

Process analysis and flow measurement with ultrasound

Clamp-on ultrasonic measuring system for the continuous non-invasive monitoring of concentration or fluid properties in the process

Features

- Non-invasive measurement using the clamp-on technology
- Precise bi-directional, highly dynamic flow measurement
- Determination of concentration, density, degree of conversion or other qualitative material properties from the measured sound speed and fluid temperature
- Optional PIOX SM: determination of mass flow and mass
- No contact with the fluid, no special materials required, hygienic measurement, suitable for ultra clean fluids
- Ideal for aggressive, toxic or abrasive fluids
- FM approved transducers for hazardous areas available
- Maintenance free measurement, no wear
- Transducers available for a wide range of inner pipe diameters and fluid temperatures

Applications

- Chemical industry
- Petrochemical industry
- Oil and gas industry
- Pharmaceutical industry
- Semiconductor industry
- Mechanical and electrical engineering
- Food industry



Measurement with transducers mounted with PermaRail



PIOX S704



PIOX S705

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Function

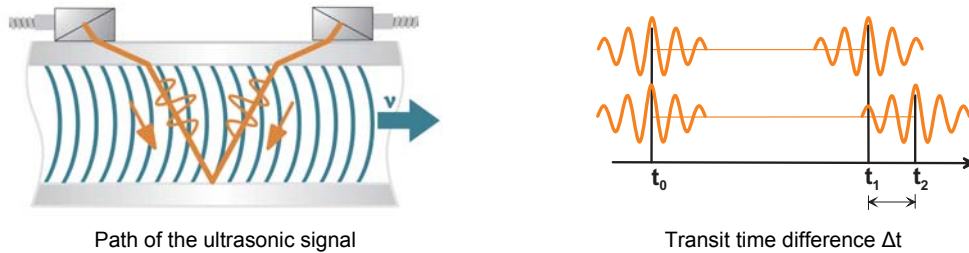
Measurement principle

In order to measure the flow of a fluid in a pipe, ultrasonic signals are used, employing the transit time difference principle. Ultrasonic signals are emitted by a transducer installed on the pipe and received by a second transducer. These signals are emitted alternately in the flow direction and against it.

As the fluid in which the signals propagate is flowing, the transit time of the ultrasonic signals in the flow direction is shorter than 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.



Calculation of volumetric flow rate

$$\dot{V} = k_{Re} \cdot A \cdot k_a \cdot \Delta t / (2 \cdot t_{fl})$$

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_{fl} = transit time in the fluid

Calculation of sound speed

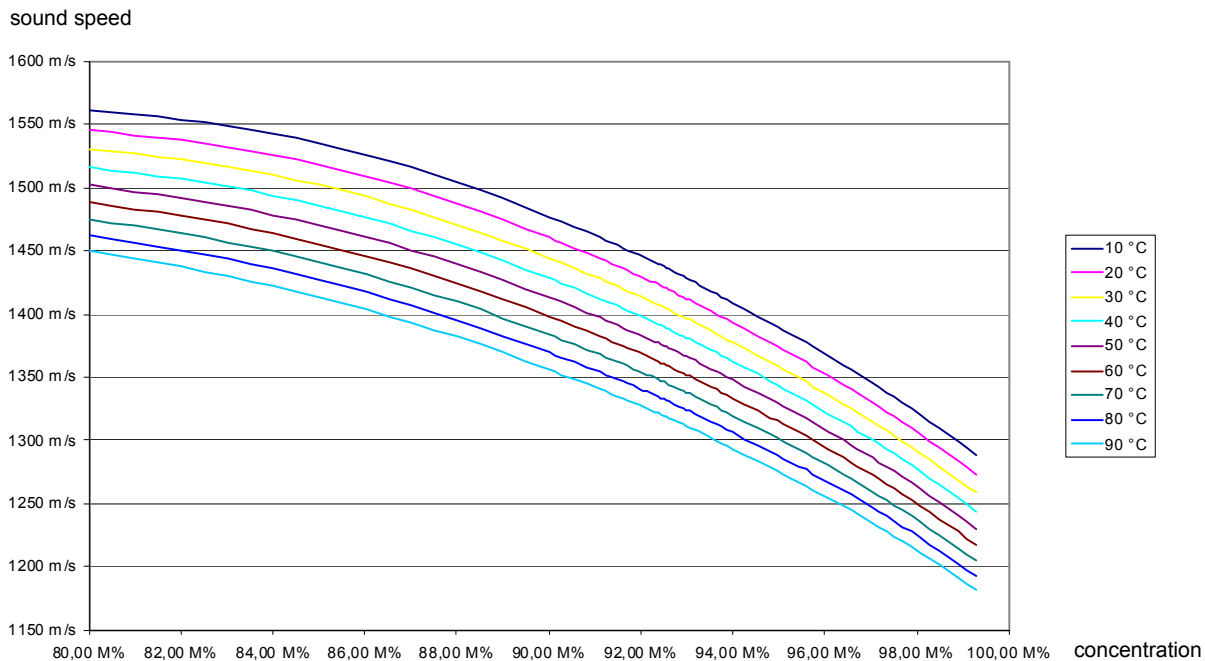
$$c_{fl} = l_{fl} / ((t_1+t_2) / 2 - t_p)$$

- c_{fl} = sound speed in the fluid
- l_{fl} = path of the ultrasonic signal in the fluid
- t_1, t_2 = transit time in the fluid
- t_p = transit time in the transducer and in the pipe wall

The sound speed is the quotient of the path of the ultrasonic signal in the fluid and transit time. The transit time is calculated as average of the transit times of both transducer signals in the fluid, corrected by the transit time in the transducer and in the pipe wall.

A field calibration is recommended to reduce the influence of the pipe parameters on the accuracy of the measurement.

Further physical quantities, e.g. concentration, density, degree of conversion, can be calculated in dependence on the measured sound speed and fluid temperature in the transmitter. This requires a set of characteristic curves where physical quantity, sound speed and fluid temperature are correlated. The characteristic curves can be prepared by FLEXIM if required.



Example for the dependence of the sound speed of sulfuric acid from concentration and temperature

Calculation of mass flow (optional)

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

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

The mass flow is calculated on the base of operating density and volume flow:

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

- ρ = operating density
- K = concentration
- T = temperature
- \dot{m} = mass flow rate
- \dot{V} = volumetric flow rate

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. Both of the transducers are mounted on the same side of the pipe. Correct positioning of the transducers is easier.

- **diagonal arrangement**

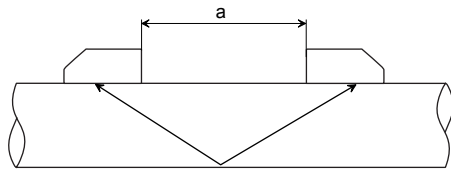
The number of sound paths is odd. Both of the transducers are mounted on opposite sides of the pipe.

- **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.

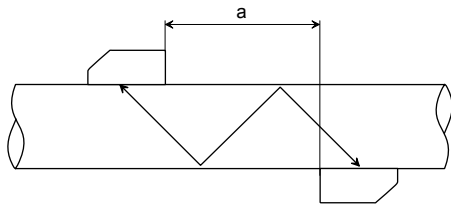
The preferred method of installation depends on the application. While increasing the number of sound paths increases the accuracy of the measurement, signal attenuation increases as well. The optimum number of sound paths for the parameters of the application will be determined automatically by the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

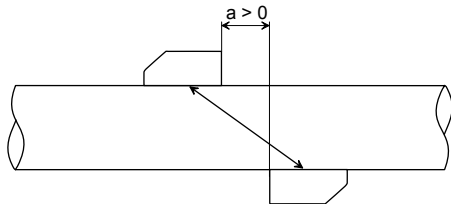


Reflect arrangement, number of sound paths: 2

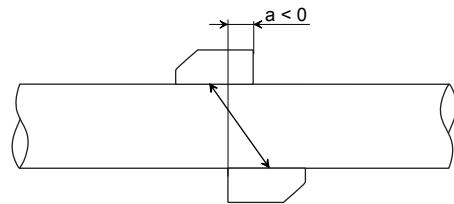
a = transducer distance



Diagonal arrangement, number of sound paths: 3

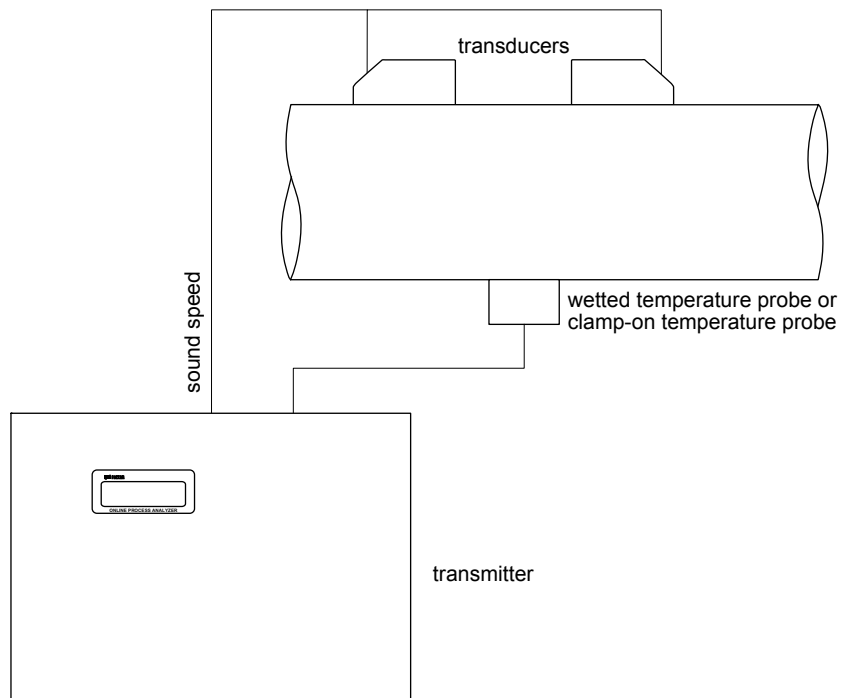


Direct mode, number of sound paths: 1



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







Typical measurement setup



Example of a concentration measurement with clamp-on transducers

Transmitter

Technical data

PIOX	S704**-NN S704**-F2	S705**-NN S705**-F2	
design	standard field device	field device with stainless steel housing	
			
