Simply a question of better measurement

SCHMIDT® Flow Sensor
SS 20.600
Instructions for Use

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Imprint:

Ausgabe: 535084.02B

Subject to modifications

1 Important information

The instructions for use contain all required information for a fast commissioning and a safe operation of **SCHMIDT®** flow sensors.

- These instructions for use must be read completely and observed carefully, before putting the unit into operation.
- Any claims under the manufacturer's liability for damage resulting from non-observance or non-compliance with these instructions will become void.
- Tampering with the device in any way whatsoever - with the exception of the designated use and the operations described in these instructions for use - will forfeit any warranty and exclude any liability.
- The unit is designed exclusively for the use described below (refer to *chapter 2*). In particular, it is not designed for direct or indirect protection of personal or machinery.
- **SCHMIDT Technology** cannot give any warranty as to its suitability for a certain purpose and cannot be held liable for errors contained in these instructions for use or for accidental or sequential damage in connection with the delivery, performance or use of this unit.

Symbols used in this manual

The symbols used in this manual are explained in the following section.

Danger warnings and safety instructions. Read carefully!

Non-observance of these instructions may lead to injury of personal or malfunction of the device.

General note

All dimensions are given in mm.

2 Application range

The **SCHMIDT® flow sensor SS 20.600** is designed for stationary measurement of the flow velocity as well as the temperature of pure[1] air and gas with operating temperature up to 120 °C and working pressure up to 40 bar.

The sensor is based on the measuring principle of a thermal anemometer and measures the mass flow of the measuring medium as flow velocity which is output in a linear way as standard velocity[2] w_N (unit: m/s), based on standard conditions of 1013.25 hPa and 20 °C. Thus, the resulting output signal is independent of the pressure and temperature of the medium to be measured.

When using the sensor outdoors, it must be protected against direct exposure to the weather.

If the sensor head is immersed in water and operated under pressure, the sensor may be damaged irreversibly.

Using the sensor in flammable gases the regulations of ATEX guidelines has to be applied (see below).

The sensor variants for use in potentially explosive atmosphere (ATEX) and oxygen (O2) are not combinable.

ATEX

The ATEX version of the sensor is designed for use in explosive gas atmosphere of zone 2 (corresponding to EPL Gc). ATEX-specific information can be found in the additional ATEX instructions.

The additional **ATEX instructions** (535698.02) must be read and observed carefully when using the sensors in ATEX areas.

The operation in continuously or frequently occurring explosive atmosphere is not allowed.

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[1] No chemically aggressive contents /abrasive particles; check suitability in individual cases
[2] Corresponds to the actual velocity under standard conditions

Grease-free and O2

In version “grease-free and for O2 > 21 %”, the sensor, the accessories and the packaging have been cleaned especially according to the standard IEC/TR 60877:1999.

This standard may be restricted by:

- The operating specification of the **SS 20.600** with regard to temperature and pressure.
- Special conditions regarding the use of diatomic oxygen (O_2).

The use of the oxygen version is limited to:

- Maximum pressure of the medium of **20 bar**.
- Maximum temperature of the medium of **60 ° C**.

Exceeding these limits can lead to danger to persons and material.

The improper use of gas mixtures having an oxygen percentage of at least 21% or pure oxygen can cause fire or explosion.

It is explicitly pointed out that the customer, when opening the packaging, assumes full responsibility for the cleanliness of the sensor and its accessories according to the standard IEC/TR 60877:1999.

Information concerning the compliant handling of O2

The general rule is that a soiling of sensor parts that come into contact with oxygen must be absolutely avoided:

- The installation site must be carefully cleaned before mounting the sensor.
- Make sure to use only clean tools and material for the installation.
- Before opening the packaging film, remove the dirt such as dust from the film, if necessary.
- If possible, open the packaging film and take out the sensor directly at the installation site.
- Otherwise open the packaging film at an appropriate and clean workplace and store the sensor in an appropriate, cleaned, dust- and humidity-tight container.
- Do not touch the oxygen contacting sensor parts with bare hands.
- Use clean and non-fluffy gloves or cloths or similar to handle the sensor.

Special gases

The “gas” version of the **SS 20.600** is equipped with a correction for the measurement of certain gases and gas mixtures. The sensor is adjusted and calibrated in air. Then a special correction for the medium to be measured is applied to the sensor. The correction has been determined for many gases in real gas ducts. For gas mixtures, the correction is calculated according to the set volumic mixing ratio.

The customer is responsible for the observance of all relevant statutory provisions, standards and directives relating to the use of gases.

Mechanical versions

The sensor **SS 20.600** is available in a version as compact sensor and as a remote sensor. The dimensions can be found in the dimensional drawings in chapter 9.

3 Mounting instructions

General information on handling

The flow sensor **SS 20.600** is a precision instrument with high measuring sensitivity. In spite of the robust construction of the sensor head, soiling of the inner sensor elements can lead to distortion of measurement results (see also *chapter* 8). During procedures like transport, mounting or dismounting of the sensor that facilitates soiling, it is generally necessary to attach the enclosed protective cap of **SCHMIDT Technology** to the sensor head and remove it only during operation.

During processes with risk of soiling such as transport or mounting, the protective cap should be placed on the sensor head.

Mounting method

The **SS 20.600** can be mounted only by means of a through-bolt joint which supports the sensor tube and ensures positive clamping. The through bolt joint as well as a pressure protection kit is included in the scope of delivery. Due to the variety of applications the through bolt joint exhibits different versions which share the following features:

- Pressure range:	40 bar (overpressure)
- Media temperature:	min. -20 … +120 °C
- Material:	Screw-joint components made of stainless steel 1.4571
Clamping ring made of VA steel

Variations are made on the one hand by the design of the external screw thread (order option: G½ or R½), on the other hand by the materials and properties of the used O-seals:

- Standard:	NBR (operating parameters see above)
- Oxygen (O_2):	FKM (BAM approval)
- ATEX:	FKM (suitable from -40 °C)

Systems with overpressure

Depending on the version, the **SS 20.600** is designed for a maximum working pressure of 16 bar (standard) or 40 bar (option). As long as the medium to be measured is operated with overpressure, make sure that:

- There is no overpressure in the system during mounting.

  Mounting and dismounting of the sensor can be carried out only as long as the system is **in a depressurized state**.

- Only suitable pressure-tight mounting accessories are used.
- Appropriate safety devices are installed to avoid unintended discarding of the sensor due to overpressure.

  For measurements in media with overpressure, appropriate safety measures must be taken to prevent unintended discarding of the sensor.

If other accessories than the delivered pressure protection kit or alternative mounting solutions are used, the customer must ensure the corresponding safety measures.

The pressure-tight mounting, the fastening of the screw pipe connection and the discarding protection must be checked before pressure is applied. These tightness checks must be repeated at reasonable intervals.

The components of the pressure protection kit (bolt, chain and bracket) have to be checked regularly for integrity.

Thermal boundary conditions

With medium temperatures exceeding or underrunning the permitted ambient temperatures of the electronics, a cooling or heating section of the sensor tube of at least 50 mm must be provided (see Figure 3-1) to prevent that the electronic components located in the electronic housing are influenced by the medium temperature.

