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1 Outline
This application note explains the features, basic usage and some notices of OMRON MEMS Flow Sensor (D6F series) before use.

2 What is a Flow Sensor?
A flow sensor is a sensor that detects the flow rate and flow velocity of a gas. In general, there are various types of flow sensors, such as a propeller type, a float type, an ultrasonic type, a hot wire type, and so on. OMRON flow sensors adopt a MEMS heat wire type, and have relatively excellent characteristics in comparison with other types of flow sensors.

<table>
<thead>
<tr>
<th>Table1. Various Types of Flow Sensor and Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
</tr>
<tr>
<td>Propeller</td>
</tr>
<tr>
<td>Float</td>
</tr>
<tr>
<td>Ultrasonic</td>
</tr>
<tr>
<td>Heat Wire</td>
</tr>
<tr>
<td>Sensitivity</td>
</tr>
<tr>
<td>Response Time</td>
</tr>
<tr>
<td>Pressure Drop</td>
</tr>
<tr>
<td>Current Consumption</td>
</tr>
<tr>
<td>Sensing Size Element</td>
</tr>
<tr>
<td>Mechanical Endurance</td>
</tr>
<tr>
<td>Conventional Sensors</td>
</tr>
<tr>
<td>OMRON MEMS Heat Wire</td>
</tr>
<tr>
<td>Volumetric Flow Sensor</td>
</tr>
<tr>
<td>Mass Flow Sensor</td>
</tr>
</tbody>
</table>

3 Structure
3.1 Basic composition of flow sensors
OMRON flow sensors are dedicated to gas, it can be used for detecting the mass flow of various types of gases. The basic composition of flow sensors consist of a MEMS flow sensor chip that can detect the flow rate, the amplifier circuit for amplifying sensor output and the optimized flow path that is designed for each application by CAE (Computer Aided Engineering). Optimizing these three compositions is very important because gas flow is a vector volume.
3.2 Flow Sensor Product Lineup

OMRON’s flow sensor lineup consists of three categories, Mass flow sensors that output a flow rate, Flow velocity sensors that output a flow velocity and Differential pressure sensors that can detect a small pressure drop.

For more information about differential pressure sensors, please refer to the application notes of MDMK-13-0196.

A flow sensor's shape and size will differ depending on the type of gas to be measured, the flow rate, and the port style. Please refer to the datasheet at the following URL for more information.

