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-intrusive 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 14 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 (6...6500 mm) and fluid temperatures (-40...+400 °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

FLUXUS F601 supported by handle

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

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

Measurement equipment in transport case

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Function

Measurement Principle

Transit Time Difference Principle

In order to measure the flow of a medium 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 medium 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.

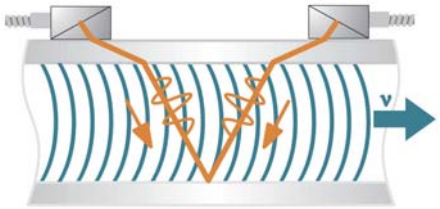
The transit time difference, Δt, is measured and allows the flowmeter to determine the average flow velocity along the propagation path of the ultrasonic signals. A flow profile correction is then performed in order to obtain the area averaged flow velocity, which is proportional to the volumetric flow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

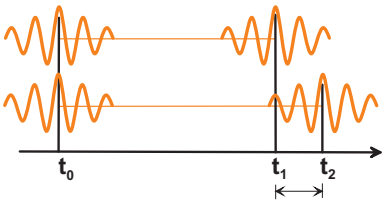
HybridTrek

If the gaseous or solid content in the medium 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 medium

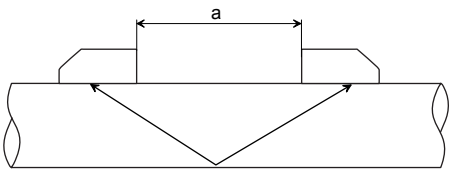
Number of Sound Paths

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

- **reflection mode**
  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 mode**
  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 medium, pipe and coatings, diagonal mode with 1 sound path will be used.

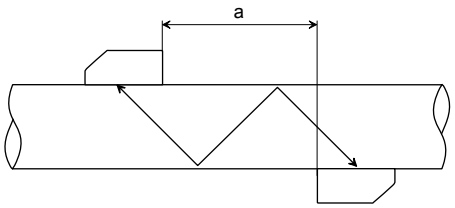
The preferred method of installation depends on the application. While increasing the number of sound paths increases the accuracy of the measurement, signal attenuation increases as well. The optimum number of sound paths for the parameters of the application will be determined automatically by the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