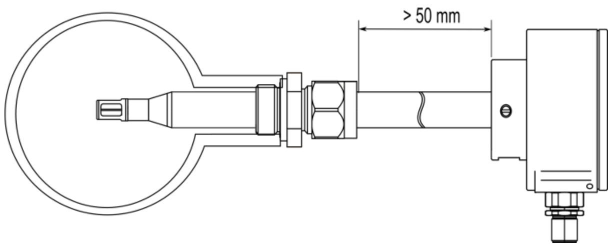


Figure 3-1

Make sure that the transmission of the medium temperature does not cause the temperature of the electronics to exceed or underrun the permitted operating temperature range.

Flow characteristics

Local turbulences of the medium can cause distortion of measurement results. Therefore, appropriate mounting conditions must be guaranteed to ensure that the gas flow is supplied to the sensor in a laminar[3], i.e. quiet and low in turbulence, state. The corresponding measures depend on the system properties (pipe, chamber, etc.) which are described in the following subchapters for different mounting variants.

Correct measurements require a (laminar) flow low in turbulence.

[3] The term “laminar” means here an air flow low in turbulence (not according to its physical definition saying that the Reynolds number is < 2300).

General installation conditions

The sensor head of **SS 20.600** consists of two basic elements:

- The enclosing measuring chamber:

  The measuring chamber, also referred to as chamber head, protects the inner sensor chip from mechanical and electrical influences.

  The aerodynamically optimized design allows tilting around the longitudinal axis of the sensor up to ±3° relative to the ideal measuring direction (see Figure 3-2) without significant impact on the measurement result[4].

  The axial tilting of the sensor head relative to the flow direction should not exceed ±3°.

  The center of the chamber head also used for specification of probe length (L) is the actual measuring point of the flow measurement and must be placed in the flow as advantageous as possible, for example in the middle of the pipe.

  Position the sensor head always at the most advantageous position for flow measurement.

- The sensor chip:

  The measurement direction is clearly defined by the measuring principle (unidirectional).

  The measuring direction is indicated by means of two arrows; the first indication is located on the front of the chamber head, the other one printed on the housing cover below the LED indication (see Figure 3-2). With the remote version, an additional arrow is located at the cable end of the sensor.

  Note:

  If the sensor has been mounted in the wrong direction (rotated by 180° relative to the flow direction) and flow is available, it does not output zero but wrong (too high) measuring values.

  The sensor measures unidirectional and must be adjusted correctly relative to the flow direction.

[4] Deviation < 1 % of the measured value

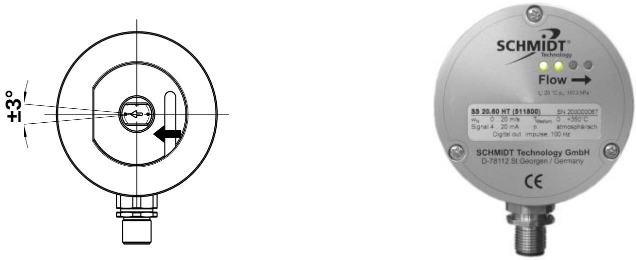


Figure 3-2 Arrangement of flow direction arrows

The design of the sensor element results in a minimal coupling between heater and medium temperature sensor, leading to a thermal crosstalk at minimal flow velocity near zero that defines the lower limit of the measuring range.

Due to system characteristics the lower measuring range limit of the sensor is 0.2 m/s.

Under unfavorable installation conditions, convection increases thermal crosstalk.

Measurements in a downward flow (downdraft flow, see Figure 3-3) lead to considerably increased measuring values in the lower flow range. The area concerned depends on the system pressure. Correct measuring values are displayed above[5] 2 m/s.

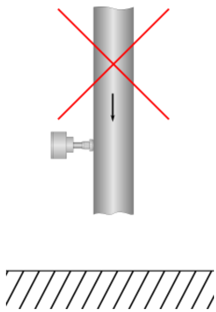


Figure 3-3

Avoid installation in a pipe or chamber with downward flow because the lower measuring range limit can rise significantly.

[5] In case of a vertical downdraft flow and a overpressure of 16 bar.

Mounting in pipes with circular cross-section

Typical applications for this type are compressed air networks or burner gas supply lines. They are characterized by long thin pipes with a quasi-parabolic flow profile.

The easiest method to achieve a low-turbulence flow is to provide a sufficiently long and absolutely straight distance without disturbances (such as edges, seams, bends etc.) in front (inlet) and behind the sensor (outlet) (see installation drawing Figure 3-4). It is also necessary to pay attention to the design of the outlet distance because the flow is also influenced by disturbances generating turbulences against the flow direction.

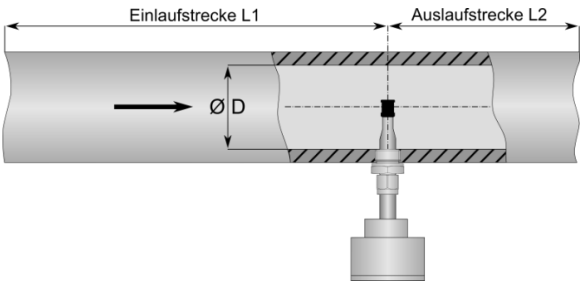


Figure 3-4

L1	Length of the inlet distance
L2	Length of the outlet distance
D	Inner diameter of the measuring section

The absolute length of the corresponding distances is defined by the inner diameter of the pipe because the flow abatement depends directly on the aspect ratio of measuring distance and diameter. Therefore, the required abatement distances are specified as a multiple of the pipe diameter D. Besides, the degree of turbulence generation by the corresponding disturbing object plays an important role. A slightly curved bend directs the air with a relative low-disturbance level, whereas a valve generates massive turbulences with its abrupt change of the flow-guiding cross-section that require a relatively long distance for abatement.

The required abatement section (based on the inner pipe diameter D) in case of different fault causes is shown in Table 1.

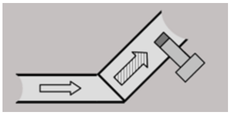
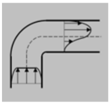
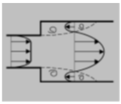
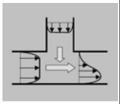
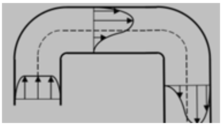
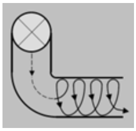
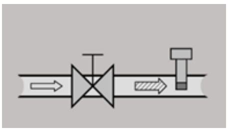
Flow obstacle upstream of measuring distance		Minimum length inlet (L1)	Minimum length outlet (L2)
Light bend (< 90°)		**10 x D**	**5 x D**
Reduction, expansion, 90° bend or T-junction	  	**15 x D**	**5 x D**
Two 90° bends in one plane (2-dimensional)		**20 x D**	**5 x D**
Two 90° bends (3-dimensional change in direction)		**35 x D**	**5 x D**
Shut-off valve		**45 x D**	**5 x D**

Table 1 Inlet and outlet distance

This table lists the minimum values required in each case. If it is not possible to observe the specified abatement distances, increased deviations of the measurement results are to be expected or it is necessary to take additional measures, for example to use flow rectifiers[6]. The profile factors specified in Table 2 may become void by the use of flow rectifiers.

[6] For example, honeycombs made of plastic or ceramics.

