

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**-*555A



PIOX R721**-*555S

Measurement principle	3
Refractive index	3
Measurement with refractometer PIOX R.	3
Measuring setup	5
Transmitter	6
Technical data	6
Dimensions.	8
2" pipe mounting kit	9
Storage	9
Terminal assignment	10
Sensor	11
Technical data	11
Dimensions.	12
Sensor mounting positions	12
Connection	13
Sensor order code	14

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

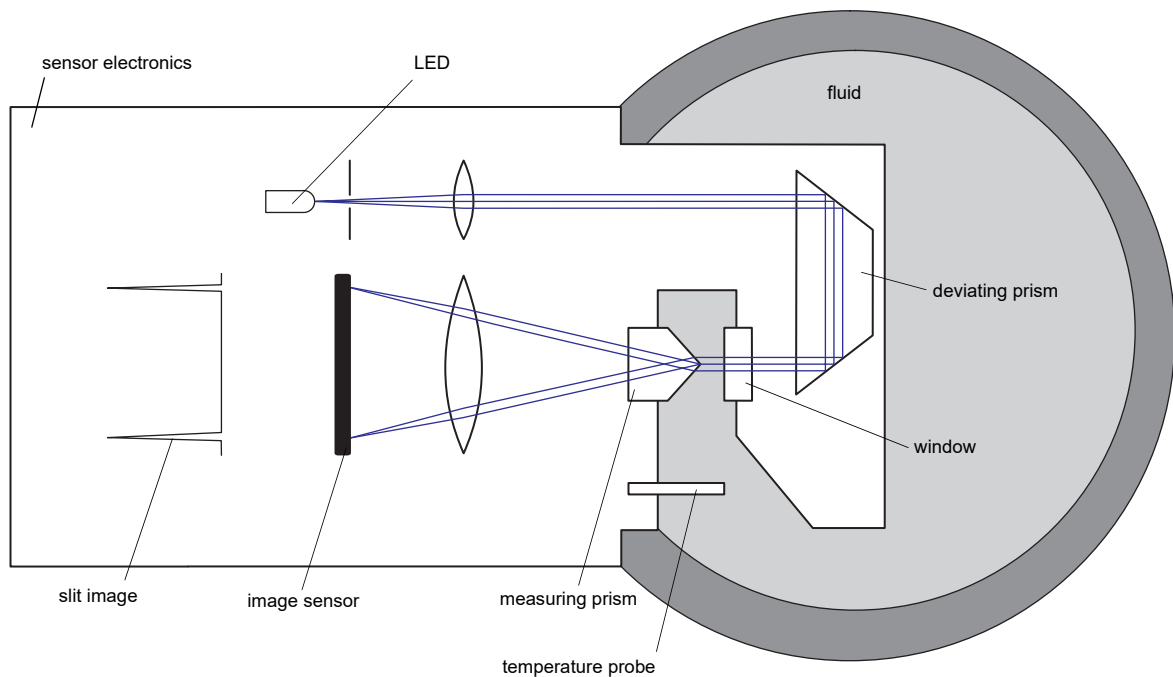
A special LED with a wave length $\lambda = 590$ nm (sodium D line) is used as the light source. The light passes through a slit, is parallelized by a lens and reversed by a deviating prism. Then it enters the fluid through a window in the sensor head. When the light beam re-enters the sensor, it is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

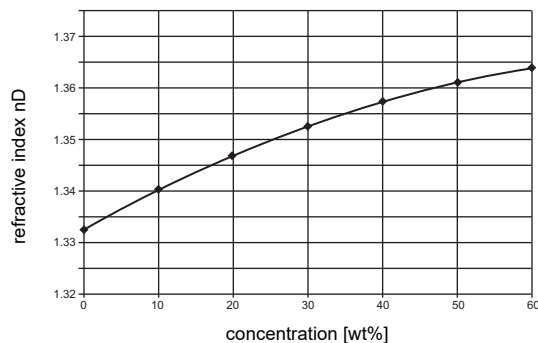
The transmitter calculates application-specific analysis quantity such as M%, Vol%, g/l, nDT (temperature-compensated refractive index), operating density, laboratory density, Brix value either with standardized fluid data sets from the library or with customized ones.

