

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
- 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

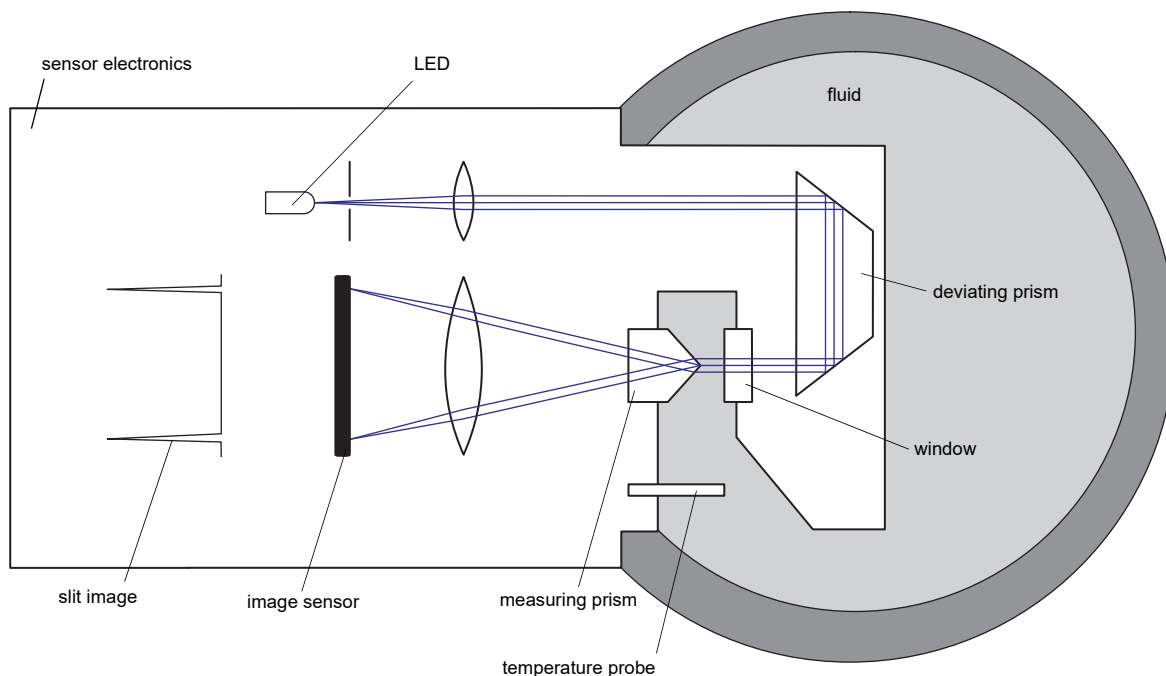
A special LED with a wave length $\lambda = 590 \text{ nm}$ (sodium D line) is used as the light source. The light passes through a slit, is parallelized by a lens and reversed by a deviating prism. Then it enters the fluid through a window in the sensor head. When the light beam re-enters the sensor,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



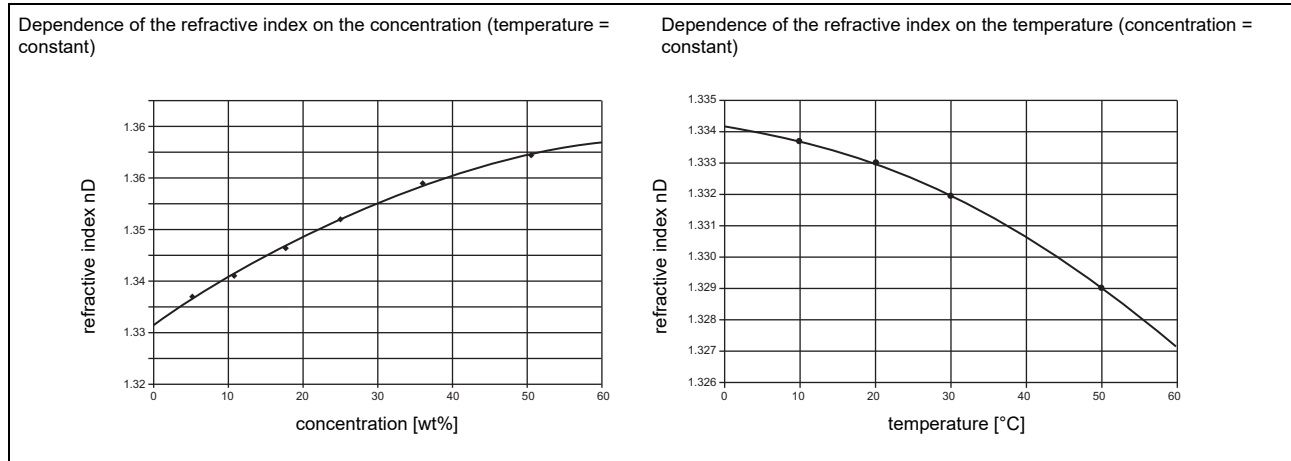
Processing in the transmitter

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.

