

Transmitted light process refractometer

For a wide range of applications in the field of hygiene

Sensor

Properties

- unique transmitted light process refractometer
- one sensor type applicable for all relevant process medium as the accuracy is constant in a wide range of refractive indices
- integrated temperature measurement of the process medium
- sapphire optics with high chemical resistance and mechanical hardness
- optical system insensitive to deposits
- design without dead spaces
- calibration of the sensor using microcontrollers, independent of the transmitter
- digital data transmission
- internal self diagnosis for rapid error detection

Design

- compact design
- access to the pipe from one side
- process connections for Varivent and Tri-clamp installations for a wide range of pipe and vessel dimensions
- ATEX: zone 0/1, 2 approved sensors for hazardous areas available

Measurement

- stable zero point and no drift due to difference measurement
- not sensitive to pressure and temperature fluctuations in the process
- insensitive to bubbles
- no minimum flow required
- independent of viscosity

Transmitter

- standard applications, e.g., measurement of sugar concentration in °Brix, stored in the transmitter
- processing of media data sets for each application
- calculation of application-specific source quantities, e.g., density, M%, Vol%, g/l, dry mass
- measurement of mixtures containing three or more components using additional external quantities (e.g., sound speed, density, conductance)
- integrated inputs and outputs as well as a data logger (SD card)
- transmitter for ATEX zone 2 available



Sensor PIOX R400, type of construction MH, Varivent connection



Sensor PIOX R400, type of construction MH, Tri-clamp connection



PIOX R704



PIOX R705

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Fields of Application

Food and Beverage Industry, Biochemicals

- soft drinks, fruit juices
- original wort (cold and hot wort) in the beer production
- citric acid, acetic acid
- pectin
- sweets

Pharmaceutical Industry

- vitamin C production
- ascorbic acid, ketogulonic acid

Measurement principle

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 R400

Sensor

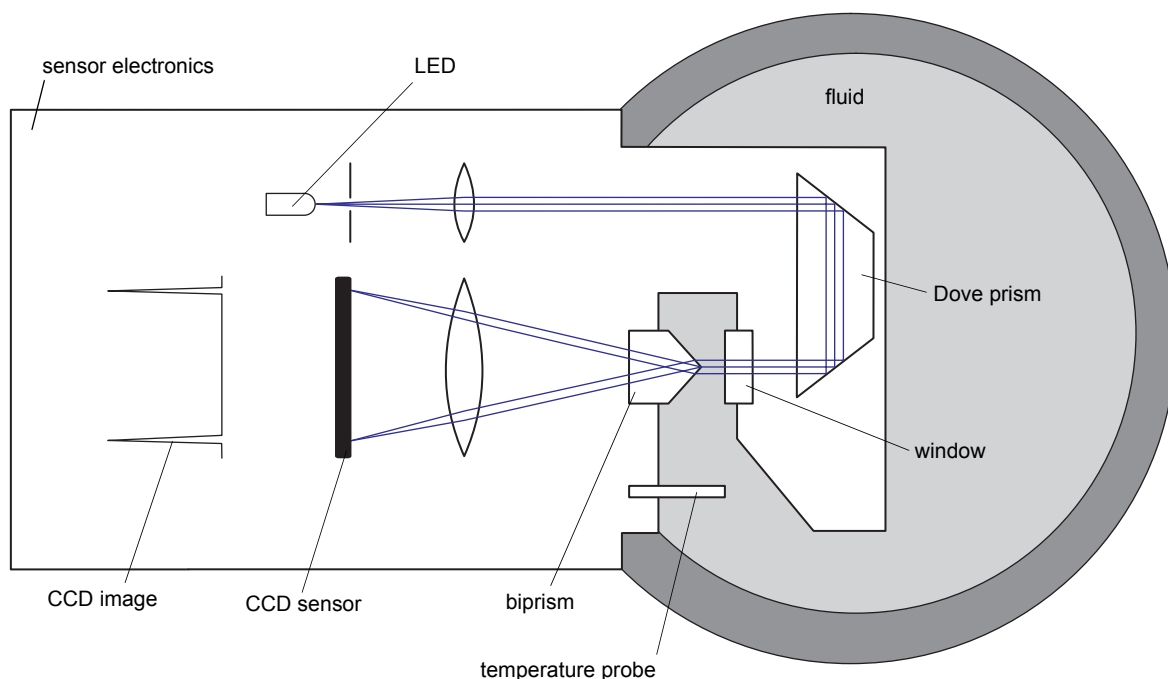
A special LED with a wave length $\lambda = 590$ nm (sodium D line) is used as the light source. The light passes through a slit, is parallelized by a lens and reversed by a Dove prism. Then it enters the fluid through a window in the sensor head. When the light beam re-enters the sensor, it is split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

The two resulting measuring beams are focused by a lens, generating sharp images of the slit on the detector, a CCD sensor with 2048 pixels.