Table 2 Outline Specifications of D6F series

<table>
<thead>
<tr>
<th>Series Name</th>
<th>Medium</th>
<th>Flow Rate</th>
<th>Type</th>
<th>Port Style</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>D6F-□A1</td>
<td>Air</td>
<td>1 ~ 2 lpm</td>
<td>Mass Flow</td>
<td>Bamboo Joint</td>
<td>Compact Size</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>High Precision</td>
</tr>
<tr>
<td>D6F-□N2</td>
<td>City gas*1</td>
<td>1 ~ 5 lpm</td>
<td>Mass Flow</td>
<td>Rc1/4 Screw</td>
<td>Flammable Gas</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Metal Body</td>
</tr>
<tr>
<td>D6F-02L2</td>
<td>LPG</td>
<td>2 lpm</td>
<td>Mass Flow</td>
<td>Rc1/4Screw</td>
<td>Flammable Gas</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Metal Body</td>
</tr>
<tr>
<td>D6F-03A</td>
<td>Air</td>
<td>3 lpm</td>
<td>Mass Flow</td>
<td>M5 Screw</td>
<td>High Response Time</td>
</tr>
<tr>
<td>D6F-□A5</td>
<td>Air</td>
<td>10 ~ 50 lpm</td>
<td>Mass Flow</td>
<td>Manifold</td>
<td>Compact Size</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>High Flow Rate</td>
</tr>
<tr>
<td>D6F-□A6□</td>
<td>Air</td>
<td>10 ~ 50 lpm</td>
<td>Mass Flow</td>
<td>Rc1/4 Screw</td>
<td>Compact Size</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>High Flow Rate</td>
</tr>
<tr>
<td>D6F-□□7</td>
<td>City gas*1</td>
<td>2 ~ 50 lpm</td>
<td>Mass Flow</td>
<td>Quick Joint (P10)</td>
<td>Quick Joint</td>
</tr>
<tr>
<td>D6F-□□6</td>
<td>Air</td>
<td>10 ~ 50 lpm</td>
<td>Mass Flow</td>
<td>Rc1/4 Screw</td>
<td>Compact Size</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NPT1/8 Screw</td>
<td>High Flow Rate</td>
</tr>
<tr>
<td>D6F-□□7</td>
<td>LPG / Air</td>
<td>2 ~ 50 lpm</td>
<td>Mass Flow</td>
<td>Quick Joint (P10)</td>
<td>Quick Joint</td>
</tr>
<tr>
<td>D6F-□AB71</td>
<td>Air</td>
<td>30 ~ 70 lpm</td>
<td>Mass Flow</td>
<td>Quick Joint (P14)</td>
<td>Quick Joint Pulsation Reduction</td>
</tr>
<tr>
<td>D6F-P</td>
<td>Air</td>
<td>0.1 ~ 1 lpm</td>
<td>Mass Flow</td>
<td>Bamboo / Manifold</td>
<td>DSS*2 / Bidirectional</td>
</tr>
<tr>
<td>D6F-W</td>
<td>Air</td>
<td>1 ~ 10 m/s</td>
<td>Flow Velocity</td>
<td>-</td>
<td>DSS*2</td>
</tr>
<tr>
<td>D6F-V03A1</td>
<td>Air</td>
<td>3 m/s</td>
<td>Flow Velocity</td>
<td>-</td>
<td>Low Cost of D6F-W</td>
</tr>
<tr>
<td>D6F-PH</td>
<td>Air</td>
<td>±500 Pa</td>
<td>Differential Pressure</td>
<td>Bamboo Joint</td>
<td>Digital Output Differential Pressure</td>
</tr>
</tbody>
</table>


4 Operating principle
4.1 Basic structure of MEMS flow sensor chip
The basic structure of a MEMS flow sensor chip is shown in Fig.3. This sensor chip adopts a
mass flow sensing method by using heat wire. It has a heater in the center of the chip, and the upstream thermopile (A) and the downstream thermopile (B) are located on either side of the heater, the base thermo-scope near the thermopile is made by a semiconductor process. The cavity is formed at the bottom of the heater and the thermopile arrays, so then it is possible to detect the heat from the heater effectively.

Fig.3. Flow Sensor Chip Structure
4.2 Detecting principle of mass flow sensor

As shown in Fig.4, the constant current is flowing to the heater at the center of the chip and the heater becomes hot. When there is no flow, the heat distribution around the heater is symmetric, so $V_u$ and $V_d$ of the electromotive force from both thermopiles will be equal.

On the other hand, when there is a flow of gas on the sensor surface, the heat source is biased on the downstream side according to the flow of gas. The electromotive force of the downstream thermopile will be larger than the upstream thermopile ($V_d > V_u$). The output difference between the two thermopiles is approximately proportional to the square root of the mass flow rate of the gas through the sensor surface. The output sensitivity and the mass flow rate depend on the composition ratio of the gas. Through amplification, it is possible to electronically detect the flow rate of the gas. The flow velocity sensor is adjusted so that it can output a voltage that corresponds to the flow velocity at the condition of 25°C, 101.3kPa from the mass flow rate.

When the flow direction is perpendicular to the thermopiles and heater.

$$V_d = V_u$$

The heat distribution is symmetric.

$$V_{out} = V_{off} + (V_d - V_u) \times \text{gain}$$

$V_{out}$: Output voltage, $V_{off}$: Offset voltage

$V_d - V_u \propto \sqrt{(\text{Flow rate})}$

**Fig4.** Sensing image of mass flow sensor using heat wire
5 Product Features

- Mass Flow Sensing
- Wide Range Sensing Ability
- Low Power Consumption
- Ultra Small Size of MEMS Sensor