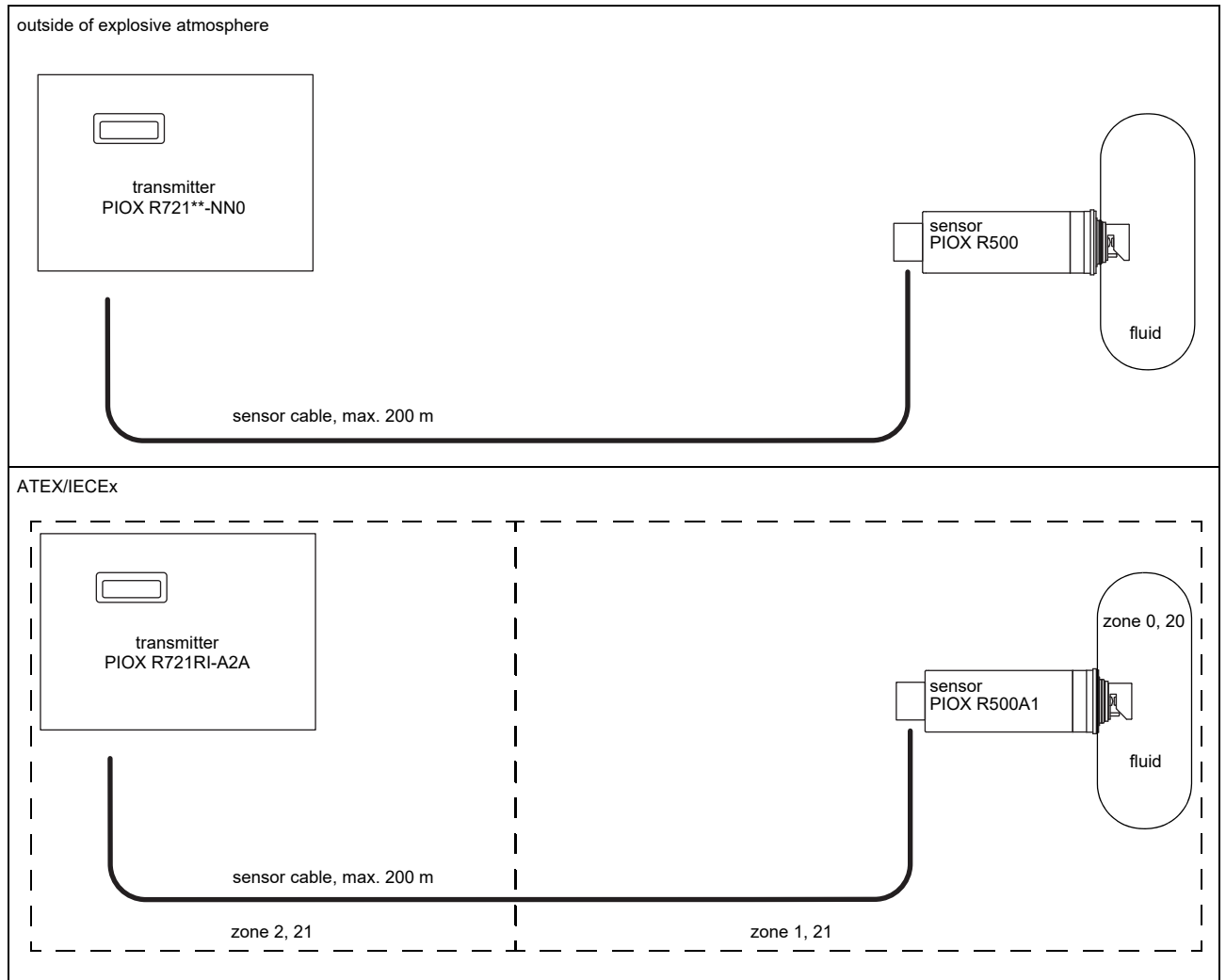
The transmitter can be equipped with electrical inputs, allowing for the input of additional available fluid quantities, e.g. sound speed, density or conductance, and using them for the measurement of three-component mixtures.

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).

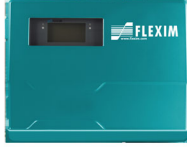



Measuring setups



Transmitter

Technical data

	PIOX R721**-NN01A	PIOX R721**-NN01S	PIOX R721RI-A2A1S
			
design	standard field device nonEx	field device with stainless steel housing nonEx	field device with stainless steel housing zone 2
transmitter			
power supply	<ul style="list-style-type: none"> • 100...230 V/50...60 Hz or • 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
dimensions	mm	see dimensional drawing	
weight	kg	5.4	5.1
fixation		wall mounting, optional: 2" pipe mounting	
ambient temperature	°C	-40...+60 (< -20 °C without operation of the display)	-40...+60 (< -20 °C without operation of the display)
display		128 x 64 dots, backlight	
menu language		English, German, French, Spanish, Dutch, Russian, Polish	
explosion protection			
• ATEX/IECEX			
marking			II(1)3G I(M1) II(1)2D Ex ec nC ic [ia Ga] IIC T4 Gc [Ex ia I Ma] Ex tb [ia Da] IIIC T120 °C Db T _a -40...+60 °C
certification ATEX			IBExU06ATEX1075 X
certification IECEX			IECEX IBE 10.0003X
intrinsic safety parameters			U _m = 120 V
measuring functions			
physical quantities		refractive index, fluid temperature, more with application specific output parameters	
diagnostic functions		signal amplitude, sensor humidity, sensor temperature	
communication interfaces			
service interfaces		measured value transmission, parametrization of the transmitter: <ul style="list-style-type: none"> • USB¹ • LAN¹ 	
process interfaces		max. 1 option ² : <ul style="list-style-type: none"> • Modbus RTU • HART • Profibus PA • FF H1 • Modbus TCP 	
accessories			
serial data kit		USB cable	
software		<ul style="list-style-type: none"> • FluxDiagReader: download of measured values and parameters, graphical presentation • FluxDiag (optional): download of measurement data, graphical presentation, report generation, parametrization of the transmitter 	
data logger			
loggable values		all physical quantities, totaled values and diagnostic values	
capacity		max. 800 000 measured values	

