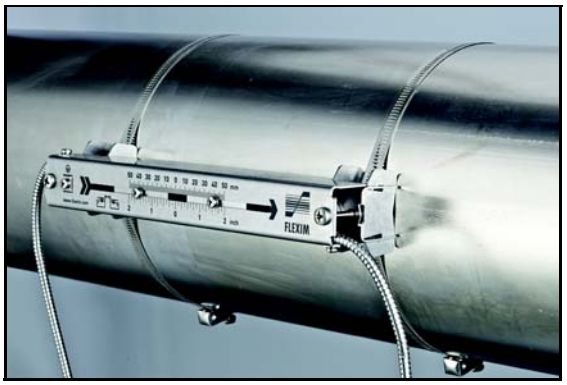
## Process Analysis and Flow Measurement with Ultrasound

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

### Features

- Non-invasive measurement using the clamp-on technology
- Precise bi-directional, highly dynamic flow measurement
- Determination of concentration, density, degree of conversion or other qualitative material properties from the measured sound velocity and medium temperature
- Optional PIOX SM: determination of mass flow and mass
- No contact with the medium, no special materials required, hygienic measurement, suitable for ultra clean media
- Ideal for aggressive, toxic or abrasive media
- FM approved transducers for hazardous areas available
- Maintenance free measurement, no wear
- Transducers available for a wide range of inner pipe diameters (0.25 to 256 in)
- Fluid temperatures -40 to +392 °F




Measurement with transducers mounted by PermaRail

Transmitter PIOX TS374

### Applications

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


Transmitter PIOX TS379

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# Function

## Measuring Principle

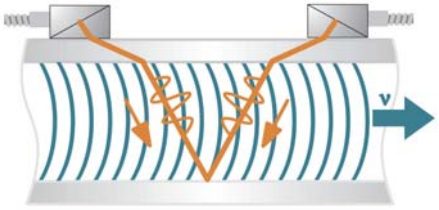
### Transit Time Difference Principle

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 one side of a pipe, reflected by the opposite pipe wall and received by a second transducer. These signals are emitted alternately in the flow direction and against it.

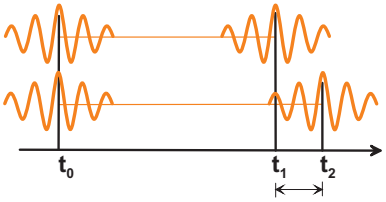
As the medium in which the signals propagate is flowing, the transit time of the ultrasonic signals in the flow direction is shorter than against the flow direction.

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.




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 |

## Calculation of Sound Velocity

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

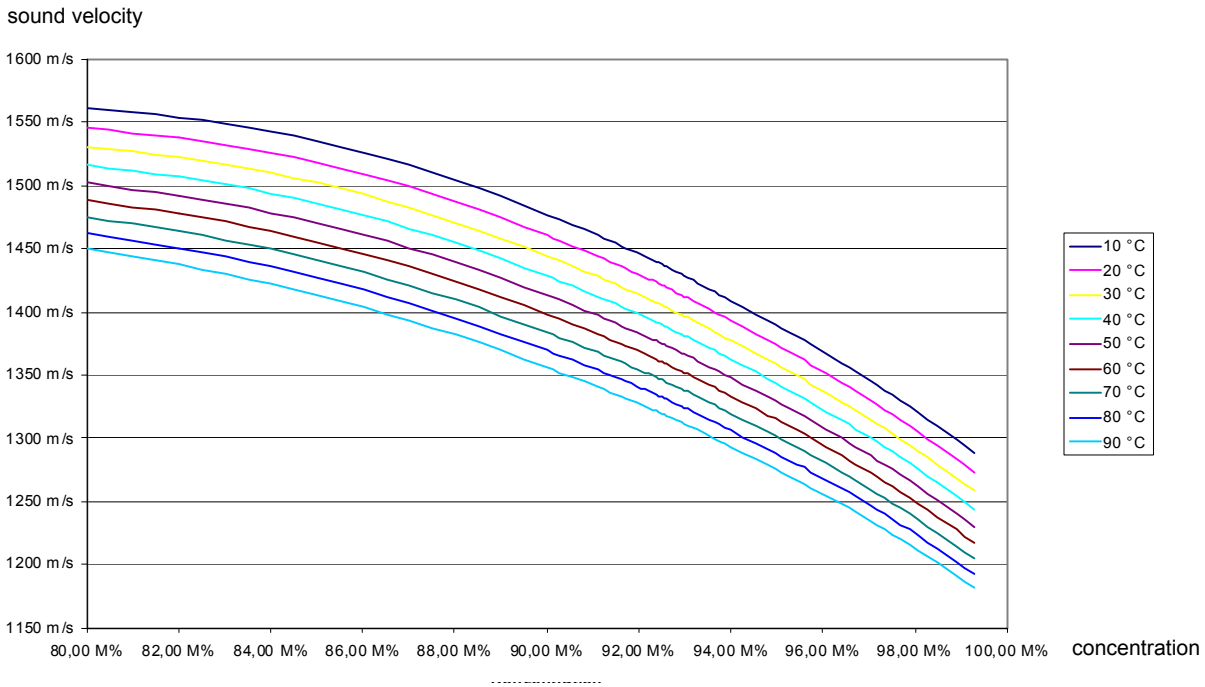
where:

$c_{fl}$ = sound velocity in the medium
$l_{fl}$ = path of the ultrasonic signal in the medium
$t_1$, $t_2$ = transit time in the medium
$t_p$ = transit time in the transducer and in the pipe wall

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

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

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




Example for the dependency of the sound velocity of sulfuric acid from concentration and temperature

## Calculation of Mass Flow (optional)

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

$\rho = f(K, T)$

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

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

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

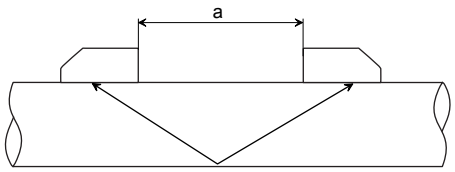
## Number of Sound Paths

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

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

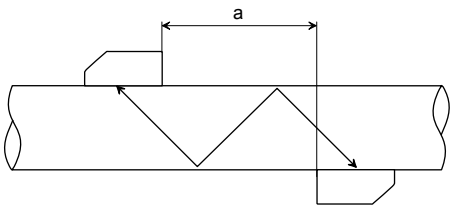
The preferred method of installation depends on the application. While increasing the number of sound paths increases the accuracy of the measurement, signal attenuation increases as well. The optimum number of sound paths for the parameters of the application will be detemined automatically by the transmitter.

