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# Flow sensors by SCHMIDT Technology improve the energy efficiency for air conditioning in cleanrooms and the security

## Halving energy costs

**The product and process safety in cleanrooms is usually ensured by maintaining defined overpressure. If the required pressure measurement by means of a flow sensor is provided additionally, for example by means of SS 20.400 by Schmidt Technology, the controlled air volume adjustment can help to improve the energy efficiency in cleanrooms significantly. The calculation performed by AL-KO Therm, one of the largest manufacturers of components for ventilation and air conditioning systems, has proven this fact with an overwhelming result.**

To ensure protection of certain products against contamination caused by people or ambient conditions or vice versa, for example protection of people and environment from biological hazardous substances, diverse processes are carried out in the cleanrooms. These requirements are typical in the medical and pharmaceutical industry, in the semiconductor manufacturing or food industry. The number of processes to be carried out in cleanrooms is growing in other industry sectors as well. The classification of cleanrooms and the distinction between clean areas and less clean areas is described in the standard EN ISO 14644. The standard contains recommendations to create the so-called impenetrable areas, however, it can be realized only with a lot of time and effort. After all people and material must enter and leave the room. A further option is to protect the clean areas against contamination from less clean areas by means of a displacement flow. This requires large openings with a relatively high volume flow which is extremely unfavorable as regards energy consumption. This is one of the reasons why the pressure difference concept with controlled overpressure is used so widely. Since in this case the openings are kept small, the required excess pressure can be obtained with a smaller volumetric flow at large pressure difference.

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The excess pressure specified in the standard lies within the range from 5 to 20 Pascal which can be traced back to reliable pressure measurement by means of differential pressure sensors. For safety reasons, medium to high air pressure values are used most often in practice. For instance in pharmaceutical cleanrooms they are usually between 15 and 30 Pascal. The air volume required to control the room pressure accounts for a considerable proportion of the energy consumption by an air conditioning system to supply cleanrooms.

In calculation models of AL-KO Therm based on practical experience just the current consumption of the ventilators makes up approximately 57 % of the energy costs. The greatest energy-saving potential derived from this fact is based on adjustment of air volume to process requirements. If the required air volume is reduced by 50 %, the increase of pressure is reduced in the system by 25 % (75 less pressure increase than for 100 % of air volume), which corresponds to a significantly reduced electric power input of 12.5 %. This means that the required electric energy is reduced exponentially to just 1/8. This ideal physical correlation can be used only partially in cleanroom applications, however, it still leads to high energy savings. This means for example that air overpressure must be decreased to a value as close to the minimum requirements of the standard as possible and then adjusted or maintained in a stable condition with the smallest possible amount of supply air, i.e. with the smallest possible ventilator output of the RLT system. Here it is especially suitable to use idle periods, for example overnight or on weekends. Reductions of prevailing pressure can also be realized during the operation hours. However, it is still necessary to ensure the functional safety of the cleanroom, i.e. to maintain a stable situation, as well as the required laminar flows. The procedure must correspond to the standard and unambiguous measurement values must be available as well as documentation of these values. However, it is difficult to achieve all these results while just using the state-of-the-art differential pressure sensors.

**Reserve and additional safety**

An additional flow measurement unit installed in a suitable wall opening from circa 50 millimeter diameter allows to measure here the so-called overflow, i.e. air flowing out of the cleanroom due to overpressure prevailing there. To evaluate the effects of room pressure on the overflow velocity, the Torricelli law can be applied.

For gases this gives the following results: $w = \sqrt{\frac{2 \cdot p}{\rho}}$

The following correlations are demonstrated for room air temperature of 20°C and standard air pressure of 1013.5 hPa:

| differential pressure | speed |
|---|---|
| [Pa] | [m/s] |
| 0,01 | 0,13 |
| 0,1 | 0,41 |
| 1 | 1,29 |
| 5 | 2,89 |
| 10 | 4,08 |
| 15 | 5,00 |
| 20 | 5,77 |
| 30 | 7,07 |

The measuring range of the flow sensor SS 20.400 by SCHMIDT Technology starts at flow velocity value ($W_N$) of 0.05 m/s. This value is far below the differential pressure of 0.01 Pa and, thus, below the capacities of a differential pressure sensor. Thus, a flow sensor detects overflow in an overflow opening at the wall of a cleanroom even at very small differential pressure. This creates sufficient reserves to keep the differential pressure in the cleanroom close to the minimum requirements of the standard and, thus, to reduce the air supply significantly.

