

Non-invasive ultrasonic volumetric flow rate measurement of compressed air

Features

- Non-invasive ultrasonic measurement of compressed air, technical and medical gases
- Integrated standard volumetric flow rate calculation, temperature and pressure compensated via process inputs
- Bidirectional measurement with flow direction detection and separate totalizers
- Drift- and maintenance-free, since there is no measurement impairment due to moisture, dirt or oil
- Perfectly suitable for leakage monitoring by detecting the smallest flow velocities from 0.01 m/s
- Smart meter/IoT ready via Ethernet interface with corresponding IP data protocols (e.g. Modbus TCP)
- Sophisticated support software for parameterization, remote control, recording and automatic state diagnosis (FluxDiagReader, FluxDiag, Advanced Meter Verification)

Applications

- Energy management and leakage monitoring in compressed air networks
- Monitoring and consumption measurement of medical, pharmaceutical and technical clean gas
- Balancing and cost distribution
- Process optimization



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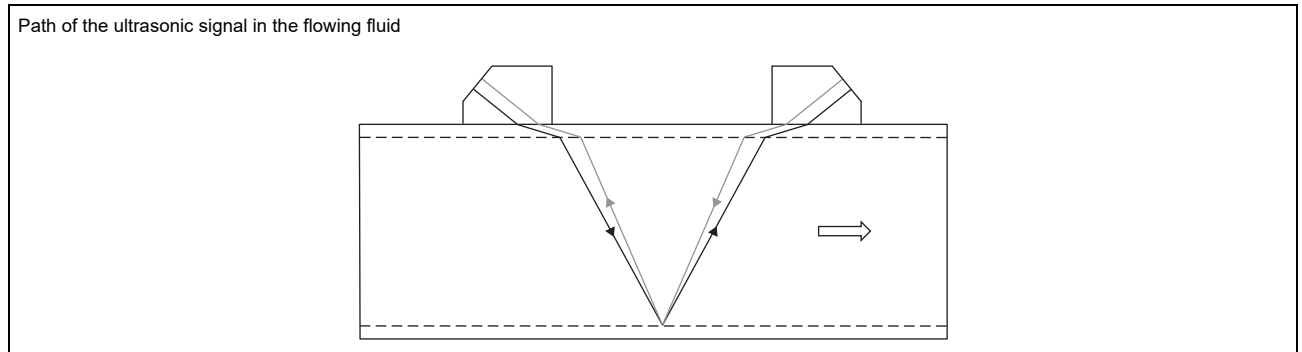
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Function

Measurement principle

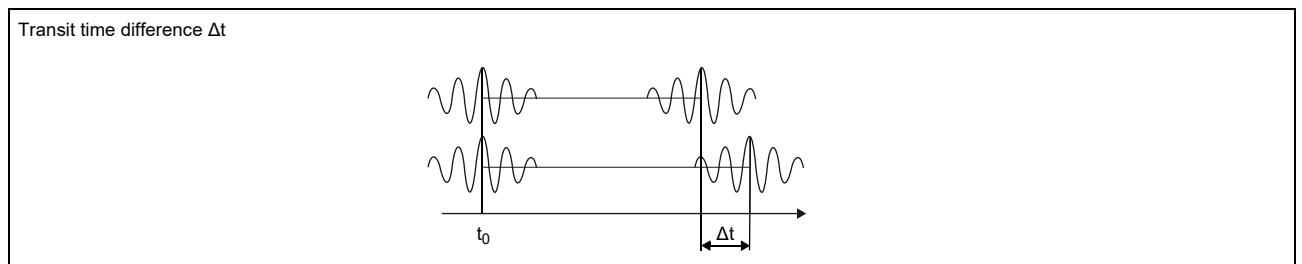
The transducers are mounted on the pipe which is completely filled with the fluid. The ultrasonic signals are emitted alternately by a transducer and received by the other. The physical quantities are determined from the transit times of the ultrasonic signals.



As the fluid where the ultrasound propagates is flowing, the transit time of the ultrasonic signal in flow direction is shorter than the one against the flow direction.

The transit time difference Δt is measured and allows the flowmeter to determine the average flow velocity along the propagation path of the ultrasonic signals. A flow profile correction is then performed in order to obtain the area averaged flow velocity, which is proportional to the volumetric flow rate.

The integrated microprocessors control the entire measuring cycle. The received ultrasonic signals are checked for measurement usability and evaluated for their reliability. Noise signals are eliminated.



Calculation of volumetric flow rate

$$\dot{V} = k_{Re} \cdot A \cdot k_a \cdot \frac{\Delta t}{2 \cdot t_{\gamma}}$$

where

- \dot{V} - volumetric flow rate
- k_{Re} - fluid mechanic calibration factor
- A - cross-sectional pipe area
- k_a - acoustic calibration factor
- Δt - transit time difference
- t_{γ} - average of transit times in the fluid

Calculation of standard volumetric flow rate

The standard volumetric flow rate can be selected as physical quantity. It is calculated with the following formula:

$$\dot{V}_N = \dot{V} \cdot \frac{p}{p_N} \cdot \frac{T_N}{T} \cdot \frac{1}{K}$$

where

- \dot{V}_N - standard volumetric flow rate
- \dot{V} - operating volumetric flow rate
- p_N - standard pressure (absolute value)
- p - operating pressure (absolute value)
- T_N - standard temperature in K
- T - operating temperature in K
- K - compressibility coefficient of gas: ratio of the compressibility factors of the gas at operating conditions and at standard conditions Z/Z_N

Number of sound paths

The number of sound paths is the number of transits of the ultrasonic signal through the fluid in the pipe. Depending on the number of sound paths, the following methods of installation exist:

• **reflection arrangement**

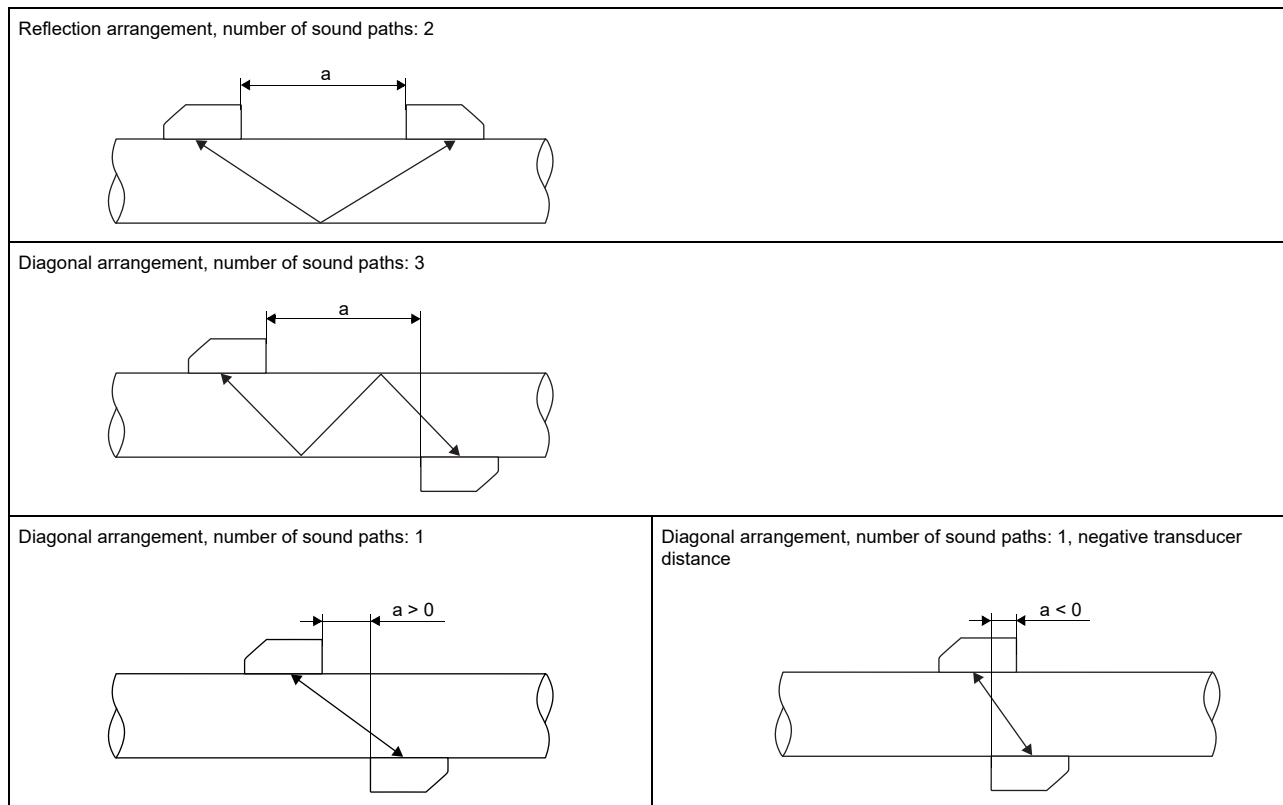
The number of sound paths is even. The transducers are mounted on the same side of the pipe. Correct positioning of the transducers is easy.

• **diagonal arrangement**

The number of sound paths is odd. The transducers are mounted on opposite sides of the pipe. In case of high signal attenuation by the fluid or pipe, diagonal arrangement with 1 sound path is used.

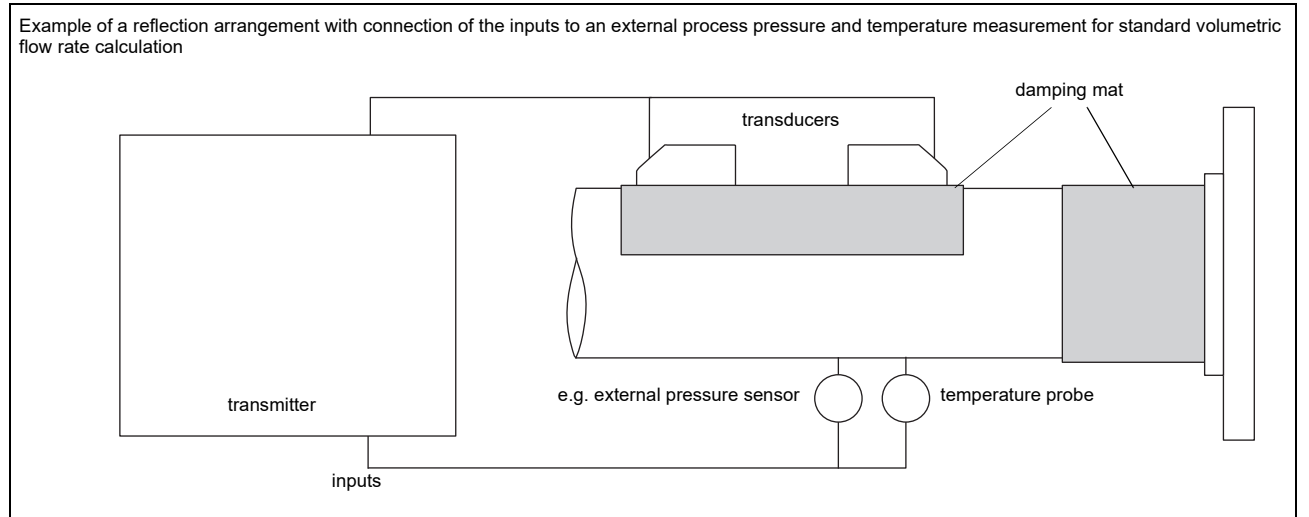
The preferred method of installation depends on the application. While increasing the number of sound paths increases the accuracy of the measurement, signal attenuation increases as well. The optimum number of sound paths for the parameters of the application will be determined automatically by the transmitter.

As the transducers can be mounted with the transducer mounting fixture in reflection arrangement or diagonal arrangement, the number of sound paths can be adjusted optimally for the application.



a - transducer distance

Typical measurement setup



Transmitter

Technical data

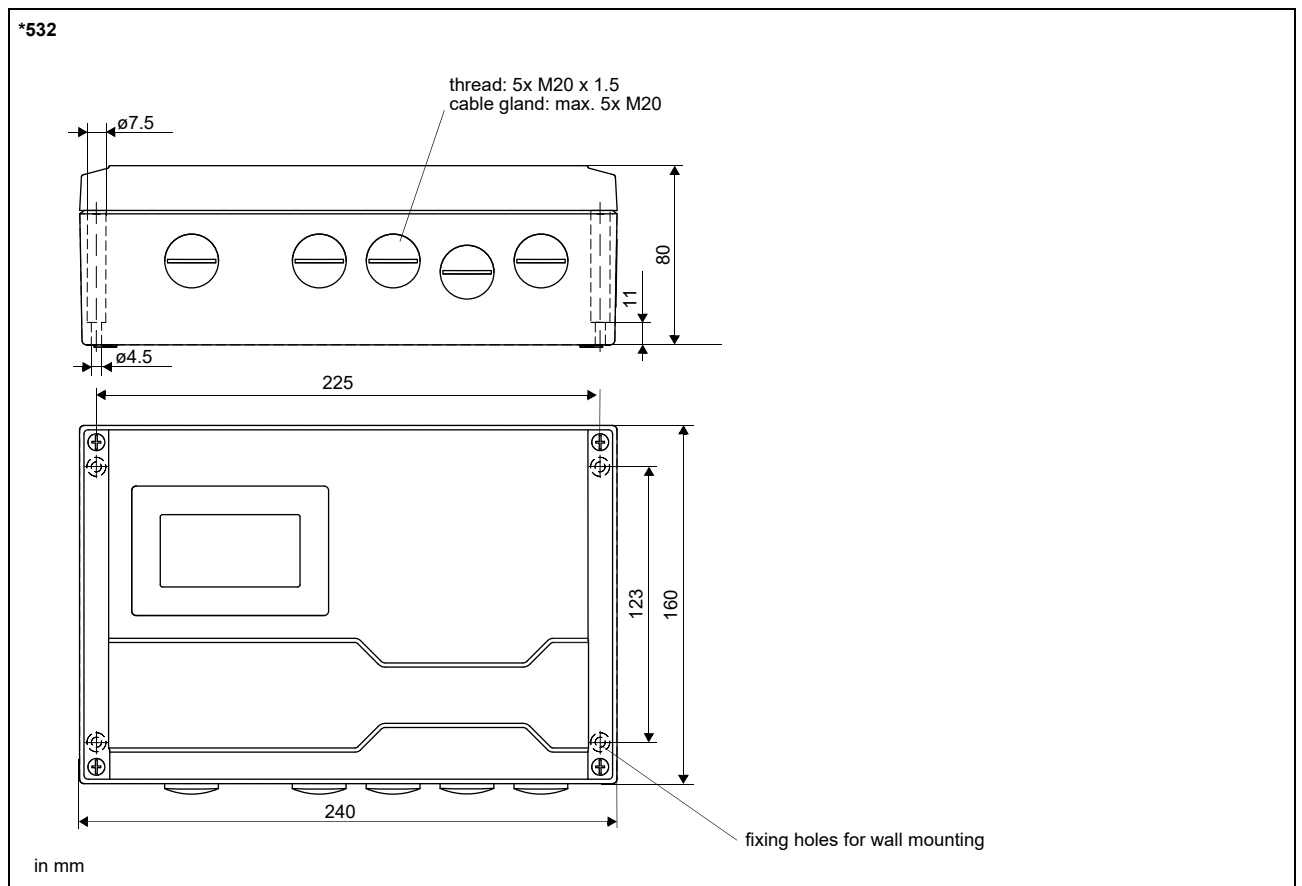
	FLUXUS G532CA (analog outputs)	FLUXUS G532CA (process interface)
		