5.1 Characteristics of flow sensors

| Type       | Flow range *1 | Application medium *2 | Port style | Max Size: ϕ8.6mm, Min Size: ϕ7.4mm | Electrical connection | Power supply voltage | Current consumption | Output signal | Accuracy | Repeatability *3 | Max. output voltage | Min. output voltage | Absolute maximum supply voltage | Absolute maximum output voltage | Case material | Protecting structure | Maximum permission pressure | Storage temperature | Storage humidity | Temperature characteristics | Insulation resistance | Withstanding voltage | Weight |
|------------|---------------|-----------------------|------------|------------------------------------|----------------------|---------------------|--------------------|--------------|----------|-------------------|---------------------|------------------------|-----------------------------|-------------------------|----------------|-------------------|------------------------|----------------|-----------------|-----------------|
| Type D6F-01A1-110 | 0~1 L/min | Air                   | Bamboo Joint |                                    | Connector (three wires) | DC10.8~26.4V | Max. 15mA, No load, Vcc=12~24V at 25°C | DC1~5V (Non-linear output, Resistive load 10kΩ) | ±3%F.S (at 25°C) | ±0.3%F.S. |                      | DC5.7V (Resistive load 10kΩ) | DC0V (Resistive load 10kΩ) | DC26.4V                  |                          | PPS          | IP40 (IEC standard) | 200kPa                 | −40~+80°C         | 35~85%RH       | Within ±3%F.S. of detected characteristics of at 25°C Over ambient temperature rang −10~+60°C | Min. 20MΩ (DC500, between lead terminal and the base) | AC500V 50/60Hz for one minute between the lead terminals and the base (Leakage current is 1mA max.) | 12.8g |

* 1. L/min (Normal) means the volumetric flow rate at 0degC, 101.3kPa (1 atm)
* 2. Use clean and dry gas without a dust and an oil mist.
* 3. Reference Value (Typical value)
5.1.1 Detection range of flow sensors

The detection range of Flow Sensors shows the flow rate range of the gas to be detected. The lower limit voltage is the output at the lower limit and the upper limit voltage is the output at the upper limit of the detection range. This detection range is based on the condition of the volumetric flow rate at the reference state (0 °C / 101.3kPa).

The detection range of Flow Velocity Sensors (D6F-W, D6F-V) shows the flow velocity range of the gas to be detected. The lower limit voltage is the output at the lower limit and the upper limit voltage is the output at the upper limit of the detection range. This flow velocity range is based on the condition of 25 °C, 101.3kPa.

5.1.2 Output signal (operating characteristics)

Analog type flow sensors increase the output signal voltage with an increase in the flow rate. The output signal voltage is a non-linear and analog value of DC voltage. As a representative example of an analog type flow sensor, the output characteristic of D6F-01A1-110 is shown in Fig.5 and Table 4. This flow rate means a normal volumetric flow rate on the condition of 0°C, 101.3kPa. These values are measured on the condition of supply voltage: DC12V±0.1V, ambient temperature: 25±5°C, ambient humidity: 35~75%RH.

Operating characteristics / Measurement conditions shown here will vary according to the type of sensor. Please refer to the operating characteristic information written in the product catalog or specifications corresponding to the sensor type.

![Fig.5 Output signal characteristic](image)

<table>
<thead>
<tr>
<th>Flow Rate(normal) (L/min)</th>
<th>0</th>
<th>0.2</th>
<th>0.4</th>
<th>0.6</th>
<th>0.8</th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Voltage (V)</td>
<td>1.00</td>
<td>2.31</td>
<td>3.21</td>
<td>3.93</td>
<td>4.51</td>
<td>5.00</td>
</tr>
<tr>
<td>Accuracy (V)</td>
<td>±0.12</td>
<td>±0.12</td>
<td>±0.12</td>
<td>±0.12</td>
<td>±0.12</td>
<td>±0.12</td>
</tr>
</tbody>
</table>

Condition: Supply voltage DC12±0.1V, Ambient temp. 25±5°C, Ambient humidity 35~75%RH
5.1.3 Permission pressure performance
When high pressure is impressed into a flow sensor, there is a concern about airproof degradation. So, the maximum pressure that can be impressed to a flow sensor is defined as Maximum Permission Pressure.

For example, the maximum permission pressure of D6F-01A1-110 is defined as 200kPa, this means that airproof specifications and operating characteristic specifications after the pressure test of 3 minutes at 200kPa are guaranteed.

