3.6 Physical Transducers

3.6.1 Pressure Sensors

Basic Principles

The principle is to measure the extent to which a diaphragm is distended by pressure from the medium and then to convert this into an electrical signal. The usual practice is to arrange two strain gauges in such a way that one is stretched and the other is squashed. Changes in resistance are evaluated in a bridge circuit. The resulting signal can either be output directly (mV) or be used as a reference signal (voltage, current). Pressure sensors are manufactured using several different methods; these depend on and are adapted to the particular application.

Thick-Film Sensors:

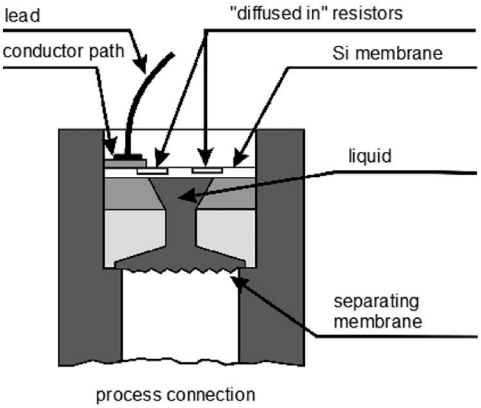
In this case expansion-sensitive elements are placed on a stainless-steel membrane by means of screen-printing.

Thin-film sensors:

In this case strain gauges are formed directly on a passivated stainless-steel membrane by means of chemical vapor deposition; this manufacturing procedure is more complex.

Piezo-resistive Sensors:

In this case expansion-sensitive resistors are diffused into a silicon membrane. A pressure transfer system, comprising a filling liquid and a stainless-steel membrane, is incorporated upstream; this avoids problems resulting from silicon's incompatibility with certain substances which might otherwise restrict the sensor's range of uses. The pressure measuring cell is temperature-compensated; the manufacturing procedure, involving vacuum processes, is also complex.



Calibration

Pressure transducers are available with 4 pressure calibrations.

Relative pressure	Pressure with respect to ambient pressure
Absolute pressure	Pressure with respect to vacuum (0 bar)
Overpressure	Pressure with respect to atmospheric pressure at the time of manufacture (approx. 1 bar)
Differential pressure	Pressure with respect to a second, variable pressure

Sensor	Advantages	Disadvantages
Thick-film sensors	Compact design Particularly suitable for use in simple monitoring and regulating circuits	Limited operating temperature range Measured values subject to long-term fluctuation
Thin-film cells	Very compact and homogeneous design, Good long-term stability and dynamic load capacity Suitable for use in harsh industrial environments in the medium and high relative pressure ranges	Highly complex, expensive manufacture
Piezo-resistive sensors	Very accurate over a wide temperature range Particularly suitable for use in high-grade measuring and regulating functions, especially in the absolute pressure range and the low to medium relative pressure ranges	A complex manufacturing procedure but cost-efficient when produced in large quantities

3.6.1.1 ALMEMO® built-in pressure transducer

ALMEMO® built-in pressure transducers incorporate a measuring cell, also piezo-resistive, suspended in an oil-filled, fully welded stainless-steel enclosure. All parts likely to come into contact with the medium are made from stainless steel; these transducers are thus also suitable for use in chemically aggressive media.

Pressure is transferred to the pressure membrane through a small hole in the threaded section: liquids should therefore not be prone to crystallizing and gases should not be heavily contaminated with dust.

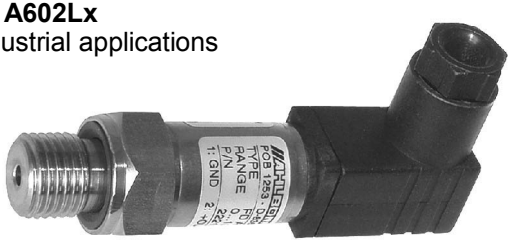
Uses

ALMEMO® pressure transducers are suitable for measuring operations in liquid and gaseous media in a wide variety of industrial applications, e.g. medical engineering, air-conditioning, hydraulic control, robotics, process engineering, motor control systems, test-beds.

Built-in pressure transducers FD A602Lx

for liquid and gaseous media, in industrial applications

Type FD A602L
Standard version, 1/4" male thread
Membrane not flush with front



Variants

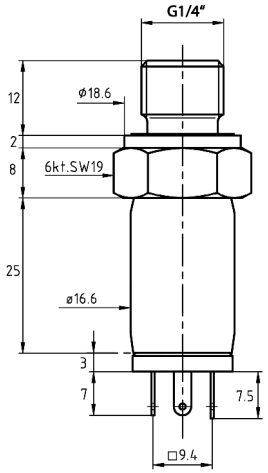
Type / Order no.	Range	Optional accessories
Relative pressure		Teflon sealing tape -200 to +260 °C
FDA602L3R	up to 2.5 bar	10 mm wide, 0.1 mm thick
FDA602L5R	up to 10 bar	Roll 12 meters long, Order no. ZB9000TB
Absolute pressure		
FDA602L4A	up to 5 bar	Quick-release coupling, Nominal width 5, up to 35 bar
FDA602L5A	up to 10 bar	1/4" male thread, brass, Order no. ZB9602N5
Overpressure		
FDA602L2U	up to 25 bar	Quick-release coupling, Nominal width 7, 2 to 35 bar
FDA602L3U	up to 50 bar	1/4" male thread, brass, Order no. ZB9602N7
FDA602L4U	up to 100 bar	

ALMEMO® built-in pressure transducer FD A602Lx

For direct connection to ALMEMO® devices these pressure transducers are provided as standard with an ALMEMO® connecting cable (length 1.5 meters, other lengths available on request).

Important parameters, e.g. measuring range and scaling, are stored in the ALMEMO® plug on the connecting cable; the output values from the pressure transducer are thus already displayed as pressure in bar.

Dimensions

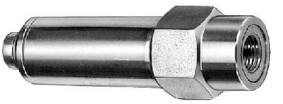


Technical data

Overload	Double the final value
Output signal	0.2 to 2.2 V
Accuracy class	±0.5% of final value (linearity + hysteresis + reproducibility)
Total error margin 0 to +50 °C -10 to +80 °C	 ±1.0 % of final value ±1.5 % of final value (linearity + hysteresis + reproducibility + temperature coeffi-cients + zero-point + range tolerance)
Response time (0 to 99%)	<5 ms
Nominal conditions	+22 °C ± 2 K 10 to 90% RH non-condensing
Power supply	6 to 15 VDC, consumption <4 mA
Operating temperature	-40 to +100 °C
Pressure connection	1/4" male thread Membrane not flush with front
Material in contact with medium	Stainless steel DIN 1.4404/1.1135 External seal, Viton
Weight	approx. 50 g
IP enclosure	IP 65

Temperature-compensated pressure transducer FD 8214

Type FD 8214
Standard version
1/4" female thread



Type FD 8214 M
Membrane flush with front
welded with end of thread
1/2" male thread
can be easily sterilized

Type FD 8214
Version with cooling fins
1/4" female thread
also with membrane flush with front

Variants

Type / Order no.	Range	Type / Order no.	Range
Relative pressure		**Absolute pressure**	
FD821401R, FD8214M01R	0 ... 100 mbar	FD821407A, FD8214M07A	0 ... 1 bar
FD821402R, FD8214M02R	0 ... 160 mbar	FD821408A, FD8214M08A	0 ... 1,6 bar
FD821403R, FD8214M03R	0 ... 250 mbar	FD821409A, FD8214M09A	0 ... 2,5 bar
FD821404R, FD8214M04R	0 ... 400 mbar	FD821410A, FD8214M10A	0 ... 4 bar
FD821405R, FD8214M05R	0 ... 600 mbar	FD821411A, FD8214M11A	0 ... 6 bar
FD821406R, FD8214M06R	0 ... 800 mbar	FD821412A, FD8214M12A	0 ... 10 bar
FD821407R, FD8214M07R	0 ... 1 bar		
FD821408R, FD8214M08R	0 ... 1,6 bar		
FD821409R, FD8214M09R	0 ... 2,5 bar		
FD821410R, FD8214M10R	0 ... 4 bar		
FD821411R, FD8214M11R	0 ... 6 bar		
FD821412R, FD8214M12R	0 ... 10 bar		
Overpressure		**Overpressure**	
FD821412U, FD8214M12U	up to10 bar	FD821418U, FD8214M18U	0 ... 160 bar
FD821413U, FD8214M13U	0 ... 16 bar	FD821419U, FD8214M19U	0 ... 250 bar
FD821414U, FD8214M14U	0 ... 25 bar	FD821420U, FD8214M20U	0 ... 400 bar
FD821415U, FD8214M15U	0 ... 40 bar	FD821421U, FD8214M21U	0 ... 600 bar
FD821416U, FD8214M16U	0 ... 60 bar	FD821422U, FD8214M22U	0 ... 1000 bar
FD821417U, FD8214M17U	0 ... 100 bar		

Other measuring ranges on request

Options (depending on type) + accessories	Order no.
Linearity 0.1% (for ranges >0.1 bar to 600 bar)	OR8214G1
Linearity 0.25%	OR8214G
Temperature of medium -25 to +100 °C	OR8214T1
Temperature of medium -25 to +150 °C, Version with cooling fins	OR8214T2
Process connection, small flange (for FD8214xxA abs. pressure) KF16 KF25	 OR8214KF16 OR8214KF25
Food compliant version with vegetable oil ASEOL Food	OR8214ML
Throttle against excess pressure	OR8214DS
Output 0 to 10 V	OR8214V
Output 0 to 20 mA	OR8214A
Output 4 to 20 mA	OR8214R4
Teflon sealing tape -200 to +260 °C, 10 mm wide, 0.1 mm thick Roll 12 meters long	ZB9000TB
Quick-release coupling, Nominal width 5, up to 35 bar Connection 1/4" male thread, brass	ZB8214N5
Quick-release coupling Nominal width 7, 2 to 35 bar Connection 1/4" male thread, brass	ZB8214N7

ALMEMO® pressure transducer FD 8214
For direct connection to ALMEMO® devices ALMEMO® connecting cable ZA-8214AK can be used; this cable has the following properties :

Type / Order no.	
Coupler socket with 2-meter cable and ALMEMO® plug Order no. ZA8214AK	Coupler socket 6-pin, Straight version Order no. ZB9030RB
	Coupler socket 6-pin, Angled version Order no. ZB9030RBW

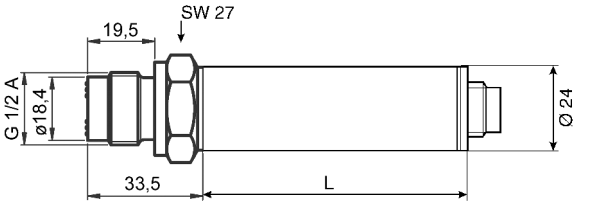
Other cable lengths are available on request.

Important parameters, e.g. measuring range and scaling, are stored in the ALMEMO® plug on the connecting cable; the output values from the pressure transducer are thus already displayed as pressure in bar or mbar.

Dimensions Type FD 8214

L = 45 mm (L = 72 mm with option of medium temperature up to 150 °C with cooling fins)

Dimensions Type FD 8214 M



L = 45 mm (L = 72 mm with option of medium temperature up to 150 °C with cooling fins)

These pressure transducers can also be provided with ASEOL Food as filling for use in the food and drink sector and pharmaceuticals.

