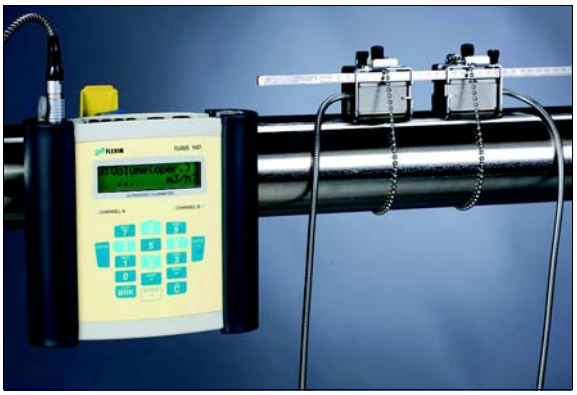
Portable ultrasonic flow measurement of liquids

Portable instrument for non-invasive, quick ultrasonic flow measurement with clamp-on technology for all types of piping

Features

- Precise bi-directional and highly dynamic flow measurement with the non-invasive clamp-on technology
- High precision at fast and slow flow rates, high temperature and zero point stability
- Portable, easy-to-use flow transmitter with 2 flow channels, multiple inputs/outputs, an integrated data logger with a serial interface
- Water and dust-tight (IP65); resistant against oil, many liquids and dirt
- Li-Ion battery provides up to 25 hours of measurement operation
- Automatic loading of calibration data and transducer detection for a fast and easy set-up (less than 5 min), providing precise and long-term stable results
- User-friendly design
- Transducers available for a wide range of inner pipe diameters and fluid temperatures (-170...+600 °C)
- Probe for wall thickness measurement available
- Robust, water-tight (IP67) transport case with comprehensive accessories
- HybridTrek automatically switches between transit time and NoiseTrek mode of measurement when high particulate flows are encountered
- QuickFix for fast mounting of the flow transmitter in difficult conditions
- Measurement is unaffected by fluid density, viscosity and solid content (max. 10 % of volume)

FLUXUS F601 supported by handle



Measurement with transducers mounted with fastening shoes, and flow transmitter fixed to the pipe with the QuickFix pipe mounting fixture

Measurement equipment in transport case

Applications

Designed for the following industries:

- Chemical industry
- Water and wastewater industry
- Oil and gas industry
- Cooling systems and air conditioners
- Facility management
- Aviation industry

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Function

Measurement principle

Transit time difference 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.

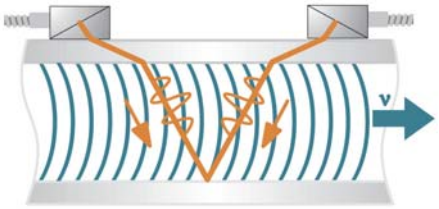
The transit time difference, Δt, is measured and allows the flowmeter to determine the average flow velocity along the propagation path of the ultrasonic signals. A flow profile correction is then performed in order to obtain the area averaged flow velocity, which is proportional to the volumetric flow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

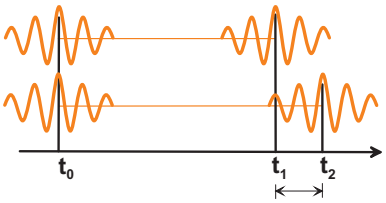
HybridTrek

If the gaseous or solid content in the fluid increases occasionally during measurement, a measurement with the transit time difference principle is no longer possible. NoiseTrek mode will then be selected by the flowmeter. This measurement method allows the flowmeter to achieve a stable measurement even with high gaseous or solid content.

The transmitter can switch automatically between transit time and NoiseTrek mode without any changes to the measurement setup.



Path of the ultrasonic signal



Transit time difference Δt

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

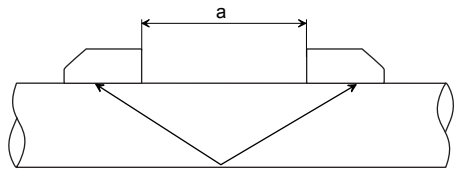
Number of sound paths

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.

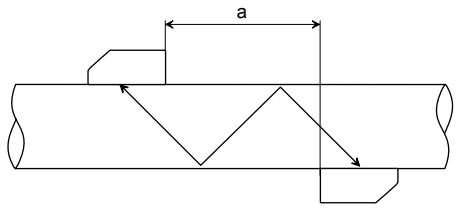
The preferred method of installation depends on the application. While increasing the number of sound paths increases the accuracy of the measurement, signal attenuation increases as well. The optimum number of sound paths for the parameters of the application will be determined automatically by the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