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.

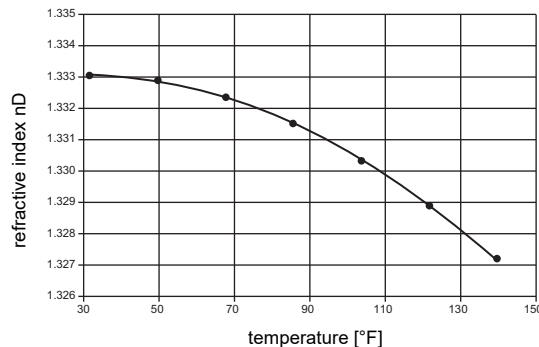
Dependence on temperature and concentration

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).

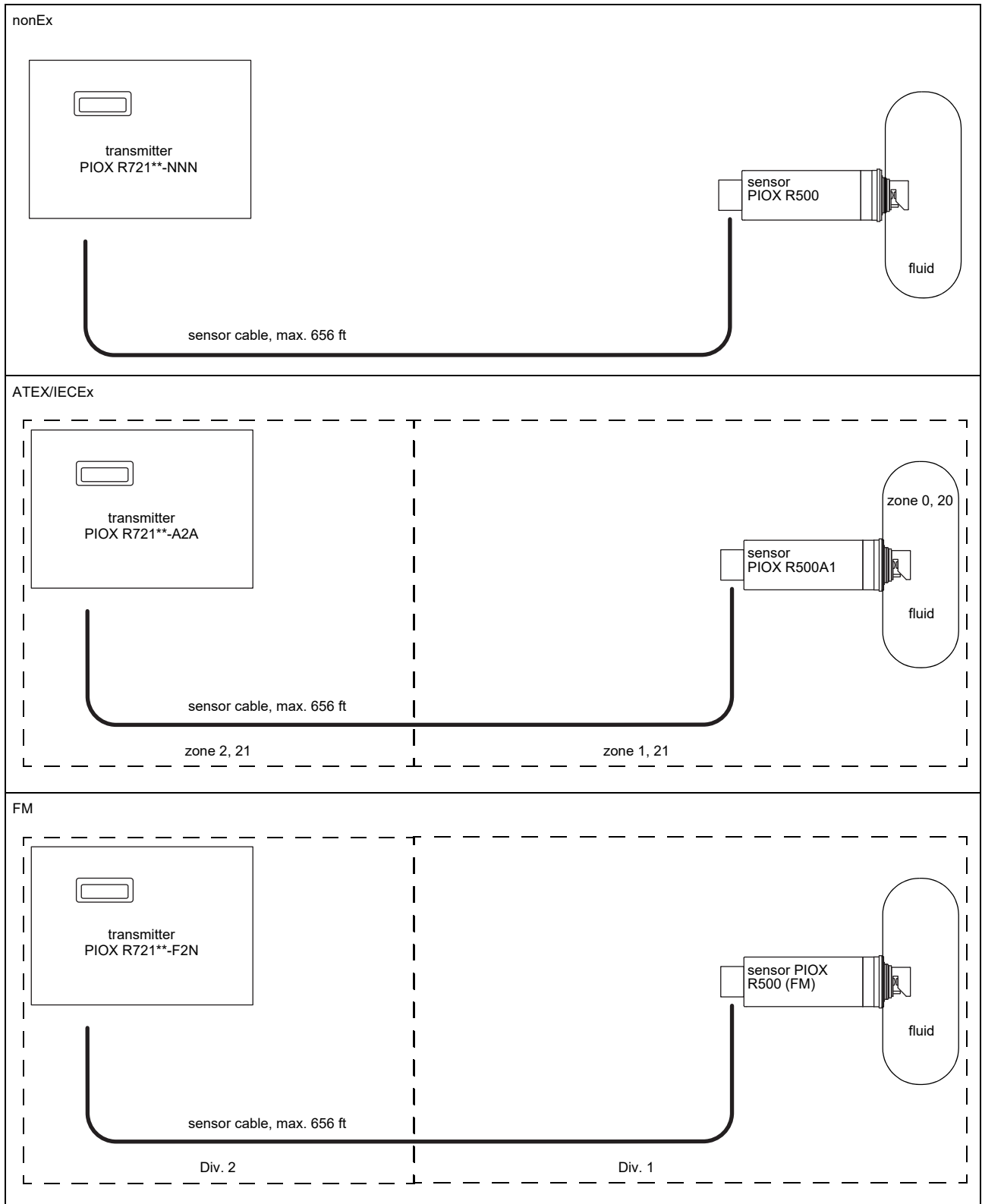
Dependence of the refractive index on the concentration (temperature = constant)