Airproof is defined as the leak rate when a constant positive pressure is impressed to a flow sensor. For example, D6F-01A1-110 guarantees that when the positive pressure of 100kPa is impressed, the leak rate is $1 \times 10^{-4} \text{ [Pa m}^3 / \text{s]}$ or less.

5.1.4 Repeatability
OMRON flow sensors have an excellent repeatability characteristic because they have a unique flow path design which results in a stable gas flow. The repeatability is not guaranteed but a reference value.

6 Usage of Flow Sensor
6.1 Electrical Connection
The load resistance (Combined resistance seen from the flow sensor side) between the Vout and GND terminals of the flow sensor should be 10kΩ or more. However, if you want to connect a resistor (R1) between the voltage output terminal (Vout) of the flow sensor and the terminal to detect the voltage (such as ADC input), please be mindful of the voltage drop by resistor (R1). In general, it is recommended that R1 is less than $1/1000$ (Less than 0.1% output voltage drop) of the parallel resistance of R3 and R2 ($R_2||R_3$). Also be sure to check the cable resistance. If the cable length is long, the resistance of the cable shall be deemed as R1.

![Fig.6 Repeatability characteristic](image)

![Fig.7 Flow path design](image)

![Fig.8 Load resistance of the output line](image)
6.2 Port style and installation method

6.2.1 Screw type
Please refer to each product datasheet about the types of screw and the tightening torque. Be sure to design the airproof structure by using a seal tape. When installing this type, the specified taper thread for piping should be used. In addition, please set to 5N\(\cdot\)m or less of the tightening torque. If the tightening torque goes beyond the limit, there is risk that the sensor will crack and/or gas leakage occurs. Please put an appropriate amount of sealant on the screw. Do not paint a sealant on two screw threads from the tip of the screw.

6.2.2 Quick fastener type
A quick fastener type for connecting a pipe with a flange is available. The quick fastener type can be attached and detached by hand (no tools necessary). Currently, there are two kinds of quick fastener types that have P14 and P10 shape. Below shows the outline dimensions of quick fastener type of P14 and P10. Please refer to the respective product datasheet to determine which type of quick fastener is recommended.

![Quick fastener P10 Outline Dimensions](image1)
![Quick fastener P14 Outline Dimensions](image2)

<List of quick fastener type in Omron>

<table>
<thead>
<tr>
<th>Code</th>
<th>Type</th>
<th>Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>D6F-□A7</td>
<td>Quick fastener type</td>
<td>P10</td>
</tr>
<tr>
<td>D6F-□N7</td>
<td>Quick fastener type</td>
<td>P10</td>
</tr>
<tr>
<td>D6F-□L7</td>
<td>Quick fastener type</td>
<td>P10</td>
</tr>
<tr>
<td>D6F-□AB71</td>
<td>Quick fastener type</td>
<td>P14</td>
</tr>
</tbody>
</table>
6.2.3 Manifold mount type

The D6F-□A5 and D6F-P series have a manifold mount type. A manifold mount type, even if there is no space in the straight pipe direction can be installed in a small space. Below shows the dimensions of the bottom view and the connection example of the manifold mount type D6F-□A5.

![Bottom view](image1)

**Fig.11** D6F-□A5 Bottom view

![Connection example](image2)

**Fig.12** Connection example for manifold mount type

### Table 5 Recommended O-ring type

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Port Style</th>
<th>Recommended O-Ring Type</th>
<th>Reference O-Ring Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>D6F-□□A5</td>
<td>Manifold</td>
<td>Designation: JIS B 2401 P5</td>
<td>Designation: ISO 3601-1 A0048G</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Size: Inner diameter: 4.80±0.15mm, Cross section: 1.90±0.08mm</td>
<td>Size: Inner diameter: 4.87±0.15mm, Cross section: 1.80±0.08mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Material: NBR (for reference)</td>
<td>Material: NBR (for reference)</td>
</tr>
<tr>
<td>D6F-□□□□AM</td>
<td>Manifold</td>
<td>Designation: JIS B 2401 P4</td>
<td>Designation: ISO 3601-1 A0037G</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Size: Inner diameter: 3.80±0.14mm, Cross section: 1.90±0.08mm</td>
<td>Size: Inner diameter: 3.75±0.14mm, Cross section: 1.80±0.08mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Material: NBR (for reference)</td>
<td>Material: NBR (for reference)</td>
</tr>
</tbody>
</table>
6.2.4 Bamboo type

