FLEXIM

Technical specification

FLUXUS F704TE

Permanently installed and non-invasive ultrasonic flowmeter for the measurement of thermal energy and volumetric flow rate

Precise and intelligent energy measuring system with extremely high measuring dynamic

Features

- Integrated measuring system for the determination of thermal energy in real time, enables smart metering
- For inner pipe diameters of DN 25...DN 1000
- High-precision temperature measurement using paired temperature probes (0.1 °C temperature difference)
- Extremely high measuring dynamic > 1000 : 1
- Measures even the lowest flow velocities down to 0.01 m/s – important for the measurement of low flow rates, e.g. during the night
- Permanent acoustic coupling of the ultrasonic transducers by long-lasting coupling pads; does not require further greasing and maintenance
- Bidirectional communication and support of standard bus systems
- Flowmeter can be configured for two independent heat flow measurements
- Integrated calculation functions for two measuring channels, e.g. sum or difference
- Standard configuration includes numerous heat transfer fluids; possible expansion of fluid data sets

FLUXUS F704TE

Variofix L

Applications

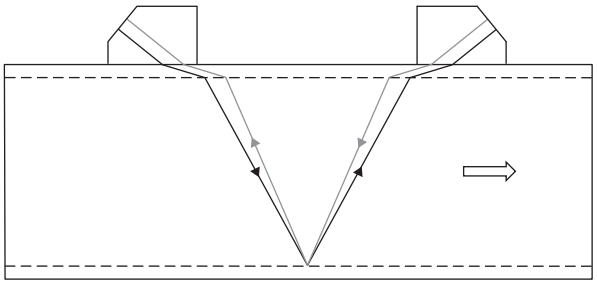
- Industrial manufacturing facilities
  - Thermal processes
  - Heating and climate control
- Facilities for the generation of renewable energies
  - Solar and geothermal energy, waste heat
- District heating
  - Heating and cooling systems
  - Heat interface units
  - Distribution nets
- Building technology
  - Heating and cooling systems
  - Internal balancing
- Energy management
  - Energy efficiency
  - Energy monitoring

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.

Path of the ultrasonic signal in the flowing fluid

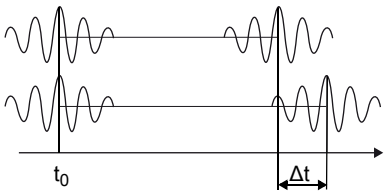


As the fluid where the ultrasound propagates is flowing, the transit time of the ultrasonic signal in flow direction is shorter than the one against the flow direction.

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.

Two integrated microprocessors control the entire measuring process. This allows the flowmeter to remove disturbance signals, and to check each received ultrasonic wave for its validity which reduces noise.

Transit time difference Δt



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 mechanics calibration factor

A - cross-sectional pipe area

k_a - acoustical calibration factor

Δt - transit time difference

t_γ - average of transit times in the fluid

Calculation of heat flow

The heat flow is internally calculated with the following formula:

$\Phi = k_i \cdot \dot{V} \cdot (T_V - T_R)$ (heating application)

$\Phi = k_i \cdot \dot{V} \cdot (T_R - T_V)$ (cooling application)

where

Φ – heat flow

k_i – heat coefficient

$\dot{V}$ – volumetric flow rate

T_V – supply temperature

T_R – return temperature

The heat coefficient k_i results from several heat flow coefficients for the specific enthalpy and density of the fluid. The heat flow coefficients of some fluids are stored in the internal database of the transmitter. Further user-defined fluids are possible.

Max. permissible error

The max. permissible error MPE of a complete heat meter is according to EN 1434 the arithmetic sum of the max. permissible errors of the subassemblies: calculator, temperature sensor pair and flow sensor.

$MPE = E_c + E_t + E_f$

where

MPE – total max. permissible error

E_c – max. permissible relative error of the calculator

E_t – max. permissible relative error of the temperature sensor pair

E_f – max. permissible relative error of the flow sensor

Number of sound paths

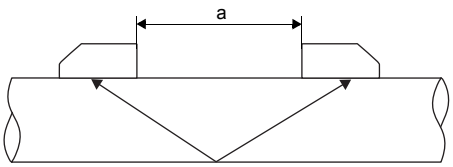
The number of sound paths is the number of transits of the ultrasonic signal through the fluid in the pipe. Depending on the number of sound paths, the following methods of installation exist:

- **reflection arrangement**
  The number of sound paths is even. Both of the transducers are mounted on the same side of the pipe. Correct positioning of the transducers is easier.
- **diagonal arrangement**
  The number of sound paths is odd. Both of the transducers are mounted on opposite sides of the pipe. In the case of a high signal attenuation by the fluid, pipe and coatings, diagonal arrangement with 1 sound path will be used.

