Flexim FLUXUS F532TE
Ultrasonic Flowmeter

Ultrasonic Measurement of Thermal Energy and Volumetric Flow Rate

Features

- Integrated flow and thermal energy calculator for the determination of the thermal power in real time
- Very high measuring dynamics and fast response time – suitable for monitoring important processes and plants
- Non-invasive measurement using ultrasonic flow transducers for inner pipe diameters 0.39 to 94.5 inch and temperatures -40 to +266 °F
- Temperature measurement and calculation of the thermal energy according to EN 1434
- Suitable for heating and cooling applications
- 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

Building technology, manufacturing industry, local and district heating/cooling, e.g. in the following areas:

- Energy management
- Internal accounting and balancing
- Network and condition monitoring
- Process optimization
- Predictive maintenance

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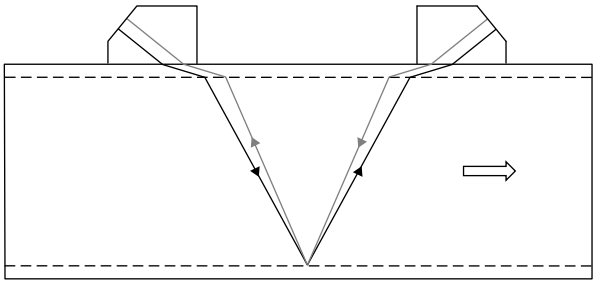
Function

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.

Path of the ultrasonic signal in the flowing fluid

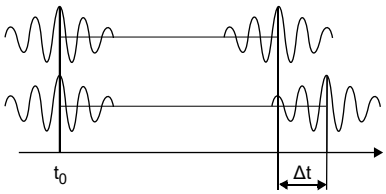


As the fluid where the ultrasound propagates is flowing, the transit time of the ultrasonic signal in flow direction is shorter than the one against the flow direction.

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.

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.

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 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 thermal energy rate

The thermal energy rate is 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 – thermal energy rate

k_i – thermal coefficient

$\dot{V}$ – volumetric flow rate

T_V – supply temperature

T_R – return temperature

The thermal coefficient k_i results from several thermal energy rate coefficients for the specific enthalpy and density of the fluid. The thermal energy rate coefficients of some fluids are stored in the internal database of the transmitter. Further customized 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

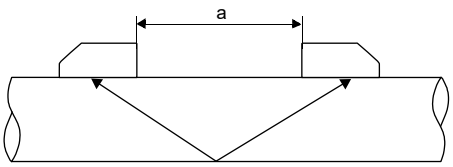
The number of sound paths is the number of transits of the ultrasonic signal through the fluid in the pipe. Depending on the number of sound paths, the following methods of installation exist:

- **reflect 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.
- **direct mode**
  Diagonal arrangement with 1 sound path. This should be used in the case of a high signal attenuation by the fluid, pipe or coatings.

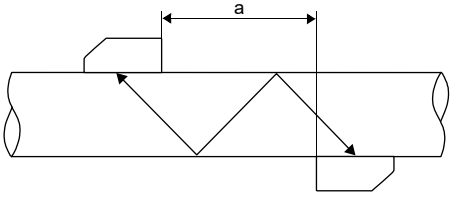
The preferred method of installation depends on the application. While increasing the number of sound paths increases the accuracy of the measurement, signal attenuation increases as well. The optimum number of sound paths for the parameters of the application will be determined automatically by the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

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

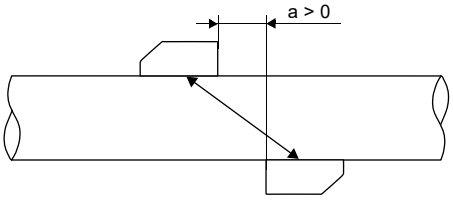
Reflect arrangement, number of sound paths: 2



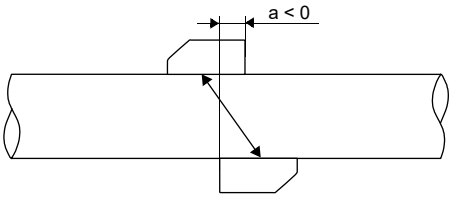
Diagonal arrangement, number of sound paths: 3