Technical data

Measuring cell	Piezo-resistive
Overload	Up to 600 bar : 1,5 times the final value (minimum 3 bar, maximum 850 bar) >600 bar : 1500 bar
Output signal Standard 0 to 2 V Option 0 to 10 V Option 0 to 20 mA Option 4 to 20 mA 2-wire	 Power supply 6.5 to 13 V (from ALMEMO® device), Current <4 mA Power supply 15 to 30 V, Load >10 kohms, Current <4 mA Power supply 9 to 33 V, >18 V at load 500 ohms, Current <25 mA Power supply 9 to 33 V, >18 V at load 500 ohms, Current <25 mA
Response time	<1.5 ms / 10 to 90 % nominal pressure
Linearity	Standard ±0.5 % of final value Option ±0.25 % of final value for all ranges Option ±0.1 % of final value for ranges >0.1 bar and up to 600 bar
Temperature of medium Optional	0 to +80 °C Temperature compensation 0 to +70 °C -25 to +100 °C Temperature compensation -25 to +85 °C -25 to +150 °C Temperature compensation -25 to +85 °C
Temperature drift	Zero point <±0,04 % of final value / °C for ranges >0.5 bar Margin <±0.02 % of final value / °C for all ranges
Nominal temperature	+22 °C ±2 K, 10 to 90% RH non-condensing
Material	Housing, pressure connection, membrane Stainless steel 1.4435
IP enclosure	IP 67
Dimensions	See section “Dimensions”
Connecting thread	Type 8214: 1/4" female thread, width 27 Option for absolute pressure: Small flange, size 16 or 25 Type 8214 M: 1/2" male thread, width 27 Other threads are available on request.
Electrical connections	Built-in plug Binder 723 series 5-pin
Weight	approx. 180 g

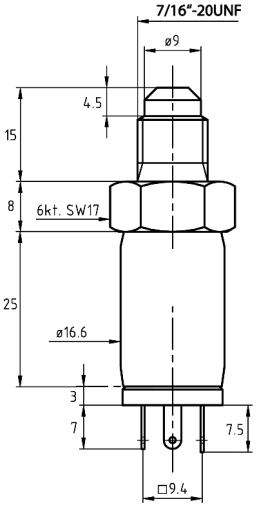
Pressure transducer for measuring the temperature of refrigerants (absolute pressure) FDA 602 LxAK
for liquid and gaseous media, in industrial applications

Type FD A602LxAK
Standard version
7/16“ male thread
Membrane not flush with front

Variants

Type / Order no.	Range
Absolute pressure resolution 0.001 bar	
FDA602L5AK	up to 10 bar
FDA602L6AK	up to 30 bar
FDA602L7AK	up to 50 bar

Dimensions [mm]



Technical data as FD A602Lx but

Pressure resolution	0.001 bar (programmed)
Pressure connection	7/16" male thread Membrane not flush with front

ALMEMO® pressure transducer for measuring the temperature of refrigerants (absolute pressure) FDA 602 LxAK

For direct connection to ALMEMO® devices these pressure transducers are provided as standard with an ALMEMO® connecting cable (length 1.5 meters, other lengths available on request).

Important parameters, e.g. measuring range and scaling, are stored in the ALMEMO® plug on the connecting cable; the output values from the pressure transducer are thus already displayed as pressure in bar with a resolution of 0.001 bar. The customer can also specify a particular refrigerant measuring channel which will - on leaving our factory - be programmed as function channel in the ALMEMO® plug. This channel indicates the refrigerant's temperature in °C with a resolution of 0.1 K.

To be able to calculate a refrigerant's temperature from the measured absolute pressure you will need ALMEMO® device option SB0000R2, temperature measuring ranges for refrigerants.

ALMEMO® device option SB0000R2

Temperature measuring ranges for refrigerants

Any ALMEMO® device as of version V6 (2590-2/ -3S/ -4S, 2690, 2890, 8590, 8690, 5690) can be provided with this option and thus be used to continuously measure a refrigerant's temperature via an absolute pressure sensor (resolution 0.001 bar). Pressure and temperature can both be individually selected or continuously indicated and / or recorded.

In special variant SB0000-R2 the ALMEMO® measuring instrument V6 is also provided with 10 measuring ranges for determining temperature from the dew-point pressure or boiling-point pressure of various refrigerants. These measuring ranges can be programmed as function channels in any absolute pressure transducer. As reference channel the appropriately scaled pressure measuring range with a resolution of 0.001 bar must be available. If the temperature measuring ranges are programmed manually the appropriate abbreviations ´Rxxx´ for the refrigerants will appear between ´DIGI´ and ´S120´. From the series measuring ranges the ranges ´Ir 1´ to ´Ir 6´ and ´L605´ are missing.

If several refrigerants are used in rotation up to maximum 3 refrigerants can be programmed on 3 function channels per plug and then activated by the choice of channel.

Technical data - refrigerants

Refrigerant	R22	R23	R134a	R404A	R404A
Pressure range	0 to 36 bar	0 to 49 bar	0 to 40.5 bar	0 to 32 bar	0 to 32 bar
Operating point	Dew point	Dew point	Dew point	Dew point	Boiling point
Temperature range	-90 to +79 °C	-100 to +26 °C	-75 to +101 °C	-60 to +65 °C	-60 to +65 °C
Resolution	0.1 K	0.1 K	0.1 K	0.1 K	0.1 K
Linearization accuracy	<-24°C: 0.2 K >-24°C: 0.1 K	<-24°C: 0.2 K >-24°C: 0.1 K	<-16 °C: 0.2 K >-16 °C: 0.1 K	0.1 K	0.1 K
Range abbreviation	R22	R23	R134	R404	'404
V24 command	B20	B19	B21	B22	B17

Refrigerant	R407C	R407C	R410	R417A	R507
Pressure range	0 to 46 bar	0 to 46 bar	0 to 49 bar	0 to 27 bar	0 to 37 bar
Operating point	Dew point	Boiling point	Dew point	Dew point	Dew point
Temperature range	-50 to +86 °C	-50 to +86 °C	-70 to +70 °C	-50 to +70 °C	-70 to +70 °C
Resolution	0.1 K	0.1 K	0.1 K	0.1 K	0.1 K
Linearization accuracy	<-30 °C: 0.2 K >-30 °C: 0.1 K	<-30 °C: 0.2 K >-30 °C: 0.1 K	<-30 °C: 0.2 K >-30 °C: 0.1 K	<-35 °C: 0.2 K >-35 °C: 0.1 K	<-30 °C: 0.2 K >-30 °C: 0.1 K
Range abbreviation	R407	'407	R410	R417	R507
V24 command	B23	B62	B25	B26	B18

The final value of the temperature range is obtained from the data available for the refrigerant in question. On pressure sensors with smaller pressure ranges only the measurable final temperature is reduced.

3.6.1.2 ALMEMO® differential pressure transducer

Differential pressure transmitter FD A602D

- This measures the differential pressure in liquid and gaseous media indirectly using two absolute pressure sensors.
- This makes it less expensive but more robust with respect to asymmetrical overload.
- The differential pressure range should be at least 5% of the standard pressure range.
- It incorporates a high-speed, high-precision microprocessor.
- All reproducible errors affecting the pressure sensors,
  i.e. involving non-linearity and temperature dependency, can be completely eliminated by means of mathematical error compensation.

Variants

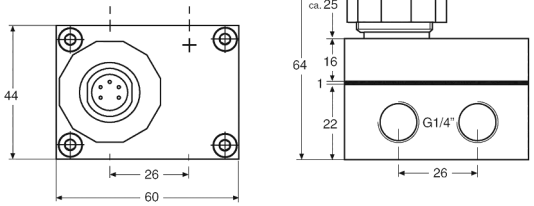
Standard pressure range, absolute pressure	Overload	Differential pressure range Please indicate final value		Order no.
Low-pressure version				
0 to 3 bar	10 bar	0 to 0.2	up to 3 bar	FDA602D01
0 to 10 bar	20 bar	0 to 0.5	up to 10 bar	FDA602D02
0 to 25 bar	40 bar	0 to 1.25	up to 25 bar	FDA602D03
Medium-pressure version				
0 to 100 bar	200 bar	0 to 5	up to 100 bar	FDA602D10
0 to 300 bar	450 bar	0 to 15	up to 300 bar	FDA602D11

ALMEMO® differential pressure transmitter FD A602D

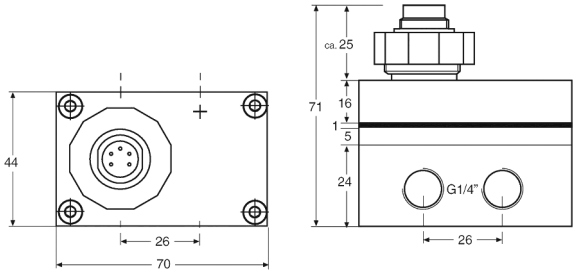
For direct connection to ALMEMO® devices these pressure transducers are provided as standard with an ALMEMO® connecting cable (length 2 meters, other lengths available on request).
Important parameters, e.g. measuring range and scaling, are stored in the ALMEMO® plug on the connecting cable; the output values from the pressure transmitter can thus be displayed as the pressure difference in bar or mbar.

Dimensions [mm]

Low-pressure version



Medium-pressure version



Technical data

Standard pressure range (maximum measurable pressure per pressure terminal) Overload, Differential pressure range	see variants
Storage / operating temperature	-40 to +100 °C
Compensated standard range	-10 to +80 °C
Error margin	≤0.05 % of final value, typical ≤0.1 % of final value, maximum with respect to standard pressure range (linearity + hysteresis + reproducibility + temperature error)
Pressure connections	1/4" female thread (2 per pressure side)
Material in contact with medium	Stainless steel, 316L, DIN 1.4435
Power supply	6 to 15 VDC via ALMEMO® plug
Output	0 to 2 V
Electrical connection	Binder plug, including ALMEMO® connecting cable, 2 meters
CE conformity	EN-61000-6-1 to 4 with shielded cable
IP enclosure	IP65
Weight Low-pressure version Medium-pressure version	 475 g 750 g

Differential pressure transducer, for wall mounting FD 8612 DPS

Pressure sensor type DPS is used to measure very small pressures and differential pressures. Pressure is measured via a membrane made from copper beryllium (CuBe) with a sensitivity suitable for the pressure range. The membrane system is scanned inductively and unaffected by mechanical forces. This pressure sensor is suitable for laboratory applications involving non-aggressive gases and also for harsh industrial environments, e.g. heating - ventilation - air-conditioning (HEVAC), clean room technology, medical engineering, filter equipment, and flue draught technology. It is not approved for Ex (potentially explosive) applications.

- The robust mechanical design ensures long-term stability, linearity, and good reproducibility.
- By selectively compensating the sensors temperature drift can be kept to a minimum.
- Thanks to the inductive, wear-resistant measuring system operation is virtually maintenance-free.

