Vortex Flowmeter DATASHEET

JUNHO 2013
FV4000, FS4000
Vortex Flowmeter / Swirl Flowmeter

2-wire Compact Design
Digital Signal Processor
Converter Technology

For metering liquids, gases and steam

FV4000 Vortex flowmeter

FS4000 Swirl flowmeter for very short steadying zones

Approvals for explosion protection
— ATEX
— IEC
— cFMus
  Zone 1, Zone 2, dust ignition protection

Magnetic pen operation
— Configuration also possible with closed housing

Integrated switching output
— Used as limit contact or pulse output

Compensation of temperature influences by means of temperature measurement integrated as an option
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1 Principles of measurement

1.1 Principle of measurement for Vortex flowmeter

The operating principle of the Vortex flowmeter is based on the Karman street. As the fluid flows over and under the solid body, vortices are shed alternately above and below. The shedding of these vortices due to the flow forms a vortex trail (Karman street).

![Image of principle of measurement, FV4000](image1)

Fig. 1: Principle of measurement, FV4000

1 Solid body 2 Piezo sensor

The frequency $f$ of vortex shedding is proportional to the flow velocity $v$ and inversely proportional to the width of the solid body $d$:

$$f = St \times \frac{v}{d}$$

$St$, known as the Strouhal number, is a dimensionless number which has a decisive impact on the quality of vortex flow measurement.

If the solid body is dimensioned appropriately, the Strouhal number $St$ will be constant across a very wide range of the Reynolds number $Re$ (Fig. 2).

$$Re = \frac{v \times D}{\nu}$$

$\nu$ = Kinematic viscosity

$D$ = Nominal size of meter tube

Consequently, the vortex shedding frequency to be evaluated is dependent solely upon the flow velocity and not at all upon media density and viscosity.

The local changes in pressure induced by vortex shedding are detected by a piezo sensor and converted into electrical pulses corresponding to the vortex frequency.

The frequency signal from the flowmeter sensor, which is proportional to the flow, undergoes downstream processing in the transmitter.

![Image of how the Strouhal number is dependent upon the Reynolds number](image2)

Fig. 2: How the Strouhal number is dependent upon the Reynolds number

St Strouhal number  Re Reynolds number  L Linear flow area

1.2 Principle of measurement for Swirl flowmeter

The inlet pipe converts the axial flow of the incoming media into rotational movement. In the center of this rotation a vortex core is formed which is forced into a secondary spiral-shaped rotation by the backflow.

The frequency of this secondary rotation is proportional to the flow and, if the internal geometry of the meter exhibits an optimum design, will be linear over a wide flow range. This frequency is measured by a piezo sensor. The frequency signal from the flowmeter sensor, which is proportional to the flow, undergoes downstream processing in the transmitter.

![Image of principle of measurement, FS4000](image3)

Fig. 3

1 Inlet pipe  2 Piezo sensor  3 Outlet pipe  4 Stagnation point  5 Housing
## 2 Overview of flowmeters

<table>
<thead>
<tr>
<th></th>
<th>FV4000-VT4</th>
<th>FV4000-VR4</th>
<th>FS4000-ST4</th>
<th>FS4000-SR4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flowmeters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(TRIO-WIRL VT)</td>
<td>(TRIO-WIRL VR)</td>
<td>(TRIO-WIRL ST)</td>
<td>(TRIO-WIRL SR)</td>
</tr>
<tr>
<td><strong>Measured value error</strong></td>
<td>Fluids</td>
<td>≤ ± 0.75 % of flow rate under reference conditions</td>
<td>≤ ± 1 % of flow rate under reference conditions</td>
<td>≤ ± 0.5 % of flow rate under reference conditions</td>
</tr>
<tr>
<td></td>
<td>Gases and steam</td>
<td>≤ ± 0.75 % of flow rate under reference conditions</td>
<td>≤ ± 1 % of flow rate under reference conditions</td>
<td>≤ ± 0.5 % of flow rate under reference conditions</td>
</tr>
<tr>
<td><strong>Reproducibility</strong></td>
<td>DN 15 ≤ ± 0.3 % of flow rate</td>
<td>DN 15 ≤ ± 0.3 % of flow rate</td>
<td>DN 20 or higher ≤ ± 0.2 % of flow rate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DN 15 to DN 150 ≤ ± 0.2 of flow rate</td>
<td>DN 15 to DN 150 ≤ ± 0.2 of flow rate</td>
<td>DN 20 or higher ≤ ± 0.2 of flow rate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DN 200 or higher ≤ ± 0.25 % of flow rate</td>
<td>DN 200 or higher ≤ ± 0.25 % of flow rate</td>
<td>DN 200 or higher ≤ ± 0.25 % of flow rate</td>
<td></td>
</tr>
<tr>
<td><strong>Permissible viscosity for fluids (&gt; 7.5 mPa s, field calibration required for FS4000)</strong></td>
<td>DN 15 ≤ 4 mPa s</td>
<td>DN 15 to DN 32 ≤ 5 mPa s</td>
<td>DN 40 or higher ≤ 7.5 mPa s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DN 25 ≤ 5 mPa s</td>
<td>DN 40 to DN 50 ≤ 10 mPa s</td>
<td>DN 80 or higher ≤ 30 mPa s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DN 40 or higher ≤ 7.5 mPa s</td>
<td>DN 15 to DN 32 ≤ 5 mPa s</td>
<td>DN 40 or higher ≤ 7.5 mPa s</td>
<td></td>
</tr>
<tr>
<td><strong>Typical span</strong></td>
<td>1:20</td>
<td>1:25</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Typical inflow / outflow sections</strong></td>
<td>15 x DN / 5 x DN</td>
<td>3 x DN / 1 x DN</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Sensor

<table>
<thead>
<tr>
<th>Process connection (DIN, ANSI, JIS)</th>
<th>Flange</th>
<th>DN 15 to DN 300 (1/2&quot; to 12&quot;)</th>
<th>DN 15 to DN 400 (1/2&quot; to 16&quot;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor design</td>
<td>Single sensor</td>
<td>Yes, optional with integrated temperature measurement (DN 50 or higher)</td>
<td>Double sensor</td>
</tr>
<tr>
<td>Fluid temperature</td>
<td>Standard</td>
<td>-55 ... 280 °C (-67 ... 536 °F)</td>
<td>-55 ... 280 °C (-67 ... 536 °F)</td>
</tr>
<tr>
<td></td>
<td>High temperature (DN 25 or higher)</td>
<td>-55 ... 400 °C (-67 ... 752 °F)</td>
<td>-</td>
</tr>
<tr>
<td>Ingress protection</td>
<td>IP 65 / IP 67 / Nema 4X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inlet / outlet pipe</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Sensor gasket</td>
<td>Graphite, Kalrez, Viton, PTFE</td>
<td>Graphite, Kalrez, Viton, PTFE</td>
</tr>
<tr>
<td>Only FVR4000 or FSR4000</td>
<td>Signal cable length between sensor and transmitter</td>
<td>-</td>
<td>max. 10 m (32.8 ft)</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>max. 10 m (32.8 ft)</td>
<td>-</td>
</tr>
</tbody>
</table>

### Transmitter

| Supply power                      | For analog output 4 ... 20 mA | 14 ... 46 V (Ex ib ≤ 28 V) |
|                                    | For PROFIBUS PA and FOUNDATION fieldbus | I < 10 mA (9 ... 32 V; Ex ia ≤ 24 V) |
| Sealing concept                   | Dual sealing acc. to ANSI / ISA-12.27.01 (VT43/VR43/ST43/SR43) |            |
| Display                            | 2 x 8-digit /2 x 16-digit | Local display / totalization with magnetic pen operation / Parameters via HART protocol / PROFIBUS PA / FOUNDATION fieldbus adjustable |
| External FRAM                      | Yes, for saving transmitter parameterization data as well as flowmeter sensor calibration data |            |
| Contact output (Optocoupler for standard) NAMUR contact (Ex ia / ib) | Can be parameterized as limit contact (flow, temperature), alarm output or pulse output |            |
| Saturated steam calculation / Temperature compensation | Yes, if sensor is fitted with temperature measurement device |            |
| Communication                      | HART protocol, PROFIBUS PA (Profile 3.0), FOUNDATION fieldbus |            |
Designs

There are generally two different designs.

Fig. 4: Integral mount design: The transmitter is installed directly on the sensor.

Fig. 5: Remote mount design: The transmitter can be installed up to 10 m away from the flowmeter sensor. The cable is permanently connected to the transmitter. It can be made shorter if required.
3 General specifications

3.1 Nominal diameter selection

The nominal diameter is selected on the basis of the maximum operating flow \( Q_{V \text{ max}} \). If maximum spans are to be achieved, this should not be less than half the maximum flowrate for each nominal diameter (\( Q_{V \text{ max DN}} \)), although reduction to approx. 0.15 \( Q_{V \text{ max DN}} \) is possible. The linear lower range limit value is dependent upon the Reynolds number (see accuracy information).

If the flow to be measured is the standard flow (standard condition: 0 °C (32 °F), 1,013 mbar) or mass flowrate, this must be converted to the operating flow and the most appropriate nominal device diameter must be selected from the flow range tables (Tables 1, 2, 3).

\[
\rho = \rho_n \times \frac{1013 + p}{1013 + \frac{273}{T}}
\]

2. Conversion to operating flow (\( Q_v \))

a) From standard flow (\( Q_n \)) -->

\[
Q_v = Q_n \times \frac{1013 + p}{1013 + \frac{273}{T}}
\]

b) From mass flowrate (\( Q_m \)) -->

\[
Q_v = Q_m \div \rho
\]

3. Dynamic viscosity (\( \eta \)) --> kinematic viscosity (\( \nu \))

\[
\nu = \frac{\eta}{\rho}
\]

Calculating the Reynolds number:

\[
Re = \frac{Q}{(2827 \cdot \nu \cdot d)}
\]

\( Q \) = Flow in m³/h

\( d \) = Pipe diameter in m

\( \nu \) = Kinematic viscosity m²/s (1 cst = 10⁻⁶ m²/s)

The current Reynolds number can also be calculated using our AP-Calc calculation program.

3.2 Measured value deviation for flow measurement

Deviation in percentage terms from the measured value under reference conditions (including the transmitter) in the linear measuring range between \( Re_{\text{min}} \) and \( Q_{\text{max}} \) (see "Measuring ranges" table).

<table>
<thead>
<tr>
<th>Fluids</th>
<th>Gases / Steam</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \leq \pm 0.75% )</td>
<td>( \pm 1% )</td>
</tr>
<tr>
<td>( \pm 0.5% )</td>
<td></td>
</tr>
</tbody>
</table>

Current output

- Additional measurement uncertainty < 0.1%  
- Temperature effect < 0.05% / 10 K

Misalignment associated with installation or deinstallation may affect the measuring error.

Additional measuring errors may occur if there are deviations from the reference conditions.

3.2.1 Reproducibility as a percentage of the measured value

<table>
<thead>
<tr>
<th>DN</th>
<th>Inch</th>
<th>FV4000-VT4/VR4</th>
<th>FS4000-ST4/SR4</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>1/2&quot;</td>
<td>0.3%</td>
<td></td>
</tr>
<tr>
<td>25 ... 250</td>
<td>1&quot; ... 6&quot;</td>
<td>0.2%</td>
<td>0.2%</td>
</tr>
<tr>
<td>200 ... 300</td>
<td>8&quot; ... 12&quot;</td>
<td>0.25%</td>
<td>0.2%</td>
</tr>
</tbody>
</table>

3.3 Measured value deviation for temperature

Measured value deviation (including transmitter) ± 2 °C

Reproducibility ≤ 0.2% of measured value

Product selection and dimensioning program

Important

The ABB "AP-Calc" program can be used free of charge when selecting an appropriate flowmeter for a given application. The program runs in a Microsoft WINDOWS ® environment.

