

**Non-invasive ultrasonic mass flow rate and volumetric flow rate measurement of saturated steam**

**Features**

- Non-invasive measurement of saturated steam up to 180 °C without fluid contact – no need to open the pipe
- Temperature-compensated mass flow rate calculation via saturated steam curve possible
- Very high measuring dynamics of 0.01...60 m/s – no need to reduce pipe diameters
- Cost-efficient due to start-up during ongoing operation and without pressure/energy loss in the steam network
- Drift-free and maintenance-free, as no wear and tear
- Compact transducers that are easy to insulate – no energy loss at the measuring point
- 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**

For the following measuring tasks in pharmaceutical, food and manufacturing industries, building technology and hospitals:

- Energy management and energy efficiency
- Quantity balancing and cost distribution
- Consumption metering
- Process/boiler optimization



**Function** ..... 3

Measurement principle ..... 3

Calculation of volumetric flow rate ..... 3

Calculation of mass flow rate ..... 4

Number of sound paths ..... 4

Typical measurement setup ..... 5

**Transmitter** ..... 6

Technical data ..... 6

Saturated steam pressure curve ..... 7

Dimensions ..... 8

2" pipe mounting kit (optional) ..... 8

Storage ..... 8

Terminal assignment ..... 9

**Transducers** ..... 10

Transducer selection ..... 10

Technical data ..... 11

**Transducer mounting fixture** ..... 12

**Coupling materials for transducers** ..... 12

**Damping coat** ..... 13

**Connection systems** ..... 14

**Junction box** ..... 15

Technical data ..... 15

Dimensions ..... 15

2" pipe mounting kit ..... 16

**Clamp-on temperature probe (optional)** ..... 17

Technical data ..... 17

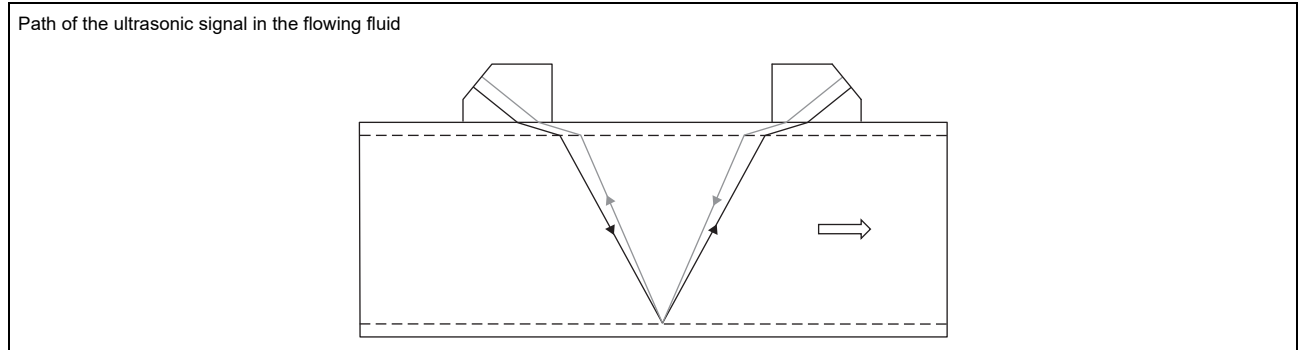
Fixation ..... 18

Junction box ..... 19

## Function

### Measurement principle

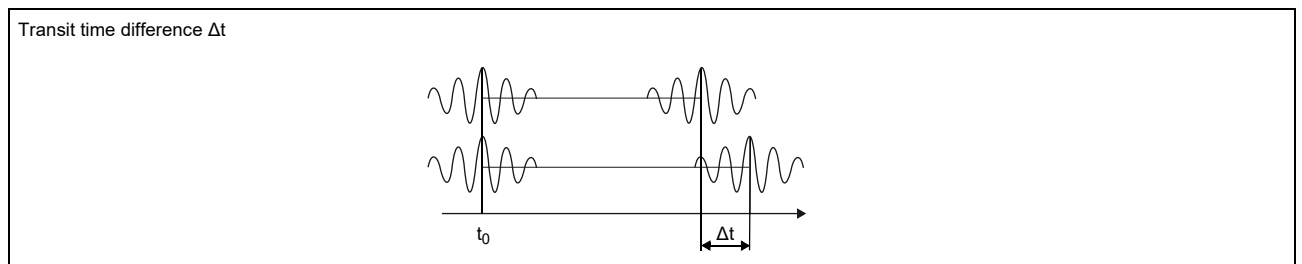
The transducers are mounted on the pipe which is completely filled with the fluid. The ultrasonic signals are emitted alternately by a transducer and received by the other. The physical quantities are determined from the transit times of the ultrasonic signals.



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  $\Delta t$  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
- $\Delta t$  - transit time difference
- $t_{\gamma}$  - average of transit times in the fluid

### Calculation of mass flow rate

The mass flow rate is calculated from the operating density and the volumetric flow rate:

$$\dot{m} = \rho \cdot \dot{V}$$

The operating density of the fluid is calculated as the function of pressure and temperature of the fluid:

$$\rho = f(p, T)$$

where

- $\rho$  - operating density
- $p$  - fluid pressure
- $T$  - fluid temperature
- $\dot{m}$  - mass flow rate
- $\dot{V}$  - volumetric flow rate

Temperature-compensated mass flow rate calculation via the saturated steam curve is possible.