measurement			
measurement principle	transit time difference correlation principle		
flow velocity	0.03 to 82 ft/s		
volumetric flow rate	0.15 % of reading ±0.03 ft/s		
- repeatability	0.15 % of reading ±0.03 ft/s		
- accuracy ¹	±1.6 % of reading ±0.03 ft/s		
- with standard calibration	±1.6 % of reading ±0.03 ft/s		
- with advanced calibration (optional)	±1.2 % of reading ±0.03 ft/s		
- with field calibration ²	±0.5 % of reading ±0.03 ft/s		
sound speed	300 to 3000 m/s		
- range	300 to 3000 m/s		
- repeatability	0.15 % of reading ±0.01 m/s		
- accuracy	0.25 % of reading ±0.1 m/s		
fluid	all acoustically conductive liquids with < 10 % gaseous or solid content in volume		
temperature compensation	corresponding to the recommendations in ANSI/ASME MFC-5.1-2011		
transmitter			
power supply	100 to 230 V/50 to 60 Hz or 20 to 32 V DC		
power consumption	< 15 W		
number of flow measuring channels	1, optional: 2		
damping	0 to 100 s, adjustable		
measuring cycle (1 channel)	100 to 1000 Hz		
response time	1 s (1 channel), option: 70 ms		
housing material	aluminum, powder coated	stainless steel 316L	
degree of protection	NEMA 4	NEMA 4X	
dimensions	see dimensional drawing		
weight	6.8 lb	10.8 lb	
fixation	wall mounting, optional: 2" pipe mounting		
ambient temperature	-40 to +140 °F (< -4 °F without operation of the display)		
display	2 x 16 characters, dot matrix, backlight		
menu language	English, German, French, Dutch, Spanish		
F M	transmitter marking	<p>S704**-F2</p> <p>F70[1 or 2]Z2**[1 or 2]:</p> <p> NI/Cl. I,II,III/Div. 2/ GP. A,B,C,D,E,F,G/ T5 Ta = 60 °C</p> <p>F70[1 or 2]Z2**9:</p> <p> NI/Cl. I,II,III/Div. 2/ GP. A,B,C,D,E,F,G/ T4A Ta = 55 °C</p>	<p>S705**-F2</p> <p>F703Z2**[1 or 2]:</p> <p> NI/Cl. I,II,III/Div. 2/ GP. A,B,C,D,E,F,G/ T5 Ta = 60 °C</p> <p>F703Z2**9:</p> <p> NI/Cl. I,II,III/Div. 2/ GP. A,B,C,D,E,F,G/ T4A Ta = 55 °C</p>

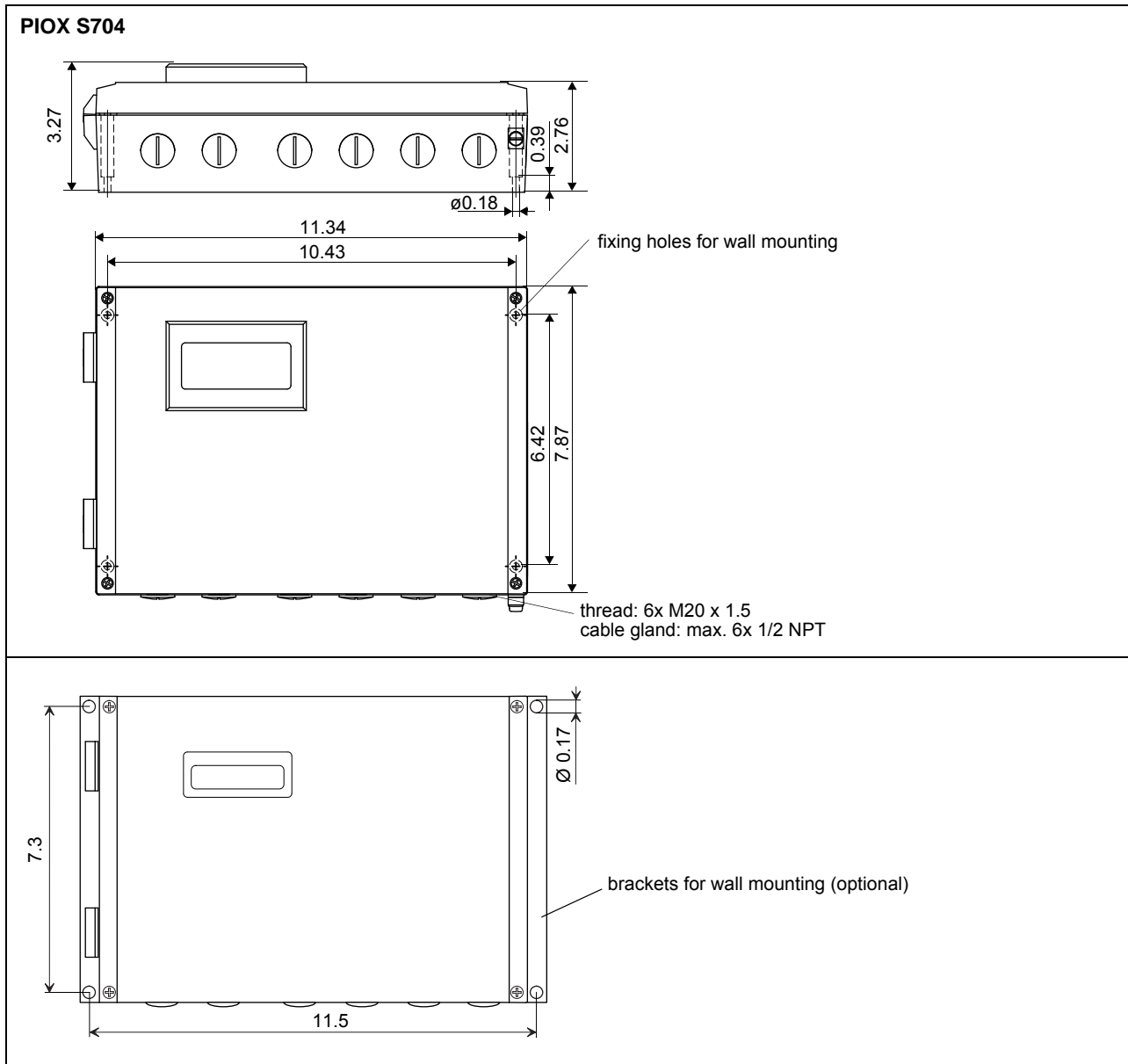
¹ for reference conditions and v > 0.49 ft/s