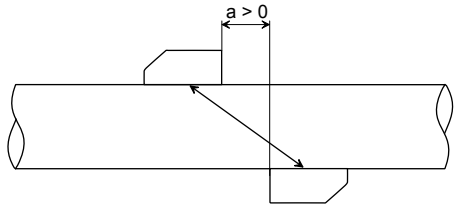


Reflection arrangement, number of sound paths: 2

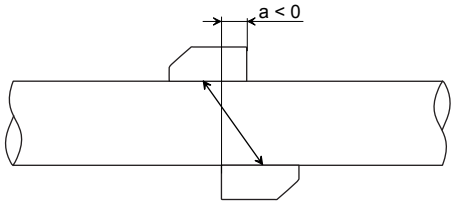
a - transducer distance



Diagonal arrangement, number of sound paths: 3

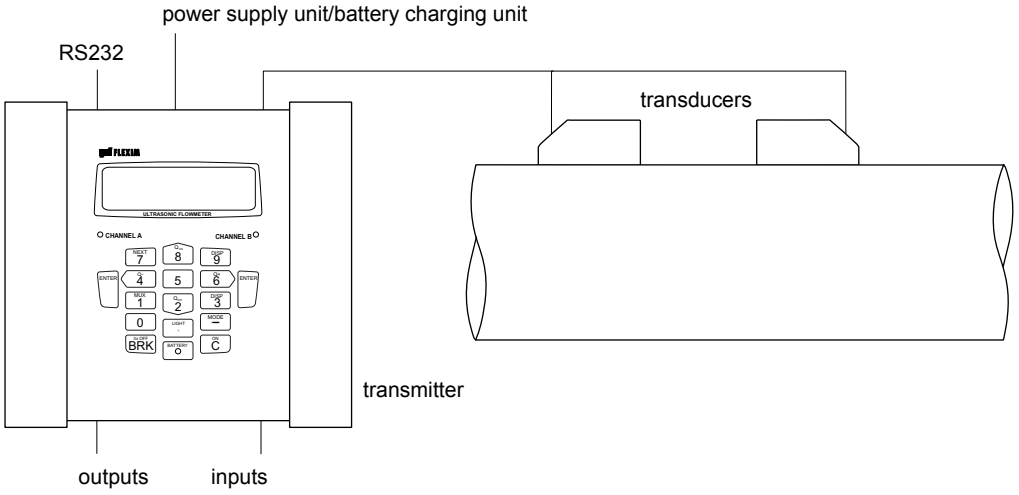


Diagonal arrangement, number of sound paths: 1

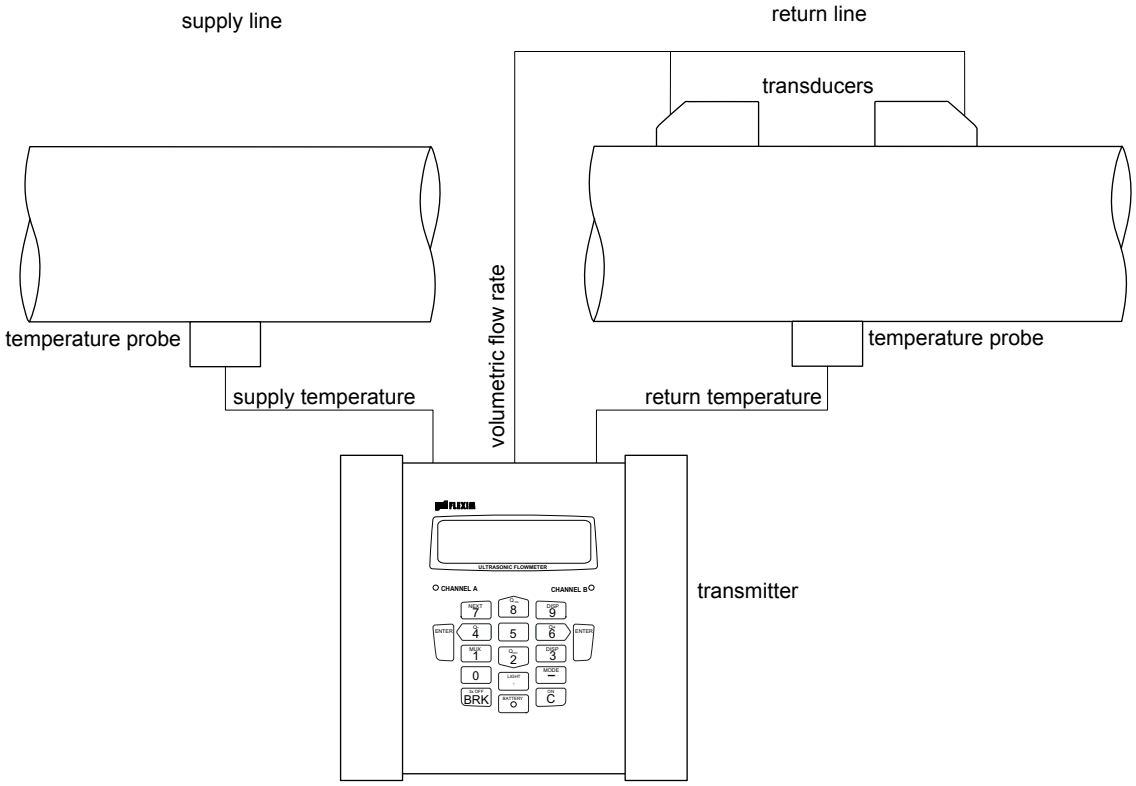


Diagonal arrangement, number of sound paths: 1, negative transducer distance

Typical measurement setup



Example of a reflection arrangement



Example of a heat flow measurement

Flow transmitter

Technical data

FLUXUS	**F601**
design	portable
	
measurement	
measurement principle	transit time difference correlation principle, automatic NoiseTrek selection for measurements with high gaseous or solid content
flow velocity	0.01...25 m/s
repeatability	0.15 % of reading ±0.01 m/s
fluid	all acoustically conductive liquids with < 10 % gaseous or solid content in volume (transit time difference principle)
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
flow transmitter	
power supply	100...230 V/50...60 Hz (power supply unit) 10.5...15 V DC (socket at transmitter) integrated battery
integrated battery - operating time	Li-Ion, 7.2 V/6.2 Ah > 14 h (without outputs, inputs and backlight) > 25 h (1 measuring channel, ambient temperature > 10 °C, without outputs, inputs and backlight)
power consumption	< 6 W (with outputs, inputs and backlight)
number of flow measuring channels	2
damping	0...100 s, adjustable
measuring cycle (1 channel)	100...1000 Hz
response time	1 s (1 channel), option: 70 ms
housing material	PA, TPE, AutoTex, stainless steel
degree of protection according to IEC/EN 60529	IP65
dimensions	see dimensional drawing
weight	2.1 kg
fixation	QuickFix pipe mounting fixture
ambient temperature	-10...+60 °C
display	2 x 16 characters, dot matrix, backlight
menu language	English, German, French, Dutch, Spanish
measuring functions	
physical quantities	volumetric flow rate, mass flow rate, flow velocity, heat flow (if temperature inputs are installed)
totalizer	volume, mass, optional: heat quantity
calculation functions	average, difference, sum
diagnostic functions	sound speed, signal amplitude, SNR, SCNR, standard deviation of amplitudes and transit times