¹ outside of explosive atmosphere (housing cover open)

² with inputs and including parametrization of the transmitter

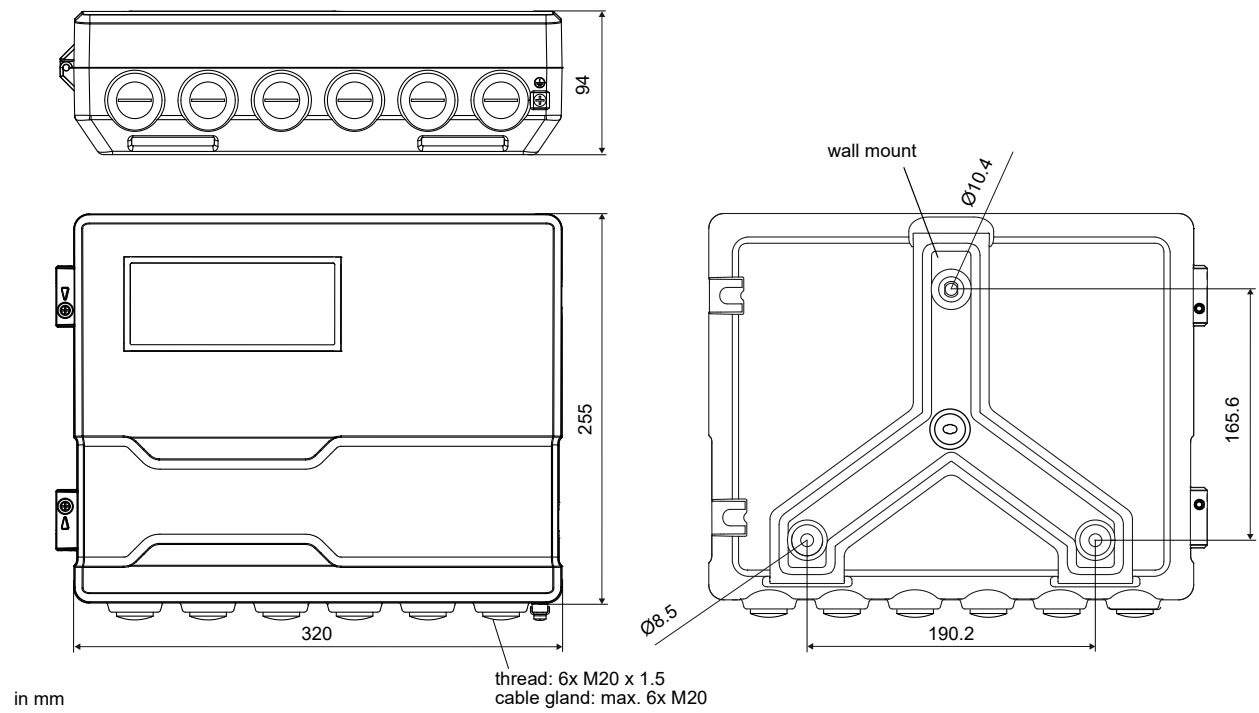
		PIOX R721**-NN01A	PIOX R721**-NN01S	PIOX R721RI-A2A1S
outputs				
		The outputs are galvanically isolated from the transmitter.		
number		on request		
• switchable current output				
		The switchable current outputs are menu selectable all together as passive or active.		
range	mA	4...20 (3.2...22)		
accuracy		0.04 % of reading $\pm 3 \mu\text{A}$		
active output		$R_{\text{ext}} < 350 \Omega$		
passive output		$U_{\text{ext}} = 8...30 \text{ V}$, depending on R_{ext} ($R_{\text{ext}} < 1 \text{ k}\Omega$ at 30 V)		
• voltage output				
range	V	0...1 or 0...10		
accuracy		0...1 V: 0.1 % of reading $\pm 1 \text{ mV}$ 0...10 V: 0.1 % of reading $\pm 10 \text{ mV}$		
internal resistance		$R_{\text{int}} = 500 \Omega$		
• binary output				
optorelay		26 V/100 mA		
binary output as alarm output				
• functions		limit		
inputs				
		The inputs are galvanically isolated from the transmitter.		
number		max. 4, on request		
• temperature input				
type		Pt100/Pt1000		
connection		4-wire		
range	$^{\circ}\text{C}$	-150...+560		
resolution	K	0.01		
accuracy		$\pm 0.01 \%$ of reading $\pm 0.03 \text{ K}$		
• current input				
accuracy		0.1 % of reading $\pm 10 \mu\text{A}$		
active input		$U_{\text{int}} = 24 \text{ V}$, $R_{\text{int}} = 50 \Omega$, $P_{\text{int}} < 0.5 \text{ W}$, not short-circuit proof		
• range	mA	0...20		
passive input		$R_{\text{int}} = 50 \Omega$, $P_{\text{int}} < 0.3 \text{ W}$		
• range	mA	-20...+20		
• voltage input				
range	V	0...1		
accuracy		0.1 % of reading $\pm 1 \text{ mV}$		
internal resistance		$R_{\text{int}} = 1 \text{ M}\Omega$		