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

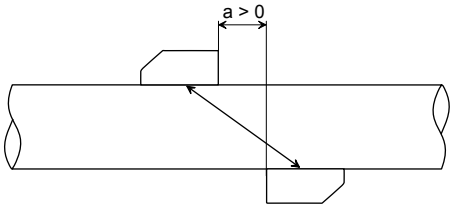



Reflection mode, number of sound paths: 2

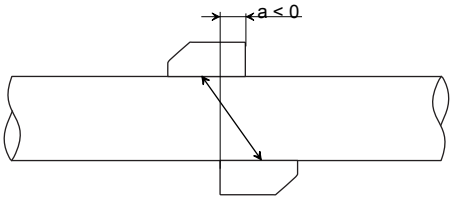
a = transducer distance




Diagonal mode, number of sound paths: 3

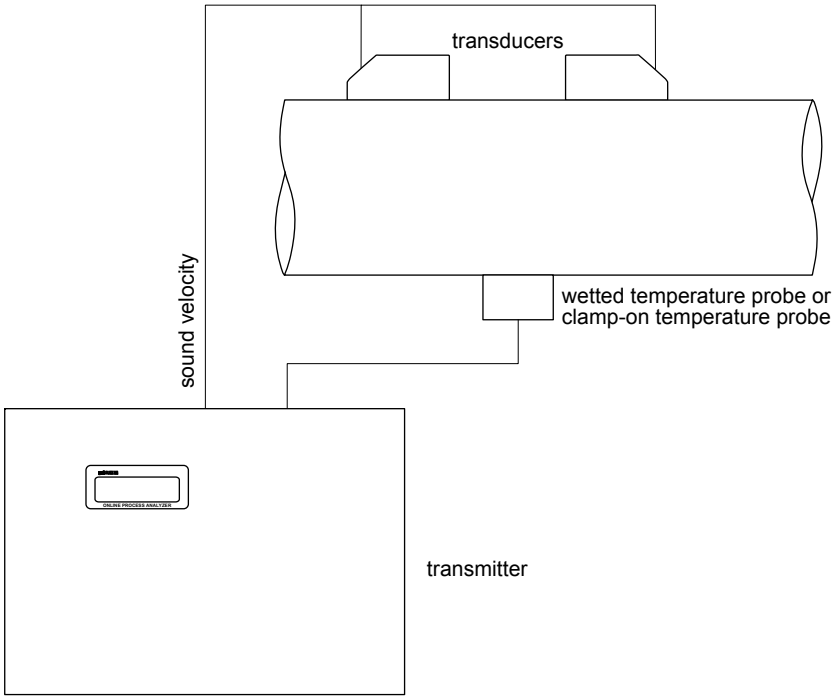



Direct mode, number of sound paths: 1




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

## Typical Measurement Setup




Example of a concentration measurement with clamp-on transducers

# Transmitter

## Technical Data

| PIOX S, PIOX SM | TS374 | TS379 |
|---|---|---|
| design | standard field device | 19 " module |
| |  |  |
| **measurement** | | |
| measurement principle | transit time difference correlation principle | |
| flow velocity<br>- range<br>- repeatability<br>- accuracy[1]<br>- with standard calibration<br>- with extended calibration (optional)<br>- with field calibration[2] | <br>0.03 to 82 ft/s<br>0.15 % of reading ±0.03 ft/s<br><br>±1.6 % of reading ±0.03 ft/s<br>±1.2 % of reading ±0.03 ft/s<br><br>±0.5 % of reading ±0.03 ft/s | |
| sound velocity<br>- range<br>- resolution<br>- repeatability<br>- accuracy | <br>300 to 3000 m/s<br>±0.03 ft/s<br>0.15 % of reading ±0.03 ft/s<br>0.25 % of reading ±0.33 ft/s | |
| medium | all acoustically conductive liquids with < 10 % gaseous or solid content in volume | |
| temperature compensation | corresponding to the recommendations in ANSI/ASME MFC-5M-1985 | |
| **transmitter** | | |
| power supply | 100 to 240 V/50 to 60 Hz or<br>20 to 32 V DC | |
| power consumption | < 15 W | |
| number of flow measuring channels | 1, optional: 2 | |
| signal attenuation | 0 to 100 s, adjustable | |
| measuring cycle (1 channel) | 100 to 1000 Hz | |
| response time | 1 s (1 channel), optional: 70 ms | |
| housing material | aluminum, powder coated | aluminum |
| degree of protection | NEMA 4 | NEMA 1 |
| dimensions | see dimensional drawing | 42HP x 3U<br>(without back panel)<br>see dimensional drawing |
| weight | 6.2 lb | 3.8 lb |
| fixation | wall mounting, optional: 2 " pipe mounting | 19 " rack mounting |
| operating temperature | -4 to +140 °F | |
| display | 2 x 16 characters, dot matrix, backlight | |
| menu language | English, German, French, Dutch, Spanish | |
| explosion protection | Class I Div. 2 (optional, on request) | - |
| **measuring functions** | | |
| physical quantities | volumetric flow rate, flow velocity, concentration, degree of conversion, Brix<br>PIOX SM: additionally mass flow rate, density<br>others on request | |
| totalizer | volume<br>PIOX SM: additionally mass | |
| calculation functions | average, difference, sum<br>(2 measuring channels necessary) | |
| diagnostic functions | sound velocity, signal amplitude, SNR, SCNR, standard deviation of amplitudes and transit times | |

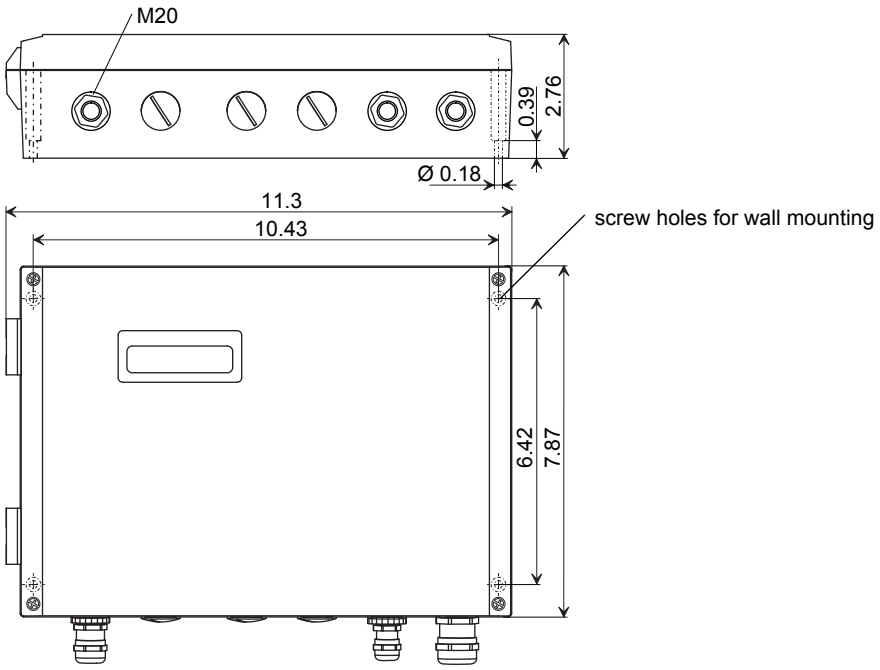
[1] for reference conditions and v > 0.49 ft/s