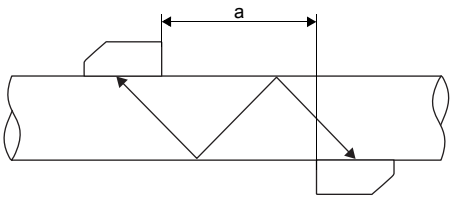
The preferred method of installation depends on the application. While increasing the number of sound paths increases the accuracy of the measurement, signal attenuation increases as well. The optimum number of sound paths for the parameters of the application will be determined automatically by the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

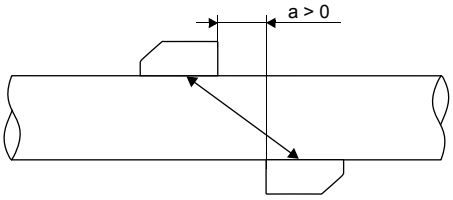
Reflection arrangement, number of sound paths: 2



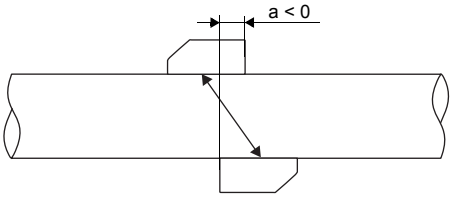
Diagonal arrangement, number of sound paths: 3



Diagonal arrangement, number of sound paths: 1



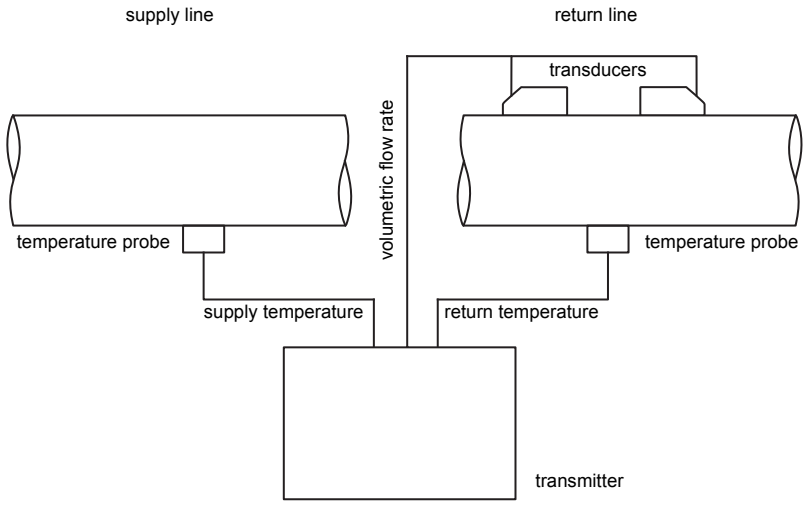
Diagonal arrangement, number of sound paths: 1, negative transducer distance



a - transducer distance

Typical measurement setup

Example of a heat flow measurement measuring the volume flow rate in the return line



Transmitter

Technical data

		FLUXUS F704TE-NN FLUXUS F704TE-A2 (Standard)	FLUXUS F704TE-NN FLUXUS F704TE-A2 (Dual)	FLUXUS F704TE-F2 (Standard)	FLUXUS F704TE-F2 (Dual)
					
design		standard field device, nonEx or ATEX/IECEx		standard field device, FM Class I Div. 2	
application		energy meter			
measurement					
• **energy**					
max. permissible relative error		calculator: $E_c = \pm(0.4 + 1\ K/\Delta\theta)$ %			
• **temperature**					
temperature difference		$\Delta\theta_{min}$ = 3 K, $\Delta\theta_{max}$ = 300 K			
max. permissible relative error		temperature sensor pair: E_t - depending on type, see Technical data of temperature probes			
• **flow**					
measurement principle		transit time difference correlation principle			
flow	m^3/h	Q_p = 17...20 000			
flow velocity	m/s	0.01...25			
fluid pressure		without influence			
pressure loss		-			
repeatability		0.15 % of reading ±0.01 m/s			
fluid		• water • glycol/H_2O: 20 %, 30 %, 40 %, 50 % • thermal fluids: BP Transcal LT, BP Transcal N, R22 Freon, R134 Freon, ammonia, Shell Termina B, Mobiltherm 594, Mobiltherm 603, R407C, R410A • others on request			
temperature compensation		corresponding to the recommendations in ANSI/ASME MFC-5.1-2011			
accuracy[1] • with standard calibration • with advanced calibration (optional) • with field calibration[2]		 ±1.6 % of reading ±0.01 m/s ±1.2 % of reading ±0.01 m/s ±0.5 % of reading ±0.01 m/s			
transmitter					
power supply		• 100...230 V/50...60 Hz or • 20...32 V DC or • 11...16 V DC			
power consumption	W	< 15			
number of measuring channels		1	2	1	2
damping	s	0...100 (adjustable)			
measuring cycle	Hz	100...1000 (1 channel)			
response time	s	1 (1 channel), option: 0.07			
housing material		aluminum, powder coated			
degree of protection		IP65			
dimensions	mm	see dimensional drawing			
weight	kg	3.1			
fixation		wall mounting, optional: 2" pipe mounting			
ambient temperature	°C	-40...+60 °C (< -20 °C without operation of the display)		-20...+60 °C	
display		2 x 16 characters, dot matrix, backlight			
menu language		English, German, French, Dutch, Spanish			
explosion protection					
• **ATEX/IECEx**					
transmitter		F704TE-A2		-	
marking		CE 0637 Ex II3G II2D Ex nA nC ic IIC T4 Gc Ex tb IIIC T 120 °C Db T_a -40...+60 °C		-	
certification ATEX		IBExU11ATEX1015		-	
certification IECEx		IECEx IBE 11.0008		-	

[1] for transit time difference principle, reference conditions and v > 0.15 m/s

[2] reference uncertainty < 0.2 %

[3] outside of explosive atmosphere (housing cover open)

[4] Further outputs and inputs are possible with FLUXUS F721 (see Technical specification TSFLUXUS_F721Vx-xXX).