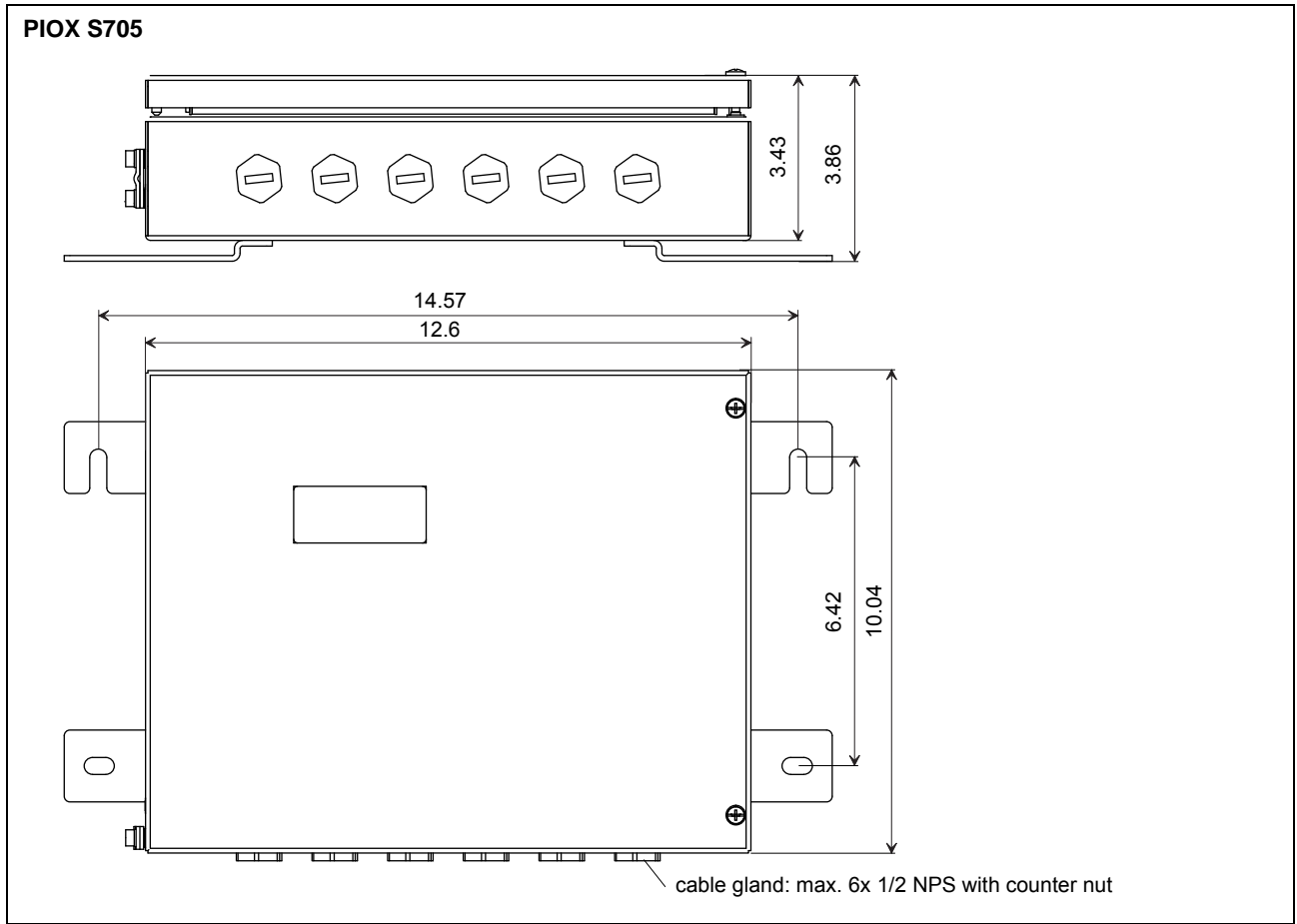
² reference uncertainty < 0.2 %

PIOX	S704**-NN S704**-F2	S705**-NN S705**-F2
measuring functions		
physical quantities	volumetric flow rate, flow velocity, concentration, degree of conversion, Brix PIOX SM: additionally mass flow rate, density others on request	
totalizer	volume, PIOX SM: additionally mass	
calculation functions	average, difference, sum (2 measuring channels necessary)	
diagnostic functions	sound speed, signal amplitude, SNR, SCNR, standard deviation of amplitudes and transit times	
data logger		
loggable values	all physical quantities, totalized values and diagnostic values	
capacity	> 100 000 measured values	
SD card, removable (nonEx, optional)		
loggable values	all physical quantities and totalized values	
capacity	min. 2 GB	
communication		
interface	- process integration (optional): RS485 (sender) or Modbus RTU or FF H1 or HART or SD card (nonEx) - diagnosis: RS232	
serial data kit (optional)		
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	
cable	RS232	
adapter	RS232 - USB	
outputs (optional)		
	The outputs are galvanically isolated from the transmitter.	
number	on request	
switchable current output		
	All switchable current outputs are switched to active or passive mode at the same time.	
- range	4 to 20 mA (3.2 to 22 mA)	
- accuracy	0.04 % of reading ±3 µA	
- active output	$R_{ext} < 350 \Omega$	
- passive output	$U_{ext} = 8 \text{ to } 30 \text{ V}$, depending on R_{ext} , $R_{ext} < 1 \text{ k}\Omega$	
current output		
range	0/4 to 20 mA	
accuracy	0.1 % of reading ±15 µA	
active output	$R_{ext} < 500 \Omega$	
passive output	$U_{ext} = 4 \text{ to } 24 \text{ V}$, depending on R_{ext} , $R_{ext} < 1 \text{ k}\Omega$	
current output I1 in HART mode		
- range	4 to 20 mA	
- passive output	$U_{ext} = 10 \text{ to } 24 \text{ V}$	
voltage output		
range	0 to 1 V or 0 to 10 V	
accuracy	0 to 1 V: 0.1 % of reading ±1 mV 0 to 10 V: 0.1 % of reading ±10 mV	
internal resistance	$R_{int} = 500 \Omega$	
frequency output		
range	0 to 5 kHz	
open collector	24 V/4 mA, $R_{int} = 66.5 \Omega$	
binary output		
Reed relay	48 V/100 mA, P1 to P4: $R_{int} = 22 \Omega$	
open collector	24 V/4 mA, P1 to P4: $R_{int} = 22 \Omega$	
optorelay	26 V/100 mA	
binary output as alarm output		
- functions	limit, change of flow direction or error	
binary output as pulse output	mainly for totalizing	
- pulse value	0.01 to 1000 units	
- pulse width	optorelay: 1 to 1000 ms Reed relay, open collector: 80 to 1000 ms	

PIOX	S704**-NN S704**-F2	S705**-NN S705**-F2
inputs		
	The inputs are galvanically isolated from the transmitter.	
number	max. 4, on request min. 1 input for fluid temperature necessary	
temperature input		
type	Pt100/Pt1000	
connection	4-wire	
range	-238 to +1040 °F	
resolution	0.01 K	
accuracy	±0.01 % of reading ±0.03 K	
current input		
accuracy	0.1 % of reading ±10 µA	
active input	U _{int} = 24 V R _{int} = 50 Ω P _{int} < 0.5 W, not short-circuit proof	
- range	0 to 20 mA	
passive input	R _{int} = 50 Ω, P _{int} < 0.3 W	
- range	-20 to +20 mA	
voltage input		
range	0 to 1 V	
accuracy	0.1 % of reading ±1 mV	
internal resistance	R _{int} = 1 MΩ	
binary input		
switching signal	5 to 30 V, 1 mA FM Class I Div. 2: 5 to 26 V, 1 mA	
functions	<ul style="list-style-type: none"> - resetting the measured values - resetting the totalizers - stopping the totalizers - activation of the measuring mode for highly dynamic flows 	

Dimensions

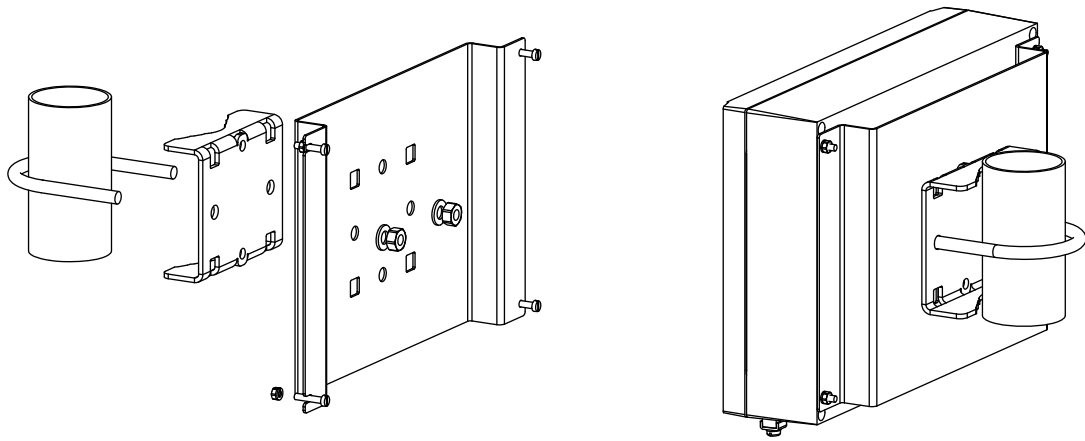




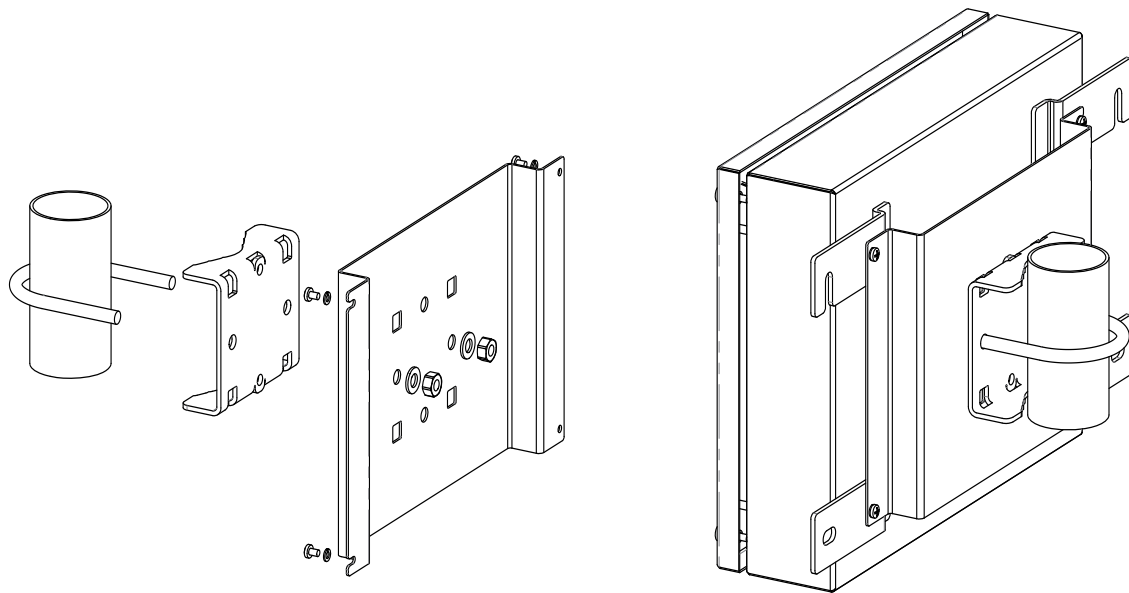
in inch

2" pipe mounting kit (optional)