¹ outside of explosive atmosphere (housing cover open)

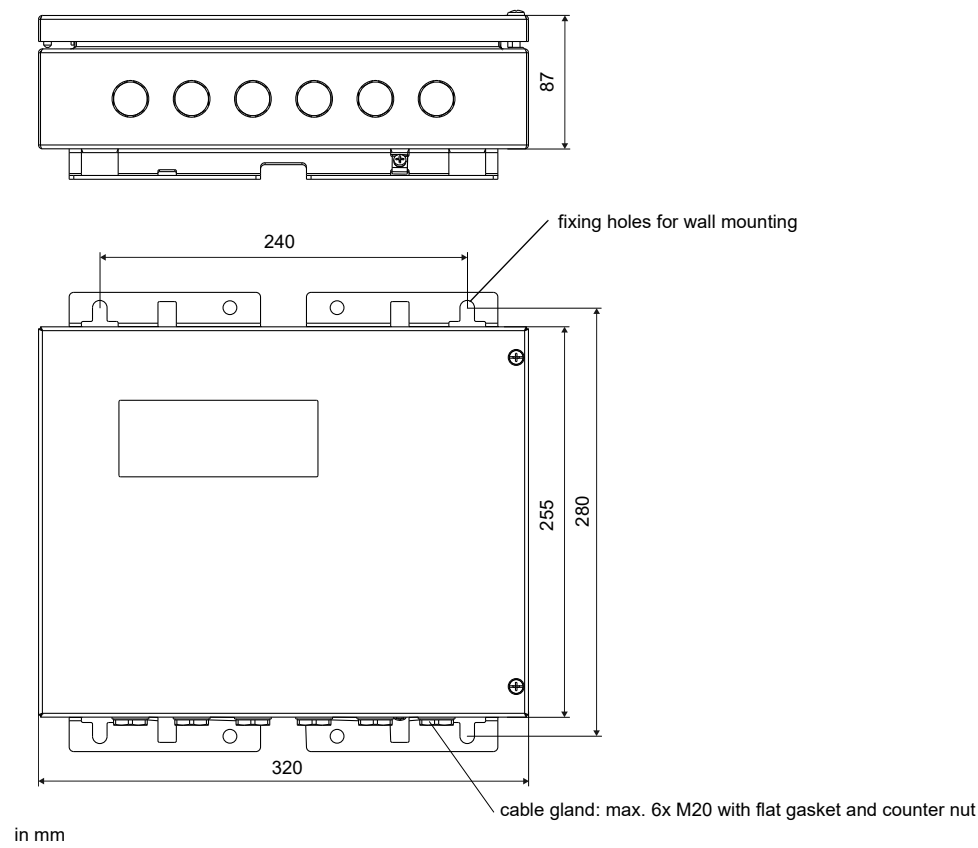
² with inputs and including parametrization of the transmitter