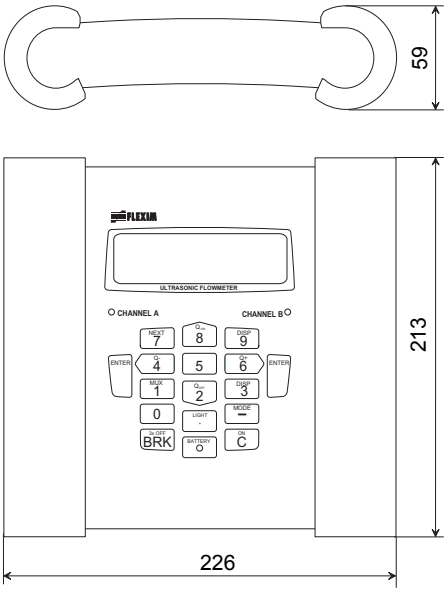
[1] for transit time difference principle, reference conditions and v > 0.15 m/s

[2] reference uncertainty < 0.2 %

FLUXUS	**F601**
communication interfaces	
diagnostic interfaces	- RS232 - USB (with adapter)
process interfaces (optional)	- Modbus RTU
serial data kit	
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
data logger	
loggable values	all physical quantities, totalized values and diagnostic values
capacity	> 100 000 measured values
transport case	
dimensions	500 x 400 x 190 mm
outputs	
	The outputs are galvanically isolated from the transmitter.
number	see standard scope of supply on page 9, max. on request
accessories	output adapter (if number of outputs > 4)
	current output
range	0/4...20 mA
accuracy	0.1 % of reading ±15 µA
active output	R_{ext} < 750 Ω (U_{int} = 24 V DC)
passive output	U_{ext} = 4...16 V, depending on R_{ext} R_{ext} < 500 Ω
	frequency output
range	0...5 kHz
open collector	24 V/4 mA
	binary output
optorelay	26 V/100 mA
binary output as alarm output - functions	 limit, change of flow direction or error
binary output as pulse output - pulse value - pulse width	mainly for totalizing 0.01...1000 units 1...1000 ms
inputs	
	The inputs are galvanically isolated from the transmitter.
number	see standard scope of supply on page 9, max. 4
accessories	input adapter (if number of inputs > 2)
	temperature input
type	Pt100/Pt1000
connection	4-wire
range	-150...+560 °C
resolution	0.01 K
accuracy	±0.01 % of reading ±0.03 K
	current input
accuracy	0.1 % of reading ±10 µA
passive input	R_{int} = 50 Ω, P_{int} < 0.3 W
- range	-20...+20 mA
	voltage input
range	0...1 V
accuracy	0.1 % of reading ±1 mV
internal resistance	R_{int} = 1 MΩ

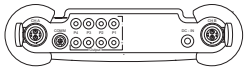
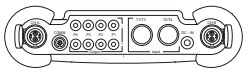
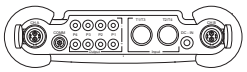
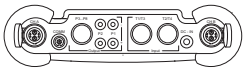
Dimensions