Variants

Type / Order no.	Measuring range Relative and differential pressure	Accessories
FD8612DPS	0 to 2.5 mbar up to 1000 mbar Please specify measuring range	1 set of silicone hoses 2 meters black / colorless Order no. ZB2295S
OD8612P10	1 mbar (100 Pa) additional charge	Silicone hose black per meter Order no. ZB2295SSL
OD8612P05	0.5 mbar (50 Pa) additional charge	Silicone hose colorless per meter Order no. ZB2295SFL

Options (depending on type) + accessories	Order no.
Linearity 0.2% of final value only for ranges $\geq$2.5 mbar	OD8612L2
Linearity 0.5% of final value only for ranges $\geq$1 mbar	OD8612L5
Power supply 230 V	OD8612N
Output 0 to 10 V Voltage supply 19 to 31 VDC	OD8612R2
Output 0 to 20 mA Voltage supply 19 to 31 VDC	OD8612R3
Output 4 to 20 mA Voltage supply 19 to 31 VDC	OD8612R4

ALMEMO® differential pressure transducer FD 8612 DPS
For direct connection to ALMEMO® devices ALMEMO® connecting cable ZA8612AK2 can be fitted before leaving the factory; this cable has the following properties :

Type	Order no.
Connecting cable, 2 meters mounted with plug for connecting to ALMEMO® devices	ZA8612AK2

Other cable lengths are available on request.

Important parameters, e.g. measuring range and scaling, are stored in the ALMEMO® plug on the connecting cable; the output values from the pressure transducer (a voltage signal 0 to 2 V, proportional to pressure) can thus be displayed as differential or relative pressure in Pa (Pascal) or mbar.

Installation

The pressure sensors are fixed in position by means of the two lateral clips. These sensors should not be used close to sources of spurious interference (e.g. transformers, transmitters, motors) or to sources of heat.
Even slight jolts or vibrations affecting the installation may result in falsified output signals.
Proper installation is in a vertical position with the pressure terminals pointing downwards. The sensors are calibrated for this position before leaving the factory. This manner of installation also prevents any condensation that may form in the pipework from entering the sensor.

Putting into service

To prepare the sensor for use first remove the lid from its housing. The sensor is connected electrically via terminals.
Care must be taken when connecting the supply voltage to use the input terminals - not the output terminals. Devices with a DC supply voltage have a system preventing accidental reverse polarity. The output signal from the sensors is non-shorting.

Pin assignment, 4-wire

(AC supply voltage, for range, see rating plate on device)

Power supply	Output
Terminal 1 = N	Terminal 2 = L1
Terminal 3 = 0	Terminal 4 = output A Current or voltage

Pin assignment, 3-wire

(DC supply voltage, for range, see rating plate on device)

Power supply	Output
Terminal 1 = 0	Terminal 2 = VDC
Terminal 3 = 0	Terminal 4 = output A Current or voltage

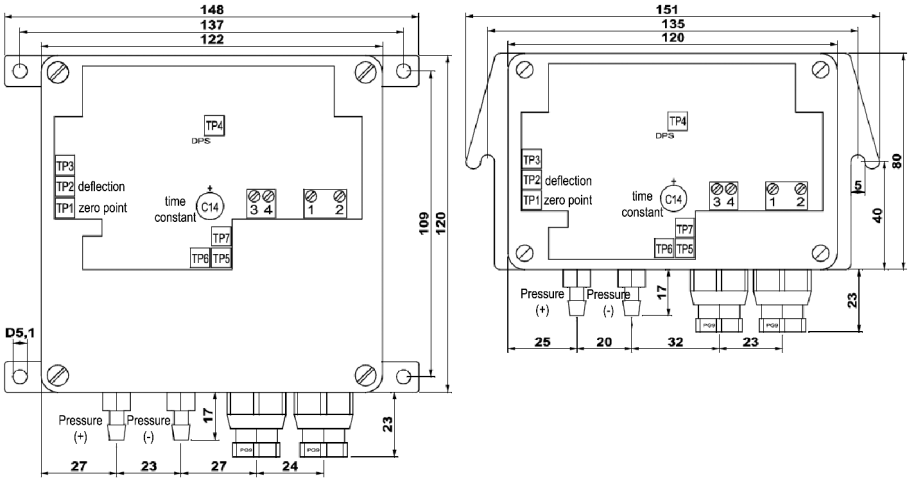
As soon as the supply voltage has been applied the output signal can be measured. In the event of any deviation in the output signal two factors must be considered.

1. The sensor needs an initial running-in period of approx. 1 hour. After this time the sensor signal for differential pressure should be zero and this should, assuming a constant ambient temperature, remain stable.
2. With small measuring ranges position is important; physically changing this may cause an appreciable shift in zero-point.
   However, this error can be adjusted - on completion of the sensor's initial running-in period - by correcting zero-point on the potentiometer; the output signal from the sensor - with open pressure inputs - is set to zero.

Do not blow into the pressure connections.
Measuring cells up to 100 hPa can be damaged or even destroyed by the pressure of air expelled from the lungs.

Calibration
The pressure sensors are calibrated before leaving the factory. If the sensor starts producing measured results that are not plausible it should be checked at the factory.

Dimensions and terminal plan



Technical data

Linearity	±1% of final value, Option ±0.2% or ±0.5%
Hysteresis	±0.1% of final value
Nominal temperature	+23 °C
Overload capacity	up to 400 mbar: 5-fold, from 500 mbar 2-fold
Max.common mode pressure	1 bar (when measuring differential pressure)
Power supply	6 VDC, Option 230 V, 50/60 Hz
Current consumption	approx. 3.5 mA
Output	0 to 2 V, Option 0 to 10 V / 0(4) to 20 mA
Connection	Electrical: Screw terminalsCable glands, screw-fit, PG 7 Pressure: 6.5 mm Hose connection
Rise time	T_{90} approx. 0.02 seconds
Temperature drift	Zero point 0.03% of final value / K Margin 0.03% of final value / K
Operative range	+10 to +50 °C, Atmosph. humidity 10 to 90 % non-condensing
Storage temperature	-10 to +70 °C
Housing	Material ABS, 120 x 80 x 55 mm (LxHxD) For DC power supply
Protection class	0
IP enclosure	IP 54
Weight	approx. 300 g
Sensor capacity	approx. 3 ml
Volume increase	approx. 0.2 ml at nominal pressure

Differential pressure transmitter for very small pressures with automatic zero-point correction FD 8612 DPT25R8AZ

Measuring principle

The measuring cell employs the piezo-resistive effect on silicon.
The silicon substrate takes the form of a thin membrane into which four strain gauges are diffused. These - subjected to mechanical pressure - are either stretched or squashed and in so doing alter their electrical resistance. The strain gauges are arranged in a Wheatstone bridge circuit; this reacts to any change in resistance by altering its bridge voltage. This voltage is proportional to the pressure difference and thus provides the sensor's output signal.

Uses

Differential pressure transmitters are used to measure low atmospheric pressures and non-combustible, non-aggressive gases. They can be used in a wide variety of applications.

- *Monitoring and regulating of air filters, ventilators, and forced-air fans and blowers*
- *Industrial air-cooling systems*
- *Monitoring and control of air flows in ventilation conduits*
- *Prevention of overheating in air heaters*

- *Regulation of airflow valves and fire protection valves*
- *Protection against frost in heat exchangers*
- *Control systems for valves, vanes, and flaps*
- *Monitoring and regulating the pressure in clean rooms*

Variants
Differential pressure transmitter FD 8612 DPT25R8AZ features 8 measuring ranges (selected by means of jumpers) and automatic zero-point correction.
The output signal can be selected :
0-10 V, load 1 kΩ minimum, 4-20 mA, 3-wire load 500 Ω maximum. The response time can also be selected, 0.8 or 4.0 seconds.

Type / Order no.	Range	Standard accessories
FD8612DPT25R8AZ	-100 to +100 Pa 0 to +100 Pa 0 to +250 Pa 0 to +500 Pa 0 to +1000 Pa 0 to +1500 Pa 0 to +2000 Pa 0 to +2500 Pa	2 fastening screws 2 plastic conduit muffs Plastic hose, 2 meters

ALMEMO® differential pressure transmitter
For direct connection to ALMEMO® devices ALMEMO® connecting cable ZA8612DPTAK can be used; this cable has the following properties :

Type / Order no.	
ALMEMO® connecting cable for differential pressure transmitter FD8612DPT 2 cables connected in the transmitter housing	1. ALMEMO® connecting cable, PVC Length = 2 meters with ALMEMO® plug
	2. Power is supplied via a mains unit. ZB1024 NA1 230 VAC/24 VDC

Important parameters, e.g. measuring range and scaling, are stored in the ALMEMO® plug on the connecting cable; the output values from the differential pressure transmitter are thus displayed as the pressure difference in Pa (Pascal).

Automatic zero point correction
This pressure transmitter features automatic zero-point correction; this eliminates any long-term drift in the piezo-resistive sensor element.
This makes the sensor virtually maintenance-free and largely dispenses with the need for periodic manual adjustment via the switch.

Typical long-term stability values are 0.1% per year.

Zero-point resetting is performed automatically every 10 minutes and takes only 4 seconds.
For the duration of correction the last measured value is retained as output value.

Differential pressure transmitter FD 8612 DPT25R8AZ is - thanks to this automatic zero-point correction feature - particularly suitable for long-term measuring operations.

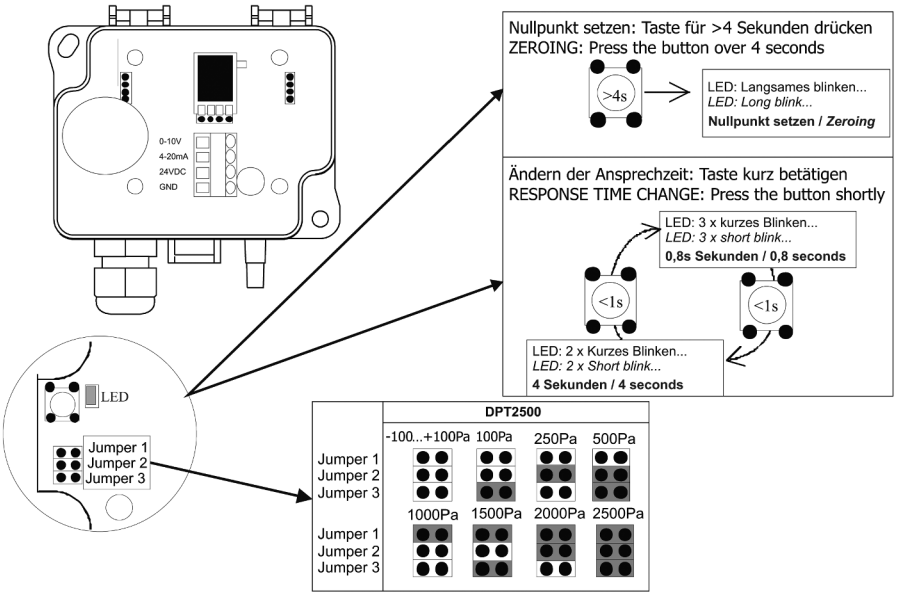
Manual zero-point correction

With differential pressure transmitter FD 8612 DPT25R8AZ the pressure switch function for manual zero-point correction is not necessary.