PIOX S704

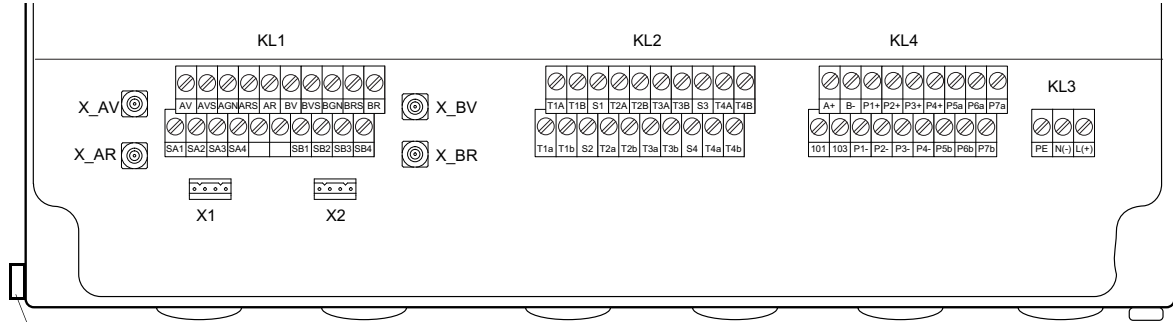


PIOX S705



Terminal assignment

PIOX S704, S705



equipotential bonding terminal (PIOX S705)

power supply

terminal strip KL3

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

transducers

terminal strip KL1

extension cable (transducers ****LI*, *****52) transducer cable (transducers ****LI*)			
measuring channel A		measuring channel B	
terminal	connection	terminal	connection
AV	signal	BV	signal
AVS	shield	BVS	shield
ARS	shield	BRS	shield
AR	signal	BR	signal

transducer cable (transducers *****52)		
measuring channel A	measuring channel B	
terminal		connection
X_AV	X_BV	SMB connector
X_AR	X_BR	SMB connector

outputs²

terminal strip KL4

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

communication interface

terminal strip KL4

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

analog inputs²

terminal strip KL2

terminal	temperature probe				passive current source connection of an active input	active current source connection of a passive input
	with connector direct connection	without connector direct connection	with connector connection with extension cable	without connector connection with extension cable		
T1a to T4a	red	red	red	white	not connected	not connected
T1A to T4A	red/blue	gray	red	black	-	+
T1b to T4b	white/blue	blue	white	red	+	not connected
T1B to T4B	white	white	white	green	not connected	-
S1 to S4	shield	shield	-	-	not connected	not connected

binary inputs²

terminal strip KL4

terminal
P1+ to P2+, P1- to P2-

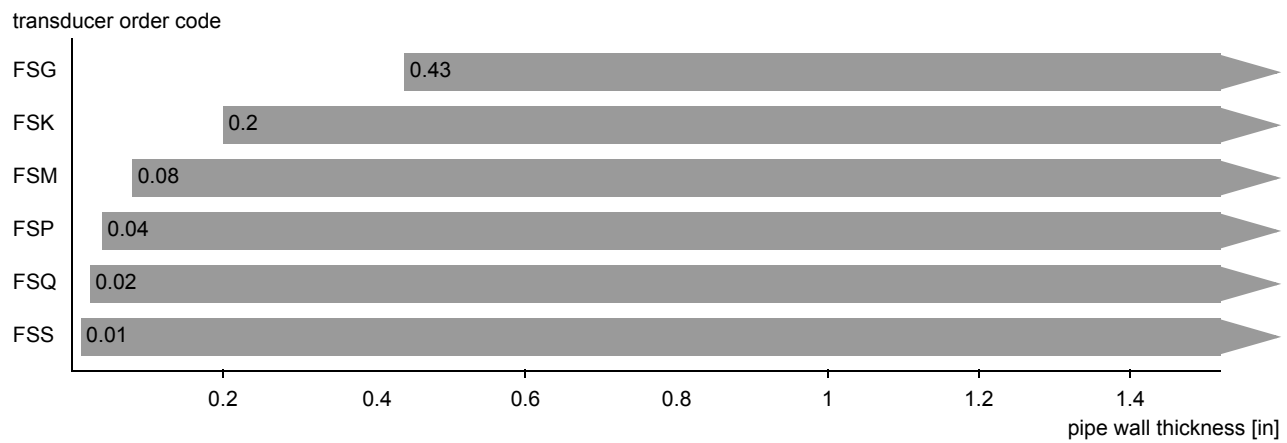
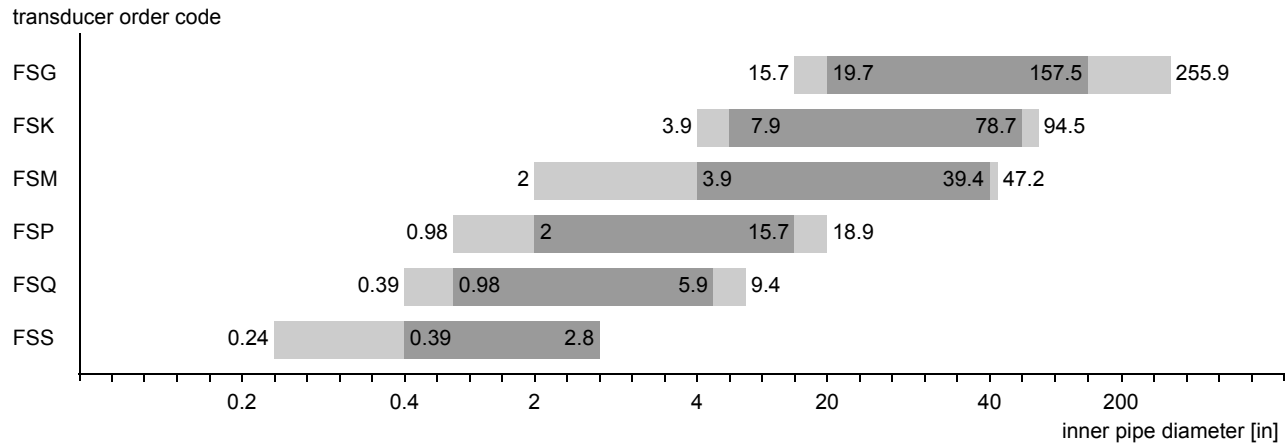
² The number, type and terminal assignment of the outputs and inputs will be customized.

Transducers

Transducer selection

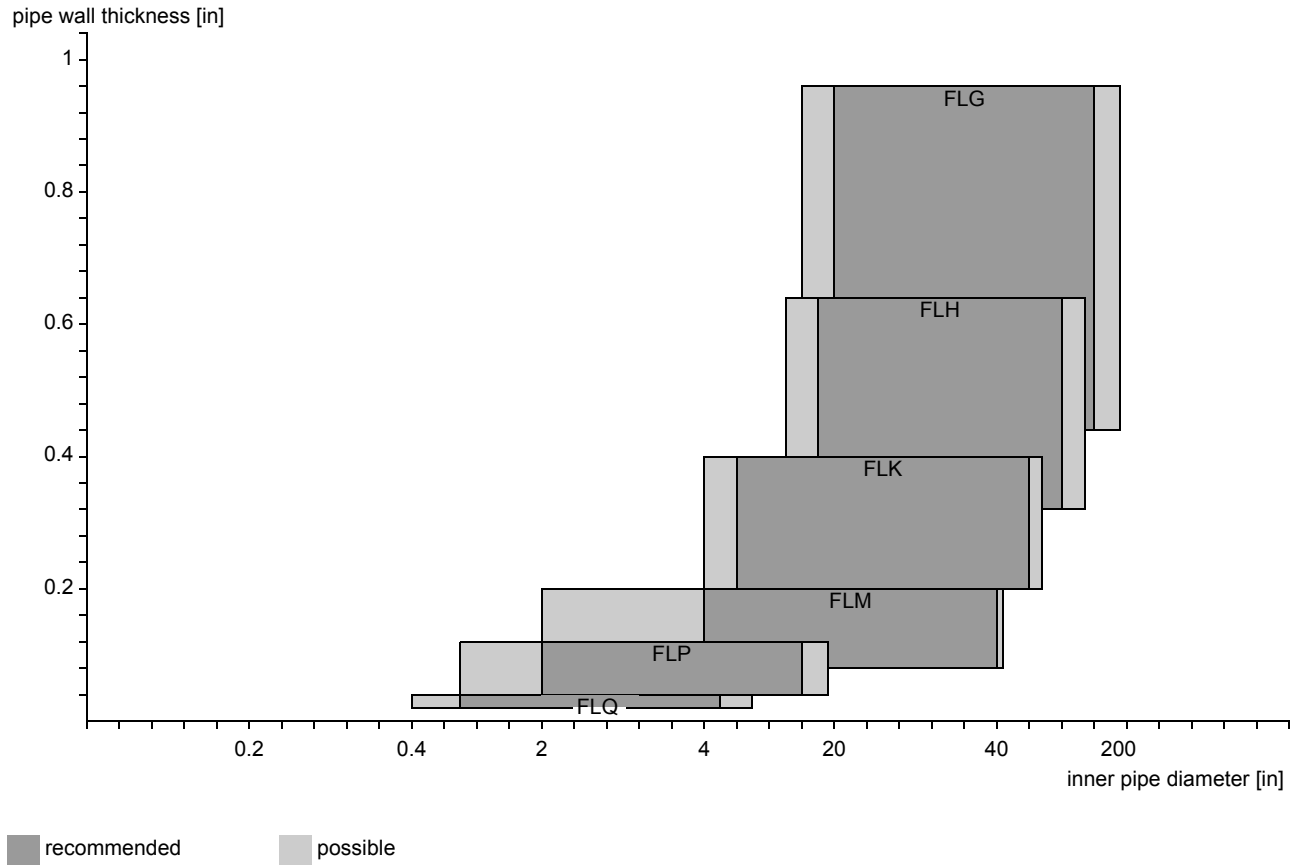
Shear wave transducers

Shear wave transducers are preferred for standard applications.



Lamb wave transducers

If the the damping of the fluid is high or the sound velocity fluctuates strongly, Lamb wave transducers might be preferred. Please contact FLEXIM.