[2] reference uncertainty < 0.2 %

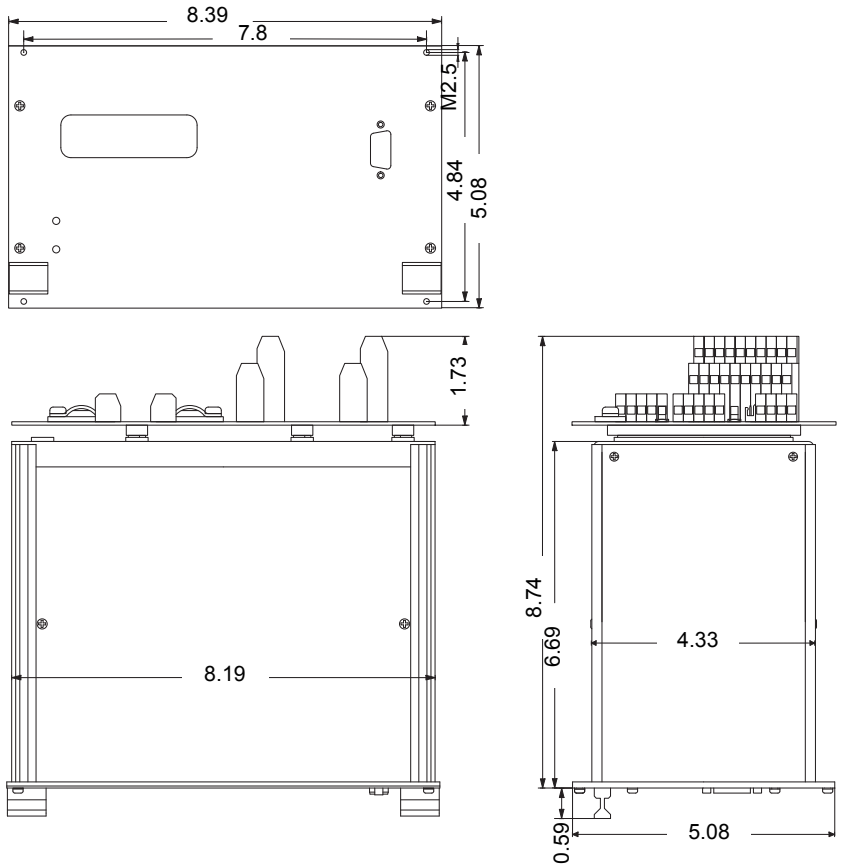
| PIOX S, PIOX SM | TS374 | TS379 |
|---|---|---|
| **data logger** | | |
| loggable values | all physical quantities, totalized values and diagnostic values | |
| capacity | > 100 000 measured values | |
| **communication** | | |
| interface | - process integration: optional: RS485<br>- diagnosis: RS232 | |
| **serial data kit (optional)** | | |
| software (all Windows™ versions) | - FluxData: download of measurement data, graphical presentation, conversion to other formats (e.g. for Excel™)<br>- FluxKoef: creating medium data sets | |
| cable | RS232 | |
| adapter | RS232 - USB | |
| **outputs (optional)** | | |
| | The outputs are galvanically isolated from the transmitter. | |
| number | on request | |
| | **current output** | |
| range | 0/4 to 20 mA | |
| accuracy | 0.1 % of reading ±15 µA | |
| active output | $R_{ext}$ < 500 Ω | |
| passive output | $U_{ext}$ = 4 to 24 V, depending on $R_{ext}$, $R_{ext}$ < 1 kΩ | |
| | **voltage output** | |
| range | 0 to 1 V or 0 to 10 V | |
| accuracy | 0 to 1 V: 0.1 % of reading ±1 mV<br>0 to 10 V: 0.1 % of reading ±10 mV | |
| internal resistance | $R_i$ = 500 Ω | |
| | **frequency output** | |
| range | 0 to 5 kHz | |
| open collector | 24 V/4 mA | |
| | **binary output** | |
| Reed relay | - | 48 V/0.25 A |
| open collector | - | 24 V/4 mA |
| optorelay | 26 V/100 mA | - |
| binary output as alarm output | | |
| - functions | limit, change of flow direction or error | limit, change of flow direction or error |
| binary output as pulse output | | |
| - pulse value | 0.01 to 1000 units | 0.01 to 1000 units |
| - pulse width | 1 to 1000 ms | 80 to 1000 ms |
| **inputs** | | |
| | The inputs are galvanically isolated from the transmitter. | |
| number | max. 4, on request<br>concentration measurement: min. 1 input for medium temperature necessary | |
| | **temperature input** | |
| type | Pt100/Pt1000 | |
| connection | 4-wire | |
| range | -238 to +1040 °F | |
| resolution | 0.01 K | |
| accuracy | ±0.01 % of reading ±0.03 K | |
| | **current input** | |
| accuracy | 0.1 % of reading ±10 µA | 0.1 % of reading ±10 µA |
| active input | $U_i$ = 24 V, $R_i$ = 50 Ω, $P_i$ < 0.5 W, not short-circuit proof | $U_i$ = 15 V, $R_i$ = 50 Ω, $P_i$ < 0.5 W, not short-circuit proof |
| - range | 0 to 20 mA | 0 to 20 mA |
| passive input | $R_i$ = 50 Ω, $P_i$ < 0.3 W | $R_i$ = 50 Ω, $P_i$ < 0.3 W |
| - range | -20 to +20 mA | -20 to +20 mA |
| | **voltage input** | |
| range | 0 to 1 V | |
| accuracy | 0.1 % of reading ±1 mV | |
| internal resistance | $R_i$ = 1 MΩ | |

## Dimensions

**PIOX TS374**



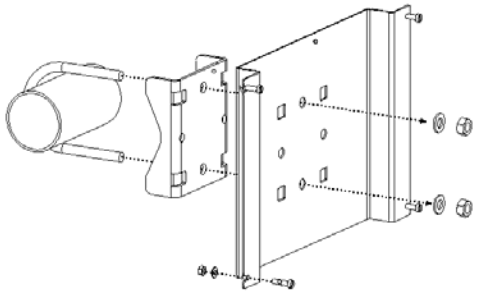

**PIOX TS379**

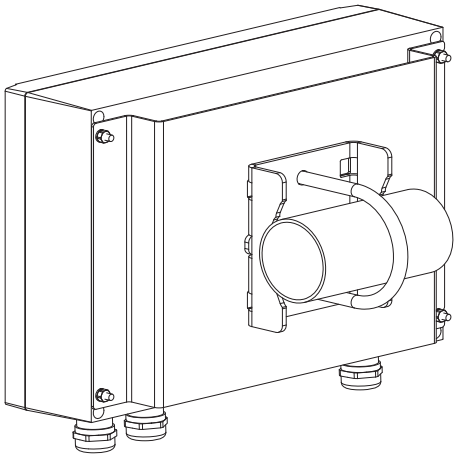



in inch

## 2 " Pipe Mounting Kit (optional)

**PIOX TS374**

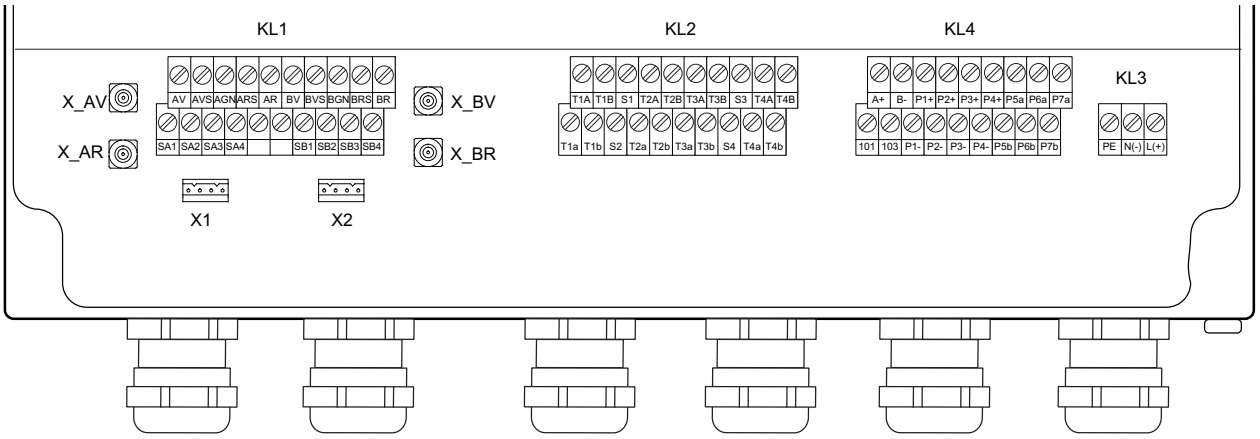




for vertical and horizontal pipes

## Terminal Assignment

### PIOX S TS374




#### power supply

terminal strip KL3

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

#### transducers

terminal strip KL1

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

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

#### outputs[2]

terminal strip KL4

| terminal | connection |
|---|---|
| P1+ to P4+, P1- to P4- | current output, voltage output, frequency output or binary output (optorelay) |
| P5a to P7a, P5b to P7b | binary output (optorelay) |

#### RS485 (optional)

terminal strip KL4

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

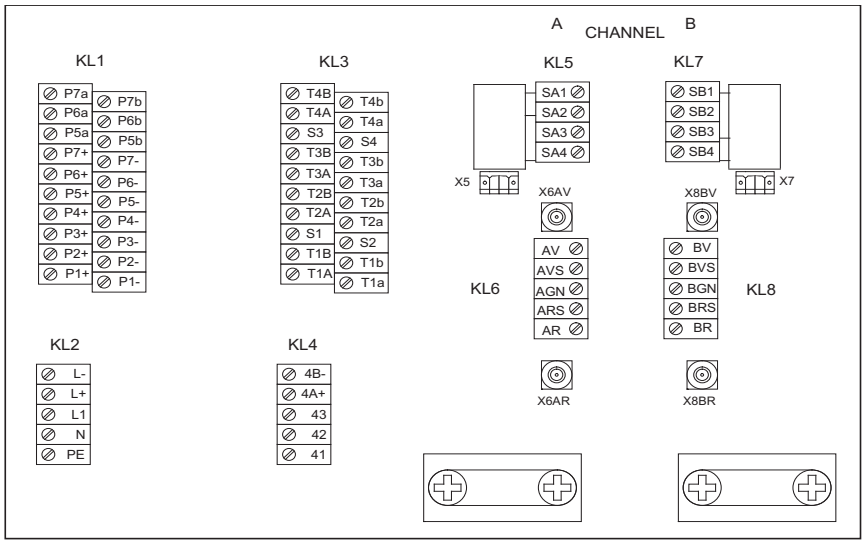
#### inputs[2]

terminal strip KL2

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

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

**PIOX S TS379**




### power supply

terminal strip KL2

| terminal | connection AC | terminal | connection DC |
|---|---|---|---|
| PE | earth | PE | earth |
| N | neutral | L- | DC- |
| L1 | phase | L+ | DC+ |