Dependence of the refractive index on the 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 to 230 V/50 to 60 Hz or • 20 to 32 V DC		• 20 to 32 V DC	• 20 to 32 V DC
power consumption	W	< 15			
number of measuring channels		1			
damping	s	0 to 100 (adjustable)			
response time	s	1			
housing material		aluminum, powder coated	stainless steel 316L		
degree of protection		IP65	IP65	IP66	IP65
dimensions	inch	see dimensional drawing			
weight	lb	11.9	11.2		
fixation		wall mounting, optional: 2" pipe mounting			
ambient temperature	°F	-4 to +131/140	-4 to +131/140	-40 to +140 (< -4 without operation of the display)	-4 to +140
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 T _a -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, parametrization 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, parametrization of the transmitter			
data logger					
loggable values		all physical quantities, totaled 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 to 20 (3.2 to 22)			
accuracy		0.04 % MV ±3 µA			
active output		R _{ext} < 250 Ω			
passive output		U _{ext} = 8 to 30 V, depending on R _{ext} (R _{ext} < 1 kΩ at 30 V)			
• voltage output					
range	V	0 to 1 or 0 to 10			
accuracy		0 to 1 V: 0.1 % MV ±1 mV 0 to 10 V: 0.1 % MV ±10 mV			
internal resistance		R _{int} = 500 Ω			
• digital output					
functions		• frequency output • binary output • pulse output			
number		3			
		5 to 30 V/< 100 mA			
frequency output					
• range	kHz	0 to 5			
binary output					
• binary output as alarm output		limit, change of flow direction or error			
pulse output					
• pulse value	units	0.01 to 1000			
• pulse width	ms	0.05 to 1000			
inputs					
		The inputs are galvanically isolated from the transmitter.			
number		max. 4, on request			
• temperature input					
type		Pt100/Pt1000			
connection		4-wire			
range	°F	-238 to +1040			
resolution	K	0.01			
accuracy		±0.01 % MV ±0.03 K			
• current input					
accuracy		0.1 % MV ±10 µA			
active input		U _{int} = 24 V, R _{int} = 50 Ω, P _{int} < 0.5 W, not short-circuit proof			
• range	mA	0 to 20			
passive input		R _{int} = 50 Ω, P _{int} < 0.3 W			
• range	mA	-20 to +20			
• voltage input					
range	V	0 to 1			
accuracy		0.1 % MV ±1 mV			
internal resistance		R _{int} = 1 MΩ			

¹ outside the explosive atmosphere (housing cover open)