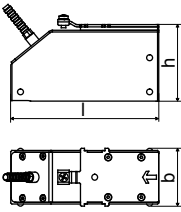
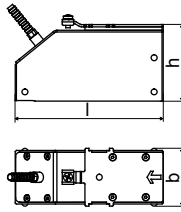
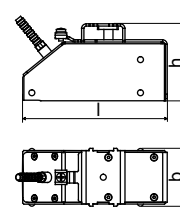
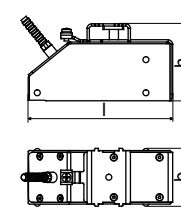






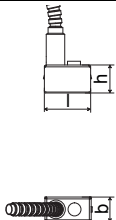

Transducer order code

1, 2	3	4	5, 6	7, 8	9 to 11	12, 13	no. of character		description
transducer	transducer frequency	-	ambient temperature	explosion protection	connection system	-	extension cable	/	option
FS									set of ultrasonic flow transducers, shear wave
FL									set of ultrasonic flow transducers, Lamb wave
	G H K M P Q S								0.2 MHz 0.3 MHz (Lamb wave only) 0.5 MHz 1 MHz 2 MHz 4 MHz 8 MHz (shear wave only)
		N E							normal temperature range extended temperature range (shear wave transducers with transducer frequency M, P, Q)
			F2 NN						FM Class I Div. 2 not explosion proof
				TS					direct connection or connection via junction box
						XXX			cable length in m, for max. length of extension cable see page 29 0 m: without junction box > 0 m: with junction box
							LC IP68 OS		long transducer cable degree of protection NEMA6P housing with stainless steel 316
example									
FS	M	-	N	F2	TS	-	030		shear wave transducer 1 MHz, normal temperature range, FM Class I Div. 2, connection system TS with junction box and extension cable 30 m (98 ft)
		-				-		/	

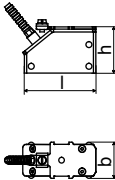
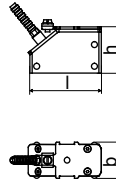
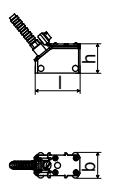



Technical data

Shear wave transducers (FM Class I Div. 2 or not explosion proof)

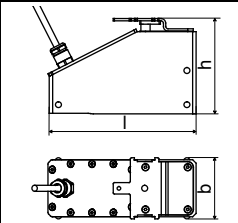
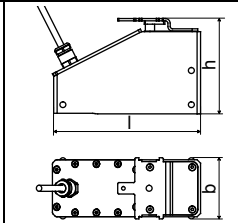
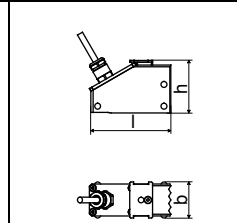
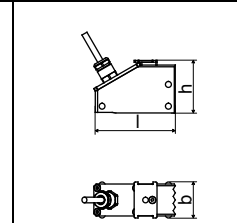
technical type		CDG1N52	CLG1N52	CDK1N52	CLK1N52	
order code		FSG-NF2TS FSG-NF2TS/OS FSG-NNNTS FSG-NNNTS/OS	FSG-NF2TS/LC FSG-NF2TS/LC/OS FSG-NNNTS/LC FSG-NNNTS/LC/OS	FSK-NF2TS FSK-NF2TS/OS FSK-NNNTS FSK-NNNTS/OS	FSK-NF2TS/LC FSK-NF2TS/LC/OS FSK-NNNTS/LC FSK-NNNTS/LC/OS	
transducer frequency	MHz	0.2	0.2	0.5	0.5	
inner pipe diameter d						
min. extended	in	15.7	15.7	3.9	3.9	
min. recommended	in	19.7	19.7	7.9	7.9	
max. recommended	in	157.5	157.5	78.7	78.7	
max. extended	in	255.9	255.9	94.5	94.5	
pipe wall thickness						
min.	in	0.43	0.43	0.2	0.2	
material						
housing		PEEK with stainless steel cap 304, option OS: 316L	PEEK with stainless steel cap 304, option OS: 316L	PEEK with stainless steel cap 304, option OS: 316L	PEEK with stainless steel cap 304, option OS: 316L	
contact surface		PEEK	PEEK	PEEK	PEEK	
degree of protection		NEMA 6	NEMA 6	NEMA 6	NEMA 6	
transducer cable						
type		1699	1699	1699	1699	
length	ft	16	29	16	29	
dimensions						
length l	in	5.1	5.1	4.98	4.98	
width b	in	2.01	2.01	2.01	2.01	
height h	in	2.64	2.64	2.66	2.66	
dimensional drawing						
ambient temperature						
min.	°F	-40	-40	-40	-40	
max.	°F	+266	+266	+266	+266	
temperature compensation		x	x	x	x	
explosion protection						
FM	order code	FSG-NF2TS FSG-NF2TS/OS	FSG-NF2TS/LC FSG-NF2TS/LC/OS	FSK-NF2TS FSK-NF2TS/OS	FSK-NF2TS/LC FSK-NF2TS/LC/OS	
	explosion protection temperature					
	min.	°F	-40	-40	-40	-40
	max.	°F	+257	+257	+257	+257
	marking		 NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860	 NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860	 NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860	 NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860
type of protection		non incandive	non incandive	non incandive	non incandive	

technical type		CDS1N52
order code		FSS-NF2TS FSS-NNNTS
transducer frequency	MHz	8
inner pipe diameter d		
min. extended	in	0.24
min. recommended	in	0.39
max. recommended	in	2.8
max. extended	in	2.8
pipe wall thickness		
min.	in	0.01
material		
housing		stainless steel 304
contact surface		PEI
degree of protection		NEMA 4
transducer cable		
type		1699
length	ft	6
dimensions		
length l	in	0.98
width b	in	0.51
height h	in	0.67
dimensional drawing		
ambient temperature		
min.	°F	-22
max.	°F	+266
temperature compensation		-
explosion protection		
order code		FSS-NF2TS
explosion protection temperature		
min.	°F	-40
max.	°F	+257
F M	marking	NI/Cl. I,II,III/Div. 2 /  GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860
	type of protection	non incendive

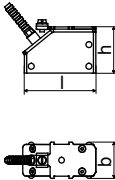
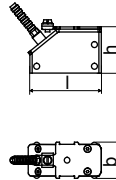
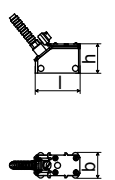



Shear wave transducers (FM Class I Div. 2 or not explosion proof)

technical type		CDM2N52	CDP2N52	CDQ2N52	
order code		FSM-NF2TS FSM-NF2TS/OS FSM-NNNTS FSM-NNNTS/OS	FSP-NF2TS FSP-NF2TS/OS FSP-NNNTS FSP-NNNTS/OS	FSQ-NF2TS FSQ-NF2TS/OS FSQ-NNNTS FSQ-NNNTS/OS	
transducer frequency	MHz	1	2	4	
inner pipe diameter d					
min. extended	in	2	0.98	0.39	
min. recommended	in	3.9	2	0.98	
max. recommended	in	39.4	15.7	5.9	
max. extended	in	47.2	18.9	9.4	
pipe wall thickness					
min.	in	0.08	0.04	0.02	
material					
housing		PEEK with stainless steel cap 304, option OS: 316L	PEEK with stainless steel cap 304, option OS: 316L	PEEK with stainless steel cap 304, option OS: 316L	
contact surface		PEEK	PEEK	PEEK	
degree of protection		NEMA 6	NEMA 6	NEMA 6	
transducer cable					
type		1699	1699	1699	
length	ft	13	13	9	
dimensions					
length l	in	2.52	2.52	1.57	
width b	in	1.26	1.26	0.87	
height h	in	1.59	1.59	1	
dimensional drawing					
ambient temperature					
min.	°F	-40	-40	-40	
max.	°F	+266	+266	+266	
temperature compensation		x	x	x	
explosion protection					
FM	order code		FSM-NF2TS FSM-NF2TS/OS	FSP-NF2TS FSP-NF2TS/OS	FSQ-NF2TS FSQ-NF2TS/OS
	explosion protection temperature				
	min.	°F	-40	-40	-40
	max.	°F	+374	+374	+374
	marking		 NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860	 NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860	 NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860
type of protection		non incandive	non incandive	non incandive	

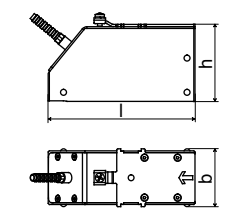
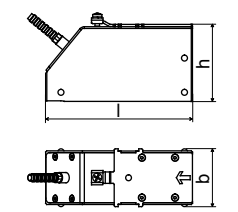
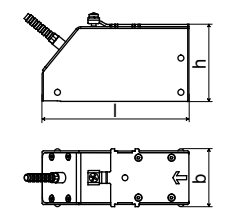



Shear wave transducers (not explosion proof, NEMA 6P)

technical type		CDG1LI8	CDK1LI8	CDM2LI8	CDP2LI8
order code		FSG-NNNTS/IP68	FSK-NNNTS/IP68	FSM-NNNTS/IP68	FSP-NNNTS/IP68
transducer frequency	MHz	0.2	0.5	1	2
inner pipe diameter d					
min. extended	in	15.7	3.9	2	0.98
min. recommended	in	19.7	7.9	3.9	2
max. recommended	in	157.5	78.7	39.4	15.7
max. extended	in	255.9	94.5	47.2	18.9
pipe wall thickness					
min.	in	0.43	0.2	0.08	0.04
material					
housing		PEEK with stainless steel cap 316Ti	PEEK with stainless steel cap 316Ti	PEEK with stainless steel cap 316Ti	PEEK with stainless steel cap 316Ti
contact surface		PEEK	PEEK	PEEK	PEEK
degree of protection		NEMA 6P	NEMA 6P	NEMA 6P	NEMA 6P
transducer cable					
type		2550	2550	2550	2550
length	ft	39	39	39	39
dimensions					
length l	in	5.12	5.12	2.76	2.76
width b	in	2.13	2.13	1.26	1.26
height h	in	3.29	3.29	1.81	1.81
dimensional drawing					
ambient temperature					
min.	°F	-40	-40	-40	-40
max.	°F	+212	+212	+212	+212
temperature compensation		x	x	x	x

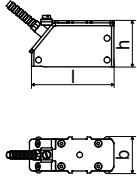
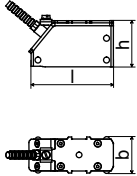
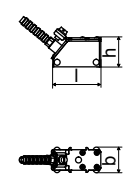