### transducers

terminal strip KL6, KL8

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

### outputs[2]

terminal strip KL1

| terminal | connection |
|---|---|
| P1+ to P7+, P1- to P7- | current output, voltage output, frequency output or binary output (open collector) |
| P5a to P7a, P5b to P7b | binary output (Reed relay) |

### RS485 (optional)

terminal strip KL4

| terminal | connection |
|---|---|
| 4A+ | signal + |
| 4B- | signal - |
| 43 | shield |

### inputs[2]

terminal strip KL2

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

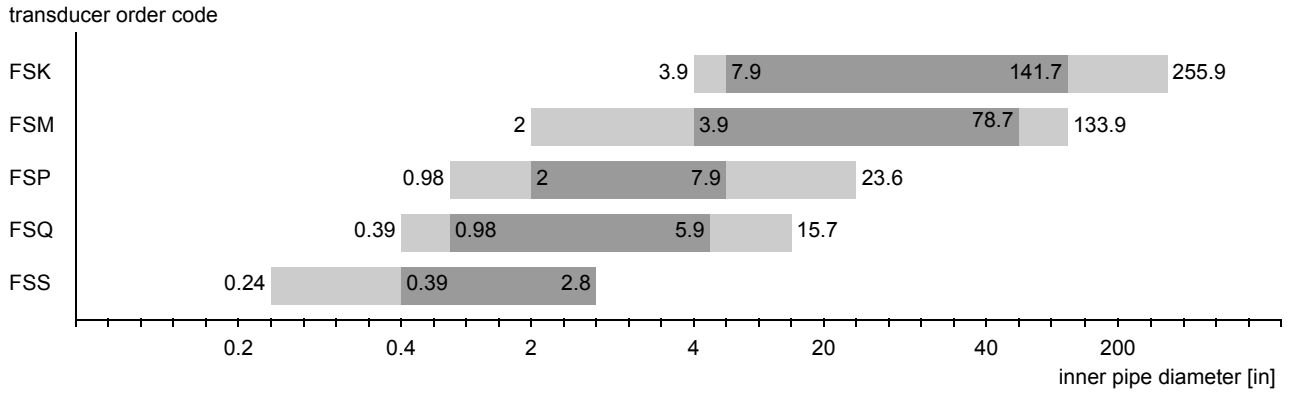
[2] The number, type and terminal assignment of the outputs and inputs will be customized.

# Transducers

## Transducer Selection

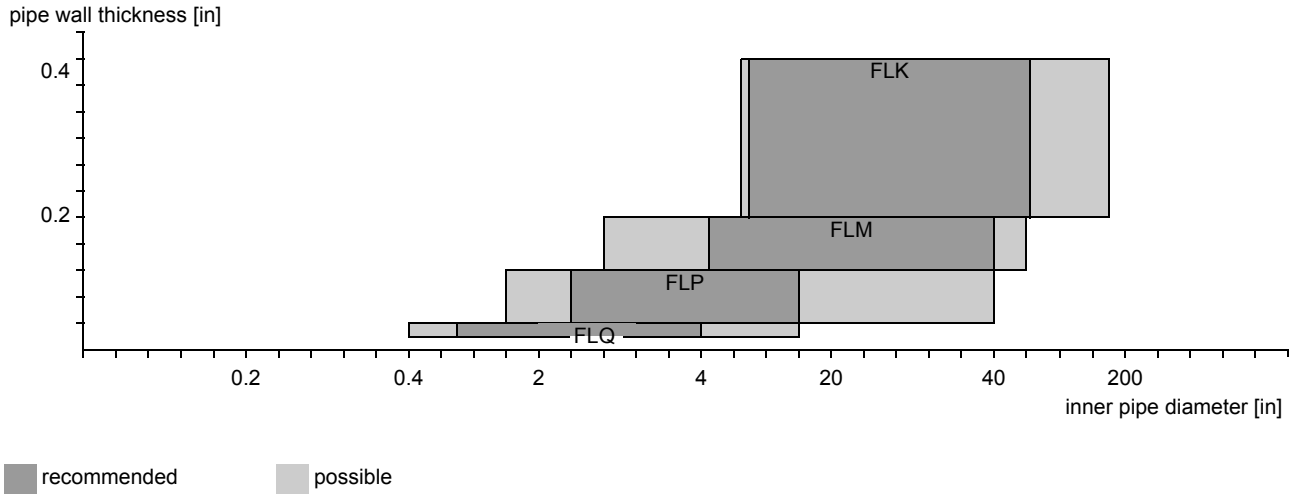
### Shear Wave Transducers

Shear wave transducers are preferred for standard applications.




### Lamb Wave Transducers

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

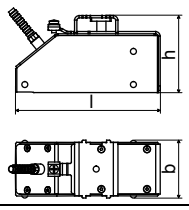
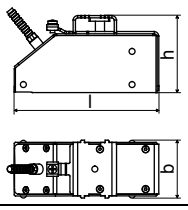
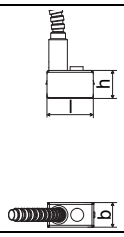


## Transducer Order Code

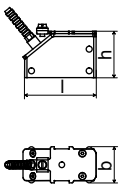
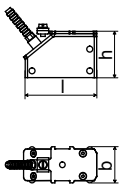
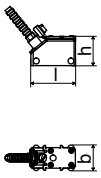
| 1, 2 | 3 | | 4 | 5, 6 | 7, 8 | | 9 to 11 | | 12, 13 | no. of character |
|---|---|---|---|---|---|---|---|---|---|---|
| transducer | transducer frequency | - | operating temperature | explosion protection | connection system | - | extension cable | / | option | description |
| FS | | | | | | | | | | set of ultrasonic flow transducers, shear wave |
| FL | | | | | | | | | | set of ultrasonic flow transducers, Lamb wave |
| | K | | | | | | | | | 0.5 MHz |
| | M | | | | | | | | | 1 MHz |
| | P | | | | | | | | | 2 MHz |
| | Q | | | | | | | | | 4 MHz |
| | S | | | | | | | | | 8 MHz (shear wave only) |
| | | | N | | | | | | | normal temperature range |
| | | | E | | | | | | | extended temperature range (shear wave transducers with transducer frequency M, P, Q) |
| | | | | F2 | | | | | | FM Class I Div. 2 |
| | | | | NN | | | | | | not explosion proof |
| | | | | | TS | | | | | direct connection or connection via junction box |
| | | | | | | | XXX | | | cable length in m, for max. length of extension cable see page 24<br>0 m: without junction box<br>> 0 m: with junction box JB03 or JBP3 (transducers NEMA 6P) |
| | | | | | | | | | LC | long transducer cable (only FSK) |
| | | | | | | | | | IP68 | degree of protection NEMA6P |
| | | | | | | | | | OS | housing with stainless steel 316 |
| example | | | | | | | | | | |
| FS | M | - | N | F2 | TS | - | 030 | | | shear wave transducer 1 MHz, normal temperature range, FM Class I Div. 2, connection system TS with junction box JB03 and extension cable 30 m (98 ft) |
| | | - | | | | - | | / | | |