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

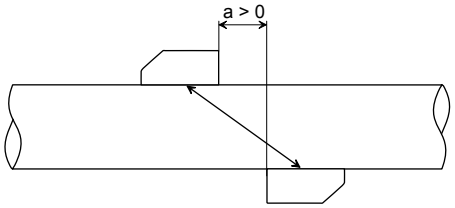


Reflection mode, number of sound paths: 2

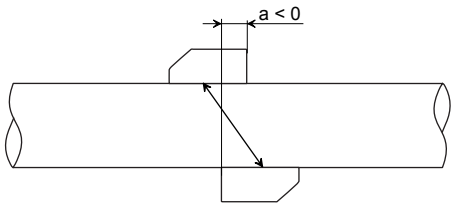
a - transducer distance



Diagonal mode, number of sound paths: 3

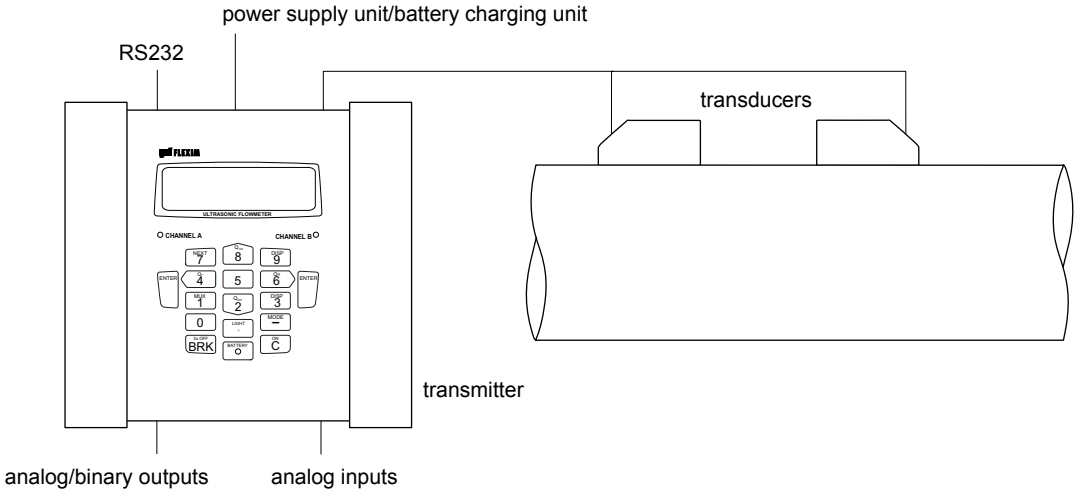


Diagonal mode, number of sound paths: 1

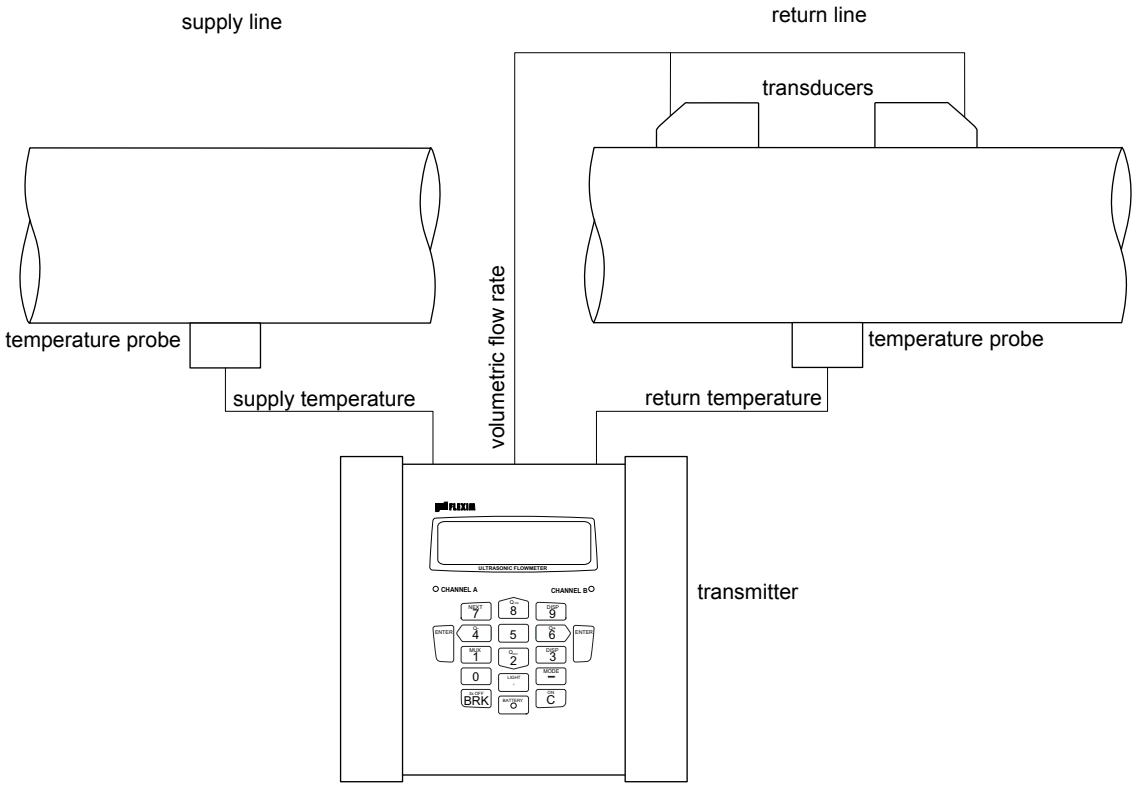


Diagonal mode, number of sound paths: 1,
negative transducer distance

Typical Measurement Setup



Example of a measurement setup in reflection mode



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
medium	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-5M-1985
accuracy[1]	
with standard calibration	±1.6 % of reading ±0.01 m/s
with extended calibration (optional)	±1.2 % of reading ±0.01 m/s
with field calibration[2]	±0.5 % of reading ±0.01 m/s
flow transmitter	
power supply	100...240 V/50...60 Hz (power supply unit), 10.5...15 V DC (socket at transmitter), integrated battery
battery	Li-Ion, 7.2 V/4.5 Ah operating time (without outputs, inputs and backlight): > 14 h
power consumption	< 6 W
number of flow measuring channels	2
signal attenuation	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	1.9 kg
fixation	QuickFix pipe mounting fixture
operating 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
data logger	
loggable values	all physical quantities, totalized values and diagnostic values
capacity	> 100 000 measured values

