Bronkhorst High-Tech B.V., the European market leader in thermal Mass Flow Meters/Controllers and Electronic Pressure Controllers, has more than 35 years experience in designing and manufacturing precise and reliable measurement and control devices. With a wide range of instruments, Bronkhorst offers innovative solutions for many different applications in many different markets. The instruments are made to customers’ specification, in various styles, suitable for use in laboratory, industrial and hazardous areas, in such diverse applications as semiconductor and analytical installations, to name but two.

**LOW-ΔP-FLOW series for low pressure drop or corrosive gases**

In a number of applications for measuring and controlling gas flows there is only little differential pressure available and/or allowable. These are the applications for which Bronkhorst developed the LOW-ΔP-FLOW series, in which the flow resistance is minimised by using a large bore capillary (thermal bypass sensor) in combination with a cylindrical flow splitter (laminar flow element). Based on this concept, mass flow capacities between 0…10 ml/min and 0…1000 m³/h can be measured. At a flow up to 2 l/min a pressure drop of less than 1 mbar is required.

Furthermore the larger flow channels minimise the risk of clogging and facilitate the cleaning and purging of these LOW-ΔP-FLOW instruments, which will contribute to a significantly longer lifetime when the instruments are used on corrosive gas service. All fluid wetted parts are of electro-polished stainless steel. Optionally the flow meter body, sensor and flow element can be supplied in Hastelloy or Monel.

**For laboratory or industrial conditions**

The LOW-ΔP-FLOW series are derived from the laboratory style EL-FLOW series, however they can also be supplied with a rugged IP65 (dust and waterproof) IN-FLOW housing, suitable for industrial environments. The latter are also ATEX Category 3, approved for use in Zone 2 hazardous areas. In addition to the standard analog I/O-signals and the RS232 connection, there is the possibility of integrating an interface board with DeviceNet™, PROFIBUS DP, EtherCAT®, PROFINET, Modbus or FLOW-BUS protocol.

**Mass flow control with low differential pressure**

The control of mass flow with small pressure difference comprises the LOW-ΔP-FLOW Mass Flow Controllers in compact construction (model series F-200/201/202). The integrated proportional, electromagnetic control valves of these MFC’s have extremely fast and smooth control characteristics. Depending on the operating properties, the maximum flow in these models is 1…50 l/min air-equivalent.

For the control of higher flow rates at very low differential pressures Bronkhorst High-Tech have devised special control valves with pressure compensation bellows (series F-004). These control valves are close-coupled to the flow meter while the electric PI-control function is an integral part of the flow meter. This F-004 valve has proven to be an excellent alternative to large, slow and expensive servo driven valves.

**LOW-ΔP-FLOW features**

- very low pressure drop
- suitable for corrosive gases
- wetted parts: electro-polished stainless steel; other on request
- also available with IP65 housing, ATEX approval Cat.3, Zone 2
- analog and digital (fieldbus) communication
- alarm and counter functions
## Technical specifications

### Measurement / control system
- **Accuracy (incl. linearity):** ± 1% FS (of Full Scale) (based on actual calibration)
- **Turndown:** 1 : 50 (2 ... 100%)
- **Repeatability:** < 0.2% Rd (of Reading)
- **Settling time (controller):** standard: 2 ... 3 seconds
- **Control stability:** < ±0.1% FS (typical for 1 l/min N2)
- **Operating temperature:** -10 ... +70°C for ATEX Cat.3 0 ... 50°C
- **Max. operating pressure:** 10 bar
- **Temperature sensitivity:** 0.1% FS/°C;
- **Pressure sensitivity:** 0.1% Rd/bar typical N2
- **Leak integrity:** tested < 2 x 10^-9 mbar l/s He
- **Mounting position:** horizontal
- **Warm-up time:** 30 min. for optimum accuracy; 2 min for accuracy ± 2% FS