3.4 Permissible pipeline vibrations

Guide values: The values specified for acceleration g are intended as guide values. The actual limits will depend on the nominal diameter, the measuring range within the entire measuring span, and the frequency of the vibrations. Therefore, the acceleration value g has only limited meaning.

**FV4000:**
- Fluid: max. 1.0 g, 0 ... 130 Hz
- Gas / steam: max. 0.3 g, 0 ... 130 Hz

**FS4000:**
- Fluid: max. 0.3 g, 0 ... 130 Hz
- Gas / steam: max. 0.3 g, 0 ... 130 Hz
## 3.5 Reference conditions for flow measurement

<table>
<thead>
<tr>
<th></th>
<th>FV4000-VR4</th>
<th>FS4000-ST/SR4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set flow range</td>
<td>0.5 ... 1 x QmaxDN</td>
<td></td>
</tr>
<tr>
<td>Ambient temperature</td>
<td>20 °C (68 °F) ± 2 K</td>
<td></td>
</tr>
<tr>
<td>Humidity</td>
<td>65 % rel. humidity ± 5 %</td>
<td></td>
</tr>
<tr>
<td>Air pressure</td>
<td>86 ... 106 kPa</td>
<td></td>
</tr>
<tr>
<td>Supply power</td>
<td>24 V DC</td>
<td></td>
</tr>
<tr>
<td>Signal cable length</td>
<td>10 m (32.8 ft) (FV4000-VR or FS4000-SR only)</td>
<td></td>
</tr>
<tr>
<td>Current output load</td>
<td>250 Ω (4 ... 20 mA only)</td>
<td></td>
</tr>
<tr>
<td>Fluid for calibration</td>
<td>Water: approx. 20 °C (68 °F), 2 bar (29 psi)</td>
<td></td>
</tr>
<tr>
<td>Calibration loop internal diameter</td>
<td>= internal diameter of meter</td>
<td></td>
</tr>
<tr>
<td>Unobstructed straight upstream section</td>
<td>15 x DN</td>
<td>3 x DN</td>
</tr>
<tr>
<td>Downstream section</td>
<td>5 x DN</td>
<td>1 x DN</td>
</tr>
<tr>
<td>Pressure measurement</td>
<td>3 ... 5 x DN downstream of meter</td>
<td></td>
</tr>
<tr>
<td>Temperature measurement</td>
<td>2 ... 3 x DN downstream after pressure measurement</td>
<td></td>
</tr>
</tbody>
</table>

### 3.6 FV4000-VT4 / VR4 flowrates

#### 3.6.1 Fluid flowrates

<table>
<thead>
<tr>
<th>DN</th>
<th>Re min</th>
<th>QmaxDN (m³/h)</th>
<th>Frequency (Hz) at Qmax</th>
<th>Re min</th>
<th>QmaxDN (m³/h)</th>
<th>Frequency (Hz) at Qmax</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 1/2&quot;</td>
<td>10000</td>
<td>6</td>
<td>370</td>
<td>11000</td>
<td>5,5</td>
<td>24</td>
</tr>
<tr>
<td>25 1&quot;</td>
<td>20000</td>
<td>18</td>
<td>240</td>
<td>23000</td>
<td>18</td>
<td>79</td>
</tr>
<tr>
<td>40 1 1/2&quot;</td>
<td>20000</td>
<td>48</td>
<td>270</td>
<td>23000</td>
<td>48</td>
<td>211</td>
</tr>
<tr>
<td>50 2&quot;</td>
<td>20000</td>
<td>70</td>
<td>180</td>
<td>22000</td>
<td>66</td>
<td>291</td>
</tr>
<tr>
<td>80 3&quot;</td>
<td>43000</td>
<td>170</td>
<td>140</td>
<td>48000</td>
<td>160</td>
<td>704</td>
</tr>
<tr>
<td>100 4&quot;</td>
<td>33000</td>
<td>270</td>
<td>100</td>
<td>44000</td>
<td>216</td>
<td>951</td>
</tr>
<tr>
<td>150 6&quot;</td>
<td>67000</td>
<td>630</td>
<td>50</td>
<td>80000</td>
<td>530</td>
<td>2334</td>
</tr>
<tr>
<td>200 8&quot;</td>
<td>120000</td>
<td>1100</td>
<td>45</td>
<td>128000</td>
<td>935</td>
<td>4117</td>
</tr>
<tr>
<td>250 10&quot;</td>
<td>96000</td>
<td>1700</td>
<td>29</td>
<td>115000</td>
<td>1445</td>
<td>6362</td>
</tr>
<tr>
<td>300 12&quot;</td>
<td>155000</td>
<td>2400</td>
<td>26</td>
<td>157000</td>
<td>2040</td>
<td>8982</td>
</tr>
</tbody>
</table>

The flowrates apply for fluids at 20 °C (68 °F), 1,013 mbar (14.69 psi), = 998 kg/m³ (62.30 lb/ft³).

#### 3.6.2 Gas / Steam flowrates

<table>
<thead>
<tr>
<th>DN</th>
<th>Re min</th>
<th>QmaxDN (m³/h)</th>
<th>Frequency (Hz) at Qmax</th>
<th>Re min</th>
<th>QmaxDN (m³/h)</th>
<th>QmaxDN (US gal/min)</th>
<th>Frequency (Hz) at Qmax</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 1/2&quot;</td>
<td>10000</td>
<td>24</td>
<td>1520</td>
<td>11000</td>
<td>22</td>
<td>13</td>
<td>1980</td>
</tr>
<tr>
<td>25 1&quot;</td>
<td>20000</td>
<td>150</td>
<td>2040</td>
<td>23000</td>
<td>82</td>
<td>48</td>
<td>1850</td>
</tr>
<tr>
<td>40 1 1/2&quot;</td>
<td>20000</td>
<td>390</td>
<td>2120</td>
<td>23000</td>
<td>340</td>
<td>200</td>
<td>1370</td>
</tr>
<tr>
<td>50 2&quot;</td>
<td>20000</td>
<td>500</td>
<td>1200</td>
<td>22000</td>
<td>450</td>
<td>265</td>
<td>1180</td>
</tr>
<tr>
<td>80 3&quot;</td>
<td>43000</td>
<td>1200</td>
<td>1000</td>
<td>48000</td>
<td>950</td>
<td>559</td>
<td>780</td>
</tr>
<tr>
<td>100 4&quot;</td>
<td>33000</td>
<td>1900</td>
<td>700</td>
<td>44000</td>
<td>1800</td>
<td>1059</td>
<td>635</td>
</tr>
<tr>
<td>150 6&quot;</td>
<td>67000</td>
<td>4500</td>
<td>480</td>
<td>80000</td>
<td>4050</td>
<td>2384</td>
<td>405</td>
</tr>
<tr>
<td>200 8&quot;</td>
<td>120000</td>
<td>8000</td>
<td>285</td>
<td>128000</td>
<td>6800</td>
<td>4002</td>
<td>240</td>
</tr>
<tr>
<td>250 10&quot;</td>
<td>96000</td>
<td>14000</td>
<td>260</td>
<td>115000</td>
<td>12000</td>
<td>7063</td>
<td>225</td>
</tr>
<tr>
<td>300 12&quot;</td>
<td>155000</td>
<td>20000</td>
<td>217</td>
<td>157000</td>
<td>17000</td>
<td>10006</td>
<td>195</td>
</tr>
</tbody>
</table>

The flowrates apply for gas at = 1.2 kg/m³ (0.075 lb/ft³).
### 3.7 FS4000-ST4 / SR4 flowrates

#### 3.7.1 Fluid flowrates

<table>
<thead>
<tr>
<th>DN</th>
<th>Re min</th>
<th>( Q_{\text{vmaxDN}} ) (m³/h)</th>
<th>( Q_{\text{vmaxDN}} ) (US gal/min)</th>
<th>Frequency (Hz) at ( Q_{\text{vmaxDN}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 1/2&quot;</td>
<td>2100</td>
<td>1.6</td>
<td>7.0</td>
<td>185</td>
</tr>
<tr>
<td>20 3/4&quot;</td>
<td>3500</td>
<td>2</td>
<td>8.8</td>
<td>100</td>
</tr>
<tr>
<td>25 1&quot;</td>
<td>5200</td>
<td>6</td>
<td>26</td>
<td>135</td>
</tr>
<tr>
<td>32 1 1/4&quot;</td>
<td>7600</td>
<td>10</td>
<td>44</td>
<td>107</td>
</tr>
<tr>
<td>40 1 1/2&quot;</td>
<td>13500</td>
<td>16</td>
<td>70</td>
<td>110</td>
</tr>
<tr>
<td>50 2&quot;</td>
<td>17300</td>
<td>25</td>
<td>110</td>
<td>90</td>
</tr>
<tr>
<td>80 3&quot;</td>
<td>15000</td>
<td>100</td>
<td>440</td>
<td>78</td>
</tr>
<tr>
<td>100 4&quot;</td>
<td>17500</td>
<td>150</td>
<td>660</td>
<td>77</td>
</tr>
<tr>
<td>150 6&quot;</td>
<td>43000</td>
<td>370</td>
<td>1620</td>
<td>50</td>
</tr>
<tr>
<td>200 8&quot;</td>
<td>44000</td>
<td>500</td>
<td>2200</td>
<td>30</td>
</tr>
<tr>
<td>300 12&quot;</td>
<td>115000</td>
<td>1000</td>
<td>4400</td>
<td>16</td>
</tr>
<tr>
<td>400 16&quot;</td>
<td>160000</td>
<td>1800</td>
<td>7920</td>
<td>13</td>
</tr>
</tbody>
</table>

The flowrates apply for fluids at 20 °C (68 °F), 1,013 mbar (14.69 psi), \( \nu = 1 \) cSt, \( \rho = 998 \) kg/m³ (62.30 lb/ft³).

#### 3.7.2 Gas / Steam flowrates

<table>
<thead>
<tr>
<th>DN</th>
<th>( Q_{\text{vmin}} ) (m³/h)</th>
<th>( Q_{\text{vmaxDN}} ) (m³/h)</th>
<th>( Q_{\text{vmin}} ) (ft³/min)</th>
<th>( Q_{\text{vmaxDN}} ) (ft³/min)</th>
<th>Frequency (Hz) at ( Q_{\text{vmaxDN}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 1/2&quot;</td>
<td>2.5</td>
<td>16</td>
<td>1.4</td>
<td>9.4</td>
<td>1900</td>
</tr>
<tr>
<td>20 3/4&quot;</td>
<td>5</td>
<td>25</td>
<td>2.9</td>
<td>14</td>
<td>1200</td>
</tr>
<tr>
<td>25 1&quot;</td>
<td>5</td>
<td>50</td>
<td>2.9</td>
<td>14</td>
<td>1200</td>
</tr>
<tr>
<td>32 1 1/4&quot;</td>
<td>8</td>
<td>130</td>
<td>4.7</td>
<td>76</td>
<td>1300</td>
</tr>
<tr>
<td>40 1 1/2&quot;</td>
<td>12</td>
<td>200</td>
<td>7.0</td>
<td>117</td>
<td>1400</td>
</tr>
<tr>
<td>50 2&quot;</td>
<td>18</td>
<td>350</td>
<td>10</td>
<td>206</td>
<td>1200</td>
</tr>
<tr>
<td>80 3&quot;</td>
<td>60</td>
<td>850</td>
<td>35</td>
<td>500</td>
<td>690</td>
</tr>
<tr>
<td>100 4&quot;</td>
<td>65</td>
<td>1500</td>
<td>38</td>
<td>882</td>
<td>700</td>
</tr>
<tr>
<td>150 6&quot;</td>
<td>150</td>
<td>3600</td>
<td>88</td>
<td>2110</td>
<td>470</td>
</tr>
<tr>
<td>200 8&quot;</td>
<td>200</td>
<td>4900</td>
<td>117</td>
<td>2880</td>
<td>320</td>
</tr>
<tr>
<td>300 12&quot;</td>
<td>530</td>
<td>10000</td>
<td>311</td>
<td>5880</td>
<td>160</td>
</tr>
<tr>
<td>400 16&quot;</td>
<td>1050</td>
<td>20000</td>
<td>618</td>
<td>11770</td>
<td>150</td>
</tr>
</tbody>
</table>

The flowrates apply for gas / steam at \( \rho = 1.2 \) kg/m³ (0.075 lb/ft³).