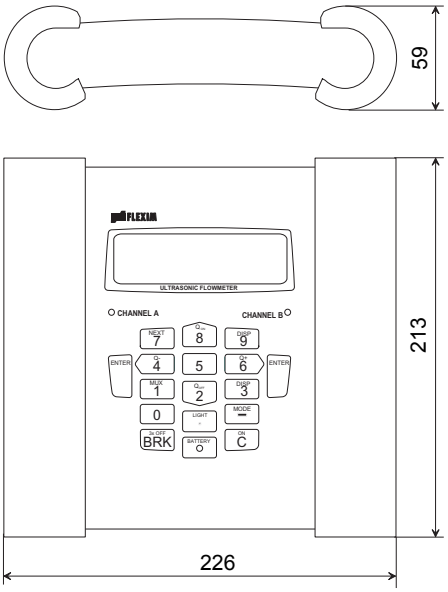
[1] for transit time difference principle, reference conditions and v > 0.15 m/s

[2] reference uncertainty < 0.2 %

FLUXUS	F601
communication	
interface	RS232/USB
serial data kit	
software (all Windows™ versions)	- FluxData: download of measurement data, graphical presentation, conversion to other formats (e.g. for Excel™) - FluxKoef: creating medium data sets
cable	RS232
adapter	RS232 - USB
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 accuracy active output passive output	0/4...20 mA 0.1 % of reading ±15 µA R_{ext} < 200 Ω U_{ext} = 4...16 V, depending on R_{ext} R_{ext} < 500 Ω
	frequency output
range open collector	0...5 kHz 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	 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 connection range resolution accuracy	Pt100/Pt1000 4-wire -150...+560 °C 0.01 K ±0.01 % of reading ±0.03 K
	current input
accuracy passive input - range	0.1 % of reading ±10 µA R_i = 50 Ω, P_i < 0.3 W -20...+20 mA
	voltage input
range accuracy internal resistance	0...1 V 0.1 % of reading ±1 mV R_i = 1 MΩ

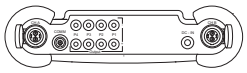
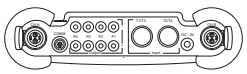
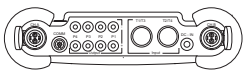
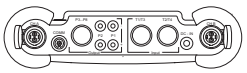
Dimensions