### 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**

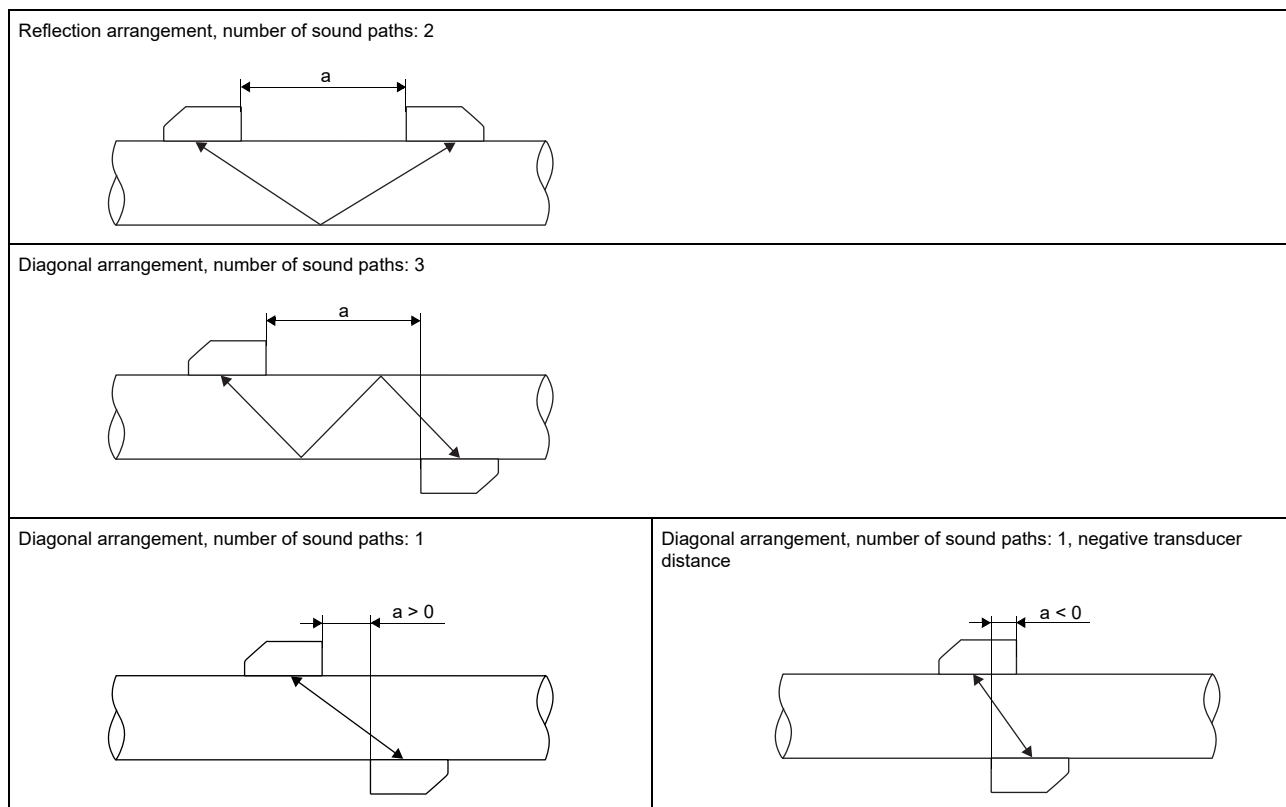
The number of sound paths is even. The transducers are mounted on the same side of the pipe. Correct positioning of the transducers is easy.

• **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.

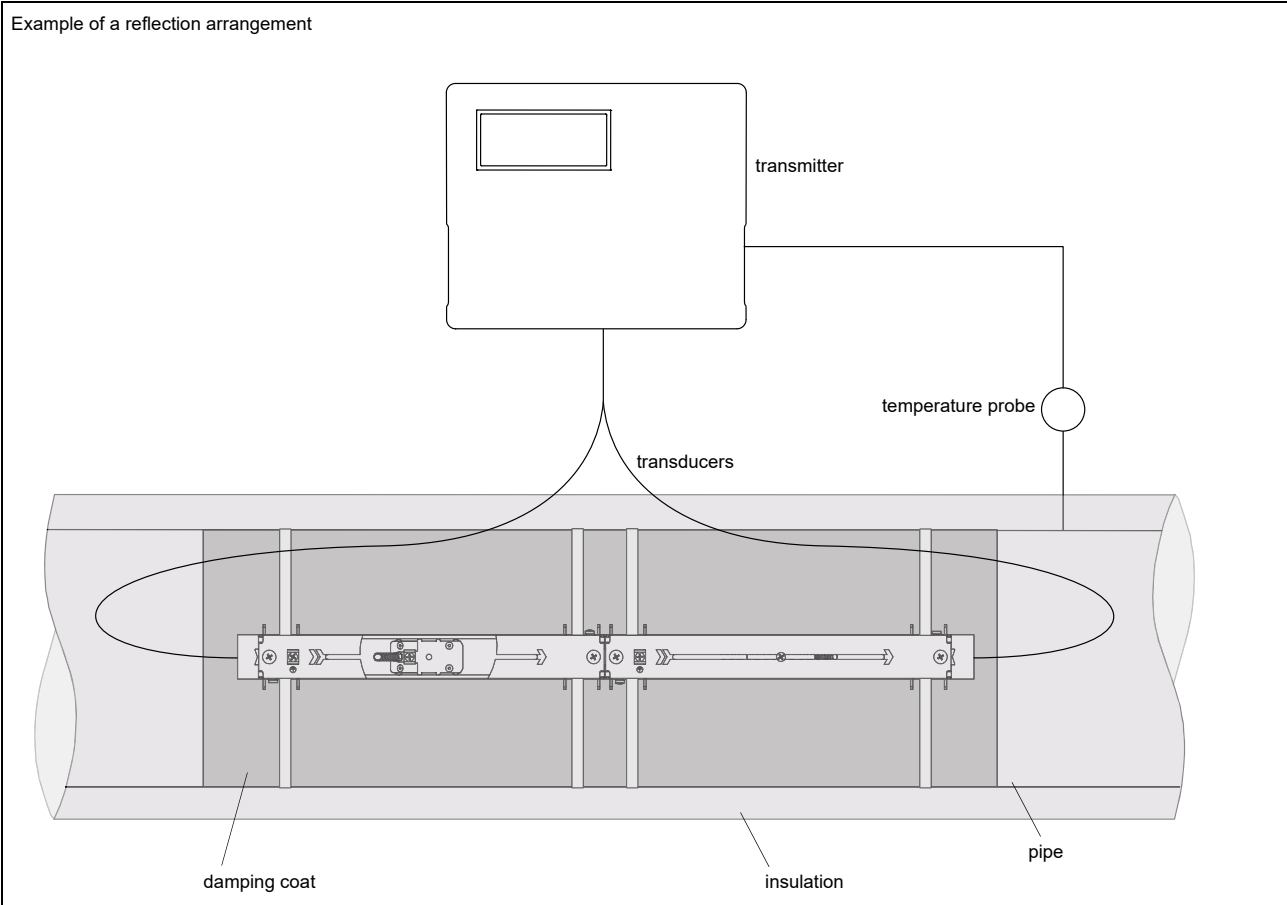
The preferred method of installation depends on the application. While increasing the number of sound paths increases the accuracy of the measurement, signal attenuation increases as well. The optimum number of sound paths for the parameters of the application will be determined automatically by the 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 G532ST-LT (analog outputs)	FLUXUS G532ST-LT (process interface)
		