		FLUXUS F704TE-NN FLUXUS F704TE-A2 (Standard)	FLUXUS F704TE-NN FLUXUS F704TE-A2 (Dual)	FLUXUS F704TE-F2 (Standard)	FLUXUS F704TE-F2 (Dual)
• FM					
marking		-		F70[1 or 2]Z2**[1 or 2]: NI/Cl. I,II,III/Div. 2/ GP. A,B,C,D,E,F,G/ T5 Ta = 60 °C F70[1 or 2]Z2**9: NI/Cl. I,II,III/Div. 2/ GP. A,B,C,D,E,F,G/ T4A Ta = 55 °C	
measuring functions					
physical quantities		heat flow, volumetric flow rate, mass flow rate, flow velocity			
totalizer		heat quantity, volume, mass			
calculation functions		-	average, difference, sum	-	average, difference, sum
diagnostic functions		sound speed, signal amplitude, SNR, SCNR, standard deviation of amplitudes and transit times			
communication interfaces					
service interfaces		• RS232[3] • USB (with adapter)[3]		• RS232 • USB (with adapter)	
process interfaces		max. 1 option: • RS485 (ASCII sender) • Modbus RTU • BACnet MS/TP • M-Bus (nonEx)		max. 1 option: • RS485 (ASCII sender) • Modbus RTU • BACnet MS/TP	
accessories					
serial data kit • cable • adapter		 RS232[3] RS232 - USB[3]		 RS232 RS232 - USB	
software		• FluxDiagReader: download of measured values and parameters, graphical presentation • FluxDiag (optional): download of measurement data, graphical presentation, report generation • FluxSubstanceLoader: upload of fluid data sets			
data logger					
loggable values		all physical quantities, totalized values and diagnostic values			
capacity		> 100 000 measured values			
outputs					
		The outputs are galvanically isolated from the transmitter.			
• switchable current output					
		All switchable current outputs are switched to active or passive mode at the same time.			
number		1, optional: 2[4]	2, optional: 4[4]	1, optional: 2[4]	2, optional: 4[4]
range	mA	4...20 (3.2...22)			
accuracy		0.04 % of reading ±3 µA			
active output		R_{ext} < 350 Ω			
passive output		U_{ext} = 8...30 V, depending on R_{ext}, R_{ext} < 1 kΩ			
• binary output					
number		3			
optorelay		26 V/100 mA			
binary output as alarm output					
• functions		limit, change of flow direction or error			
binary output as pulse output					
• functions		mainly for totalizing			
• pulse value	units	0.01...1000			
• pulse width	ms	1...1000			
inputs					
		The inputs are galvanically isolated from the transmitter.			
• temperature input					
number		2[4]	4	2[4]	4
type		Pt100/Pt1000			
connection		4-wire			
range	°C	-150...+560			
resolution	K	0.01			
accuracy		±0.01 % of reading ±0.03 K			

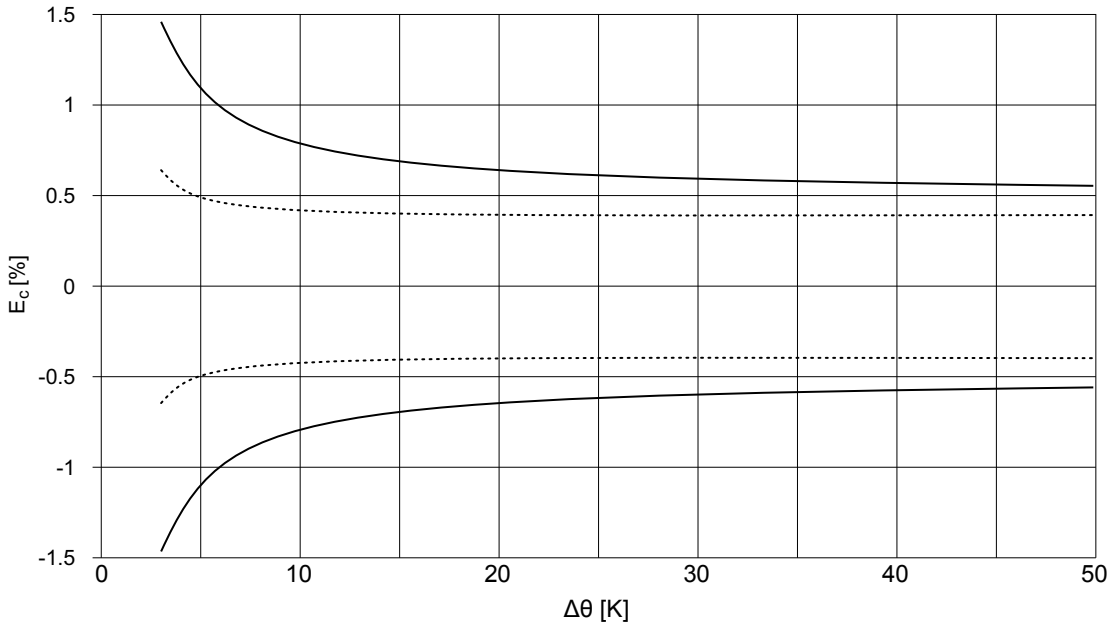
[1] for transit time difference principle, reference conditions and v > 0.15 m/s