FLUXUS F601

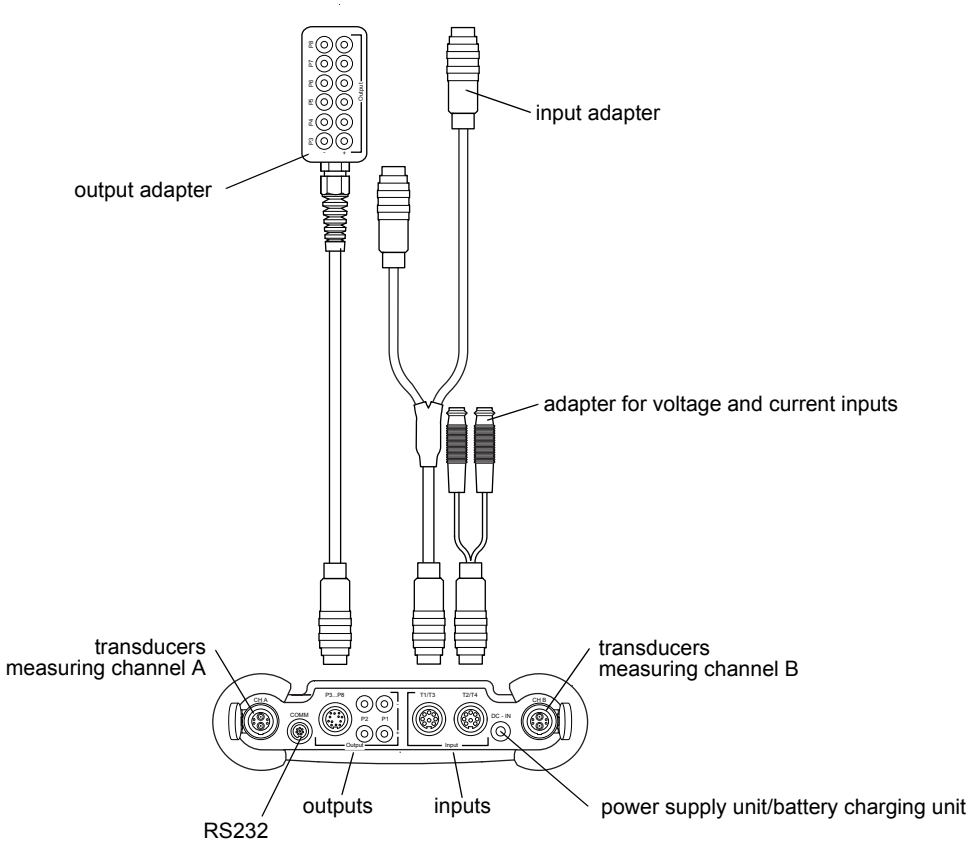


in mm

Standard Scope of Supply

	F601 Standard	F601 Energy	F601 Double Energy	F601 Multifunctional
application	flow measurement on liquids			
	2 independent measuring channels			
		temperature-compensated calculation of mass flow rate		
		integrated heat flow computer for monitoring of energy flows		
		simultaneous monitoring of energy flow and 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	4
binary output	2	2	2	2
inputs				
temperature input	-	2	4	2
passive current input	-	-	-	2
accessories				
transport case	x	x	x	x
power supply unit, mains cable	x	x	x	x
battery	x	x	x	x
output adapter	-	-	-	x
input adapter	-	-	2	2
adapter for voltage and current inputs	-	-	-	2
QuickFix pipe mounting fixture for transmitter	x	x	x	x
serial data kit	x	x	x	x
measuring tape	x	x	x	x
user manual, Quick Start Guide	x	x	x	x
connector board at the upper side of the transmitter				

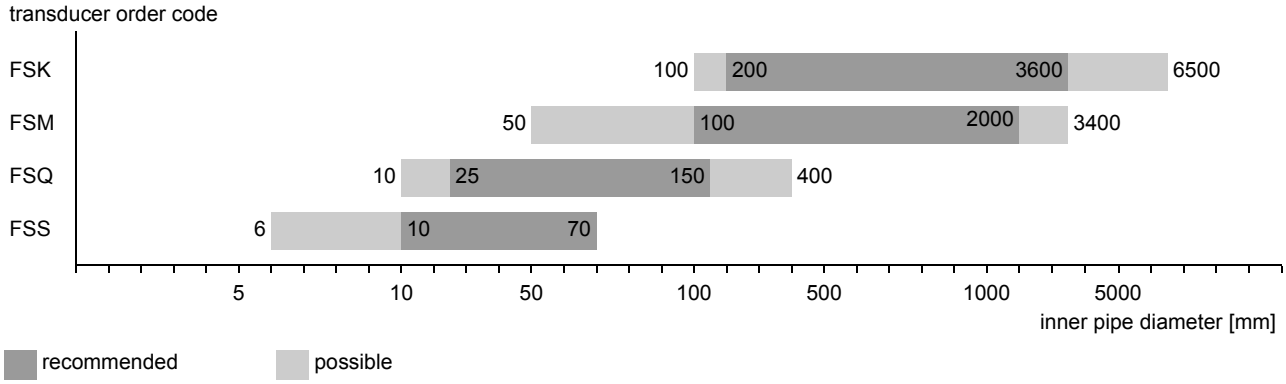
Connection of Adapters



Example for the Equipment of a Transport Case

Transducers

Transducer Selection

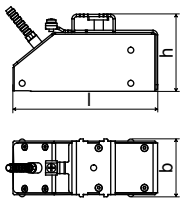
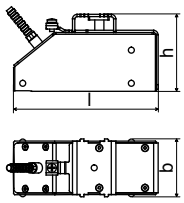
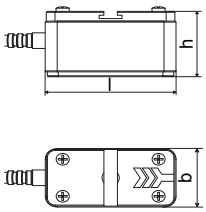