design	field device with 1 measuring channel	
application	flow measurement of compressed air, industrial, pharmaceutical and clean gases	
measurement		
measurement principle	transit time difference correlation principle	
flow direction	bidirectional	
flow velocity	m/s	0.01...35, depending on pipe diameter
repeatability	0.15 % MV \pm 0.005 m/s	
fluid	compressed air, oxygen, nitrogen, argon, helium	
temperature compensation	corresponding to the recommendations in ANSI/ASME MFC-5.1-2011	
measurement uncertainty (volumetric flow rate)		
measurement uncertainty of the measuring system ¹	\pm 0.3 % MV \pm 0.005 m/s	
measurement uncertainty at the measuring point	\pm 1...2 % MV \pm 0.005 m/s, depending on the application	
transmitter		
power supply	<ul style="list-style-type: none"> • 90...250 V/50...60 Hz or • 11...32 V DC 	
power consumption	W	< 10
number of measuring channels	1	
damping	s	0...100 (adjustable)
measuring cycle	Hz	100...1000
response time	s	1
housing material	aluminum, powder coated	
degree of protection	IP66	
dimensions	mm	see dimensional drawing
weight	kg	2.25
fixation	wall mounting, optional: 2" pipe mounting	
ambient temperature	°C	-20...+60
display	128 x 64 pixels, backlight	
menu language	English, German, French, Spanish, Dutch, Russian, Polish, Turkish, Italian, Chinese	
measuring functions		
physical quantities	operating volumetric flow rate, standard volumetric flow rate, mass flow rate, flow velocity	
totaliser	volume, mass	
diagnostic functions	sound speed, signal amplitude, SNR, SCNR, standard deviation of amplitudes and transit times	
communication interfaces		
service interfaces	measured value transmission, parametrisation of the transmitter: <ul style="list-style-type: none"> • USB • LAN 	measured value transmission, parametrisation of the transmitter: <ul style="list-style-type: none"> • USB • LAN
process interfaces	-	<ul style="list-style-type: none"> • Modbus RTU or • BACnet MS/TP or • M-Bus or • Modbus TCP or • BACnet IP
accessories		
data transmission kit	USB cable	
software	<ul style="list-style-type: none"> • 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 and totalised physical quantities	
capacity	max. 800 000 measured values	
outputs		
	The outputs are galvanically isolated from the transmitter.	
• switchable current output		
	configurable according to NAMUR NE43	
number	1	
range	mA	4...20 (3.2...24)
accuracy	0.04 % MV \pm 3 μ A	
active output	$R_{ext} < 530 \Omega$	
passive output	$U_{ext} = 9...30 \text{ V}$, depending on R_{ext} ($R_{ext} < 458 \Omega$ at 20 V)	

¹ with aperture calibration of the transducers

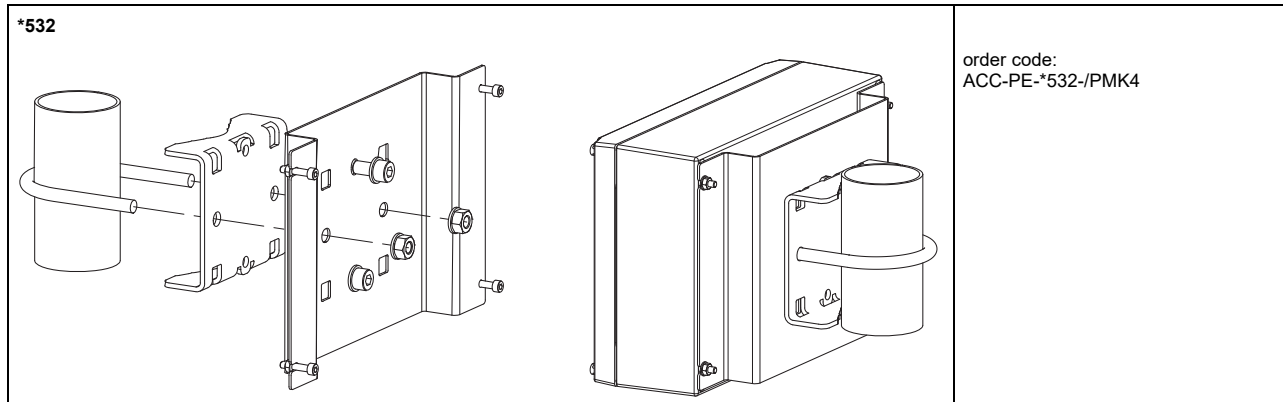
		FLUXUS G532CA (analog outputs)	FLUXUS G532CA (process interface)
• digital output			
number		2	-
functions		<ul style="list-style-type: none"> • frequency output • binary output • pulse output 	-
operating parameters		$U_{ext} = (8.2 \pm 0.1) \text{ V DC}$	-
frequency output			
• range	kHz	0...10	-
binary 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.	
• temperature input			
number		1	
type		Pt100/Pt1000	
connection		4-wire	
range	°C	-150...+560	
resolution	K	0.01	
accuracy		$\pm 0.01 \% \text{ MV} \pm 0.03 \text{ K}$	
• switchable current input			
number		1	
accuracy		$\pm 0.1 \% \text{ MV} \pm 0.01 \text{ mA}$	
active input		$U_{out} = \text{max. } 28 \text{ V}, R_{int} = 75 \Omega$	
• range	mA	0...24	
passive input		$R_{int} = 35 \Omega, U_{out} = 26 \text{ V}, I_{max} \leq 24 \text{ mA}$	
• range	mA	0...20	