# Technical Data

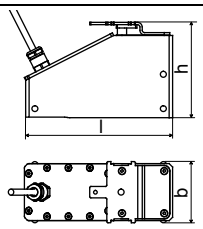
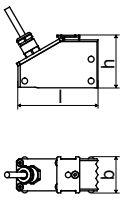
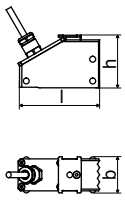
## Shear Wave Transducers (FM or without explosion protection)

| technical type | | CDK1N52 | CLK1N52 | CDS1N52 |
|---|---|---|---|---|
| order code | | **FSK-NF2TS<br>FSK-NF2TS/OS<br>FSK-NNNTS<br>FSK-NNNTS/OS** | **FSK-NF2TS/LC<br>FSK-NF2TS/LC/OS<br>FSK-NNNTS/LC<br>FSK-NNNTS/LC/OS** | **FSS-NF2TS<br>FSS-NNNTS** |
| transducer frequency | MHz | 0.5 | 0.5 | 8 |
| **inner pipe diameter d** | | | | |
| min. extended | in | 3.9 | 3.9 | 0.24 |
| min. recommended | in | 7.9 | 7.9 | 0.39 |
| max. recommended | in | 141.7 | 141.7 | 2.8 |
| max. extended | in | 255.9 | 255.9 | 2.8 |
| **pipe wall thickness** | | | | |
| min. | in | - | - | - |
| max. | in | - | - | - |
| **material** | | | | |
| housing<br><br>contact surface | | PEEK with stainless steel cap 304, option OS: 316L<br>PEEK | PEEK with stainless steel cap 304, option OS: 316L<br>PEEK | stainless steel 304<br><br>PEI |
| degree of protection | | NEMA 6 | NEMA 6 | NEMA 4 |
| **transducer cable** | | | | |
| type | | 1699 | 1699 | 1699 |
| length | ft | 16 | 29 | 6 |
| **dimensions** | | | | |
| length l | in | 4.98 | 4.98 | 0.98 |
| width b | in | 2.01 | 1.85 | 0.51 |
| height h | in | 2.66 | 2.2 | 0.67 |
| dimensional drawing | |  |  |  |
| **operating temperature** | | | | |
| min. | °F | -40 | -40 | -22 |
| max. | °F | +266 | +266 | +266 |
| temperature compensation | | x | x | x |
| **explosion protection** | | | | |
| **FM** transducer | | FSK-NF2TS<br>FSK-NF2TS/OS | FSK-NF2TS/LC<br>FSK-NF2TS/LC/OS | FSS-NF2TS |
| **explosion protection temperature** | | | | |
| min. | °F | -40 | -40 | -40 |
| max. | °F | +257 | +257 | +257 |
| marking | | NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860 | NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860 | NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860 |
| type of protection | | non incendive | non incendive | non incendive |

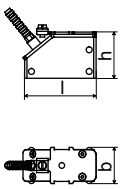
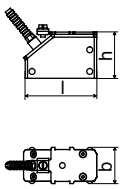
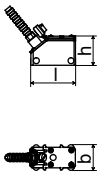
## Shear Wave Transducers (FM or without explosion protection)

| technical type | | CDM2N52 | CDP2N52 | CDQ2N52 |
|---|---|---|---|---|
| order code | | **FSM-NF2TS**<br>**FSM-NF2TS/OS**<br>**FSM-NNNTS**<br>**FSM-NNNTS/OS** | **FSP-NF2TS**<br>**FSP-NF2TS/OS**<br>**FSP-NNNTS**<br>**FSP-NNNTS/OS** | **FSQ-NF2TS**<br>**FSQ-NF2TS/OS**<br>**FSQ-NNNTS**<br>**FSQ-NNNTS/OS** |
| transducer frequency | MHz | 1 | 2 | 4 |
| **inner pipe diameter d** | | | | |
| min. extended | in | 2 | 0.98 | 0.39 |
| min. recommended | in | 3.9 | 2 | 0.98 |
| max. recommended | in | 78.7 | 7.9 | 5.9 |
| max. extended | in | 133.9 | 23.6 | 15.7 |
| **pipe wall thickness** | | | | |
| min. | in | - | - | - |
| max. | in | - | - | - |
| **material** | | | | |
| housing<br><br>contact surface | | PEEK with stainless steel cap 304, option OS: 316L<br>PEEK | PEEK with stainless steel cap 304, option OS: 316L<br>PEEK | PEEK with stainless steel cap 304, option OS: 316L<br>PEEK |
| degree of protection | | NEMA 6 | NEMA 4 | NEMA 4 |
| **transducer cable** | | | | |
| type | | 1699 | 1699 | 1699 |
| length | ft | 13 | 13 | 9 |
| **dimensions** | | | | |
| length l | in | 2.46 | 2.46 | 1.54 |
| width b | in | 1.26 | 1.26 | 0.87 |
| height h | in | 1.59 | 1.59 | 1 |
| dimensional drawing | |  |  |  |
| **operating temperature** | | | | |
| min. | °F | -40 | -40 | -40 |
| max. | °F | +266 | +266 | +266 |
| temperature compensation | | x | x | x |
| **explosion protection** | | | | |
| **FM** transducer | | FSM-NF2TS<br>FSM-NF2TS/OS | FSP-NF2TS<br>FSP-NF2TS/OS | FSQ-NF2TS<br>FSQ-NF2TS/OS |
| **explosion protection temperature** | | | | |
| **FM** min. | °F | -67 | -67 | -67 |
| **FM** max. | °F | +374 | +374 | +374 |
| **FM** marking | | NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860 | NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860 | NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860 |
| **FM** type of protection | | non incendive | non incendive | non incendive |

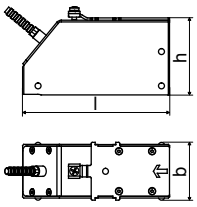
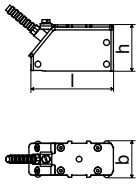
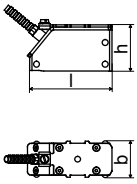
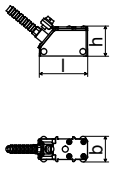
## Shear Wave Transducers (without explosion protection, NEMA 6P)

| technical type | | CDK1LI8 | CDM2LI8 | CDP2LI8 |
|---|---|---|---|---|
| order code | | **FSK-NNNTS/IP68** | **FSM-NNNTS/IP68** | **FSP-NNNTS/IP68** |
| transducer frequency | MHz | 0.5 | 1 | 2 |
| **inner pipe diameter d** | | | | |
| min. extended | in | 3.9 | 2 | 0.98 |
| min. recommended | in | 7.9 | 3.9 | 2 |
| max. recommended | in | 141.7 | 78.7 | 7.9 |
| max. extended | in | 255.9 | 133.9 | 23.6 |
| **pipe wall thickness** | | | | |
| min. | in | - | - | - |
| max. | in | - | - | - |
| **material** | | | | |
| housing<br><br>contact surface | | PEEK with stainless steel cap 316Ti<br>PEEK | PEEK with stainless steel cap 316Ti<br>PEEK | PEEK with stainless steel cap 316Ti<br>PEEK |
| degree of protection | | NEMA 6P | NEMA 6P | NEMA 6P |
| **transducer cable** | | | | |
| type | | 2550 | 2550 | 2550 |
| length | ft | 39 | 39 | 39 |
| **dimensions** | | | | |
| length l | in | 5.06 | 2.76 | 2.76 |
| width b | in | 2.13 | 1.26 | 1.26 |
| height h | in | 3.29 | 1.81 | 1.81 |
| dimensional drawing | |  |  |  |
| **operating temperature** | | | | |
| min. | °F | -40 | -40 | -40 |
| max. | °F | +212 | +212 | +212 |
| temperature compensation | | x | x | x |

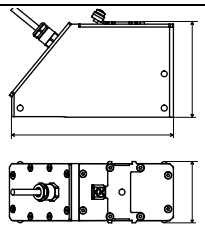
## Shear Wave Transducers (extended temperature range, FM or without explosion protection)