FLUXUS F601

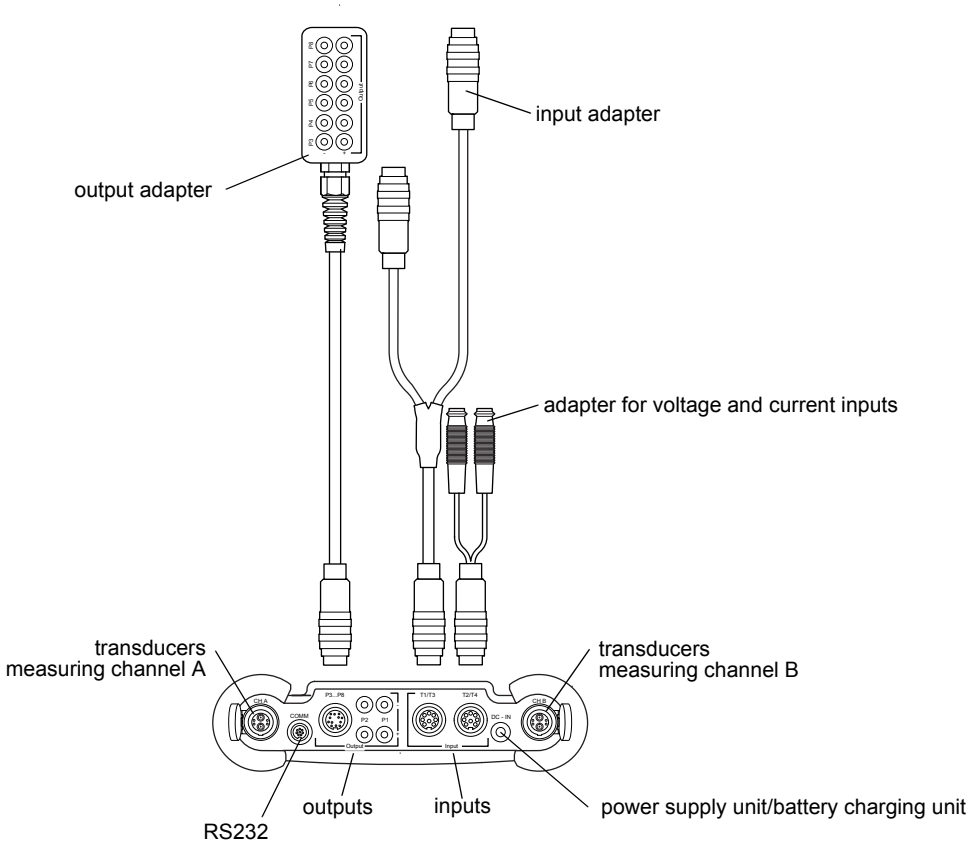


in mm

Standard scope of supply

	F601 Standard		**F601 Energy**		**F601Double Energy**		**F601Multi-functional**	
application	flow measurement of liquids							
	2 independent measuring channels							
			temperature-compensated calculation of mass flow rate					
			integrated heat flow computer for monitoring of energy flows					
			simultaneous monitoring of flow and energy flow, e.g. heating systems		simultaneous monitoring of 2 energy flows, e.g. heating systems, heat exchangers)		flow measurement taking into account other process quantities, e.g. density, viscosity	
outputs								
passive current output	2	2	2	2	2	2	4	2
binary output	2	1	2	1	2	1	2	2
Modbus	-	x	-	x	-	x	-	x
inputs								
temperature input	-	-	2	2	4	4	2	2
passive current input	-	-	-	-	-	-	2	2
accessories								
transport case	x	x	x	x	x	x	x	x
power supply unit, mains cable	x	x	x	x	x	x	x	x
battery	x	x	x	x	x	x	x	x
output adapter	-	-	-	-	-	-	x	x
input adapter	-	-	-	-	2	2	2	2
adapter for voltage and current inputs	-	-	-	-	-	-	2	2
QuickFix pipe mounting fixture for transmitter	x	x	x	x	x	x	x	x
serial data kit	x	x	x	x	x	x	x	x
measuring tape	x	x	x	x	x	x	x	x
user manual, Quick start guide	x	x	x	x	x	x	x	x
connector board at the upper side of the transmitter								