Direct mode, number of sound paths: 1



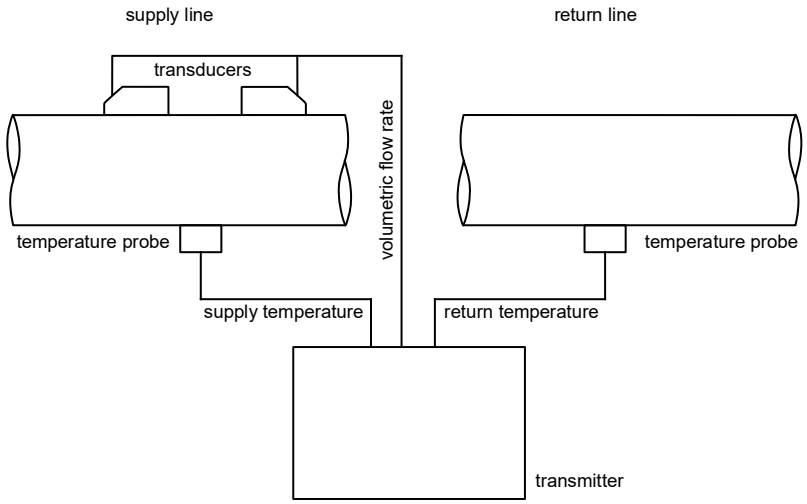
Direct mode, number of sound paths: 1, negative transducer distance



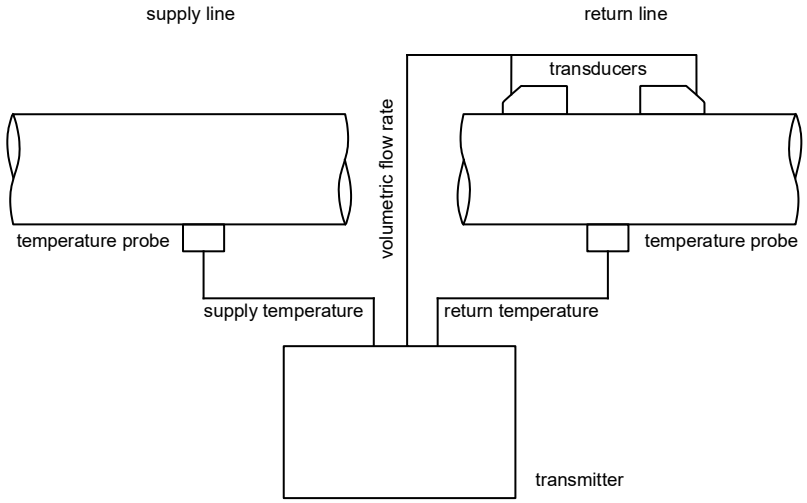
a - transducer distance

Typical measurement setup

Example of a thermal energy rate measurement measuring the volumetric flow rate in the supply line



Example of a thermal energy rate measurement measuring the volumetric flow rate in the return line



Transmitter

Technical data

		FLUXUS F532TE (analog outputs)	FLUXUS F532TE (process interface)
design		field device with 1 measuring channel	
application		energy meter	
measurement			
• energy			
max. permissible relative error		complies to EN 1434 standard	
• temperature			
temperature difference		≤ 0.06 °F (2x Pt matched)	
max. permissible relative error		complies to EN 1434 standard	
• flow			
measurement principle		transit time difference correlation principle	
flow direction		bidirectional	
flow	gpm	example for 2 sound paths and factory default of the cut-off flow: • ANSI 2": Qp = 0.9 to 1145 • ANSI 6": Qp = 7.5 to 6164 • ANSI 20": Qp = 70 to 40947	
flow velocity	ft/s	0.03 to 82	
repeatability		0.15 % MV ±0.02 ft/s	
fluid		water, water/glycol: 0 to 100 %	
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]		±0.3 % MV ±0.02 ft/s includes calibration certificate traceable to NIST	
measurement uncertainty at the measuring point[2]		±1 % MV ±0.02 ft/s	
transmitter			
power supply		• 90 to 250 V/50 to 60 Hz or • 11 to 32 V DC	
power consumption	W	< 10	
number of measuring channels		1	
damping	s	0 to 100 (adjustable)	
measuring cycle	Hz	100 to 1000	
response time	s	1	
housing material		aluminum, powder coated	
degree of protection		IP66	
dimensions	inch	see dimensional drawing	
weight	lb	7	
fixation		wall mounting, optional: 2" pipe mounting	
ambient temperature	°F	-4 to +140	
display		128 x 64 pixels, backlight	
menu language		English, German, French, Spanish, Dutch, Russian, Polish, Turkish, Italian, Chinese	
certificates			
use in unclassified (ordinary) locations		optional: FM APPROVED FM23NUS0010 FM23NCA0007	
measuring functions			
physical quantities		thermal energy rate, volumetric flow rate, mass flow rate, flow velocity	
totalizer		thermal energy, volume, mass	
diagnostic functions		sound speed, signal amplitude, SNR, SCNR, standard deviation of amplitudes and transit times	

