX/IECEx															
marking	-	II1G CE 0637 I M1 II1D Ex ia op is IIC T4 Ga Ex ia op is I Ma Ex ia IIIC T120 °C Da Ta -40...+70 °C Tm -20...+130 °C	-	-	II1G CE 0637 I M1 II1D Ex ia op is IIC T4 Ga Ex ia op is I Ma Ex ia IIIC T120 °C Da Ta -40...+70 °C Tm -20...+130 °C	-									
certification	-	IBExU06ATEX1075 X, IECEx IBE 10.0003X	-	-	IBExU06ATEX1075 X, IECEx IBE 10.0003X	-									
• FM															
marking	-	-	APPROVED	IS, Cl. I,II,III/ Div. 1/GP. A,B,C,D, E,F,G / T4 Ta = -40°C to 70°C	-	APPROVED IS, Cl. I,II,III/ Div. 1/GP. A,B,C,D, E,F,G / T4 Ta = -40°C to 70°C									
temperature probe															
type		Pt1000													
resolution	K	0.01													
accuracy at 20 °C	K	0.15													
response time	s	5													
¹ R500-LCTF: depending on temperature and flow velocity: max. 2.5 m/s at 20 °C max. 1 m/s at 80 °C															

Dimensions

R500-MCS4, FLEXIM flange	R500-LCS4, direct flange																									
R500-MCTF																										
	<table border="1"> <thead> <tr> <th>pipe diameter</th><th>D mm</th><th>h mm</th><th>weight kg</th></tr> </thead> <tbody> <tr> <td>DN 50, 2"</td><td>Ø100</td><td>15</td><td>1.84</td></tr> <tr> <td>DN 80, 3"</td><td>Ø122</td><td>20</td><td>2.04</td></tr> </tbody> </table>	pipe diameter	D mm	h mm	weight kg	DN 50, 2"	Ø100	15	1.84	DN 80, 3"	Ø122	20	2.04													
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2"	Ø102	17	2.19	ANSI/ASME B 16.5 class 150																						
3"	Ø124	17	2.5	ASTM D 4024 BS 1560 BS EN 1759																						

in mm

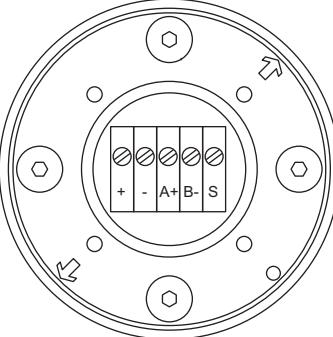
Sensor mounting positions

R500-M	
horizontal pipe	vertical pipe ¹
	
R500-L	
vessel	T-piece ¹
	 installation close to the outlet

¹ The pipe always has to be completely filled. The preferred flow direction is upward, in exceptional cases downward.

Connection

Terminal assignment

	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr style="background-color: #cccccc;"> <th style="text-align: left;">terminal</th><th style="text-align: left;">connection</th></tr> </thead> <tbody> <tr> <td>+</td><td>yellow</td></tr> <tr> <td>-</td><td>green</td></tr> <tr> <td>A+</td><td>brown</td></tr> <tr> <td>B-</td><td>white</td></tr> <tr> <td>S</td><td>shield</td></tr> </tbody> </table> <p style="margin-top: 5px;">equipotential bonding terminal on housing cover</p>	terminal	connection	+	yellow	-	green	A+	brown	B-	white	S	shield
terminal	connection												
+	yellow												
-	green												
A+	brown												
B-	white												
S	shield												

Sensor cable

	R500	R500A1
item number	TR10126	TR10125
type	LIYCY 2 x 2 x 0.75 grey	EB CY 2x2x0.75
length m	max. 200	max. 200
weight kg/m	approx. 0.106	approx. 0.106
ambient temperature °C	-40...+80	-40...+80
properties	flame retardant according to IEC 60332-1-2	
cable jacket		
material	PVC	PVC
outer diameter mm	8.5	8.7
colour	grey	blue
shield	x	x

Sensor order code

1, 2	3...5	6	7	8, 9	10, 11	12, 13	14, 15	16...18	19	20...22	no. of character	
measurement principle			type of construction	design	material (wetted parts)	gaskets	explosion protection	certification	process pressure	flange	flange size (flange = D)	description
R												transmitted light refractometer
	500											
		M										standard sensor
		L										long sensor
		C										chemistry design
			S4									stainless steel 316Ti (1.4571)
			TF									PTFE
				KR								FFKM (Kalrez)
					A1							zone 0/1
					F1							FM Class I Div. 1
					NN							not explosion-proof
						NN						-
							P10					PN 10
							P15					150 psi
							P16					PN 16
							P30					300 psi
							P40					PN 40 (on request)
								F				FLEXIM flange (R500-MC)
								D				direct flange (R500-LCS4, R500-*CTF)
								050				DN 50 (R500-LCS4)
								080				DN 80 (R500-LCS4)
								002				2" (R500-LCS4)
								003				3" (R500-LCS4)
								H50				DN 50 (loose-type flange (R500-LCTF) or sight glass fitting (R500-MCTF))
								H80				DN 80 (loose-type flange (R500-LCTF) or sight glass fitting (R500-MCTF))
								H02				2" (loose-type flange (R500-LCTF) or sight glass fitting (R500-MCTF))
								H03				3" (loose-type flange (R500-LCTF) or sight glass fitting (R500-MCTF))