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 following quantities are measured/calculated in the sensor and sent to the transmitter:

- refractive index n_D (= matched to the sodium D line), calculated from the angle of refraction
- fluid temperature measured by the integrated temperature probe Pt1000
- signal amplitude, calculated from the CCD signals
- internal sensor temperature
- relative humidity, measured in the sensor electronics



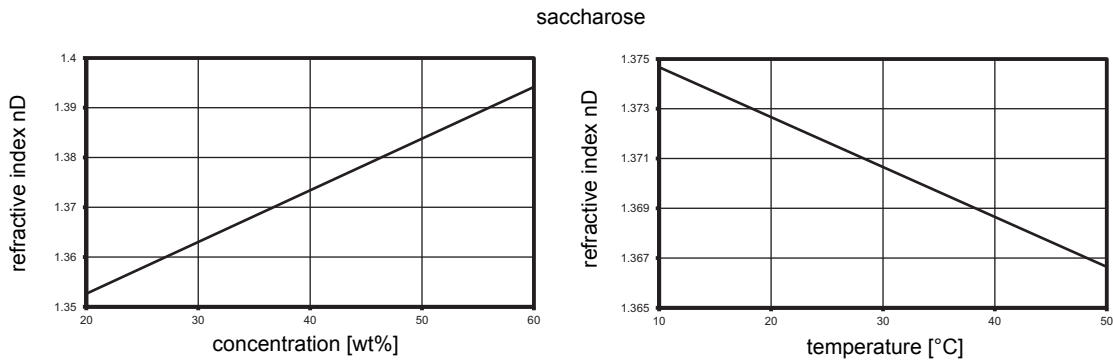
Processing in the transmitter

The refractive index and the fluid temperature sent by the sensor are used for the calculation of process parameters, e.g. the temperature-compensated refractive index nDT, the ° Brix value or the concentration in mass or volume percent. Additional process parameters can be configured by means of the program RMKoeff (see page 6).

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.

Temperature dependence

As the refractive index depends on the fluid temperature, the process parameters can often only be calculated if the fluid temperature is known. The temperature measured by the integrated temperature probe is used for the calculation of the temperature-compensated refractive index nDT.



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

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

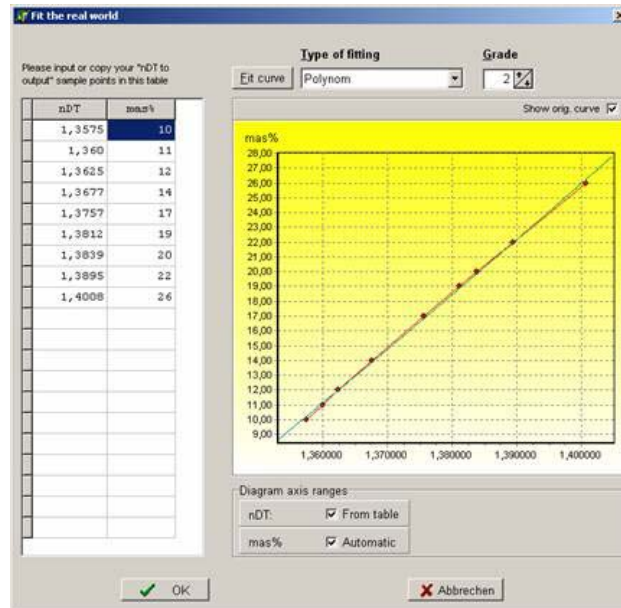
Program RMKoeff

The transmitter has an internal database for storing the data sets of commonly used fluids. Data sets for additional fluids can be easily added and managed on a PC using the program RMKoeff.

The characteristics is generated by polynomials of grade 1...3 from a data table or from a test series. The X axis quantity is the refractive index nDT related to a standard temperature. The Y axis quantity is the required process parameter and its unit of measurement are user defined, e.g. concentration in wt%, g/l or mol/l.