[1] with aperture calibration of the transducers

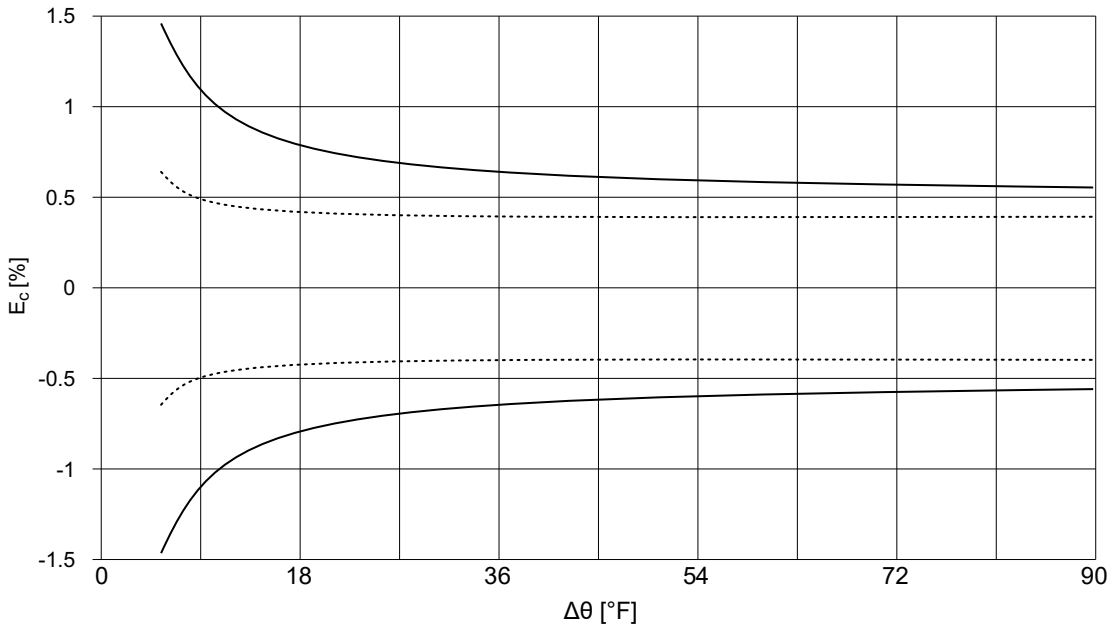
[2] for transit time difference principle and reference conditions

		FLUXUS F532TE (analog outputs)	FLUXUS F532TE (process interface)
communication interfaces			
service interfaces		measured value transmission, parametrization of the transmitter: • USB • LAN	measured value transmission, parametrization of the transmitter: • USB • LAN
process interfaces		-	1 option: • Modbus RTU • BACnet MS/TP • HART • Modbus TCP • BACnet IP
accessories			
data transmission kit		USB cable	
software		• FluxDiagReader: reading of measured values and parameters, graphical representation • FluxDiag (optional): reading of measurement data, graphical representation, report generation, parametrization of the transmitter	
data logger			
loggable values		all physical quantities and totalized physical quantities	
capacity		max. 800 000 measured values	
outputs			
		The outputs are galvanically isolated from the transmitter.	
• switchable current output			
		configurable according to NAMUR NE 43	
number		1	optional: 1 (HART)
range	mA	4 to 20 (alarm current: 3.2 to 3.99, 20.01 to 24, hardware fault current: 3.2)	4 to 20 (alarm current: 3.2 to 3.99, 20.01 to 24, hardware fault current: 3.2)
uncertainty		0.04 % of output value ±3 µA	0.04 % of output value ±3 µA
active output		R_{ext} = 250 to 530 Ω, $U_{opencircuit}$ = 28 V DC	R_{ext} = 250 to 530 Ω, $U_{opencircuit}$ = 28 V DC
passive output		U_{ext} = 9 to 30 V DC, depending on R_{ext} (R_{ext} < 458 Ω at 20 V)	U_{ext} = 9 to 30 V DC, depending on R_{ext} (R_{ext} < 458 Ω at 20 V)
current output in HART mode			
• range	mA	-	4 to 20 (alarm current: 3.5 to 3.99, 20.01 to 22, hardware fault current: 3.2)
• active output		-	R_{ext} = 250 to 530 Ω, $U_{opencircuit}$ = 28 V DC
• passive output		-	U_{ext} = 9 to 30 V DC, depending on R_{ext} (R_{ext} = 250 to 458 Ω at 20 V)
• digital output			
number		2	-
functions		• frequency output • binary output • pulse output	-
type		open collector (passive)	-
operating parameters		5 to 30 V, I_{max} = 100 mA, R_{int} = 20 Ω Low: U < 2 V at I_{loop} = 2 mA (R_{ext} = 12 kΩ at U_{ext} = 24 V) High: U > 15 V (R_{ext} = 12 kΩ at U_{ext} = 24 V)	-
frequency output			
• range	kHz	0.002 to 10	-
• damping	s	0 to 999.9 (adjustable)	-
• pulse-to-pause ratio		1:1	-
binary output			
• binary output as alarm output		limit, change of flow direction or error	-
pulse output			
• pulse value	units	0.01 to 1000	-
• pulse width	ms	0.05 to 1000	-
• pulse rate		max. 10 000 pulses	-
inputs			
		The inputs are galvanically isolated from the transmitter.	
• temperature input			
number		2	
type		Pt100/Pt1000	
connection		4-wire	
range	°F	-238 to +1040	
resolution	K	0.01	
accuracy		±0.01 % MV ±0.03 K at 64 to 82 °F ±0.01 % MV ±0.03 K ±0.0005 %/K at <64 °F/>82 °F	
cable resistance	Ω	max. 1000	