Process connection

Direct flange for PIOX R500-LCS4KR-****-P**D

The sensor is welded to the direct flange (EN 1092-1 type 05 or ASME B16.5 150/300 psi).

description		sensor order code	pressure rating (flange)	pipe diameter	dimensions [mm]		dimensional drawing
					D	h	
direct flange	D050	R500-LCS4KR-****-P**D050	PN 16 optional: PN 40	DN 50	ø165	18	
	D080	R500-LCS4KR-****-P16D080	PN 16	DN 80	ø200	20	
	D002	R500-LCS4KR-****-P15D002 R500-LCS4KR-****-P30D002	150 psi 300 psi	2"	ø6"	19.1	
	D003	R500-LCS4KR-****-P15D003 R500-LCS4KR-****-P30D003		3"	ø7.5"	23.9	

special materials on request

Process connection for PIOX R500-MCS4KR-****-P**F

Order code

process connection	connection type	pipe diameter	explosion protection	material ¹	gaskets	pressure rating (flange) ¹	/	option	description
PCR	process connection								
FD	flow chamber with flanges according to EN 1092-1 type 11								
FA	flow chamber with flanges according to ASME B 16.5 150/300 psi								
FT	flow chamber with screwed connection								
FW	flow chamber with welded connection to the process pipe								
WR	round welding plate for vessel installation								
WS	square welding plate for vessel installation								
xxx		DN xxx (xxx = 015, 025, 050, 080) 1" (xxx = 001), 2" (xxx = 002), 3" (xxx = 003), 3/8" (xxx = G38), 1/2" (xxx = G12), 3/4" (xxx = G34) welding plate (xxx = T00)							
		F1							
		NN							
		S4							
		FE							
		Py							
		pressure rating PN yy in bar (yy = 10, 16, on request: 40) 150 psi (yy = 15), 300 psi (yy = 30)							
		HCL							
		cleaning line (PCR-F*)							

¹ possible pipe diameters/materials/pressure ratings to be selected from table on page 17. Observe national regulations when selecting the flange size depending on the pressure rating.

Technical data

description	order code	pres- sure ra- ting (flange) Pyy	pipe dia- meter xxx	dimensions [mm]			weight [kg]	dimensional drawing
				I	b	h		
flow chamber with flanges accessories: blind cover, sensor mounting kit optional: cleaning line ¹	PCR-FDxxx--S4FE-P16	PN 16	DN 15	170	ø95	58	4.3	
			DN 25	176	ø115	58	5	
			DN 50	190	ø165	80	8.3	
			DN 80	200	ø200	107	11.9	
	PCR-FAxxx--S4FE-Pyy	150 psi 300 psi	ANSI 1"	8.32"	ø4.25"	2.3"	5.1	
			ANSI 2"	8.94"	ø6"	3.15"	8.8	
			ANSI 3"	9.69"	ø7.48"	4.21"	13.4	
flow chamber with screwed connection accessories: blind cover, sensor mounting kit optional: cleaning line ¹	PCR-FTxxx--S4FE-Pyy		G 3/8"	100	100	100	3.3	
			G 1/2"				3.2	
			G 3/4"				3.2	
flow chamber with welded connection to the process pipe accessories: blind cover, sensor mounting kit optional: cleaning line ¹	PCR-FWxxx--S4FE-Pyy		DN 15	100	100	58	2.8	
			DN 25	100	100	58	2.7	
			DN 50	100	100	80	4.2	
			DN 80	100	100	107	3.1	
			1"	3.94"	3.94"	2.3"	2.7	
			2"	3.94"	3.94"	3.15"	4.2	
			3"	3.94"	3.94"	4.21"	3.1	
round welding plate for vessel installation accessories: blind cover, sensor mounting kit	PCR-WRT00--S4FE-Pyy				ø100	20		
square welding plate for vessel installation accessories: blind cover, sensor mounting kit	PCR-WST00--S4FE-Pyy			100	100	20		

xxx, yy - see order code

PN 40 on request

¹ cleaning connection:

- thread: G1/4"
- cable gland
- stainless steel pipe 6 x 1 mm, length: 150 mm

Accessories

sensor mounting kit		sensor mounting kit		item number								
				<table border="1"> <tr> <td>slit ring</td><td>TR4492-SP</td></tr> <tr> <td>set of screws</td><td>8x TR4214-SP</td></tr> <tr> <td>O-ring</td><td>TR2661-SP</td></tr> <tr> <td>blind cover</td><td>TR4494-SP</td></tr> </table>	slit ring	TR4492-SP	set of screws	8x TR4214-SP	O-ring	TR2661-SP	blind cover	TR4494-SP
slit ring	TR4492-SP											
set of screws	8x TR4214-SP											
O-ring	TR2661-SP											
blind cover	TR4494-SP											
				included in supply								

Direct flange for PIOX R500-LCTFKR-****-P**D

The sensor is connected to the direct flange. It is fixed with a loose-type flange.

description	sensor order code	pressure rating (flange)	pipe diameter	dimensions [mm]		dimensional drawing	
				D	h		
loose-type flange	DH50	R500-LCTFKR-****-P10DH50	PN 10	DN 50	165	20	
	DH80	R500-LCTFKR-****-P10DH80		DN 80	200	20	
	DH02	R500-LCTFKR-****-P15DH02	150 psi	2"	165	24	
	DH03	R500-LCTFKR-****-P15DH03		3"	200	27	

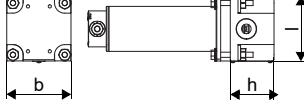
included in supply

Process connection for PIOX R500-MCTFKR-****-P**D

Order code

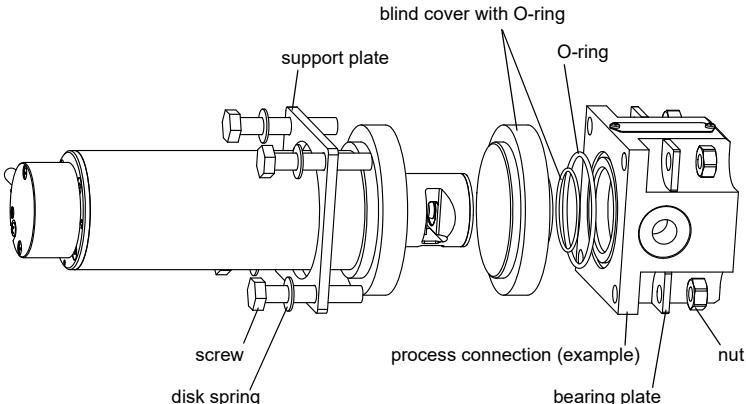
process connection	connection type	pipe diameter	explosion protection	material (wetted parts)	gaskets	pressure rating (flange)	description
PCR							process connection
	FH						sight glass fitting
	PH						flow chamber PVDF
	xxx						DN xxx (xxx = 025, 050, 080) 1" (xxx = 001), 2" (xxx = 002), 3" (xxx = 003), 4" (xxx = 004) 3/8" (xxx = G38), 1/2" (xxx = G12), 3/4" (xxx = G34)
		F1					FM Class I Div. 1
		NN					not explosion-proof, zone 0/1
			PF				sight glass fitting with PFA liner
			PV				PVDF
			FE				FPM with FEP coating
			NN				without gasket (self-sealing)
			yy				pressure rating PN yy in bar (yy = 10) 150 psi (yy = 15)

description	order code	pres- sure ra- ting (flange)	pipe dia- meter	dimensions [mm]				dimensional drawing
				I	b	g	h	
sight glass fitting with PFA liner (self-sealing)	PCR-FH050-**-PFNN-P10	PN 10	DN 50	230	120	ø80	185	
	PCR-FH080-**-PFNN-P10		DN 80	310	ø190	ø100	246	
	PCR-FH002-**-PFNN-P15	150 psi	2"	230	120	ø80	185	
	PCR-FH003-**-PFNN-P15		3"	310	ø190	ø100	246	
flow chamber with flanges (PVDF)	PCR-PH025-**-PVFE-P10	PN 10	DN 25	200				
	PCR-PH001-**-PVFE-P15	150 psi	1 "	200				

description	order code	pres- sure ra- ting (flange)	pipe dia- meter	dimensions [mm]				dimensional drawing
				I	b	g	h	
flow chamber with screw- ed connection (PVDF) • sensor: PIOX R500- MCTFKR-***-P10DH50 • gasket: TR2644-SP ¹	PCR-PHG38-**-PVFE- P15	150 psi	NPT 3/8"	100	100		68	
	PCR-PHG12-**-PVFE- P15		NPT 1/2"					
	PCR-PHG34-**-PVFE- P15		NPT 3/4"					

¹ gasket TR2644-SP: 63.17 x 2.62 FEP (FPM), included in supply

Accessories

sensor mounting kit																			
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