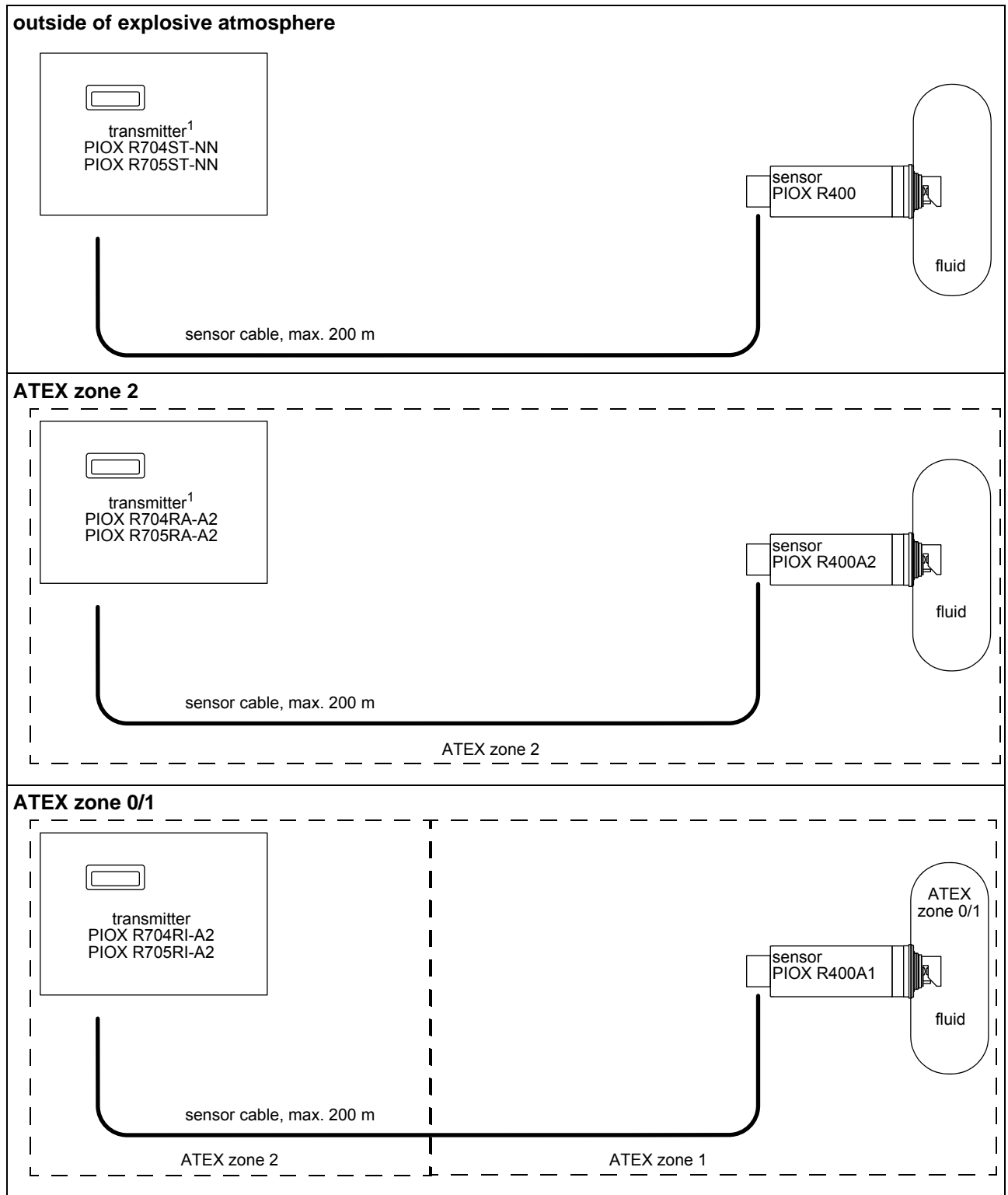
The customized data sets will be transferred between transmitter and PC via the serial interface RS232 or USB.

Data sets, even with high complexity, can also be generated in the FLEXIM laboratory.