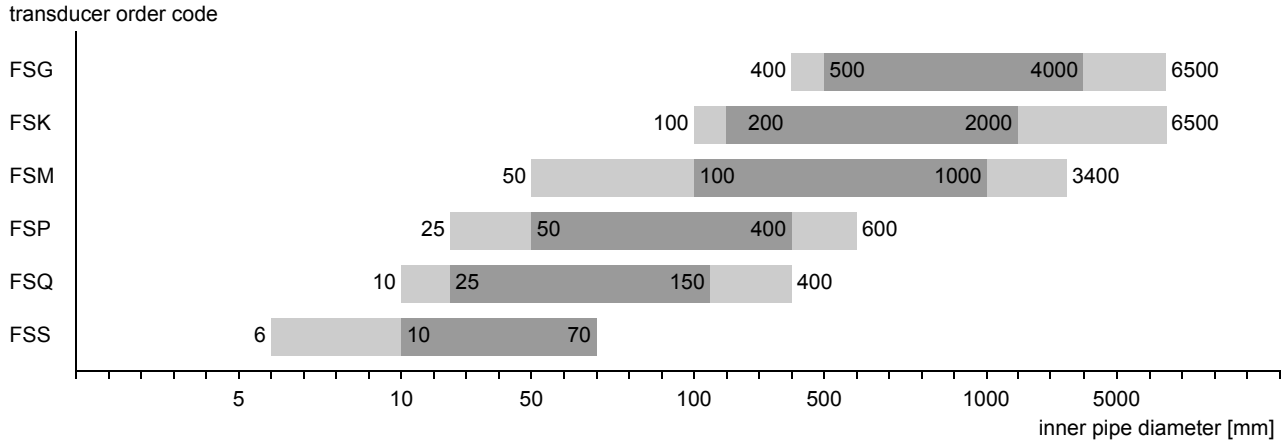
Connection of adapters

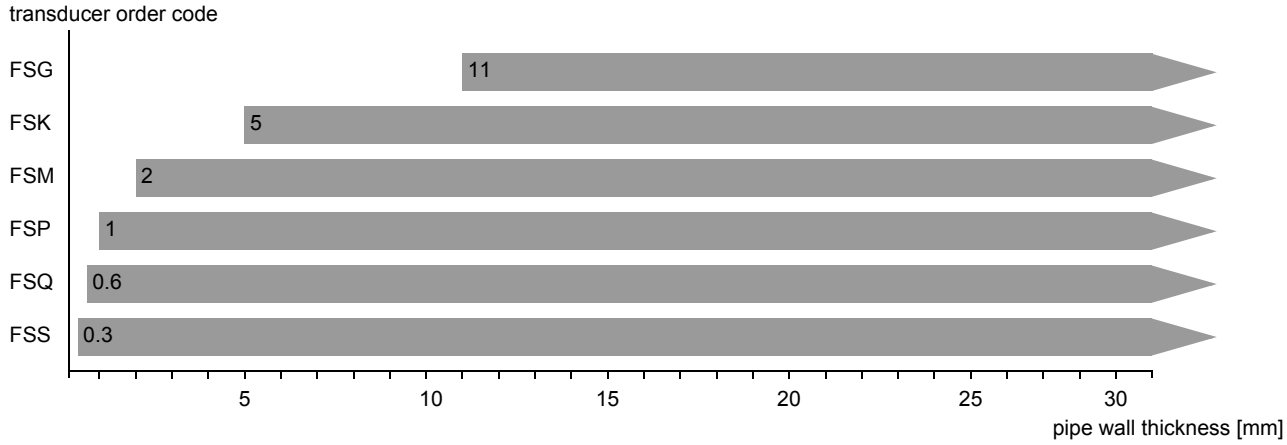


Example for the equipment of a transport case

Transducers

Transducer selection





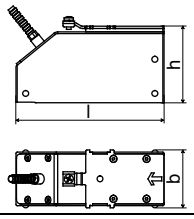
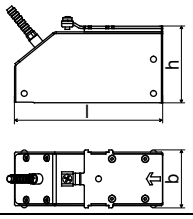
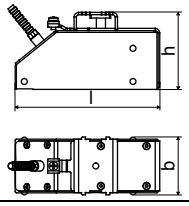
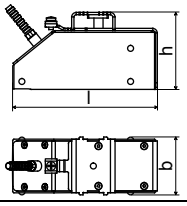
recommended possible

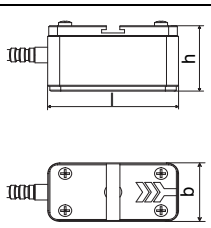
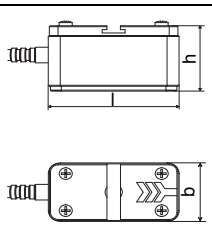
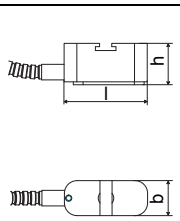
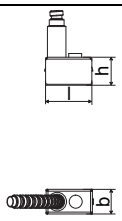
Transducer order code

1, 2	3		4	5, 6	7, 8		9...11		12, 13	no. of character
transducer	transducer frequency	-	ambient temperature	explosion protection	connection system	-	extension cable	/	option	description
FS										set of ultrasonic flow transducers for liquids measurement, shear wave
	G									0.2 MHz
	K									0.5 MHz
	M									1 MHz
	P									2 MHz
	Q									4 MHz
	S									8 MHz
			N							normal temperature range
			E							extended temperature range (FSM, FSP, FSQ)
				NN						not explosion proof
					NL					with Lemo connector
							XXX			cable length in m, for max. length of extension cable see page 22
									LC	long transducer cable
example										
FS	M	-	N	NN	NL	-	000			shear wave transducer 1 MHz, normal temperature range, connection system NL with Lemo connector
		-				-		/		

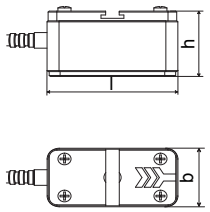
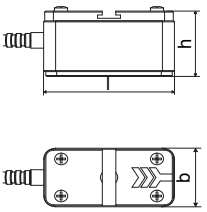
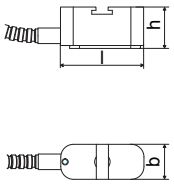
Technical data

Shear wave transducers

technical type		CDG1NZ7	CLG1NZ7	CDK1NZ7	CLK1NZ7
order code		**FSG-NNNNL**	**FSG-NNNNL/LC**	**FSK-NNNNL**	**FSK-NNNNL/LC**
transducer frequency	MHz	0.2	0.2	0.5	0.5
inner pipe diameter d					
min. extended	mm	400	400	100	100
min. recommended	mm	500	500	200	200
max. recommended	mm	4000	4000	2000	2000
max. extended	mm	6500	6500	6500	6500
pipe wall thickness					
min.	mm	11	11	5	5
material					
housing contact surface		PEEK with stainless steel cap 304 (1.4301) PEEK	PEEK with stainless steel cap 304 (1.4301) PEEK	PEEK with stainless steel cap 304 (1.4301) PEEK	PEEK with stainless steel cap 304 (1.4301) PEEK
degree of protection according to IEC/ EN 60529		IP67	IP67	IP67	IP67
transducer cable					
type length	 m	1699 5	1699 9	1699 5	1699 9
dimensions					
length l width b height h	mm mm mm	129.5 51 67	129.5 51 67	126.5 51 67.5	126.5 51 67.5
dimensional drawing					
ambient temperature					
min. max.	°C °C	-40 +130	-40 +130	-40 +130	-40 +130
temperature compen-sation		x	x	x	x

technical type		CDM1NZ7	CDP1NZ7	CDQ1NZ7	CDS1NZ7
order code		**FSM-NNNNL**	**FSP-NNNNL**	**FSQ-NNNNL**	**FSS-NNNNL**
transducer frequency	MHz	1	2	4	8
inner pipe diameter d					
min. extended	mm	50	25	10	6
min. recommended	mm	100	50	25	10
max. recommended	mm	1000	400	150	70
max. extended	mm	3400	600	400	70
pipe wall thickness					
min.	mm	2	1	0.6	0.3
material					
housing contact surface		stainless steel 304 (1.4301) PEEK	stainless steel 304 (1.4301) PEEK	stainless steel 304 (1.4301) PEEK	stainless steel 304 (1.4301) PEI
degree of protection according to IEC/ EN 60529		IP67	IP67	IP67	IP65
transducer cable					
type		1699	1699	1699	1699
length	m	4	4	3	2
dimensions					
length l	mm	60	60	42.5	25
width b	mm	30	30	18	13
height h	mm	33.5	33.5	21.5	17
dimensional drawing					
ambient temperature					
min.	°C	-40	-40	-40	-30
max.	°C	+130	+130	+130	+130
temperature compen-sation		x	x	x	-

Shear wave transducers (extended temperature range)

