

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



Sensor PIOX R500-MH, Varivent connection



Sensor PIOX R500-MH, Tri-Clamp connection



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

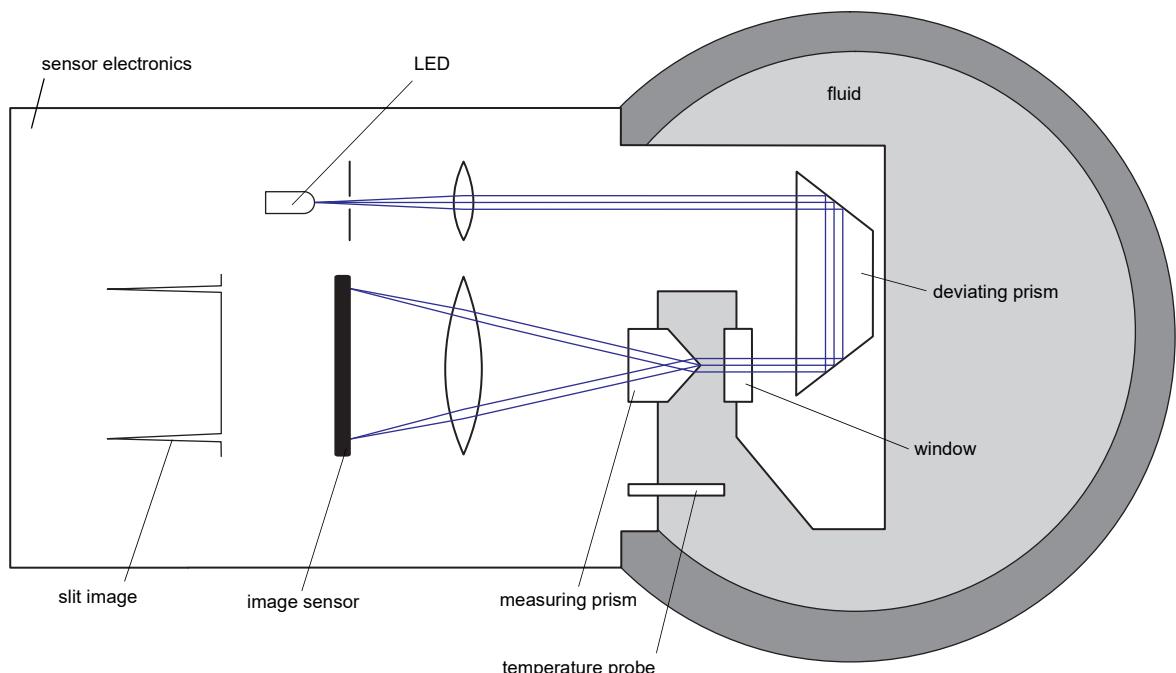
A special LED with a wave length $\lambda = 590$ nm (sodium D line) is used as the light source. The light passes through a slit, is parallelised by a lens and reversed by a deviating prism. Then it enters the fluid through a window in the sensor head. When the light beam re-enters the sensor, it is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