Program RMKoeff - generation of a concentration characteristics



Measuring setups



¹ optional: connection of 2 sensors

Transmitter

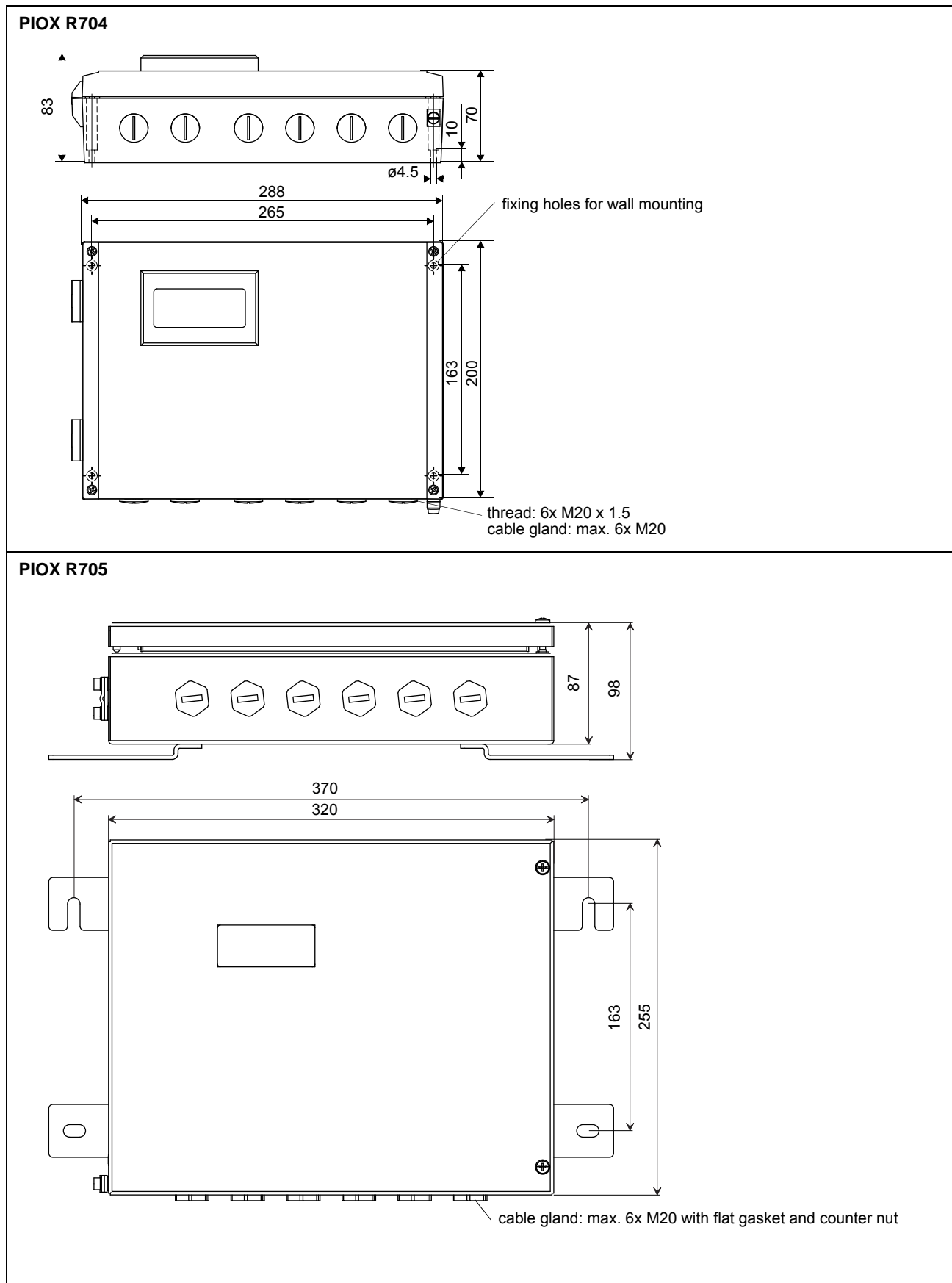
Technical data

PIOX	R704ST-NN R704RA-A2	R704RI-A2	R705ST-NN R705RA-A2	R705RI-A2		
	standard field device		field device with stainless steel housing			
						
power supply	100...230 V/50...60 Hz or 20...32 V DC					
power consumption	< 15 W					
number of measuring channels	1, optional (on request): 2	1	1, optional (on request): 2	1		
damping	0...100 s, adjustable					
response time	1 s					
housing material	aluminum, powder coated		stainless steel 316L (1.4404)			
degree of protection according to IEC/EN 60529	IP65		IP66			
dimensions	see dimensional drawing					
weight	2.8 kg		4.76 kg			
fixation	wall mounting, optional: 2" pipe mounting					
ambient temperature	-40...+60 °C (-40...-20 °C without operation of the display)					
display	2 x 16 characters, dot matrix, backlight					
menu language	English, German					
explosion protection						
ATEX	transmitter	R704RA-A2	R704RI-A2	R705RA-A2	R705RI-A2	
	zone	2	2	2	2	
	marking	CE ^{Ex} II3G Ex nA nC ic IIC T4 Gc II3D Ex tc IIIC T 120 °C Dc Ta -40...+60 °C	CE 0637 ^{Ex} II(2)3G Ex nA [ib Gb] IIC T4 Gc I (M2) [Ex ib Mb] I II2D Ex tb [ib] IIIC T 120 °C Db Ta -40...+60 °C	CE ^{Ex} II3G Ex nA nC ic IIC T4 Gc II3D Ex tc IIIC T 120 °C Dc Ta -40...+60 °C	CE 0637 ^{Ex} II(2)3G Ex nA [ib Gb] IIC T4 Gc I (M2) [Ex ib Mb] I II2D Ex tb [ib] IIIC T 120 °C Db Ta -40...+60 °C	
	certification ATEX	-	IBExU06ATEX1075 X	-	IBExU06ATEX1075 X	
	type of protection	gas: non sparking dust: protection by enclosure	gas: non sparking dust: protection by enclosure	gas: non sparking dust: protection by enclosure	gas: non sparking dust: protection by enclosure	
intrinsic safety parameters	-	U _m = 250 V intrinsically safe power supply for zone 1 sensors: P _o = 1.1 W U _o = 13.2 V I _o = 84 mA C _o = 0.24 µF RS485 (intrinsic safety): P _o = 0.2 W U _o = 6 V I _o = 76 mA C _o = 39.3 µF	-	U _m = 250 V intrinsically safe power supply for zone 1 sensors: P _o = 1.1 W U _o = 13.2 V I _o = 84 mA C _o = 0.24 µF RS485 (intrinsic safety): P _o = 0.2 W U _o = 6 V I _o = 76 mA C _o = 39.3 µF		