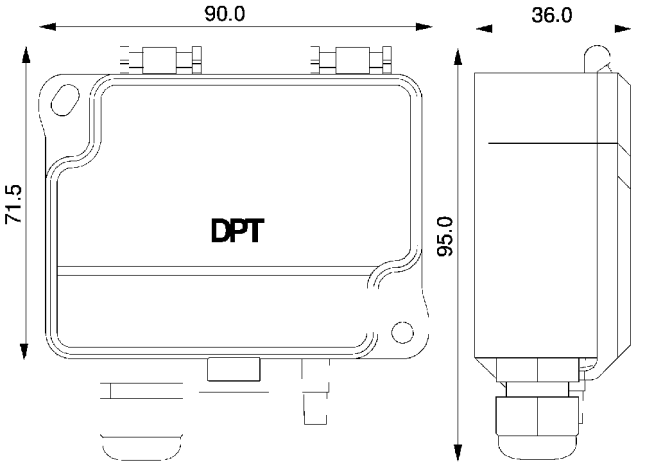
Putting into service

Safety instructions
The assembly and installation of electrical equipment may only be carried out by a qualified and trained electrician. These modules must not be used in conjunction with equipment which is intended directly or indirectly to safeguard the health or physical survival of human beings or whose operation may incur any sort of risk for humans, animals, or property.

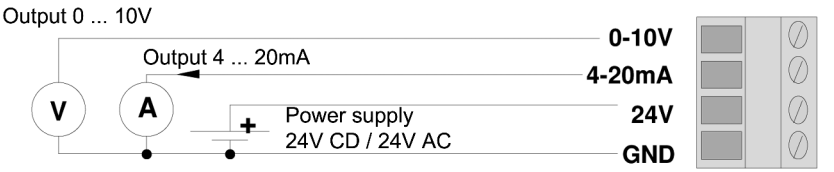
1. Before putting into service it is absolutely imperative to ensure that all electrical supply, switching, and measuring wires have been properly connected and all pressure tubes properly fitted. Before putting into service all pressure tubes must be thoroughly checked for hermeticity.
2. When connecting the device all process lines must be unpressurized.
3. Care must be taken to ensure that the device is only used to measure media for which it is completely suitable.
4. Care must be taken to keep within the maximum permitted pressures.



Dimensions



Electrical connections



These devices are designed for operation at safety extra-low voltage (SELV). Care must be taken when connecting the device electrically to observe the Technical Data. For sensors incorporating a converter this should normally be operated in the middle of the measuring range; at the extremes of the measuring range the risk of deviation increases. The ambient temperature surrounding the measuring converter electronics should be kept constant.
The operating voltage for a measuring converter must also be kept constant (± 0.2 V). The user must implement some mechanism on site to prevent current / voltage peaks when switching the supply voltage ON / OFF.

Technical data

Measuring element	Piezoelectronic measuring cell
Measuring range	(selected via jumper?*?s) -100 to +100 Pa 0 to +100 Pa 0 to +250 Pa 0 to +500 Pa 0 to +1000 Pa 0 to +1500 Pa 0 to +2000 Pa 0 to +2500 Pa
Measuring accuracy	±1.5 % of the measuring range selected
Long-term stability	0.1 % per year, typical
Response time	0.8 or 4.0 seconds (selected via jumper)
Maximum pressure	25 kPa
Bursting pressure	50 kPa
Medium	Air and non-aggressive gases
Operating temperature	-5 to +50 °C
Storage temperature	-20 to +70 °C
Ambient humidity	0 to 95 % RH, non-condensing
Housing, Housing cover, Connecting muff, Conduit muff	ABS (acrylonitrile butadiene styrene)
IP enclosure	IP54
Dimensions	90 x 71.5 x 36 mm (LxWxH)
Weight	150 g
Pressure connection	2 hose connection muffs, Ø 5 / 6.3 mm
Electrical connections	Screw terminal, maximum 1,5 mm²
Cable entry	M16
Supply voltage	24 VAC or 24 VDC, ±10 % Output <1 W
Output signal (selected via jumper)	0-10 V , load 1 kΩ minimum, 4-20 mA, 3-wire, load 500 Ω maximum

ALMEMO® plug-in pressure probe for measuring differential pressure FD A612 SR, FD A602 S2K

The ALMEMO® range of sensors includes plug-in piezo-resistive pressure measuring probes with a choice of two fittings for measuring the relative or differential pressure of gases. (see 3.5.3) These can be plugged directly onto the measuring instruments. A plug-in probe of this sort is also available for measuring atmospheric pressure. (see 3.4.1)

Variants

Type / Order no.	Range	Standard accessories
Plug-in pressure measuring probe for differential pressure		including manufacturer's test certificate, including one set of silicone hoses, 2 meters
FDA612SR	±1000 mbar	
FDA602S2K	±250 Pa irrespective of position	
FDA602S1K (see 3.5.3)	±1250 Pa irrespective of position	
FDA602S6K (see 3.5.3)	±6800 Pa irrespective of position	

Accessories	
Connecting cable, 0.2 meters	Order no. ZA9060AK1
Extension cable, 2 meters	Order no. ZA9060VK2
Extension cable, 4 meters	Order no. ZA9060VK4

Advisory note when used in conjunction with ALMEMO® 2890, 5690, 5790, 8590, 8690

The new ALMEMO® plug-in pressure measuring probe is very slightly higher (8.8 mm). As a result the adjacent input socket on the ALMEMO® device may be partly covered. However, the first input socket can be used without restriction. Or, alternatively, the ALMEMO® plug-in pressure measuring probe can be plugged in at any input socket using connecting cable ZA9060AK1.

Technical data Plug-in pressure measuring probe FDA612-SR, FDA602S2K

Measuring range	See variants
Overload capacity FDA612SR FDA602S2K	 Maximum 1.5 times final value maximum 250 mbar
Accuracy (zero-point adjusted)	±0.5% of final value in range 0 to positive final value
Common mode pressure	FDA602S2K maximum 700 mbar
Nominal temperature	+25 °C
Temperature drift FDA612SR FDA602S2K	 <±1.5 % of final value compensated temperature range 0 to +70 °C <±2 % of final value compensated temperature range -25 to +85 °C
Operating range	-10 to +60 °C, 10 to 90 % RH. non-condensing
Dimensions	74 x 20 x 8.8 mm
Hose connections	Ø 5 mm, length 12 mm
Sensor material	Aluminum, nylon, silicone, silica gel, brass

3.6.2 Force Transducers

Measuring force, basic principles
The technical characteristics of force transducers are laid down definitively by VDI/VDE guideline 2637. The most important terms are described below.

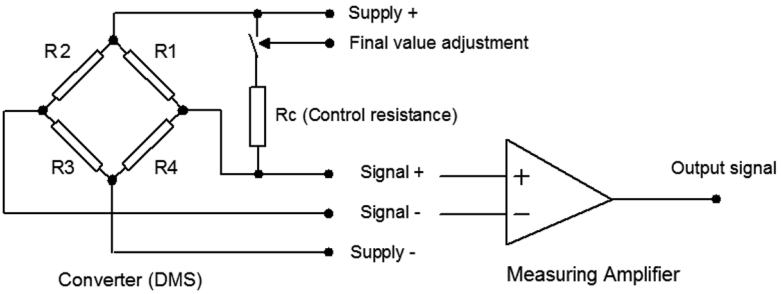
Term	Explanation
Measuring range	This is the load range within which the guaranteed error limits will not be exceeded.
Nominal load	The nominal load is the upper limit of the measuring range. The nominal load may - depending on the sensor - be either a compressive (push) or tensile (pull) load.
Working load	The working load is the load that can be applied to the sensor - over and beyond the nominal load - without the specified characteristics being affected. The full working load range should only be used in exceptional circumstances.
Load limit	The load limit is the maximum permissible load that can be applied to the measuring cell without risking the possible destruction of the measuring system. At this load the specified error limits no longer apply.
Breaking load	The breaking load is the load at which permanent change or destruction occurs.
Maximum dynamic load	This is the stress amplitude of a force, related to the rated force, operating in the direction of the sensor's measuring axis, and subject to sinusoidal change. The sensor, at a load of 107 cycles and used repeatedly up to its rated force, suffers no significant change in its measuring characteristics.
Creep	Creep is the maximum permissible change in the sensor's output signal over the specified period of time at constant load and under stable ambient conditions.

Physical units and conversions
A force is what causes a body to change its manner and rate of movement.
The SI unit of force is the newton [N].
1 newton is the net force required to accelerate a mass of 1 kilogram at a rate of 1 m/s²

	Newton	Dyne	Kilopond (Kilogram-force)	Pound-force	Poundal
1 N	≡ 1 kg·m/s²	= 105 dyn	≈ 0.102 kp	≈ 0.225 lbf	≈ 7.233 pdl
1 dyn	= 10−5 N	≡ 1 g·cm/s²	= 1/980665 kp	≈ 1/4448 lbf	≈ 1/13825.5 pdl
1 kp	= 9.80665 N	= 980665 dyn	≡ gN · 1 kg	≈ 2.205 lbf	≈ 70.932 pdl
1 lbf	=4.448221615 N	≈ 444822 dyn	= 0.45359237kp	≡ gN · 1 lb	≈ 32.174 pdl
1 pdl	=0.138254954 N	≈ 13825.5 dyn	≈ 0.0141 kp	≈ 0.0311 lbf	≡ 1 lb·ft/s²

Measuring principle

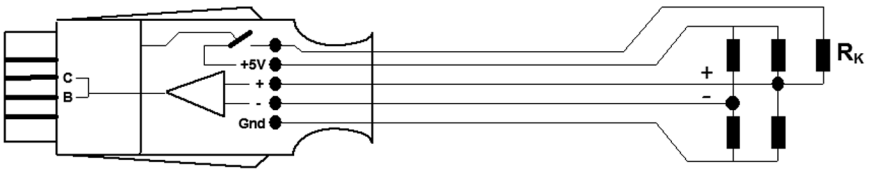
A force transducer's measuring chain comprises an electro-mechanical converter and an amplifier for the purpose of standardizing the signal. The strain gauges are arranged in a full-bridge circuit in 4-conductor technology; i.e. the strain gauges are fed via 2 supply wires and the measuring signal is tapped via 2 other wires.



For final adjustment of the measuring range the force transducer incorporates an appropriately dimensioned control resistor which checks and as and when necessary recalibrates it.

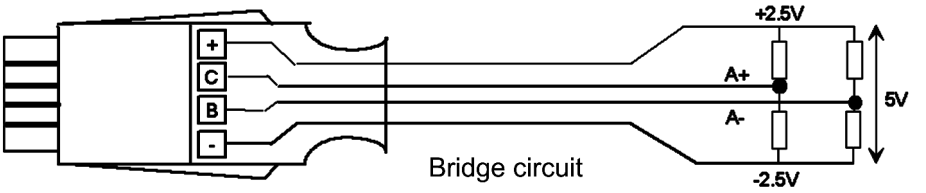
ALMEMO® input connector for force transducers
Variants ZA 9612-FS

Plug connector for all ALMEMO® force transducers is measuring amplifier module ZA 9612-FS; this incorporates an integrated precision differential amplifier (amplification 10) and a stable bridge voltage supply of 5 VDC (0.5%, typical 20 ppm/K). The output signal is present on pin B and C to pin A (GND). For force transducers with integrated calibration resistor RK the measuring amplifier module includes an electronic switch by means of which this calibration resistor can be activated from the device.