A bamboo type is used in a state where the urethane tube or others is inserted. Inserting is very easy. It can be done by hand (no tools necessary). In addition, there is the benefit that the variation due to human error is less likely to occur. Both the D6F-□A1 series and D6F-P series are available in bamboo type. In the case of the D6F-□A1 series, the inner diameter of the pipe is φ4mm, maximum outer diameter is φ8.6mm, and minimum outer diameter is φ7.4mm. In the case of the D6F-P series, the maximum outer diameter of the pipe is φ4.9mm. When using a bamboo type, be sure to design an airproof structure. If leakage occurs from the joint, a correct measurement cannot be achieved.

Please note that don't turn the pipe to the right when connecting the pipe to the bamboo joint. In case the pipe is turned to the right, the internal part of the bamboo joint might be worked loose and worked off.
6.3 Attention for piping and connection

6.3.1 Cleanup of the inflow gas

The fluid should be dry and clean without dust and oil mist. Dust and oil mist may cause characteristic changes and failures. A filter or a mist separator should be installed upstream of the pipe. Foreign substances into the pipe can cause failures. Please be careful when handling so that the foreign substances do not enter the pipe after removing the sensor from the packaging bag.

6.3.2 Stabilization

When using a diaphragm pump, pulsation can occur. This can adversely affect the measurement accuracy of the flow rate. Some models in OMRON’s flow sensor lineup have an internal system for reducing the influence of pulsation, but it may not completely remove the effect of pulsation. If the effect of pulsation is a concern, please use countermeasures to reduce pulsation, such as changing to a pump less likely to cause pulsation or establish a buffer tank and/or an orifice in the flow path.

6.3.3 Measurement of high flow

By making a bypass flow path by pulling some gas from the main flow path at a high flow rate, it is possible to measure the gas flow rate of the whole piping by measuring the flow rate in the bypass section. The differential pressure between inflow and outflow to the bypass section is generated by making a resistor, such as an orifice in main flow path. Gas will flow into the bypass flow path by this differential pressure. An example of a bypass flow connection and differential pressure calculation to be generated are shown in Fig. 15 and 16.

\[
\Delta P = \frac{1}{2} C^2 \rho V^2
\]

**Fig.15 Example of Bypass Flow Connection**

**Fig.16 Example of differential pressure calculation**
6.3.4 Consideration of the laminar flow

If a pipe has sufficient straight section before and after the sensor, the fluid inside the pipe will achieve laminar flow. However, the fluid becomes turbulent when there is not enough straight section of pipe. In general, the following requirements are needed in order to achieve laminar airflow inside a pipe.

- The sensor inlet side requires a length of 10 times the internal orifice diameter of straight pipe.
- The sensor outlet side requires a length of 5 times the internal orifice diameter of straight pipe.

Furthermore, it is possible to reduce the influence of turbulence with regards to mounting the sensor.

1. Against gas flow coming into the sensor
   - Put a guide to the sensor inlet in order to stabilize the gas flow. Flow rate is stabilized with a long and straight guide, but you may be able to measure by attaching a guide of about 5mm.

2. Against gas flow exiting from the sensor
   - By putting a buffer tank and/or by putting the orifice at the outlet of the buffer tank, it makes squeeze the flow rate.

3. Put the jig (rotation direction in particular) so that the sensor direction can be fixed.

Fig.17 Example of the gas flow stabilization

6.4 The influence of environment

Flow sensors are affected by an influence of ambient environment and use conditions, which can lead to changing output characteristics. Please be sure to check the output characteristics in actual conditions before use, and also check the product specifications regarding characteristics and use conditions that are guaranteed.