PIOX	R704ST-NN R704RA-A2	R704RI-A2	R705ST-NN R705RA-A2	R705RI-A2
measuring functions				
physical quantities	refractive index, fluid temperature, °Brix, wt% (saccharose), more with application specific output parameters			
diagnostic functions	signal amplitude, sensor humidity, sensor temperature			
data logger				
type	SD card, removable			
capacity	min. 2 GB			
communication				
interface	- process integration: RS485 (optional) - diagnosis: RS232 ¹			
serial data kit				
software (all Windows™ versions)	RMKoeff: management of fluid data sets			
cable	RS232 ¹			
adapter	RS232 - USB ¹			
outputs (optional)				
	The outputs are galvanically isolated from the transmitter.			
number	on request			
current output				
range	0/4...20 mA			
accuracy	0.1 % of reading ± 15 µA			
active output	$R_{ext} < 500 \Omega$			
passive output	$U_{ext} = 4...24 \text{ V}$, depending on R_{ext} $R_{ext} < 1 \text{ k}\Omega$			
voltage output				
range	0...1 V or 0...10 V			
accuracy	0...1 V: 0.1 % of reading ± 1 mV 0...10 V: 0.1 % of reading ± 10 mV			
internal resistance	$R_i = 500 \Omega$			
frequency output				
range	0...5 kHz			
open collector	24 V/4 mA, $R_i = 66.5 \Omega$			
binary output				
Reed relay	48 V/100 mA P1...P4: $R_i = 22 \Omega$			
open collector	24 V/4 mA P1...P4: $R_i = 22 \Omega$			
optorelay	26 V/100 mA			
binary output as alarm output - functions	limit			
inputs (optional)				
	The inputs are galvanically isolated from the transmitter.			
number	max. 4, on request			
current input				
accuracy	0.1 % of reading ± 10 µA			
active input	$U_i = 24 \text{ V}$, $R_i = 50 \Omega$, $P_i < 0.5 \text{ W}$, not short-circuit proof			
- range	0...20 mA			
passive input	$R_i = 50 \Omega$, $P_i < 0.3 \text{ W}$			
- range	-20...+20 mA			
voltage input				
range	0...1 V			
accuracy	0.1 % of reading ± 1 mV			
internal resistance	$R_i = 1 \text{ M}\Omega$			

¹ R70***-A2: connection of the interface RS232 outside of explosive atmosphere (housing cover open)