¹ with aperture calibration of the transducers

Dimensions



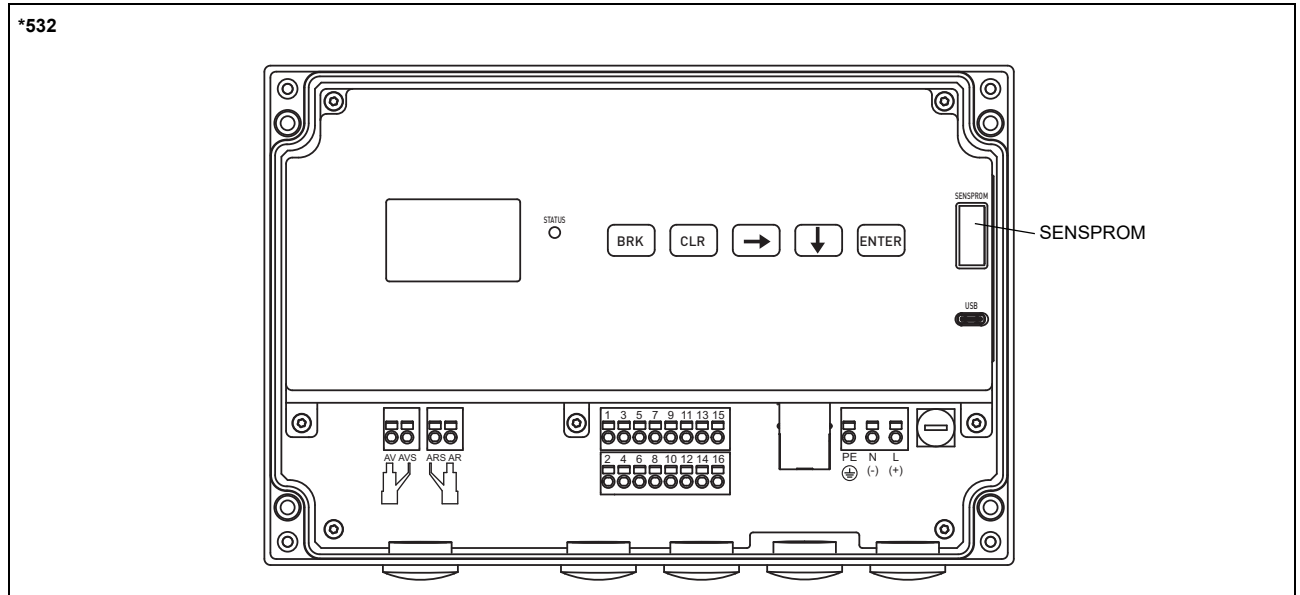
2" pipe mounting kit (optional)



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 supply ¹			
terminal	connection (AC)	terminal	connection (DC)
PE	protective earth	PE	protective earth
N	neutral	(-)	-
L	phase	(+)	+
transducers			
terminal	connection	transducer	
AV	signal		
AVS	internal shield		
ARS	internal shield		
AR	signal		
cable gland	external shield		
outputs, inputs ^{1, 2}			
terminal	connection		
13+, 14-	passive current output		
13-, 14+	active current output		
9+, 10- 11+, 12-	digital output		
1, 2, 3, 4	temperature input		
5+, 6-	passive current input		
5-, 6+	active current input		
temperature probe			
terminal	direct connection	connection with extension cable	
1	red	red	
2	white	white	
3	red/blue	grey	
4	white/blue	blue	
communication interfaces			
terminal	connection	communication interface	
15	signal +	<ul style="list-style-type: none"> • Modbus RTU¹ • BACnet MS/TP¹ • M-Bus¹ 	
16	signal -		
USB	type C Hi-Speed USB 2.0 Device	service (FluxDiag/FluxDiagReader)	
LAN	RJ45 10/100 Mbps Ethernet	<ul style="list-style-type: none"> • service (FluxDiag/FluxDiagReader) • Modbus TCP • BACnet IP 	

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.

Transducers

Technical data

Lamb wave transducers

order code		GLK-N**T1/**	GLM-N**T1/**	GLP-N**T1/**	GLQ-N**T1/**
technical type		G(RT)K1N53	G(RT)M1N53	G(RT)P1N53	G(RT)Q1N53
transducer frequency	MHz	0.5	1	2	4
fluid pressure¹					
min. extended	bar	metal pipe: 10 (d > 120 mm) 3 (d < 120 mm)	metal pipe: 3 (d < 60 mm)	metal pipe: 3 (d < 35 mm)	metal pipe: 3 (d < 15 mm)
min.	bar	metal pipe: 15 (d > 120 mm) 10 (d < 120 mm) plastic pipe: 1	metal pipe: 10 (d > 60 mm) 5 (d < 60 mm) plastic pipe: 1	metal pipe: 10 (d > 35 mm) 5 (d < 35 mm) plastic pipe: 1	metal pipe: 10 (d > 15 mm) 5 (d < 15 mm) plastic pipe: 1
inner pipe diameter d²					
min. extended	mm	60	30	15	7
min. recommended	mm	80	40	20	10
max. recommended	mm	300	150	50	22
max. extended	mm	360	180	60	30
pipe wall thickness					
min.	mm	5	2.5	1.2	0.6
max.	mm	10	5	3	1.2
material					
housing		PPSU with stainless steel cover 304 (1.4301), ***-****/OS: 316L (1.4404)			
contact surface		PPSU			
degree of protection		IP67	IP65		
transducer cable					
type		1699			
length	m	5	4		3
length (**-****/LC)	m	9			
dimensions					
length l	mm	128.5	74		42
width b	mm	51	32		22
height h	mm	67.5	40.5		25.5
dimensional drawing					
weight (without cable)	kg	0.471	0.077		0.019
pipe surface temperature	°C	-40...+130			
ambient temperature	°C	-40...+130			
temperature compensation		x			

¹ depending on the application, typical absolute value for natural gas, nitrogen, compressed air

² Lamb wave transducer:
 typical values for natural gas, nitrogen, oxygen; pipe diameters for other fluids on request
 inner pipe diameter max. recommended: in reflection arrangement (diagonal arrangement) and for a flow velocity of 15 m/s (30 m/s)
 inner pipe diameter max. extended: in reflection arrangement (diagonal arrangement) and for a flow velocity of 12 m/s (25 m/s)