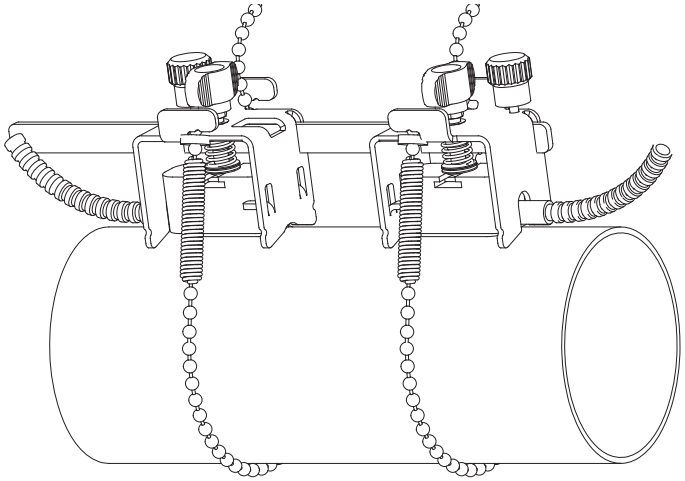
technical type		CDM1EZ7	CDP1EZ7	CDQ1EZ7
order code		**FSM-ENNNL**	**FSP-ENNNL**	**FSQ-ENNNL**
transducer frequency	MHz	1	2	4
inner pipe diameter d				
min. extended	mm	50	25	10
min. recommended	mm	100	50	25
max. recommended	mm	1000	400	150
max. extended	mm	3400	600	400
pipe wall thickness				
min.	mm	2	1	0.6
material				
housing contact surface		stainless steel 304 (1.4301) Sintimid	stainless steel 304 (1.4301) Sintimid	stainless steel 304 (1.4301) Sintimid
degree of protection according to IEC/ EN 60529		IP65	IP65	IP65
transducer cable				
type		1699	1699	1699
length	m	4	4	3
dimensions				
length l	mm	60	60	42.5
width b	mm	30	30	18
height h	mm	33.5	33.5	21.5
dimensional drawing				
ambient temperature				
min.	°C	-30	-30	-30
max.	°C	+200	+200	+200
temperature compen-sation		x	x	x

Transducer mounting fixture

Order code

1, 2	3		4	5		6	7...9	no. of character
transducer mounting fixture	transducer	-	measurement arrangement	size	-	fixation	outer pipe diameter	description
FS								fastening shoes
VP								portable Variofix
TB								tension belts
WL								transducer box for WaveInjector
	A							all transducers
	K							transducers with transducer frequency G, K
	M							transducers with transducer frequency M, P
	Q							transducers with transducer frequency Q
	S							transducers with transducer frequency S
			D					reflection arrangement or diagonal arrangement
			R					reflection arrangement
				S				small
				M				medium
						C		chains
						N		without fixation
							010	10...100 mm
							025	10...250 mm
							055	10...550 mm
							150	50...1500 mm
							210	50...2100 mm
example								
VP	A	-	D	M	-	C	055	portable Variofix and chains
		-			-			

fastening shoes FS and chains



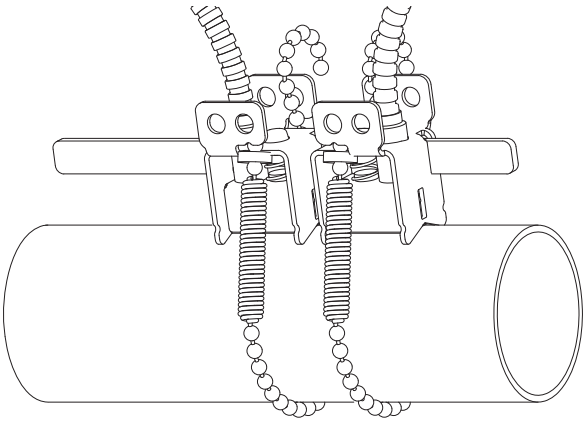
transducer frequency: M, P, Q

material: stainless steel 304 (1.4301), 301 (1.4310), 303 (1.4305)

dimensions:
M, P: 420 x 48 x 68 mm
Q: 420 x 43 x 58 mm

chain length: 0.5/1/2 m

outer pipe diameter:
max. 150/310/600 mm



transducer frequency: S

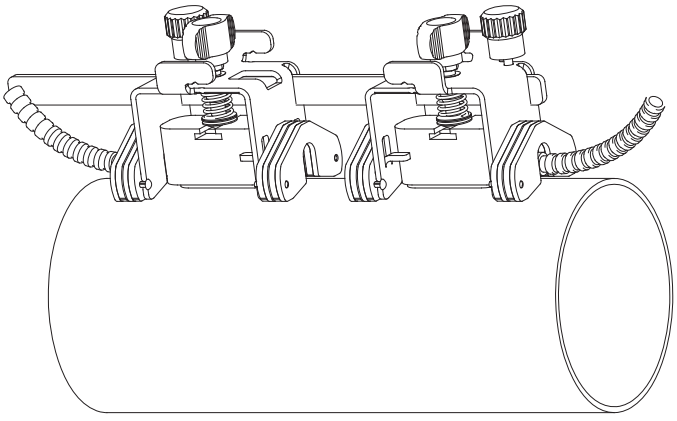
material: stainless steel 304 (1.4301), 301 (1.4310), 303 (1.4305)

