

Flexim PIOX R721/R500 Process Refractometer



Transmitted Light Process Refractometer - Chemistry Design

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

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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

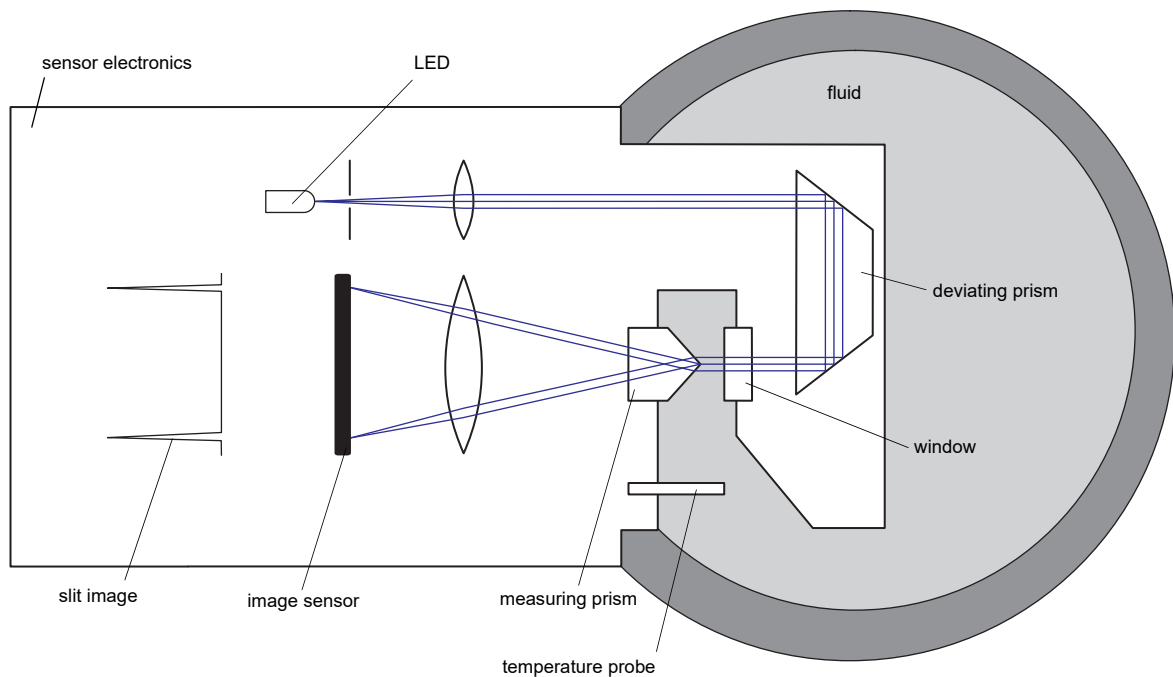
A special LED with a wave length $\lambda = 590$ nm (sodium D line) is used as the light source. The light passes through a slit, is parallelized by a lens and reversed by a deviating prism. Then it enters the fluid through a window in the sensor head. When the light beam re-enters the sensor, it is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

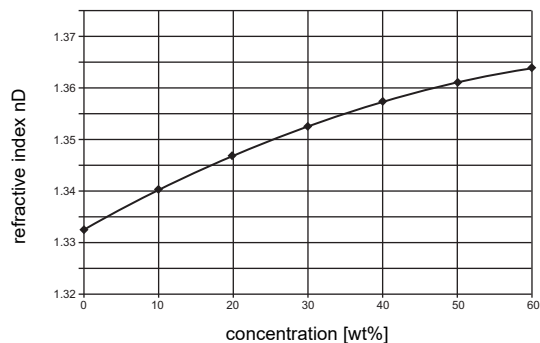
The transmitter calculates application-specific analysis quantity such as M%, Vol%, g/l, nDT (temperature-compensated refractive index), operating density, laboratory density, Brix value either with standardized fluid data sets from the library or with customized ones.

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.

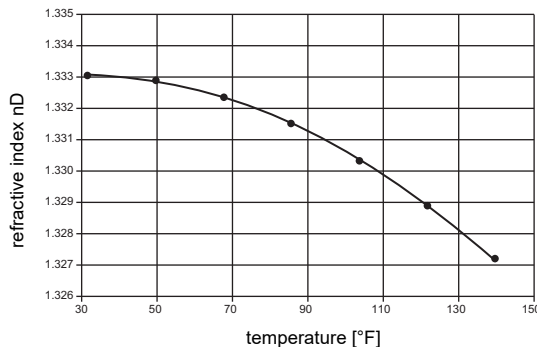
Dependence on temperature and concentration

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).