Dimensions

*721**_****A

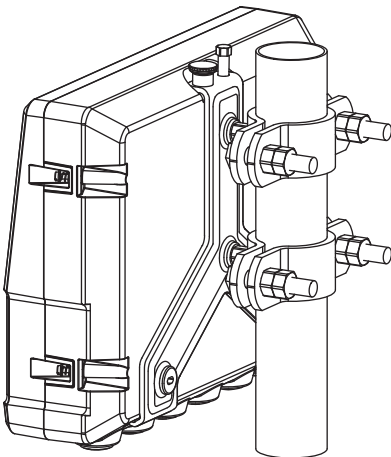


*721**_****S

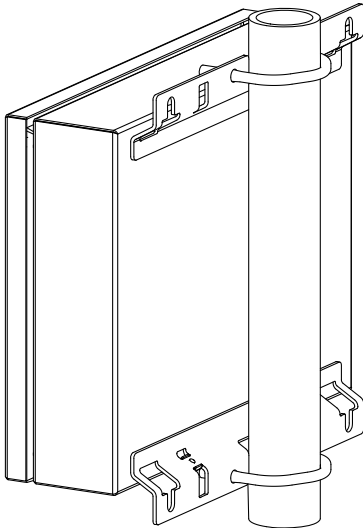


2" pipe mounting kit

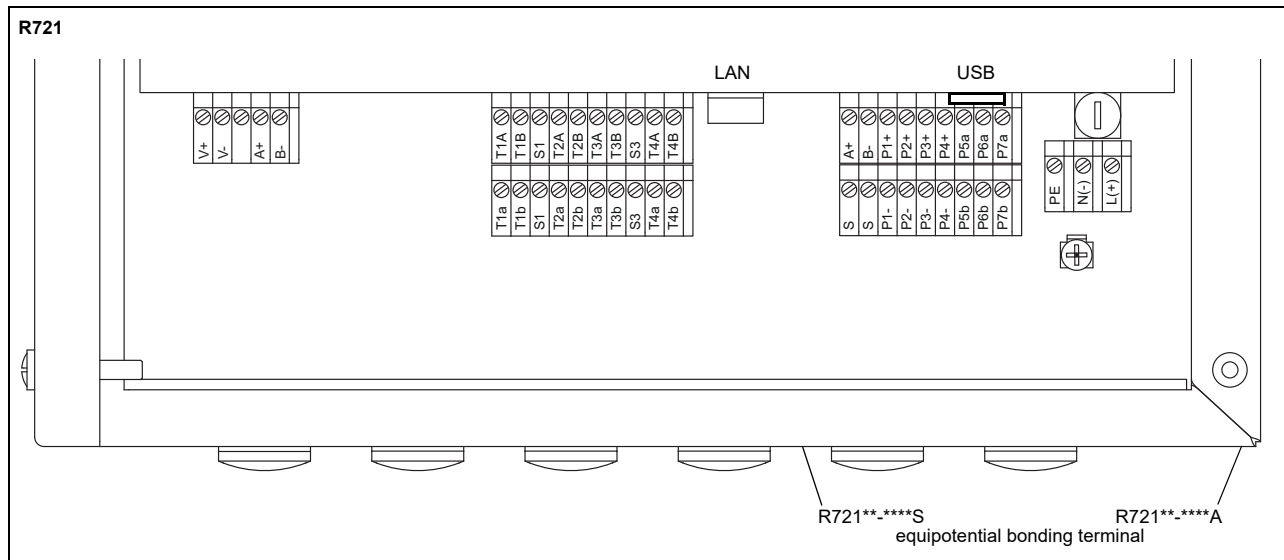
*721**_****A



*721**_****S



Terminal assignment



power supply ¹				
terminal	connection (AC)		connection (DC)	
PE	earth		earth	
N(-)	neutral		-	
L(+)	phase		+	
transducers				
terminal	transducer cable			
V+	yellow			
V-	green			
A+	brown			
B-	white			
outputs ^{1, 2}				
terminal	connection	terminal	connection	communication interface
P1+...P4+ P1-...P4-	current output, voltage output	A+	signal +	<ul style="list-style-type: none"> • Modbus RTU¹ • HART¹ • Profibus PA¹ • FF H1¹
		B-	signal -	
P5a...P7a P5b...P7b	binary output	S	shield	
		USB	type B	<ul style="list-style-type: none"> • service (FluxDiag/FluxDiagReader)
		LAN	RJ45	<ul style="list-style-type: none"> • 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 leads, with insulated wire end ferrules, lead cross sectional area: 0.25...2.5 mm²

² The number, type and terminal assignment will be customized.