To connect force transducers from other manufacturers without such integrated calibration resistor ALMEMO® plug ZA9105FSx can be used instead.

Variants ZA9105FSx



Type	Measuring range	Resolution	Order no.
55 mVDC	-10.0 to +55.0 mV	1 µV	Order no. ZA9105FS0
26 mVDC	-26.0 to +26.0 mV	1 µV	Order no. ZA9105FS1
260 mVDC	-260.0 to +260.0 mV	10 µV	Order no. ZA9105FS2
2.6 VDC	-2.6 to +2.6 V *	0.1 mV	Order no. ZA9105FS3

* Data may vary depending on device; (see data sheet per device).

Technical data ZA9105FSx

Sensor supply voltage → voltage UF	5 ±0.05 V
Temperature coefficient	<50 ppm / °C
Output current	maximum 100 mA
Quiescent current	approx. 3 mA
Energy saving	So long as the measuring point is not selected, the bridge voltage remains switched OFF.

Tare function

For all measuring operations involving weight and force, the tare function is important; if there is an initial load or a zero-point error this function presets the measured value to zero. On all ALMEMO® devices this is performed by the "BASE VALUE" function. (see 6.3.11)

To use this function the locking mode must be set to 4.

Force transducer adjustment (two-point adjustment)

Many ALMEMO® devices perform not only the usual zero-point adjustment but also automatic final value correction. The adjustment values for BASIC and FACTOR are saved as usual in the connector EEPROM. For complete scaling it may be necessary in certain circumstances to shift the decimal point and specify the units. (see 6.3.11 and 6.3.5)

For all new devices the adjustment procedure using keys is described in the operating instructions under "Entering the setpoint"; the adjustment procedure via the interface is described in the Manual, section 6.4.2. For this purpose the locking mode must be set to level 4.

Force transducer adjustment is performed via the MEASURED VALUE function / display.

1. Zero-point adjustment
Remove load from transducer.
Perform zero-point adjustment by means of the function "Set measured value to zero".
The zero-point error is saved as BASIC and the measured value display should show 0000.
2. Specifying the final value
Activate the final value calibration resistor (on ALMEMO® force transducers only).
For transducers without the calibration resistor apply the nominal load.
The final value should now be displayed.
3. Final value correction
Enter and adjust the setpoint value by means of the function "Entering the setpoint".
The gain error is saved as FACTOR and the measured value display should show the setpoint.
Step 3 can be repeated as and when necessary.
4. Completing the correction procedure
Remove nominal load, if necessary.
Quit the adjustment function. The calibration resistor is now deactivated.
The measured value display should show 00000 again.
On devices without the facility for entering the setpoint the factor (setpoint value / actual value) can be calculated and programmed by the user. (see 6.3.11)

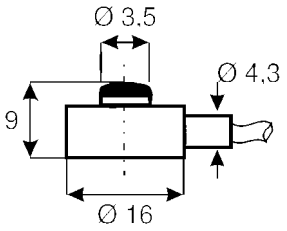
ALMEMO® force transducers
The ALMEMO® range of sensors includes force transducers in 3 variants.

Type of force	Type / Order no.	Measuring range
Push force	FK A022	100N, 200 N, 500 N, 1000 N, 2000 N
	FK A613	0.5 kN, 1 kN, 2 kN, 5 kN, 10 kN, 20 kN (50 kN available on request)
Push / pull force	FK A0251	0.02 kN, 0.05 kN, 0.1 kN, 0.2 kN, 0.5 kN, 1 kN, 2 kN, 5 kN, 10 kN
	FK A0252	20 kN,
	FK A0255	50 kN

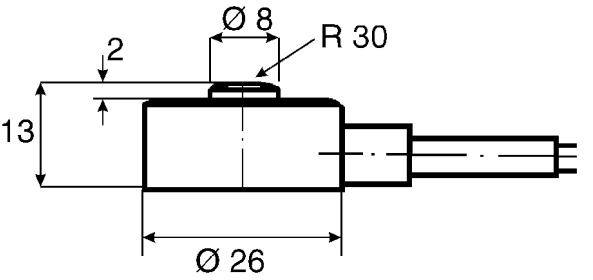
Important parameters, e.g. measuring range and scaling, are stored in the ALMEMO® plug on the connecting cable; the output values from the ALMEMO® force transducer are thus already displayed as push / pull force in N (newton).
An option is available with the same measuring ranges but in kilograms instead of newton. Another option is available that displays measured values on the ALMEMO® device in both units one after the other

Options for all force transducers	Order no.
Measured values displayed on ALMEMO® device in kg	Order no. OK9000K
Measured values displayed on ALMEMO® device in N and kg	Order no. OK9000K

Push sensors, dimensions FK A022, FK A613



FK A022

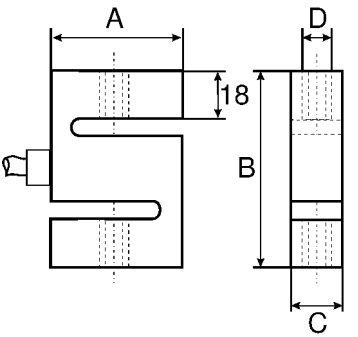


FK A613

Technical data Push sensors FK A022, FK A613

Push sensors	FK A022	FK A613
Measuring ranges	100 N, 200 N, 500 N, 1000 N, 2000 N	0.5 kN, 1 kN, 2 kN,5 kN, 10 kN, 20 kN (50 kN available on request)
Accuracy	<±0.5% of final value	
Nominal measuring displacement	< 0.2 mm	
Operative range	-10 to +50 °C	
Creep error under continuous load	<±0.1% per 30 minutes	
IP enclosure	IP 65	
Material	Stainless steel	

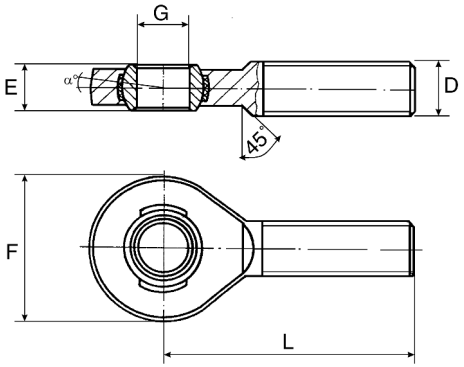
Push and pull sensors, dimensions FK A025 (1, 2, 5)



Technical data Push and pull sensors FK A025 (1, 2, 5)

Push and pull sensors	FKA 0251, FKA 0252, FKA 0255
Measuring ranges	0.02 kN, 0.05 kN, 0.1 kN, 0.2 kN, 0.5 kN,1 kN, 2 kN, 5 kN, 10 kN, 20 KN, 50 KN
Maximum load limit	150% of final value
Maximum dynamic load	70% of final value
Reference temperature	+23 °C
Cable(s)	3 meters, axial, with ALMEMO® plug
Accuracy, pull	<±0.1% of final value
Accuracy, push and pull	<±0.2% of final value
Nominal measuring displacement	<0.15 mm
Operative range	-10 to +70 °C
Creep error under continuous load	<0.07% per 30 minutes
Permissible lateral forces	±60% of final value
IP enclosure	up to 1 kN IP 65, from 2 kN IP 67
Material	up to 1 kN Aluminum; 2 to 50 kN Stainless steel
Dimensions in mm up to 10 kN	A=50, B=75, C=20, D=M12
Dimensions in mm 20 kN, 50 kN	A=65, B=85, C=40, D=M24 x2

Accessories for FK A025 (1, 2, 5)



Type	Order no.
Knuckle eyes with external thread M 12 (set of 2 pieces) Dimensions in mm D = M 12, E = 16, F = 32, G = 12, L = 54	ZB902512
Knuckle eyes with external thread M 24 x 2 (set of 2 pieces) Dimensions in mm D = M 24 x 2, E = 26, F = 62, G = 25, L = 94	ZB902524

3.6.3 Displacement Transducer, Displacement Tracer

Measuring Principle
Different methods can be used depending on the limiting and environmental conditions.

Measuring Method	Characteristics and Advantages
Linear inductive displacement transducer and displacement tracer	very accurate, high resoluting, robust, acceleration-resistant, cost-effective, interference-proof, very high long-term stability, environmentally stable (dirt, moisture), point-shaped, virtually non-contact measurement, simple mounting and handling
Non-contacting displacement measuring systems based on eddy current	very accurate, very fast, high resoluting,environmentally stable (dirt, moisture), interference-proof in electromagnetic environment, temperature-stable, long-term stable, can measure objects of all electrically conductive materials, non-magnetic and also ferromagentic, compact special designs,extensive operating temperature range
Non-contacting inductive displacement measuring systems	accurate, temperature-stable, fast, cost-effective, especially for ferromagnetic measuring objects
Long-travel sensors based on eddy current	large measuring distances, robust and compact, no mechanical wear, simple handling, pressure-resistant
Non-contacting optical displacement measuring system	point-shaped measurement, accurate, fast, large base spacing, material-independent
Cable-line displacement sensors	very accurate, long measuring travels, easy mounting, cost-effective
Non-contacting capacitive displacement measuring systems	very accurate, very temperature-stable, fast, high-resoluting, very high long-term stability, material-independent in case of metal object, also suitable for insulator materials, easy to operate, extensive operating temperature range
Conductive plastic potentiometer	high-resoluting, good linearity, cost-effective, good temperature and humidity coefficients, extensive operating temperature range

Linear inductive displacement transducer and displacement tracer:
Transducers according to the differential-transformator principle (LVDT) consist of one primary and two secondary coils. The coupling is performed via a soft-magnetic core. The voltages that are induced in the secondary coils act proportionally to the position of the core (ram). Transducers according to the differential-inductor principle consist of two coils that are switched to form a half-bridge and that have one shared moving magnetic core. A displacement of the core (ram) changes both coil inductances which, by the corresponding amplifier electronics, are converted into a displacement-dependent signal.

Non-contacting displacement meas. systems based on eddy current:
High-frequency alternating current flows through a coil that has been embedded in a plastic moulding. The electromagnetic coil field induces eddy currents in the conductive object under test, which absorb energy from the resonant circuit. The sensor amplitude changes dependent on the distance. When demodulated, linearised and amplified, this amplitude change provides a voltage that is proportional to the distance.

Non-contacting inductive displacement measuring systems:
A coil is part of a resonant circuit. The coil inductance changes on approach to a conducting object under test. The demodulated signal is proportional to the distance between the sensor and the object under test.

Long-travel sensors based on eddy current:
An aluminium tube is moved concentrically and without contact above a bar with an integrated coil. The tube position causes a mistuning of the coil, by inducing eddy currents.

Non-contacting optical displacement measuring systems:
A laser beam is directed onto the object. The light spot is optically guided to a linear detector that provides currents proportional to the light spot position.

Cable-line displacement sensors:
A linear movement is converted via a flexible steel rope into a rotation and is analysed by means of a potentiometer or encoder.

Non-contacting capacitive displacement measuring systems:
The ideal plate capacitor changes its capacitance when the plate spacing changes. For the capacitive method, the sensor and the opposite positioned object under test form a plate electrode. In the measuring system an alternating current with a constant frequency flows through the sensor. The voltage amplitude at the sensor is proportional to the distance between the sensor electrode and object under test and is demodulated in a special circuit.