[1] with aperture calibration of the transducers

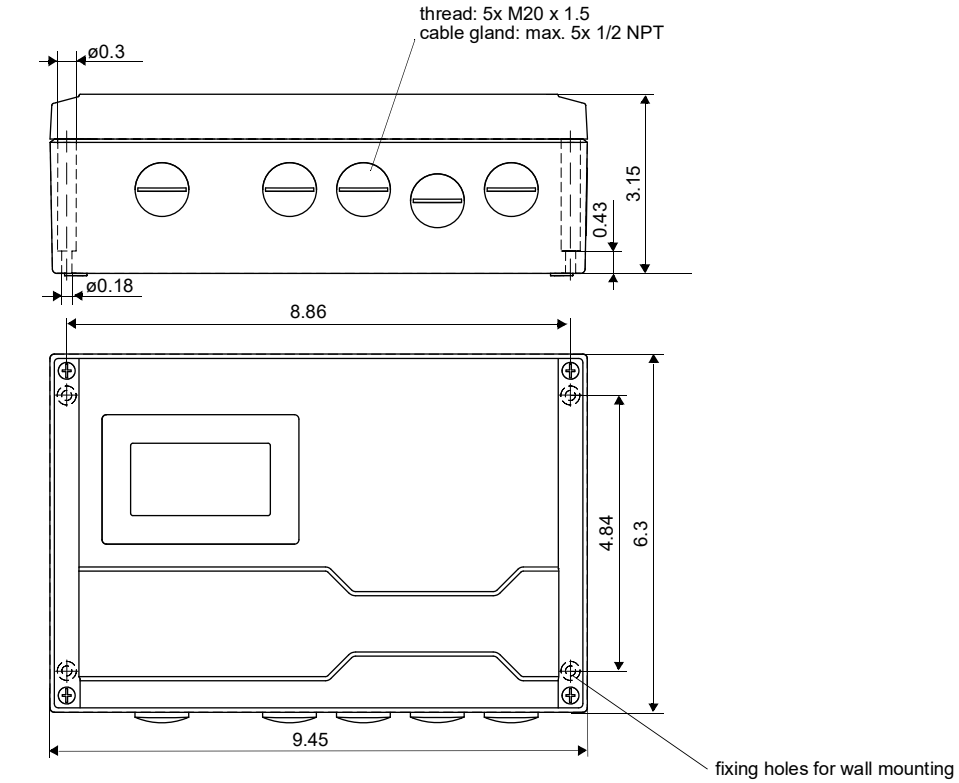
[2] for transit time difference principle and reference conditions

Max. permissible error of the calculator



Dimensions

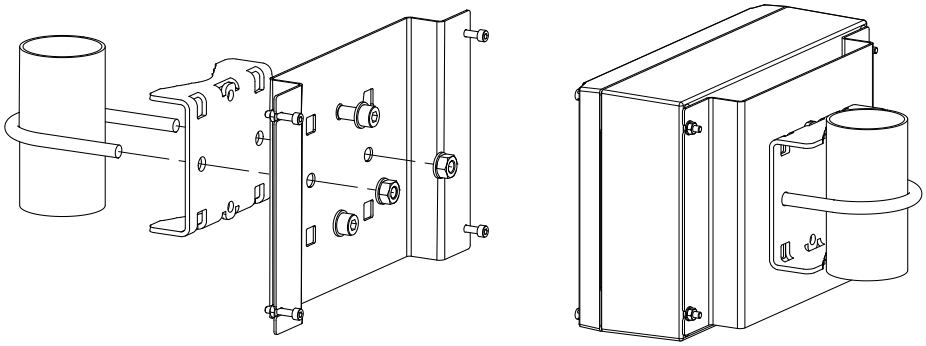
***532**



in inch

2" pipe mounting kit (optional)