It is possible to determine whether there is an overflow or not even in case of pressure drops that occur frequently in the cleanroom areas and during which no concrete information can be given on the protective function and a possible airborne contamination. Therefore, the benefit of an additionally installed current measurement unit is not only significant improvement of energy efficiency during air conditioning but also additional safety of the product and people. Even if a pressure sensor does not indicate any pressure, the flow direction of the cleanroom air is essential. If it is flowing from clean into the unclean area, the function of the cleanroom is ensured and the product safety is given. Such reliable measuring values allow to release some produced charges in spite of the alarm message of the pressure sensor.

**Bidirectional flow measurement**

The functionality of SS 20.400 flow sensors by SCHMIDT Technology contributes decisively to ensure such safety. They are capable of measuring the flow directions bidirectionally, including possible detection of reverse flows. The base is a thermopile sensor which uses a heatable semiconductor to detect cooling induced by an air flow. It is often referred to as thermal anemometry which is described in detail at http://schmidt-technology.testimonialsites.de/en/fakten/stromungsmessung-durch-erzwungene-konvektion-2/
Basically, these sensors offer the following benefits, they can measure the minimum flow velocities, they do not have any moving parts and, thus, there is no wear, they generate a very small flow resistance or a small pressure drop at the measuring point. Furthermore, the flow sensors SS 20.400 also offer another advantage mentioned above, they are capable of reliable identification of the flow direction by means of parallel connection of two such semiconductors.
For protection against mechanical load SCHMIDT Technology has integrated the sensor element in an measurement chamber, the evaluation electronics is integrated in the probe tube. An external transducer is also not necessary, this facilitates installation correspondingly.

**Calculated according to the standard**

Due to precise detection even of the smallest air flows and their bidirectional recognition, the flow sensors SS 20.400 are perfectly suitable for use in cleanrooms. The calculations performed by AL-KO Therm prove that the use of available differential pressure sensors allows to improve functional safety of cleanrooms and the energy efficiency significantly. For comparison, a typical cleanroom constellation has been examined consisting of the RLT-system with the air volume of 30.000 $m^3$/h, with 20.000 $m^3$/h of circulation air and an external air supply of just 10.000 $m^3$/h . The power input of the supply air ventilator is around 20.8 kW and that of the exhaust air ventilator around 15.5 kW. In this case the energy consumption of the ventilators accounts for 57 % of the entire energy consumption. This demonstrates clearly that more than half of the energy is required only for air ventilation. This examination should also include for example the energy consumption for air cooling with further 26 % which correlates with the amount of the conveyed air. The energy shares required for humidification or heating must be considered in a similar manner. This shows clearly that reducing airflow bears an enormous saving potential. Even the reduction of air input in off-peak periods, i.e. idle periods, provides enormous amounts. According to the calculation by AL-KO Therm based on practical experience it would be possible to reduce the required air volume to 20.000 $m^3$, with 15.000 $m^3$ of circulating air and 5.000 $m^3$ of supply air. As a result the power input of the supply air ventilator would be around 12.2 kW and that of the exhaust air ventilator around 8.2 kW. Profitability analysis according to DIN V 18599-3 and VDI 2067-1 gives the reduction of energy costs by 50 % for a period of five years. Of course, it is also understandable that the installation of measuring units for air volume measurement (air passage velocity) causes very small additional costs as regards expenditures and yet it brings significant savings as regards the costs for electricity due to possible reductions of the conveyed air volume. Further saving potentials using pressure reductions during operation times are not included here yet. Examination of cascaded cleanrooms which usually have significantly higher prevailing overpressure also suggests even greater saving potentials.

((Captions))

**SCHMIDT Technology-1003-Energy efficiency - Figure1**:
Just the current supply for the ventilators of the RTL-system accounts for 57 % of the energy costs in the cleanroom.

**SCHMIDT Technology-1003-Energy efficiency - Figure2**:
The flow sensors SS 20.400 by SCHMIDT Technology can be used to identify the flow direction using the parallel connection of both semiconductors and the information regarding the warmer one.

**SCHMIDT Technology-1003-Energy efficiency - Figure3**:

For installation of an additional flow sensor, it is sufficient to create a small opening of approx. 50 millimeters, as shown here, above the access door.

**SCHMIDT Technology-1003-Energy efficiency - Figure4**:
AL-KO Therm has calculated an overwhelming energy-saving potential which can be obtained by reducing the air input to the minimum values specified by the standard.

**SCHMIDT Technology-1003-Energy efficiency - Figure5**:
A flow sensor SS 20.400 can measure the compensation flow at an overflow opening in the cleanroom wall precisely.

**SCHMIDT Technology-1003-Energy efficiency - Figure6**:
The bidirectional flow sensor by SCHMIDT Technology is perfectly suitable for the complementary use in cleanrooms.

SCHMIDT Technology-1003-Energieeffizienz Reinraum-BE