dimensions:
210 x 32 x 44 mm

chain length: 0.5 m

outer pipe diameter:
max. 150 mm

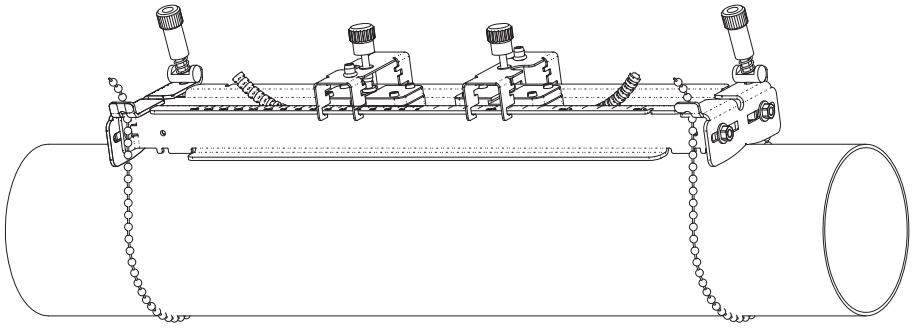
fastening shoes FS and magnet (optional)



material: stainless steel 304 (1.4301), 301 (1.4310), 303 (1.4305)

dimensions:
M, P: 420 x 48 x 68 mm
Q: 420 x 43 x 58 mm

portable Variofix VP and chains

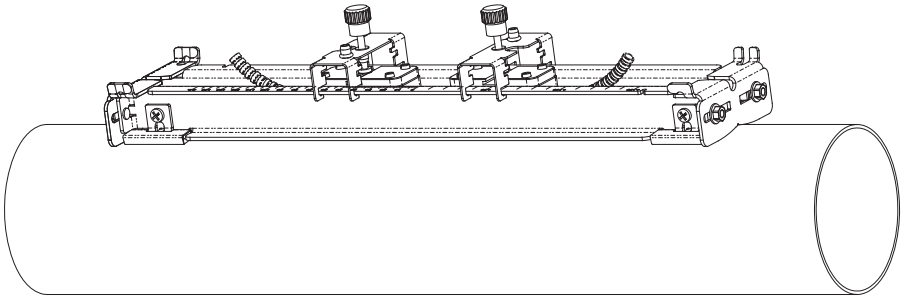


material: stainless steel 304 (1.4301), 301 (1.4310), 303 (1.4305)

dimensions:
414 x 94 x 76 mm

chain length: 2 m

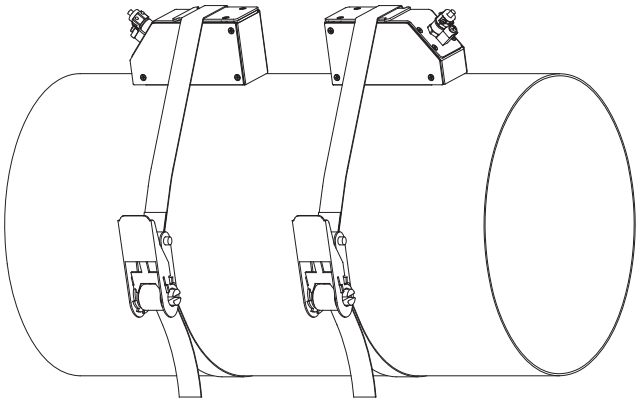
portable Variofix VP and magnet (optional)



material: stainless steel 304 (1.4301), 301 (1.4310), 303 (1.4305)

dimensions:
414 x 94 x 40 mm

tension belts TB



transducer frequency: G, K

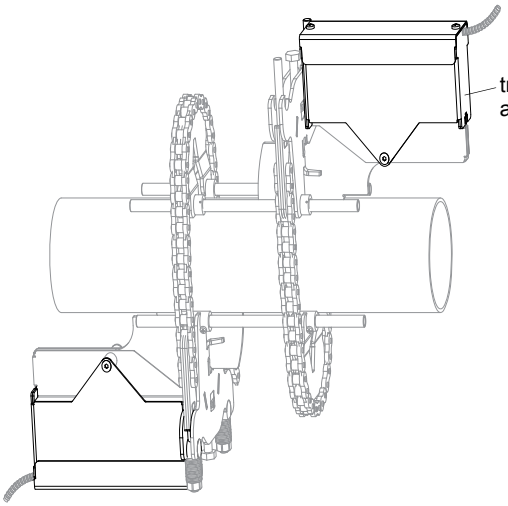
material: steel, powder coated and textile tension belt

length: 5/7 m

ambient temperature:
max. 60 °C

outer pipe diameter:
max. 1500/2100 mm

transducer box WL for WaveInjector



see Technical specification
TSWaveInjectorVx-x

Coupling materials for transducers

normal temperature range (4th character of transducer order code = N)		**extended temperature range (4th character of transducer order code = E)**		**WaveInjector WI-400**	
< 100 °C	< 170 °C	< 150 °C	< 200 °C	< 280 °C	280...400 °C
coupling compound type N	coupling compound type E	coupling compound type E	coupling compound type E or H	coupling foil type A and coupling foil type VT	coupling foil type B and coupling foil type VT

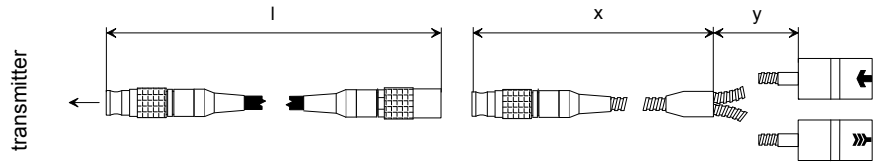
Technical data

type	**ambient temperature** °C	**material**
coupling compound type N	-30...+130	mineral grease paste
coupling compound type E	-30...+200	silicone paste
coupling compound type H	-30...+250	fluoropolymer paste
coupling foil type A	max. 280	lead
coupling foil type B	> 280...400	silver
coupling foil type VT	-10...+200	fluoroelastomer

coupling foil not to be used for transducer mounting fixture with magnets

Connection systems

connection system NL



	transducer frequency (3d character of transducer order code)		F, G, H, K			M, P			Q			S		
			x	**y**	**l**[1]	**x**	**y**	**l**[1]	**x**	**y**	**l**[1]	**x**	**y**	**l**
N	cable length	m	2	3	≤ 25	2	2	≤ 25	2	1	≤ 25	1	1	≤ 20
L	cable length (option LC)	m	2	7	≤ 25	-	-	-	-	-	-	-	-	-