***532**



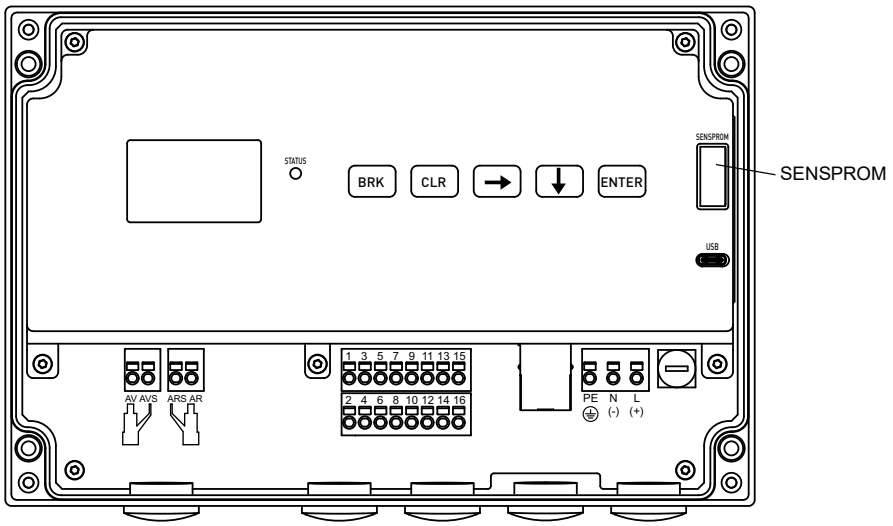
item number: 532037-1

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: -4…+140 °F

Terminal assignment

***532**



power supply[1]			
terminal	**connection (AC)**	**terminal**	**connection (DC)**
PE	protective conductor	PE	protective conductor
N	neutral conductor	(-)	-
L	line conductor	(+)	+

transducers, extension cable		
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
15+, 16-	passive current output/HART
15-, 16+	active current output/HART
1, 2, 3, 4 5, 6, 7, 8	temperature input

temperature probe			
terminal	**direct connection (clamp-on)**	**connection with extension cable (clamp-on)**	**direct connection (inline)**
1, 5	red	white	white
2, 6	white	red	red
3, 7	red	black	black
4, 8	white	green	green

communication interfaces		
terminal	**connection**	**communication interface**
15	signal +	• Modbus RTU[1] • BACnet MS/TP[1]
16	signal -	
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

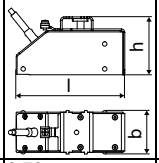
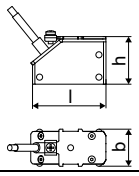
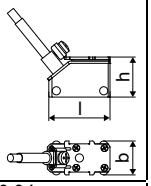
[1] cable (by customer): e.g., flexible wires, with insulated wire ferrules, wire cross-section: AWG14 to 24

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

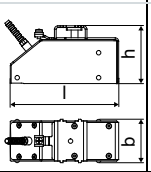
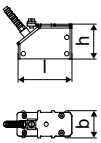
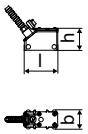
Transducers