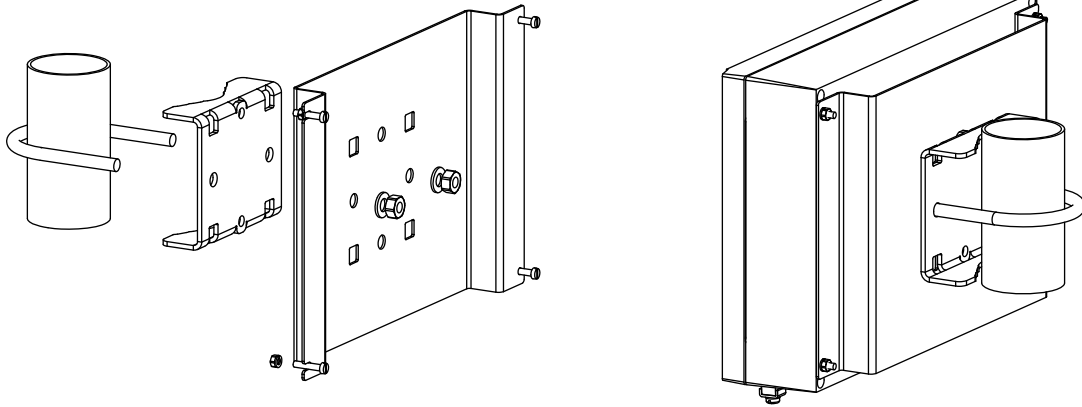
Dimensions



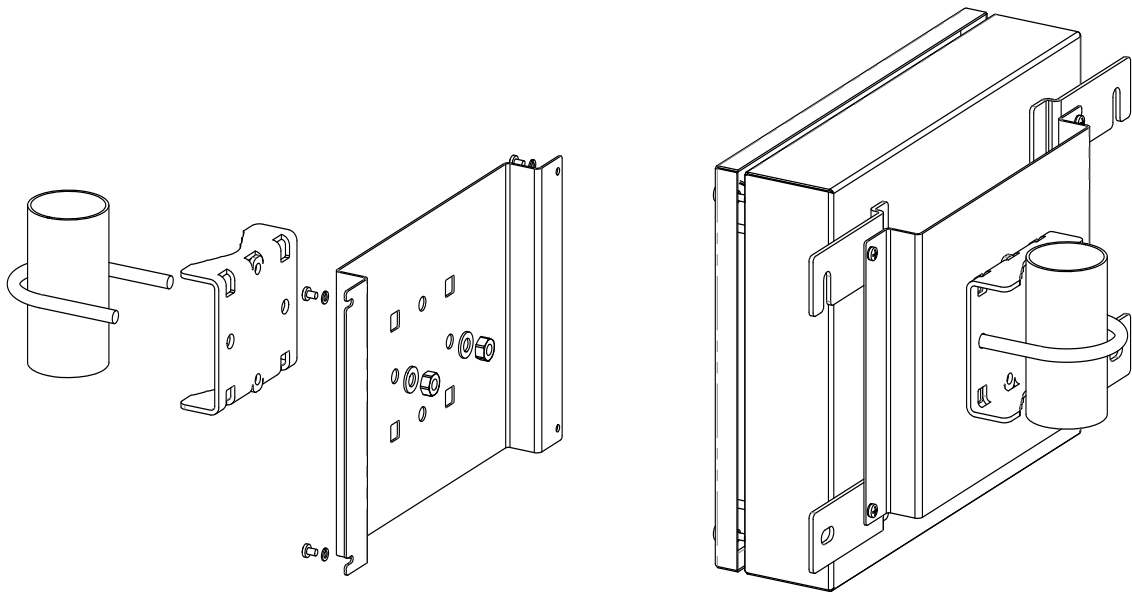
in mm

2" pipe mounting kit (optional)

PIOX R704

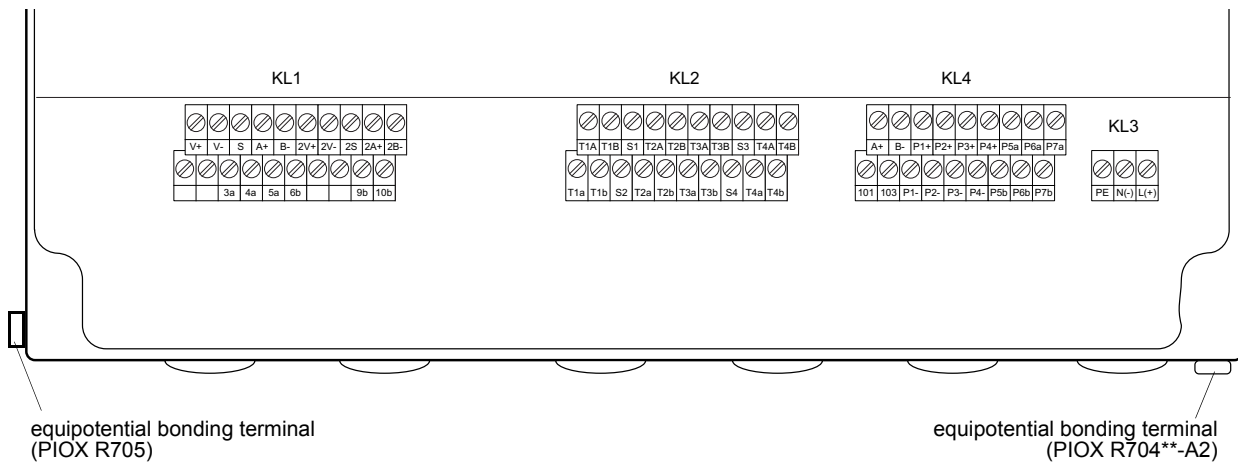


PIOX R705



Terminal assignment

PIOX R704, R705



power supply

terminal strip KL3

terminal	connection (AC)	connection (DC)
PE	earth	earth
N(-)	neutral	-
L(+)	phase	+

transducers

terminal strip KL1

terminal measuring channel A	terminal measuring channel B	transducer cable	extension cable
V+	2V+	yellow	yellow
V-	2V-	green	green
A+	2A+	brown	brown
B-	2B-	white	white

outputs¹

terminal strip KL4

terminal	connection
P1+...P4+, P1-...P4-	current output, voltage output, frequency output or binary output (Reed relay, open collector)
P5a...P7a, P5b...P7b	binary output

RS485 (optional)

terminal strip KL4

terminal	connection
A+	signal +
B-	signal -
101	shield

inputs¹

terminal strip KL2

terminal	passive current source connection of an active input	active current source connection of a passive input
T1a...T4a	not connected	not connected
T1A...T4A	-	+
T1b...T4b	+	not connected
T1B...T4B	not connected	-
S1...S4	not connected	not connected