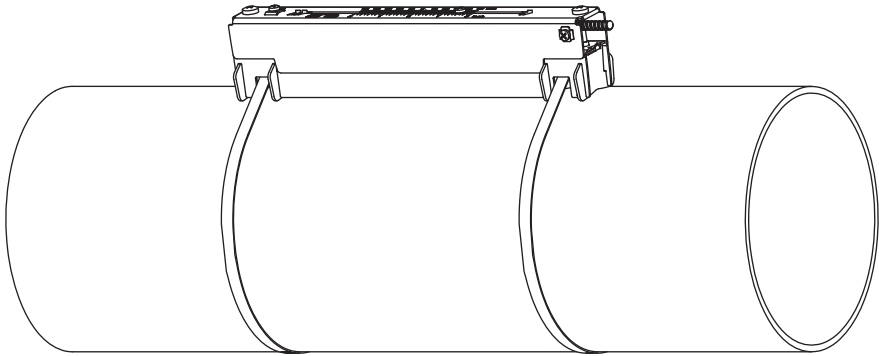
Shear wave transducers (optional)

order code		GSK-N**T1/**	GSM-N**T1/**	GSP-N**T1/**	GSQ-N**T1/**
technical type		G(DL)K1N53	G(DL)M2N53	G(DL)P2N53	G(DL)Q2N53
transducer frequency	MHz	0.5	1	2	4
fluid pressure¹					
min. extended	bar	metal pipe: 20			
min.	bar	metal pipe: 30, plastic pipe: 1			
inner pipe diameter d²					
min. extended	mm	60	30	15	7
min. recommended	mm	80	40	20	10
max. recommended	mm	300	150	50	22
max. extended	mm	360	180	60	30
pipe wall thickness					
min.	mm	5	2.5	1.2	0.6
material					
housing		PEEK with stainless steel cover 304 (1.4301), ***-*****/OS: 316L (1.4404)			
contact surface		PEEK			
degree of protection		IP67			
transducer cable					
type		1699			
length	m	5	4		3
length (***-*****/LC)	m	9			
dimensions					
length l	mm	126.5	64		40
width b	mm	51	32		22
height h	mm	67.5	40.5		25.5
dimensional drawing					
weight (without cable)	kg	0.36	0.066		0.016
pipe surface temperature	°C	-40...+130			
ambient temperature	°C	-40...+130			
temperature compensation		x			

¹ depending on the application, typical absolute value for natural gas, nitrogen, compressed air

² shear wave transducer:
 typical values for natural gas, nitrogen, oxygen; pipe diameters for other fluids on request
 inner pipe diameter max. recommended/max. extended: in reflection arrangement and for a flow velocity of 15 m/s

Transducer mounting fixture

<p>Variofix L (VLK, VLM, VLQ)</p> 	<p>material: stainless steel 304 (1.4301), 301 (1.4310), 410 (1.4006) inner length: VLK: 348 mm VLM: 234 mm VLQ: 176 mm dimensions: VLK: 423 x 90 x 93 mm VLM: 309 x 57 x 63 mm VLQ: 247 x 43 x 47 mm</p>
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Coupling materials for transducers

type	ambient temperature °C
coupling compound type N	-30...+130
coupling foil type VT	-10...+200

Damping mats

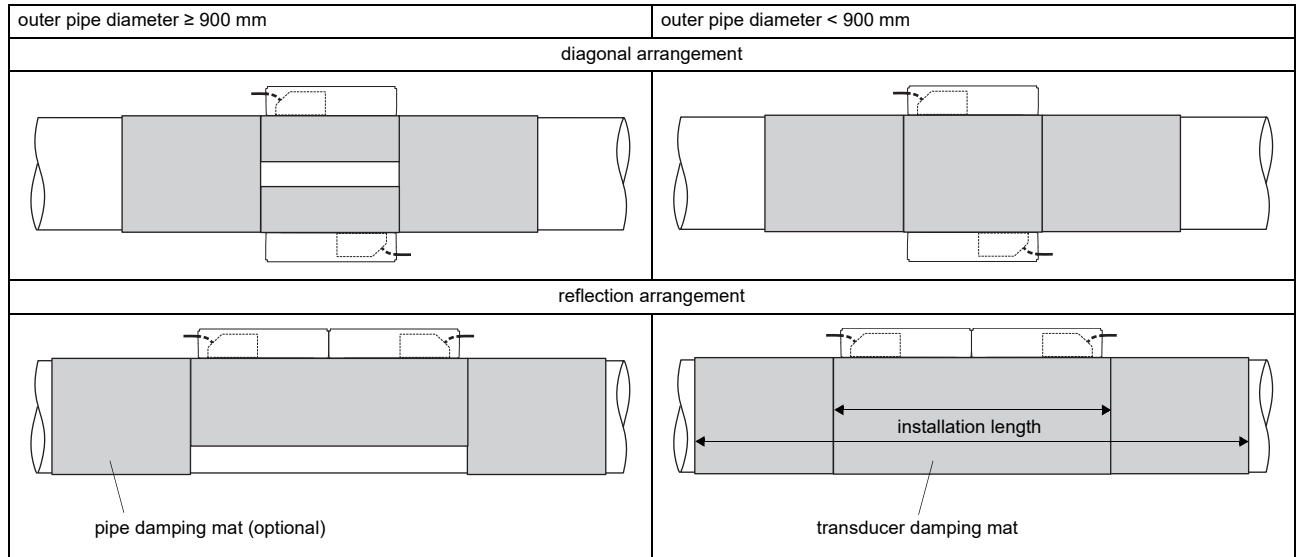
Damping mats will be used for the gas measurement to reduce acoustic noise influences on the measurement.

transducer damping mat

Transducer damping mats will be installed below the transducers.

pipe damping mat

Pipe damping mats will be installed if the sound propagation is disturbed at reflection points (e.g. flange, weld). Depending on the noise, the pipe damping mats will be installed at one or both sides of the transducer damping mat. If the local conditions are unknown, pipe damping mats should be installed.



Technical data

type		E30R4	E30R3
order code		ACC-PE-GNNN/DPD2	ACC-PE-GNNN/DPD1
width	mm	225	50
thickness	mm	0.7	
length (per roll)	m	10	
weight	kg/ m ²	1.015	
ambient temperature	°C	-30...+80	
properties		self-adhesive	

Dimensioning

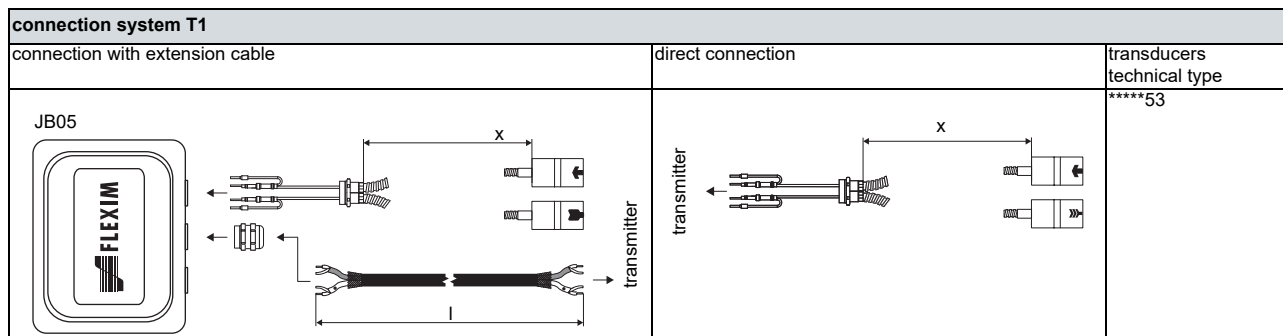
transducer		damping mat							
transducer mounting fixture	order code	type	number of layers	transducer damping mat			transducer damping mat + 2x pipe damping mat		
				max. installation length [mm]	number of rolls ¹		max. installation length [mm]	number of rolls ¹	
					standard ²	extended ²		standard	extended
VarioFix L									
VLK	GLK	E30R4	1	890	1	1	1830	2	2
VLM	GLM	E30R3	1	660	1	1	1360	2	2
	GLP		1		1	1		1	1
VLQ	GLQ	E30R3	1	540	1	1	1120	1	1