Technical data

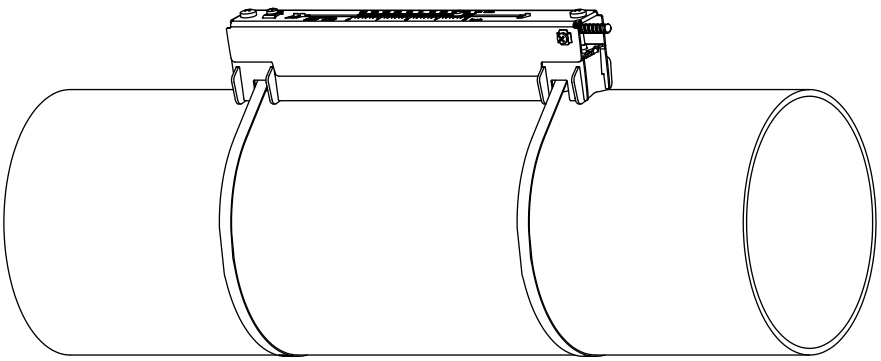
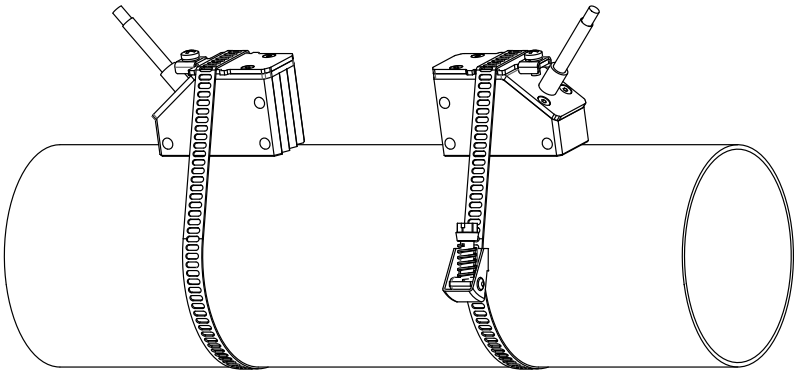
Shear wave transducers (max. 212 °F)

order code		FSK-LNNN-**T1	FSM-LNNN-**T1	FSP-LNNN-**T1	FSQ-LNNN-**T1
technical type		CDK1LZ7	CDM2LZ1	CDP2LZ1	CDQ2LZ1
transducer frequency	MHz	0.5	1	2	4
inner pipe diameter d					
min. extended	inch	3.9	2	0.98	0.39
min. recommended	inch	7.9	3.9	2	0.98
max. recommended	inch	78.7	39.4	15.7	5.9
max. extended	inch	94.5	47.2	18.9	9.4
pipe wall thickness					
min.	inch	0.2	0.1	0.05	0.02
material					
housing		PEEK with stainless steel cover 316Ti			
contact surface		PEEK			
degree of protection		IP66			
transducer cable					
type		2606			
length	ft	32			
dimensions					
length l	inch	4.98	2.52		1.57
width b	inch	2.01	1.26		0.87
height h	inch	2.66	1.59		1
dimensional drawing					
weight (without cable)	lb	0.79	0.15		0.04
pipe surface temperature	°F	-40 to +212			
ambient temperature	°F	-40 to +212			

Shear wave transducers (max. 266 °F)

order code		FSK-NNNN-**T1	FSM-NNNN-**T1	FSP-NNNN-**T1	FSQ-NNNN-**T1
technical type		C(DL)K1N53	C(DL)M2N53	C(DL)P2N53	C(DL)Q2N53
transducer frequency	MHz	0.5	1	2	4
inner pipe diameter d					
min. extended	inch	3.9	2	0.98	0.39
min. recommended	inch	7.9	3.9	2	0.98
max. recommended	inch	78.7	39.4	15.7	5.9
max. extended	inch	94.5	47.2	18.9	9.4
pipe wall thickness					
min.	inch	0.2	0.1	0.05	0.02
material					
housing		PEEK with stainless steel cover 316L			
contact surface		PEEK			
degree of protection		IP66	IP66/IP67		
transducer cable					
type		1699			
length	ft	16	13		9
dimensions					
length l	inch	4.98	2.52		1.57
width b	inch	2.01	1.26		0.87
height h	inch	2.66	1.59		1
dimensional drawing					
weight (without cable)	lb	0.79	0.15		0.04
pipe surface temperature	°F	-40 to +266			
ambient temperature	°F	-40 to +266			
temperature compensation		x			

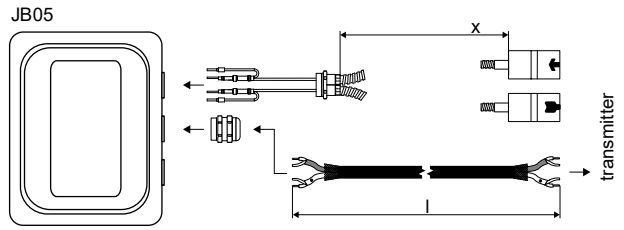
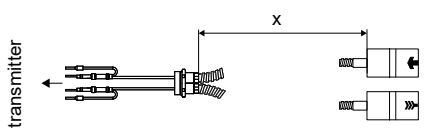
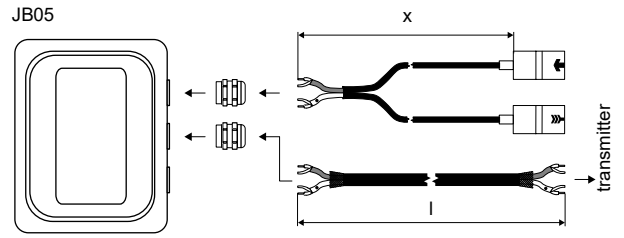
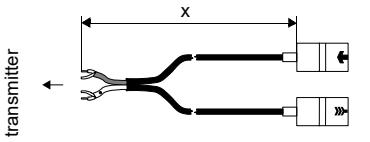
Transducer mounting fixture