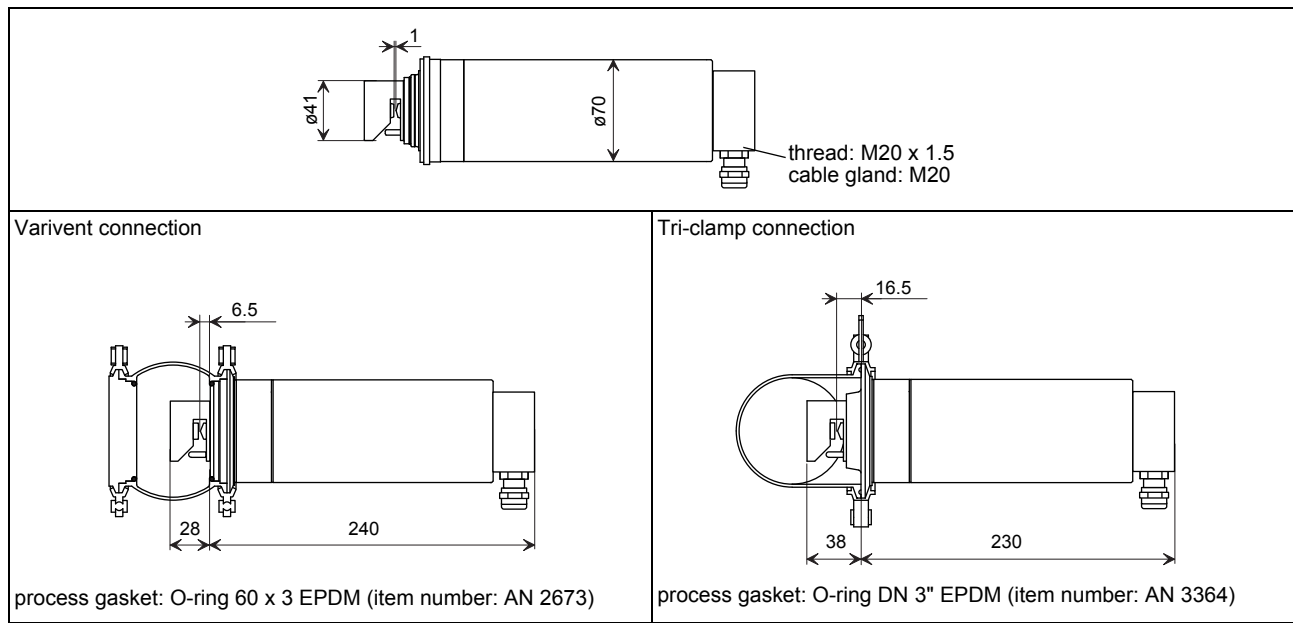
¹ The number, type and terminal assignment of the outputs and inputs will be customized.

Sensor

Technical data

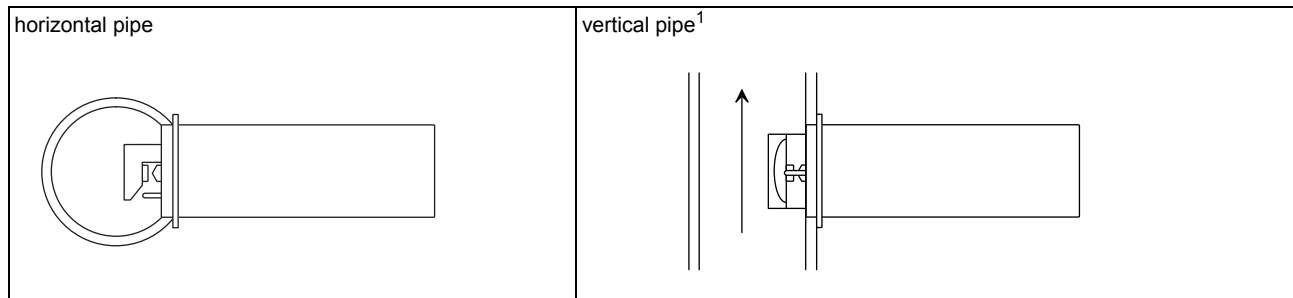
PIOX	R400	R400A2	R400A1	
process parameters				
medium	all liquids with a turbidity < 10 000 FAU			
fluid temperature (depending on ambient temperature)	-20...+150 °C (150 °C at an ambient temperature of 20 °C)	-20...+130 °C		
fluid pressure	PN 10, PN 16, PN 40 (on request, depending on process connection)			
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, typical 0.1 wt%)			
repeatability	nD: 0.000 02 (corresponds to 0.01 °Brix, typical 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 or FKM (Viton)			
prism	sapphire, nD ≈ 1.76			
degree of protection according to IEC/EN 60529	IP67			
flange	for Varivent (N) or Tri-clamp 3 "			
dimensions with flange	see dimensional drawing			
weight	min. 2 kg			
ambient temperature	-20...+60 °C			
explosion protection				
ATEX	zone	-	2	1
	marking	-	CE Ex II3G Ex nA op is IIC T4 Gc II3D Ex tc IIIC T 120 °C Dc Ta -40...+60 °C Tm -20...+130 °C	CE 0637 Ex II1/2G Ex ib op is IIC T4 Ga/Gb I M2 Ex ib op is I Mb II2D Ex ib IIIC T 120 °C Db Ta -40...+60 °C Tm -20...+130 °C
	certification ATEX	-	-	IBExU06ATEX1075 X
	type of protection	-	gas: non sparking dust: protection by enclosure	intrinsic safety, inherently safe optical radiation
	intrinsic safety parameters	-	-	power supply: C _i = 141.6 nF L _i = 0 μH data: C _i = 22.7 nF L _i = 0 μH
temperature probe				
type	Pt1000			
resolution	0.01 K			
accuracy at 20 °C	0.15 K			
response time	5 s			