Conductive plastic potentiometer:
Based on a voltage divider circuit and a conductive plastic resistor element, the slip ring voltage is, without load, tapped by means of an operational amplifier that is switched as a voltage follower.

Applications
The range of applications for displacement transducers and displacement tracers is various. Not every application can be directly identified as a displacement measurement. Often, it is a completely different measuring variable that can be traced back to a displacement or distance variable.

Displacement transducers
are suitable for direct, accurate measurement of displacements in automatic control and metrology. The pickup of the displacement is performed using a pull rod with a universal joint. This allows for an actuation that is free from backlash and transverse forces, even in case of parallel and angular displacements of transducer and measuring direction.

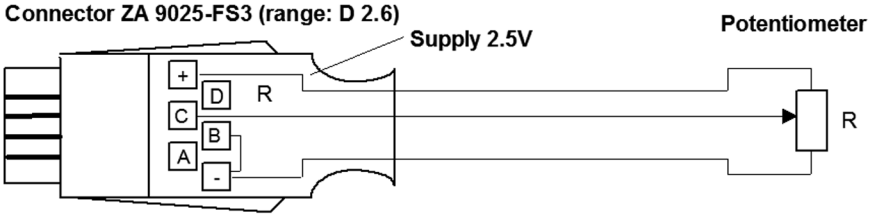
Displacement tracers
are suitable for direct measurements of displacement without a form-locking connection, position detection at stationary measuring objects, tolerance measurements and for continuous contour measurement. The pull rod, which is supported on both sides, allows for accepting transverse forces that, for example, occur during a continuous scanning of curves or spline parts. A rear limit stop is used to provide a simple mechanical coupling of automatic retraction systems, for example, pneumatic cylinders or electromagnets.

ALMEMO® Displacement Transducers/Tracers
The ALMEMO® sensor range includes a selection of conductive plastic potentiometers as displacement transducers and tracers for various travels:

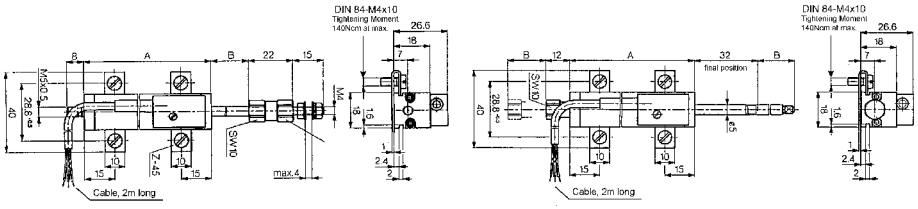
Travel	Resolution	Transducer	Tracer
25 mm	0.001 mm	FW A025 T	FW A025 TR
50 mm	0.01 mm	FW A050 T	FW A050 TR
75 mm	0.01 mm	FW A075 T	FW A075 TR
100 mm	0.01 mm	FW A100 T	FW A100 TR
150 mm	0.01 mm	FW A150 T	

The potentiometers are connected through the connector ZA9025FS3 with a stable 2.5V supply (see section 4.2.4). This leads to a measuring range from 0 to 2.5V for the overall travel. A pre-adjustment is performed in the factory through correction values.

The precise adjustment can be locally performed by the user with final measures after the installation.



Abmessungen



Technische Daten

Displacement Transducer T/ Displacement Tracer TR	T25/ TR25	T50/ TR50	T75/ TR75	T100/TR 100	T150
Independent linearity:	±0.2%	±0.15%	±0.1%	±0.075%	±0.075%
Length of housing, in mm: (dim. A +1 mm):	63	88/94.4	113/134.4	138/166	188
Mechanical stroke, in mm (dim. B ±1.5 mm):	30	55	80	105	155
Total weight, in g (incl. 2m cable):	140/120	160/150	170/180	190/200	220
Mass of pull rod incl. coupling and slip ring block, in g:	35/25	43/36	52/48	58/57	74
Maximum actuation frequency (displacement tracer TR): (for most critical application "measuring tip upwards")	18 Hz	14 Hz	11 Hz	10 Hz	
Movability of universal joint (displacement transducer T):	±1 mm parallel displacement, ±2.5° angular displacement				
Actuation force (horizontal):	Transducer T: ≤ 0.30 N, Tracer TR: ≤ 5 N				
Reproducibility:	0.002 mm				
Dielectric resistance:	≥10 M W (at 500 V DC, 1 bar, 2 s)				
Dielectric strength:	≤ 100 mA (at 50 Hz, 2s, 1 bar, 500 V AC)				
Max. permissible. tightening torque of mounting screws:	140 Ncm				
Temperature range:	–30 to +100°C				
Temperature coefficient of the voltage divider ratio:	typically 5 ppm/°C				
Vibration:	5 to 2000 Hz/Amax = 0.75 mm / amax = 20 g				
Shock:	50 g/11 ms				
Life:	> 100 x 106 strokes				
Operating environment/Sealing:	IP 40				

3.6.4 Flow measurement, basic principles

Flow rate is a measurable variable describing the movement of a fluid or liquid medium.
Volume flow is the volume of medium that passes through a certain cross-section over a certain period of time; volume flow can be defined as follows :

$$Q = \frac{(\delta V)}{(\delta t)}$$

Q = volume flow in [m³/s], [l/min], [m³/h]
V = Volume in [cm³], [dm³], [m³]
t = Time in [s], [min], [h]

For fluids (gases and liquids) the following applies :

$$Q = v_m * A$$

Q = Volume flow in [m³/s]
v_m = Mean flow velocity in [m/s]
A = Cross-section area at the measuring point in [m²]

If the cross-section area (pipe, tube, conduit) is known and the flow velocity at a certain point can be measured, this formula can be used to calculate the volume flow.
Since the flow velocity over the said cross-section is rarely constant, mean flow velocity vm is determined by integration.
A wide variety of flow sensors is available for the purpose of measuring the volume flow.
Flow sensor (also known as flowmeter) is a general term for all sensors that measure the flow rate of a gas or liquid through a pipe.

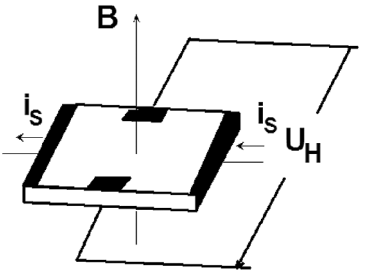
Physical units (conversion)

m³ / s	m³ / min	m³ / h	l / s	l / min	l / h
0.0000166666	1,000	0.06	0.016666	1	60
0.00027777	0.01666666	1	0.27777777	16.66666600	1000

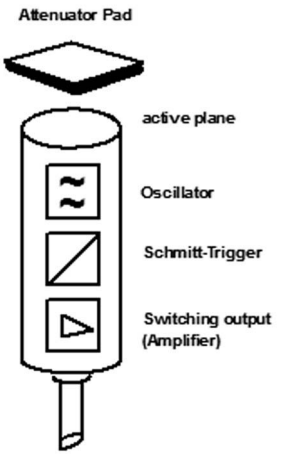
3.6.4.1 Turbine flowmeter for liquids

Measuring principle
The sensor contains an impeller or paddle-wheel that is made to rotate by the flow of medium. Its rotational speed is proportional to the mean flow velocity and thus to the current flow rate. This measuring principle - unlike purely visual sampling - is also suitable for opaque, non-transparent liquids.
To generate an electrical output signal two different methods can be used.

Hall sensor
The rotor is fitted with permanent magnets; the effect that these exert is detected by a Hall sensor located in the transducer. The integrated electronics converts the Hall signal into an electronic pulse signal at the output.



Inductive proximity switch
The rotor blades are fitted with stainless-steel caps; these, as the blades approach the transducer, cause its level of inductance to change and a pulse-type output signal is generated accordingly.



Calibration
The calibration factor of a turbine flowmeter is the exact expression of its pulse rate. To determine this calibration factor a transducer is calibrated and then adjusted to customer specifications and the actual operative viscosities.
The following equation is used for the flow rate :

$$Q = f * (\frac{60}{K})$$

Q = Flow rate in l/min
f = Frequency in Hz
K = Calibration factor in pulses / liter

Uses
Thanks to their compact design and wide measuring ranges ALMEMO® turbine flowmeters are particularly suitable for a wide variety of uses, e.g. :
- *cooling water flow, medical engineering, plastics industry, solar energy systems, bakery equipment, machine tools, catering equipment, photographic laboratory equipment, dispensers, dosing equipment, cooling equipment, heating applications, calorimetry*

ALMEMO® turbine flowmeters
For measuring volume flow and for various dosing tasks the ALMEMO® range of sensors includes turbine flowmeters for a wide variety of measuring ranges and operating conditions.
- Axial turbine flowmeter **FV A915 VTH25** with impeller and turbine body made of brass → for large flow rates → 4 to 160 liters / minute
- Axial turbine flowmeter **FV A915 VTH**M with impeller and turbine body made of brass → for small flow rates → 2 to 40 liters / minute
- Axial turbine flowmeter **FV A915 VTHK** with impeller and turbine body made of plastic → for small flow rates → 2 to 40 liters / minute

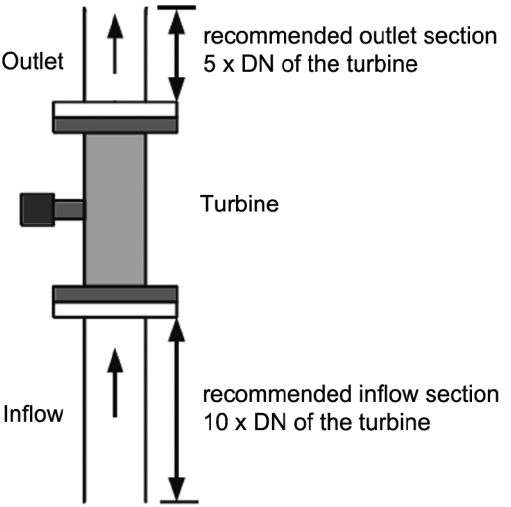
Important parameters, e.g. measuring range and scaling, are stored in the ALMEMO® plug on the connecting cable; the measured value is displayed in liters / minute.

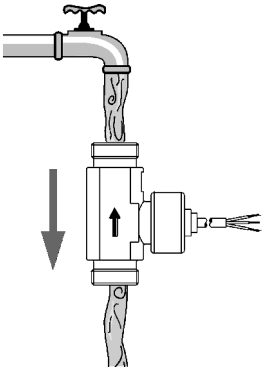
The pulse signal from the sensor is measured on ALMEMO® devices using the 'Frequency' measuring range. The term $(\frac{60}{K})$ from the equation for flow rate corresponds to the current scaling value.
Across the specified measuring range the flow rate signal remains linear (within measuring accuracy tolerances). However, in applications requiring flow rate regulation, e.g. maintaining constant flow rate despite filters get clogged up, the sensor can also be operated in a non-linear mode because the level of repeatability here too is sufficient.

General installation instructions

Before installation check whether the materials used for the flow sensor are suitable for the medium to be measured.
The VTH types (brass and plastic variants) - because of the materials used - are not suitable for measuring oils. The strength of the plastic components used in their construction would be severely impaired.