| technical type | | CDM2E52 | CDP2E52 | CDQ2E52 |
|---|---|---|---|---|
| order code | | **FSM-EF2TS<br>FSM-EF2TS/OS<br>FSM-ENNTS<br>FSM-ENNTS/OS** | **FSP-EF2TS<br>FSP-EF2TS/OS<br>FSP-ENNTS<br>FSP-ENNTS/OS** | **FSQ-EF2TS<br>FSQ-EF2TS/OS<br>FSQ-ENNTS<br>FSQ-ENNTS/OS** |
| transducer frequency | MHz | 1 | 2 | 4 |
| **inner pipe diameter d** | | | | |
| min. extended | in | 2 | 0.98 | 0.39 |
| min. recommended | in | 3.9 | 2 | 0.98 |
| max. recommended | in | 78.7 | 7.9 | 5.9 |
| max. extended | in | 133.9 | 23.6 | 15.7 |
| **pipe wall thickness** | | | | |
| min. | in | - | - | - |
| max. | in | - | - | - |
| **material** | | | | |
| housing<br><br>contact surface | | PI with stainless steel cap 304, option OS: 316L<br>PI | PI with stainless steel cap 304, option OS: 316L<br>PI | PI with stainless steel cap 304, option OS: 316L<br>PI |
| degree of protection | | NEMA 4 | NEMA 4 | NEMA 4 |
| **transducer cable** | | | | |
| type | | 6111 | 6111 | 6111 |
| length | ft | 13 | 13 | 9 |
| **dimensions** | | | | |
| length l | in | 2.46 | 2.46 | 1.54 |
| width b | in | 1.26 | 1.26 | 0.87 |
| height h | in | 1.59 | 1.59 | 1 |
| dimensional drawing | |  |  |  |
| **operating temperature** | | | | |
| min. | °F | -22 | -22 | -22 |
| max. | °F | +392 | +392 | +392 |
| temperature compensation | | x | x | x |
| **FM** transducer | | FSM-EF2TS<br>FSM-EF2TS/OS | FSP-EF2TS<br>FSP-EF2TS/OS | FSQ-EF2TS<br>FSQ-EF2TS/OS |
| **explosion protection temperature** | | | | |
| **FM** min. | °F | -49 | -49 | -49 |
| **FM** max. | °F | +455 | +455 | +455 |
| **FM** marking | | NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860 | NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860 | NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860 |
| **FM** type of protection | | non incendive | non incendive | non incendive |

## Lamb Wave Transducers (FM or not explosion proof)

| technical type | | CRK1N52 | CRM1N52 | CRP1N52 | CRQ1N52 |
|---|---|---|---|---|---|
| order code | | **FLK-NF2TS**<br>**FLK-NF2TS/OS**<br>**FLK-NNNTS**<br>**FLK-NNNTS/OS** | **FLM-NF2TS**<br>**FLM-NF2TS/OS**<br>**FLM-NNNTS**<br>**FLM-NNNTS/OS** | **FLP-NF2TS**<br>**FLP-NF2TS/OS**<br>**FLP-NNNTS**<br>**FLP-NNNTS/OS** | **FLQ-NF2TS**<br>**FLQ-NF2TS/OS**<br>**FLQ-NNNTS**<br>**FLQ-NNNTS/OS** |
| transducer frequency | MHz | 0.5 | 1 | 2 | 4 |
| **inner pipe diameter d** | | | | | |
| min. extended | in | 8.7 | 2.8 | 1.6 | 0.39 |
| min. recommended | in | 9.8 | 4.7 | 2.4 | 0.98 |
| max. recommended | in | 82.7 | 39.4 | 15.7 | 3.9 |
| max. extended | in | 177.2 | 78.7 | 39.4 | 15.7 |
| **pipe wall thickness** | | | | | |
| min. | in | 0.2 | 0.12 | 0.04 | 0.02 |
| max. | in | 0.43 | 0.2 | 0.12 | 0.04 |
| **material** | | | | | |
| housing | | PPSU with stainless steel cap 304, option OS: 316L | PPSU with stainless steel cap 304, option OS: 316L | PPSU with stainless steel cap 304, option OS: 316L | PPSU with stainless steel cap 304, option OS: 316L |
| contact surface | | PPSU | PPSU | PPSU | PPSU |
| degree of protection | | NEMA 6 | NEMA 4 | NEMA 4 | NEMA 4 |
| **transducer cable** | | | | | |
| type | | 1699 | 1699 | 1699 | 1699 |
| length | ft | 16 | 13 | 13 | 9 |
| **dimensions** | | | | | |
| length l | in | 5.06 | 2.91 | 2.91 | 1.65 |
| width b | in | 2.01 | 1.26 | 1.26 | 0.87 |
| height h | in | 2.66 | 1.59 | 1.59 | 1 |
| dimensional drawing | |  |  |  |  |
| **operating temperature** | | | | | |
| min. | °F | -40 | -40 | -40 | -40 |
| max. | °F | +338 | +338 | +338 | +338 |
| temperature compensation | | x | x | x | x |
| **explosion protection** | | | | | |
| **FM** transducer | | **F**LK-NF2TS<br>**F**LK-NF2TS/OS | **F**LM-NF2TS<br>**F**LM-NF2TS/OS | **F**LP-NF2TS<br>**F**LP-NF2TS/OS | **F**LQ-NF2TS<br>**F**LQ-NF2TS/OS |
| **explosion protection temperature** | | | | | |
| min. | °F | -40 | +67 | +67 | +67 |
| max. | °F | +329 | +329 | +329 | +329 |
| marking | | NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860 | NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860 | NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860 | NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860 |
| type of protection | | non incendive | non incendive | non incendive | non incendive |

## Lamb Wave Transducers (not explosion proof, NEMA 6P)

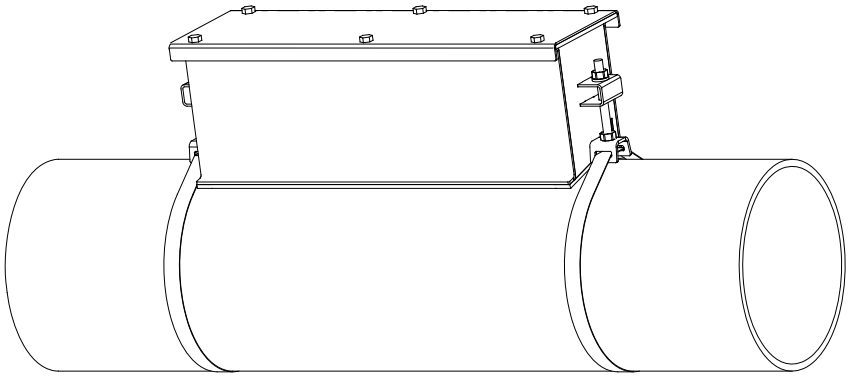
| technical type | | CRK1LI8 |
|---|---|---|
| order code | | **FLK-NNNTS/IP68** |
| transducer frequency | MHz | 0.5 |
| **inner pipe diameter d** | | |
| min. extended | in | 8.7 |
| min. recommended | in | 9.8 |
| max. recommended | in | 82.7 |
| max. extended | in | 177.2 |
| **pipe wall thickness** | | |
| min. | in | 0.2 |
| max. | in | 0.43 |
| **material** | | |
| housing | | PPSU with stainless steel cap 316Ti |
| contact surface | | PPSU |
| degree of protection | | NEMA 6P |
| **transducer cable** | | |
| type | | 2550 |
| length | ft | 39 |
| **dimensions** | | |
| length l | in | 5.65 |
| width b | in | 2.13 |
| height h | in | 3.29 |
| dimensional drawing | |  |
| **operating temperature** | | |
| min. | °F | -40 |
| max. | °F | +212 |
| temperature compensation | | x |

## Transducer Mounting Fixture

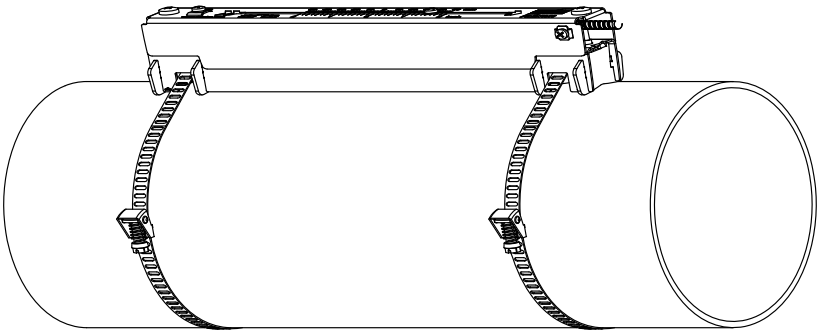
## Order Code

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

## PermaLok PL



## PermaRail VL



material: stainless steel 304, 301
option OS: 316, 316L, 17-7PH

inner length:
**VLK**: 13.7 in,
option IP68: 14.5 in
**VLM**: 9.2 in
**VLQ**: 6.9 in

dimensions:
**VLK**: 16.65 x 3.54 x 3.66 in,
option IP68: 17.44 x 3.7 x 4.13 in
**VLM**: 12.17 x 2.24 x 2.48 in
**VLQ**: 9.72 x 1.69 x 1.85 in