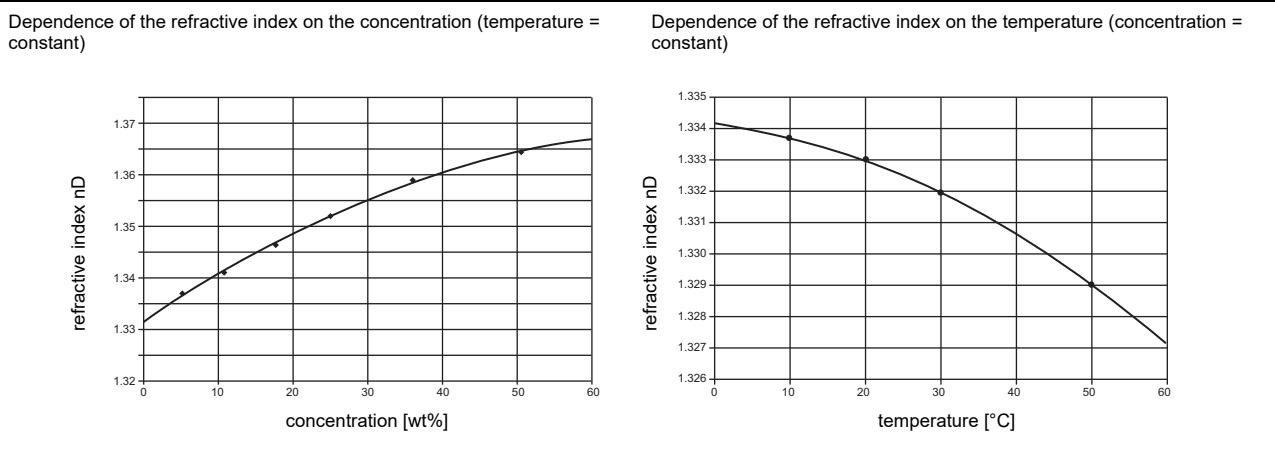
Processing in the transmitter

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.

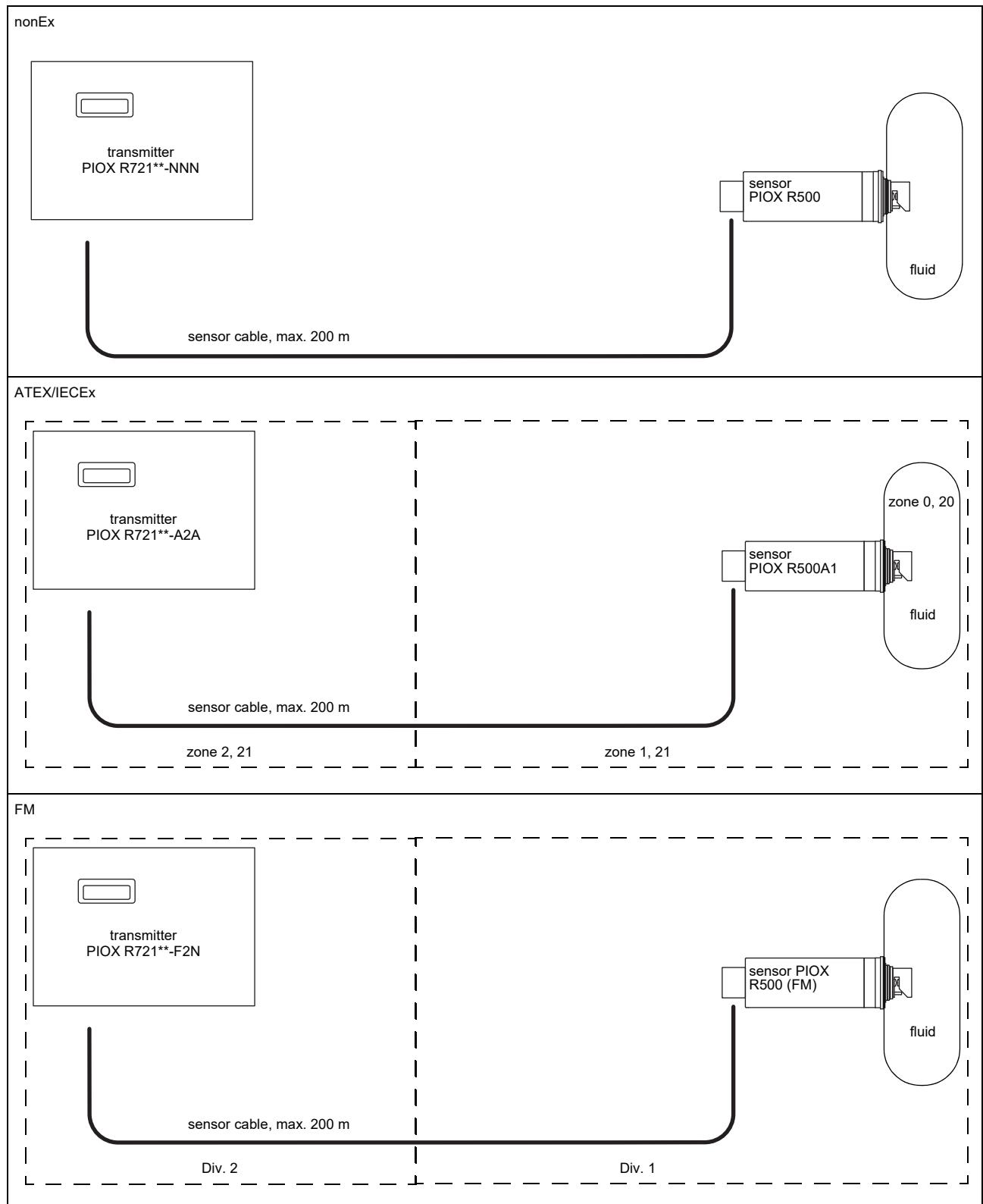
The transmitter can be equipped with electrical inputs, allowing for the input of additional available fluid quantities, e.g. sound speed, density or conductance, and using them for the measurement of three-component mixtures.