Calculation of volume flow

A quasi-parabolic speed profile is formed over the pipe cross-section under laminar conditions, whereas the flow velocity at the pipe walls remains almost zero, in the middle of the pipe it reaches the optimum measuring point, its maximum w_N. This measured variable can be converted to an average flow velocity $\overline{w_N}$ that is constant over the pipe cross-section by means of the correction factor which is called profile factor PF. The profile factor depends on the pipe diameter[7] and is shown in Table 2.

PF	Tube Ø		Volume flow [m³/h]						
	Inner [mm]	Outer [mm]	Min. @ 0.2 m/s	@ Sensor measuring range 10 m/s	20 m/s	60 m/s	90 m/s	140 m/s	220 m/s
0.796	26.0	31.2	0.3	15.2	30.4	91.3	136.9	213.0	334.7
0.748	39.3	44.5	0.7	32.7	65.3	196.0	294.0	457.3	718.6
0.772	51.2	57.0	1.1	57.2	114.4	343.3	515.0	801.1	1258
0.786	70.3	76.1	2.2	109.8	219.7	659.0	988.5	1537	2416
0.797	82.5	88.9	3.1	153.4	306.8	920.3	1380	2147	3374
0.804	100.8	108.0	4.6	231.0	462.0	1385	2078	3233	5081
0.812	125.0	133.0	7.2	358.7	717.5	2152	3228	5022	7892
0.817	150.0	159.0	10.4	519.8	1039	3118	4677	7276	11434
0.829	206.5	219.1	20.0	999.5	1999	5997	8995	13993	21989
0.835	260.4	273.0	32.0	1600	3201	9605	14408	22412	35219
0.84	309.7	323.9	45.6	2278	4556	13668	20502	31892	50116
0.841	339.6	345.6	54.8	2742	5484	16454	24681	38393	60331
0.845	388.8	406.4	72.2	3611	7223	21669	32504	50562	79455
0.847	437.0	457.0	91.5	4573	9146	27440	41160	64027	100614
0.85	486.0	508.0	113.5	5676	11353	34059	51088	79471	124883
0.852	534.0	559.0	137.4	6869	13738	41216	61824	96170	151125
0.854	585.0	610.0	165.3	8263	16526	49580	74371	115688	181796
0.86	800.0		311.2	15562	31124	93373	140059	217870	342368
0.864	1000.0		488.6	24429	48858	146574	219861	342006	537438
0.872	1500.0		1109	55474	110948	332845	499268	776639	1220433
0.877	2000.0		1983	99186	198372	595118	892677	1388609	2182100

Table 2 Profile factors and volume flows

[7] Both inner air friction and sensor locking are responsible.

Thus, it is possible to calculate the standard volume flow of the medium using the measured standard flow velocity in a pipe with known inner diameter:

$$A = \frac{\pi}{4} \cdot D^2$$

$$\overline{w}_N = PF \cdot w_N$$

$$\dot{V}_N = \overline{w}_N \cdot A$$

D	Inner diameter of the pipe [m]
A	Cross-section area of the pipe [m^2]
w_N	Flow velocity in the middle of the pipe [m/s]
$\overline{w}_N$	Average flow velocity in the pipe [m/s]
PF	Profile factor (for pipes with a circular cross-section)
$\dot{V}_N$	Standard volume flow [m^3/s]

For calculating the flow velocity or volume flow in pipes for the different sensor types, **SCHMIDT Technology** offers a flow calculator that can be downloaded from its homepage:

www.schmidt-sensors.com or www.schmidttechnology.com

Installation in systems with square cross-section

For most applications, there is a distinction between two borderline cases as regards the flow conditions:

- Quasi-uniform flow field

  The lateral dimensions of the flow-guiding system are approximately as large as its length in the flow direction and the flow velocity is small so that a stable trapezoidal[8] speed profile of the flow is formed. The width of the flow gradient zone at the wall is negligible in relation to the chamber width so that a constant flow velocity can be expected over the whole chamber cross-section (the profile factor is in this case 1). The sensor must be mounted here in such a way that its sensor head is far enough from the wall and it measures in the area with the constant flow field.

  Typical applications are:

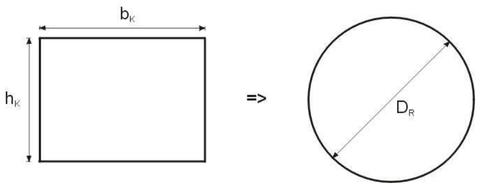
  - Exhaust ventilation shafts for drying processes
  - Chimneys

[8] A uniform flow field prevails in the largest part of the space cross-section.

- Quasi-parabolic flow profile

  The system length is large compared to the cross-section surface and the flow velocity is so high that the ratios correspond to that of the circular pipe. This means that the same requirements apply here to the installation conditions.

  Since the situation is similar to that in a pipe[9], the volume flow in a square chamber can be calculated by equating the hydraulic diameter of both cross-section forms. The result for a rectangle according to Figure 3-5 is a hydraulic “pipe diameter” D_R:



b_K: Width of rectangular channel
h_K: Height of rectangular channel

D_R: Equivalent pipe diameter

$$D_R = \frac{2 \cdot b_k \cdot h_k}{b_k + h_k}$$

Figure 3-5

According to this, the volume flow in a chamber is calculated:

$$A_R = \frac{\pi}{4} \cdot D_R^2 = \frac{\pi}{4} \cdot \left(\frac{2 \cdot b_K \cdot h_K}{b_K + h_K} \right)^2 = \pi \cdot \left(\frac{b_K \cdot h_K}{b_K + h_K} \right)^2$$

$$\overline{w}_N = PF \cdot w_N$$

$$\dot{V}_N = \overline{w}_N \cdot A_R = PF \cdot \pi \cdot \left(\frac{b_K \cdot h_K}{b_K + h_K} \right)^2 \cdot w_N$$

b_K/h_K	Width/height of the square chamber [m]
D_R	Hydraulic inner diameter of the chamber [m]
A_R	Cross-section area of the equivalent pipe [m^2]
w_N	Maximum flow velocity in the middle of the pipe [m/s]
$\overline{w}_N$	Average flow velocity in the pipe [m/s]
PF	Pipe profile factor
$\dot{V}_N$	Standard volume flow [m^3/s]

Typical applications are:

- Ventilation shaft
- Exhaust air duct

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[9] The profile factors are equal for both cross-section forms.

Mounting with a through-bolt joint

The through-bolt joint is mounted using a G½ or R½ external thread. Typically, a bushing is welded as a fitting onto a bore in the medium-guiding system wall. In most applications, these are pipes which are taken as an example for the description of the mounting procedure below (see Figure 3-6).

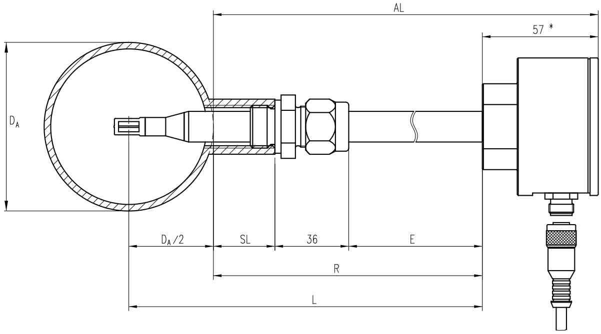


Figure 3-6

L	Sensor length [mm]	D_A	Outer diameter of the pipe [mm]
SL	Length of the weld-in sleeve [mm]	E	Sensor tube setting length [mm]
AL	Projecting length [mm]	R	Reference length [mm]

Installation process:

Depressurize the system for measurements with overpressure media and mount the pressure protection kit.