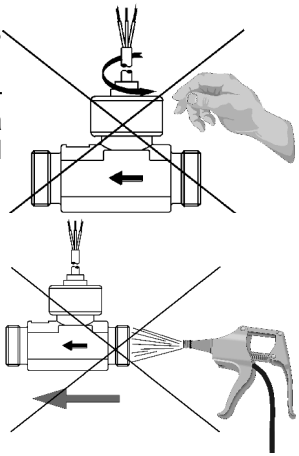
1. The flow sensor can be fitted in any position. If installed in horizontal pipework with the housing upright it is easier to deaerate. If installed in vertical pipework the recommended direction of flow is from bottom to top. Installation in an open-ended pipe is not advisable.
2. The arrow on the flow sensor (→) indicates the only direction of flow possible.
3. The medium to be measured should contain as few solids as possible. Any particles it does contain must not be larger than 0.5 mm; it may be necessary to install a filter.
4. Upstream from the flow sensor a 'straight' inlet path must be provided, with a length of at least 10 x DN (diamètre nominal), e.g. 15 cm for DN15 pipe. Downstream from the flow sensor a 'straight' outlet path must be provided, with a length of (at least) 5 x DN, e.g. 7.5 cm for DN15 pipe. The inside diameter of both the inlet path and the outlet path must correspond to that of the flow sensor, e.g. 15 mm for DN15 pipe. Further upstream and further downstream the pipe may be narrowed or widened.





5. To clean the flow sensor from contaminants it should be rinsed through against the normal flow direction.

Warnings



The screw collar on the cable outlet is sealed.

If this is ever undone the fixture of the turbine system becomes loose and there is a serious risk of damage. The system would then have to be repaired at our factory.

For FVA 915VTHM / VTHK only

Blowing through the device using compressed air is permitted - but never in the flow direction - ONLY in the opposite direction.

For FVA 915VTH25 only

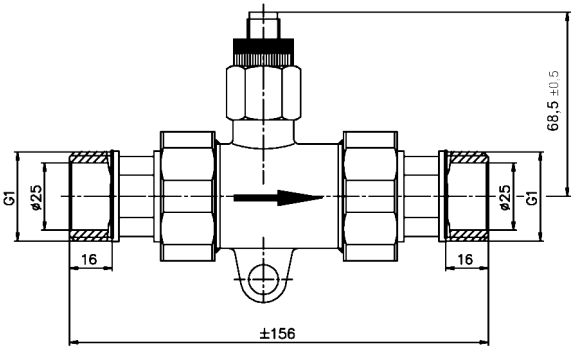
Blowing through the device using compressed air is NOT permitted. This may cause damage to the bearings.

Axial turbine flowmeter FVA 915 VTH 25

Installation in a pipe system

First of all the connection adapters must be fitted hermetically onto the pipework. Care must be taken in so doing to ensure that no fibrous packing material (hemp or Teflon tape) is allowed to enter the turbine.

The turbine itself is then installed using the union nut and the flat gaskets supplied.



Technical data FV A915 VTH25

Type	FV A915 VTH25M
Material used for pipe piece	Brass
Nominal width	DN25
Measuring range	4 to 160 l/min Continuous load maximum 80 l/min
Measuring accuracy	±3% of measured value
Reproducibility	±0.5 %
Signal output	from <1 l/min
Maximum size of particles in medium	0.63 mm
Maximum temperature of medium	+85 °C
Nominal pressure	PN10
Process connection	1¼" male thread including adapter for 1" thread (absolutely necessary)
Pressure loss	approx. 0.1 bar at 80 l/min approx. 0.45 bar at 160 l/min
IP enclosure	IP 54
Output signal Pulse rate / K factor	65 pulses / liter
Resolution	15 ml / pulse
Signal form	NPN open collector (neg-pos-neg)
Transducer	Hall sensor
Supply voltage	4.5 to 24 VDC (from ALMEMO® device)
Electrical connections	4-pin plug M12x1 including PVC line (Tmax=70°C) with ALMEMO® plug

It is possible to measure liquids of a higher viscosity but data may deviate from that indicated above.

Materials

Type	FV A915 VTH25M
Pipe piece	Brass, CuZn36Pb2As CW602N
Turbine cage	PPO Noryl GFN 3V 960
Impeller	PPO Noryl GFN 2V 73701
Impeller fittings	Permanent magnets, Recona 28, nickel-plated
Axle / bearing	Stainless steel 1.4436 / sapphire, PA
Transducer sleeve	PPO Noryl GFN 1630V
O-ring	72 NBR 872

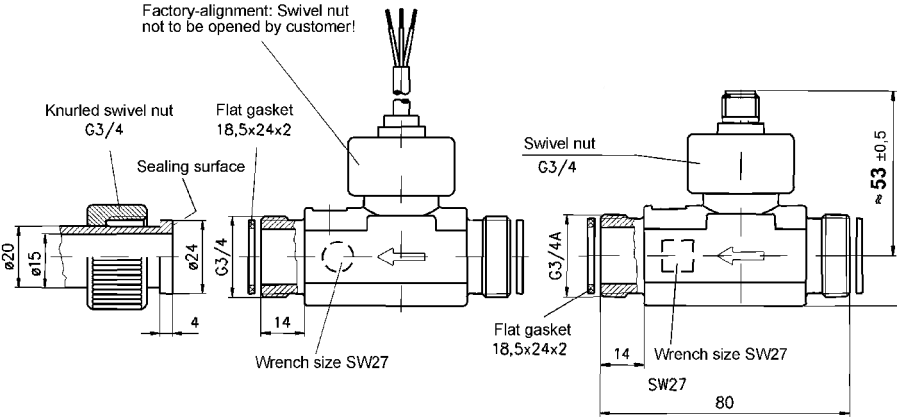
3.6.4.2 Axial turbine flowmeter FVA 915 VTHM, FVA 915 VTHK

Installation in a pipe system

The pipework to be connected must have a suitable flange. The end of this flange acts as the sealing surface; it is pressed onto the flat gasket by means of the knurled union nuts supplied. It may becomes necessary to pack the male thread; care must be taken in so doing to ensure that no fibrous packing material (hemp or Teflon tape) is allowed to enter the flow of medium.

Tightening torque
Plastic union nuts maximum 8 Nm
Brass union nuts maximum 30 Nm

Axial turbine flowmeters, dimensions FV A915 VTHM, FVA 915 VTHK



Technical data FV A915 VTH

Type	FV A915 VTH M	FV A915 VTH K
Material used for pipe piece	Brass	Plastic PPO
Nominal width	DN15	
Measuring range	2 to 40 l/min, Continuous load maximum 20 l/min	
Measuring accuracy	±1 % of final value	
Reproducibility	±0.2 %	
Signal output	from 0.3 l/min	
Maximum size of particles in medium	0.5 mm	
Max. temperature of medium	+85 °C	
Nominal pressure	PN10	
Process connection	¾" male thread and union nuts	
Pressure loss in bar	Δp = 0.00145 x Q2 (Q in liters / minute) approx. 0.6 bar at 20 l/min approx. 2.3 bar at 40 l/min	
IP enclosure	IP 54	
Output signal Pulse rate / K factor Resolution	 940 pulses / liter 1.1 ml / pulse	
Signal form	Rectangular signal, NPN, open collector	
Transducer	Hall sensor	
Supply voltage	4.5 to 24 VDC (from ALMEMO® device)	
Electrical connections	4-pin plug M12x1 including PVC line (Tmax=70°C) with ALMEMO® plug	

It is possible to measure liquids of a higher viscosity but data may deviate from that indicated above.

Materials

Type	FV A915 VTH M	FV A915 VTH K
Pipe piece	Brass CuZn36Pb2As	PPO Noryl GFN3
Flat gasket	NBR	
Turbine cage	PEI ULTEM	
Impeller	PEI ULTEM	
Impeller fittings	Hard ferrite magnets	
Axle / bearing	Axle Arcap AP1D with carbide pins in sapphire bearings	
Bearing holder	Arcap AP1D	
Transducer	PPO Noryl GFN3	
O-ring	NBR	
Union nut *	PA GF 30	

* This does not come into contact with the medium.

3.6.4.3 Vortex flowmeters FV A645 GVx

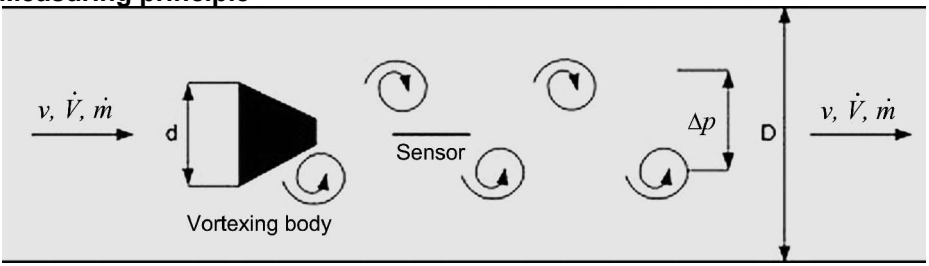
Basic principles

In fluid mechanics a vortex is the circular flow of a fluid. Liquid or gas flowing past an obstacle creates a turbulence in which eddies forming on both sides of the obstacle swirl into the lower-pressure gap immediately behind it; this results in a pattern of short reverse flows which, on approaching the back of the obstacle, are shed behind it in a row, alternately, periodically offset, and rotating counter to one another.

The character of vortex formation can be defined in terms of the Reynolds number Re. The Reynolds number Re represents the ratio between inertial forces and viscous forces; it can be calculated from the flow velocity, the diameter of the object past which the fluid flows, and the viscosity of the medium. The frequency of vortex shedding is represented by the Strouhal number St. Since these two numbers represent physical constants , such calculations show a linear relationship between vortex shedding frequency and flow velocity - and thus also volume flow.

So-called vortex streets were first discerned and calculated in 1911/12 by Hungarian engineer Theodore von Kármán; these form the basis for today's vortex measuring methods.

Measuring principle



The physical effect of the Kármán vortex street is employed in the measurement of vortex flows, namely by having a suitable vortexing body fitted on the flow sensor behind which such a vortex street is formed. Since the vortices on either side rotate in opposite directions and at an offset to one another, local pressure differences are formed. The sensor measures the so-called vortex frequency by counting the pressure pulses per time unit. As the flow velocity increases so does the vortex frequency too. The frequency of pressure pulses gives the flow velocity; this together with the known cross-section of the measuring section can be used to generate a signal proportional to the flow; in the sensor this provides the electrical output signal.

Uses

ALMEMO® vortex flowmeters all share the following special features :

- Measuring section in sturdy, industry-quality stainless steel
- No moving parts exposed to the medium
- No abrasion and no wear and tear on the measuring system
- Flow rate and temperature measured in one and the same sensor
- Wide temperature range
- High-speed response time
- Low pressure loss

Thanks to these special features ALMEMO® vortex flowmeters can be used in a wide variety of applications in many sectors of industry.