design	field device with 1 measuring channel	
application	steam measurement <sup>2</sup>	
<b>measurement</b>		
measurement principle	transit time difference correlation principle	
flow velocity	depending on pipe diameter and transducer, see diagrams	
repeatability	0.15 % MV $\pm$ 0.005 m/s	
fluid	saturated steam, superheated steam	
fluid pressure	bar (a)	3...10
fluid temperature	°C	135...180
temperature compensation	corresponding to the recommendations in ANSI/ASME MFC-5.1-2011	
<b>measurement uncertainty (volumetric flow rate)</b>		
measurement uncertainty of the measuring system <sup>1</sup>	$\pm$ 0.3 % MV $\pm$ 0.005 m/s	
measurement uncertainty at the measuring point	$\pm$ 1...3 % MV $\pm$ 0.005 m/s, depending on the application	
<b>transmitter</b>		
power supply	<ul style="list-style-type: none"> <li>• 90...250 V/50...60 Hz or</li> <li>• 11...32 V DC</li> </ul>	
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
<b>measuring functions</b>		
physical quantities	operating 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	
<b>communication interfaces</b>		
service interfaces	measured value transmission, parametrisation of the transmitter: <ul style="list-style-type: none"> <li>• USB</li> <li>• LAN</li> </ul>	measured value transmission, parametrisation of the transmitter: <ul style="list-style-type: none"> <li>• USB</li> <li>• LAN</li> </ul>
process interfaces	-	<ul style="list-style-type: none"> <li>• Modbus RTU or</li> <li>• BACnet MS/TP or</li> <li>• M-Bus or</li> <li>• Modbus TCP or</li> <li>• BACnet IP</li> </ul>
<b>accessories</b>		
data transmission kit	USB cable	
software	<ul style="list-style-type: none"> <li>• FluxDiagReader: reading of measured values and parameters, graphical representation</li> <li>• FluxDiag (optional): reading of measurement data, graphical representation, report generation, parametrisation of the transmitter</li> </ul>	
<b>data logger</b>		
loggable values	all physical quantities and totalised physical quantities	
capacity	max. 800 000 measured values	

<sup>1</sup> with aperture calibration of the transducers

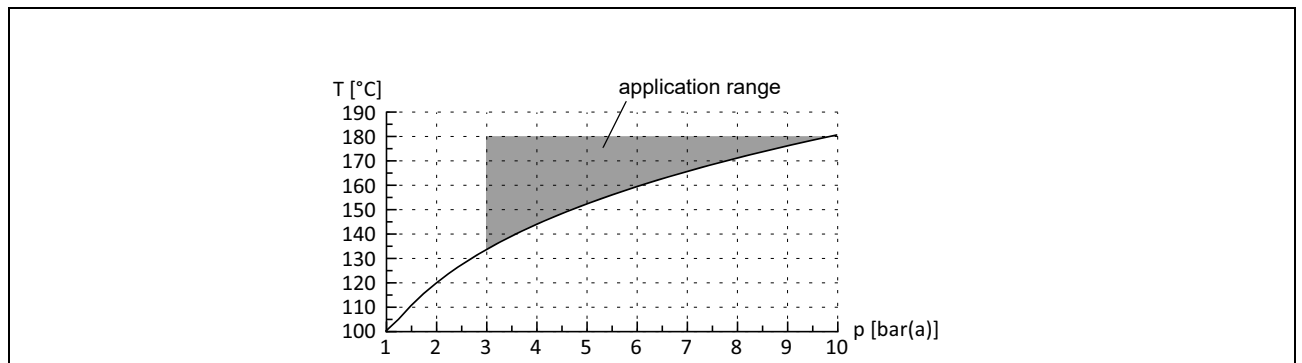
<sup>2</sup> test measurement to validate the application required in advance

		FLUXUS G532ST-LT (analog outputs)	FLUXUS G532ST-LT (process interface)
<b>outputs</b>			
The outputs are galvanically isolated from the transmitter.			
<b>• switchable current output</b>			
		configurable according to NAMUR NE43 All switchable current outputs are jointly switched to active or passive.	
number		1	-
range	mA	4...20 (3.2...24)	-
accuracy		0.04 % MV ±3 µA	-
active output		$R_{ext} < 530 \Omega$	-
passive output		$U_{ext} = 9...30 V$ , depending on $R_{ext}$ ( $R_{ext} < 458 \Omega$ at 20 V)	-
<b>• digital output</b>			
number		2	-
functions		<ul style="list-style-type: none"> <li>• frequency output</li> <li>• binary output</li> <li>• pulse output</li> </ul>	-
operating parameters		$U_{ext} = (8.2 \pm 0.1) V$ DC	-
<b>frequency output</b>			
• range	kHz	0...10	-
<b>binary output</b>			
• binary output as alarm output		limit, change of flow direction or error	-
<b>pulse output</b>			
• pulse value	units	0.01...1000	-
• pulse width	ms	0.05...1000	-
<b>inputs</b>			
The inputs are galvanically isolated from the transmitter.			
<b>• temperature input</b>			
number		1	
type		Pt100/Pt1000	
connection		4-wire	
range	°C	-150...+560	
resolution	K	0.01	
accuracy		±0.01 % MV ±0.03 K	

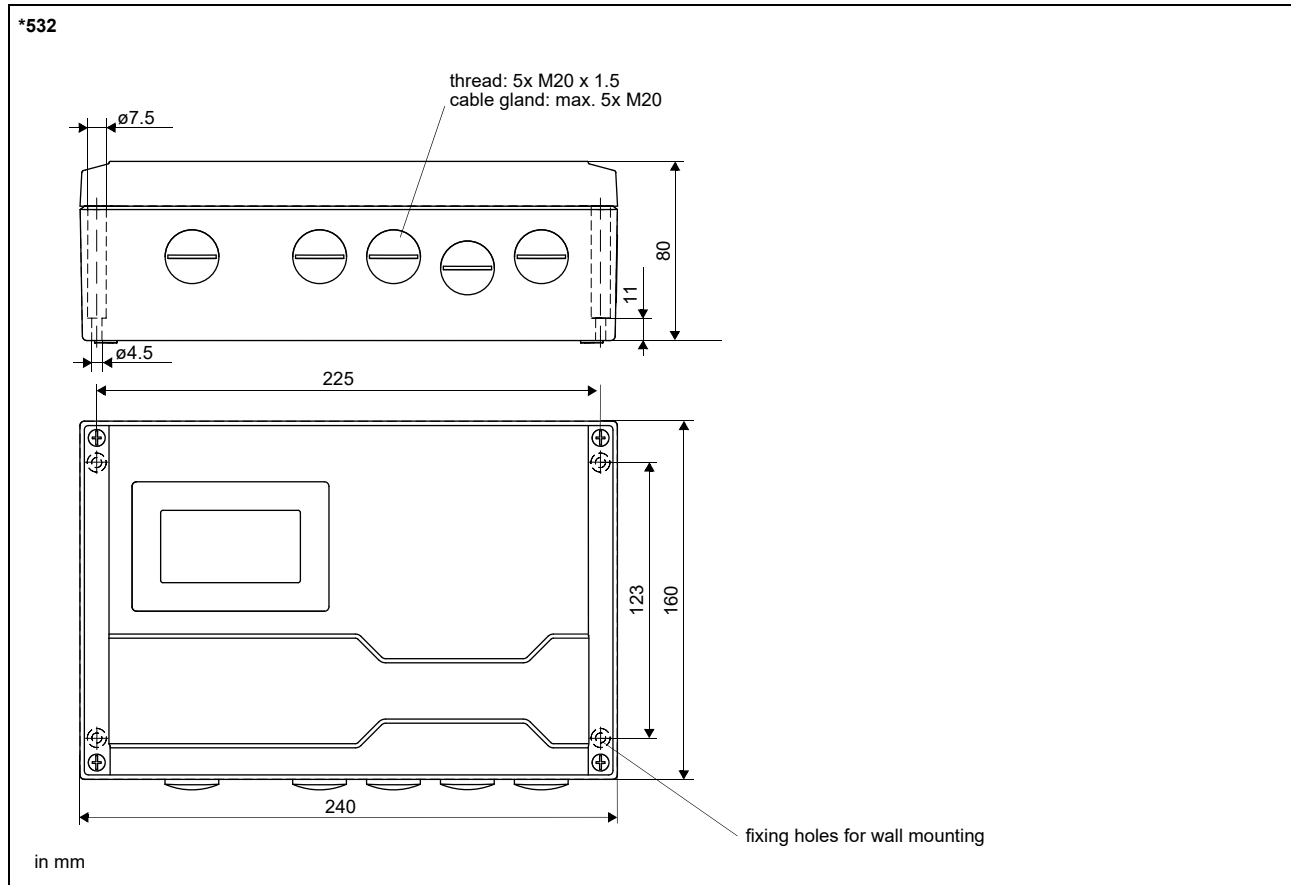
<sup>1</sup> with aperture calibration of the transducers