[2] reference uncertainty < 0.2 %

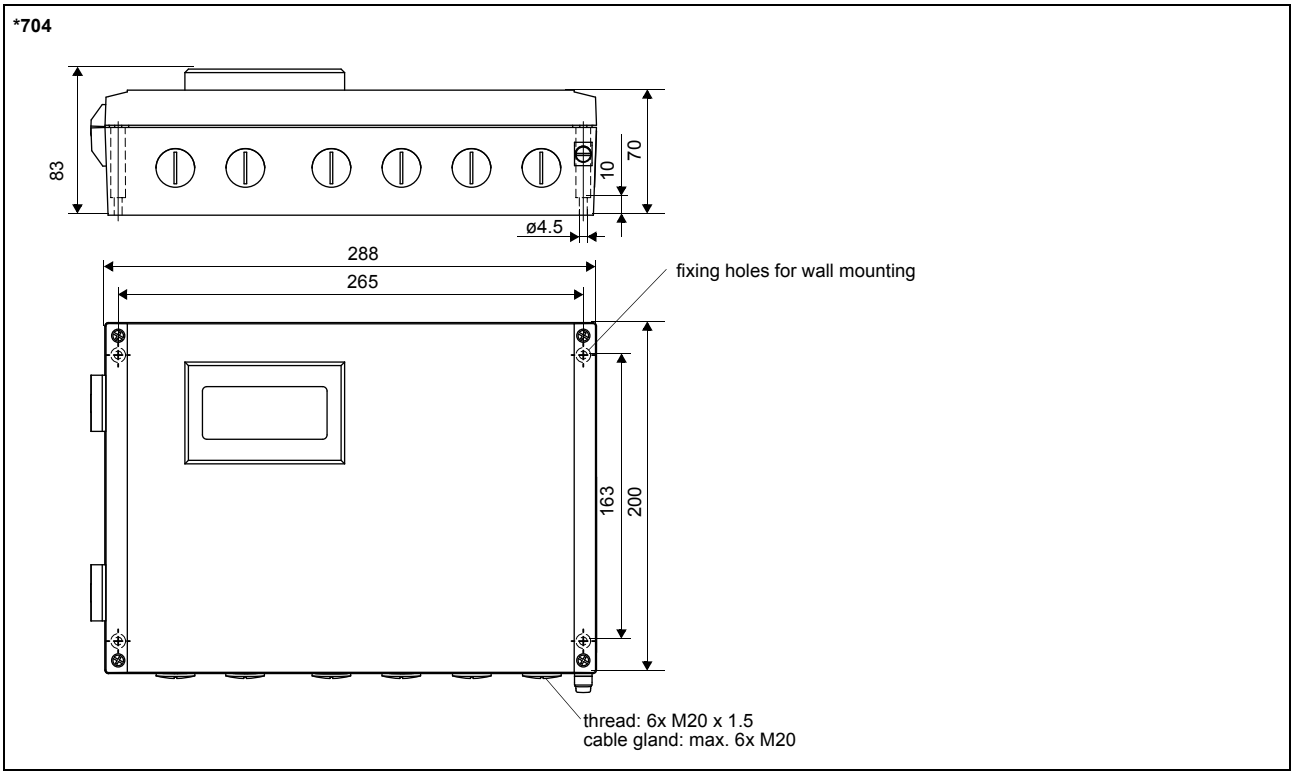
[3] outside of explosive atmosphere (housing cover open)

[4] Further outputs and inputs are possible with FLUXUS F721 (see Technical specification TSFLUXUS_F721Vx-xXX).