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
certification	-	-	-	FM22US0078X, FM22CA0058X
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		$U_{int} = 24$ 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)

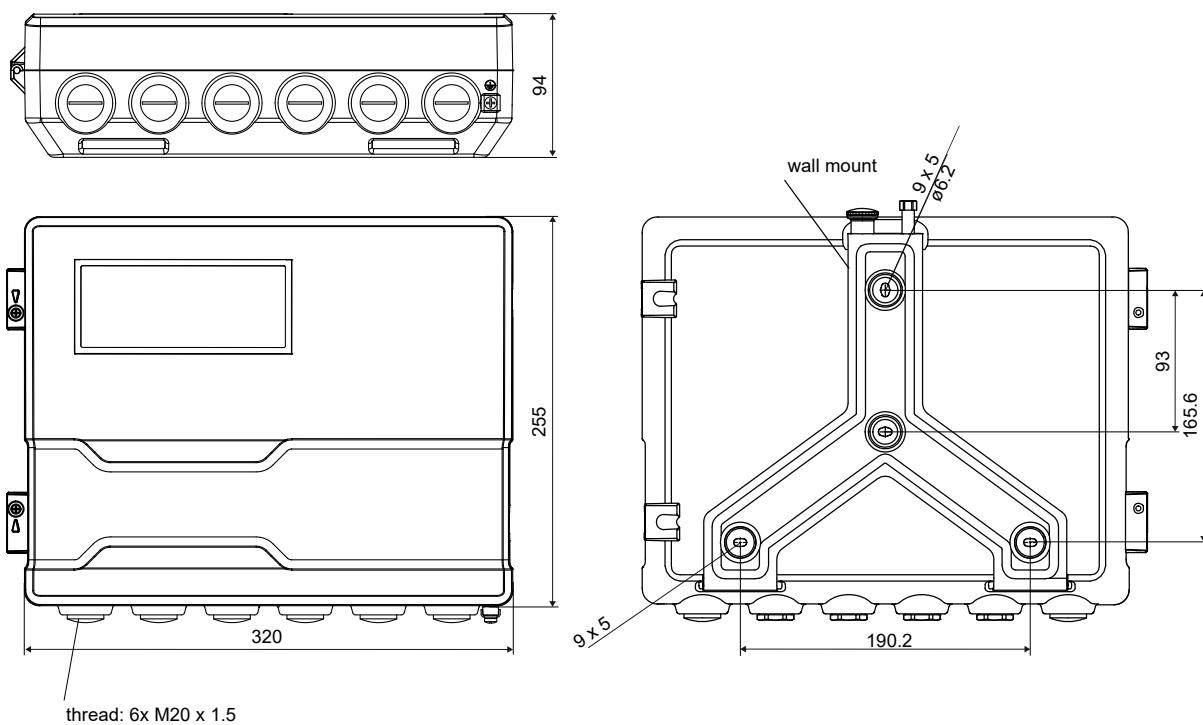
Physical quantities

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, wt% (saccharose)	
SSF	standard fluid data set	refractive index, fluid temperature, °Brix, wt% (saccharose), concentration	application-specific fluid data set from FLEXIM database
SCF	customised fluid data set	refractive index, fluid temperature, °Brix, wt% (saccharose), further customised physical quantities	data set developed by FLEXIM in cooperation with the customer