Dimensions



in mm

Mounting positions of sensor



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

Transducer order code

1, 2	3..5	6, 7	6, 7	8, 9	10, 11	12, 13	14	15...17	no. of character	
measurement principle	type	-	type of construction	design	material (wetted parts)	gaskets	explosion protection	flange	cable length	description
R	400		M							transmitted light refractometer
				H						standard sensor
					V4					hygiene design
					SO					stainless steel 316L (1.4404)
						EP				special materials (on request)
						FK				EPDM
							A1			FKM (Viton)
							A2			ATEX zone 1 (sensor head in zone 0) (R400A1)
							NN			ATEX zone 2 (R400A2)
								V		not explosion proof (R400)
								T		Varivent flange N
									XXX	Tri-clamp flange 3 "
										in m, for max. cable length see page 17
example										
R	400	-	M	H	V4	EP	A1	V	030	standard sensor, hygiene design, wetted parts; stainless steel 316L, gaskets: EPDM, zone 1 (R400A1), Varivent flange N, cable length 30 m
R	400	-								

Process connection

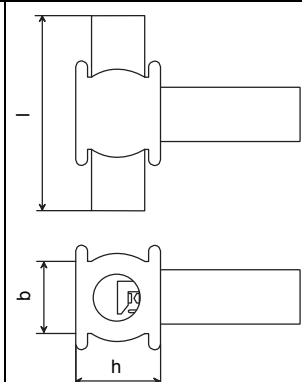

Sensor PIOX R400-*H*****V

Order code

process connection	-	connection type	pipe diameter ¹	material ¹	gaskets	process pressure ¹	description
PCR							process connection of refractometer
		VW					Varinline housing nominal size N with welded connection to the process pipe (R400-MH*****V)
		VR					Varivent connection with housing connection flange type T, nominal size N
			xxx				DN xxx (xxx = 010, 015, 020, 025, 040, 050, 080, 100, 125)
				V4			stainless steel 316L (1.4404)
					EP		EPDM
					FK		FKM (Viton)
						10	pressure stage PN 10, 150 lbs
example							
PCR	-	VW	050	V4	EP	10	process connection of refractometer, Varinline housing nominal size N with welded connection to the process pipe, pipe diameter: DN50, material: stainless steel 316L, gaskets: EPDM, process pressure: PN10
PCR	-						

¹ possible pipe diameters/materials/process pressures to be selected from table on page 16.

Technical data

description	order code	process pressure	pipe diameter xxx	dimensions [mm]			dimensional drawing
				l	b	h	
Varinline housing nominal size N with welded connection to the process pipe (R400-MH*****V)	PCR-VWxxxV4EP10	PN 10	DN 40	180	68	72	
	PCR-VWxxxV4FK10		DN 50	180	68	84	
	PCR-VWxxxSOEP10		DN 65	250	68	100	
	PCR-VWxxxSOFK10		DN 80	250	68	115	
			DN 100	250	68	134	
			DN 125	250	68	159	
Varivent connection with housing connection flange type T, nominal size N	PCR-VRxxxV4EP10	PN 10			ø165	24.5	
	PCR-VRxxxV4FK10						
	PCR-VRxxxSOEP10						
	PCR-VRxxxSOFK10						

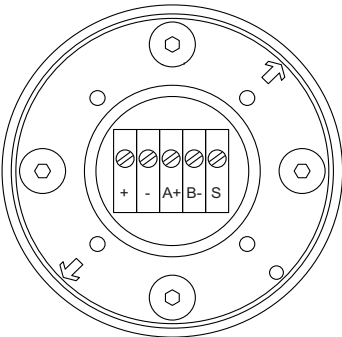
xxx - see order code

Connection systems

Sensor cable

PIOX		R400A1	R400A2	R400
item number		TR10125	TR10126	
type		LIYCY 2 x 2 x 0.75 blue	LIYCY 2 x 2 x 0.75 grey	
max. length	m	200	200	
weight (approx.)	kg/m	0.112	0.106	
ambient temperature	°C	-10...+80	-40...+80	
properties		flame retardant according to DIN VDE 0482, part 265-2-1 self-extinguishing	flame retardant according to IEC 60332-1-2	
cable jacket				
material		PVC	PVC	
outer diameter	mm	8.9	8.5	
colour		blue	grey	
shield		x	x	

Terminal assignment



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

equipotential bonding terminal on housing cover



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TSPIOXR400-xHV2-1-2EN_Leu, 9/5/17