¹ calculation on the base of:

max. installation length (installation of one transducer mounting fixture per transducer in reflection arrangement) and max. recommended pipe diameter (standard) or max. extended pipe diameter (extended)

² calculation of the number of rolls when both transducers are mounted in one transducer mounting fixture (reflection arrangement) or in diagonal arrangement: number of rolls/2 and round up to the nearest integer

Connection systems



Cable

transducer cable		
type		1699
weight	kg/m	0.094
ambient temperature	°C	-55...+200
cable jacket		
material		PTFE
outer diameter	mm	2.9
thickness	mm	0.3
colour		brown
shield		x
sheath		
material		stainless steel 304 (1.4301) option OS: 316Ti (1.4571)
outer diameter	mm	8

extension cable		
type		2615
order code		ACC-PE- GNNN-/EXEXXX
weight	kg/m	0.18
ambient temperature	°C	-30...+70
properties		halogen-free fire propagation test according to IEC 60332-1 combustion test according to IEC 60754-2
cable jacket		
material		PUR
outer diameter	mm	12
thickness	mm	2
colour		black
shield		x

XXXX - cable length in m

Cable length

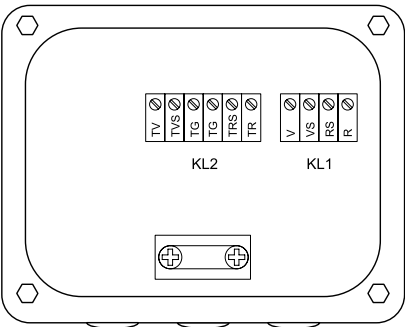
transducer frequency		K		M, P		Q	
transducers technical type		x	l	x	l	x	l
****5*	m	5	≤ 300	4	≤ 300	3	≤ 90
option LC: ****5*	m	9	≤ 300	9	≤ 300	9	≤ 90

x - transducer cable length

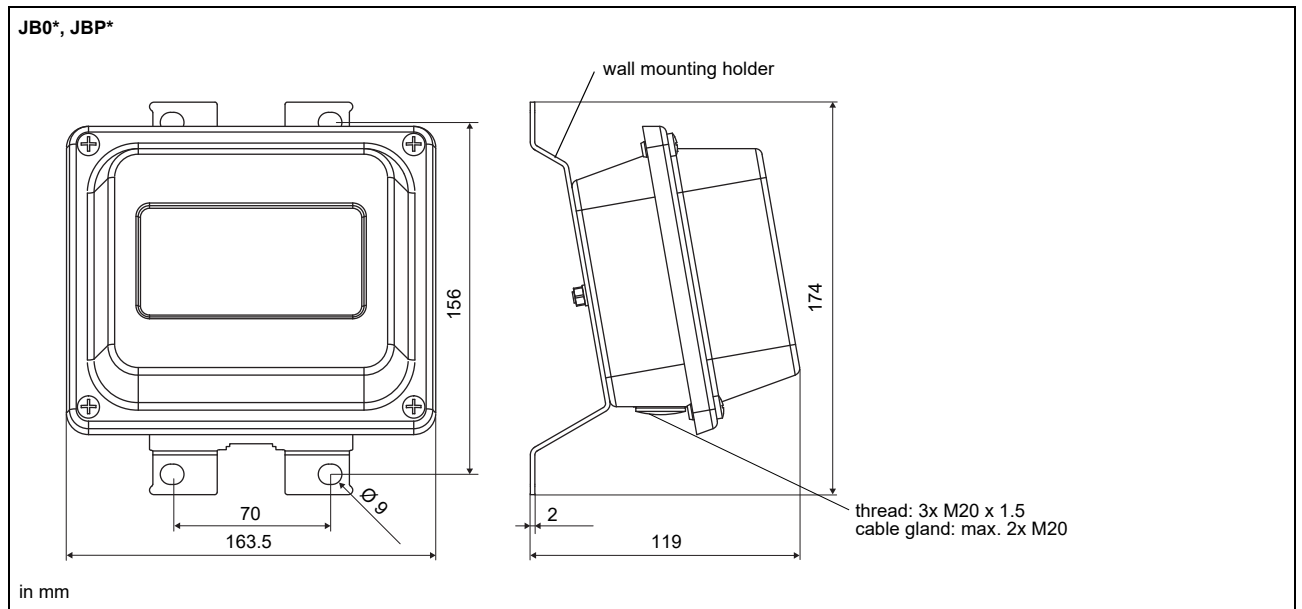
l - max. length of extension cable (depending on the application)

Junction box

Technical data

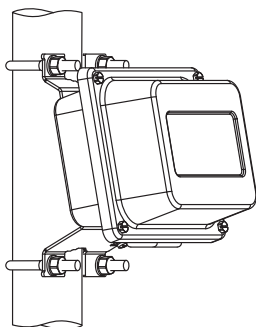
JB05																													
weight	kg	1.2 kg																											
fixation		wall mounting optional: 2" pipe mounting																											
material																													
housing		stainless steel 316L (1.4404)																											
gasket		silicone																											
degree of protection		IP67																											
ambient temperature	°C	-40...+80																											
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>Connection</p>  </div> <div style="width: 45%;"> <p>Transducers</p> <table border="1"> <thead> <tr> <th>terminal strip</th> <th>terminal</th> <th>connection</th> <th>transducer</th> </tr> </thead> <tbody> <tr> <td rowspan="4">KL1</td> <td>V</td> <td>signal</td> <td rowspan="2">↑</td> </tr> <tr> <td>VS</td> <td>internal shield</td> </tr> <tr> <td>RS</td> <td>internal shield</td> <td rowspan="2">⌋</td> </tr> <tr> <td>R</td> <td>signal</td> </tr> </tbody> </table> <p>Extension cable</p> <table border="1"> <thead> <tr> <th>terminal strip</th> <th>terminal</th> <th>connection</th> </tr> </thead> <tbody> <tr> <td rowspan="4">KL2</td> <td>TV</td> <td>signal</td> </tr> <tr> <td>TVS</td> <td>internal shield</td> </tr> <tr> <td>TRS</td> <td>internal shield</td> </tr> <tr> <td>TR</td> <td>signal</td> </tr> </tbody> </table> </div> </div>			terminal strip	terminal	connection	transducer	KL1	V	signal	↑	VS	internal shield	RS	internal shield	⌋	R	signal	terminal strip	terminal	connection	KL2	TV	signal	TVS	internal shield	TRS	internal shield	TR	signal
terminal strip	terminal	connection	transducer																										
KL1	V	signal	↑																										
	VS	internal shield																											
	RS	internal shield	⌋																										
	R	signal																											
terminal strip	terminal	connection																											
KL2	TV	signal																											
	TVS	internal shield																											
	TRS	internal shield																											
	TR	signal																											