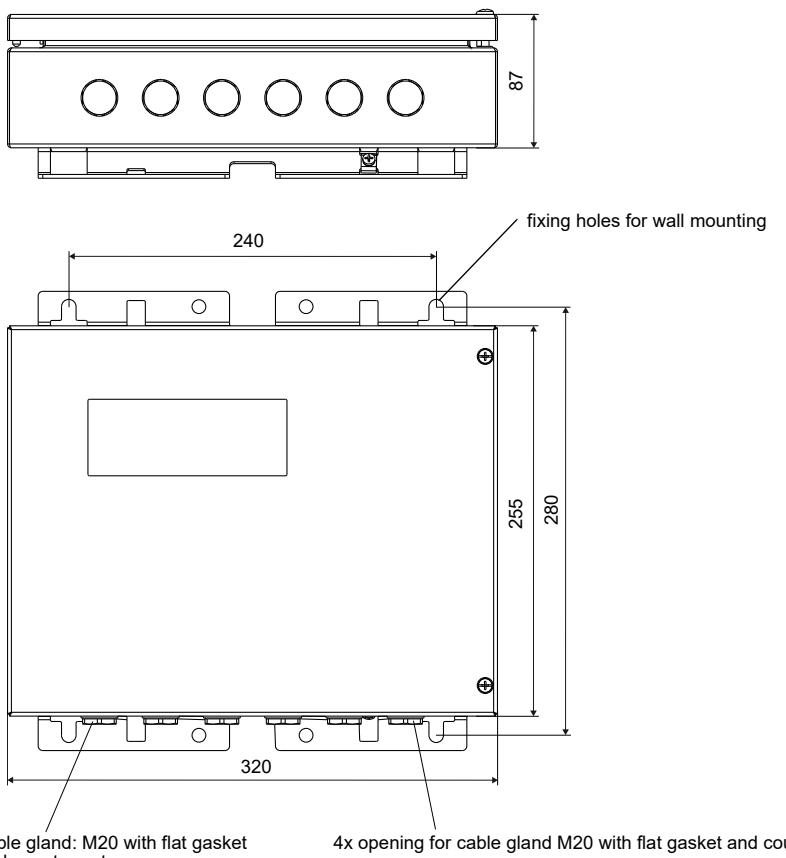
Dimensions

R721**-****-*A



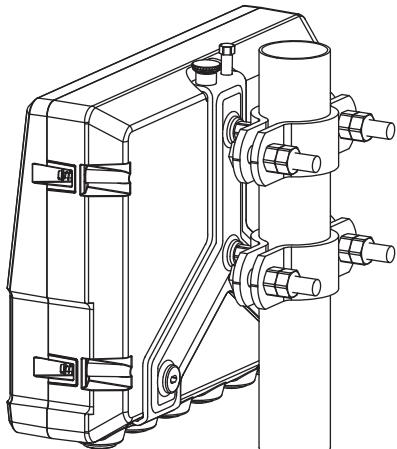
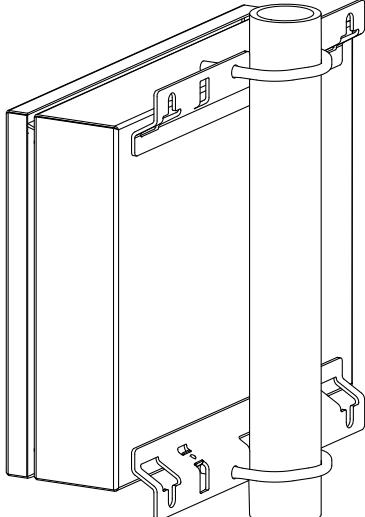
in mm