## Coupling Materials for Transducers

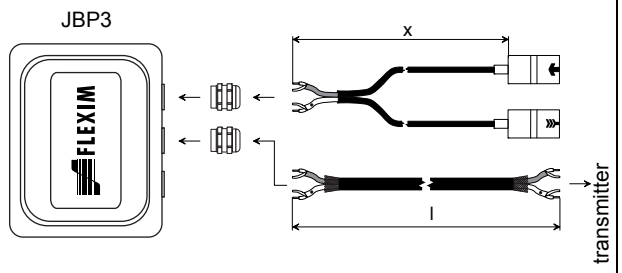
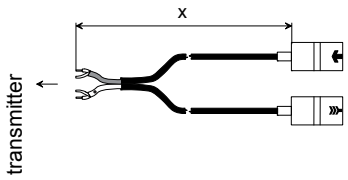
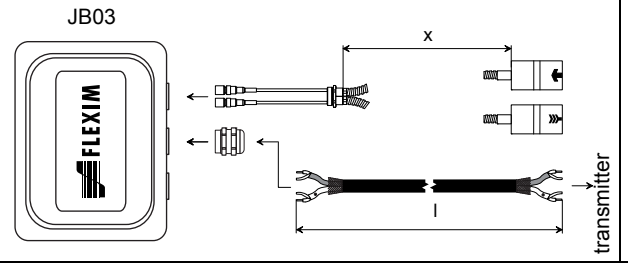
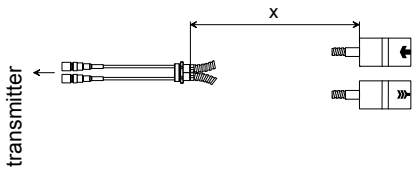
| | | **normal temperature range (4th character of transducer order code = N)** | | **extended temperature range (4th character of transducer order code = E)** | |
|---|---|---|---|---|---|
| | | < 212 °F | 212 to 338 °F | < 302 °F | 302 to 392 °F |
| < 2 h | | coupling compound type N | coupling compound type E | coupling compound type E | coupling compound type E or H |
| < 24 h | | coupling compound type N | coupling compound type E | coupling compound type E | coupling foil type VT |
| long time measure-ment | indoor | coupling compound type N | coupling compound type E | coupling foil type VT[1] | coupling foil type VT[2] |
| | outdoor | coupling foil type VT | coupling foil type VT | coupling foil type VT[1] | coupling foil type VT[2] |

[1] < 5 years
[2] < 6 months

## Technical Data

| **type** | **order code** | **operating temperature** °F | **material** | **remark** |
|---|---|---|---|---|
| coupling compound type N | 990739-1 | -22 to +266 | mineral grease paste | |
| coupling compound type E | 990739-2 | -22 to +392 | silicone paste | |
| coupling compound type H | 990739-3 | -22 to +482 | fluoropolymer paste | |
| coupling foil type VT | 990739-0 | 14 to 302, short-time peak max. 392 | 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 |

## Connection Systems

| connection system TS | | |
|---|---|---|
| connection with extension cable | direct connection | transducers |
|  |  | technical type:<br>****LI* |
|  |  <br>(only TS374) | technical type:<br>*****52 |

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

x, y = transducer cable length

l = max. length of extension cable

## Transducer Cable

### Technical Data

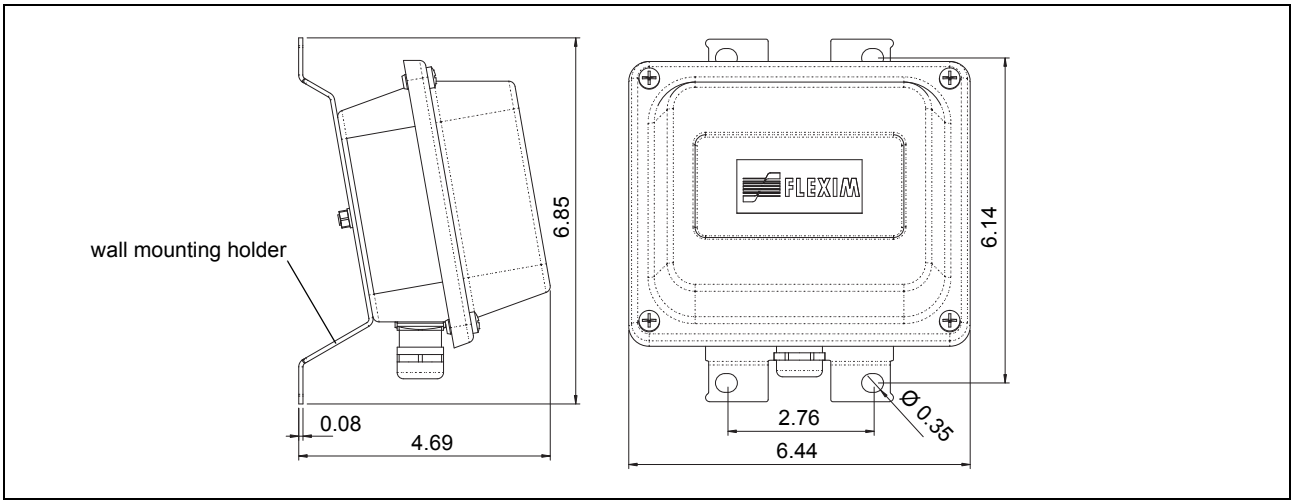
| | | transducer cable | | | extension cable |
|---|---|---|---|---|---|
| type | | 1699 | 2550 | 6111 | 2615 |
| standard length | ft | see table above | 39 | see table above | - |
| max. length | ft | - | - | - | see table above |
| operating temperature | °F | -67 to +392 | -40 to +212 | -148 to +437 | -40 to +158 |
| properties | | | longitudinal water tight | | halogen free<br>fire propagation test according to IEC 60332-1<br>combustion test according to IEC 60754-2 |
| **sheath** | | | | | |
| material | | stainless steel 304<br>option OS: 316L | - | stainless steel 304<br>option OS: 316L | - |
| outer diameter | in | 0.31 | - | 0.31 | - |
| **cable jacket** | | | | | |
| material | | PTFE | PUR | PFA | PUR |
| outer diameter | in | 0.11 | 0.2 ±0.01 | 0.11 | 0.47 |
| thickness | in | 0.01 | 0.04 | 0.02 | 0.08 |
| color | | brown | gray | white | black |
| shield | | x | x | x | x |

# Junction Box

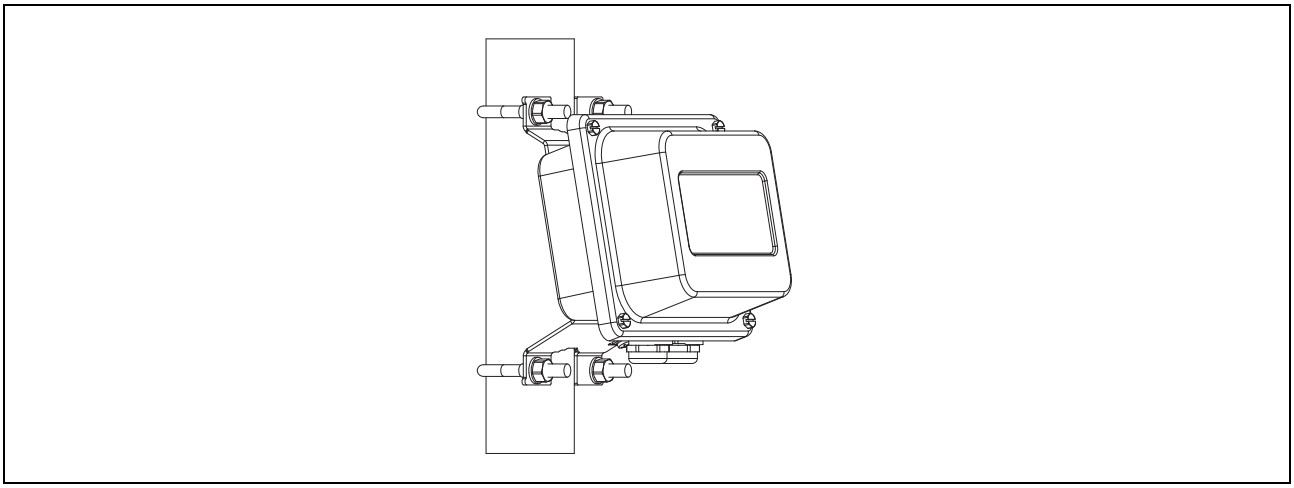
## Technical Data

| technical type | | JB03 | JBP3 |
|---|---|---|---|
| dimensions | | see dimensional drawing | see dimensional drawing |
| fixation | | wall mounting, optional: 2 " pipe mounting | wall mounting, optional: 2 " pipe mounting |
| **material** | | | |
| housing<br><br>gasket | | stainless steel 304<br>option OS: 316L<br>silicone | stainless steel 316L<br><br>silicone |
| degree of protection | | NEMA 6 | NEMA 6 |
| cable gland | | 1/2 NPT | 1/2 NPT |
| **operating temperature** | | | |
| min.<br>max. | °F<br>°F | -40<br>+176 | -40<br>+176 |