### Mechanical parts
- **Material (wetted parts):** stainless steel, other on request
- **Process connections:** compression type or face seal couplings; wafer type on series F-106; DIN or ANSI flanges on series F-107
- **Seals:** standard: Viton®; options: EPDM, Kalrez® (FFKM)
- **Ingress protection (housing):** IP40 or IP65

### Electrical properties
- **Power supply:** +15 ... 24 Vdc
- **Max. power consumption:**
  - At voltage I/O: 15 V: 95 mA, 24 V: 65 mA
  - At current I/O: 15 V: 125 mA, 24 V: 85 mA
- **Meter:** 15 V: 290 mA, 24 V: 320 mA
- **Controller:** 15 V: 200 mA, 24 V: 215 mA
- **Extra for fieldbus:**
  - PROFIBUS DP: add 53 mA (at 15 V) or 30 mA (at 24 V)
  - EtherCAT®: add 66 mA (at 15 V) or 41 mA (at 24 V)
  - PROFINET: add 77 mA (15 V supply) or 48 mA (24 V supply)
  - DeviceNet™: add 48 mA (at 24 V)
- **Analog output/command:** 0 ... 5 (10) Vdc or 0 (4) ... 20 mA (sourcing output)
- **Digital communication:**
  - Standard: RS232
  - Options: PROFIBUS DP, DeviceNet™, EtherCAT®, Modbus-RTU/ASCII, PROFINET, FLOW-BUS

### Electrical connection
- **IP40 configuration:**
  - Analog/RS232: 9-pin D-connector (male);
  - PROFIBUS DP: bus: 9-pin D-connector (female);
  - Power: 9-pin D-connector (male);
  - DeviceNet™: 5-pin M12-connector (male);
  - Modbus/FLOW-BUS: RJ45 modular jack
  - EtherCAT®/PROFINET: 2 x RJ45 modular jack (in/out)

### Electrical connection
- **IP65 configuration:**
  - Analog/RS232: 8 DIN (male);
  - PROFIBUS DP: bus: 5-pin M12 (female);
  - Power: 8 DIN (male);
  - DeviceNet™: 5-pin M12 (male);
  - Modbus/FLOW-BUS: 5-pin M12 (male)

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### Technical specifications subject to change without notice.
1. Viscosity factor = 0.34 (see table below)
   Conversion factor = 0.49 (see table below)

F-101E or F-101EI MFM resp. F-201EV or F-201EI MFC.

Highest flow rate = 2.94 l/min so we can select model F-101E or F-101EI MFM resp. F-201EV or F-201EI MFC.

Example: Freon-22, 1 l/min
Conversion factor = 0.49 (see table below)
Viscosity factor = 0.34 (see table below)

1. $\varnothing_{visc} \text{Air} = \frac{\varnothing_{visc} \text{gas}}{\text{conversion factor}}$
2. $\varnothing_{visc} \text{Air} = \frac{\varnothing_{visc} \text{gas}}{\text{viscosity factor}}$

The highest flow rate calculated determines the flow capacity.

---

### Conversion factors and viscosity factors

<table>
<thead>
<tr>
<th>Name</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>Name</th>
<th>A</th>
<th>B</th>
<th>C</th>
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<td>Acetylene (ethylene)</td>
<td>C2H2</td>
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<td>Freon-13B1</td>
<td>C2F3</td>
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<td>Deuterium</td>
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A = Symbol  -  B = conversion factor © 20°C. 1 atm.  -  C = viscosity factor © 20°C. 1 atm.
> Dimensions (mm)

### IP40 Mass Flow Meter

<table>
<thead>
<tr>
<th>Model</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>H</th>
<th>K</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-100D (1/8” OD)</td>
<td>47</td>
<td>98</td>
<td>47</td>
<td>111</td>
<td>25</td>
<td>0.4</td>
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<tr>
<td>F-101D/F-101E (1/4” OD)</td>
<td>69</td>
<td>126</td>
<td>47</td>
<td>111</td>
<td>25</td>
<td>0.5</td>
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<tr>
<td>F-102E (1/2” OD)</td>
<td>69</td>
<td>134</td>
<td>47</td>
<td>123</td>
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<td>0.6</td>
</tr>
<tr>
<td>F-103E (1/2” OD)</td>
<td>110</td>
<td>177</td>
<td>47</td>
<td>168</td>
<td>89</td>
<td>4.8</td>
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### IP40 Mass Flow Controller