R721**-****-*S



in mm

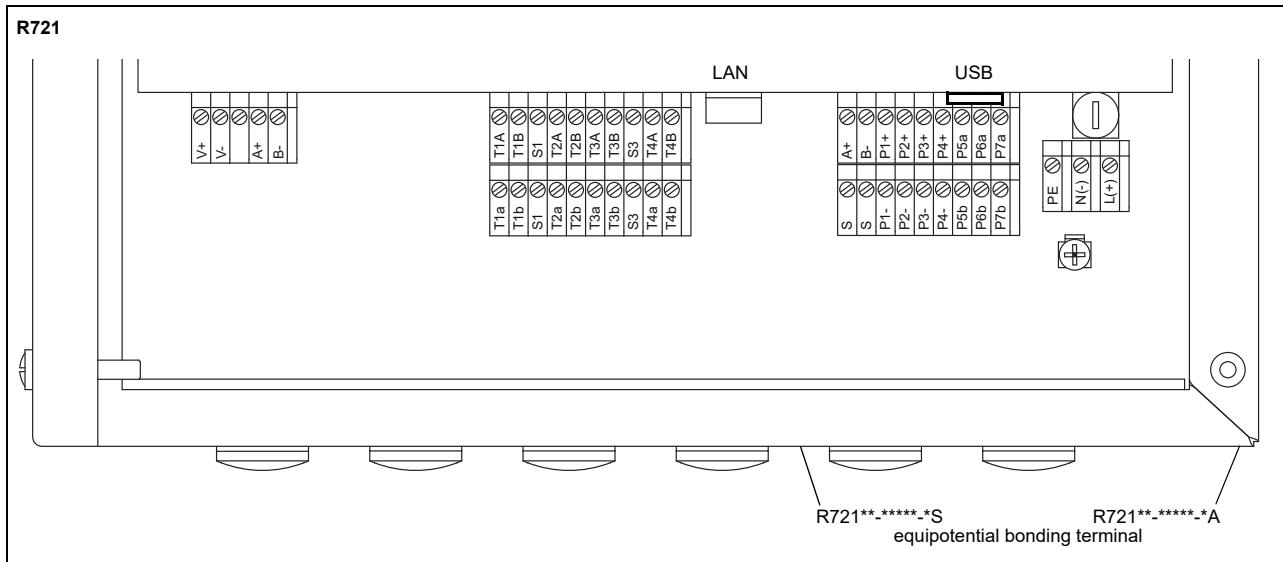
2" pipe mounting kit

*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

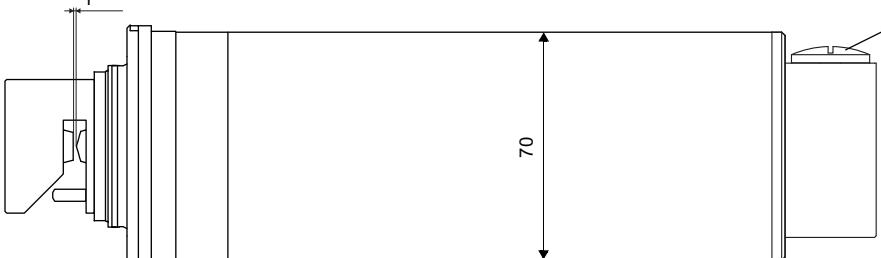
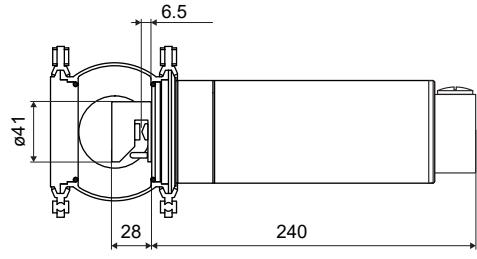
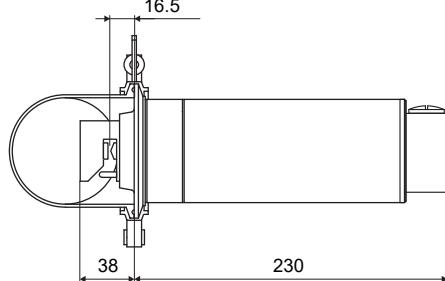
¹ cable (by customer): e.g. flexible wires, with insulated wire ferrules, wire cross-section: 0.25...2.5 mm²