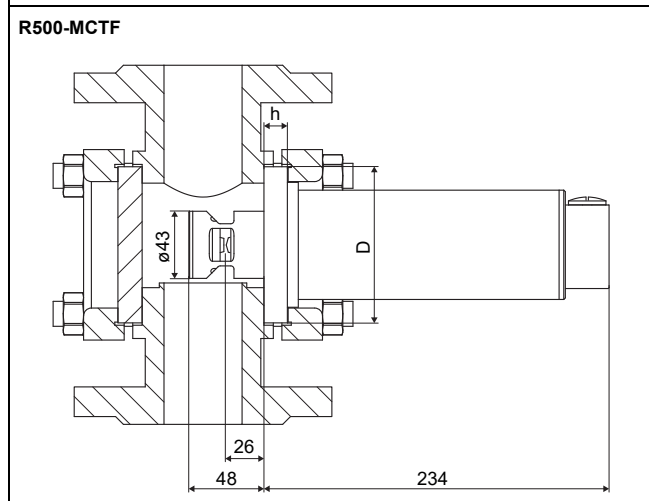
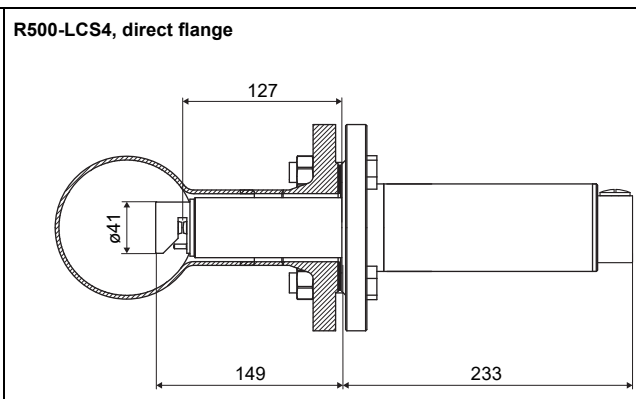
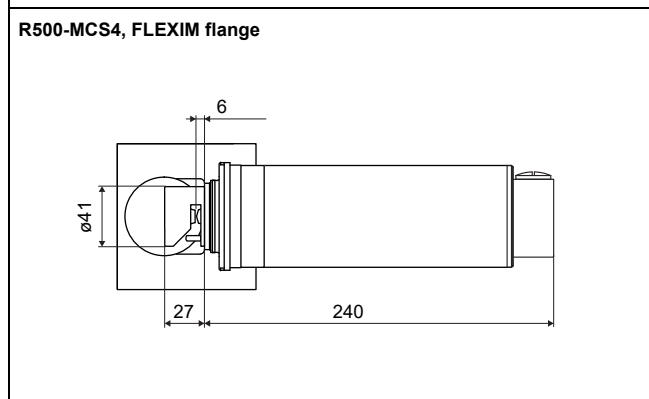
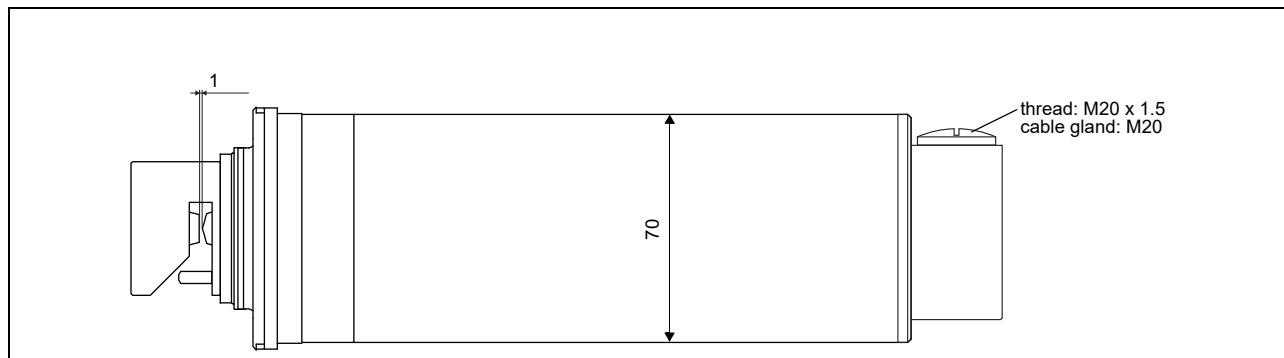
Sensor

Technical data

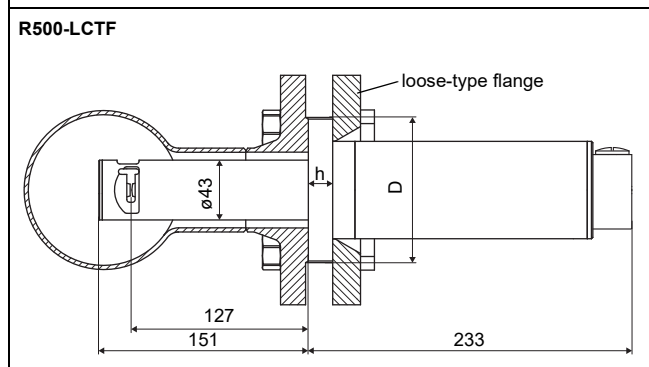
	R500	R500A1	R500	R500A1
order code	R500-*CS4KRNN	R500-*CS4KRA1	R500-*CTFKRNN	R500-*CTFKRA1
process parameters				
fluid	all liquids with a turbidity < 10 000 FAU		all liquids with a turbidity < 10 000 FAU	
fluid temperature (depending on ambient temperature)	°C -20...+150 (150 °C at an ambient temperature of 20 °C)	-20...+130	-20...+120	
fluid pressure	PN 10, PN 16, PN 40 (on request, depending on process connection)		PN 10	
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 (typical 0.1 wt%)		nD: 0.000 2 (typical 0.1 wt%) ¹	
repeatability	nD: 0.000 02 (typical 0.01 wt%)		nD: 0.000 02 (typical 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 according to IEC/EN 60529	IP67		IP67	
flange	dependent on the type of construction (see sensor order code)		dependent on the type of construction (see sensor order code)	
dimensions	see dimensional drawing		see dimensional drawing	
weight	kg	min. 2	see dimensional drawing	
ambient temperature	°C	-20...+60	-20...+60	
explosion protection				
• ATEX/IECEx				
marking	-	II1G CE 0637 Ex IM1 II1D Ex ia op is IIC T4 Ga Ex ia op is I Ma Ex ia op is IIIC T120 °C Da Ta -40...+60 °C Tm -20...+130 °C	-	II1G CE 0637 Ex IM1 II1D Ex ia op is IIC T4 Ga Ex ia op is I Ma Ex ia op is IIIC T120 °C Da Ta -40...+60 °C Tm -20...+120 °C
certification ATEX	-	IBExU06ATEX1075 X	-	IBExU06ATEX1075 X
certification IECEx	-	IECEx IBE 10.0003X	-	IECEx IBE 10.0003X
temperature probe				
type		Pt1000		Pt1000
resolution	K	0.01		0.01
accuracy at 20 °C	K	0.15		0.15
response time	s	5		20