Max. permissible error of the calculator



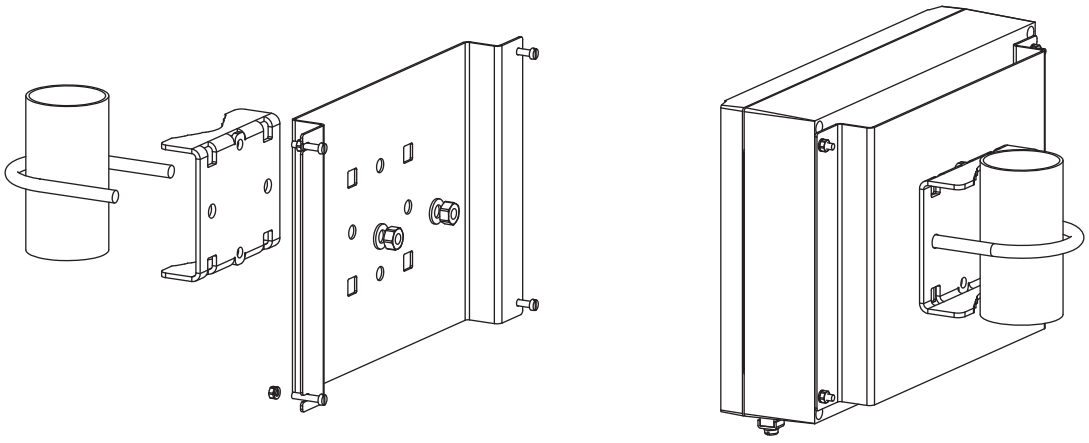
Dimensions



in mm

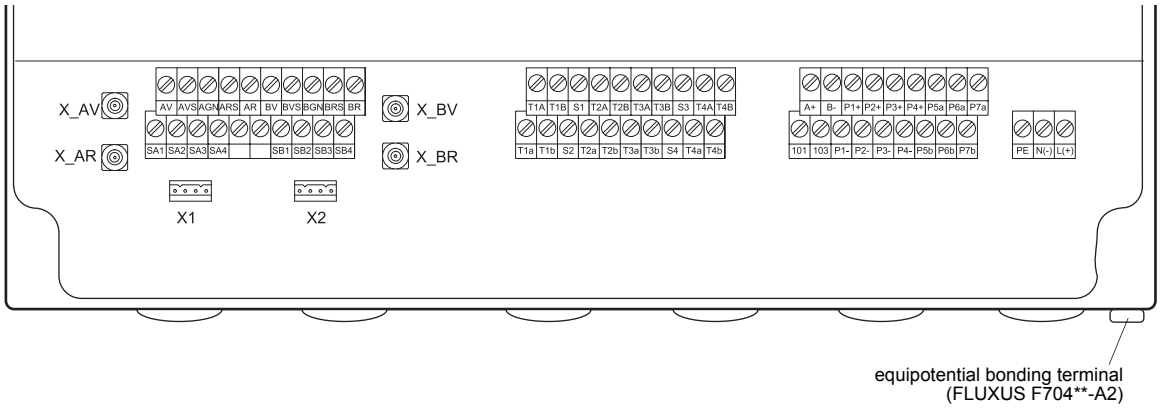
2" pipe mounting kit

***704**



Terminal assignment

***704**



power supply[1]		
terminal	**connection (AC)**	**connection (DC)**
PE	earth	earth
N(-)	neutral	-
L(+)	phase	+

transducers

extension cable					transducer cable		
measuring channel A		**measuring channel B**			**measuring channel A**	**measuring channel B**	
terminal	**connection**	**terminal**	**connection**	**transducer**	**terminal**		**connection**
AV	signal	BV	signal		X_AV	X_BV	SMB connector
AVS	shield	BVS	shield				
ARS	shield	BRS	shield		X_AR	X_BR	SMB connector
AR	signal	BR	signal				

outputs[1, 2]		**communication interfaces**[1, 2]		
terminal	**connection**	**terminal**	**connection**	**communication interface**
P1+...P4+ P1-...P4-	current output	A+	signal +	• RS485 • Modbus RTU • BACnet MS/TP • M-Bus
		B-	signal -	
P5a...P7a P5b...P7b	binary output	101	shield	

analog inputs[1, 2]

	temperature probe		
terminal	**direct connection (clamp-on)**	**connection with extension cable (clamp-on)**	**direct connection (inline)**
T1a...T4a	red	red	red
T1A...T4A	red/blue	grey	grey
T1b...T4b	white/blue	blue	blue
T1B...T4B	white	white	white
S1, S3	shield	shield	-

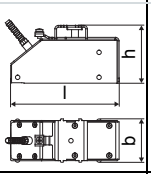
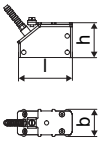
[1] cable (by customer): lead cross sectional area: 0.5...1.5 mm^2

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

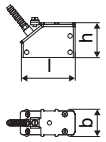
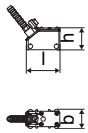
Transducers

Technical data

Shear wave transducers (nonEx, ATEX/IECEx (zone 2) or FM Class I Div. 2)

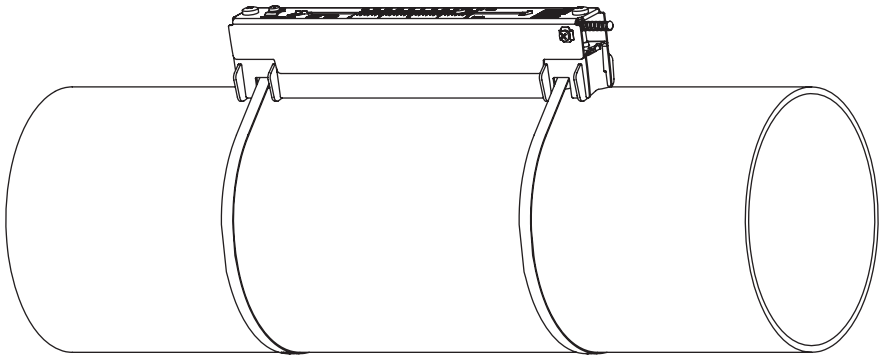
technical type		C(DL)K1N52	C(DL)M2N52	C(DL)P2N52	C(DL)Q2N52
transducer frequency	MHz	0.5	1	2	4
nominal size					
min.		DN 300	DN 200	DN 100	DN 25
max.		DN 1000	DN 600	DN 400	DN 150
material					
housing		PEEK with stainless steel cap 304 (1.4301)			
contact surface		PEEK			
degree of protection (nonEx)		IP67			
transducer cable					
type		1699			
length	m	5, ***-*****/LC: 9	4, ***-*****/LC: 9		3, ***-*****/LC: 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
ambient temperature					
min.	°C	-40			
max.	°C	+130			
temperature compensation		x			
explosion protection					
• **ATEX/IECEx**					
explosion protection temperature (pipe surface)					
• min.	°C	-55			
• max.	°C	gas: +190, dust: +180			
marking		CE 0637 Ex II3G II2D Ex nA IIC T6...T2 Gc Ex tb IIIC TX Db			
certification ATEX		IBExU10ATEX1163 X			
certification IECEx		IECEx IBE 12.0005X			
degree of protection		IP65			
• **FM**					
explosion protection temperature					
• min.	°C	-40			
• max.	°C	+125			
marking		FM APPROVED NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860			
degree of protection		IP66			