- Drill a mounting bore in a pipe wall.
- Weld the pipe union with an internal thread G½ or R½ in the center above the mounting opening on the pipe.
  Recommended length of the pipe union: 15 ... 40 mm
- Plug the holding bracket of the pressure protection chain into the thread of the through-bolt joint.
- Screw the threaded part of the through-bolt joint tightly into the pipe union (hexagon AF27).
- Observe the correct seat and alignment of the chain bracket.
- Check if there is an O-ring seal available and if it is fitted tightly.

- Loosen the spigot nut of the through-bolt joint so that the sensor probe can be inserted without jamming.
- Remove the protective cap from the sensor head; carefully insert the sensor into the guide of the through-bolt joint so that the center of the chamber head is placed at the measuring position in the middle of the pipe.
- Adjust the sensor manually at the sensor housing by turning it counterclockwise by approx. 80° (observe the flow arrow on the housing cover). Make sure that the immersion depth is maintained.
- Tighten the spigot nut slightly by means of a key wrench (AF24) to fasten the sensor.
- Use a fork wrench (AF27) to lock the hexagon bolt at the screw pipe connection. Use another key wrench (AF24) to tighten the spigot nut of the through-bolt joint until the arrow on the sensor housing complies with the direction of the pipe flow.
- Check the set angular position carefully, for example by placing a bubble level on the aligning surface of the sensor housing.

  The angular deviation should not be greater than ± 3° relative to the ideal measuring direction. Otherwise, the measurement accuracy may be affected.
- In case of wrong adjustment, the through-bolt joint has to be loosened and the alignment procedure must be repeated.
- Shorten the safety chain by removing the superfluous chain links so that the chain is slightly tensioned after being locked at the housing. Finally, secure the chain with a padlock.

General note:

Do not use the aligning surface of the housing for mechanical alignment, such as locking. There is risk of damage to the sensor.

Mounting of the remote version

The sensor probe of the remote version is mounted with a through-bolt joint in the same way as the compact sensor. A wall mounting bracket is provided for fastening the sensor housing.

Accessories

The accessories required for mounting and operation of the **SCHMIDT® flow sensor SS 20.600** are listed in Table 3 below.

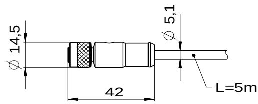
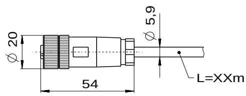
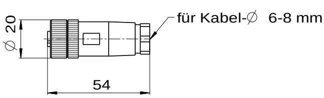
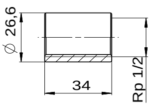
Type / Article No.	Drawing	Assembly
Connecting cable Standard with fixed length: 5 m 524921		- Threaded ring, knurl - Plug injection-moulded - Material: Brass, nickel-plated PUR, PVC
Connecting cable Standard with optional length: x m 524942		- Threaded ring, knurl - Material: Brass, nickel-plated Polyamide, PUR, PP Halogen-free[10]
Coupler socket With thread locking 524929		- Threaded ring, knurl - Material: Brass, nickel-plated Polyamide, PUR, PP - Connection of wires: Screwed (0.25 mm²)
Clamp[11] a.) 524916 b.) 524882		- Internal thread G½, R½ - Material: a.) Steel, black b.) Stainless steel 1.4571

Table 3 Accessories

Informations about further accessories for mounting and display can be found on our homepage:

www.schmidt-sensors.com or www.schmidttechnology.com

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[10] According to IEC 60754
[11] According to EN 10241; must be welded.

4 Electrical connection

Make sure that no operating voltage is active during electrical installation and that the operating voltage cannot be switched on inadvertently.

The sensor is equipped with a plug-in connector which is firmly integrated in the housing. The connector has the following data:

Number of connection pins:	8 (plus shield connection at the metallic housing)
Type:	Male
Fixation of connecting cable:	M12 thread (spigot nut at the cable)
Type of protection:	IP67 (with screwed cable)
Model:	Binder, series 763
Pin numbering:	

View of plug-in connector of the sensor

Figure 4-1

The pin assignment of the plug-in connector can be seen from the following Table 4.

Pin	Designation	Function	Wire color
1	Pulse 1	Output signal Flow (digital: Impulse)	White
2	U_B	Operating voltage: 24 V_{DC} ± 20%	Brown
3	Analog T_M	Output signal Temperature of medium (analog: U / I)	Green
4	Analog w_N	Output signal Flow (analog: U / I)	Yellow
5	AGND	Reference potential for analog outputs	Gray
6	Pulse 2	Galvanically decoupled pulse output (relay)	Pink
7	GND	Operating voltage: Ground	Blue
8	Pulse 2	Galvanically decoupled pulse output (relay)	Red
	Shield	Electromechanical shielding	Meshwork

Table 4

The analog signals have an own AGND reference potential.

The specified wire colors are valid when one of the **SCHMIDT®** connecting cables is used (see subchapter "Accessories", Table 3).

The appropriate protection class III (SELV) respective PELV has to be considered.

Operating voltage

For operation in accordance with its designated use, the sensor requires a DC voltage with a nominal value of 24 V_{DC} at an allowed tolerance of ± 20 %.

Deviating values can lead to measurement errors or even defects and, therefore, should be avoided.

Operate the sensor only within the defined voltage range (24 V_{DC} ± 20 %).
Undervoltage may result in malfunction; overvoltage may lead to irreversible damage.

The operating current of the sensor (including analog signal currents, without pulse outputs) is normally approx. 80 mA. With pulse output[12], the required current value increases to max. 200 mA[13].

The specifications for the operating voltage are valid for the connection to the sensor. Voltage drops generated due to line resistances must be taken into account by the customer.

Wiring of analog outputs

Both analog outputs for flow and temperature are designed as high-side driver with “Auto-U/I” feature and have a permanent short circuit protection against both rails of the operating voltage.

- Use of only one analog output

  It is recommended to connect the same resistance value to both analog outputs, even if only one of them is used. For example, if only the “flow” analog output is operated as current output with a resistance value of a few ohms, it is recommended to connect the other analog output (“temperature”) with the same resistance value or directly to AGND.

- Nominal operation

  The measuring resistance R_L must be connected between the corresponding signal output and the electronic reference potential of the sensor (see Figure 4-2). Normally, AGND must be selected as measuring reference potential for the signal output. The supply line GND can also be used as reference potential, however, the ground offset can cause significant measurement errors in the “Voltage” operating mode.

[12] Without signal current of the semiconductor relay.
[13] Both signal outputs with 22 mA (maximum measurement values); supply voltage minimal

Typically, AGND has to be selected as measuring reference potential for the signal output.