¹ R500-LCTF: dependent on temperature and flow:
max. 2.5 m/s at 20 °C
max. 1 m/s at 80 °C

Dimensions



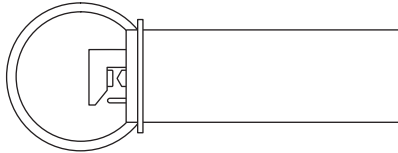
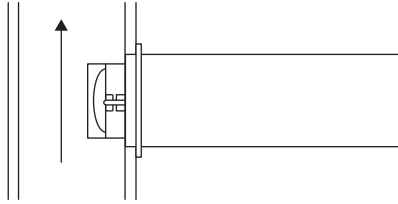
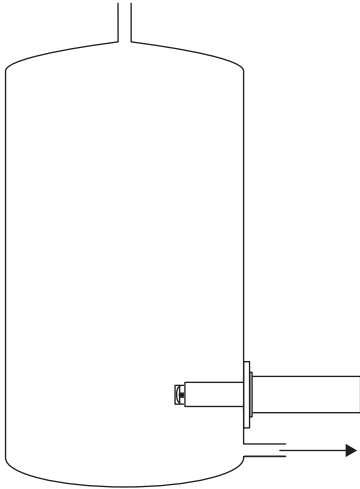
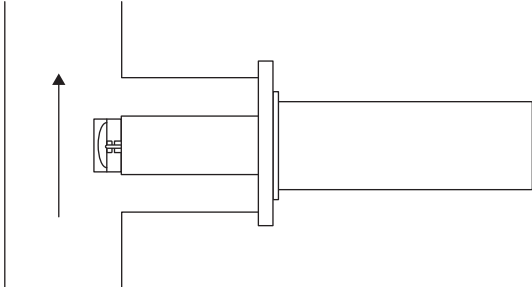
pipe diameter	D mm	h mm	weight kg
DN 50, 2"	Ø100	15	1.84
DN 80, 3"	Ø122	20	2.04



pipe diameter	D mm	h mm	weight kg	connecting dimensions according to
DN 50	Ø102	17	2.19	ISO 7005 EN 1092
DN 80	Ø124	17	2.5	BS 4504 DIN 2501
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

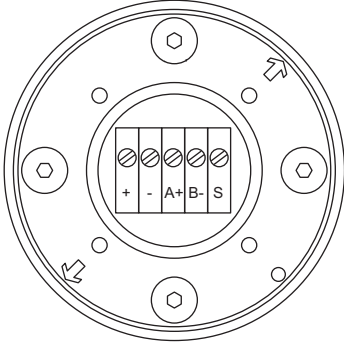
Mounting positions of sensor

<p>R500-M</p>	
<p>horizontal pipe</p> 	<p>vertical pipe¹</p> 
<p>R500-L</p>	
<p>vessel</p>  <p>installation close to the outlet</p>	<p>T-piece¹</p> 

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

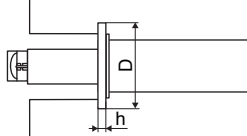
Sensor order code

1, 2	3...5	6	7	8, 9	10, 11	12, 13	14...16	17	18...20	21...23	no. of character	
measurement principle	type	-	type of construction	design	material (wetted parts)	gaskets	explosion protection	process pressure	flange	flange size (flange = D)	cable length	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 (Kalrez)
						A1						zone 0/1
						NN						not explosion proof
							P10					PN 10
							P16					PN 16
							P40					PN 40
								F				FLEXIM flange (R500-MC)
								D				direct flange (R500-LCS4, R500-*CTF)
									050			DN 50 (R500-LCS4)
									065			DN 65 (R500-LCS4)
									080			DN 80 (R500-LCS4)
									100			DN 100 (R500-LCS4)
									002			2" (R500-LCS4)
									003			3" (R500-LCS4)
									004			4" (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))
										XXX		in m

Process connection

Direct flange for PIOX R500-LCS4KR**D

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

description	sensor order code	process pressure	pipe diameter	dimensions [mm]		dimensional drawing	
				D	h		
direct flange	D050	R500-LCS4****D050	PN 16 optional: PN 40	DN 50	ø165	18	
	D080	R500-LCS4****D080		DN 80	ø200	20	
	D100	R500-LCS4****D100		DN 100	ø220	20	
	D125	R500-LCS4****D125		DN 125	ø250	22	
	D002	R500-LCS4****D002		2"	ø6"	19.1	
	D003	R500-LCS4****D003		3"	ø7.5"	23.9	
	D004	R500-LCS4****D004		4"	ø9"	23.9	

special materials on request

Process connection for PIOX R500-MCS4KR**F

Order code

process connection	connection type	pipe diameter	material ¹	gaskets	process pressure 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 lbs
	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 = 010, 015, 020, 025, 040, 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)
			S4				stainless steel 316Ti (1.4571)
				FE			FPM with FEP coating
					yy		pressure stage PN yy in bar (yy = 10, 16, on request: 40) 150 lbs (yy = 10)
						CL	cleaning line (PCR-F*)

¹ possible pipe diameters/materials/process pressures to be selected from table on page 16. Observe national regulations when selecting the flange size depending on the process pressure.