Transducer Order Code

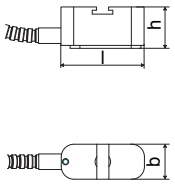
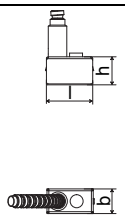
1, 2	3		4	5, 6	7, 8		9...11		12, 13	no. of character
transducer	transducer frequency	-	operating temperature	explosion protection	connection system	-	extension cable	/	option	description
FS										set of ultrasonic flow transducers for liquids measurement, shear wave
	K									0.5 MHz
	M									1 MHz
	Q									4 MHz
	S									8 MHz
			N							normal temperature range
			E							extended temperature range (shear wave transducers with transducer frequency M, Q)
				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 (only FSK)
example										
FS	M	-	N	NN	NL	-	000			shear wave transducer 1 MHz, normal temperature range, connection system NL with Lemo connector
		-				-		/		

Technical Data

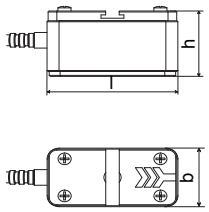
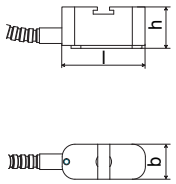
Shear Wave Transducers

technical type		CDK1NZ7	CLK1NZ7	CDM1NZ7
order code		**FSK-NNNNL**	**FSK-NNNNL/LC**	**FSM-NNNNL**
transducer frequency	MHz	0.5	0.5	1
inner pipe diameter d				
min. extended	mm	100	100	50
min. recommended	mm	200	200	100
max. recommended	mm	3600	3600	2000
max. extended	mm	6500	6500	3400
pipe wall thickness				
min.	mm	-	-	-
max.	mm	-	-	-
material				
housing contact surface		PEEK with stainless steel cap 304 (1.4301) PEEK	PEEK with stainless steel cap 304 (1.4301) PEEK	stainless steel 304 (1.4301) PEEK
degree of protection according to IEC/EN 60529		IP67	IP67	IP67
transducer cable				
type		1699	1699	1699
length	m	5	9	4
dimensions				
length l	mm	126.5	126.5	60
width b	mm	51	51	30
height h	mm	67.5	67.5	33.5
dimensional drawing				
operating temperature				
min.	°C	-40	-40	-40
max.	°C	+130	+130	+130
temperature compensation		x	x	x

Shear Wave Transducers

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

Shear Wave Transducers (extended temperature range)

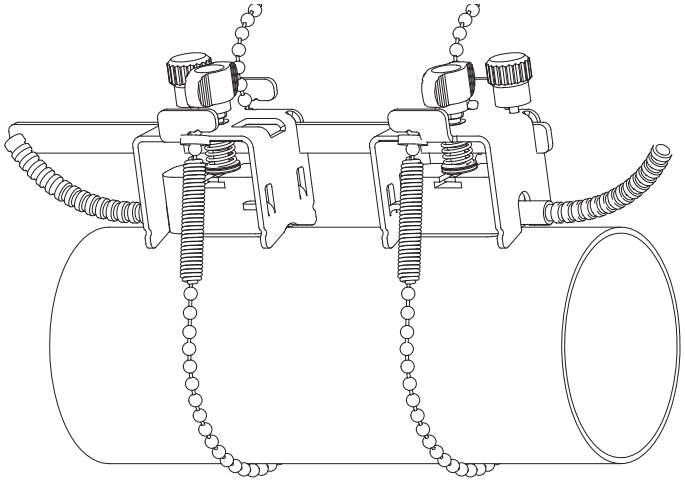
technical type		CDM1EZ7	CDQ1EZ7
order code		**FSM-ENNNL**	**FSQ-ENNNL**
transducer frequency	MHz	1	4
inner pipe diameter d			
min. extended	mm	50	10
min. recommended	mm	100	25
max. recommended	mm	2000	150
max. extended	mm	3400	400
pipe wall thickness			
min.	mm	-	-
max.	mm	-	-
material			
housing contact surface		stainless steel 304 (1.4301) Sintimid	stainless steel 304 (1.4301) Sintimid
degree of protection according to IEC/EN 60529		IP65	IP65
transducer cable			
type		1699	1699
length	m	4	3
dimensions			
length l	mm	60	42.5
width b	mm	30	18
height h	mm	33.5	21.5
dimensional drawing			
operating temperature			
min.	°C	-30	-30
max.	°C	+200	+200
temperature compensation		x	x