Shear wave transducers (extended temperature range - nonEx, ATEX/IECEx (zone 2) or FM Class I Div. 2)

technical type		C(DL)M2E52	C(DL)P2E52	C(DL)Q2E52
transducer frequency	MHz	1	2	4
nominal size				
min.		DN 200	DN 100	DN 25
max.		DN 600	DN 400	DN 150
material				
housing		PI with stainless steel cap 304 (1.4301)		
contact surface		PI		
degree of protection (nonEx)		IP56		
transducer cable				
type		6111		
length	m	4, ***-*****/LC: 9		3, ***-*****/LC: 9
dimensions				
length l	mm	64		40
width b	mm	32		22
height h	mm	40.5		25.5
dimensional drawing				
weight (without cable)	kg	0.066		0.017
ambient temperature				
min.	°C	-30		
max.	°C	+200		
temperature compensation		x		
explosion protection				
• **ATEX/IECEx**				
explosion protection temperature (pipe surface)				
• min.	°C	-45		
• max.	°C	gas: +235, dust: +225		
marking		CE 0637 Ex II3G II2D Ex nA IIC T6...T2 Gc Ex tb IIIA TX Db		
certification ATEX		IBExU10ATEX1163 X		
certification IECEx		IECEx IBE 12.0005X		
degree of protection		IP56		
• **FM**				
explosion protection temperature				
• min.	°C	-40		
• max.	°C	+235		
marking		FM APPROVED NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860		
degree of protection		IP66		

Transducer mounting fixture

Variofix L (VLK, VLM, VLQ)



material: stainless steel 304 (1.4301), 301 (1.4310), 410 (1.4006)
option OS: 316 (1.4571), 316L (1.4404), 17-7PH (1.4568)

inner length:
VLK: 348 mm,
option IP68: 368 mm
VLM: 234 mm
VLQ: 176 mm

dimensions:
VLK: 423 x 90 x 93 mm
option IP68: 443 x 94 x 105 mm
VLM: 309 x 57 x 63 mm
VLQ: 247 x 43 x 47 mm

Coupling materials for transducers

	< 100 °C	< 170 °C
< 24 h	coupling compound type N or coupling foil type VT	coupling compound type E or coupling foil type VT
long time measurement	coupling foil type VT[1]	coupling foil type VT[2]

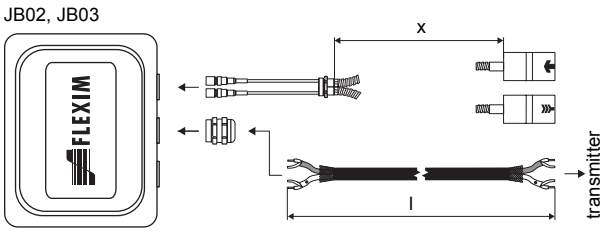
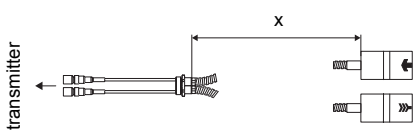
[1] < 5 years

[2] < 6 months

Technical data

type	**ambient temperature** °C	**material**
coupling compound type N	-30...+130	mineral grease paste
coupling compound type E	-30...+200	silicone paste
coupling foil type VT	-10...+200	fluoroelastomer

Connection systems

connection system TS		
connection with extension cable	direct connection	transducers technical type
		*****52

Cable

transducer cable			
type		**1699**	**6111**
weight	kg/m	0.094	0.092
ambient temperature	°C	-55...+200	-100...+225
cable jacket			
material		PTFE	PFA
outer diameter	mm	2.9	2.7
thickness	mm	0.3	0.5
colour		brown	white
shield		x	x
sheath			
material		stainless steel 304 (1.4301) option OS: 316Ti (1.4571)	stainless steel 304 (1.4301) option OS: 316Ti (1.4571)
outer diameter	mm	8	8

extension cable			
type		**2615**	**5245**
weight	kg/m	0.18	0.38
ambient temperature	°C	-30...+70	-30...+70
properties		halogen free fire propagation test according to IEC 60332-1 combustion test according to IEC 60754-2	halogen free fire propagation test according to IEC 60332-1 combustion test according to IEC 60754-2
cable jacket			
material		PUR	PUR
outer diameter	mm	12	12
thickness	mm	2	2
colour		black	black
shield		x	x
sheath			
material		-	steel wire braid with copolymer sheath
outer diameter	mm	-	15.6

Cable length

transducer frequency		**F, G, H, K**		**M, P**		**Q**		**S**	
connection system TS									
transducers technical type		x	l	x	l	x	l	x	l
*****5*	m	5	≤ 300	4	≤ 300	3	≤ 90	2	≤ 40
option LC *****5*	m	9	≤ 300	9	≤ 300	9	≤ 90	-	≤ 40

x - transducer cable length

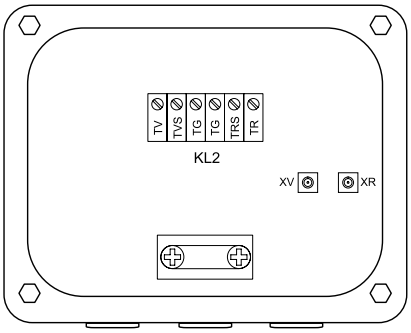
l - max. length of extension cable

Junction box

Technical data

JB02, JB03		
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
explosion protection		
• **ATEX**		
junction box		JB02
marking		CE Ex II3G Ex nA IIC (T6)...T4 Gc II3D Ex tc IIIC T 100 °C Dc Ta -40...+(70)80 °C