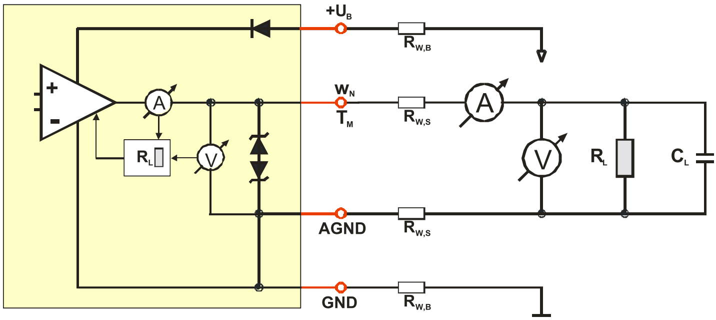


Figure 4-2

Depending on the value of resistance R_L, the signal electronics switches automatically between the operation as voltage interface (mode: U) and current interface (mode: I), hence the designation “Auto-U/I”. The switching threshold is in range between 500 and 550 Ω (for details refer to chapter 5). However, a low resistance value in voltage mode may cause significant voltage losses via the line resistances $R_{W,S}$, which can lead to measuring errors.

For voltage mode, a measuring resistance of at least 10 kΩ is recommended.

The maximum load capacitance C_L is 10 nF.

- Short circuit mode

  In case of a short circuit against the positive rail of the supply voltage ($+U_B$), the signal output is switched off.

  In case of a short circuit against the negative rail (GND) of the operating voltage, the output switches to the current mode (R_L is calculated to 0) and provides the required signal current.

  If the signal output is connected to $+U_B$ via a resistance, the value R_L is calculated incorrectly and false signal values are caused.

Wiring of the pulse output (Highside driver)

The pulse output is current-limited, short-circuit protected and has the following technical characteristics:

Design:	Highside driver, open collector
Minimum high level $U_{S,H,min}$:	U_B – 3 V (with maximum switching current)
Maximum low level $U_{S,L,max}$:	0 V
Short circuit current limitation:	Approx. 100 mA
Maximum leakage current $I_{Off,max}$:	10 µA
Minimum load resistance $R_{L,min}$:	Depending on the switching voltage U_B (see below)
Maximum load capacitance C_L:	10 nF
Maximum cable length:	100 m
Wiring:	

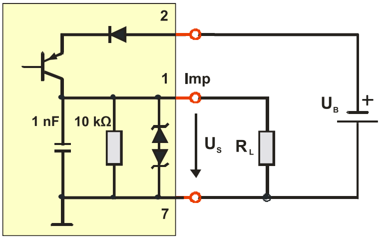


Figure 4-3

The pulse output can be used as follows:

- Direct driving of low-impedance loads (e.g. optocoupler, relays, etc.) with a maximum current consumption of approx. 100 mA.

  This allows calculating the minimum permitted (static) load resistance $R_{L,min}$ depending on the operating voltage U_B [14]:

$$R_{L,\min} = \frac{U_B - 3V}{0.1A}$$

  Example:

  In case of the maximum permissible operating voltage of $U_{B,max}$ = 28.8 V the minimal load is $R_{L,min}$ = 258 Ω.
  Here the excessive heating power of the load has to be considered.

The pulse output is protected by means of different mechanisms:

- Current limiter:

  The current is limited to approx. 100 mA.

  If the resistance values are too low, the length of the interconnection phases is limited to 100 µs.

  The maximum load capacitance C_L is 10 nF. A higher capacitance reduces the limit of the current limiter.

[14] Overcurrent peaks are absorbed by the short circuit limiter.

In case of a high capacitive load C_L, the inrush current impulse may trigger the quick-reacting short-circuit protection (permanently) although the static current requirement is below the maximum current $I_{S,max}$. An additional resistor connected in series to C_L can eliminate the problem.

- Protection against overvoltage.

  The pulse output is protected against short-term overvoltage peaks (e.g. due to ESD or burst) of both polarities by means of a TVS diode[15]. Long-term overvoltage destroys the electronics.

Overvoltage can destroy the pulse output.

Wiring of the relay

The output is realized by a semiconductor relay and has the following technical characteristics:

Type:	SSR (PhotoMOS relay)
Maximum leakage current $I_{Off,max}$:	2 µA
Maximum resistance R_{ON}:	16 Ω (typ. 8 Ω)
Maximum switching current I_S:	50 mA
Maximum switching voltage U_S:	30 V_{DC} / 21 $V_{AC,eff}$
Wiring:	

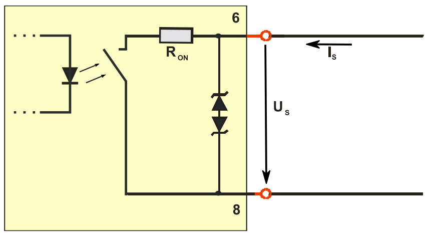


Figure 4-4

The relay output is protected against short-term overvoltage peaks (e.g. due to ESD or burst) of both polarities by means of a TVS diode. Long-term overvoltage destroys the electronics.

The specified electrical operating values may not be exceeded. Exceeding the operating values may lead to irreversible damage.
Protective measures for incorrect wiring are not taken for this output.

[15] Transient Voltage Suppressor Diode, breakdown voltage approx. 30 V, pulse capacity 4 kW (8 / 20 µs)

5 Signaling

LEDs

The **SCHMIDT® flow sensor SS 20.600** has four tricolor LEDs[16] (see Figure 5-1) that are either indicating the flow velocity during error-free operation in a quantitative way or signal the cause of the problem (see Table 5).

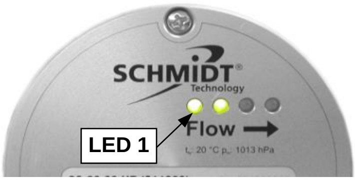


Figure 5-1

No.	State	LED 1	LED 2	LED 3	LED 4
1	Ready for operation & flow < 5 %	orange	off	off	off
2	Flow > 5 %	green	off	off	off
3	Flow > 20 %	green	green	off	off
4	Flow > 50 %	green	green	green	off
5	Flow > 80 %	green	green	green	green
6	Flow > 100 % = overflow	green	green	green	orange
7	Sensor element defective	red flashing	red flashing	red flashing	red flashing
8	Operating voltage too low	red flashing	red flashing	off	off
9	Operating voltage too high	off	off	red flashing	red flashing
10	Electronic temperature too low	off	red flashing	red flashing	off
11	Electronic temperature too high	red flashing	off	off	red flashing
12	Medium temperature too low	orange	red flashing	red flashing	orange
13	Medium temperature too high	red flashing	orange	orange	red flashing

Table 5

- (off symbol) LED off
- (green symbol) LED on: green
- (orange symbol) LED on: orange
- (red symbol) LED flashes[17]: red

[16] Component with two integrated LEDs (red and green) that can be controlled individually and indicate a mixed color orange together.
[17] Approx. 1 Hz

Analog outputs

- Switching characteristic Auto-U/I

Resistance value interval R_L	Signaling mode	Signaling range
≤ 500 (550) Ω	Current (I)	4 ... 20 mA
> 500 (550) Ω	Voltage (U)	0 ... 10 V

Table 6

A hysteresis of approx. 50 Ω ensures a stable transition behavior which is shown in Figure 5-2 below.

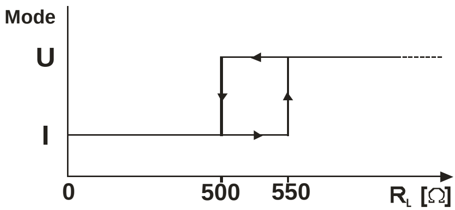


Figure 5-2

Depending on the provided output signal characteristic the accuracy of the switching point detection can be reduced. Therefore, it is recommended to select the resistance such that a safe detection can be maintained (< 300 Ω for current mode and > 1 kΩ for voltage mode).