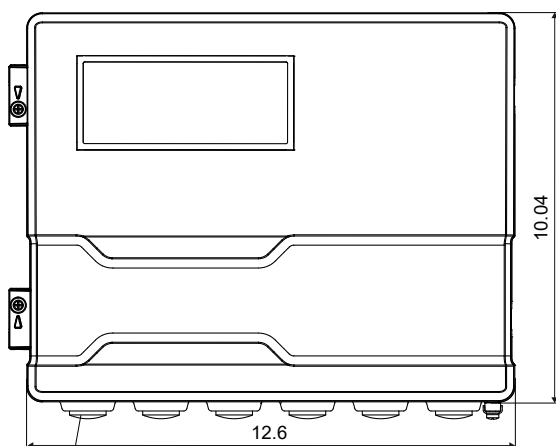
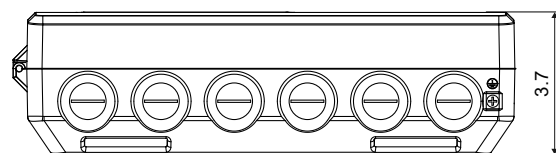
Physical quantities

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

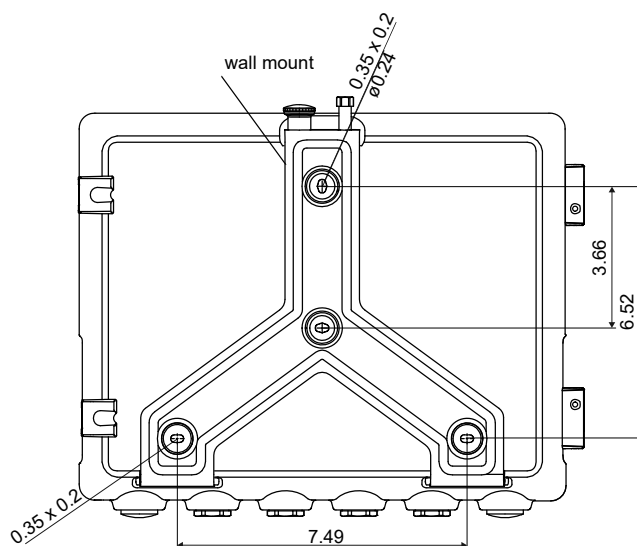
Dimensions

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

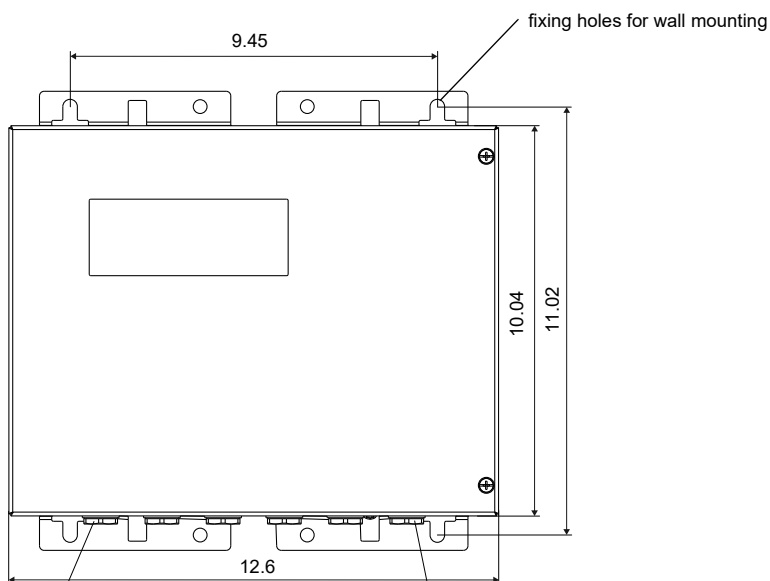
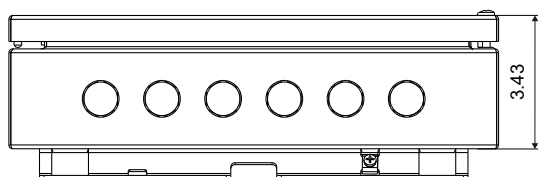