connection



transducers

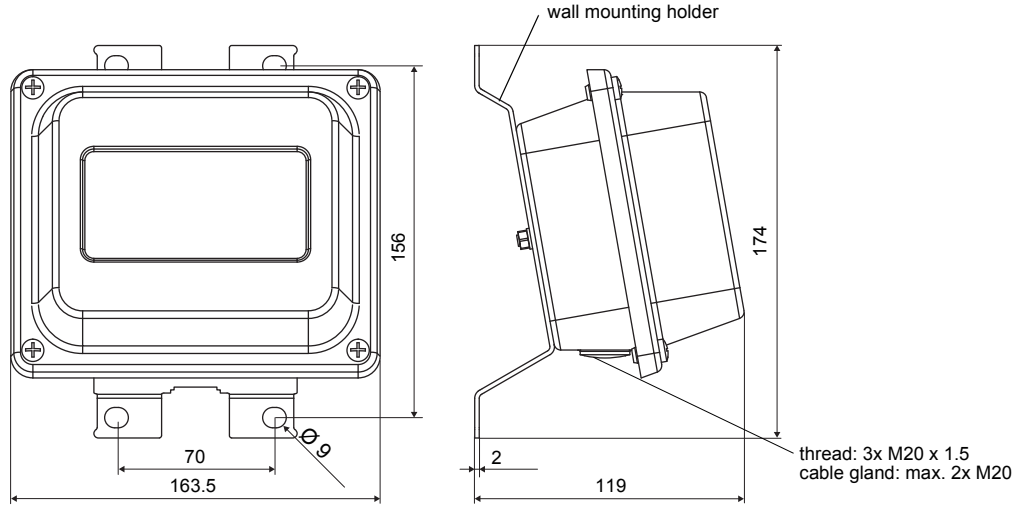
	terminal	connection	transducer
	XV	SMB connector	
	XR	SMB connector	

extension cable

terminal strip	terminal	connection
KL2	TV	signal
	TVS	internal shield
	TRS	internal shield
	TR	signal

Dimensions

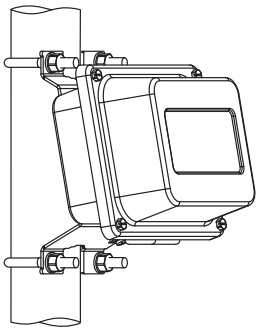
JB0x



in mm

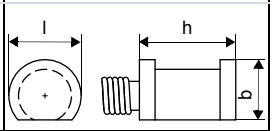
2" pipe mounting kit

JBxx

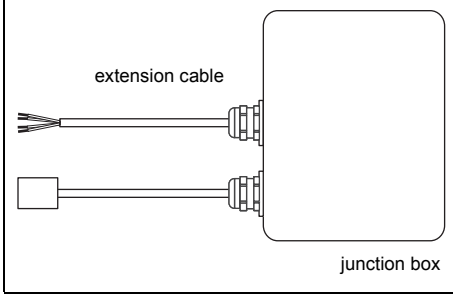
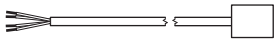


Clamp-on temperature probe (optional)

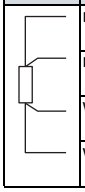
Technical data

PT12N - nonEx, ATEX		
type		2x Pt100, matched according to EN 1434
connection		4-wire
measuring range	°C	-30...+250
accuracy θ		±(0.15 °C + 2 · 10^{-3} · |θ [°C]|) class A
max. permissible relative error		E_t = 0.1 K (3 K < Δθ ≤ 6 K) E_t = 0.2 K (6 K < Δθ ≤ 30 K) E_t = 0.3 K (30 K < Δθ ≤ 50 K)
response time	s	50
housing		aluminum
degree of protection		IP66
dimensions		
length l	mm	15
width b	mm	13
height h	mm	20
dimensional drawing		
weight	kg	0.25
accessories		
thermal conductivity foil 250 °C		x
explosion protection (optional)		
• **ATEX**		
explosion protection temperature		
min.	°C	-30
max.	°C	+250
marking		CE Ex II3G Ex nA IIC T6...T2 Gc Ta -30...+250 °C

connection system

connection with extension cable	direct connection
	

connection

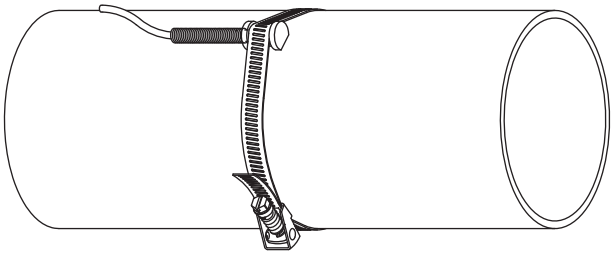
	temperature probe
	red
	red/blue
	white/blue
	white

cable

		temperature probe	extension cable
type		4 x 0.25 mm² black	LIYCY 8 x 0.14 mm² grey
standard length	m	3	5/10/25
max. length	m	-	200
cable jacket		PTFE	PVC