Dimensions



2" pipe mounting kit

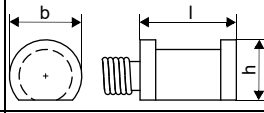
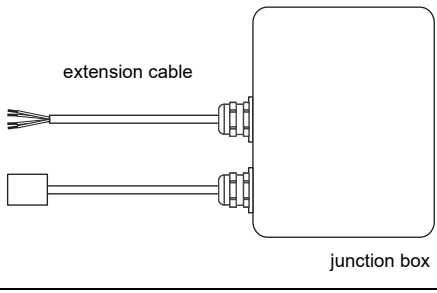
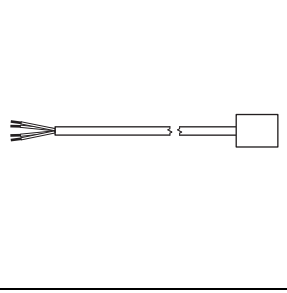
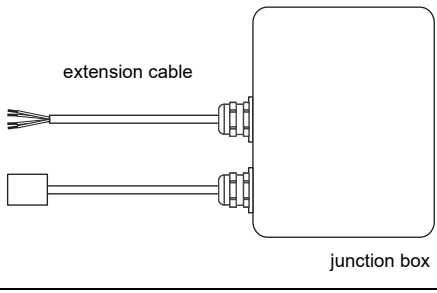
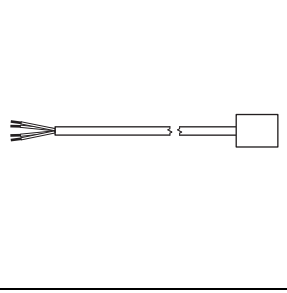
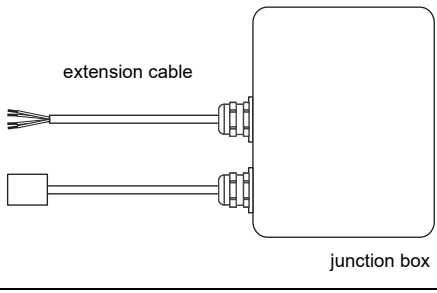
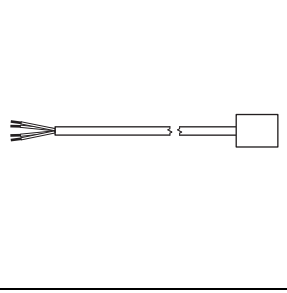












JB**



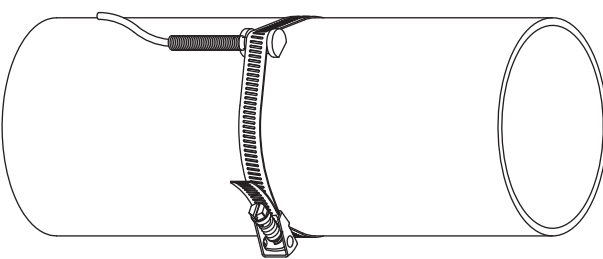
order code:
ACC-PE-GNNN-/JBPMK4

Temperature probes

Technical data

PT12N, PT12N-LC																																													
order code	PT12N: • ACC-PE-GNNN-/T312 PT12N-LC: • ACC-PE-GNNN-/T313																																												
design	clamp-on option: with long cable																																												
type	Pt100																																												
connection	4-wire																																												
measuring range	°C -30...+250																																												
accuracy T	$\pm(0.15 \text{ °C} + 2 \cdot 10^{-3} \cdot T \text{ [°C] })$ class A																																												
response time	s 50																																												
housing material	aluminum																																												
degree of protection	IP54																																												
dimensions																																													
length l	mm 20																																												
width b	mm 15																																												
height h	mm 13																																												
dimensional drawing																																													
weight	kg 0.25																																												
accessories																																													
thermal conductivity foil 250 °C	x																																												
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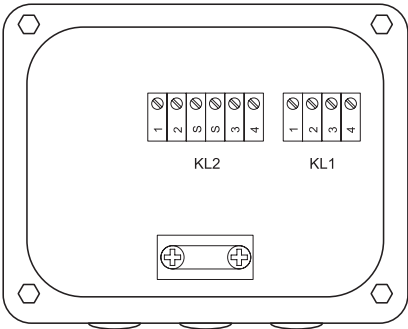
Fixation

tension strap PT12N	
	material: stainless steel 301 (1.4310), 410 (1.4006) thermal insulation necessary

Junction box

JBT3	
order code	ACC-PE-GNNN-/JB6
weight	kg 1.2 kg
fixation	wall mounting optional: 2" pipe mounting
material	
housing	stainless steel 316L (1.4404)
gasket	silicone
degree of protection	IP67
ambient temperature	
min.	°C -40
max.	°C +80