thread: 6x M20 x 1.5

in inch



R721**-*****-S



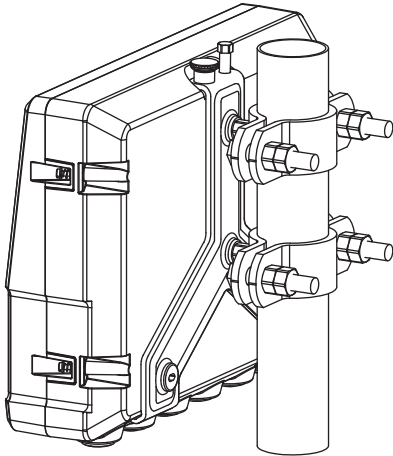
cable gland: M20 with flat gasket
and counter nut

4x opening for cable gland 1/2 NPS with counter nut

in inch

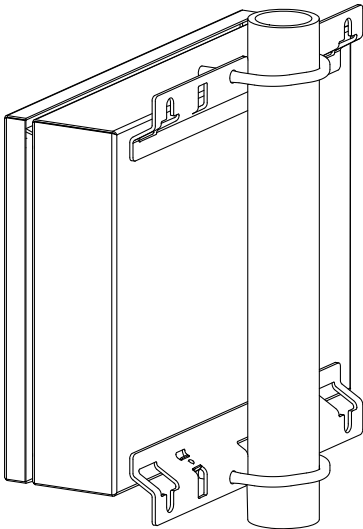
2" pipe mounting kit

*72***-****-*A



item number: 721037-4

*72***-****-*S

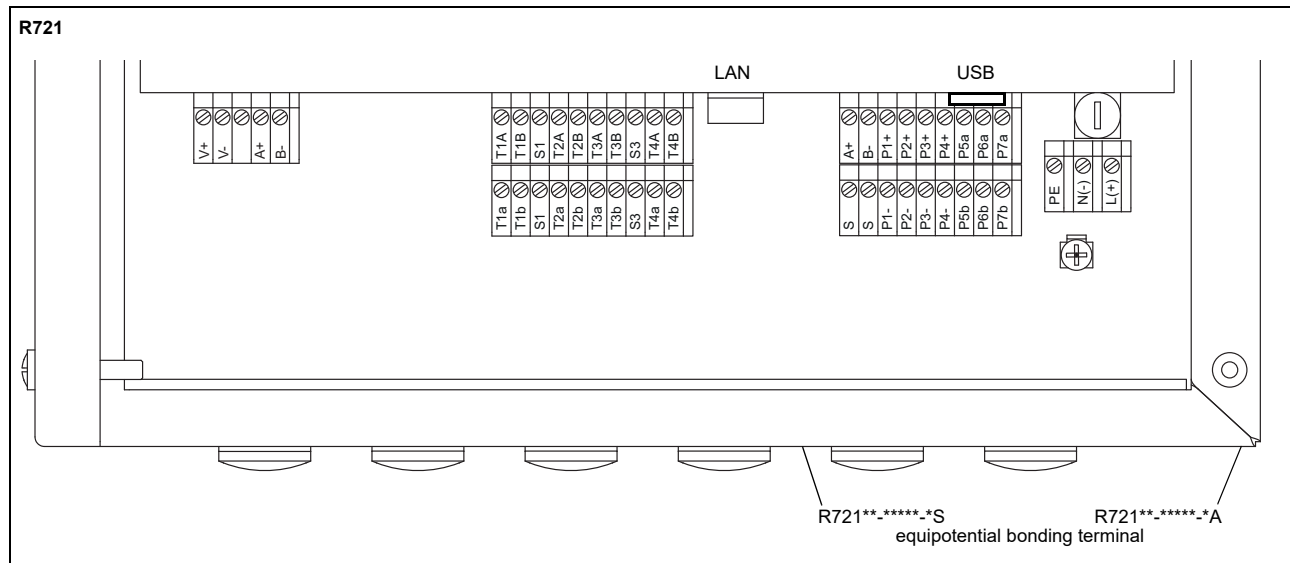



item number: 721110-4

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: -4...+140 °F

Terminal assignment




power supply ¹				
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 inter- face