Variofix L (VL) 	material: stainless steel 316Ti, 316L, 17-7PH inner length: **VLK**: 13.7 inch **VL(MP)**: 9.2 inch **VLQ**: 6.9 inch dimensions: **VLK**: 16.65 x 3.54 x 3.66 inch **VL(MP)**: 12.17 x 2.24 x 2.48 inch **VLQ**: 9.72 x 1.69 x 1.85 inch
quick release clasps and tension straps 	material: stainless steel 410, 200

Coupling materials for transducers

type	ambient temperature °F	remark
coupling compound type N	-22 to +266	< 24 h
coupling pad type VT	14 to +392	

Connection systems

connection system T1		
connection with extension cable	direct connection	transducers technical type
		*****53
		****LZ*

Cable

transducer cable			
type		**1699**	**2606**
weight	lb/ft	0.06	0.07
ambient temperature	°F	-67 to +392	-40 to +212
cable jacket			
material		PTFE	PUR
outer diameter	inch	0.11	0.2
thickness	inch	0.01	
color		brown	gray
shield		x	x
sheath			
material		stainless steel 316Ti	-
outer diameter	inch	0.31	-

extension cable		
type		**2615**
weight	lb/ft	0.12
ambient temperature	°F	-22 to +158
properties		halogen-free fire propagation test according to IEC 60332-1 combustion test according to IEC 60754-2
cable jacket		
material		PUR
outer diameter	inch	0.47
thickness	inch	0.08
color		black
shield		x

Cable length

transducer frequency		**K**		**M, P**		**Q**	
transducers technical type		x	l	x	l	x	l
CDK1LZ7	ft	32	≤ 984	-	-	-	-
CD*2LZ1	ft	-	-	32	≤ 984	32	≤ 295
****N53	ft	16	≤ 984	13	≤ 984	9	≤ 295

x = transducer cable length

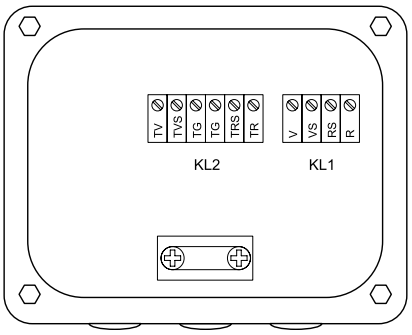
l = max. length of extension cable (depending on the application)

Junction box

Technical data

JB05		
weight	lb	2.6 lb
fixation		wall mounting optional: 2" pipe mounting
material		
housing		stainless steel 316L
gasket		silicone
degree of protection		IP66/IP67
ambient temperature	°F	-40 to +176

Connection



Transducers

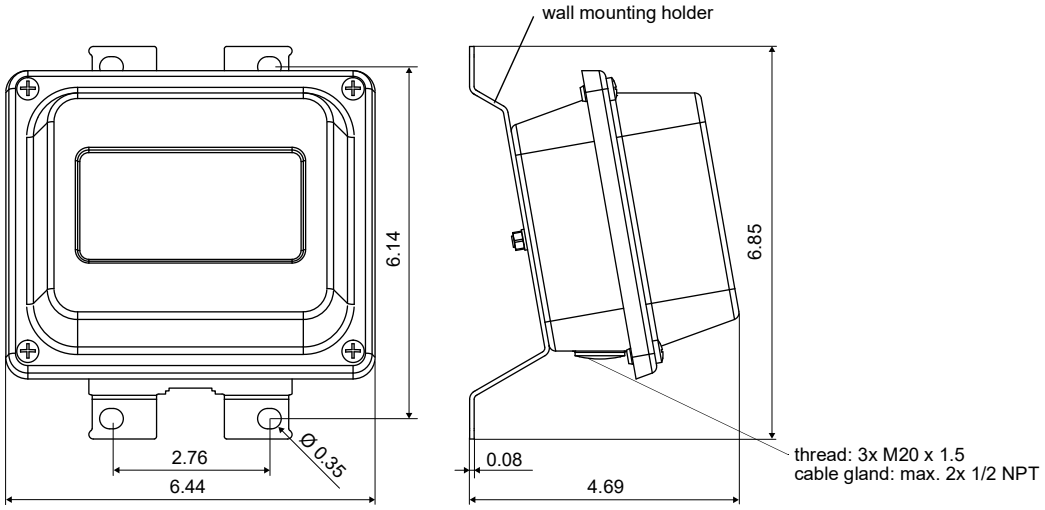
terminal strip	terminal	connection	transducer
KL1	V	signal	
	VS	internal shield	
	RS	internal shield	
	R	signal	