Transducer Mounting Fixture

Order Code

1, 2	3		4	5		6	7...9	no. of character
transducer mounting fixture	transducer	-	measuring mode	size	-	fixation	outer pipe diameter	description
FS								fastening shoes
VP								portable Variofix
TB								tension belts
WL								transducer clamping fixture for WaveInjector
	A							all transducers
	K							transducers with transducer frequency K
	M							transducers with transducer frequency M
	Q							transducers with transducer frequency Q
	S							transducers with transducer frequency S
			D					reflection mode or diagonal mode
			R					reflection mode
				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	M	-	D	M	-	C	055	portable Variofix and chains for transducers with transducer frequency M
		-			-			

fastening shoes FS and chains



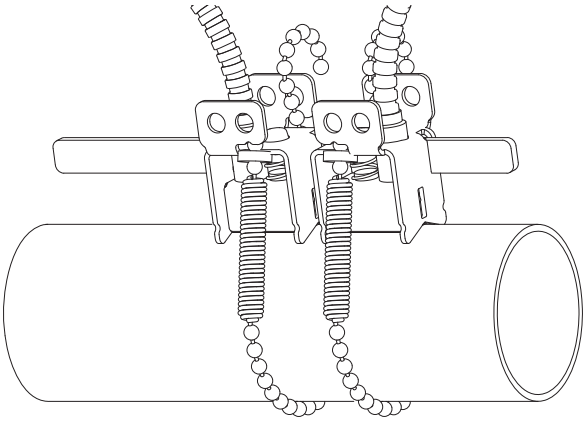
transducer frequency: M, Q

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

dimensions:
420 x 48 x 68 mm

chain length: 0.5/1/2 m

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



transducer frequency: S

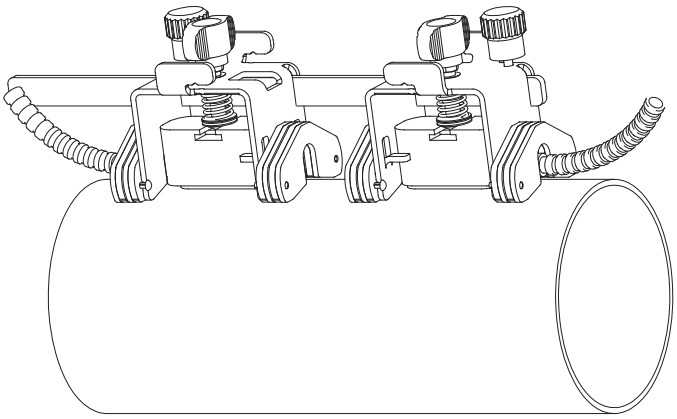
material: stainless steel 304 (1.4301), 301 (1.4310), 303 (1.4305)

dimensions:
210 x 32 x 44 mm

chain length: 0.5 m

outer pipe diameter:
max. 150 mm

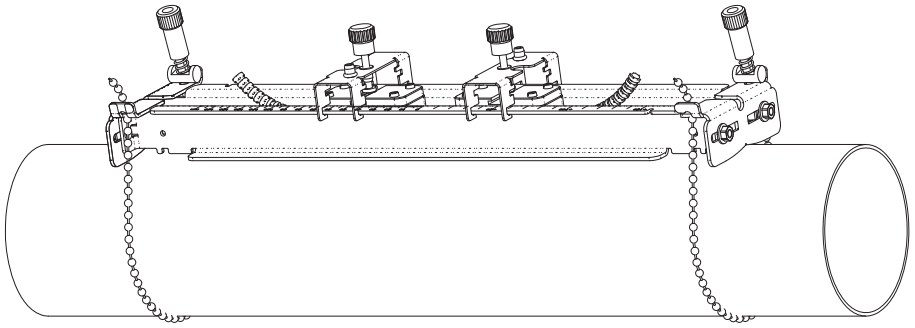
fastening shoes FS and magnet (optional)