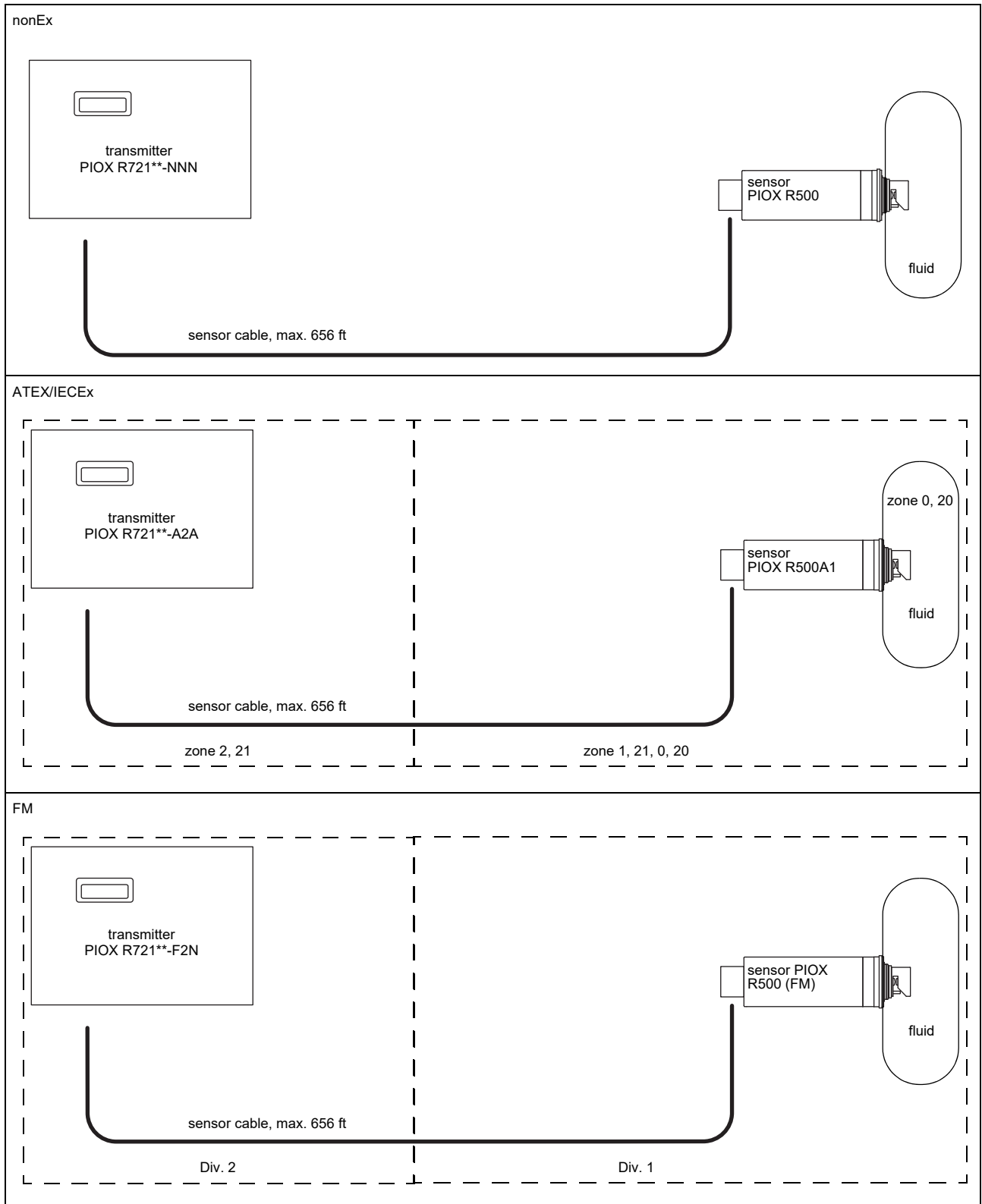
Dependence of the refractive index on the concentration (temperature = constant)