P1+ to P4+ P1- to P4-	current output, voltage output	A+	signal +	• Modbus RTU ¹ • HART ¹
		B-	signal -	
P5a to P7a P5b to 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 to T4a		not connected	not connected	
T1A to T4A		-	+	
T1b to T4b		+	not connected	
T1B to T4B'		not connected	-	
S1, S3		not connected	not connected	

¹ cable (by customer): e.g., flexible wires, with insulated wire ferrules, wire cross-section: AWG14 to 24

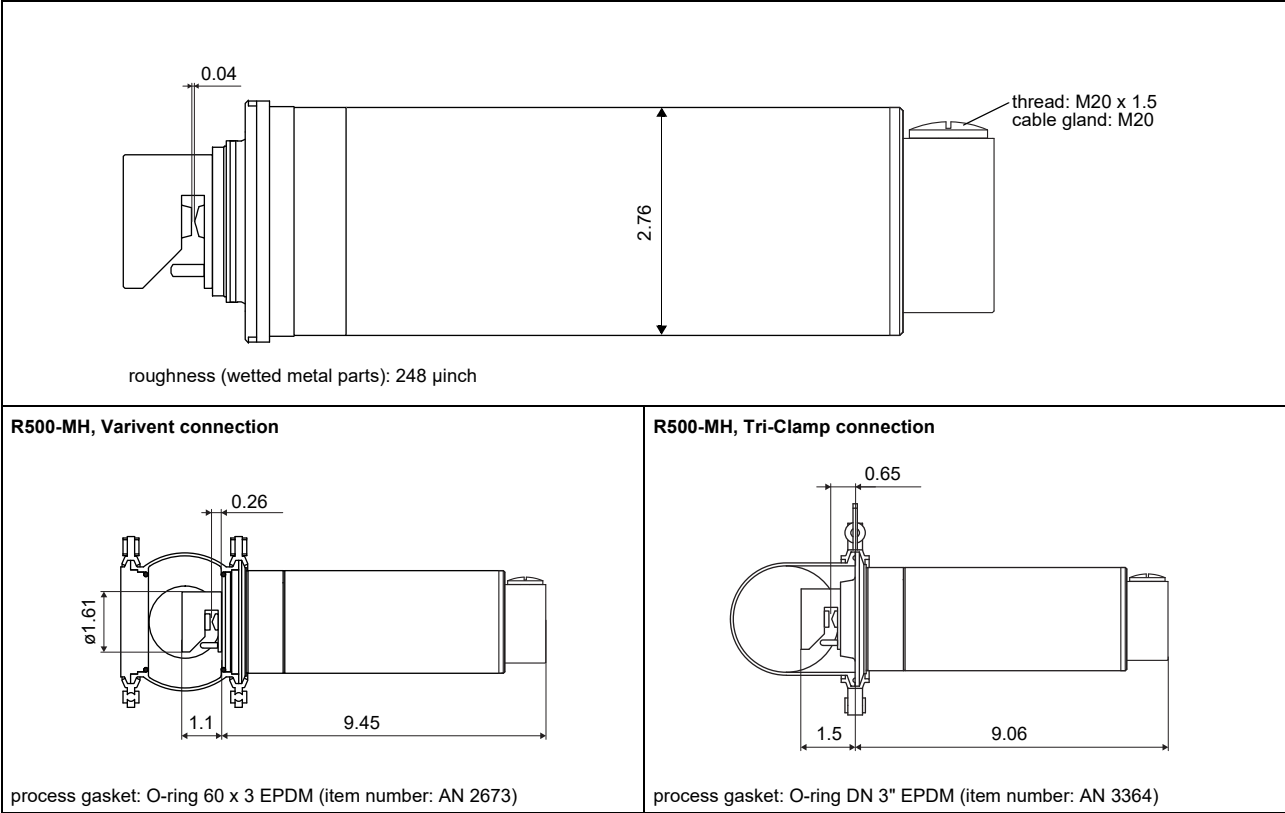
² The number, type and terminal assignment are customized.