Extension cable

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

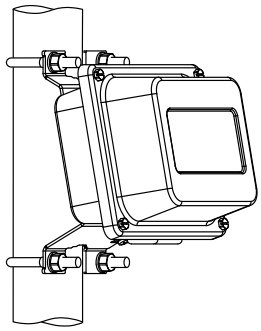
Dimensions

JB0*, JBP*



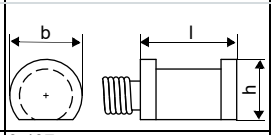
in inch

2" pipe mounting kit

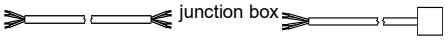
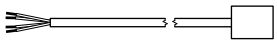
JB** 	item number: 751035-2

Clamp-on temperature probe (optional)

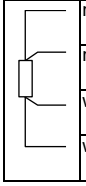
Technical data

PT13N		
design		clamp-on
type		2x Pt1000, matched according to EN 1434
connection		4-wire
measuring range	°F	-40 to +392
accuracy θ		±(0.27 °F + 2 · 10^{-3} · (|θ [°F]| - 32 °F)) class A
accuracy Δθ		≤ 0.0 °F (2x Pt matched, at 50 °F)
housing material		360 brass alloy
degree of protection		NEMA 4
dimensions		
length l	inch	0.79
width b	inch	0.59
height h	inch	0.49
dimensional drawing		
weight	lb	0.437
accessories		
thermal conductivity foil 482 °F		x

Connection system

connection with extension cable	direct connection
extension cable 	

Connection

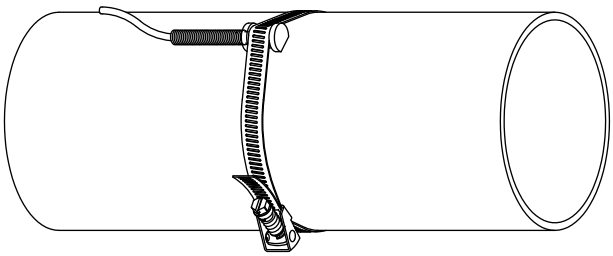
	temperature probe
	red
	red
	white
	white

Cable

		temperature probe	extension cable
type		4 x 24 AWG	4 x 18 AWG
standard length	ft	20	-
max. length	ft	-	656
cable jacket		PTFE	LS PVC

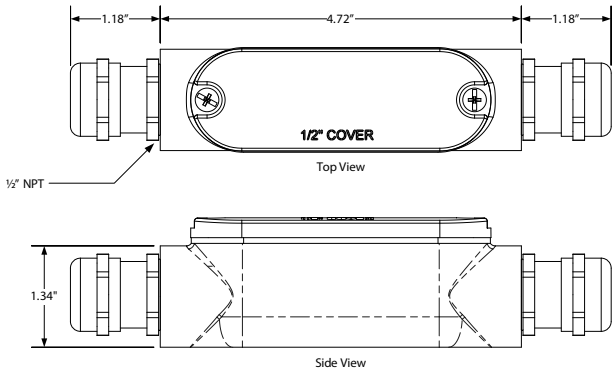
Fixation

tension strap PT13N



material: stainless steel 301, 410
thermal insulation necessary

Junction box



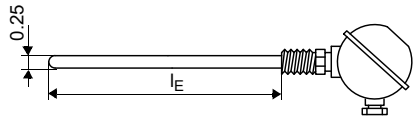
Connection

temperature probe	extension cable
red	white
red	black
white	green
white	red

Inline temperature probe (optional)

Technical data

A2179		
order code		US-TEMP.yy US-TEMP.Pyy (matched)
design		inline
type		Pt1000
connection		4-wire
measuring range	°F	-58 to +500 °F
accuracy ΔT (2x Pt matched according to EN 1434)		≤ 0.03 °F (at 32 °F)
housing		stainless steel 316 connecting head: aluminum
thread		1/2 NPT
mounting length l_E	inch	yy = 02.5, 04, 06, 09



in inch

connection

	temperature probe
	red
	red
	white
	white

cable

		temperature probe
type		4 x 18 AWG
standard length	ft	-
max. length	ft	656
cable jacket		LS PVC

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