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



Measuring setup



Transmitter

Technical data

		PIOX R721**-NNN**-1ST	PIOX R721**-A2A**-1ST	PIOX R721**-F2N**-1ST
				
design		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		stainless steel 316L		
degree of protection		IP65	IP66	IP65
dimensions	inch	see dimensional drawing		
weight	lb	11.2		
fixation		wall mounting, optional: 2" pipe mounting		
ambient temperature	°F	-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, Chinese		
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 Associated apparatus providing IS circuits for Cl. I, II, III, Div. 1, GP. A, B, C, D, E, F, G.
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**-1ST	PIOX R721**-A2A**-1ST	PIOX R721**-F2N**-1ST
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		

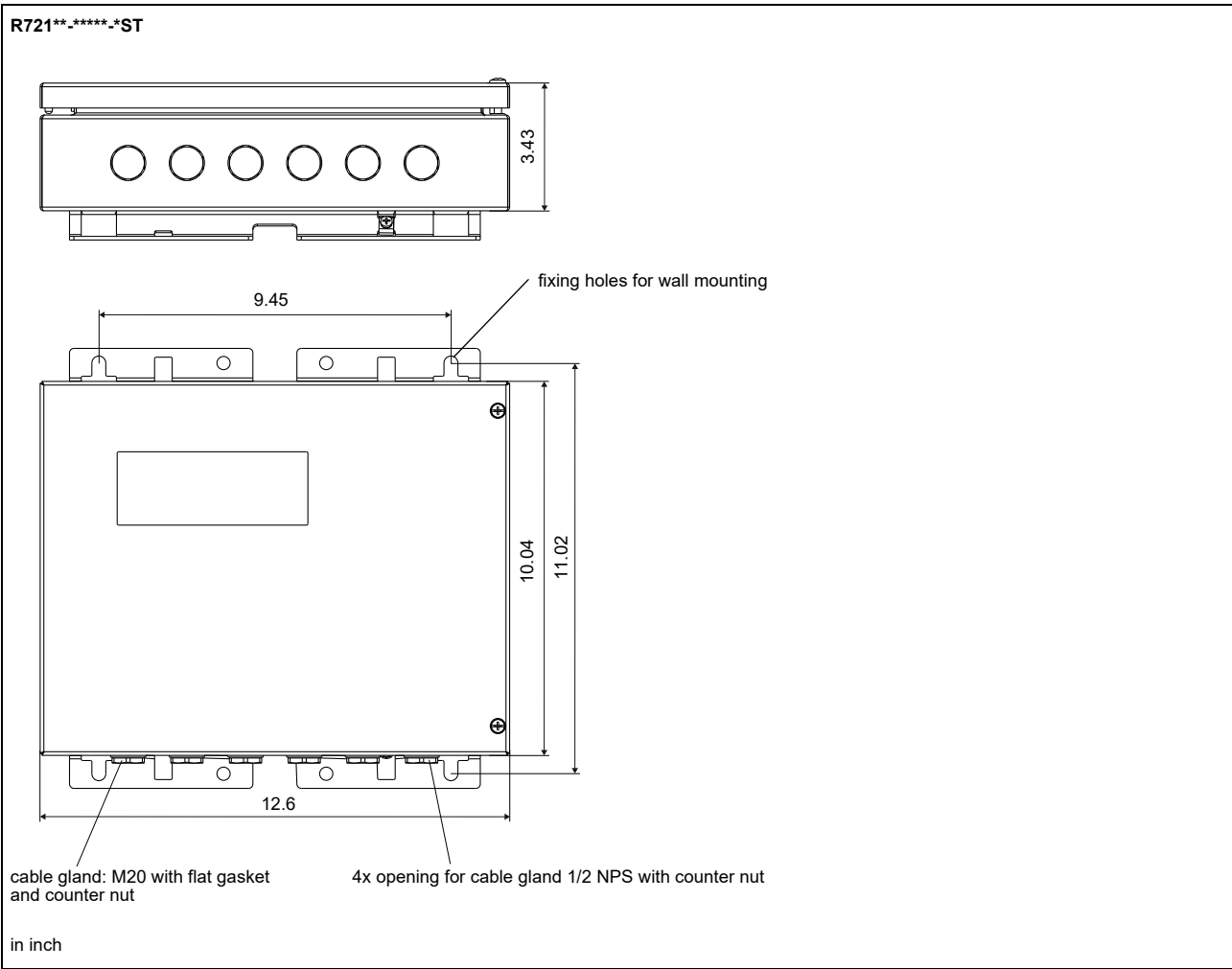
¹ outside the explosive atmosphere (housing cover open)