In this paragraph, the characteristics in the conditions of which are not defined in the product specifications are described for customer evaluation. Please understand that it is not guaranteed but only for reference.
6.4.1 Temperature characteristics

Basic characteristics of OMRON's flow sensors specify the output characteristics and the accuracy at the conditions of 25±5°C but the flow sensor has temperature characteristics. If the ambient temperature is changed, the output characteristics of the flow sensor will vary. Variation due to temperature change is expressed in %FS as the maximum amount of variation within the operating temperature range defined in specifications, which is represented based on the output at 25 °C. This variation counts towards the precision to be defined as the basic specifications. For example, when using in -10 ~ 60°C ambient temperature, the variation of D6F-01A1-110 will be ± 3%F.S. of 25°C characteristics, which means that there is a case where the variation of ± 0.12V occurs as a flow sensor voltage output. As a general example, Fig.18 shows the output variation of D6F-01A1-110 from the characteristics at 25°C.

![Temperature Characteristics of D6F-01A1](image)

Fig 18. Temperature characteristic of D6F-01A1-110

6.4.2 The influence of dust

If dust is deposited on the flow channel and the sensor chip, it changes the flow sensor's output characteristics. Therefore, it is recommended a filter be used with the sensor depending on the gas that is used.
6.4.3 The influence of pressure and temperature

OMRON’s flow sensors can measure a mass flow rate. In order to comply with the combined gas law, even in the same gas volume flow, the mass flow rate becomes low when the pressure is low or the temperature is high. On the other hand, the mass flow rate becomes high when the pressure is high or the temperature is low. For example, when measuring the same volumetric flow rate at a high altitude (or high temperature) and a low altitude (or low temperature), the mass flow rate at a high altitude (high temperature) is smaller than that at a low altitude (or low temperature).

Equation of state of ideal gas

\[ PV = nRT \]

Boyle-Charle's law

\[ \frac{PV}{T} = \frac{P'V'}{T'} \]

6.4.4 The influence of the mounting direction

The mounting direction can influence the output characteristics of a flow sensor. These characteristics can vary slightly due to the heat distribution of the flow sensor chip, as shown in Fig.20. The variation will be about 0.4%FS in actual measurement. OMRON recommends a horizontal installation in product specifications for this reason. It should be considered that there are some characteristics variations with vertical installation.

Fig.19 Influence of pressure and temperature

Contraction
Pressure is high / Temperature is low

Expansion
Pressure is low / Temperature is high

But, the mass is same.

Fig.20 Influence of mounting direction of the sensor chip

Symmetry of the temperature distribution is broken in the natural convection heat
6.4.5 Output changes in various gases

By the measurement principle of flow sensors, the output characteristics are affected by the physical properties of the medium involved in the heat conduction. For example, constant pressure specific heat, thermal conductivity, density and viscosity coefficient will affect the sensitivity of the sensor. This means that the output characteristics depend on the type of gases. Application media to be measured are specified for respective models. When performing the measurement of gas flow that is not stated in the specifications, the output characteristics are different from the output characteristics in the specifications. Please be careful to check the output characteristics in use. Fig.21 shows a comparison of the output characteristics of the D6F-01A1-110 for He and Air.

![Output characteristics measured value of Air and He in D6F-01A1-110](image)

(Left graph : 0 to 1 L/min range , Right graph : 0 to 40L/min range)

6.4.6 The behavior in over flow rate range

OMRON’s flow sensors define the assumed flow rate range (wind speed range in air flow sensor) in each type. Even if the flow rate is below the minimum or the flow rate is over the maximum, there is little adverse effect on the sensor itself. If the flow rate exceeds the upper limit of the specified flow range, the output is gradually increased beyond the upper limit of the output signal, and then saturated at a constant output voltage. Similarly in the case where the flow rate is below the lower limit of the flow rate range, the output signal is reduced beyond the lower limit, and then saturated at a constant output voltage. Output characteristics that exceed the defined flow rate range are not covered under warranty.