The frequency information is for orientation purposes only. For individual nominal diameters and designs, ranges are supplied in which typical frequencies lie.

### 3.8 Static overpressure in the case of fluids

To avoid cavitation, a static overpressure is required downstream of the flowmeter (downstream pressure). This can be estimated using the following formula:

\[
p_2 \geq 1.3 \cdot p_{\text{Dampf}} + 2.6 \cdot \Delta p'
\]

\[
p_2 = \text{Static overpressure downstream of the flowmeter (mbar)}
\]

\[
p_{\text{Dampf}} = \text{Steam pressure of fluid at operating temperature (mbar)}
\]

\[
\Delta p' = \text{Pressure drop, medium (mbar)}
\]
3.10 Temperature of medium

Important
Please note the information in the section titled "Explosion protection". Compliance with the permissible temperature range for the gaskets is mandatory.

<table>
<thead>
<tr>
<th>VF4000-VT4/VR4</th>
<th>FS4000-ST4/SR4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>-55 ... 280 °C (-67 ... 536 °F)</td>
</tr>
<tr>
<td>HT design</td>
<td>-55 ... 400 °C (-67 ... 752 °F)</td>
</tr>
</tbody>
</table>

3.11 Flowmeter insulation

The pipeline may be insulated up to a maximum of 100 mm (4 inch) upper edge.

Use of trace heating

Trace heating may be used under the following conditions:

- If it is fixed directly on or around the pipeline
- If, in the case of existing pipeline insulation, it is installed inside the insulation (the maximum height of 100 mm (4 inch) must not be exceeded)
- If the maximum temperature the trace heating is able to produce ≤ the maximum temperature of the medium

The requirements to be met by integrators set out in EN 60079-14 must be complied with!

Please note that the use of trace heaters will not impair EMC protection or generate additional vibrations.

3.12 Ambient conditions

Resistance to climate to DIN 40040

Permissible ambient temperature range

<table>
<thead>
<tr>
<th>Explosion protection / Model</th>
<th>Temperature range</th>
</tr>
</thead>
<tbody>
<tr>
<td>None / VT40 and VR40 / ST40 and SR40</td>
<td>-20 ... 70 °C (-4 ... 158 °F)</td>
</tr>
<tr>
<td>Ex ib / VT41 and VR41 / ST41 and SR41</td>
<td>-20 ... 70 °C (-4 ... 158 °F)</td>
</tr>
<tr>
<td>Ex ia / VT4A and VR4A / ST4A and SR4A</td>
<td>-20 ... 60 °C (-4 ... 140 °F)</td>
</tr>
<tr>
<td>Ex d / VT42 and VR42 / ST42 and SR42</td>
<td>-20 ... 60 °C (-4 ... 140 °F)</td>
</tr>
<tr>
<td>cFMUS / VT43 and VR43 / ST43 and SR43</td>
<td>-20 ... 70 °C (-4 ... 158 °F)</td>
</tr>
</tbody>
</table>

1) Category 2D (dust-ignition proof) maximum 60 °C (140 °F)

Permissible air humidity

<table>
<thead>
<tr>
<th>Design</th>
<th>Humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>Relative humidity max. 85 %, annual mean ≤ 65 %</td>
</tr>
<tr>
<td>Climate-proof</td>
<td>Relative humidity ≤ 100 % permanent</td>
</tr>
</tbody>
</table>

Fig. 6: Flowmeter insulation

1 Maximum 100 mm (4 inch)

Fig. 7: Relationship between the temperature of the fluid and the ambient temperature

1 Ambient temperature
2 Media temperature
3 Permissible temperature range for standard design (≤ 280 °C (≤ 536 °F))
4 Installation for medium temperature > 150 °C (302 °F)
5 HT design (≤ 400 °C (≤ 752 °F)), VF4000-VT4 only

1) For the supply circuit (terminals 31 / 32) and the switching outputs 41 and 42, cables suitable for temperatures up to T = 110 °C (230 °F) may be used without restriction. Cables which are only suitable for temperatures up to T = 80 °C (176 °F) restrict the temperature ranges. These restrictions also apply to the VR version (remote design) and the PROFIBUS PA design with plug connector.

Important

The legibility of the display can be impaired at temperatures < 0 °C (< 32 °F) and > 55 °C (> 131 °F). The functionality of the meter and the outputs remains unaffected by this. Please refer to the order information for ambient temperatures < -20 °C (< -4 °F).

Please note the information in the section titled 5 „Transmitter specifications“.
3.13 Installation Requirements

A Vortex or Swirl flowmeter can be installed at any point in the pipeline system. However, the following installation conditions must be considered:

- Compliance with the ambient conditions
- Compliance with the recommended inflow/outflow sections
- The flow direction must correspond to that indicated by the arrow on the flowmeter sensor.
- Compliance with the required minimum interval for removing the transmitter and replacing the sensor
- Avoidance of mechanical vibrations of the pipeline (by fitting supports if necessary)
- The internal diameter of the flowmeter sensor and the pipe must be identical.
- Avoidance of pressure vibrations at zero flow by fitting gates at intervals in long pipeline systems
- Attenuation of alternating (pulsating) flow during piston pump or compressor conveying by using appropriate damping devices. The residual pulse must not exceed 10%. The frequency of the conveying equipment must not be within the range of the measuring frequency of the flowmeter.
- Valves / gates should normally be arranged in the flow direction downstream of the flowmeter (typically: 3 x DN). If the medium is conveyed through piston/plunger pumps or compressors (pressures for fluids > 10 bar (145 psi)), it may be subject to hydraulic vibration in the pipeline when the valve is closed. If this does occur, the valve absolutely has to be installed in the flow direction upstream of the flowmeter. Suitable damping devices (e.g. air vessels) might need to be fitted.
- When fluids are measured, the sensor must always be filled with media and must not run dry.
- When fluids are measured and during damping there must be no evidence of cavitation.
- The relationship between the temperature of the media and the ambient temperature has to be taken into account (see "Ambient conditions" in the section titled "Technical data").
- At high media temperatures > 150 °C (302 °F), the flowmeter sensor must be installed so that the electronics are pointing to the side or downward.

3.14 Recommended inflow and outflow sections

3.14.1 Vortex flowmeter

In order to maximize operational reliability, the flow profile at the inflow end must not be distorted if at all possible. Provision should be made for an inflow section measuring approx. 15 times the nominal diameter. At elbows, the inflow section should measure at least 25 times the nominal diameter, at round elbows 40 times the nominal diameter and where shutoff valves appear in the inflow section, 50 times the nominal diameter. A value 5 times the size of the nominal diameter is required at the outflow end.

![Recommended inflow and outflow sections](image1)

3.14.2 Swirl flowmeter

On account of its operating principle, the Swirl flowmeter functions virtually without inflow and outflow sections. The figure below shows the recommended inflow and outflow sections for various installations. Inflow and outflow sections are not required if the elbow radius of single or double pipe elbows upstream and downstream of the meter is greater than 1.8 x D. Similarly, additional inflow and outflow sections are not required downstream of reductions with flange transition pieces conforming to DIN 28545 (α/2 = 8).

![Recommended inflow and outflow sections](image2)
3.15 Installation at high media temperatures > 150°C (302°F)

At high media temperatures > 150°C (302°F) the flowmeter sensor must be installed so that the transmitter is pointing to the side or downward (see the figure below).

![Fig. 10: Arrangement of temperature and pressure measuring points](image1)

3.16 Installation for pressure and temperature measurement

As an option, the flowmeter can be fitted with a Pt100 for direct temperature measurement. This temperature measurement supports, for example, the monitoring of the media temperature or the direct measurement of saturated steam in mass flow units.

If pressure and temperature are to be compensated externally (e.g. with the "Sensycal"), the measuring points must be installed as illustrated in the figure below.

![Fig. 11: Arrangement of temperature and pressure measuring points](image2)

3.17 Installation of final controlling equipment

Final controlling equipment must be arranged at the outflow end spaced at a minimum 5 x DN.

![Fig. 12: Installation of final controlling equipment](image3)

If the medium is conveyed through piston / plunger pumps or compressors (pressures for fluids > 10 bar (145 psi)), it may be subject to hydraulic vibration in the pipeline when the valve is closed. If this does occur, the valve absolutely has to be installed in the flow direction upstream of the flowmeter. The FS4000 Swirl flowmeter is particularly suited to such scenarios. Suitable dampers (e.g. air vessels in the case of pumping using a compressor) might need to be used.
3.18 Process connections

<table>
<thead>
<tr>
<th>Flange design</th>
<th>Operating pressure</th>
<th>Wafer flange design</th>
<th>Operating pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FV4000-VT4/VR4</strong></td>
<td><strong>Process connection</strong></td>
<td><strong>Process connection</strong></td>
<td><strong>Operating pressure</strong></td>
</tr>
<tr>
<td>DN15 … DN300</td>
<td>O-ring gasket: DIN PN 10 … PN 40, ASME Class 150 / 300, option up to 900 lb</td>
<td>DN25 … DN150</td>
<td>O-ring gasket: DIN PN 64, option up to 100 lb</td>
</tr>
<tr>
<td></td>
<td>Flat gasket (graphite): Maximum PN 64 / ASME Class 300 lb</td>
<td></td>
<td>Flat gasket (graphite): Maximum PN 64 / ASME Class 300 lb</td>
</tr>
<tr>
<td><strong>FS4000-ST4/SR4</strong></td>
<td>DN 15 … DN 200 ¹)</td>
<td>DN 300 … DN 400 ¹)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>O-ring gasket: DIN PN 10 … PN 40 ASME Class 150/300</td>
<td>O-ring gasket: Maximum PN 64 / ASME Class 300 lb</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flat gasket (graphite): Maximum PN 64 / ASME Class 150</td>
<td>Flat gasket (graphite): Maximum PN 64 / ASME Class 300 lb</td>
<td></td>
</tr>
</tbody>
</table>

¹ Other designs on request.