Physical quantities

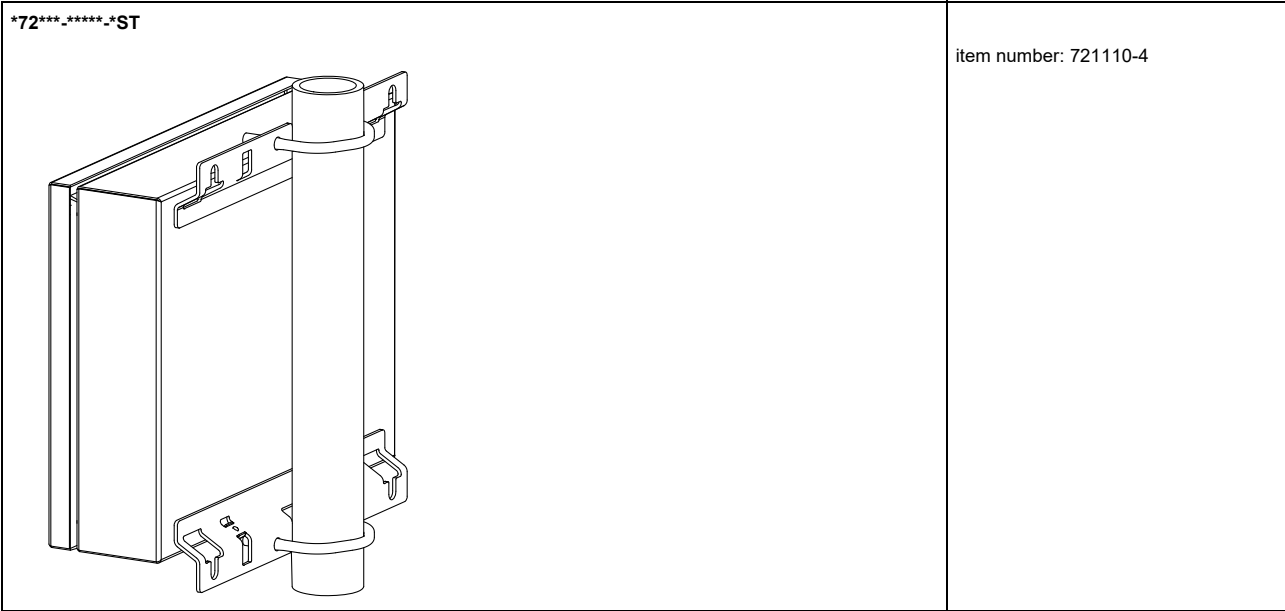
The available physical quantities depend on the fluid data set in the transmitter.

fluid data set	physical quantities	remark
no fluid data set	refractive index, fluid temperature, $^{\circ}\text{Brix}$	
SSF	standard fluid data set	refractive index, fluid temperature, $^{\circ}\text{Brix}$, concentration
SCF	customized fluid data set	refractive index, fluid temperature, $^{\circ}\text{Brix}$, further customized physical quantities