Shear wave transducers (extended temperature range, FM Class I Div. 2 or not explosion proof)

technical type		CDM2E52	CDP2E52	CDQ2E52	
order code		FSM-EF2TS FSM-EF2TS/OS FSM-ENNTS FSM-ENNTS/OS	FSP-EF2TS FSP-EF2TS/OS FSP-ENNTS FSP-ENNTS/OS	FSQ-EF2TS FSQ-EF2TS/OS FSQ-ENNTS FSQ-ENNTS/OS	
transducer frequency	MHz	1	2	4	
inner pipe diameter d					
min. extended	in	2	0.98	0.39	
min. recommended	in	3.9	2	0.98	
max. recommended	in	39.4	15.7	5.9	
max. extended	in	47.2	18.9	9.4	
pipe wall thickness					
min.	in	0.08	0.04	0.02	
material					
housing		PI with stainless steel cap 304, option OS: 316L	PI with stainless steel cap 304, option OS: 316L	PI with stainless steel cap 304, option OS: 316L	
contact surface		PI	PI	PI	
degree of protection		NEMA 4	NEMA 4	NEMA 4	
transducer cable					
type		6111	6111	6111	
length	ft	13	13	9	
dimensions					
length l	in	2.52	2.52	1.57	
width b	in	1.26	1.26	0.87	
height h	in	1.59	1.59	1	
dimensional drawing					
ambient temperature					
min.	°F	-22	-22	-22	
max.	°F	+392	+392	+392	
temperature compensation		x	x	x	
explosion protection					
F M	order code	FSM-EF2TS FSM-EF2TS/OS	FSP-EF2TS FSP-EF2TS/OS	FSQ-EF2TS FSQ-EF2TS/OS	
	explosion protection temperature				
	min.	°F	-40	-40	-40
	max.	°F	+455	+455	+455
	marking		 NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860	 NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860	 NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860
type of protection		non incandive	non incandive	non incandive	

Lamb wave transducers (FM Class I Div. 2 or not explosion proof)

technical type		CRG1N52	CRH1N52	CRK1N52
order code		FLG-NF2TS FLG-NF2TS/OS FLG-NNNTS FLG-NNNTS/OS	FLH-NF2TS FLH-NF2TS/OS FLH-NNNTS FLH-NNNTS/OS	FLK-NF2TS FLK-NF2TS/OS FLK-NNNTS FLK-NNNTS/OS
transducer frequency	MHz	0.2	0.3	0.5
inner pipe diameter d¹				
min. extended	in	15.7	13.8	3.9
min. recommended	in	19.7	17.7	7.9
max. recommended	in	157.5	118.1	78.7
max. extended	in	189	141.7	94.5
pipe wall thickness				
min.	in	0.43	0.31	0.2
max.	in	0.94	0.63	0.39
material				
housing		PPSU with stainless steel cap 304, option OS: 316L	PPSU with stainless steel cap 304, option OS: 316L	PPSU with stainless steel cap 304, option OS: 316L
contact surface		PPSU	PPSU	PPSU
degree of protection		NEMA 6	NEMA 6	NEMA 6
transducer cable				
type		1699	1699	1699
length	ft	16	16	16
dimensions				
length l	in	5.06	5.06	5.06
width b	in	2.01	2.01	2.01
height h	in	2.66	2.66	2.66
dimensional drawing				
ambient temperature				
min.	°F	-40	-40	-40
max.	°F	+338	+338	+338
temperature compensation		X	X	X
explosion protection				
order code		FLG-NF2TS FLG-NF2TS/OS	FLH-NF2TS FLH-NF2TS/OS	FLK-NF2TS FLK-NF2TS/OS
explosion protection temperature				
min.	°F	-40	-40	-40
max.	°F	+329	+329	+329
marking		 NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860	 NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860	 NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860
type of protection		non incandive	non incandive	non incandive

¹ Lamb wave transducer:
 typical values for water, pipe diameters for other fluids on request
 inner pipe diameter max. recommended: in reflect arrangement (diagonal arrangement) and for a flow velocity of 23 ft/s (46 ft/s)
 inner pipe diameter max. extended: in reflect arrangement (diagonal arrangement) and for a flow velocity of 16 ft/s (33 ft/s)

technical type		CRM1N52	CRP1N52	CRQ1N52
order code		FLM-NF2TS FLM-NF2TS/OS FLM-NNNTS FLM-NNNTS/OS	FLP-NF2TS FLP-NF2TS/OS FLP-NNNTS FLP-NNNTS/OS	FLQ-NF2TS FLQ-NF2TS/OS FLQ-NNNTS FLQ-NNNTS/OS
transducer frequency	MHz	1	2	4
inner pipe diameter d¹				
min. extended	in	2	0.98	0.39
min. recommended	in	3.9	2	0.98
max. recommended	in	39.4	15.7	5.9
max. extended	in	47.2	18.9	9.4
pipe wall thickness				
min.	in	0.08	0.04	0.02
max.	in	0.2	0.12	0.04
material				
housing		PPSU with stainless steel cap 304, option OS: 316L	PPSU with stainless steel cap 304, option OS: 316L	PPSU with stainless steel cap 304, option OS: 316L
contact surface		PPSU	PPSU	PPSU
degree of protection		NEMA 4	NEMA 4	NEMA 4
transducer cable				
type		1699	1699	1699
length	ft	13	13	9
dimensions				
length l	in	2.91	2.91	1.65
width b	in	1.26	1.26	0.87
height h	in	1.59	1.59	1
dimensional drawing				
ambient temperature				
min.	°F	-40	-40	-40
max.	°F	+338	+338	+338
temperature compensation		x	x	x
explosion protection				
order code		FLM-NF2TS FLM-NF2TS/OS	FLP-NF2TS FLP-NF2TS/OS	FLQ-NF2TS FLQ-NF2TS/OS
explosion protection temperature				
F M	min.	°F	-40	-40
	max.	°F	+329	+329
	marking		 NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860	 NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860
type of protection		non incandive	non incandive	non incandive

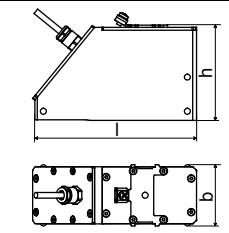
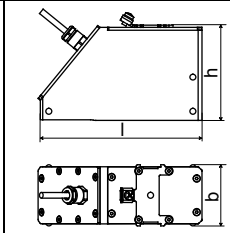
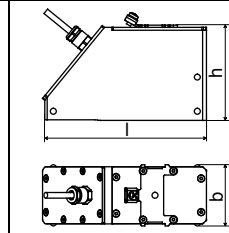
¹ Lamb wave transducer:

typical values for water, pipe diameters for other fluids on request

inner pipe diameter max. recommended: in reflect arrangement (diagonal arrangement) and for a flow velocity of 23 ft/s (46 ft/s)

inner pipe diameter max. extended: in reflect arrangement (diagonal arrangement) and for a flow velocity of 16 ft/s (33 ft/s)

Lamb wave transducers (not explosion proof, NEMA 6P)

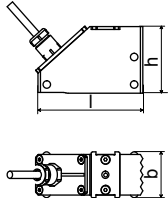
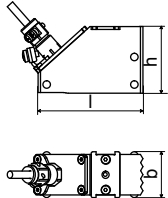
technical type		CRG1LI8	CRH1LI8	CRK1LI8
order code		FLG-NNNTS/IP68	FLH-NNNTS/IP68	FLK-NNNTS/IP68
transducer frequency	MHz	0.2	0.3	0.5
inner pipe diameter d¹				
min. extended	in	19.7	15.7	8.7
min. recommended	in	23.6	17.7	9.8
max. recommended	in	196.9	137.8	82.7
max. extended	in	255.9	196.9	177.2
pipe wall thickness				
min.	in	0.43	0.28	0.16
max.	in	0.91	0.59	0.35
material				
housing		PPSU with stainless steel cap 316Ti	PPSU with stainless steel cap 316Ti	PPSU with stainless steel cap 316Ti
contact surface		PPSU	PPSU	PPSU
degree of protection		NEMA 6P	NEMA 6P	NEMA 6P
transducer cable				
type		2550	2550	2550
length	ft	39	39	39
dimensions				
length l	in	5.65	5.65	5.65
width b	in	2.13	2.13	2.13
height h	in	3.29	3.29	3.29
dimensional drawing				
ambient temperature				
min.	°F	-40	-40	-40
max.	°F	+212	+212	+212
temperature compensation		x	x	x

¹ Lamb wave transducer:

typical values for water, pipe diameters for other fluids on request

inner pipe diameter max. recommended: in reflect arrangement (diagonal arrangement) and for a flow velocity of 23 ft/s (46 ft/s)

inner pipe diameter max. extended: in reflect arrangement (diagonal arrangement) and for a flow velocity of 16 ft/s (33 ft/s)

technical type		CRM1LI8	CRP1LI8
order code		FLM-NNNTS/IP68	FLP-NNNTS/IP68
transducer frequency	MHz	1	2
inner pipe diameter d¹			
min. extended	in	2	0.98
min. recommended	in	3.9	2
max. recommended	in	39.4	15.7
max. extended	in	47.2	18.9
pipe wall thickness			
min.	in	0.08	0.04
max.	in	0.2	0.12
material			
housing		PPSU with stainless steel cap 316Ti	PPSU with stainless steel cap 316Ti
contact surface		PPSU	PPSU
degree of protection		NEMA 6P	NEMA 6P
transducer cable			
type		2550	2550
length	ft	39	39
dimensions			
length l	in	2.87	2.87
width b	in	1.24	1.24
height h	in	1.81	1.81
dimensional drawing			
ambient temperature			
min.	°F	-40	-40
max.	°F	+212	+212
temperature compensation		x	x

¹ Lamb wave transducer:

typical values for water, pipe diameters for other fluids on request

inner pipe diameter max. recommended: in reflect arrangement (diagonal arrangement) and for a flow velocity of 23 ft/s (46 ft/s)