[1] > 25...100 m on request

x, y - transducer cable length
l - max. length of extension cable

Transducer cable

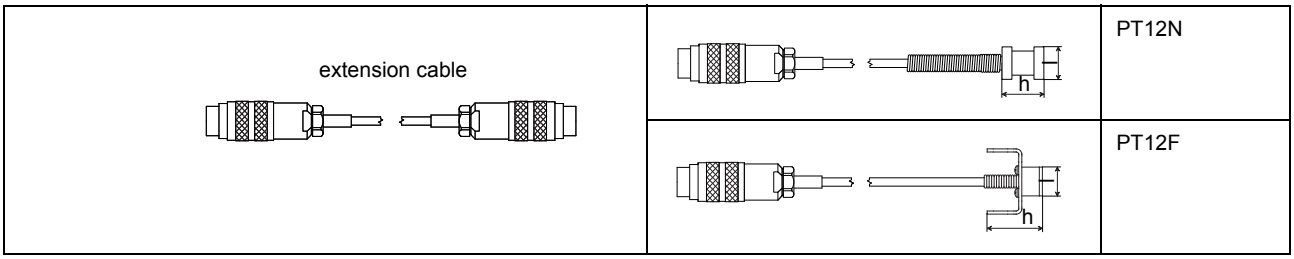
Technical data

		transducer cable	extension cable	
type		1699	2551	1750
standard length	m	see table above	-	5 10
max. length	m	-	see table above	10
ambient temperature	°C	-55...+200	-25...+80	< 80
cable jacket				
material		PTFE	TPE-O	PE
outer diameter	mm	2.9	8	6
thickness	mm	0.3		0.5
colour		brown	black	black
shield		x	x	x
sheath				
material		stainless steel 304 (1.4301)	-	stainless steel 304 (1.4301)
outer diameter	mm	8	-	9
remark				optional

Clamp-on temperature probe (optional)

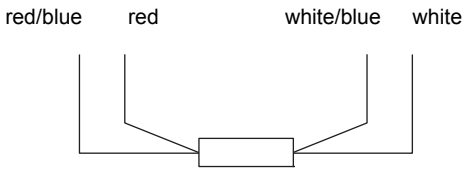
Technical data

technical type		**PT12N**	**PT12F**
design			short response time
type		Pt100	Pt100
connection		4-wire	4-wire
measuring range	°C	-30...+250	-50...+250
accuracy T		±(0.15 °C + 2 · 10^{-3} · |T [°C]|) class A	±(0.15 °C + 2 · 10^{-3} · |T [°C]|) class A
accuracy ΔT (2x Pt matched according to EN 1434-1)		≤ 0.1 K (3 K < ΔT < 6 K), more corresponding to EN 1434-1	≤ 0.1 K (3 K < ΔT < 6 K), more corresponding to EN 1434-1
response time	s	50	8
housing		aluminum	PEEK, stainless steel 304 (1.4301), copper
degree of protection according to IEC/ EN 60529		IP66	IP66
weight (without connector)	kg	0.25	0.32
fixation		clamp-on	clamp-on
accessories			
thermal conductivity paste 200 °C		x	x
thermal conductivity foil 250 °C		x	x
plastic protection plate, insulation foam		-	x
dimensions			
length l	mm	15	14
width b	mm	15	30
height h	mm	20	27



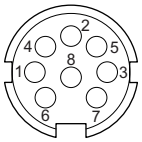
Connection

Temperature probe



Connector

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



Cable

		cable of 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

Wall thickness measurement (optional)

The pipe wall thickness is an important pipe parameter which has to be determined exactly for a good measurement. However, the pipe wall thickness often is unknown.

The wall thickness probe can be connected to the transmitter instead of the flow transducers and the wall thickness measurement mode is activated automatically.

Acoustic coupling compound is applied to the wall thickness probe which then is placed firmly on the pipe. The wall thickness is displayed and can be stored directly in the transmitter.

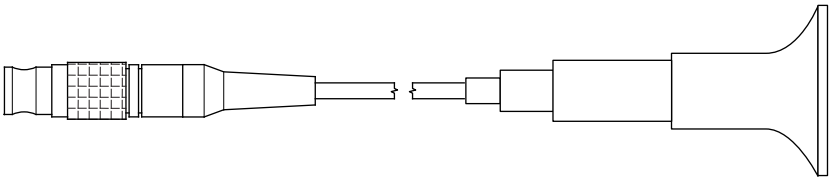
Technical data

technical type		DWR1NZ7
measuring range[1]	mm	1...250
resolution	mm	0.01
accuracy		1 % ± 0.1 mm
fluid temperature	°C	-20...+200, short-time peak max. 500
cable		
type		2616
length	m	1.5

[1] The measuring range depends on the attenuation of the ultrasonic signal in the pipe. For strongly attenuating plastics (e.g. PFA, PTFE, PP) the measuring range is smaller.

Cable

type		2616
ambient temperature	°C	<200
cable jacket		
material		FEP
outer diameter	mm	5.1
colour		black
shield		x



DWR1NZ7

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