Dimensions



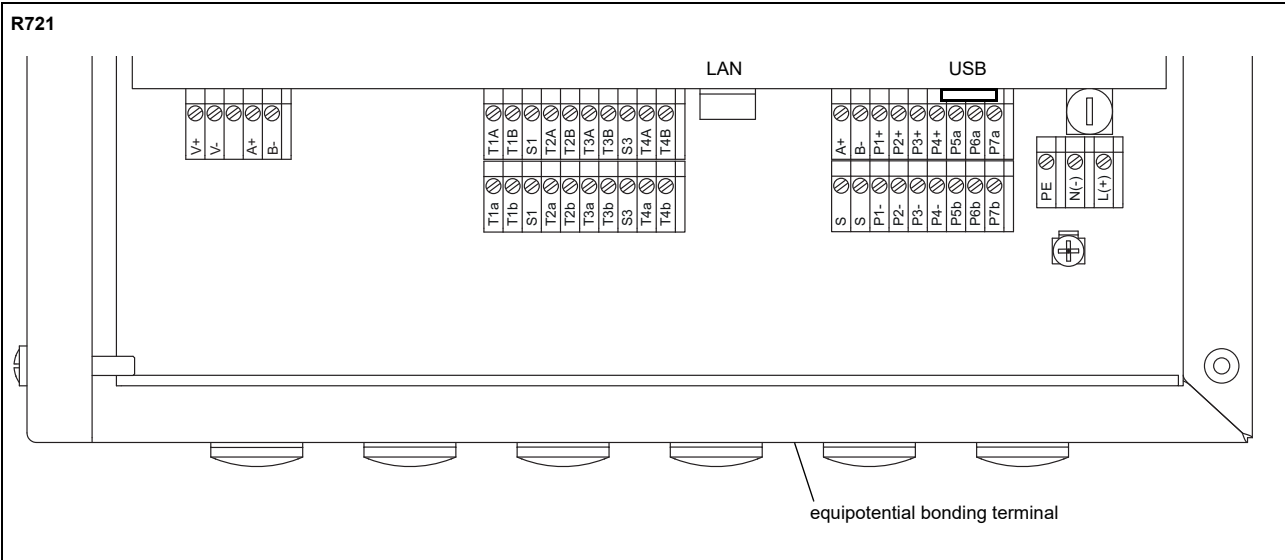
2" pipe mounting kit



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: -4...+140 °F

Terminal assignment



power supply¹

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

transducers

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

outputs^{1, 2}

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

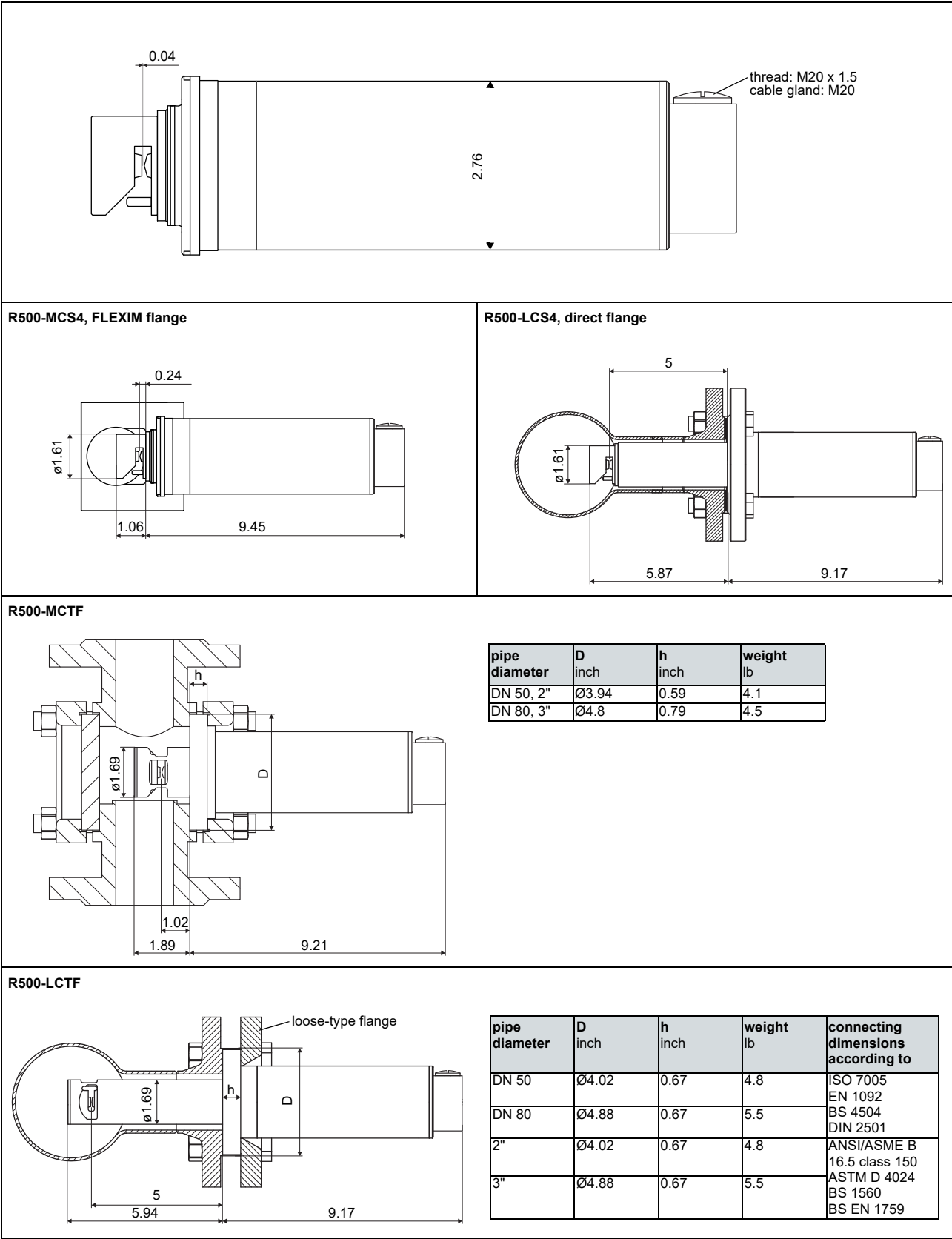
Sensor

Technical data

	R500	R500A1	R500 (FM)	R500	R500A1	R500 (FM)
order code	RS1-R500-*CS4K*-NN	RS1-R500-*CS4K*-A1	RS1-R500-*CS4K*-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)	°F	-4 to +302 (302 °F at an ambient temperature of 68 °F)	-4 to +266	-4 to +248		
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 to 1.7			nD: 1.3 to 1.7		