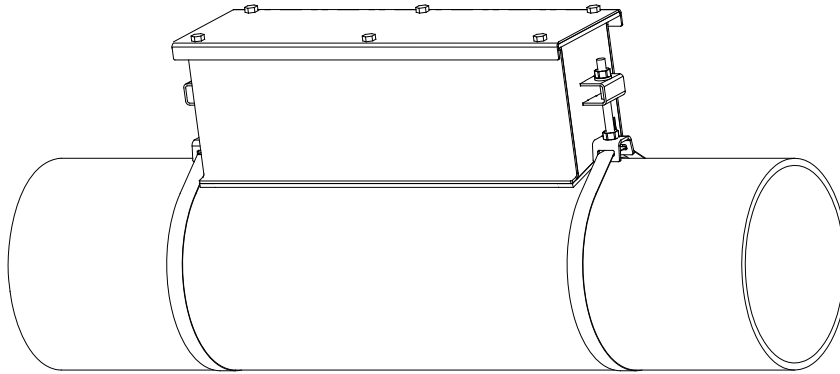
inner pipe diameter max. extended: in reflect arrangement (diagonal arrangement) and for a flow velocity of 16 ft/s (33 ft/s)

Transducer mounting fixture

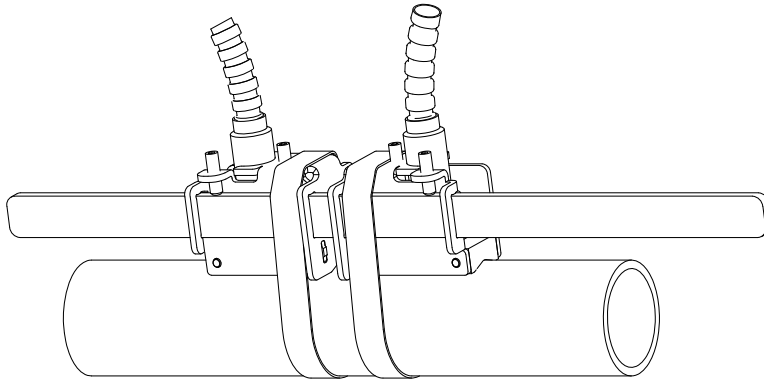
Order code

1, 2	3	4	5	6	7 to 9	10, 11	no. of character			
transducer mounting fixture	transducer	-	measurement arrangement	size	-	fixation	outer pipe diameter	/	option	description
PL										PermaLok
VL										PermaRail
	K									transducers with transducer frequency G, H, K
	M									transducers with transducer frequency M, P
	Q									transducers with transducer frequency Q
	S									transducers with transducer frequency S
			D							reflect arrangement or diagonal arrangement/direct mode
			R							reflect arrangement
				S						small
				M						medium
				L						large
						S				tension straps
						W				welding
						N				without fixation
							SK1			0.5 to 2.5 in
							SK2			3 to 6 in
							SK3			8 to 10 in
							SK4			12 to 18 in
							SK5			20 to 36 in
							SK6			42 to 100 in
							SK7			100 to 170 in
							SK8			170 to 370 in
							NDR			any
								IP68		degree of protection NEMA6P
								OS		housing with stainless steel 316
								Z		special design
example										
VL	M	-	D	S	-	S	200			PermaRail and tension straps for transducers with transducer frequency M, P
		-			-			/		

PermaLok PL

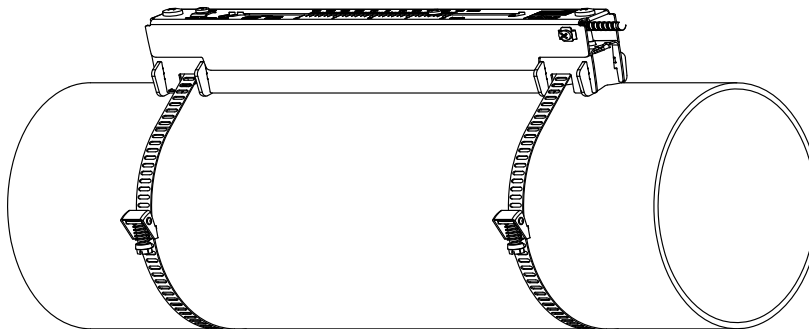


PermaRail (VLS)



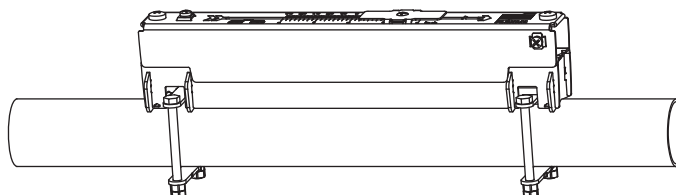
transducers:
CDS1N52
material: stainless steel 304, 303

PermaRail (VLK, VLM, VLQ)



material: stainless steel 304,
301, 410
option OS: 316, 316L, 17-7PH
inner length:
VLK: 13.7 in,
option IP68: 14.5 in
VLM: 9.2 in
VLQ: 6.9 in
dimensions:
VLK: 16.65 x 3.54 x 3.66 in,
option IP68: 17.44 x 3.7 x 4.13 in
VLM: 12.17 x 2.24 x 2.48 in
VLQ: 9.72 x 1.69 x 1.85 in

PermaRail with bolt mounting plates



material: stainless steel 304,
301, 410
option OS: 316, 316L, 17-7PH
inner length:
VLM: 9.2 in
VLQ: 6.9 in
dimensions:
VLM: 12.17 x 2.24 x 2.48 in
VLQ: 9.72 x 1.69 x 1.85 in
outer pipe diameter:
max. 1.9 in

Coupling materials for transducers

	normal temperature range (4th character of transducer order code = N)		extended temperature range (4th character of transducer order code = E)	
	< 212 °F	< 338 °F	< 302 °F	< 392 °F
< 24 h	coupling compound type N or coupling pad type VT	coupling compound type E or coupling pad type VT	coupling compound type E or coupling pad type VT	coupling compound type E or H or coupling pad type VT
long time measurement	coupling pad type VT ¹	coupling pad type VT ²	coupling pad type VT ¹	coupling pad type VT ²

¹ < 5 years

² < 6 months

Technical data

type	ambient temperature °F	material
coupling compound type N	-22 to +266	mineral grease paste
coupling compound type E	-22 to +392	silicone paste
coupling compound type H	-22 to +482	fluoropolymer paste
coupling pad type VT	14 to +392	fluoroelastomer

Connection systems

connection system TS		connection with extension cable	direct connection	transducers technical type
JBP3				****L*
JB03, JB04				*****52

transducer frequency (3d character of transducer order code)		G, H, K		M, P		Q		S		
T	cable length	ft	x 16	l ≤ 984	x 13	l ≤ 984	x 9	l ≤ 295	x 6	l ≤ 131
S	cable length (option LC)	ft	29	≤ 984	-	-	-	-	-	-
	cable length (option IP68)	ft	39	≤ 984	39	≤ 984	-	-	-	-

x = transducer cable length
l = max. length of extension cable


Transducer cable

Technical data

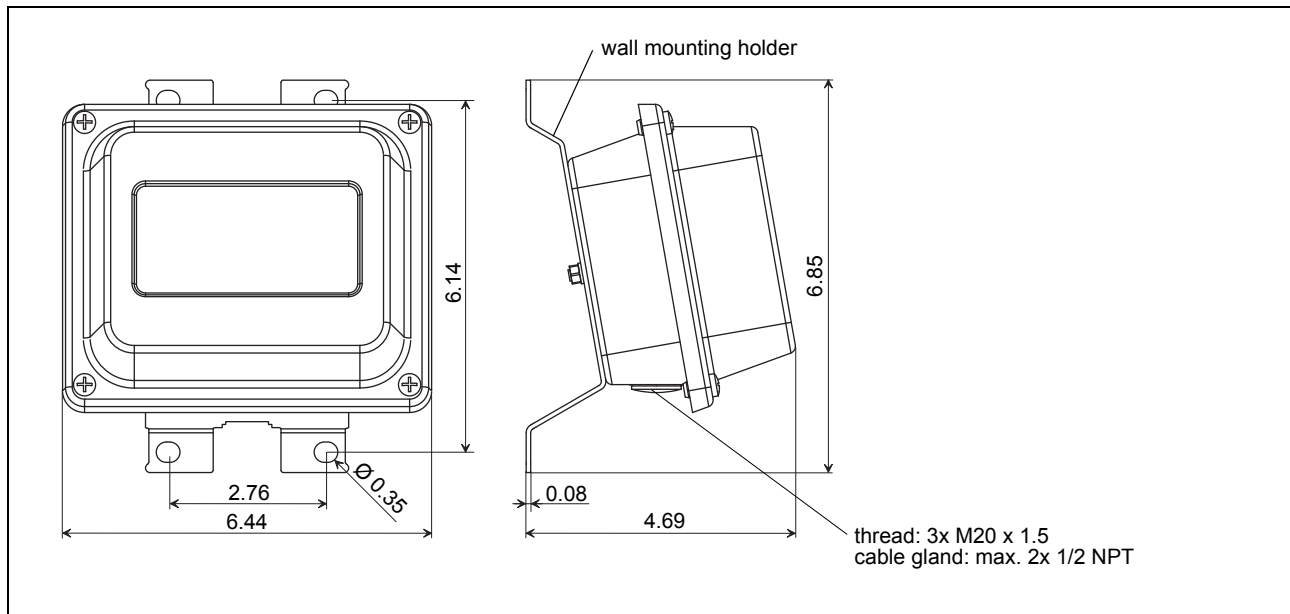
		transducer cable			extension cable	
type		1699	2550 (option IP68)	6111	2615	5245
standard length	ft	see table above			-	
max. length	ft	-			see table above	
ambient temperature	°F	-67 to +392	-40 to +212	-148 to +437	-22 to +158	-22 to +158
properties			longitudinal water tight		halogen free fire propagation 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		PTFE	PUR	PFA	PUR	PUR
outer diameter	in	0.11	0.2 ±0.01	0.11	0.47	0.47
thickness	in	0.01	0.04	0.02	0.08	0.08
color		brown	gray	white	black	black
shield		x	x	x	x	x
sheath						
material		stainless steel 304 option OS: 316Ti	-	stainless steel 304 option OS: 316Ti	-	steel wire braid with copolymer sheath
outer diameter	in	0.31	-	0.31	-	-