To detect possible alternating load in an actual zero signal, the electronics generates test pulses that correspond to an effective value of approx. 1 mV. However, the latest measuring devices may trigger in response to such a pulse in DC voltage measuring mode and display short-term measuring values of up to 20 mV. In this case, it is recommended to install an RC filter at the measuring input with a time constant of 20 … 100 ms.

- Error signaling

  In current mode, the interface outputs 2 mA[18].

  In voltage mode, the output switches to 0 V.

[18] In accordance with the Namur specification.

- Representation of the measuring range

  The measuring range of the corresponding measuring value is mapped in a linear way to the mode-specific signaling range of the associated analog output.

  For flow measurement, the measuring range ranges from zero flow to the selectable end of the measuring range $w_{N,max}$ (see Table 7).

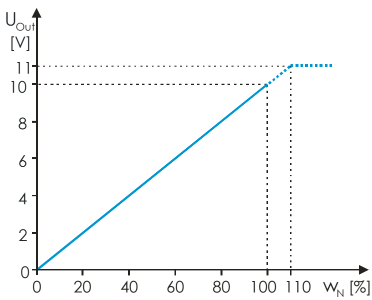
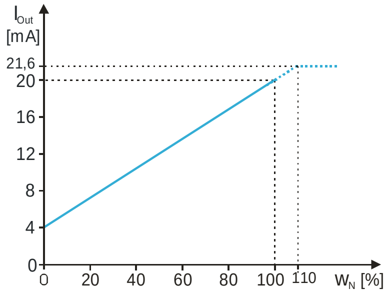
Voltage mode (U)	**Current mode (I)**
	
$w_N = \frac{w_{N,\max}}{10V} \cdot U_{Out,wN}$	$w_N = \frac{w_{N,\max}}{16mA} \cdot (I_{Out,wN} - 4mA)$

Table 7 Representation specification for flow measurement

The measuring range of the medium temperature starts at the selected measuring range start T_{Min} and ends at 120 °C (see Table 8).

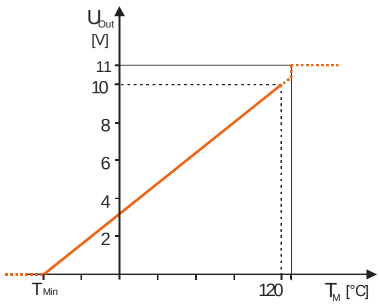
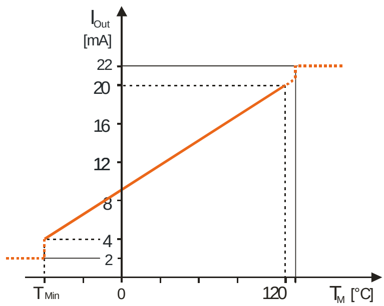
Voltage mode (U)	**Current mode (I)**
	
$T_M = \frac{120 - T_{Min}}{10V} \cdot U_{Out,TM} + T_{Min}$	$T_M = \frac{120 - T_{Min}}{16mA} \cdot (I_{Out,TM} - 4mA) + T_{Min}$

Table 8 Representation specification for measurement of medium temperature

- Exceeding measuring range of flow w_N

  Measuring values larger than $w_{N,max}$ are output in a linear way up to 110 % of the signaling range (this corresponds to 11 V resp. 21.6 mA max., see graphics in Table 7). At higher values of w_N, the output signal remains constant.

  Error signaling does not take place because damage of the sensor is unlikely.

- Medium temperature T_M outside specification range

  Operation beyond the specified limits can lead to damage to the sensor and, therefore, is seen as a critical error. This leads to the following reaction depending on the temperature limit (also refer to the graphics in Table 8):

  - Medium temperature below the lower temperature limit

    The analog output for T_M switches to error (0 V or 2 mA)[19].
    The measuring function for the flow velocity is switched off its analog output also signals an error (0 V resp. 2 mA).

  - Medium temperature above 120 °C

    T_M is output in a linear way up to at least 130 °C, for example to enable overshooting of heating control. The flow velocity is measured and displayed further on.
    Above this critical limit, flow measurement is switched off and the analog output w_N switches to error signaling (0 V or 2 mA). The signal output T_M switches directly to the maximum values of 11 V resp. 22 mA, as opposed to the normal error signaling.
    In case of excessive temperature, this avoids harmful coupling of the heating control that might be measuring by means of the medium temperature sensor. The standard error signaling of 0 V (possibly also 2 mA) could be identified by the control as a very low temperature of the medium which would lead to further heating.

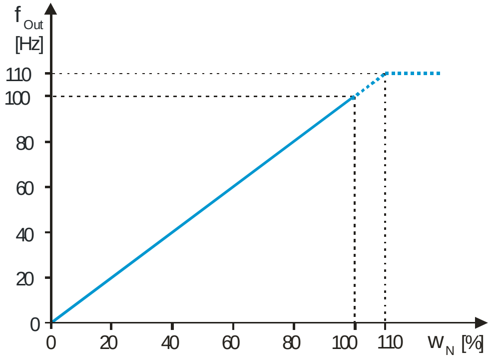
---

[19] The switching hysteresis for the threshold is approx. 5 K.

Pulse outputs

The pulse outputs as opposed to the analog outputs represent the flow velocity w_N.

- The standard version maps the flow velocity w_N proportional to a selectable frequency range from 0 to f_{max} (see Figure 5-3).



$$f_{max} = 10 \ldots 100\,Hz$$

$$w_N = \frac{f}{f_{max}} \cdot w_{N,max}$$

$$\dot{V}_N = \frac{f}{f_{max}} \cdot \dot{V}_{N,max}$$

$\dot{V}_N$: Standard volume flow

Figure 5-3 Example for f_{max} = 100 Hz

The volume flow and the pulse valence $V_{N,Imp}$ (= volume per pulse) can be determined on base of the output frequency, the measuring range of the sensor and the pipe diameter D.

$$\dot{V}_N = w_N \cdot PF \cdot A_D = w_N \cdot PF \cdot \frac{\pi}{4} \cdot D^2 \;;\qquad V_{N,Imp} = \frac{\dot{V}_{N,max}}{f_{max}}$$

- The version configured according to the requirements of the customer supplies pulses with predefined pulse valency (e.g. 1 m³/pulse).

  To do this, the pipe diameter must be specified when ordering.

Exceeding the measuring range of the flow w_N is also output up to 110 % of the measuring range. The output of higher flow values is limited to 110 % of the measuring range.

If an error occurs, 0 Hz or no pulses will be output. The current initial state remains unchanged.

Note:
The relay can be used as a S0-Interface according DIN 43 864.

6 Commissioning

Prior to switching on the **SCHMIDT® flow sensor SS 20.600**, the following checks have to be carried out:

- Mechanical installation:
  - Correct immersion depth and alignment of the sensor probe according to the flow direction
  - Tightening of the fastening screw or spigot nut
  - Installation of the pressure safety devices

  For measurements in media with overpressure, check if the fastening screw is tightened properly and pressure safety devices are installed.

- Connecting cable:
  - Correct connection in the field (switch cabinet or similar)
  - Tightness of the sensor connector and connecting cable (flat seal must be inserted correctly into the female cable connector)
  - Tight fit of the spigot nut on the cable connector at the sensor housing

After switching on the operating voltage, the sensor signals initialization by switching all four LEDs sequentially to red, orange and green.