3.19 Materials

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
<th>Temperature range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>FV4000-VT4/VR4</strong></td>
<td><strong>FS4000-ST4/SR4</strong></td>
</tr>
<tr>
<td>Meter housing</td>
<td>Stainless steel 1.4571 (316Ti) / 316L / CF8 / CF8C, Option: Hastelloy C</td>
<td>-55 ... 400 °C (-67 ... 752 °F)</td>
</tr>
<tr>
<td>Swirl body / Inlet/outlet pipes</td>
<td>Stainless steel 1.4571 (316Ti) / 316L / CF8 / CF8C, Option: Hastelloy C</td>
<td>(CF8): -55 ... 300 °C (-67 ... 572 °F)</td>
</tr>
<tr>
<td>Sensor</td>
<td>Stainless steel 1.4571, Option: Hastelloy C</td>
<td></td>
</tr>
<tr>
<td>Sensor gasket ¹)</td>
<td>Kalrez (3018) o-ring</td>
<td>0 ... 280 °C (32 ... 536 °F)</td>
</tr>
<tr>
<td></td>
<td>Kalrez (6375) o-ring</td>
<td>-20 ... 275 °C (-4 ... 527 °F)</td>
</tr>
<tr>
<td></td>
<td>Viton o-ring</td>
<td>-55 ... 230 °C (-67 ... 446 °F)</td>
</tr>
<tr>
<td></td>
<td>PTFE o-ring</td>
<td>-55 ... 200 °C (-67 ... 392 °F)</td>
</tr>
<tr>
<td></td>
<td>Graphite</td>
<td>-55 ... 280 °C (-67 ... 536 °F)</td>
</tr>
<tr>
<td></td>
<td>Graphite special</td>
<td>-55 ... 400 °C (-67 ... 752 °F) (High temperature)</td>
</tr>
<tr>
<td>Housing, electronics</td>
<td>Cast aluminum, varnished</td>
<td></td>
</tr>
</tbody>
</table>

¹ Other designs on request.

3.20 Weights

The dimension tables contain weight details.
3.20.1 Permissible operating pressures FV4000

Process connection DIN flange

![Graph showing PS vs TS for FV4000](image)

Fig. 13: High temperature design only, version FV4000 (TRIO-WIRL VT / VR)

PS Pressure (bar) TS Temperature (°C)

Process connection ASME flange

![Graph showing PS vs TS for FV4000](image)

Fig. 14: High temperature design only, version FV4000 (TRIO-WIRL VT / VR)

PS Pressure (bar) TS Temperature (°C)

Aseptic flange to DIN 11864-2

- DN 25 to DN 40:
  - PS = 25 bar to TS = 140 °C if suitable gasket materials are selected
- DN 50 and DN 80:
  - PS = 16 bar to TS = 140 °C if suitable gasket materials are selected

Process connection DIN wafer

![Graph showing PS vs TS for FV4000](image)

Fig. 15: High temperature design only

PS Pressure (bar) TS Temperature (°C)

3.20.2 Permissible operating pressures FS4000

Process connection DIN flange

![Graph showing PS vs TS for FS4000](image)

Fig. 16: High temperature design only

PS Pressure (bar) TS Temperature (°C)

Process connection ASME wafer

![Graph showing PS vs TS for FS4000](image)

Fig. 17

PS Pressure (bar) TS Temperature (°C)

Process connection ASME flange

![Graph showing PS vs TS for FS4000](image)

Fig. 18

PS Pressure (bar) TS Temperature (°C)
4 Dimensions

4.1 FV4000-VR4 (TRIO-WIRL V), wafer design

Fig. 19: Dimensions in mm (inch), projection in accordance with ISO method E

1 Flow direction
2 Power supply
3 Display with VT4 design only
4 Required minimum distance for removing the transmitter and disassembling the sensor unit
5 Can be rotated 330°

*) Reduced dimension for VR4 design with remote transmitters

<table>
<thead>
<tr>
<th>Nominal diameter DN</th>
<th>Nominal pressure PN</th>
<th>L (Dimensions in mm (inch))</th>
<th>E</th>
<th>D</th>
<th>G</th>
<th>d</th>
<th>Weight in kg (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>64</td>
<td>65 (2.56)</td>
<td>274 (10.79)</td>
<td>73 (2.87)</td>
<td>293 (11.54)</td>
<td>28.5 (11.12)</td>
<td>4.1 (9.0)</td>
</tr>
<tr>
<td>40</td>
<td>64</td>
<td>65 (2.56)</td>
<td>290 (11.42)</td>
<td>94 (3.70)</td>
<td>309 (12.17)</td>
<td>43 (1.69)</td>
<td>4.8 (10.6)</td>
</tr>
<tr>
<td>50</td>
<td>64</td>
<td>65 (2.56)</td>
<td>298 (11.73)</td>
<td>109 (4.29)</td>
<td>317 (12.48)</td>
<td>54.4 (14.4)</td>
<td>5.6 (12.4)</td>
</tr>
<tr>
<td>80</td>
<td>64</td>
<td>65 (2.56)</td>
<td>312 (12.28)</td>
<td>144 (5.67)</td>
<td>331 (13.03)</td>
<td>82.4 (3.24)</td>
<td>7.6 (16.8)</td>
</tr>
<tr>
<td>100</td>
<td>64</td>
<td>65 (2.56)</td>
<td>320 (12.6)</td>
<td>164 (6.46)</td>
<td>339 (13.35)</td>
<td>106.8 (4.20)</td>
<td>8.5 (18.7)</td>
</tr>
<tr>
<td>150</td>
<td>64</td>
<td>65 (2.56)</td>
<td>352 (13.86)</td>
<td>220 (8.66)</td>
<td>371 (14.61)</td>
<td>159.3 (6.27)</td>
<td>13 (28.7)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nominal diameter DN</th>
<th>Pressure PN</th>
<th>L (Dimensions in mm (inch))</th>
<th>E</th>
<th>D</th>
<th>G</th>
<th>d</th>
<th>Weight in kg (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1''</td>
<td>300 80</td>
<td>112.5 (4.43)</td>
<td>284 (11.18)</td>
<td>70.5 (2.78)</td>
<td>303 (11.93)</td>
<td>24.3 (8.96)</td>
<td>5.1 (11.2)</td>
</tr>
<tr>
<td>1 1/2''</td>
<td>300 80</td>
<td>113 (4.45)</td>
<td>290 (11.42)</td>
<td>89.5 (3.52)</td>
<td>309 (12.17)</td>
<td>38.1 (1.50)</td>
<td>6.1 (13.5)</td>
</tr>
<tr>
<td>2''</td>
<td>150 / 300 80</td>
<td>112.5 (4.43)</td>
<td>296 (11.65)</td>
<td>106.5 (4.19)</td>
<td>315 (12.40)</td>
<td>49.2 (1.94)</td>
<td>8.4 (18.5)</td>
</tr>
<tr>
<td>3''</td>
<td>300 80</td>
<td>111 (4.37)</td>
<td>312 (12.28)</td>
<td>138.5 (5.45)</td>
<td>331 (13.03)</td>
<td>73.7 (2.90)</td>
<td>11.2 (24.7)</td>
</tr>
<tr>
<td>4''</td>
<td>300 80</td>
<td>116 (4.57)</td>
<td>325 (12.80)</td>
<td>176.5 (6.95)</td>
<td>344 (13.54)</td>
<td>97.2 (3.83)</td>
<td>17.2 (37.9)</td>
</tr>
<tr>
<td>6''</td>
<td>300 80</td>
<td>137 (5.39)</td>
<td>352 (13.86)</td>
<td>222.2 (8.75)</td>
<td>371 (14.61)</td>
<td>146.4 (5.76)</td>
<td>25.7 (56.7)</td>
</tr>
</tbody>
</table>
4.2 FV4000-VT4/VR4 (TRIO-WIRL V), flange design, DIN

Fig. 20: Dimensions in mm (inch), projection in accordance with ISO method E

1 Flow direction
2 Power supply
3 Display with VT4 design only
4 Required minimum distance for removing the transmitter and disassembling the sensor unit
5 Can be rotated 330°
6 Number of holes N

*) Reduced dimension for VR4 design with remote transmitters
### Table: Dimensions in mm (inch)

<table>
<thead>
<tr>
<th>Nominal diameter DN</th>
<th>Nominal pressure DN</th>
<th>Dimensions in mm (inch)</th>
<th>Weight in kg (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1)</td>
<td>E</td>
<td>D</td>
<td>G</td>
</tr>
<tr>
<td><strong>L1)</strong></td>
<td>280 °C / 536 °F</td>
<td><strong>T&lt;sub&gt;max&lt;/sub&gt;</strong></td>
<td></td>
</tr>
<tr>
<td><strong>DN</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>10 ... 40</td>
<td>200 (7.87)</td>
<td>296 (11.65)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>64 / 100</td>
<td>200 (7.87)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>160</td>
<td>200 (7.87)</td>
</tr>
<tr>
<td>25</td>
<td>10 ... 40</td>
<td>200 (7.87)</td>
<td>313 (12.32)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>64</td>
<td>210 (8.27)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>160</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>10 ... 40</td>
<td>200 (7.87)</td>
<td>291 (11.46)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>64</td>
<td>220 (8.66)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100</td>
<td>220 (8.66)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>160</td>
<td>225 (8.86)</td>
</tr>
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<td>160</td>
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<td>414 (16.30)</td>
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<td></td>
<td></td>
<td>40</td>
<td>350 (13.78)</td>
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<tr>
<td></td>
<td></td>
<td>64</td>
<td>370 (14.57)</td>
</tr>
<tr>
<td>250</td>
<td>10 / 16</td>
<td>450 (17.72)</td>
<td>439 (17.28)</td>
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<td></td>
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<td></td>
<td>64</td>
<td>470 (18.50)</td>
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<tr>
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<td>10 / 16</td>
<td>500 (19.69)</td>
<td>464 (18.27)</td>
</tr>
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<td></td>
<td></td>
<td>64</td>
<td>530 (20.87)</td>
</tr>
</tbody>
</table>

1) Dimension tolerance: DN 15 ... DN 200 +0 / -3 mm; DN 300 ... DN 400: +0 / -6 mm
4.3 FV4000-VT4/VR4 (TRIO-WIRL V), flange design, ASME

Fig. 21: Dimensions in mm (inch), projection in accordance with ISO method E

1 Flow direction
2 Power supply
3 Display with VT4 design only
4 Required minimum distance for removing the transmitter and disassembling the sensor unit
5 Can be rotated 330°
6 Number of holes N

*) Reduced dimension for VR4 design with remote transmitters
<table>
<thead>
<tr>
<th>Nominal diameter DN</th>
<th>Pressure PN</th>
<th>Dimensions in mm (inch)</th>
<th>Weight in kg (lb)</th>
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<tr>
<td></td>
<td></td>
<td>E</td>
<td>D</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>150 40</td>
<td></td>
<td>200 (7.87)</td>
<td>88,9 (3,5)</td>
</tr>
<tr>
<td>300 40</td>
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<td>200 (7.87)</td>
<td>95,2 (3,75)</td>
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<td>600 40</td>
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<td>200 (7.87)</td>
<td>95,3 (3,75)</td>
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</tr>
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<td>1&quot;</td>
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<td></td>
</tr>
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<td>150 80</td>
<td></td>
<td>200 (7.87)</td>
<td>108 (4,25)</td>
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<td></td>
<td>200 (7.87)</td>
<td>124 (4,88)</td>
</tr>
<tr>
<td>600 80</td>
<td></td>
<td>200 (7.87)</td>
<td>124 (4,88)</td>
</tr>
<tr>
<td>900 80</td>
<td>240 (9,45)</td>
<td>149,3 (5,88)</td>
<td></td>
</tr>
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<td>1 1/2&quot;</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>150 80</td>
<td></td>
<td>200 (7.87)</td>
<td>127 (5,0)</td>
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<td>155,6 (6,13)</td>
<td></td>
</tr>
<tr>
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<td>260 (10,24)</td>
<td>177,8 (7,0)</td>
<td></td>
</tr>
<tr>
<td>2&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>150 80</td>
<td></td>
<td>200 (7.87)</td>
<td>152,4 (6,0)</td>
</tr>
<tr>
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</tr>
<tr>
<td>600 80</td>
<td>240 (9,45)</td>
<td>165 (6,5)</td>
<td></td>
</tr>
<tr>
<td>900 80</td>
<td>300 (11,81)</td>
<td>215,9 (8,5)</td>
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</tr>
<tr>
<td>3&quot;</td>
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<td></td>
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</tr>
<tr>
<td>150 80</td>
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<td>200 (7.87)</td>
<td>190,5 (7,5)</td>
</tr>
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<td>300 80</td>
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<td>900 80</td>
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<td>4&quot;</td>
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</tr>
<tr>
<td>150 80</td>
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<td>250 (9,84)</td>
<td>228,6 (9,0)</td>
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<td>292,1 (11,5)</td>
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</tr>
<tr>
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</tr>
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<td>150 80</td>
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<td>300 (11,81)</td>
<td>279,4 (11,0)</td>
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<td>300 (11,81)</td>
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<td>381 (15)</td>
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</tr>
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<td>343 (13,5)</td>
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<td>300 80</td>
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</tr>
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<td>419,1 (16,5)</td>
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<td>469,9 (18,5)</td>
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</tr>
<tr>
<td>10&quot;</td>
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<td>500 (19,69)</td>
<td>558,8 (22)</td>
</tr>
</tbody>
</table>
4.4 FS4000-ST4/SR4 (TRIO-WIRL S)