Junction box

Technical data

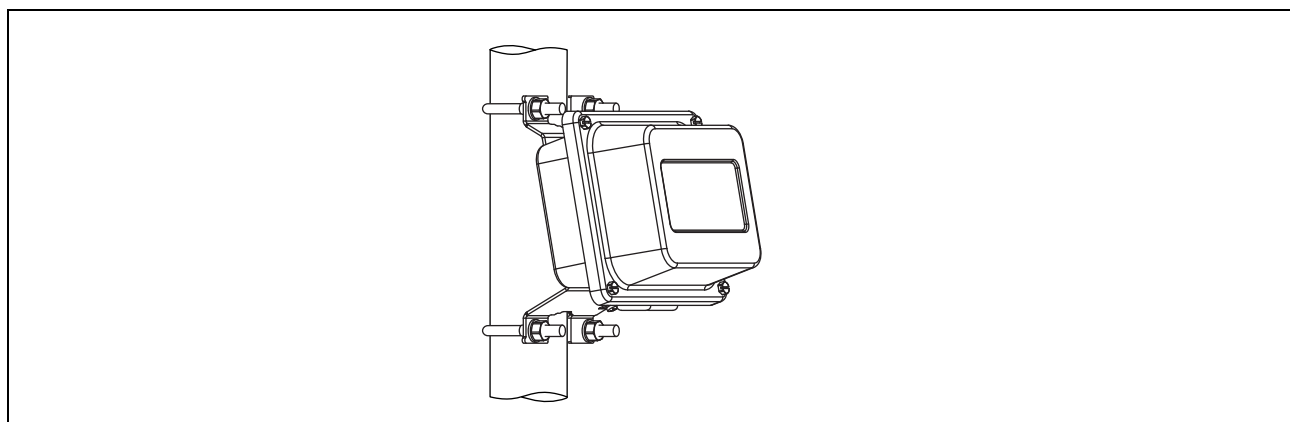
technical type		JB03	JB04	JBP3
dimensions		see dimensional drawing	see dimensional drawing	see dimensional drawing
weight	lb	2.6 lb	2.6 lb	2.6 lb
fixation		wall mounting, optional: 2 " pipe mounting	wall mounting, optional: 2 " pipe mounting	wall mounting, optional: 2 " pipe mounting
material				
housing		stainless steel 316L	stainless steel 316L	stainless steel 316L
gasket		silicone	silicone	silicone
degree of protection		NEMA 6	NEMA 4X	NEMA 6
ambient temperature				
min.	°F	-40	-40	-40
max.	°F	+176	+176	+176
explosion protection				
F	marking	-	 NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ T6 Ta = -40...+60 °C	-
M				

Dimensions



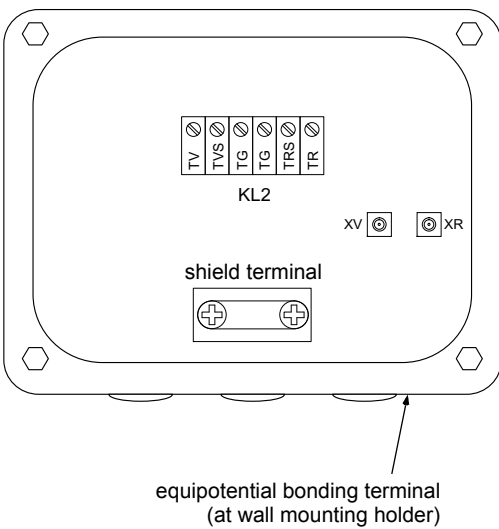
in inch

2 " pipe mounting kit (optional)



Terminal assignment

JB03, JB04



transducers

terminal	connection
XV	transducer ↗, SMB connector
XR	transducer ↘, SMB connector
cable gland	external shield

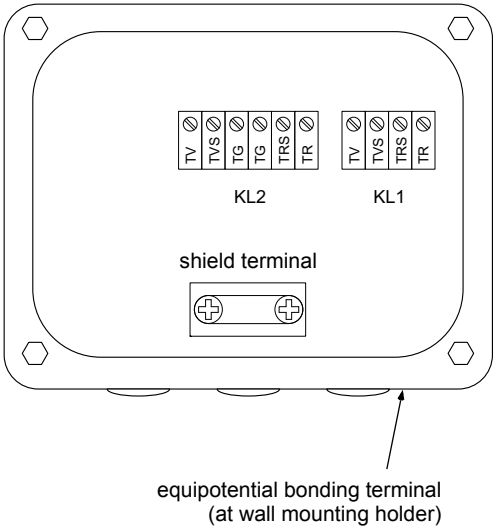
extension cable

terminal strip KL2

terminal	connection
TV	signal
TVS	internal shield
TRS	internal shield
TR	signal
shield terminal	external shield

equipotential bonding terminal
(at wall mounting holder)

JBP3



transducers

terminal strip KL1

terminal	connection
TV	transducer ↗, signal
TVS	transducer ↗, internal shield
TRS	transducer ↘, internal shield
TR	transducer ↘, signal
cable gland	external shield

extension cable

terminal strip KL2

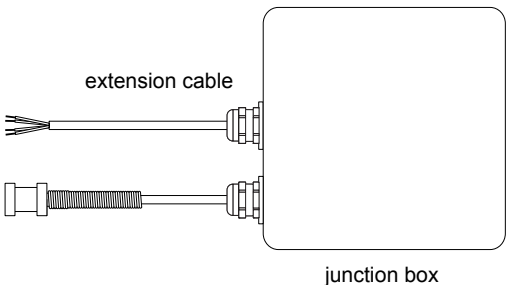
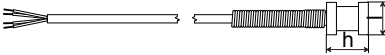
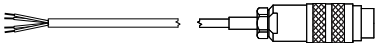
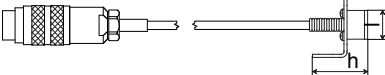
terminal	connection
TV	signal
TVS	internal shield
TRS	internal shield
TR	signal
shield terminal	external shield

equipotential bonding terminal
(at wall mounting holder)

Clamp-on temperature probe (optional)

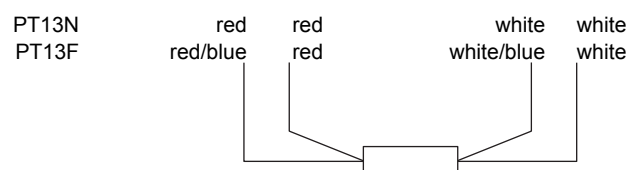
Technical data

technical type		PT13N	PT13F
design			short response time, with connector
type		Pt1000	Pt1000
connection		4-wire	4-wire
measuring range	°F	-40 to +392	-58 to +482
accuracy T		$\pm(0.27 \text{ }^\circ\text{F} + 2 \cdot 10^{-3} \cdot (T \text{ [}^\circ\text{F]} - 32 \text{ }^\circ\text{F}))$ class A	$\pm(0.27 \text{ }^\circ\text{F} + 2 \cdot 10^{-3} \cdot (T \text{ [}^\circ\text{F]} - 32 \text{ }^\circ\text{F}))$ class A
response time	s		8
housing		360 brass alloy	PEEK, stainless steel 304, copper
degree of protection			NEMA 4
weight	lb	0.437	0.7
fixation		clamp-on	clamp-on
accessories			
thermal conductivity paste 392 °F		-	x
thermal conductivity foil 482 °F		x	x
plastic protection plate, insulation foam		-	x
dimensions			
length l	in	0.59	0.55
width b	in	0.49	1.18
height h	in	0.79	1.06

connection with extension cable	direct connection	technical type
		PT13N
		PT13F

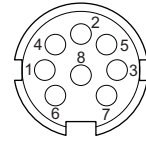
Connection

Temperature probe



Connector

pin	cable of temperature probe PT13F	cable of temperature probe PT13N	extension cable
1	white/blue	white	white
2	red/blue	red	black
3, 4, 5	not connected		
6	red	red	green
7	white	white	red
8	not connected		



Cable

		cable of temperature probe		extension cable
		PT13F	PT13N	
temperature probe				
type		4 x 0.25 mm ² black	4 x 24 AWG	4 x 18 AWG
standard length	ft	9	20	-
max. length	ft	-	-	656
cable jacket		PTFE	PTFE	LS PVC

Junction box

technical type	JBT3	
dimensions	see dimensional drawing	
fixation	wall mounting optional: 2 " pipe mounting	
material		
housing	stainless steel 316L	
gasket	silicone	
degree of protection	NEMA 6	
cable gland	max. 2x 1/2 NPT	
ambient temperature		
min.	°F	-40
max.	°F	+176

Terminal assignment

JBT3

temperature probe (PT13F)
terminal strip KL1

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

temperature probe (PT13N)
terminal strip KL1

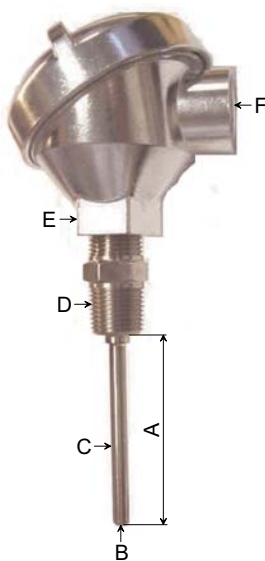
terminal	connection
1	red
2	red
3	white
4	white

extension cable
terminal strip KL2

terminal	connection
1	white
2	black
3	green
4	red

equipotential bonding terminal (at wall mounting holder)

Wetted temperature probe (optional)



	type	Pt1000
A	insertion length	6 " or specified length
B	resistance	1 000 Ω, 00385
C	insertion length sheath material	6 " or specified length stainless steel 316
D	thread	1/2 " NPT HEX CPLG. spring loaded
E	head	aluminum screw cover head 4 terminal block
F	thread	3/4 " NPT



FLEXIM AMERICAS Corporation
Edgewood, NY 11717
USA
Tel.: (631) 492-2300
Fax: (631) 492-2117

internet: www.flexim.com
e-mail: usinfo@flexim.com
1-888-852-7473

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