Fixation

tension strap PT12N



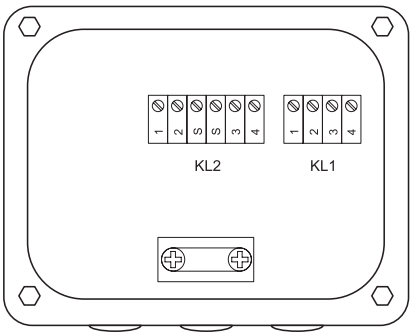
material: stainless steel 301 (1.4310), 410 (1.4006)

Junction box

Technical data

JBT2, JBT3		
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
explosion protection		
• **ATEX**		
junction box		JBT2
marking		CE Ex II3G Ex nA IIC (T6)...T4 Gc II3D Ex tc IIIC T 100 °C Dc Ta -40...+(70)80 °C

connection



temperature probe

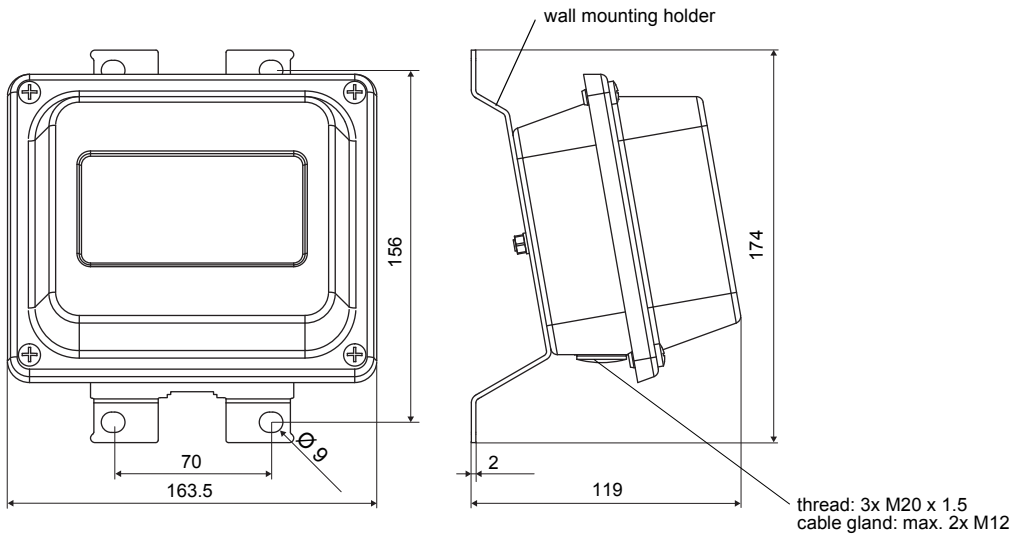
terminal strip	terminal	connection
KL1	1	red
	2	red/blue
	3	white
	4	white/blue

extension cable

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

Dimensions

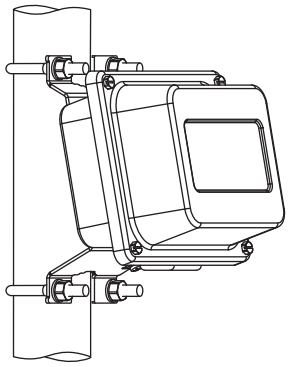
JBTx



in mm

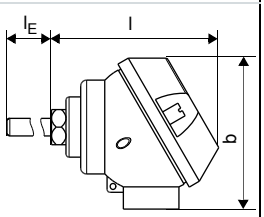
2" pipe mounting kit

JBxx

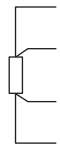


Inline temperature probe (optional)

Technical data

PT12N-IT-P PT12N-IU-P		
type		2x Pt100 matched according to EN 1434
connection		4-wire
measuring range	°C	-30...+200
accuracy θ		±(0.15 °C + 2 · 10^{-3} · |T [°C]|) class A
max. permissible relative error	%	$E_t = \pm 0.9 \cdot (0.5 + 3 \cdot \Delta\theta_{min}/\Delta\theta)$
response time	s	T50: 5, T90: 19
housing		316Ti (1.4571) connecting head J: aluminum
degree of protection		IP65
dimensions		
length l	mm	72 PT12N-IT-P: l_E = 140 PT12N-IU-P: l_E = 230
width b	mm	51
dimensional drawing		
weight	kg	PT12N-IT-P: 0.136 PT12N-IU-P: 0.142

connection

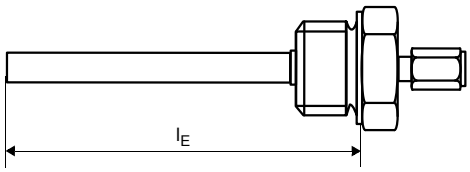
	temperature probe	cable
	red	red
	red	grey
	white	blue
	white	white

cable

		temperature probe
type		LIYCY 8 x 0.14 mm² grey
standard length	m	10/20
max. length	m	200
cable jacket		PVC

Fixation

threaded thermowell PT12N-I



		PT12N-IT-P	PT12N-IU-P
mounting length l_E	mm	120	210
material			
threaded thermowell		stainless steel 316L (1.4404)	
clamping nut		zinc coated steel 1.0037, PTFE	
weight	kg	0.08	0.091
outer diameter	mm	8	
process connection		G 1/2“	
fluid pressure		PN25 (water)	
max. flow velocity[1]			
water, thermal oil	m/s	6.93	4.37
glycol/H_2O	m/s	8.4	3.78

[1] max. permissible values for laminar flows; further influences like motors, pumps, valves which provoke turbulences, water hammers, pulsations, oscillations, etc. have to be considered by the customer

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