<table>
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<tr>
<th>Model</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>H</th>
<th>K</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-200DV (1/8” OD)</td>
<td>77</td>
<td>128</td>
<td>47</td>
<td>111</td>
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<td>F-201DV/F-201EV (1/4” OD)</td>
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<td>F-202EV (1/2” OD)</td>
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### IP65 Mass Flow Meter, low/medium flow

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<th>K</th>
<th>L</th>
<th>Weight (kg)</th>
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<tbody>
<tr>
<td>F-100DI (1/8” OD)</td>
<td>47</td>
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<td>74</td>
<td>125</td>
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<td>0.8</td>
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<td>F-101DI/F-101EI (1/4” OD)</td>
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### IP65 Mass Flow Controller

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<tr>
<th>Model</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>H</th>
<th>K</th>
<th>L</th>
<th>Weight (kg)</th>
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<tr>
<td>F-200DI (1/8” OD)</td>
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### IP65 Mass Flow Meter, high flow, wafer type

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<th>L</th>
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### F-004 series Control Valves

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<tr>
<td>F-004BI (1/2” OD)</td>
<td>85</td>
<td>152</td>
<td>174</td>
<td>65</td>
<td>3.4</td>
</tr>
</tbody>
</table>

Dimensions subject to change without notice. For certified drawings and for dimensions of F-101Z series flanged type mass flow meters please contact factory.
### Ranges and pressure drop Mass Flow Meters

<table>
<thead>
<tr>
<th>Model</th>
<th>Flow (m³/min Air)</th>
<th>ΔP (mbar) at atm.</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-100D/F-100DI</td>
<td>10</td>
<td>0.8</td>
</tr>
<tr>
<td>F-100D/F-100DI</td>
<td>15</td>
<td>0.8</td>
</tr>
<tr>
<td>F-101D/F-101DI</td>
<td>20</td>
<td>0.8</td>
</tr>
<tr>
<td>F-101D/F-101DI</td>
<td>50</td>
<td>0.8</td>
</tr>
<tr>
<td>F-101D/F-101DI</td>
<td>100</td>
<td>0.8</td>
</tr>
<tr>
<td>F-101D/F-101DI</td>
<td>200</td>
<td>0.8</td>
</tr>
<tr>
<td>F-101D/F-101DI</td>
<td>500</td>
<td>0.8</td>
</tr>
<tr>
<td>F-101D/F-101DI</td>
<td>1000</td>
<td>0.8</td>
</tr>
</tbody>
</table>

### Fields of application

The LOW-ΔP-FLOW series have been successfully applied in a wide variety of both OEM and laboratory applications, e.g.:

- Environmental air sampling at atmospheric conditions
- Leak rate and permeability measurements
- Burner control
- Measurement of gas consumption, for example of natural gas, in low pressure gas distribution systems

### Air sampling

An interesting example to control a flow rate is using a LOW-ΔP-FLOW Mass Flow Meter in combination with a sampling pump. In this configuration the speed of the pump is controlled to obtain the required mass flow rate, determined by the setpoint value.

### Burner control

Burner control using Mass Flow Controllers brings many advantages compared to conventional systems, where flow is adjusted through needle valves. When burner orifices get clogged or when gas supply pressure varies, an MFC will automatically adapt to the changed conditions. For the control of relatively large flows with low differential pressure, which is typical for natural gas or CH₄, LOW-ΔP-FLOW Mass Flow Meters in combination with F-004 pressure compensated bellow valves have proven to be a successful solution.
### Model number identification

<table>
<thead>
<tr>
<th>Base</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Valve only</td>
</tr>
<tr>
<td>1</td>
<td>Meter</td>
</tr>
<tr>
<td>2</td>
<td>Controller</td>
</tr>
</tbody>
</table>