<sup>2</sup> test measurement to validate the application required in advance

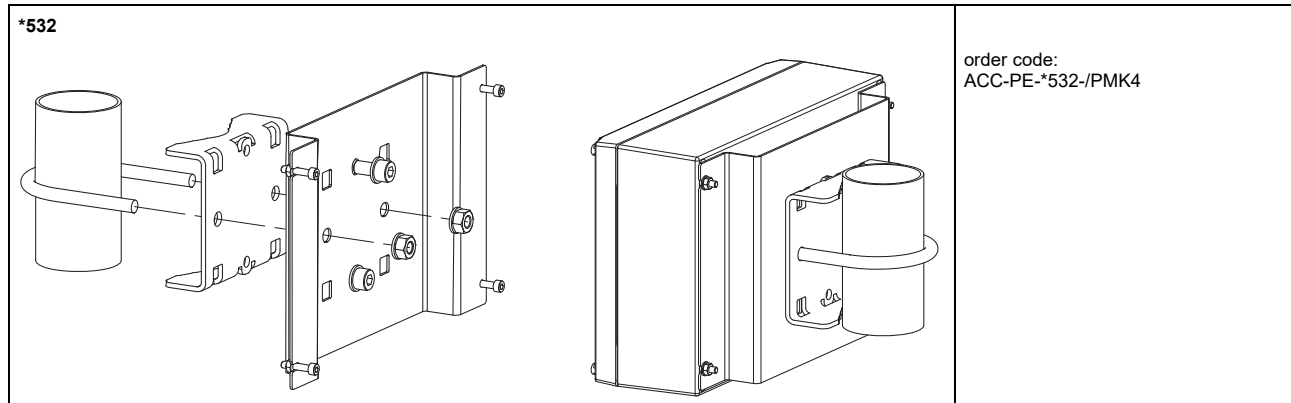
### Saturated steam pressure curve



### Dimensions



### 2" pipe mounting kit (optional)

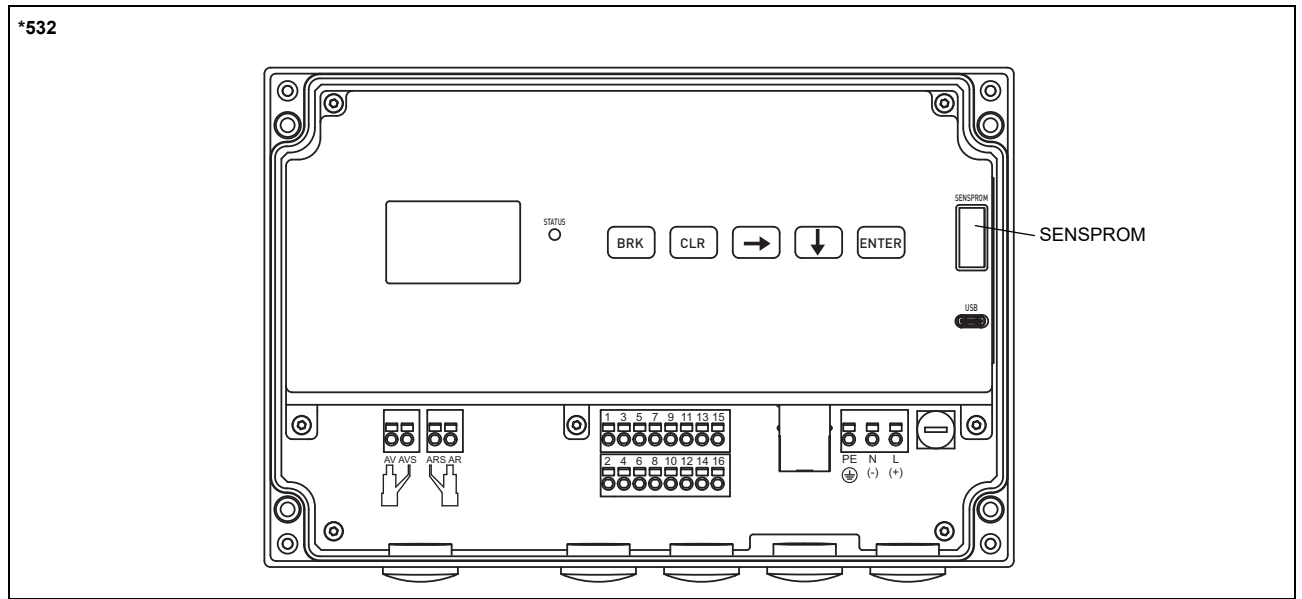


### Storage

- 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 <sup>1</sup>			
terminal	connection (AC)	terminal	connection (DC)
PE	earth	PE	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 <sup>1, 2</sup>	
terminal	connection
13+, 14-	passive current output
13-, 14+	active current output
9+, 10- 11+, 12-	digital output
1, 2, 3, 4	temperature 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 +	• Modbus RTU <sup>1</sup>
16	signal -	• BACnet MS/TP <sup>1</sup>
		• M-Bus <sup>1</sup>
USB	type C Hi-Speed USB 2.0 Device	service (FluxDiag/FluxDiagReader)
LAN	RJ45 10/100 Mbps Ethernet	• service (FluxDiag/FluxDiagReader)
		• Modbus TCP
		• BACnet IP

<sup>1</sup> cable (by customer): e.g. flexible wires, with insulated wire ferrules, wire cross-section: 0.25...2.5 mm<sup>2</sup>

<sup>2</sup> The number, type and terminal assignment are customised.