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

dimensions:
420 x 55 x 68 mm

portable Variofix VP and chains

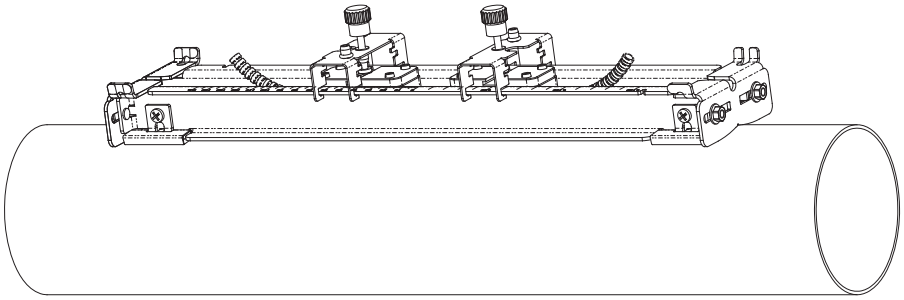


material: stainless steel 304 (1.4301), 301 (1.4310), 303 (1.4305)

dimensions:
414 x 94 x 76 mm

chain length: 2 m

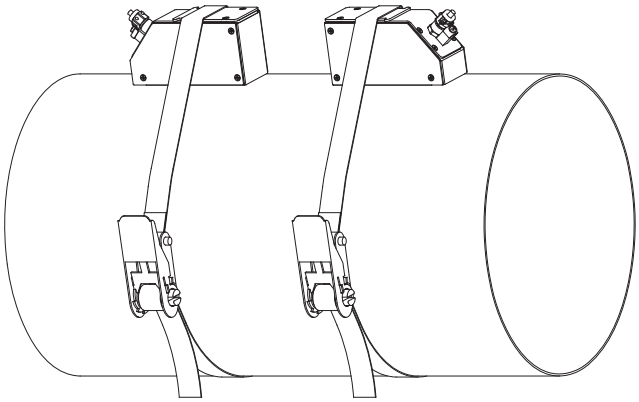
portable Variofix VP and magnet (optional)



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

dimensions:
414 x 94 x 40 mm

tension belts TB



transducer frequency: K

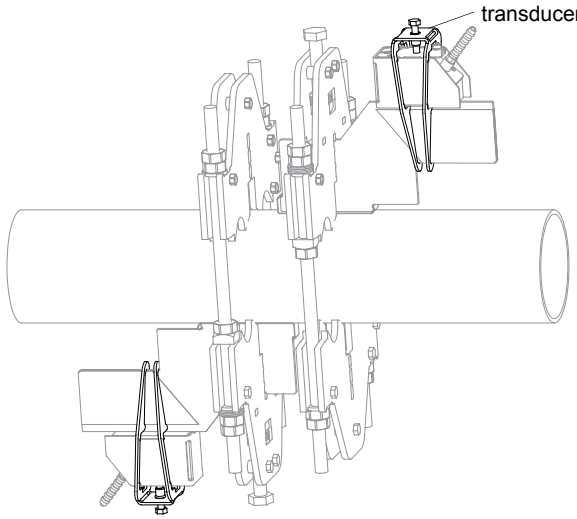
material: steel, powder coated and textile tension belt

length: 5/7 m

operating temperature:
max. 60 °C

outer pipe diameter:
max. 1500/2100 mm

transducer clamping fixture for WaveInjector WL



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	100...170 °C	< 150 °C	150...200 °C	< 280 °C	280...400 °C
< 2 h	coupling compound type N	coupling compound type E	coupling compound type E	coupling compound type E or H	coupling foil type A	coupling foil type B
< 24 h	coupling compound type N	coupling compound type E	coupling compound type E	coupling foil type VT	coupling foil type A	coupling foil type B
< 3 months	coupling compound type N	coupling compound type E	coupling foil type VT	coupling foil type VT	coupling foil type A	coupling foil type B

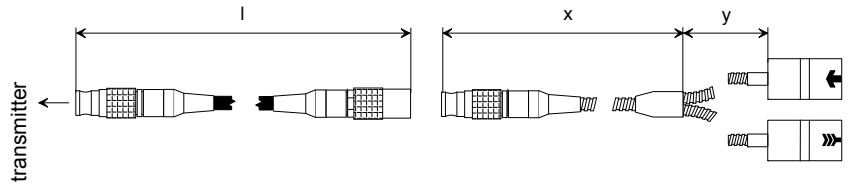
Technical Data

type	**order code**	**operating temperature** °C	**material**	**remark**
coupling compound type N	990739-1	-30...+130	mineral grease paste	
coupling compound type E	990739-2	-30...+200	silicone paste	
coupling compound type H	990739-3	-30...+250	fluoropolymer paste	
coupling foil type A	990739-7	max. 280	plomb	
coupling foil type B	990739-8	> 280...400	silver	
coupling foil type VT	990739-0	-10...+150, short-time peak max. 200	fluoroelastomer	for transducers with transducer frequency G, H, K
	990739-6			for shear wave transducers with transducer frequency M, P
	990739-14			for shear wave transducers IP68 and Lambwave transducers with transducer frequency M, P
	990739-15			for shear wave transducers with transducer frequency Q
	990739-5			for Lambwave transducers with transducer frequency Q