accuracy (absolute)	nD: 0.000 2 (typically 0.1 wt%)			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			stainless steel 304, epoxy-powder coated		
wetted parts	stainless steel 316Ti (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	lb	min. 4.4		see dimensional drawing		
ambient temperature	°F	-40 to +158		-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	-	-	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	-	-	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	-	-	 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		Pt1000		
resolution	K	0.01		0.01		
accuracy at 68 °F	K	0.15		0.15		
response time	s	5		20		

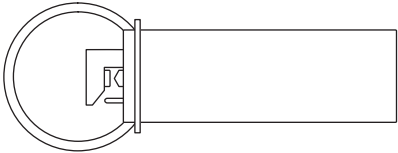
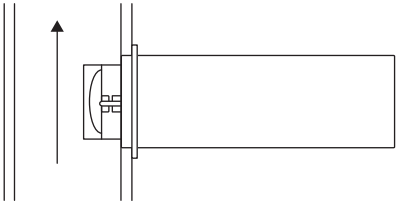
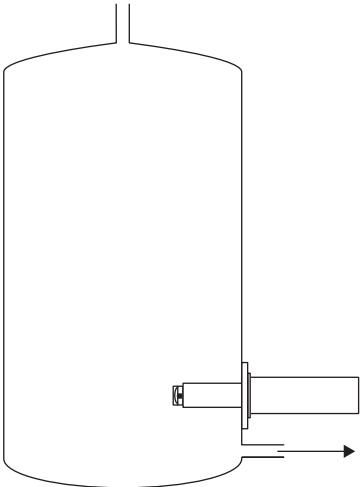
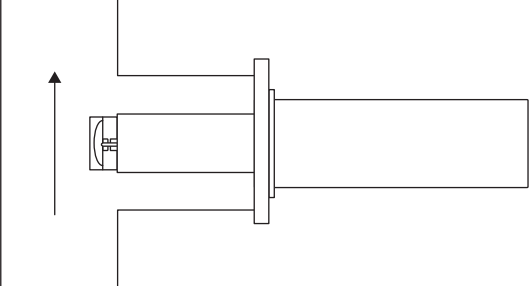
¹ R500-LCTF: depending on temperature and flow velocity:
 max. 8 ft/s at 68 °F
 max. 3 ft/s at 176 °F