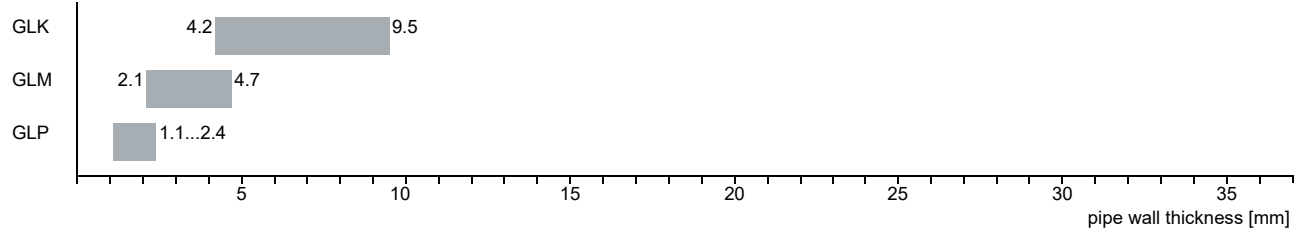
# Transducers

## Transducer selection

### Step 1

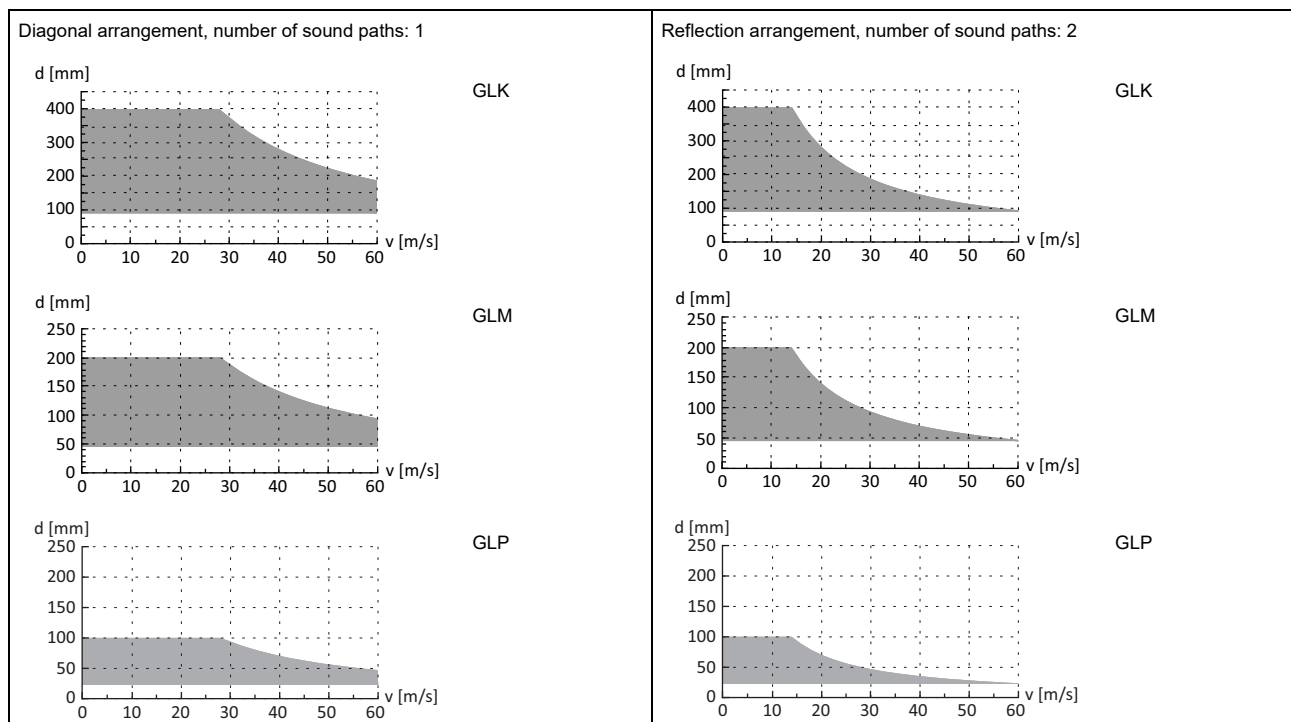
pipe wall thickness

transducer order code



### Step 2

inner pipe diameter  $d$  dependent on the flow velocity  $v$  of the fluid in the pipe



inner pipe diameter and max. flow velocity for a steam application

## Technical data

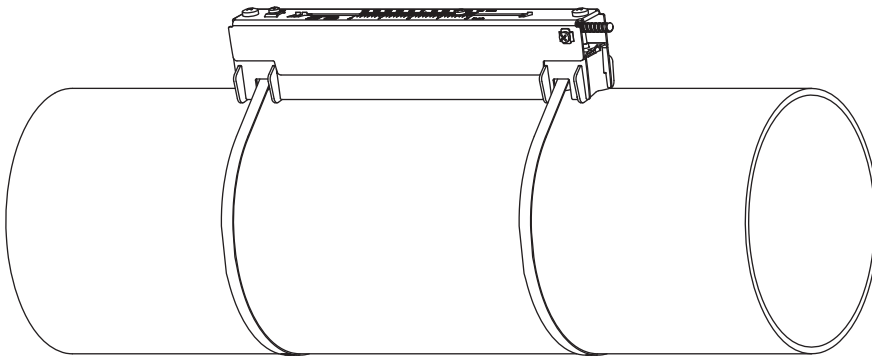
### Lamb wave transducers

order code		GLK-SNNT1/**	GLM-SNNT1/**	GLP-SNNT1/**
technical type		G(RT)K1S53	G(RT)M1S53	G(RT)P1S53
transducer frequency	MHz	0.5	1	2
fluid pressure		see saturated steam pressure curve		
<b>inner pipe diameter d</b>				
min.	mm	90	45	23
max.	mm	400	200	100
<b>pipe wall thickness</b>				
min.	mm	4.2	2.1	1.1
max.	mm	9.5	4.7	2.4
<b>material</b>				
housing		PPSU with stainless steel cover 316Ti (1.4571)		
contact surface		PPSU		
degree of protection		IP65		
<b>transducer cable</b>				
type		1699		
length	m	5	4	
length (***_***/LC)	m	9	9	
<b>dimensions</b>				
length l	mm	128.5	74	
width b	mm	51	32	
height h	mm	67.5	40.5	
dimensional drawing				
weight (without cable)	kg	0.8	0.16	
<b>storing temperature</b>				
storing temperature	°C	-40...+180		
operating temperature	°C	100...180		
warm-up time	h	3	1	
temperature compensation		x		