Connection



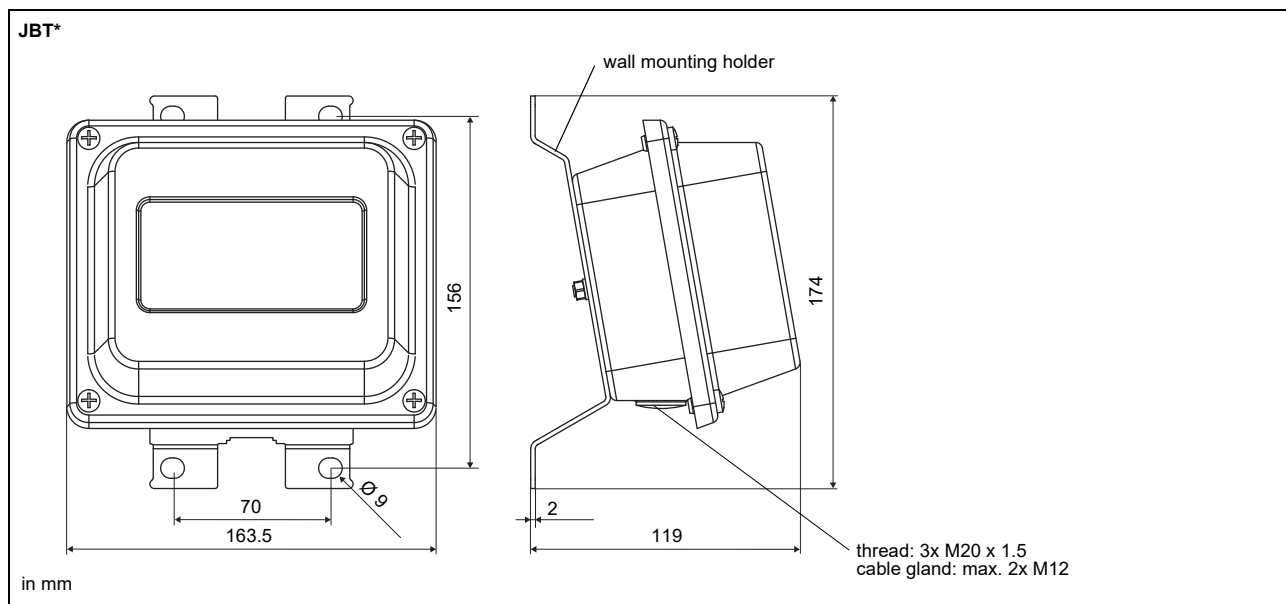
Temperature probe

terminal strip	terminal	connection
KL1	1	red
	2	red/blue
	3	white
	4	white/blue

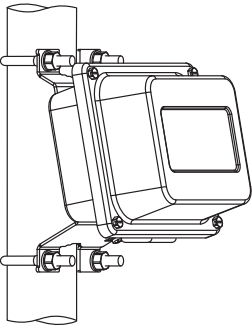
Extension cable

terminal strip	terminal	connection
KL2	1	red
	2	grey
	3	white
	4	blue

Dimensions

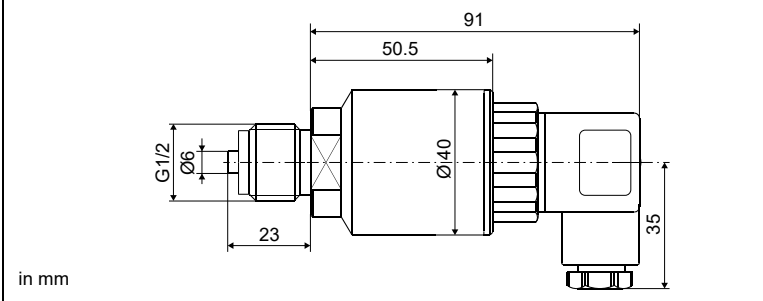
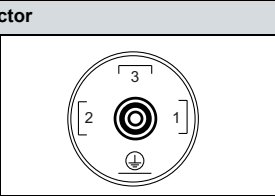
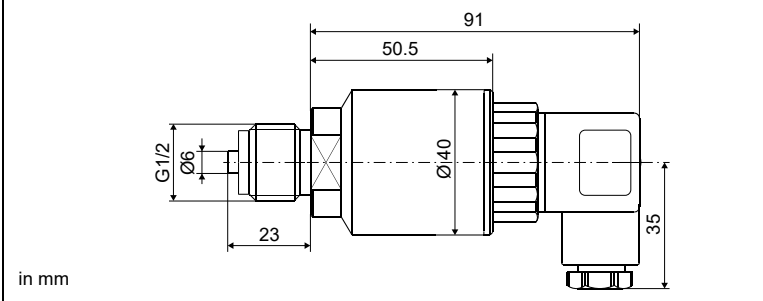
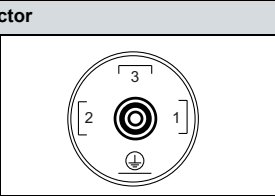
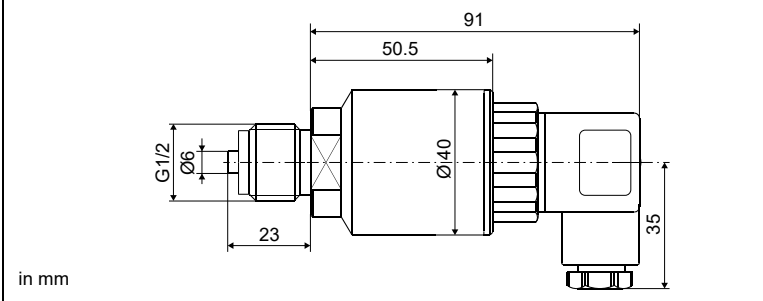
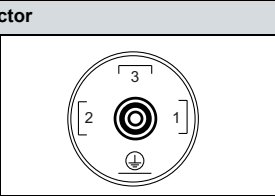


2" pipe mounting kit

<p>JB**</p> 	<p>order code: ACC-PE-GNNN-JBPMK4</p>
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Pressure transmitter (optional)

Technical data

Nöding P 121																																								
connection	2-wire																																							
measuring range	bar (a) 0...16																																							
fluid pressure	bar (a) -1...40																																							
accuracy	≤ ±0.2 % FS ≥ 0.1 bar at 25 °C																																							
temperature coefficient	≤ ±0.015 % FS/K (zero)																																							
long term stability	≤ ±0.15 % per year																																							
response time	ms 200 (T ₉₀)																																							
power supply	V DC 9...30																																							
ambient temperature	°C -25...+80																																							
fluid temperature	°C -40...+100 max. 125 (< 0.5 h)																																							
material																																								
housing	stainless steel 316L (1.4404)																																							
measuring cell	Al ₂ O ₃																																							
process connection	stainless steel 316L (1.4404)																																							
process gasket	FPM																																							
degree of protection	IP65																																							
weight (without connector)	kg 0.236																																							
current output	mA 4...20																																							
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <table border="1"> <thead> <tr> <th colspan="2">Dimensions</th> </tr> </thead> <tbody> <tr> <td colspan="2" style="text-align: center;">  </td> </tr> </tbody> </table> </div> <div style="width: 45%;"> <table border="1"> <thead> <tr> <th colspan="2">Connection</th> </tr> </thead> <tbody> <tr> <th colspan="2">connector</th> </tr> <tr> <td>pin</td> <td rowspan="2" style="text-align: center;">  </td> </tr> <tr> <td>1(+)</td> </tr> <tr> <td>2(-)</td> <td></td> </tr> <tr> <th colspan="2">Cable</th> </tr> <tr> <td colspan="2" style="text-align: center;">8038</td> </tr> <tr> <td>type</td> <td>2 x 0.5 mm²</td> </tr> <tr> <td>standard length</td> <td>m 5 15</td> </tr> <tr> <td>weight</td> <td>kg/m 0.045</td> </tr> <tr> <td>ambient temperature</td> <td>°C -40...+80</td> </tr> <tr> <td>bend radius</td> <td>mm min. 29</td> </tr> <tr> <td>properties</td> <td>self-extinguishing, flame retardant according to IEC 60332-1</td> </tr> <tr> <th colspan="2">cable jacket</th> </tr> <tr> <td>material</td> <td>PVC</td> </tr> <tr> <td>outer diameter</td> <td>mm 5.7</td> </tr> <tr> <td>colour</td> <td>grey</td> </tr> <tr> <td>shield</td> <td>x</td> </tr> </tbody> </table> </div> </div>		Dimensions				Connection		connector		pin		1(+)	2(-)		Cable		8038		type	2 x 0.5 mm ²	standard length	m 5 15	weight	kg/m 0.045	ambient temperature	°C -40...+80	bend radius	mm min. 29	properties	self-extinguishing, flame retardant according to IEC 60332-1	cable jacket		material	PVC	outer diameter	mm 5.7	colour	grey	shield	x
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