Fig. 22: All dimensions in mm (inch), projection in accordance with ISO method E

1) Dimension tolerance: DN 15 ... DN 200: +0 / -3 mm; DN 300 ... DN 400: +0 / -5 mm
<table>
<thead>
<tr>
<th>Nominal diameter</th>
<th>Nominal pressure</th>
<th>Dimensions in mm (inch)</th>
<th>Weight in kg (lb)</th>
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<td></td>
<td></td>
<td>L¹</td>
<td>G</td>
</tr>
<tr>
<td>DN</td>
<td>lb</td>
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</tr>
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<td></td>
<td></td>
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<td>200 (7.87)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3/4&quot;</td>
<td>150</td>
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<tr>
<td></td>
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<td>300</td>
<td>230 (9,06)</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>150 (5,91)</td>
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<td>200 (7.87)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2&quot;</td>
<td>150</td>
</tr>
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<td></td>
<td>300</td>
<td>200 (7.87)</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>6&quot;</td>
<td>150</td>
</tr>
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<td></td>
<td></td>
<td>300</td>
<td>480 (18,9)</td>
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<td>8&quot;</td>
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<td></td>
<td></td>
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<td>600 (23,62)</td>
</tr>
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<td>12&quot;</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16&quot;</td>
<td>150</td>
</tr>
</tbody>
</table>

¹ Dimension tolerance: DN 15 ... DN 200 +0 / -3 mm; DN 300 ... DN 400: +0 / -5 mm
5 Transmitter specifications

5.1.1 General specifications

Fig. 23: Transmitter keypad and LCD display
1 Magnet sensors  
2 Control buttons for direct entry  
3 Can be rotated +/- 90°

Measuring ranges
The full-scale value can be set at any point between the maximum possible upper range value 1.15 \times Q_{\text{maxDN}} and 0.15 \times Q_{\text{maxDN}}.

Parameter setting
Data can be entered using 3 control buttons (not with the Ex "d" hazardous area design) or, if the housing is sealed, directly from an external location using a magnetic pen.

Flow operating modes
The following operating modes can be selected dependent upon the design purchased (with or without Pt100):

- **Fluid medium:**
  - Operating flow
  - Mass flow with constant or temperature-dependent density

- **Gas/steam medium:**
  - Operating flow
  - Mass flow with constant or temperature-dependent density (at constant pressure)
  - Standard flow with constant or temperature-dependent standard factor (at constant pressure)
  - Mass flow with saturated steam and temperature-driven density

Data backup
Counter readings and parameters for specific measuring points backed up in FRAM (more than 10 years without supply power) in the case of shutdown or should the supply voltage fail.

Damping
Configurable from 1 ... 100 s, corresponds to 5 \tau.

\( Q_{v \text{min}} \) (flow low)
Configurable between 2 ... 25 % of \( Q_{\text{maxDN}} \) (max. operating flow per nominal size). The actual low flow is determined by application and installation.

Function tests
Software-internal function tests can be used to test individual internal modules. For the purpose of commissioning and testing, the current output (4 ... 20 mA design) or the digital output signal (fieldbus designs) can be simulated in line with flowrates selected by the user (manual process control). The switching output can also be controlled directly for the purpose of function testing.

Electrical connection
Screw-type terminals, plug-in connection on PROFIBUS PA (option) cable gland: -standard-, Ex "ib" / Ex "ia": M20 x 1.5, NPT 1/2" -Ex "d": NPT 1/2"

Ingress protection
IP 67 to EN 60529

Display
High-contrast LCD display, 2 x 8-digit (4 ... 20 mA design) or 4 x 16-digit (PROFIBUS PA / FOUNDATION fieldbus design). Shows the instantaneous flowrate along with the totalized flow or temperature of the medium (option). On the 4 ... 20 mA design, the multiplex function enables 2 values (e.g., flowrate and totalized flow) to be displayed virtually in parallel. Up to 4 values can be displayed on the fieldbus design.

Switching output terminals 41 / 42
(standard on all designs)
The function can be selected via the software:
- Max./min. alarm for flow or temperature
- System alarm
- Pulse output: \( f_{\text{max}}: 100 \text{ Hz}; \ t_{\text{on}}: 1 \ldots 256 \text{ ms} \)

Contact type:
- Standard and Ex "d": Optocoupler \( U_{H} = 16 \ldots 30 \text{ V} \) \( I_{L} = 2 \ldots 15 \text{ mA} \)
- Ex "ib" / Ex "ia": Configured as NAMUR contact

EMC protection
The flowmeter corresponds to NAMUR recommendations NE21. Electromagnetic compatibility of equipment for process and lab control technology 5/93 and EMC Directive 2004/108/EC (EN 61326-1). Note: EMC protection and protection against accidental contact are limited when the housing cover is open.
6 Communication

6.1 2-wire technology design

The design of the Vortex or Swirl flowmeter transmitter features 2-wire technology, i.e., the power supply and digital communication for the fieldbus interface both use the same wires. An additional switching output is also available for use at the same time.

All stored data is preserved in the event of a power failure. The SMART VISION program can be used for operation and configuration purposes. SMART VISION is a piece of universal communication software for intelligent field devices based on FDT / DTM technology.

Data can be exchanged with a comprehensive range of field devices using various means of communication. The main applications include parameter display, configuration, diagnostics, recording, and data management for all intelligent field devices that specifically meet the communication requirements involved.

6.2 4...20 mA / HART

6.2.1 Electrical connection for 4...20 mA / HART

<table>
<thead>
<tr>
<th>Supply power (terminals 31 / 32)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
</tr>
<tr>
<td>Hazardous area design</td>
</tr>
<tr>
<td>Residual ripple</td>
</tr>
<tr>
<td>Power consumption</td>
</tr>
</tbody>
</table>

Electrical connection for FV4000-VR4, FS4000-SR4

With these designs, the sensor and transmitter are separated by a signal cable of up to 10 m in length. The signal cable is permanently connected to the transmitter and can be made shorter if required. Fig. 24 shows how the supply power connection is arranged for the transmitter.

Fig. 24: Supply power from central power supply, supply power (DC or AC) from power supply unit
1. Functional ground
2. Power supply unit
UB = Supply voltage = min. 14 V DC
US = Supply voltage = 14 ... 46 V DC
RB = Maximum permissible load for the power supply unit (e.g. display, load)
R = Maximum permissible load for the output circuit (determined by the power supply unit)

Fig. 25: Load diagram for current output, load via supply power

In HART communication, the smallest load is 250 Ω. The load $R_E$ is calculated on the basis of the available supply voltage $U_S$ and the selected signal current as follows:

$$R_E = \frac{U_S}{I_B}$$

Fig. 26: Load resistance of the switching output as a function of current and voltage
6.2.3 HART protocol communication

The HART protocol is used for digital communication between a process control system / PC, a handheld terminal, and the Vortex or Swirl flowmeter.

It can be used to send all device and measuring point parameters from the transmitter to the process control system or PC. Conversely, it also provides a means of reconfiguring the transmitter. Digital communication utilizes an alternating current superimposed on the analog output (4 ... 20 mA) that does not affect any meters connected to the output.

Transmission method
FSK modulation at current output of 4 ... 20 mA based on the Bell 202 standard. Max. signal amplitude: 1.2 mA ss.

Current output load
Min. > 250 Ω, max. 750 Ω
Max. cable length: 1,500 m; AWG 24 twisted and shielded

Baud rate
1,200 baud

Display
Logic 1: 1,200 Hz, Logic 0: 2,200 Hz

Current output for alarm
High = 21 ... 23 mA, adjustable (NE43)

6.2.2 Current output for alarm

21 ... 23 mA in accordance with Namur NE43

The measurement value output at the current output is as shown in the figure: Above the low flow, the current is a straight line that would have 4 mA in Q = 0 and 20 mA in Q = Qmax operating mode. Due to low flow cutoff, the flow is set to 0 below x % Qmax or the low flow (in other words, the current is 4 mA).

Fig. 27: Electrical connection

Fig. 28: Current output

1 Low flow

The measurement value output at the current output is as shown in the figure: Above the low flow, the current is a straight line that would have 4 mA in Q = 0 and 20 mA in Q = Qmax operating mode. Due to low flow cutoff, the flow is set to 0 below x % Qmax or the low flow (in other words, the current is 4 mA).

Fig. 29

1 Current output without errors "3" and "9", output: 20.5 mA (NAMUR NE43)
2 Current output with errors "3" and "9", the output switches to alarm status (21 ... 23 mA, configurable)
3 Current output with error "9", the output switches to alarm status at 120 % of QmaxDN (21 ... 23 mA, configurable)

Qmin = Low flow

Fig. 30: HART communication

1 FSK modem
6.3 PROFIBUS PA

6.3.1 PROFIBUS PA electrical connection

1) Terminals 31, 32
Function PA+, PA-
Connection for PROFIBUS PA to IEC 1158-2
U = 9 ... 24 V, I = 10 mA (normal operation)
13 mA (in the event of an error / FDE)

2) Terminals 41, 42
Function C9, E9
Switching output: Function can be selected via software as a pulse output (fmax: 100 Hz, 1 ... 256 ms), min. / max. alarm or system alarm.
Configured as NAMUR contact to DIN 19234.
Closed: 1 KΩ
Open: > 10 KΩ

M12 plug-in connector

![Fig. 31: Assignment for connection using optional M12 plug-in connector](image)

<table>
<thead>
<tr>
<th>Pin</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PA+ (31)</td>
</tr>
<tr>
<td>2</td>
<td>NC</td>
</tr>
<tr>
<td>3</td>
<td>PA- (32)</td>
</tr>
<tr>
<td>4</td>
<td>Shield</td>
</tr>
</tbody>
</table>

6.3.2 PROFIBUS PA communication

The transmitter is suitable for connection to DP/PA segment couplers and the ABB MB204 multibarrier.

PROFIBUS PA protocol
Output signal: in accordance with EN 50170 Volume 2,
PROFIBUS transmission method: IEC 1158-2/EN 61158-2
Transmission speed: 31.25 kByte/s
PROFIBUS profile: Version 3.0

Ident Number
05DC hex

Function blocks
2 x AI,
1 x TOT

GSD files
- PA139700 (1 x AI)
- PA139740 (1 x AI, 1 x TOT)
- ABB_05DC (2 x AI, 1 x TOT + manufacturer-specific data)

![Fig. 32: Block structure for PROFIBUS PA](image)

6.3.3 Example: PROFIBUS PA communication

![Fig. 33: Example for PROFIBUS PA interface connection](image)

1 H2 bus
2 Segment coupler (incl. bus supply and termination)
6.4  FOUNDATION fieldbus

6.4.1  FOUNDATION fieldbus electrical connection

1) Terminals 31, 32
Function FF+, FF-
Connection for FOUNDATION fieldbus (H1) to IEC 1158-2
U = 9 ... 24 V, I = 10 mA (normal operation)
13 mA (in the event of an error / FDE)

2) Terminals 41, 42
Function C9, E9
Switching output: Function can be selected via software as a pulse output (fmax: 100 Hz, 1 ... 256 ms), min. / max. alarm or system alarm.
Configured as NAMUR contact to DIN 19234.
Closed: 1 KΩ
Open: > 10 KΩ

6.4.2  FOUNDATION fieldbus communication

The transmitter is suitable for connection to special power supply units, a linking device, and the ABB MB204 multibarrier.