## Dimensions

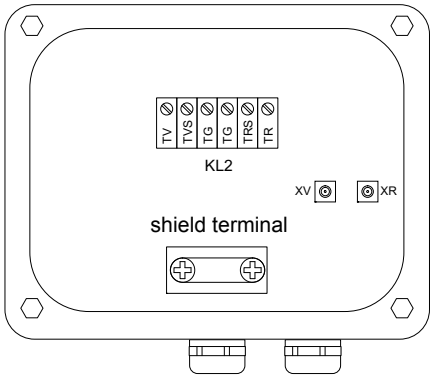



## 2 " Pipe Mounting Kit (optional)



## Terminal Assignment

### JB03




**transducers**

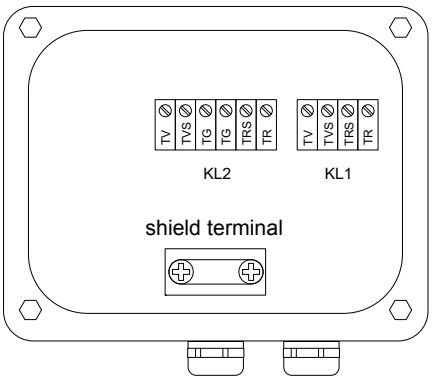
| terminal | connection |
|---|---|
| XV | transducer ↑, SMB connector |
| XR | transducer ⅄, SMB connector |
| cable gland | external shield |

**extension cable**

terminal strip KL2

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

### JBP3




**transducers**

terminal strip KL1

| terminal | connection |
|---|---|
| TV | transducer ↑, signal |
| TVS | transducer ↑, internal shield |
| TRS | transducer ⅄, internal shield |
| TR | transducer ⅄, signal |
| cable gland | external shield |

**extension cable**

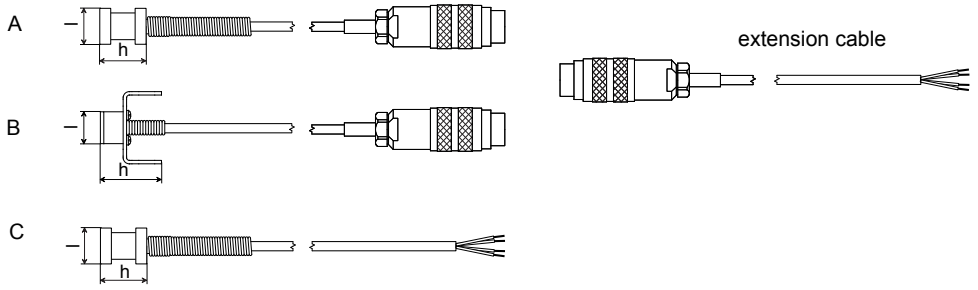
terminal strip KL2

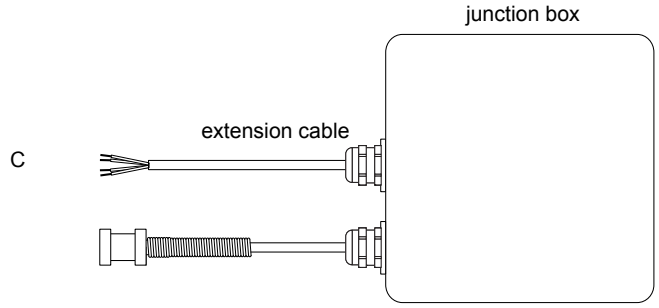
| terminal | connection |
|---|---|
| TV | signal |
| TVS | internal shield |
| TRS | internal shield |
| TR | signal |
| shield terminal | external shield |

# Temperature Probe (optional)

## Technical Data

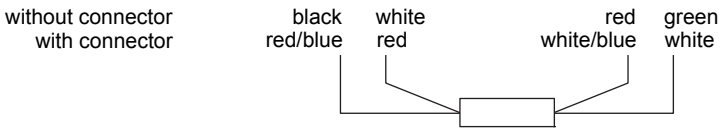
| technical type | | **PT13N** | **PT13N** | **PT13F** |
|---|---|---|---|---|
| order code | | **670415-1** | **770413-1** | **670415-2** |
| design | | with connector | without connector | short response time |
| type | | Pt1000 | Pt1000 | Pt1000 |
| connection | | 4-wire | 4-wire | 4-wire |
| measuring range | °F | -22 to +482 | -58 to +428 | -58 to +482 |
| accuracy T | | ±(0.27 °F + 2 · $10^{-3}$ · (T [°F] - 32 °F)) class A | ±(0.27 °F + 2 · $10^{-3}$ · (T [°F] - 32 °F)) class A | ±(0.27 °F + 2 · $10^{-3}$ · (T [°F] - 32 °F)) class A |
| response time | s | 50 | | 8 |
| housing | | aluminum | 360 brass alloy | PEEK, stainless steel 304, copper |
| degree of protection | | NEMA 4 | | NEMA 4 |
| weight (without connector) | lb | 0.6 | 0.437 | 0.7 |
| fixation | | clamp-on | clamp-on | clamp-on |
| accessories | | - | - | plastic protection plate, isolation foam |
| **dimensions** | | | | |
| length l | in | 0.59 | 0.59 | 0.55 |
| width b | in | 0.59 | 0.49 | 1.18 |
| height h | in | 0.79 | 0.79 | 1.06 |
| dimensional drawing | | A | C | B |



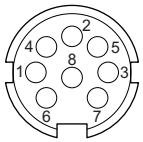

## Connection

### 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 | |



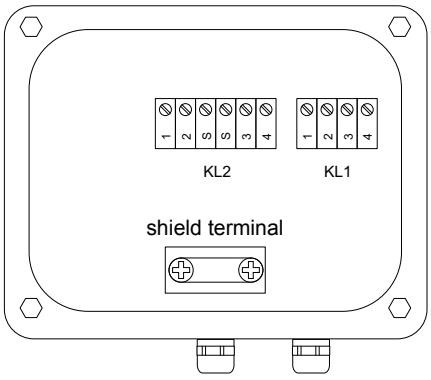

## Cable

| | | 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 | ft | 9 | 16/32/82 |
| max. length | ft | - | 656 |
| cable jacket | | PTFE | PVC |

## Junction Box

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

### JBT3




#### temperature probe (with connector)

terminal strip KL1

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

#### extension cable (with connector)

terminal strip KL2

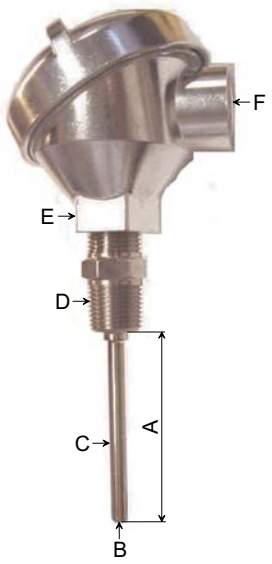
| terminal | connection |
|---|---|
| 1 | red |
| 2 | gray |
| 3 | white |
| 4 | blue |

#### Temperature Probe, Extension Cable (without connector)

terminal strip KL1

| terminal | connection |
|---|---|
| 1 | white |
| 2 | black |
| 3 | green |
| 4 | red |

## Wetted Temperature Probe (optional)




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

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