If the sensor detects a problem during initialization, it signals the problem according to Table 5. An extensive overview of errors and their causes as well as troubleshooting measures are listed in Table 9.

If the sensor is in the correct operational state, it switches to the measuring mode after initialization. Flow velocity indication (both LEDs and signal outputs) switches for a short period to maximum and levels off at the correct measuring value after about 10 seconds, if the sensor probe already has the medium temperature. Otherwise, the process will last longer until the sensor has reached the medium temperature.

7 Information concerning operation

Environmental condition Temperature

The **SCHMIDT® flow sensor SS 20.600** monitors the temperature of both medium and electronics. As soon as the specified operating range of the electronics (-20 ... +70 °C) is exceeded, the sensor switches off both measuring functions associated with the medium and signals the error by means of the LED bar according to Table 5. As soon as proper operational conditions are restored, the sensor resumes measuring mode.

Even when exceeding or underrunning the operating temperatures for a short time, the sensor may be damaged irreversibly.

Environmental conditions Medium

The **SCHMIDT® flow sensor SS 20.600** is also suitable for relatively impure gases as long as there are no damaging, chemical aggressive constituents[20]. Dust or non-abrasive particles can be tolerated as long as they do not form any deposits on the sensor chip.

Deposits or other soiling must be detected during regular inspections and removed during cleaning because they can lead to distortion of the measurement result (see *chapter 8 Service information*).

Dirt or other deposits on the sensor head cause false measurement results.
Therefore, the sensor must be checked for contamination at regular intervals and cleaned if necessary.

Condensing liquid fractions in the medium to be measured or immersion of the sensor into liquids must be avoided at all costs.

Always avoid liquids on the sensor during operation.
It leads to serious measurement distortions and can damage the sensor in the long term.

When using the sensor outdoors, it must be protected against direct exposure to the weather.

[20] Strong mineral acids e.g. can be critical; in general the suitability has to be checked.

8 Service information

Maintenance

Heavy soiling of the sensor head may lead to distortion of the measured value. Therefore, the sensor head must be checked for contamination at regular intervals. If contaminations are visible, the sensor can be cleaned as described below.

Cleaning of the sensor head

If the sensor head is soiled or dusty, it must be cleaned carefully by means of compressed air.

⚠ The sensor head is a sensitive measuring system.
During manual cleaning proceed with great care.

In case of persistent deposits, the sensor chip as well as the interior of the chamber head can be cleaned carefully by using residue-free drying alcohol (e.g. isopropyl alcohol) or soapy water with special cotton swabs.

Figure 8-1 Suitable cotton swabs with small cleaning pads

For this purpose cotton swabs that have small, soft cotton pads are suitable, e.g. type "SP4"of the brand "CONSTIX Swabs" of the manufacturer "CONTEC". The flat, narrow side of the pads fit just between chamber head wall and sensor chip and therefore exerts a controlled, minimal pressure on the chip. Conventional cotton swabs are too big and therefore can break the chip.

Under no circumstances do attempt to pressurize the chip with greater force (e.g. by swabs with thick head or lever movements with its stick).
Mechanical overloading of the sensor element can lead to irreversible damage.

The sticks must be moved only with great care parallel to the chip surface back - and – forth to rub off the pollution. If necessary, several cotton swabs have to be used.

Before putting it into operation again, wait until the sensor head is completely dried. The drying process can be accelerated by gently blowing

If this procedure does not help, the sensor must be sent to **SCHMIDT Technology** for cleaning or repair.

Eliminating malfunctions

The following Table 9 lists possible errors (error images). A description of the way to detect errors is given. Furthermore, possible causes and measures to be taken to eliminate errors are listed.

Causes of any error signaling have to be eliminated immediately. Significant exceeding or falling below the permitted operating parameters can result in permanent damage to the sensor.

Error image	Possible causes	Troubleshooting
○ ○ ○ ○ No LED is lit All signal outputs at zero	Problems with the supply voltage U_B: ➢ No U_B present ➢ U_B has wrong polarity ➢ $U_B < 15$ V Sensor defective	➢ Is the plug-in connector screwed on correctly? ➢ Is the supply voltage connected to the control? ➢ Is there voltage at the sensor plug (cable break)? ➢ Is the power supply unit large enough?
Start sequence is repeated continuously (all LEDs red - yellow - green)	U_B unstable: ➢ Power supply unit unable to supply the switch-on current ➢ Other consumers overload U_B ➢ Cable resistance is too high	➢ Is the supply voltage at the sensor stable? ➢ Is the power supply unit large enough? ➢ Are the voltage losses over cable negligible?

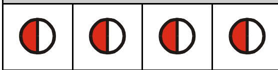
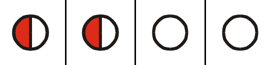
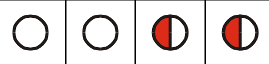
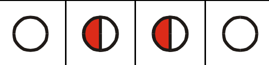
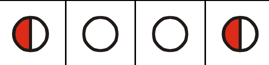
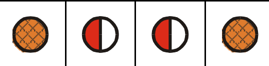
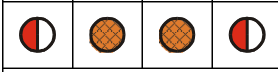
Error image				Possible causes	Troubleshooting
				Sensor element defective	Return the sensor for repair
				Supply voltage too low	Increase supply voltage
				Supply voltage too high	Reduce supply voltage
				Electronic temperature too low	Increase operating temperature of the environment
				Electronic temperature too high	Lower operating temperature of the environment
				Medium temperature too low	Increase medium temperature
				Medium temperature too high	Lower medium temperature
Low signal w_N is too large / small				Measuring range too small / large I-mode instead of U-mode or vice versa Medium to be measured does not correspond to adjustment medium Sensor element soiled	Check sensor configuration Check type or measuring resistance Is foreign gas correction considered? Clean sensor head
Flow signal w_N is fluctuating				U_B unstable Mounting conditions: ➢ Sensor head is not in the optimum position ➢ Inlet or outlet is too short Strong fluctuations of pressure or temperature	Check the voltage supply Check mounting conditions Check operating parameters
Analog signal voltage permanently at max.				Load resistance of signal output connected to $+U_B$	Connect measuring resistance to AGND
Analog signal voltage permanently at zero				Error signaling Short circuit against (A)GND	Eliminate errors Eliminate short circuit

Table 9

Transport / Shipment of the sensor

Before transport or shipment of the sensor, the delivered protective cap must be placed onto the sensor head. Avoid contaminations or mechanical stress.

Calibration

If the customer has made no other provisions, we recommend repeating the calibration at a 12-month interval. To do so, the sensor must be sent in to the manufacturer.

Spare parts or repair

No spare parts are available, since a repair is only possible at the manufacturer's facilities. In case of defects, the sensors must be sent in to the supplier for repair.

A completed declaration of decontamination must be attached.

The “Declaration of decontamination” form is attached to the sensor and can also be downloaded from

www.schmidttechnology.com

under “Downloads” in “Service returns”.

If the sensor is used in systems important for operation, we recommend you to keep a replacement sensor in stock.

Test certificates and material certificates

Every new sensor is accompanied by a certificate of compliance according to EN10204-2.1. Material certificates are not available.

Upon request, we shall prepare, at a charge, a factory calibration certificate, traceable to national standards.