Technical data

description	order code	process pressure yy	pipe diameter xxx	dimensions [mm]			weight [kg]	dimensional drawing
				l	b	h		
flow chamber with flanges accessories: blind cover, sensor mounting kit optional: cleaning line ¹	PCR-FDxxxS4FEyy	PN 16	DN 10	170	ø90	58	4.1	
			DN 15	170	ø95	58	4.3	
DN 20			176	ø105	58	4.7		
DN 25			176	ø115	58	5		
DN 50			190	ø165	80	8.3		
	PCR-FAxxxS4FE10	150 lbs	ANSI 1" ANSI 2"	8.32 8.94	ø4.25" ø6"	2.3" 3.15"	5.1 8.8	
flow chamber with screwed connection accessories: blind cover, sensor mounting kit optional: cleaning line ¹	PCR-FTxxxS4FEyy	PN 16	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-FWxxxS4FEyy	PN 16	DN 10	100	100	58	2.8	
			DN 15	100	100	58	2.8	
			DN 20	100	100	58	2.8	
			DN 25	100	100	58	2.7	
			DN 40	100	100	70	3.13	
			DN 50	100	100	80	4.2	
			DN 80	100	100	107	3.1	
			1/2"	3.94"	3.94"	2.3"	2.8	
			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-WRT00S4FEyy	PN 16			ø100 ²	20		
square welding plate for vessel installation accessories: blind cover, sensor mounting kit	PCR-WST00S4FEyy	PN 16		100	100	20		

xxx, yy - see order code
PN 40 on request

- ¹ cleaning connection:
- thread: G1/4"
- cable gland
- stainless steel pipe 6 x1 mm, length: 150 mm

Accessories

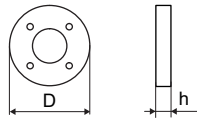
sensor mounting kit

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.

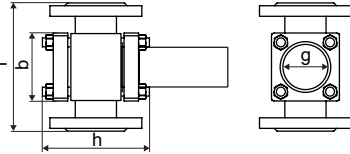
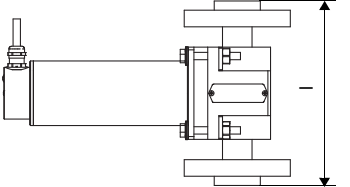
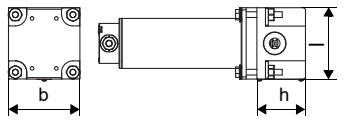
description	sensor order code	process pressure	pipe diameter	dimensions [mm]		dimensional drawing	
				D	h		
loose-type flange	DH50	R500-LCTFKR**DH50	PN 10	DN 50	165	20	
	DH80	R500-LCTFKR**DH80		DN 80	200	20	
	DH02	R500-LCTFKR**DH02		2"	165	24	
	DH03	R500-LCTFKR**DH03		3"	200	27	

included in supply

Process connection for PIOX R500-MCTFKR**D

Order code

process connection	connection type	pipe diameter	wetted parts	gaskets	process pressure	option	description
PCR							process connection
	FH						sight glass fitting
	PH						flow chamber PVDF
		xxx					DN xxx (xxx = 025, 050, 080, 100) 1" (xxx = 001), 2" (xxx = 002), 3" (xxx = 003), 4" (xxx = 004) 3/8" (xxx = G38), 1/2" (xxx = G12), 3/4" (xxx = G34)
			PF				sight glass fitting with PFA liner
			PV				PVDF
				FE			FPM with FEP coating
					yy		pressure stage PN yy in bar (yy = 10) 150 lbs (yy = 10)

description	order code	process pressure yy	pipe diameter xxx	dimensions [mm]				dimensional drawing
				l	b	g	h	
sight glass fitting with PFA liner (self-sealing)	PCR-FH050PFFE10	PN 10	DN 50	230	120	ø80	185	
	PCR-FH080PFFE10		DN 80	310	ø190	ø100	246	
	PCR-FH002PFFE10		2"	230	120	ø80	185	
	PCR-FH003PFFE10		3"	310	ø190	ø100	246	
flow chamber with flanges (PVDF) gasket: TR2644-SP ¹	PCR-PH025PVFE10	PN 10	DN 25	200				
	PCR-PH001PVFE10		1"	200				
flow chamber with screw connection (PVDF) gasket: TR2644-SP ¹	PCR-PHG38PVFE10	PN 10	NPT 3/8"	100	100		68	
	PCR-PHG12PVFE10		NPT 1/2"					
	PCR-PHG34PVFE10		NPT 3/4"					

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

Accessories

sensor mounting kit

The diagram shows an exploded view of the sensor mounting kit. From left to right, the components are: a cylindrical sensor, a support plate with four screws, a blind cover with an O-ring, a process connection (example) with a bearing plate and nut, and a disk spring. Labels with leader lines identify each part: 'sensor', 'support plate', 'screw', 'disk spring', 'blind cover with O-ring', 'O-ring', 'process connection (example)', 'bearing plate', and 'nut'.

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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