completely thermally insulated transducer installation necessary

## Transducer mounting fixture

Variofix L (VLK, VLM)



material: stainless steel 304 (1.4301),  
 301 (1.4310), 410 (1.4006)  
 option OS: 316Ti (1.4571), 316L  
 (1.4404), 17-7PH (1.4568)  
 inner length:  
**VLK:** 348 mm,  
**VLM:** 234 mm  
 dimensions:  
**VLK:** 423 x 90 x 93 mm  
**VLM:** 309 x 57 x 63 mm

## Coupling materials for transducers

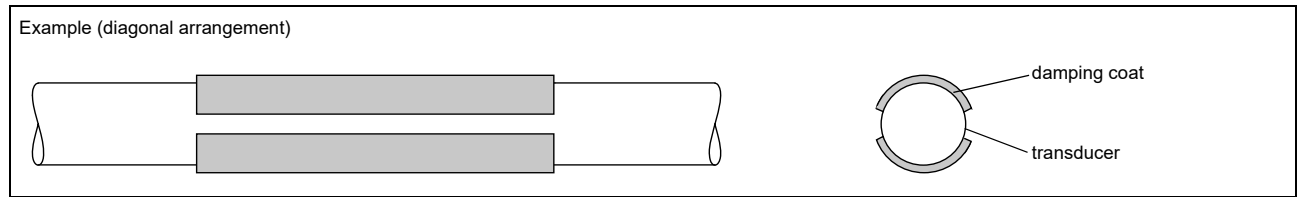
type	ambient temperature °C
coupling foil type VT <sup>1</sup>	-10...+200
coupling compound type E <sup>2</sup>	-30...+200

<sup>1</sup> fluid temperature 200 °C: min. 2 years

<sup>2</sup> in combination with type VT only

## Damping coat

The damping coat will be used to reduce acoustic noise influences on the measurement.



## Technical data

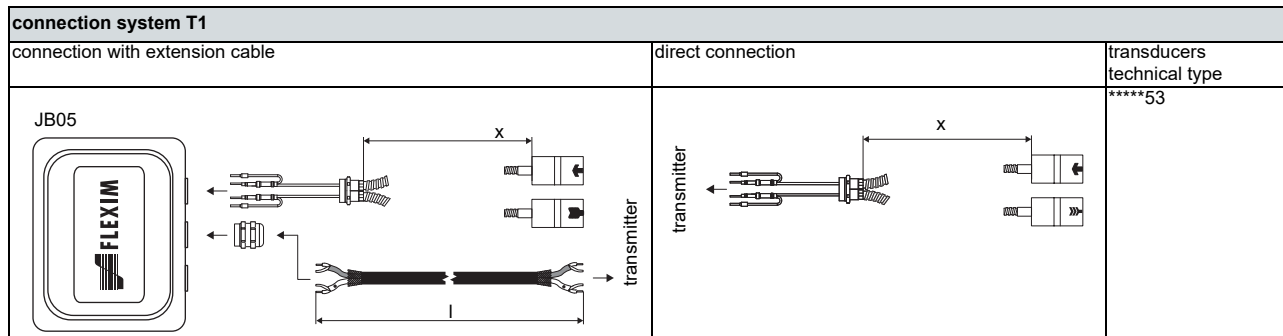
order code		ACC-PE-GNNN-/DPL1
material		multipolymeric matrix/inorganic ceramic coating
packing drum	I	1
properties		heat-resistant, inert
fluid temperature when applying	°C	10...200
drying time (example)		approx. 3 h at 20 °C approx. 15 min at 150 °C
temperature resistance in dry state	°C	max. 650
durability of the packing drum (unopened)		2 years

Observe installation instructions (TI\_DampingCoat).

## Dimensioning

transducer frequency	number of packing drums	
	outer pipe diameter	
	≤300 mm	≤500 mm
K	2	2
M	2	-
P	1	-

## Connection systems



### Cable

transducer cable		
type		1699
weight	kg/m	0.094
ambient temperature	°C	-55...+200
<b>cable jacket</b>		
material		PTFE
outer diameter	mm	2.9
thickness	mm	0.3
colour		brown
shield		x
<b>sheath</b>		
material		stainless steel 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
<b>cable jacket</b>		
material		PUR
outer diameter	mm	max. 12
thickness	mm	2
colour		black
shield		x
<b>sheath</b>		
material		-
outer diameter	mm	-

XXX - cable length in m

### Cable length

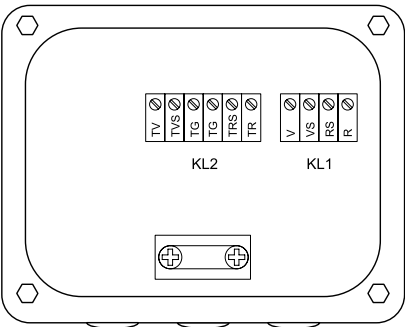
transducer frequency	K			M, P	
	x	l		x	l
transducers technical type					
*R***5*	m	5	≤ 300	4	≤ 300
option LC: *T***5*	m	9	≤ 300	9	≤ 300