### Pressure rating

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>64 bar</td>
</tr>
</tbody>
</table>

### Ranges

See page 2 of this leaflet, "Models and flow ranges"

### Communication (I/O)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>RS232 + analog (n/c control)</td>
</tr>
<tr>
<td>B</td>
<td>RS232 + analog (n/o control)</td>
</tr>
<tr>
<td>D</td>
<td>RS232 + DeviceNet™ (n/c control)</td>
</tr>
<tr>
<td>E</td>
<td>RS232 + DeviceNet™ (n/o control)</td>
</tr>
<tr>
<td>M</td>
<td>RS232 + Modbus (n/c control)</td>
</tr>
<tr>
<td>N</td>
<td>RS232 + Modbus (n/o control)</td>
</tr>
<tr>
<td>P</td>
<td>RS232 + PROFIBUS DP (n/c control)</td>
</tr>
<tr>
<td>Q</td>
<td>RS232 + PROFIBUS DP (n/o control)</td>
</tr>
<tr>
<td>R</td>
<td>RS232 + FLOW-BUS (n/c control)</td>
</tr>
<tr>
<td>S</td>
<td>RS232 + FLOW-BUS (n/o control)</td>
</tr>
<tr>
<td>T</td>
<td>RS232 + EtherCAT® (n/c control)</td>
</tr>
<tr>
<td>U</td>
<td>RS232 + EtherCAT® (n/o control)</td>
</tr>
<tr>
<td>V</td>
<td>RS232 + PROFINET (n/c control)</td>
</tr>
<tr>
<td>W</td>
<td>RS232 + PROFINET (n/o control)</td>
</tr>
</tbody>
</table>

### Analog output

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0…5 Vdc</td>
</tr>
<tr>
<td>B</td>
<td>0…10 Vdc</td>
</tr>
<tr>
<td>F</td>
<td>0…20 mA sourcing</td>
</tr>
<tr>
<td>G</td>
<td>4…20 mA sourcing</td>
</tr>
</tbody>
</table>

### Supply voltage

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>+15…24 Vdc</td>
</tr>
</tbody>
</table>

### Compression type couplings

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>11</td>
<td>⅛” OD compression type</td>
</tr>
<tr>
<td>22</td>
<td>¼” OD compression type</td>
</tr>
<tr>
<td>33</td>
<td>6 mm OD compression type</td>
</tr>
<tr>
<td>44</td>
<td>12 mm OD compression type</td>
</tr>
<tr>
<td>55</td>
<td>½” OD compression type</td>
</tr>
<tr>
<td>66</td>
<td>20 mm OD compression type</td>
</tr>
<tr>
<td>88</td>
<td>⅜” Face seal male</td>
</tr>
<tr>
<td>99</td>
<td>other</td>
</tr>
</tbody>
</table>

### Mounting between flanges

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>mounting betw. flange, DIN PN10</td>
</tr>
<tr>
<td>02</td>
<td>mounting betw. flange, DIN PN16</td>
</tr>
<tr>
<td>03</td>
<td>mounting betw. flange, DIN PN40</td>
</tr>
<tr>
<td>06</td>
<td>mounting betw. flange, ANSI 150</td>
</tr>
<tr>
<td>07</td>
<td>mounting betw. flange, ANSI 300</td>
</tr>
<tr>
<td>13</td>
<td>Flanged connection, DIN PN40</td>
</tr>
<tr>
<td>26</td>
<td>Flanged connection, ANSI 150</td>
</tr>
<tr>
<td>99</td>
<td>other</td>
</tr>
</tbody>
</table>

### Internal seals

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>Viton® (factory standard)</td>
</tr>
<tr>
<td>E</td>
<td>EPDM</td>
</tr>
<tr>
<td>K</td>
<td>Kalrez® (FFKM)</td>
</tr>
</tbody>
</table>

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F-101DI Mass Flow Meter, IP65 configuration

F-102E Mass Flow Meter, IP40 configuration