Dimensions



in inch

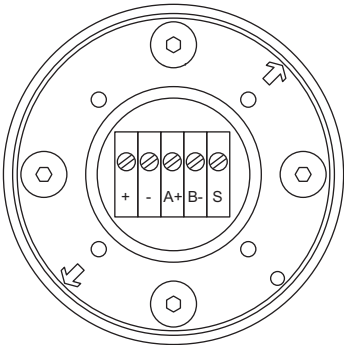
Sensor mounting positions

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

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

Connection

Terminal assignment



terminal	connection
+	yellow
-	green
A+	brown
B-	white
S	shield

equipotential bonding terminal on housing cover

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

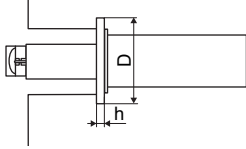
Sensor order code

1, 2	3 to 5	6	7	8, 9	10, 11	12, 13	14, 15	16 to 18	19	20 to 22	no. of character			
measurement principle	type	-	type of construction	design	material (wetted parts)	gaskets	-	explosion protection	certification	-	process pressure	flange	flange size (flange = D)	description
R	500													transmitted light refractometer
	M													standard sensor
	L													long sensor
	C													chemistry design
	S4													stainless steel 316Ti (1.4571)
	TF													PTFE
	KR													FFKM (standard)
	KA													FFKM (oleum specialized)
	A1													ATEX zone 0/1/IECEx zone 0/1
	F1													FM Class I Div. 1
	NN													not explosion-proof
	NN													-
	P10													PN 10
	A15													150 psi
	P16													PN 16
	A30													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-LCS4K*-*-*-***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 [inch]		dimensional drawing
					D	h	
direct flange	D050	R500-LCS4K*-*-*-***-P**D050	PN 16 optional: PN 40	DN 50	ø6.5	0.71	
	D080	R500-LCS4K*-*-*-***-P16D080	PN 16	DN 80	ø7.87	0.79	
	D002	R500-LCS4K*-*-*-***-A15D002 R500-LCS4K*-*-*-***-A30D002	150 psi 300 psi	2"	ø6	0.75	
	D003	R500-LCS4K*-*-*-***-A15D003 R500-LCS4K*-*-*-***-A30D003		3"	ø7.5	0.94	

special materials on request

Process connection for PIOX R500-MCS4K*-*-*-***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					FM Class I Div. 1
			NN					not explosion-proof, zone 0/1
				S4				stainless steel 316Ti
					FE			FPM with FEP coating
						Pyy		pressure rating PN yy in bar (yy = 10, 16, on request: 40)
						Ayy		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 [inch]			weight [lb]	dimensional drawing
				l	b	h		
flow chamber with flanges accessories: blind cover, sensor mounting kit optional: cleaning line ¹	PCR-FDxxx-**-S4FE-P16	PN 16	DN 15	6.69	ø3.74	2.28	9.5	
			DN 25	6.93	ø4.53	2.28	11	
			DN 50	7.48	ø6.5	3.15	18.3	
			DN 80	7.87	ø7.87	4.21	26.2	
	PCR-FAxxx-**-S4FE-Ayy	150 psi 300 psi	ANSI 1"	8.32	ø4.25	2.3	11.2	
			ANSI 2"	8.94	ø6	3.15	19.4	
			ANSI 3"	9.69	ø7.48	4.21	29.5	
flow chamber with screwed connection accessories: blind cover, sensor mounting kit optional: cleaning line ¹	PCR-FTxxx-**-S4FE-Pyy		G 3/8"	3.94	3.94	3.94	7.3	
			G 1/2"				7.1	
			G 3/4"				7.1	
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	3.94	3.94	2.28	6.2	
			DN 25	3.94	3.94	2.28	6	
			DN 50	3.94	3.94	3.15	9.3	
			DN 80	3.94	3.94	4.21	6.8	
			1"	3.94	3.94	2.3	6	
			2"	3.94	3.94	3.15	9.3	
			3"	3.94	3.94	4.21	6.8	
round welding plate for vessel installation accessories: blind cover, sensor mounting kit	PCR-WRT00-**-S4FE-Pyy				ø3.94	0.79		
square welding plate for vessel installation accessories: blind cover, sensor mounting kit	PCR-WST00-**-S4FE-Pyy			3.94	3.94	0.79		

xxx, yy - see order code

PN 40 on request

¹ cleaning connection:

- thread: G1/4"

- cable gland

- stainless steel pipe 0.24 x 0.04 inch, length: 5.91 inch

Accessories

sensor mounting kit

An exploded view diagram of a sensor mounting kit. On the left is a cylindrical sensor body with a process connection. To its right is a 'slit ring with set of screws', which is a circular flange with eight screws. Further right is an 'O-ring', a small circular seal. To the right of the O-ring is a 'blind cover', a hexagonal plate with a central circular opening. The 'process connection (example)' is indicated by a line pointing to the central opening of the blind cover.

sensor mounting kit	item number
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-****-***D