x - transducer cable length

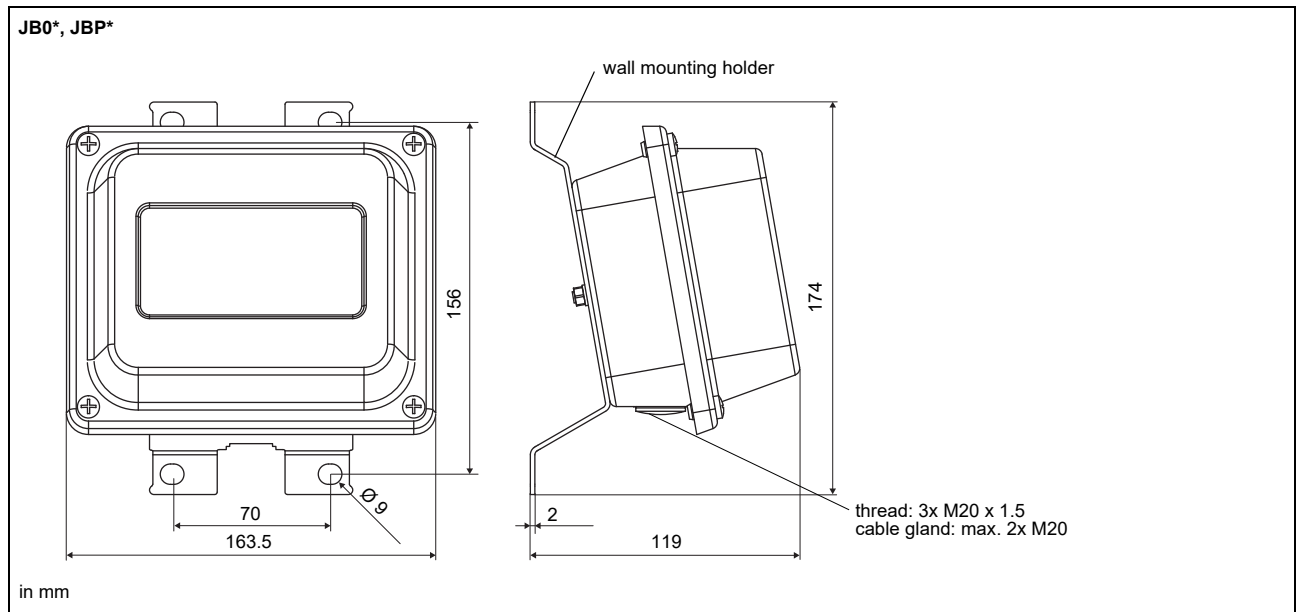
l - max. length of extension cable (depending on the application)

# Junction box

## Technical data

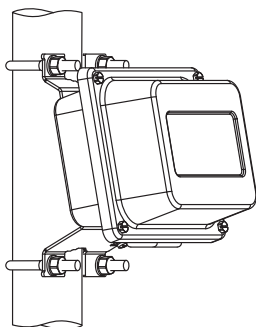
JB05																													
weight	kg	1.2 kg																											
fixation		wall mounting optional: 2" pipe mounting																											
<b>material</b>																													
housing		stainless steel 316L (1.4404)																											
gasket		silicone																											
degree of protection		IP67																											
ambient temperature	°C	-40...+80																											
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p><b>Connection</b></p>  </div> <div style="width: 45%;"> <p><b>Transducers</b></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><b>Extension cable</b></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\*\*

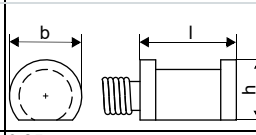
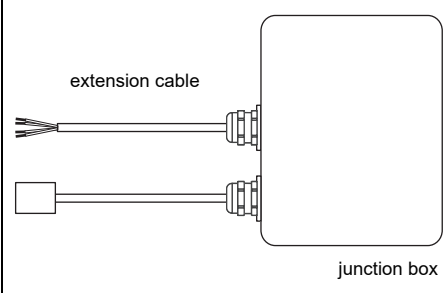
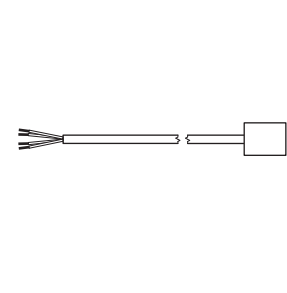
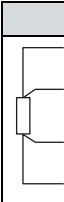


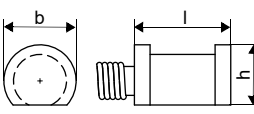
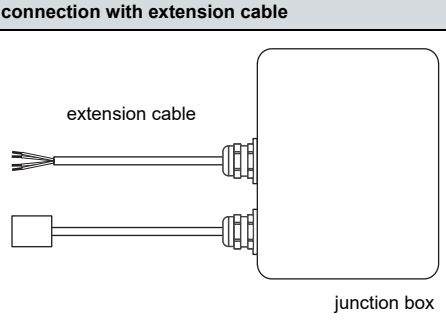
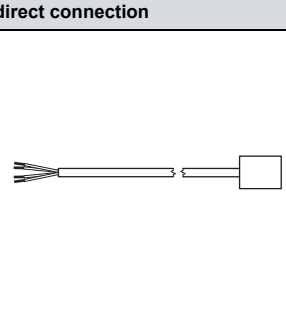
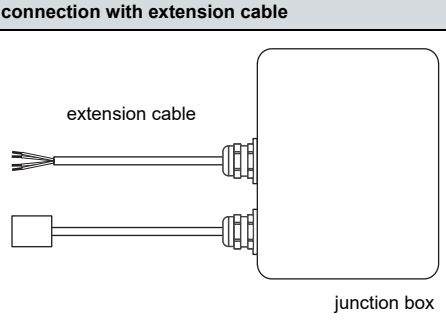
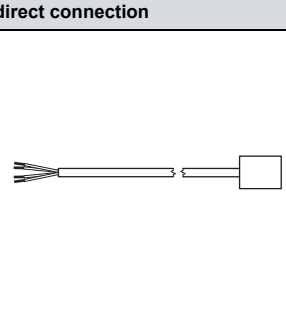
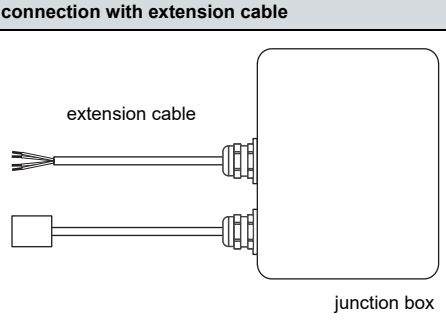
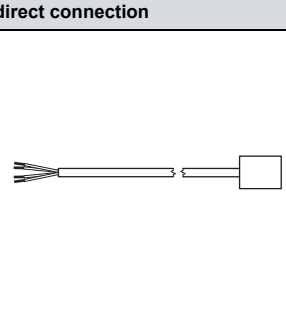
order code:  
ACC-PE-GNNN-/JBPMK4



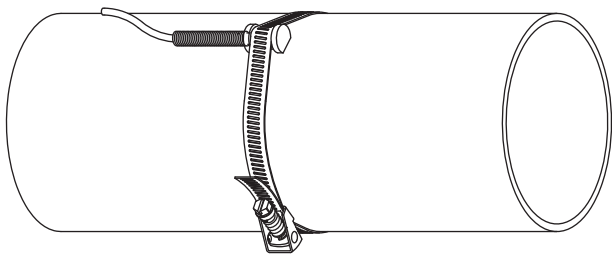
# Clamp-on temperature probe (optional)