- *petrochemicals , energy, heating, pharmaceuticals, dyestuffs, agricultural chemicals, cosmetics, food and drinks*

Special uses

- *Circuits for water, solar, and water-glycol mixture for system optimization or for determining quantities of thermal energy*
- *Thermal output measurement in heating systems and cooling plant*

ALMEMO® vortex flowmeters

The ALMEMO® vortex flow sensor comprises a measuring section, a sensor element, and a triangular vortexing body for shedding vortices on both sides. The sensor element used to measure the fine pressure pulses is a piezo-resistor arranged in the form of a Wheatstone bridge; any changes in pressure causes this to change its electrical resistance accordingly. The temperature sensor, also integrated on the sensor chip, is needed primarily to compensate the measuring signal but the acquired temperature value is also output as a signal itself. Being in direct contact with the medium ensures very short response times for flow rate and temperature over an operative range of 0 to 100 °C.

For measuring volume flow with integrated temperature measurement the ALMEMO® range of sensors includes vortex flowmeters for a wide variety of measuring ranges and operating conditions.

Type Order no.	Range	Resolution	Process connection Thread	Insert length	Dynamic viscosity Medium *
FVA645GV12QT	1 to 12 l/min	0.06 l/min	3/4“ male	approx. 110 mm	<4 mm²/s
FVA645GV40QT	2 to 40 l/min	0.2 l/min	3/4“ male	approx. 110 mm	<4 mm²/s
FVA645GV100QT	5 to 100 l/min	0.5 l/min	1“ male	approx. 129 mm	<2 mm²/s
FVA645GV200QT	10 to 200 l/min	1.0 l/min	1 1/4“ male	approx. 137.5 mm	<2 mm²/s

* Conversion 1 St = 1 cm²/s, 1 St = 10-4 m²/s, 1 cSt = 1 mm²/s

Important parameters, e.g. measuring range and scaling, are stored in the ALMEMO® plug on the connecting cable; the output voltage values from the ALMEMO® flow sensor and the temperature sensor are thus already displayed in liters/minute and °C.

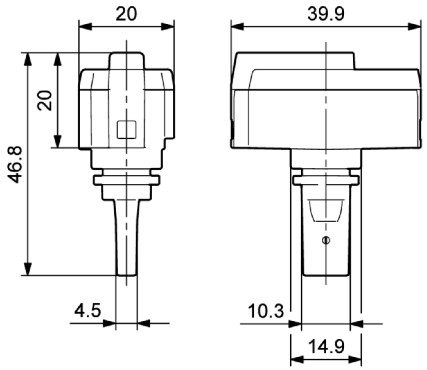
Installation in a pipe system

1. The arrow on the flow sensor (→) indicates the only direction of flow possible.
2. Upstream from the flow sensor a 'straight' inlet path must be provided, with a length of at least 10 x DN (diamètre nominal), and downstream from the flow sensor a 'straight' outlet path, with a length of (at least) 5 x DN

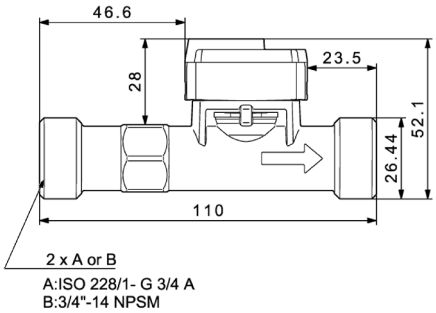
3

Vortex flowmeters, dimensions FV A645 GVx (Dimensions in mm)

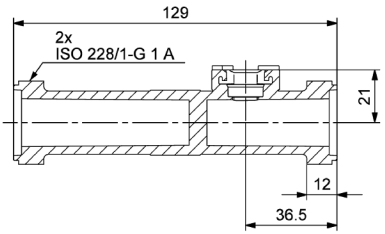
Sensor element
FVA 645 GV12QT, FVA 645 GV40QT, FVA 645 GV100QT, FVA 645 GV200QT



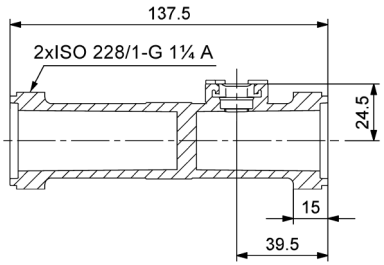
Turbine boby
FVA 645 GV12QT, FVA 645 GV40QT



Turbine boby **FVA 645 GV100QT**



Turbine boby **FVA 645 GV200Q**



Technical data

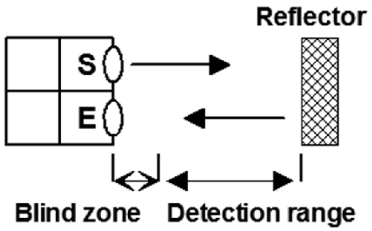
Flow measuring circuit	
Measuring principle	Pressure pulses, Kármán vortex street
Measuring range	see under variants
Accuracy FVA 645 GV12QT/40QT	±1.5 % of final value at 0 to +100 °C Water as medium Water-glycol as medium (glycol approx. 40 %) Dynamic viscosity approx. 4 mm²/s (i.e. at approx. 30 °C) ±5 % of final value
Resolution	see under variants
Response time (63%)	<1 second (<3 s for FVA 645 GV12QT)
Temperature measuring circuit	
Measuring range	0 to +100 °C
Accuracy	±1 K at +25 to +80 °C ±2 K at 0 to +100 °C
Resolution	0.5 K
Response time (63%)	<1 second under flow conditions 50% of final value
Process connection	2x male thread see under variants
Pressure	10 bar Bursting pressure >16 bar
Pressure loss	0.1 bar, typical under flow conditions 50% of final value
Suitable conditions	
Media Dynamic viscosity	Liquids FVA 645 GV12QT/40QT <4 mm²/s FVA 645 GV100QT/200QT <2 mm²/s
Temperature of medium	0 to +100 °C
Ambient temperature	-25 to +60 °C
Ambient humidity	up to 95 % RH, non-condensing
Electrical connections	
Output signal	2x 0.5 to 3.5 V
Power supply	5 VDC (±5 %), <10 mA via ALMEMO® plug
Connection	Sensor with connecting cable, 2.9 meters, and ALMEMO® plug
Insert length	see under variants
Materials (in contact with media)	Corrosion-resistant coating EPDM, PPS, PPA 40-GF
Pipe piece	Stainless steel 1.4408 Inside pipe PPA 40-GF

3.6.5 Tachometers

Measuring Principle

The optical reflection method has become the most accepted method for the measurement of revolutions of shafts, wheels, fans etc.

Retroreflective Light Barrier



With single unit retroreflective photoelectric sensors the transmitters and receivers form one single unit. The light sent by the transmitter is, by an opposite located object, reflected to the receiver. The sensor performs a switch when the reflected amount of light exceeds a specific, adjustable limit value at the receiver.

This quantity of light is depending on the size and the reflection properties of the object. When measuring revolutions, special reflective tapes should be used to increase the sensing range and to improve the signal-to-noise ratio.

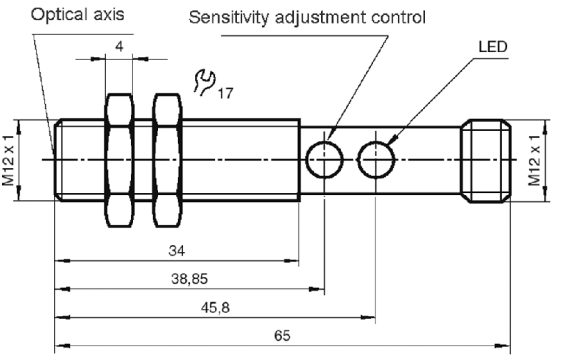
Measuring Method	Characteristics
Single unit retroreflective photoelectric sensor (DIN EN 60947: type D)	Can only detect opaque objects. The coverage depends on the reflection properties of the object, i.e. surface quality and colour. Sensitive with respect to contamination and changing reflection properties of the object(s). These influences can, within certain limits, be compensated by a sensitivity adjustment control. Easy installation as the sensor consists of only one unit and usually requires only a rough alignment.
Retroreflective Light Barrier (DIN EN 60947: type R)	Long sensing ranges and an improved signal-to-noise ratio are achieved by using retroreflectors. Low susceptibility to problems, therefore, well suited for applications with demanding operating conditions, e.g. outdoor operation or operation in contaminated environments.

ALMEMO® tachometer

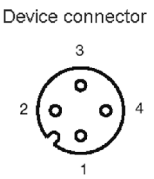
For the purposes of measuring rotational speed the spectrum of ALMEMO® sensors includes tachometer probe FU A919-2. This probe is a retroreflective photoelectric sensor; its sensitivity can be set by means of a potentiometer; this increases functional reliability. The tachometer probe is equipped with a special frequency meter module for evaluating pulses: this calculates, from the period between two pulses, the number of revolutions per minute; (see Section 4.2.9). A stable read-out is achieved by averaging over a minimum of 500 ms.
The circumference of the object should have a clear light / dark contrast. If the object has several bright sections (e.g. rotor blades) the measured rotational speed will be too high by the according amount. For pulse generation in such cases reflective marks as bright as possible (white or reflective stickers) must be used. To adjust sensitivity the potentiometer must first be completely turned down and then slowly turned up again until the LED lights up evenly and the display on the measuring instrument is stable.
The top end of the measuring range will depend on the duty factor light to dark. At a duty factor 1:1 (50%) it will reach 30000 rpm, while at 1:10 (10%) it will be accordingly lower, i.e. only 6000 rpm.

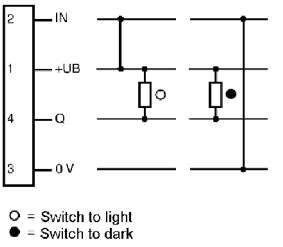
The same probe, fitted with a different frequency meter module, is also suitable for use as a photoelectric barrier, e.g. for counting purposes etc.

Dimensions of the Tachometer Probe:



Electrical connections:





Technical Data

Measurement range:	8 to 30,000rpm (maximum)
Response time:	> 1ms
Resolution:	1rpm
Accuracy:	to 15,000rpm: ± 0.02% of aver. ± 1 digit to 30,000rpm: ± 0.05% of aver. ± 1 digit
Operating distance:	20 to 200mm (depending on reflector)
Sensitivity adjustment:	via potentiometer
Detectable object:	opaque, or reflector
Distance hysteresis:	≤ 10%
Indication of operating condition:	LED yellow
Type of light (emitter LED):	visible red light 660nm
Limit of external light sources:	sunlight: ≤ 20,000 lux halogen light: ≤ 5,000 lux
Ambient temperature:	-25°C to + 55°C
Storage temperature:	-40°C to +70°C
Operating environment/Sealing:	IP 67 (according to EN 60529)
Optics:	2-lens system PC
Permissible shock load:	b ≤ 30g, T ≤ 1ms
Permissible vibratory stress:	f ≤ 55Hz, a ≤ 1mm
No-load current:	≤ 20mA
Supply voltage:	> 8.5 V DC from measuring device, power supply adapter is recommended
Connection:	Device connector M12x1 including socket M12x1, angled, with 1.5 meters cable and ALMEMO® connector
Material:	housing: brass, nickel-plated light Outlet: PMMA
Dimensions:	diameter: M12 x 1 mm length: 55 mm
Weight:	15g
Conformity to standards:	EN 60 947-5-2