6.4.7 The influence of humidity

Humidity of the fluid can have an adverse effect on the measurement accuracy in mass flow sensors. Please use dry gas taking into account that the mass increases if the humidity is high.
## 6.5 Application example

<table>
<thead>
<tr>
<th>Category</th>
<th>Application</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Conditioner</td>
<td>HVAC / VAV Air Filter</td>
<td>Clogged Filter Detection</td>
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<tr>
<td></td>
<td></td>
<td>Leak Detection</td>
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</tr>
<tr>
<td>Burning Control</td>
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<td></td>
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<td>Medical Equipments</td>
<td>Oxygen Concentration Device Respirator Anesthetic Apparatus Home Medical Equipments</td>
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<tr>
<td></td>
<td></td>
<td>Control for Gas Supply</td>
</tr>
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<td>Measurement of Gas Consumption</td>
</tr>
<tr>
<td>Others</td>
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<td>Chemical Analyzer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Measurement of Gas Consumption</td>
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<tr>
<td></td>
<td></td>
<td>Leak Detection</td>
</tr>
</tbody>
</table>
7 Glossary

- **MEMS**
  The MEMS, which stands for "Micro Electro Mechanical Systems", is a generic term for devices that consist of micromechanical component parts, sensors, actuators, and electrical circuits that are integrated on a silicon substrate, glass substrate or organic material and are fabricated by semiconductor integrated circuit technology.

- **%F.S. and %RD**
  %FS is the accuracy for the output full scale in the detection range of flow rate (flow velocity) and %RD is the accuracy for the output reading. In the case of %F.S. prescript, the output error is constant for all detection ranges because the output full-scale is constant. On the other hand, in the case of %RD prescript, the output error depends on the reading value. Herein, the output full scale is the difference between the minimum output value and the maximum output value in flow rate detection range and the output reading is the difference between the minimum output value and the output value at a certain flow rate. Also temperature characteristics may be expressed as the difference between the characteristics of a specific temperature by %RD and %F.S.

\[
\text{Output} = \text{Flow Rate} \times \Delta \text{output}
\]

\[
\text{F.S.} = \text{Output at maximum output} - \text{Output at minimum output}
\]

\[
\text{RD} = \text{Output at certain flow rate} - \text{Output at minimum output}
\]

\[
\%F.S. = \frac{\Delta \text{output}}{\text{F.S.}} \times 100\%
\]

\[
\%RD = \frac{\Delta \text{output}}{\text{RD}} \times 100\%
\]

**Fig. 22** Accuracy in %F.S. prescript

**Fig. 23** Accuracy in %RD prescript

- **%R.D.**
  %RD is the accuracy for the output reading in a certain flow rate. In the case of %RD prescript, the output error depends on the reading value. Herein, the output reading is the difference between the output value at a certain flow rate and the output value at the minimum output value.

\[
\%R.D. = \frac{\Delta \text{output}}{\text{RD}} \times 100\%
\]

Ex) 1-5V output type @ +/- 3%RD
Output voltage is 3V at a certain flow rate
\[
\%R.D. = \frac{3V - 1V}{3V} \times 100\% = 66.67\%
\]

**Fig. 23** Accuracy in %RD prescript
Volumetric flow rate and Mass flow rate

The volumetric flow rate is the volume of gas flowing per unit time. It is proportional to the temperature, which is inversely proportional to the pressure. It is described as m³/s, m³/min, L/s, or L/min in case of SI unit. The volume of gas is influenced by the pressure and the temperature, so then the condition of the pressure and the temperature should be considered in case of the volumetric flow rate.

On the other hand, the mass flow rate is the mass of gas flowing per unit time. It does not depend on the temperature and the pressure. It is described as kg/s, kg/min in case of SI unit. OMRON’s MEMS flow sensor will output an equivalent value with the mass flow rate.

Normal Volumetric Flow Rate and Standard Volumetric Flow Rate

To define this mass flow rate, it is common to express as the volumetric flow rate at the conditions which defines the pressure and temperature. The condition of the pressure and temperature are 1atm (101.3kPa) and 0 degree C. Under this condition, the volumetric flow rate value is expressed as NLM (Normal Liters per Minute) or SLM (Standard Liters per Minute). Each company has each condition of this pressure and temperature and there is no rule in particular. Please be sure to check the standard condition of the product before use.
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(3) Omron will not warrant any items in 1.(5) (a) to (d) of User Application nor the Fitness.

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(b) Usage out of the Conditions
(c) Cause which could not be foreseen by the level of science and technology at the time of shipment of the product
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