² The number, type and terminal assignment are customised.

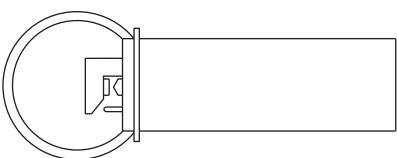
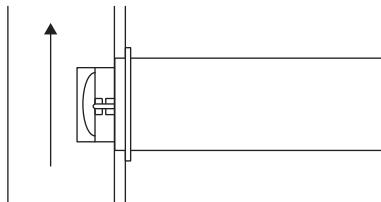
Sensor**Technical data**

	R500	R500A1	R500 (FM)
order code	RS1-R500-MHV4EP-NN	RS1-R500-MHV4EP-A1	RS1-R500-MHV4EP-F1
process parameters			
fluid	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	
fluid pressure	PN 10		150 psi
measurement			
measurement principle	transmitted light refractometry		
measuring range	nD: 1.3...1.7 °Brix: 0...100		
accuracy (absolute)	nD: 0.000 2 (corresponds to 0.1 °Brix, typically 0.1 wt%)		
repeatability	nD: 0.000 02 (corresponds to 0.01 °Brix, typically 0.01 wt%)		
resolution (display)	nD: 0.000 001		
material			
housing	stainless steel 304 (1.4301)		
wetted parts	stainless steel 316L (1.4404)		
gaskets	EPDM		
prism	sapphire, nD ≈ 1.76		
degree of protection	IP54, wetted parts: IP67		
flange	for Varivent (N) or Tri-Clamp 3"		
dimensions	see dimensional drawing		
weight	kg min. 2		
ambient temperature	°C -40...+70		
explosion protection			
• ATEX/IECEx			
marking	-	II1G CE 0637 Ex 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	-	IIBExU06ATEX1075 X, IECEx IBE 10.0003X	-
• FM			
marking	-	-	 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		

Dimensions

 <p>roughness (wetted metal parts): Ra 6.3</p>	
R500-MH, Varivent connection  <p>process gasket: O-ring 60 x 3 EPDM (item number: AN 2673)</p>	R500-MH, Tri-Clamp connection  <p>process gasket: O-ring DN 3" EPDM (item number: AN 3364)</p>
in mm	

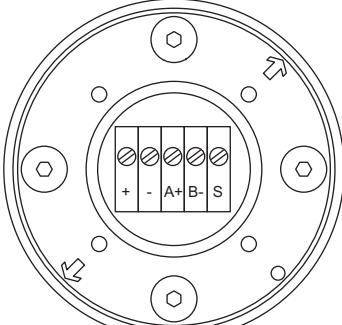
Sensor mounting positions

R500-M	
horizontal pipe 	vertical pipe ¹ 

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"> <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>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>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	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	no. of character	
measurement principle			type of construction	design	material (wetted parts)	gaskets	explosion protection	certification	process pressure	flange	description
R											transmitted light refractometer
	500		M								standard sensor
			H								hygiene design
			V4								stainless steel 316L (1.4404)
				EP							EPDM
					A1						zone 0/1
					F1						FM Class I Div. 1
					NN						not explosion-proof
					NN						-
						P10					PN 10
						P15					150 psi
							V				flange, compatible with Varivent N ¹
							T				flange, compatible with Tri-Clamp 3" ¹

¹ process connection by customer



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