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

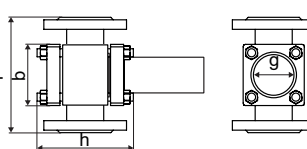
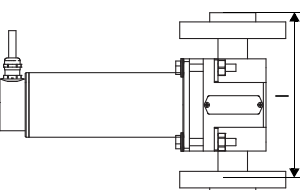
description	sensor order code	pressure rating (flange)	pipe diameter	dimensions [inch]		dimensional drawing
				D	h	
loose-type flange	DH50	R500-LCTFKR-****-P10DH50	PN 10	DN 50	6.5	0.79
	DH80	R500-LCTFKR-****-P10DH80		DN 80	7.87	0.79
	DH02	R500-LCTFKR-****-A15DH02	150 psi	2"	6.5	0.94
	DH03	R500-LCTFKR-****-A15DH03		3"	7.87	1.06

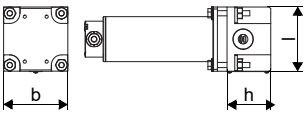
included in supply

Process connection for PIOX R500-MCTFKR-****-***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)
						Pyy	pressure rating PN yy in bar (yy = 10)
						Ayy	150 psi (yy = 15)

description	order code	pressure rating (flange)	pipe diameter	dimensions [inch]				dimensional drawing
				l	b	g	h	
sight glass fitting with PFA liner (self-sealing) • sensor: PIOX R500-MCTFKR-****-P10DH** (pipe diameter of sight glass fitting and sensor flange size must match each other)	PCR-FH050-**-PFNN-P10	PN 10	DN 50	9.06	4.72	ø3.15	7.28	
	PCR-FH080-**-PFNN-P10		DN 80	12.2	ø7.48	ø3.94	9.69	
	PCR-FH002-**-PFNN-A15	150 psi	2"	9.06	4.72	ø3.15	7.28	
	PCR-FH003-**-PFNN-A15		3"	12.2	ø7.48	ø3.94	9.69	
flow chamber with flanges (PVDF) • sensor: PIOX R500-MCTFKR-****-P10DH50 • gasket: TR2644-SP ¹	PCR-PH025-**-PVFE-P10	PN 10	DN 25	7.87				
	PCR-PH001-**-PVFE-A15	150 psi	1"	7.87				

description	order code	pres- sure ra- ting (flange)	pipe dia- meter	dimensions [inch]				dimensional drawing
				l	b	g	h	
flow chamber with scre- wed connection (PVDF) • sensor: PIOX R500- MCTFKR-****-P10DH50 • gasket: TR2644-SP ¹	PCR-PHG38-**-PVFE- A15	150 psi	NPT 3/8"	3.94	3.94		2.68	
	PCR-PHG12-**-PVFE- A15		NPT 1/2"					
	PCR-PHG34-**-PVFE- A15		NPT 3/4"					

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

Accessories

sensor mounting kit

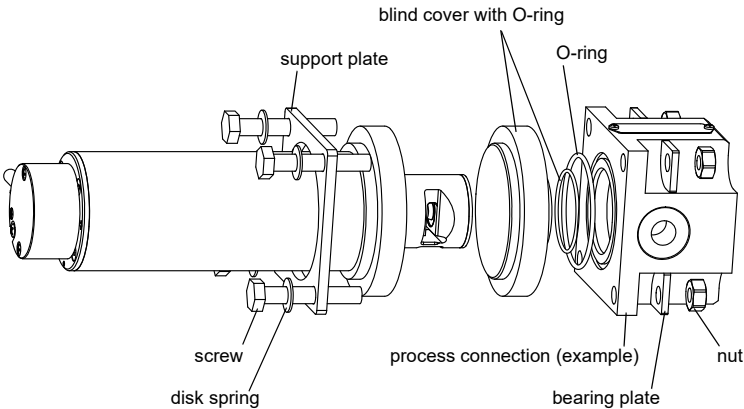


Diagram labels: support plate, blind cover with O-ring, O-ring, screw, disk spring, process connection (example), nut, bearing plate.

sensor mounting kit	item number
support plate	TR2013-SP
bearing plate	4x TR2014-SP
screw	4x TR9180-SP
nut	4x TR4294-SP
disk spring	4x TR4209-SP
O-ring	TR2644-SP
blind cover	TR3922-SP
O-ring	TR2646-SP

included in supply

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