9 Dimensions

Compact sensor

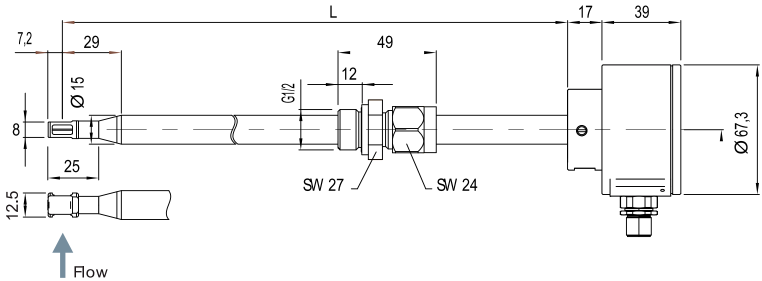


Figure 9-1

Remote sensor including wall mounting bracket

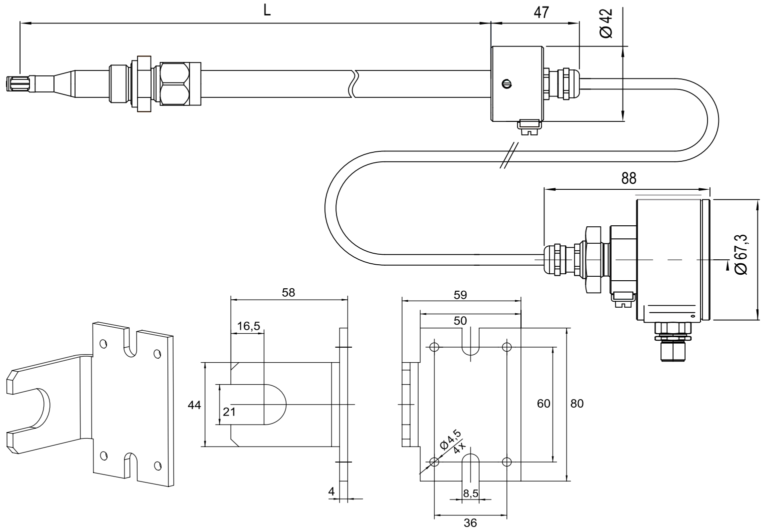


Figure 9-2

10 Technical data

Measurement-specific data	
Measuring values	Standard velocity w_N based on standard conditions of 20 °C and 1,013.25 hPa Temperature of medium T_M
Medium to be measured	Standard: Air or nitrogen Optional: natural gas, biogas, CO_2 and special gases or gas mixtures
Measuring range w_N	Standard: 0 ... 10 / 20 / 60 / 90 / 140 / 220 m/s Special: 10 … 220 m/s in steps of 0.1 m/s
Lower detection limit w_N	0.2 m/s
Measuring range T_M	Standard / O_2 version: - 20 ... + 120 °C ATEX version: - 40 ... + 120 °C
Measuring accuracy	
Standard w_N	± 3 % of measured value + (0.4 % of final value; min. 0.08 m/s)[21]
High precision w_N	± 1 % of measured value + (0.4 % of final value; min. 0.08 m/s)[21] (only for air, nitrogen, oxygen)
Reproducibility w_N	± 1 % of measured value
Response time (t_{90}) w_N	1 s (jump from 0 to 5 m/s in air)
Temperature gradient w_N	< 8 K/min for w_N = 5 m/s
Recovery time constant	< 10 s at temperature jump Δϑ = 40K @ w_N = 5m/s
Measuring accuracy T_M	± 1 K (10 ... 30 °C); ± 2 K remaining measuring range @ w_N > 5 m/s
Operating temperature	
Sensor	Standard: - 20 … + 120 °C Oxygen-version: - 20 … + 60 °C ATEX-version: - 40 ... + 120 °C
Electronics	- 20 … + 70 °C
Storage temperature	- 20 … + 85 °C
Material	
Housing	Anodized aluminum
Sensor tube	Stainless steel 1.4571
Through-bolt joint	Stainless steel 1.4571, NBR (or FKM)
Sensor head	Platinum element (glass passivated), PPO / PA
Sensor cable (remote sensor)	Sheathing TPE, halogen-free

[21] Under reference conditions

General data	
Humidity range	0 … 95 % rel. humidity, non-condensing
Operating pressure (max.)	Standard version: 16 bar Oxygen version: 20 bar Optional version: 40 bar
Display	4 x dual LEDs (green /red / orange)
Supply voltage	24 V_{DC} ± 20 %
Current consumption	Approx. 80 mA (without pulse outputs); max. 200 mA[22]
Analog outputs - Type: Auto U / I Switching Auto-U/I - Voltage output - Current output - Switching hysteresis Maximum load capacitance	Flow velocity, temperature of medium Automatic switching signal mode based on load resistance R_L 0 … 10 V for $R_L \geq 550\ \Omega$ 4 … 20 mA for $R_L \leq 500\ \Omega$ 50 Ω 10 nF
Pulse outputs - Signaling: - Pulse output 1: - Pulse output 2:	 f ~ w_N: 0 m/s … $w_{N,max}$ → 0 Hz … f_{max} Standard: f_{max} = 100 Hz Option : f_{max} = 10 … 99 Hz Quantity: 1 pulse / 1 m³ | 1 pulse / 0.1 m³ | 1 pulse / 0.01 m³ (max. 100 Hz) High-side driver connected to supply voltage (without galvanic separation) High level: > supply voltage - 3 V Short circuit current limitation: 100 mA Leakage current: I_{Off} < 10 µA Semiconductor relay (output galvanically separated) max. 30 V_{DC} / 21 $V_{AC,eff}$ / 50 mA
Connection	Plug-in connector M 12, 8-pin, male, screwed
Maximum cable length	Voltage signal: 15 m, current signal / pulse: 100 m
Installation position	As desired (for vertical downdraft flow: lower range limit 2 m/s at 16 bar)
Mounting tolerance	± 3° relative to flow direction
Minimum immersion depth	DN 25
Type of protection	IP 66 (housing), IP 67 (sensor probe)
Protection class	III (SELV) or PELV (EN 50178)
ATEX category	II 3G Ex nA IIC T4 Gc
Probe length - Compact sensor - Remote sensor	 Standard: 120 / 250 / 400 / 600 mm Special: 120 ... 1,000 mm Probe: 120 / 250 / 400 / 600 mm Cable: 10 m (in steps of 10 cm)
Weight	Approx. 500 g max. (without connecting cable)

[22] Without signal current of pulse output 2 (relay)

11 Declaration of Conformity

EU-Declaration of conformity

SCHMIDT Technology

SCHMIDT Technology GmbH herewith declares that the product

SCHMIDT® Flow Sensor SS 20.600

Part-No. **524 600**

is in compliance with the following European guideline:

No.: **2014/30/EU**

Text: Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to **electromagnetic compatibility (EMC)**

The following European standards were used for assessment of the product therefore:

- Emission (residence): **EN 61000-6-3: 2007/A1:2011/AC:2012**
- Imission (industrial): **EN 61000-6-2: 2006+A1:2011**

This declaration certificates the compliance with the mentioned directive but comprises no confirmation of attributes. The security advices of the included product documentation have to be observed. The above mentioned product was tested in a typical configuration.

St. Georgen, 20.04.2016

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