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)		G, H, K			M, P			Q			S		
			x	**y**	**l**[1]	**x**	**y**	**l**[1]	**x**	**y**	**l**[1]	**x**	**y**	**l**
N L	cable length	m	2	3	≤ 25	2	2	≤ 25	2	1	≤ 25	1	1	≤ 20
	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

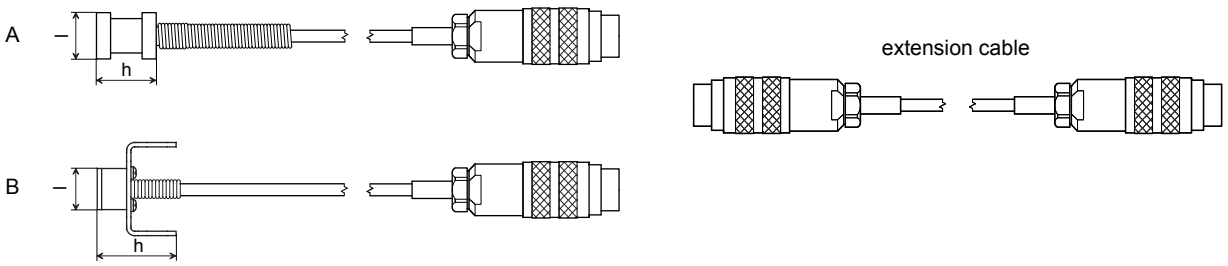
Technical Data

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

Clamp-on Temperature Probe (optional)

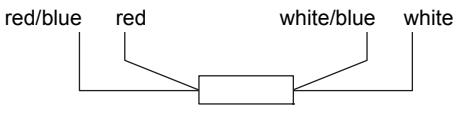
Technical Data

technical type		**PT12N**	**PT12N**	**PT12F**	**PT12F**
order code		**670415-1**	**670414-1**	**670415-2**	**670414-2**
design		short response time			
type		Pt100	Pt100 matched according to EN 1434-1	Pt100	Pt100 matched according to EN 1434-1
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		-	≤ 0.1 K, (3K < ΔT < 6 K), more corresponding to EN 1434-1	-	≤ 0.1 K, (3K < 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	0.5	0.32	0.64
fixation		clamp-on		clamp-on	
accessories		-		plastic protection plate, insulation foam	
dimensions					
length l	mm	15		14	
width b	mm	15		30	
height h	mm	20		27	
dimensional drawing		A	A	B	



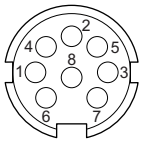
Connection

Temperature Probe



Connector

pin	cable of temperature probe	extension cable
1	white/blue	blue
2	red/blue	gray
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 mm^2 black or white	LIYCY 8 x 0.14 mm^2 gray
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.

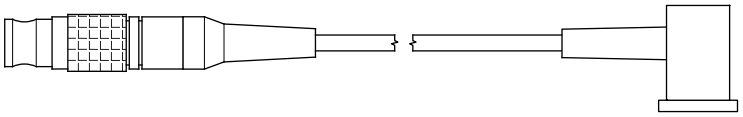
Acoustic coupling compound is applied to the wall thickness probe which then is placed firmly on the pipe. The wall thickness is displayed and can be stored directly in the transmitter.

Wall thickness measurement

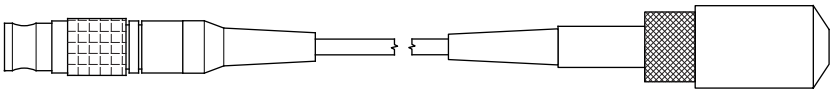
Technical Data

technical type		DWQ1xZ7	DWP1EZ7
		reverse polarity protected	
measuring range[1]	mm	1...200	
resolution	mm	0.01	
accuracy		1 % ± 0.01 mm	
operating temperature	°C	-20...+60	-20...+200, short-time peak max. 540
cable length	m	1.5	1.2

[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.



DWQ1xZ7



DWP1EZ7

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