FOUNDATION fieldbus protocol
Output signal: in accordance with the FOUNDATION fieldbus protocol
Specification: 1.4 / ITK 4.01 for the H1 bus
Transmission method: IEC 1158-2 / EN 61158-2
Transmission speed: 31.25 kByte/s
Manufacturer ID: 0x000320 Device ID: 0x0015
Reg. number: IT013600

Function blocks
2 x analog inputs

Stack
With LAS functionality

Fig. 34: Block structure for FOUNDATION fieldbus
The channel selector can be used to select the initial variable (volume / mass / standard flow, counter or temperature).

6.4.3  Example: FOUNDATION fieldbus communication

Fig. 35: Example for FOUNDATION fieldbus interface connection
1  HSE bus  2  Linking device (incl. bus supply and termination)
7 Ex relevant specifications for transmitter

7.1 Ex "ib" / Ex "n" design for VT41/ST41 and VR41/SR41 (4 ... 20 mA / HART)

**Important**
The devices may only be operated in explosive areas if the housing covers have been fully closed.

EC type-examination certificate TÜV 08 ATEX 554808 X / TÜV 10 ATEX 387786 X

**Declaration of conformity TÜV 08 ATEX 554833 X / TÜV 10 ATEX 556214 X**

**Certificate of conformity IECEx TUN 07.0014 X / TUN 10.0024 X**

1) Not for Shanghai production site

---

**Flowmeter sensor wire colors**

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Wire color</th>
</tr>
</thead>
<tbody>
<tr>
<td>81</td>
<td>Red</td>
</tr>
<tr>
<td>82</td>
<td>Blue</td>
</tr>
<tr>
<td>83</td>
<td>Pink</td>
</tr>
<tr>
<td>84</td>
<td>Gray</td>
</tr>
<tr>
<td>85</td>
<td>Yellow</td>
</tr>
<tr>
<td>86</td>
<td>Green</td>
</tr>
<tr>
<td>86</td>
<td>Brown</td>
</tr>
<tr>
<td>87</td>
<td>White</td>
</tr>
</tbody>
</table>

---

**Fig. 36:** Electrical connection for VT41 / ST41 and VR41 / SR41

1) Flowmeter sensor
2) Transmitter

---

1) Supply power terminals 31 / 32
   a) Ex ib: \( U_i = 28 \) V DC
   b) Ex nA [nL]: \( U_B = 14 \ldots 46 \) V DC

2) Switching output, terminals 41 / 42
   a) NAMUR with switching amplifier
   b) Switching output (optocoupler)
      - Ex ib: \( U_i = 15 \) V
      - Ex nA [nL]: \( U_B = 16 \ldots 30 \) V

**Important**
The installation instructions in accordance with EN 60079-14 must be complied with.

When commissioning the flowmeter, refer to IEC 61241-1-2 regarding use in areas with combustible dust. The transmitter housing cover must be secured by means of the safety locking device. After switching off the supply power, wait \( t > 2 \) minutes before opening the transmitter housing.

---

**Fig. 37**

The minimum voltage \( U_S \) of 14 V is based on a load of 0 Ω.

\( U_S = \) supply voltage

\( R_B = \) Maximum permissible load in power supply circuit, e.g., indicator, recorder or power resistor
### 7.1.2 Approval data for hazardous areas

<table>
<thead>
<tr>
<th>Power supply circuit</th>
<th>Terminals 31, 32</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of protection</strong></td>
<td><strong>U_{in} = 60 V</strong></td>
</tr>
<tr>
<td>Zone 1: Ex ib IIC</td>
<td>$T_{amb} = (-40 , ^\circ C) - 20 \ldots 70 , ^\circ C$</td>
</tr>
<tr>
<td>$U_i = 28 , V$</td>
<td>$I_i = 110 , mA$</td>
</tr>
<tr>
<td>$P_i = 770 , mW$</td>
<td>Effective internal capacitance: 14.6 nF</td>
</tr>
<tr>
<td>Effective internal capacitance to ground: 24.4 nF</td>
<td>Effective internal inductance: 0.27 mH</td>
</tr>
<tr>
<td>Zone 2: Ex nA [nL] IIC</td>
<td>$T_{amb} = (-40 , ^\circ C) - 20 \ldots 70 , ^\circ C$</td>
</tr>
<tr>
<td>$U_B = 14 \ldots 46 , V$</td>
<td>$I_B = 2 \ldots 15 , mA$</td>
</tr>
<tr>
<td>Zone 21 / 22: Ex tD A21 / Ex tD A22</td>
<td>$T_{amb} = -20 , ^\circ C \ldots 60 , ^\circ C$</td>
</tr>
</tbody>
</table>

The devices must be installed in a protected environment in accordance with the specific conditions on the test certificate. Pollution degree 3 (see IEC 60664-1) must not be exceeded for the macro environment of the device. The devices conform to degree of protection IP 65 / IP 67. If the device is installed as intended, this requirement is met by the housing as standard.

When connected to the line supply / not connected to the line supply, the electrical circuits must not exceed overvoltage category III / II.

### 7.1.3 Medium temperatures / Temperature classes

For the supply circuit "Terminals 31, 32" and the switching outputs "Terminals 41, 42", cables suitable for temperatures up to $T = 110 \, ^\circ C$ ($T = 230 \, ^\circ F$) can be used without restriction.

**Category 2/3G**
For cables suitable only for temperatures up to $T = 80 \, ^\circ C$ ($T = 176 \, ^\circ F$), the interconnection of both circuits needs to be taken into account in the event of a fault. Otherwise, the restricted temperature ranges listed in the following table shall apply.

**Category 2D**
For cables suitable only for temperatures up to $T = 80 \, ^\circ C$ ($T = 176 \, ^\circ F$), the restricted temperature ranges listed in the following table shall apply.

<table>
<thead>
<tr>
<th>Ambient temperature 2)</th>
<th>Max. temperature at used connecting cable, &quot;Terminals 31, 32&quot;, &quot;Terminals 41, 42&quot;</th>
<th>Max. permissible medium temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>$(-40) -20 \ldots 70 , ^\circ C$ 3)</td>
<td>110 °C (230 °F)</td>
<td>280 °C / 400 °C 1) (536 °F / 752 °F) 1)</td>
</tr>
<tr>
<td>$((-40) -4 \ldots 158 , ^\circ F)$ 3)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ambient temperature 2)</th>
<th>Max. temperature at used connecting cable, &quot;Terminals 31, 32&quot;, &quot;Terminals 41, 42&quot;</th>
<th>Max. permissible medium temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>$(-40) -20 \ldots 60 , ^\circ C$</td>
<td>80 °C (176 °F)</td>
<td>240 °C (464 °F)</td>
</tr>
<tr>
<td>$((-40) -4 \ldots 140 , ^\circ F)$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ambient temperature 2)</th>
<th>Max. temperature at used connecting cable, &quot;Terminals 31, 32&quot;, &quot;Terminals 41, 42&quot;</th>
<th>Max. permissible medium temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>$(-40) -20 \ldots 55 , ^\circ C$</td>
<td>280 °C (536 °F)</td>
<td></td>
</tr>
<tr>
<td>$((-40) -4 \ldots 131 , ^\circ F)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$(-40) -20 \ldots 50 , ^\circ C$</td>
<td>320 °C (608 °F)</td>
<td></td>
</tr>
<tr>
<td>$((-40) -4 \ldots 122 , ^\circ F)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$(-40) -20 \ldots 40 , ^\circ C$</td>
<td>400 °C (752 °F)</td>
<td></td>
</tr>
<tr>
<td>$((-40) -4 \ldots 104 , ^\circ F)$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) Medium temperatures > 280 °C (> 536 °F) with FV4000 Vortex flowmeter only
2) The permissible limits for the ambient temperature are approval- and order-specific (standard: -20 °C (4 °F)).
3) Category 2D (dust-ignition proof) maximum 60° C (140° F)

<table>
<thead>
<tr>
<th>Maximum medium temperature</th>
<th>Temperature class</th>
</tr>
</thead>
<tbody>
<tr>
<td>130 °C (266 °F)</td>
<td>T4</td>
</tr>
<tr>
<td>195 °C (383 °F)</td>
<td>T3</td>
</tr>
<tr>
<td>290 °C (554 °F)</td>
<td>T2</td>
</tr>
<tr>
<td>400 °C (752 °F)</td>
<td>T1</td>
</tr>
</tbody>
</table>
7.2 Ex "d" / Ex "ib" / Ex "n" design for VT42/ST42 and VR42/SR42 (4 ... 20 mA / HART)

Important
The devices may only be operated in explosive areas if the housing covers have been fully closed.

EC type-examination certificate TÜV 08 ATEX 554955 X / TÜV 10 ATEX 387788 X

Designation
- Transmitter / flowmeter
  II 2G Ex d [ib] IIC T6
  II 2G Ex ib IIC T4
  II 2D Ex tD A21 T 85 °C ... T_{medium} IP 67

- Flowmeter sensor
  II 2G Ex ib IIC T4
  II 2D Ex tD A21 T 85 °C ... T_{medium} IP 67

Declaration of conformity TÜV 08 ATEX 554956 X / TÜV 10 ATEX 556215 X

Designation on sensor / transmitter / flowmeter:
- II 3G Ex nA [nL] IIC T4
- II 3D Ex tD A22 T85°C...T_{medium} IP 67

Certificate of conformity IECEx TUN 08.0010 X / TUN 10.0025 X

Designation:
- Ex d [ib] IIC T6 to T1
- Ex ib IIC T4 to T1
- Ex tD A21 [P6X] T85°C...T_{medium}
- Ex nA [nL] IIC T4 to T1

1) Not for Shanghai production site

Flowmeter sensor wire colors

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Wire color</th>
</tr>
</thead>
<tbody>
<tr>
<td>81</td>
<td>Red</td>
</tr>
<tr>
<td>82</td>
<td>Blue</td>
</tr>
<tr>
<td>83</td>
<td>Pink</td>
</tr>
<tr>
<td>84</td>
<td>Gray</td>
</tr>
<tr>
<td>85</td>
<td>Yellow</td>
</tr>
<tr>
<td>86</td>
<td>Green</td>
</tr>
<tr>
<td>87</td>
<td>White</td>
</tr>
</tbody>
</table>

1) Supply power terminals 31 / 32
   - Ex ib: $U_i = 28$ V DC
   - Ex d [ib] / Ex nA [nL] $U_B = 14 \ldots 46$ V DC

2) Switching output, terminals 41 / 42
   - The switching output (passive) is designed as an optocoupler. If required, the switching output (passive) can be designed as a NAMUR contact (to DIN 19234).
   - Ex ib: $U_i = 15$ V
   - Ex d [ib] / Ex nA [nL]: $U_B = 16 \ldots 30$ V
     $I_B = 2 \ldots 15$ mA

Important
Supply current (supply power) and switching output must be either only intrinsically safe or only non-intrinsically safe. A combination of the two is not permitted. On intrinsically safe circuits, equipotential bonding must be in place along the entire length of the cable used.