## Technical data

PT12N		
order code		• ACC-PE-****-/T312
design		clamp-on
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 (t50, T1 = 25 °C, T2 = 60 °C)
housing material		aluminum
degree of protection		IP54
<b>dimensions</b>		
length l	mm	20
width b	mm	15
height h	mm	13
dimensional drawing		
weight	kg	0.25
<b>accessories</b>		
thermal conductivity foil 250 °C		x
<b>Connection system</b>		
<b>connection with extension cable</b>		<b>direct connection</b>
		
<b>Connection</b>		
	<b>temperature probe</b>	
	red	
	red/blue	
	white/blue	
	white	
<b>Cable</b>		
	<b>temperature probe</b>	<b>extension cable</b>
type	4 x 0.22 mm <sup>2</sup>	LIYCY 8 x 0.14 mm <sup>2</sup>
ambient temperature °C	-30...+250	-25...+80
min. bend radius	mm 27	68
<b>cable jacket</b>		
material	PFA	PVC
outer diameter	mm 3.8 ±0.15	4.8 ±2
colour	black	grey

PT12N-LC																															
order code	• ACC-PE-****-/T313																														
design	clamp-on 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 (t50, T1 = 25 °C, T2 = 60 °C)																														
housing material	aluminum																														
degree of protection	IP54																														
<b>dimensions</b>																															
length l	mm 20																														
width b	mm 15																														
height h	mm 13																														
dimensional drawing																															
weight	kg 0.25																														
<b>accessories</b>																															
thermal conductivity foil 250 °C	x																														
<b>Connection system</b>																															
<table border="1"> <thead> <tr> <th>connection with extension cable</th> <th>direct connection</th> </tr> </thead> <tbody> <tr> <td></td> <td></td> </tr> </tbody> </table>		connection with extension cable	direct connection																												
connection with extension cable	direct connection																														
																															
<b>Connection</b>																															
<table border="1"> <thead> <tr> <th></th> <th>temperature probe</th> </tr> </thead> <tbody> <tr> <td></td> <td>red</td> </tr> <tr> <td></td> <td>red/blue</td> </tr> <tr> <td></td> <td>white/blue</td> </tr> <tr> <td></td> <td>white</td> </tr> </tbody> </table>			temperature probe		red		red/blue		white/blue		white																				
	temperature probe																														
	red																														
	red/blue																														
	white/blue																														
	white																														
<b>Cable</b>																															
<table border="1"> <thead> <tr> <th></th> <th>temperature probe</th> <th>extension cable</th> </tr> </thead> <tbody> <tr> <td>type</td> <td>4 x 0.22 mm<sup>2</sup></td> <td>LIYCY 8 x 0.14 mm<sup>2</sup></td> </tr> <tr> <td>standard length</td> <td>m 15</td> <td>5/10/25</td> </tr> <tr> <td>max. length</td> <td>m -</td> <td>200</td> </tr> <tr> <td>ambient temperature</td> <td>°C -30...+250</td> <td>-25...+80</td> </tr> <tr> <td>min. bend radius</td> <td>mm 27</td> <td>68</td> </tr> <tr> <td colspan="3"><b>cable jacket</b></td> </tr> <tr> <td>material</td> <td>PFA</td> <td>PVC</td> </tr> <tr> <td>outer diameter</td> <td>mm 3.8 ±0.15</td> <td>4.8 ±2</td> </tr> <tr> <td>colour</td> <td>black</td> <td>grey</td> </tr> </tbody> </table>			temperature probe	extension cable	type	4 x 0.22 mm <sup>2</sup>	LIYCY 8 x 0.14 mm <sup>2</sup>	standard length	m 15	5/10/25	max. length	m -	200	ambient temperature	°C -30...+250	-25...+80	min. bend radius	mm 27	68	<b>cable jacket</b>			material	PFA	PVC	outer diameter	mm 3.8 ±0.15	4.8 ±2	colour	black	grey
	temperature probe	extension cable																													
type	4 x 0.22 mm <sup>2</sup>	LIYCY 8 x 0.14 mm <sup>2</sup>																													
standard length	m 15	5/10/25																													
max. length	m -	200																													
ambient temperature	°C -30...+250	-25...+80																													
min. bend radius	mm 27	68																													
<b>cable jacket</b>																															
material	PFA	PVC																													
outer diameter	mm 3.8 ±0.15	4.8 ±2																													
colour	black	grey																													

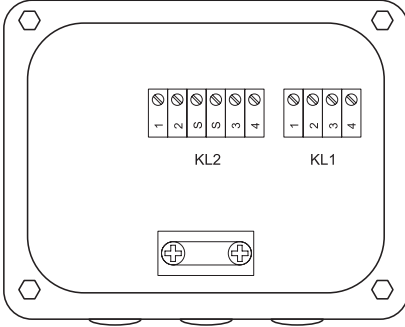
**Fixation**

<p>tension strap PT12N</p> 	<p>material: stainless steel 301 (1.4310), 410 (1.4006) thermal insulation necessary</p>
--	--

### 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**

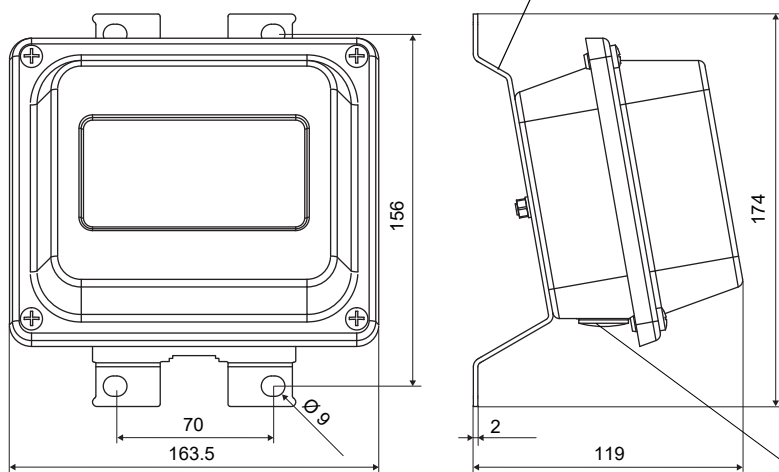
terminal strip	terminal	connection
KL1	1	red
	2	red/blue
	3	white
	4	white/blue

**Extension cable**

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

### Dimensions

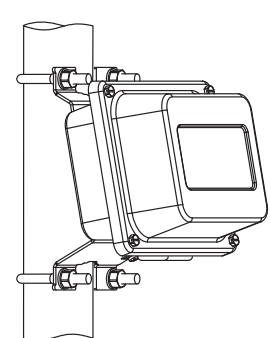
**JBT\***



in mm

thread: 3x M20 x 1.5  
cable gland: max. 2x M12

### 2" pipe mounting kit

<p>JB**</p> 	<p>order code: ACC-PE-GNNN-/JBPMK4</p>
---	--