Sensor

Technical data

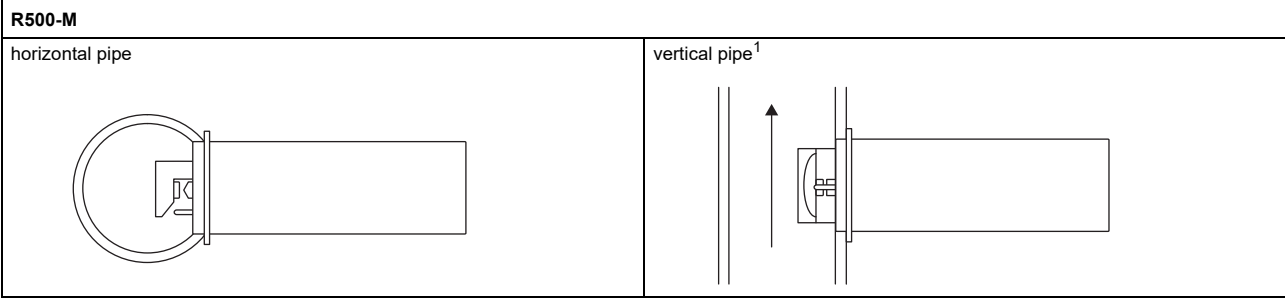
	R500	R500A1	R500 (FM)
order code	RS1-R500-MHV4EP-NN	RS1-R500-MHV4EP-A1	RS1-R500-MHV4EP-F1
process parameters			
fluid	all liquids with a turbidity < 10 000 FAU		
fluid temperature (depending on ambient temperature)	°F -4 to +302 (302 °F at an ambient temperature of 68 °F)	-4 to +266	
fluid pressure	PN 10	150 psi	
measurement			
measurement principle	transmitted light refractometry		
measuring range	nD: 1.3 to 1.7 °Brix: 0 to 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		
wetted parts	stainless steel 316L		
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	lb	min. 4.4	
ambient temperature	°F	-40 to +158	
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	-	IBExU06ATEX1075 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 68 °F	K	0.15	
response time	s	5	

Dimensions



in inch

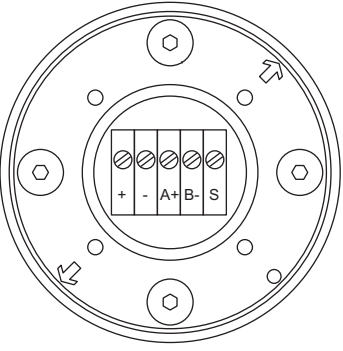
Sensor mounting positions



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 gray	EB CY 2x2x0.75
length	ft	max. 656	max. 656
weight	lb/ft	approx. 0.07	approx. 0.07
ambient temperature	°F	-40 to +176	-40 to +176
properties		flame retardant according to IEC 60332-1-2	flame retardant according to IEC 60332-1-2
cable jacket			
material		PVC	PVC
outer diameter	inch	0.33	0.34
color		gray	blue
shield		x	x

Sensor order code

1, 2	3 to 5	6	7	8, 9	10, 11	12, 13	14, 15	16 to 18	19	no. of character			
measurement principle	type	-	type of construction	design	material (wetted parts)	gaskets	-	explosion protection	certification	-	process pressure	flange	description
R	500												transmitted light refractometer
			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 [†]
											T		flange, compatible with Tri-Clamp 3" [†]

¹ process connection by customer

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Errors excepted.

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