Fig. 38: Electrical connection for VT42 / ST42 and VR42 / SR42

1 Flowmeter sensor
2 Transmitter
3 Flowmeter
### 7.2.1 Supply power or supply current

![Graph](image)

The minimum voltage $U_S$ of 14 V is based on a load of 0 $\Omega$.

\[
U_S = \text{supply voltage}
\]

\[
R_B = \text{Maximum permissible load in power supply circuit, e.g., indicator, recorder or power resistor}
\]

**Important**

The installation instructions in accordance with EN 60079-14 must be complied with.

When commissioning the flowmeter, refer to IEC 61241-1-2 regarding use in areas with combustible dust. The transmitter housing cover must be secured by means of the safety locking device. After switching off the supply power, wait $t > 2$ minutes before opening the transmitter housing.

### 7.2.2 Approval data for hazardous areas

<table>
<thead>
<tr>
<th>Power supply circuit</th>
<th>Terminals 31, 32</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1: Ex d [ib] IIC</td>
<td>$U_\text{amb} = (-40 , ^\circ\text{C}) - 20 \ldots 60 , ^\circ\text{C}$</td>
</tr>
<tr>
<td>Zone 2: Ex nA [nL] IIC</td>
<td></td>
</tr>
<tr>
<td>$U_S = 14 \ldots 46 , \text{V}$</td>
<td></td>
</tr>
<tr>
<td>Zone 1: Ex ib IIC</td>
<td>$U_\text{amb} = (-40 , ^\circ\text{C}) - 20 \ldots 70 , ^\circ\text{C}$</td>
</tr>
<tr>
<td>$U_i = 28 , \text{V}$</td>
<td></td>
</tr>
<tr>
<td>$I_i = 110 , \text{mA}$</td>
<td></td>
</tr>
<tr>
<td>$P_i = 770 , \text{mW}$</td>
<td></td>
</tr>
<tr>
<td>Effective internal capacitance: 14.6 nF</td>
<td></td>
</tr>
<tr>
<td>Effective internal capacitance to ground: 24.4 nF</td>
<td></td>
</tr>
<tr>
<td>Effective internal inductance: 0.27 mH</td>
<td></td>
</tr>
<tr>
<td>Zone 21 / 22: Ex d [ib] IIC</td>
<td>$T_\text{amb} = -20 \ldots 60 , ^\circ\text{C}$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Power supply circuit</th>
<th>Terminals 41, 42</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1: Ex d [ib] IIC</td>
<td>$U_\text{amb} = (-40 , ^\circ\text{C}) - 20 \ldots 70 , ^\circ\text{C}$</td>
</tr>
<tr>
<td>Zone 2: Ex nA [nL] IIC</td>
<td></td>
</tr>
<tr>
<td>$U_S = 16 \ldots 30 , \text{V}$</td>
<td></td>
</tr>
<tr>
<td>$I_B = 2 \ldots 15 , \text{mA}$</td>
<td></td>
</tr>
<tr>
<td>Zone 1: Ex ib IIC</td>
<td>$U_i = 15 , \text{V}$</td>
</tr>
<tr>
<td>$I_i = 30 , \text{mA}$</td>
<td></td>
</tr>
<tr>
<td>$P_i = 115 , \text{mW}$</td>
<td></td>
</tr>
<tr>
<td>Effective internal capacitance: 11.6 nF</td>
<td></td>
</tr>
<tr>
<td>Effective internal capacitance to ground: 19.6 nF</td>
<td></td>
</tr>
<tr>
<td>Effective internal inductance: 0.14 mH</td>
<td></td>
</tr>
<tr>
<td>Zone 21 / 22: Ex td A21 / Ex tD A22</td>
<td>$T_\text{amb} = -20 \ldots 60 , ^\circ\text{C}$</td>
</tr>
</tbody>
</table>

When connected to the line supply / not connected to the line supply, the electrical circuits must not exceed overvoltage category III / II.
7.2.3 Medium temperatures / Temperature classes

For the supply circuit "Terminals 31, 32" and the switching outputs "Terminals 41, 42", cables suitable for temperatures up to T = 110 °C (T = 230 °F) can be used without restriction.

Category 2/3G (Ex ib IIC)

For cables suitable only for temperatures up to T = 80 °C (T = 176 °F), the interconnection of both circuits needs to be taken into account in the event of a fault. Otherwise, the restricted temperature ranges listed in the following table shall apply.

Category 2D

For cables suitable only for temperatures up to T = 80 °C (T = 176 °F), the restricted temperature ranges listed in the following table shall apply.

<table>
<thead>
<tr>
<th>Ambient temperature 2)</th>
<th>Max. temperature at used connecting cable, &quot;Terminals 31, 32&quot;, &quot;Terminals 41, 42&quot;</th>
<th>Max. permissible medium temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>(-40) ... 60 °C (-40) ... 140 °F</td>
<td>110 °C (230 °F)</td>
<td>280 °C / 400 °C 1) (536 °F / 752 °F) 1)</td>
</tr>
<tr>
<td>(-40) ... 60 °C (-40) ... 140 °F</td>
<td>240 °C (464 °F)</td>
<td></td>
</tr>
<tr>
<td>(-40) ... 55 °C (-40) ... 131 °F</td>
<td>80 °C (176 °F)</td>
<td>280 °C (536 °F)</td>
</tr>
<tr>
<td>(-40) ... 50 °C (-40) ... 122 °F</td>
<td></td>
<td>320 °C (608 °F) 1)</td>
</tr>
<tr>
<td>(-40) ... 40 °C (-40) ... 104 °F</td>
<td></td>
<td>400 °C (752 °F) 1)</td>
</tr>
</tbody>
</table>

1) Medium temperatures > 280 °C (> 536 °F) with FV4000 Vortex flowmeter only
2) The permissible lower limits for the ambient temperature are approval- and order-specific (standard: -20 °C (-4 °F)).

Hazardous area design

<table>
<thead>
<tr>
<th>Maximum medium temperature</th>
<th>Temperature class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ex d [ib] IIC</td>
<td>80 °C (176 °F) T6 3)</td>
</tr>
<tr>
<td></td>
<td>95 °C (203 °F) T5 3)</td>
</tr>
<tr>
<td>Ex ib IIC bzw. Ex nA [nL]</td>
<td>130 °C (266 °F) T4</td>
</tr>
<tr>
<td></td>
<td>195 °C (383 °F) T3</td>
</tr>
<tr>
<td></td>
<td>290 °C (554 °F) T2</td>
</tr>
<tr>
<td></td>
<td>400 °C (752 °F) T1</td>
</tr>
</tbody>
</table>

3) Not possible for flowmeter sensor version VR42 / SR42

7.3 FM approval design for the USA and Canada for VT43/ST43 and VR43/SR43 (4 ... 20 mA / HART)

Important

The devices may only be operated in explosive areas if the housing covers have been fully closed.

Designation

<table>
<thead>
<tr>
<th>Explosion-proof</th>
<th>XP/Class I/Div 1/BCD/T4 Ta = 70 °C Type 4X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dust-ignition-proof</td>
<td>DIP/Class II,III/Div 1/EF/G/T4 Ta = 70 °C Type 4X</td>
</tr>
<tr>
<td>Intrinsic safety</td>
<td>IS/Class II,III/Div 1/ABCDEF/G/T4 Ta = 70 °C Entity Type 4X</td>
</tr>
<tr>
<td>Non-incendive</td>
<td>N/Class II/Div 2/ABCDEFG/T4 Ta = 70 °C Type 4X</td>
</tr>
<tr>
<td>Suitable</td>
<td>S/Class II,III/Div 2/FG/T4 Ta = 70 °C Type 4X</td>
</tr>
</tbody>
</table>

The devices must be installed in a protected environment in accordance with the specific conditions on the test certificate. Pollution degree 3 (see IEC 60664-1) must not be exceeded for the macro environment of the device. The devices conform to degree of protection IP65 / IP67. If the device is installed as intended, this requirement is met by the housing as standard.

When connected to the line supply / not connected to the line supply, the electrical circuits must not exceed overvoltage category III / II.

IS Entity see: SD-50-2681 (Fig. 35)

Parameters: Vmax, Imax, Pi, Li, Ci

Enclosure: Type 4X

![Diagram](Fig. 40: Electrical connection for VT43 / ST43 and VR43 / SR43)

1 Flowmeter sensor  3 Flowmeter
2 Transmitter

Flowmeter sensor wire colors

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Wire color</th>
</tr>
</thead>
<tbody>
<tr>
<td>81</td>
<td>Red</td>
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<tr>
<td>85</td>
<td>Yellow</td>
</tr>
<tr>
<td>86</td>
<td>Green</td>
</tr>
<tr>
<td>88</td>
<td>Brown</td>
</tr>
<tr>
<td>87</td>
<td>White</td>
</tr>
</tbody>
</table>
### 7.3.1 Supply power or supply current

**Fig. 41**

The minimum voltage $U_S$ of 14 V is based on a load of 0 Ω.

$U_S = $ supply voltage

$R_B = $ Maximum permissible load in power supply circuit, e.g., indicator, recorder or power resistor

### 7.3.2 Medium temperatures / Temperature classes

For the supply circuit "Terminals 31, 32" and the switching outputs "Terminals 41, 42", cables suitable for temperatures up to $T = 110 \, ^\circ C$ ($T = 230 \, ^\circ F$) can be used without restriction.

For cables suitable only for temperatures up to $T = 80 \, ^\circ C$ ($T = 176 \, ^\circ F$), the restricted temperature ranges listed in the following table shall apply.

<table>
<thead>
<tr>
<th>Ambient temperature</th>
<th>Max. temperature at used connecting cable, &quot;Terminals 31, 32&quot;, &quot;Terminals 41, 42&quot;</th>
<th>Max. permissible medium temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>(-45) -20 ... 70 °C</td>
<td>110 °C (230 °F)</td>
<td>280 °C / 400 °C (536 °C / 752 °F)</td>
</tr>
<tr>
<td>(-45) -20 ... 55 °C</td>
<td>80 °C (176 °F)</td>
<td>240 °C (464 °F)</td>
</tr>
<tr>
<td>(-45) -20 ... 50 °C</td>
<td>80 °C (176 °F)</td>
<td>280 °C (536 °F)</td>
</tr>
<tr>
<td>(-45) -20 ... 40 °C</td>
<td>80 °C (176 °F)</td>
<td>320 °C (608 °F)</td>
</tr>
</tbody>
</table>

1) Medium temperatures > 280 °C (> 536 °F) with VT43 / VR43 Vortex flowmeter only

### 7.3.3 Approval data for hazardous areas

#### Supply circuit terminals 31, 32

<table>
<thead>
<tr>
<th>Explosion-proof XP/Class I/Div 1/BCD/T4 $Ta = 70 , ^\circ C$ Type 4X</th>
<th>$U_B = 14 \ldots 46 , V$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dust-ignition-proof DIP/Class II,III/Div 1/EFG/T4 $Ta = 70 , ^\circ C$ Type 4X</td>
<td></td>
</tr>
<tr>
<td>DIP/Class II,III /Div 2 /EFG/T4 $Ta=70,^\circ C$ Type 4X</td>
<td></td>
</tr>
<tr>
<td>Intrinsic safety IS/Class I, II,III/Div 1 ABCDEFG/T4 $Ta = 70 , ^\circ C$ Entity Type 4X</td>
<td></td>
</tr>
<tr>
<td>$V_{\max} = 28 , V$</td>
<td></td>
</tr>
<tr>
<td>$I_{\max} = 110 , mA$</td>
<td></td>
</tr>
<tr>
<td>$P_i = 770 , mW$</td>
<td></td>
</tr>
<tr>
<td>Effective internal capacitance: 14.6 nF</td>
<td></td>
</tr>
<tr>
<td>Effective internal inductance: 0.27 mH</td>
<td></td>
</tr>
<tr>
<td>Non-incendive NI/Class I/Div 2/ABC/T4 $Ta = 70 , ^\circ C$ Type 4X</td>
<td></td>
</tr>
<tr>
<td>$U_B = 14 \ldots 46 , V$</td>
<td></td>
</tr>
</tbody>
</table>

#### Supply circuit terminals 41, 42

<table>
<thead>
<tr>
<th>Explosion-proof XP/Class I/Div 1/BCD/T4 $Ta = 70 , ^\circ C$ Type 4X</th>
<th>$U_B = 16 \ldots 30 , V$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dust-ignition-proof DIP/Class II,III/Div 1/EFG/T4 $Ta = 70 , ^\circ C$ Type 4X</td>
<td></td>
</tr>
<tr>
<td>DIP/Class II,III /Div 2 /EFG/T4 $Ta=70,^\circ C$ Type 4X</td>
<td></td>
</tr>
<tr>
<td>Intrinsic safety IS/Class I, II,III/Div 1 ABCDEFG/T4 $Ta = 70 , ^\circ C$ Entity Type 4X</td>
<td></td>
</tr>
<tr>
<td>$V_{\max} = 15 , V$</td>
<td></td>
</tr>
<tr>
<td>$I_{\max} = 30 , mA$</td>
<td></td>
</tr>
<tr>
<td>$P_i = 115 , mW$</td>
<td></td>
</tr>
<tr>
<td>Effective internal capacitance: 11 nF</td>
<td></td>
</tr>
<tr>
<td>Effective internal inductance: 0.14 mH</td>
<td></td>
</tr>
<tr>
<td>Non-incendive NI/Class I/Div 2/ABC/T4 $Ta = 70 , ^\circ C$ Type 4X</td>
<td></td>
</tr>
<tr>
<td>$U_B = 16 \ldots 30 , V$</td>
<td></td>
</tr>
<tr>
<td>$I_B = 2 \ldots 15 , mA$</td>
<td></td>
</tr>
</tbody>
</table>
7.3.4 Trio-Wirl control drawing
7.4 Ex "ia" design for VT4A/ST4A and VR4A/SR4A (fieldbus)

**Important**
The devices may only be operated in explosive areas if the housing covers have been fully closed.

EC type-examination test certificate TÜV 10 ATEX 556309 X / TÜV 10 ATEX 387782 X

**Designation**
Il 2G Ex ia IIC T4 Gb
Il 2 D Ex ta IIIC T85°C ... Tmedium, Db IP67 (type VT4A. / ST4A.)
Il 2 D Ex ta IIIC T85°C Db IP67 (type VR4A. / SR4A.)

Certificate of conformity IECEx CoC TUN 10.0028 X / CoC TUN 10.0029 X

**Designation**
Ex ia IIC T4 Gb
Ex ia IIC T85°C ... Tmedium, Db IP67 (type VT4A. / ST4A. / VR4A. / SR4A.)
Ex ia IIC T85°C Db IP67 (type VR4A. / SR4A.)

The hazardous area design is based on the PTB's FISCO model (FISCO = fieldbus intrinsically safe concept).

1) Not for Shanghai production site

### 7.4.1 PROFIBUS PA electrical connection

1) Terminals 31, 32
Function PA+, PA-
Connection for PROFIBUS PA to IEC 1158-2

U = 9 ... 24 V, I =
- 10 mA (normal operation)
- 13 mA (in the event of an error / FDE)

2) Terminals 41, 42
Function C9, E9
Switching output: Function can be selected via software as a pulse output (fmax: 100 Hz, 1 ... 256 ms), min. / max. alarm or system alarm.

Configured as NAMUR contact to DIN 19234.
Closed: 1 KΩ
Open: > 10 KΩ

**M12 plug-in connector**

![Assignment for connection using optional M12 plug-in connector](image)

<table>
<thead>
<tr>
<th>Pin</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PA+ (31)</td>
</tr>
<tr>
<td>2</td>
<td>NC</td>
</tr>
<tr>
<td>3</td>
<td>PA- (32)</td>
</tr>
<tr>
<td>4</td>
<td>Shield</td>
</tr>
</tbody>
</table>

### 7.4.2 FOUNDATION fieldbus electrical connection

1) Terminals 31, 32
Function FF+, FF-
Connection for FOUNDATION fieldbus (H1) to IEC 1158-2

U = 9 ... 24 V, I =
- 10 mA (normal operation)
- 13 mA (in the event of an error / FDE)

2) Terminals 41, 42
Function C9, E9
Switching output: Function can be selected via software as a pulse output (fmax: 100 Hz, 1 ... 256 ms), min. / max. alarm or system alarm.

Configured as NAMUR contact to DIN 19234.
Closed: 1 KΩ
Open: > 10 KΩ

**Important**
The installation instructions in accordance with EN 60079-14 must be complied with.

When commissioning the flowmeter, refer to IEC 61241-1-2 regarding use in areas with combustible dust. The transmitter housing cover must be secured by means of the safety locking device. After switching off the supply power, wait t > 2 minutes before opening the transmitter housing.
7.4.3 Approval data for hazardous areas

**II 2D**

\[ T_{\text{medium}} = 85 \, ^\circ\text{C} \ldots \, T_{\text{amb}} = -20 \, ^\circ\text{C} \ldots 60 \, ^\circ\text{C} \]

**Power supply circuit**

<table>
<thead>
<tr>
<th>Terminals 31/32</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of protection</strong></td>
</tr>
<tr>
<td>II 2G Ex ia IIC T4 /</td>
</tr>
<tr>
<td>( T_{\text{amb}} = (-40 , ^\circ\text{C}) \ldots -20 , ^\circ\text{C} )</td>
</tr>
<tr>
<td>( U_I = 24 , \text{V} )</td>
</tr>
<tr>
<td>( I_I = 380 , \text{mA} )</td>
</tr>
<tr>
<td>( P_I = 9.12 , \text{W} )</td>
</tr>
<tr>
<td>The effective internal capacitance and inductance are negligibly low.</td>
</tr>
</tbody>
</table>

**Power supply circuit**

<table>
<thead>
<tr>
<th>Terminals 41/42</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of protection</strong></td>
</tr>
<tr>
<td>II 2G Ex ia IIC T4</td>
</tr>
<tr>
<td>( U_I = 15 , \text{V} )</td>
</tr>
<tr>
<td>( I_I = 30 , \text{mA} )</td>
</tr>
<tr>
<td>( P_I = 115 , \text{mW} )</td>
</tr>
<tr>
<td>Effective internal capacitance: 3.6 nF</td>
</tr>
<tr>
<td>Effective internal capacitance to ground: 3.6 nF</td>
</tr>
<tr>
<td>Effective internal inductance: 0.14 mH</td>
</tr>
</tbody>
</table>

**VR4A / SR4A only**

<table>
<thead>
<tr>
<th>Terminals 85, 86, 87, 88</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of protection</strong></td>
</tr>
<tr>
<td>II 2G Ex ia IIC T4</td>
</tr>
<tr>
<td>( U_I = 8.5 , \text{V} )</td>
</tr>
<tr>
<td>( I_I = 1.073 , \text{mA} )</td>
</tr>
<tr>
<td>( P_I = 2,280 , \text{mW} )</td>
</tr>
</tbody>
</table>

---

**Important (Note)**

The devices must be installed in a protected environment in accordance with the specific conditions on the test certificate. Pollution degree 3 (see IEC 60664-1) must not be exceeded for the macro environment of the device. The devices conform to protection type IP 65 / IP 67. If the device is installed as intended, this requirement is met by the housing as standard. When connected to the line supply / not connected to the line supply, the electrical circuits must not exceed overvoltage category III / II.

---

7.4.4 Medium temperatures / Temperature classes

For the supply circuit "Terminals 31, 32" and the switching outputs "Terminals 41, 42", cables suitable for temperatures up to \( T = 110 \, ^\circ\text{C} \) (\( T = 230 \, ^\circ\text{F} \)) can be used without restriction.

**Category 2/3G**

For cables suitable only for temperatures up to \( T = 80 \, ^\circ\text{C} \) (\( T = 176 \, ^\circ\text{F} \)), the interconnection of both circuits needs to be taken into account in the event of a fault. Otherwise, the restricted temperature ranges listed in the following table shall apply.

**Category 2D**

For cables suitable only for temperatures up to \( T = 80 \, ^\circ\text{C} \) (\( T = 176 \, ^\circ\text{F} \)), the restricted temperature ranges listed in the following table shall apply.

<table>
<thead>
<tr>
<th>Ambient temperature 2)</th>
<th>Max. temperature at used connecting cable, “Terminals 31, 32”, “Terminals 41, 42”</th>
<th>Max. permissible medium temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>((-30)) -20 \ldots 70 , ^\circ\text{C} )</td>
<td>(110 , ^\circ\text{C} ) (( 230 , ^\circ\text{F} ))</td>
<td>(280 , ^\circ\text{C} ) / (400 , ^\circ\text{C} ) 1) (536 , ^\circ\text{C} / 752 , ^\circ\text{F} ) 1)</td>
</tr>
<tr>
<td>((-30)) -20 \ldots 158 , ^\circ\text{F} )</td>
<td>(160 , ^\circ\text{C} ) (( 320 , ^\circ\text{F} ))</td>
<td></td>
</tr>
<tr>
<td>((-30)) -20 \ldots 60 , ^\circ\text{C} )</td>
<td>(240 , ^\circ\text{C} ) (( 464 , ^\circ\text{F} ))</td>
<td>(280 , ^\circ\text{C} ) (( 536 , ^\circ\text{F} ))</td>
</tr>
<tr>
<td>((-30)) -20 \ldots 140 , ^\circ\text{F} )</td>
<td>(80 , ^\circ\text{C} ) (( 176 , ^\circ\text{F} ))</td>
<td></td>
</tr>
<tr>
<td>((-30)) -20 \ldots 131 , ^\circ\text{F} )</td>
<td>(320 , ^\circ\text{C} ) (( 608 , ^\circ\text{F} ) / 1)</td>
<td></td>
</tr>
<tr>
<td>((-30)) -20 \ldots 122 , ^\circ\text{F} )</td>
<td>(400 , ^\circ\text{C} ) (( 752 , ^\circ\text{F} ) / 1)</td>
<td></td>
</tr>
</tbody>
</table>

---

1) Medium temperatures > \( 280 \, ^\circ\text{C} \) (> \( 536 \, ^\circ\text{F} \)) with FV4000 Vortex flowmeter only

*2) The permissible limits for the ambient temperature are approval- and order-specific (standard: \(-20 \, ^\circ\text{C} \) (\(-4 \, ^\circ\text{F} \)).

<table>
<thead>
<tr>
<th>Maximum medium temperature</th>
<th>Temperature class</th>
</tr>
</thead>
<tbody>
<tr>
<td>(130 , ^\circ\text{C} ) (( 266 , ^\circ\text{F} ))</td>
<td>T4</td>
</tr>
<tr>
<td>(195 , ^\circ\text{C} ) (( 383 , ^\circ\text{F} ))</td>
<td>T3</td>
</tr>
<tr>
<td>(290 , ^\circ\text{C} ) (( 554 , ^\circ\text{F} ))</td>
<td>T2</td>
</tr>
<tr>
<td>(400 , ^\circ\text{C} ) (( 752 , ^\circ\text{F} ))</td>
<td>T1</td>
</tr>
</tbody>
</table>
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