Insulating gas density monitoring

Proven expertise for the power grids industry

trafag
sensors controls

Kind support of Siemens Energy

Global manufactures trust in Trafag

Gas-insulated switchgear, circuit breakers, transmission lines, transformers etc.

Hitachi Energy (former ABB)
GE Grid Solutions
Hyundai Electric
Mitsubishi Electric
Siemens Energy
Hyosung Heavy Industries
Toshiba Energy Systems
Iljin Electric

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Trafag – the hightech sensor company

Trafag, a Swiss-based company founded in 1942, is supported by a broad sales and service network in over 40 countries across the world. This allows Trafag to offer customers personalised and competent advice and ensures the best possible service. High-performance development and production departments not only guarantee the fast and reliable delivery of our high-quality and high-precision products, but also ensure that customisations can be implemented in a short time.

Density monitoring solutions with maximum accuracy

Trafag stands for precise, robust and maintenance-free instruments, developed for the monitoring of SF_6 and alternative insulating gases in the field of high- and medium-voltage switchgear. Trafag guarantees outstandingly accurate, highly shock resistant instruments that operate in the widest temperature range on the market.

Competent and customer-oriented

Technological competence, manufacturing expertise and customer-orientation form the three cornerstones of Trafag as a company. Trafag is a completely independent company with headquarters in Bubikon, Switzerland, and further manufacturing companies in Germany, Czech Republic and India. A fifth of its employees are involved in the fields of research and development, production technology or applications engineering.

Application and solution-oriented

The direct availability of these resources enables Trafag to be extremely flexible in the areas of development and production as well as in its perception and implementation of customer requirements. Thanks to modular engineering, Trafag can efficiently adapt its standard products to the specific needs of customers.

Market-oriented and always within reach

Trafag maintains an active presence in over 40 countries. A great number of customers in diverse industrial sectors such as high voltage technology, mechanical engineering, hydraulics, engine manufacturing, shipbuilding or railway technology appreciate the cooperation offered by our technically competent customer advisory service.

Adaptable and efficient

The ability to develop and manufacture its strategically important components in-house means that Trafag can both mass-produce and manufacture on a small scale at short notice. Rigorous quality management in accordance with ISO 9001, state of the art production facilities under clean room conditions and stringently monitored production processes ensure that Trafag products meet the highest quality demands.

With kind support of TransnetBW GmbH

Trafag's dedicated expertise

Pre-sales application and configuration support

Technical experts help to find the most suitable product for the specific application.

Highest quality standards in automated production processes

A well harmonized automation standard complemented with manual operations by highly skilled personnel is the basis for the leading quality and performance. Trafag density monitors and sensors are produced under increased purity requirements and then are thoroughly tested. The devices leave the factory with a test certificate that the customers can access at any time.

After-sales support

Trafag provides true end-to-end service and advice throughout the product life cycle. Many business relationships exist since decades.

Product portfolio history

Trafag has more than four decades experience in gas density monitoring

The development of a temperature compensated pressure switch in 1978 marked the beginning of the era of Trafag's density portfolio. An ingenious combination of a pressure switch with thermostat components made it possible to enter the density monitoring market of SF_6 insulation gas in high-voltage switchgear. In 1987 Trafag developed the pioneering gas density monitor with reference gas chamber, a product with unsurpassed accuracy, vibration resistance and durability to this day. A metal bellows system plays the central role in this mechanical product. In 1994, Trafag bridged the gap of continuous gas density measurement and introduced the first electronic density sensor.

1978

Trafag introduces the first density monitor with pressure switches for the international market.

1987

Invention of the reference chamber principle that has become industry standard and introduction of density monitor type 87x0 with up to 3 microswitches.

1994

Invention of the oscillating quartz sensing element and introduction of the first electronic density sensor.

2003

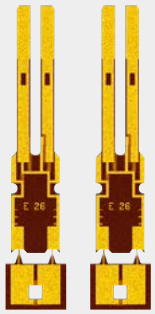
Introduction of 8774 density sensor with current loop output. Later the portfolio was extended with 8775 type with digital RS485/Modbus output.

2006

Introduction of density monitor type 87x6 with up to 4 microswitches. In the meantime, the portfolio was extended with 87x8 type for use in arctic climate zones.

2008

Introduction of 90° (radial) process connection and the low-pressure indication dial.



2010

Introduction of the hybrid density monitor type 878x (current loop output) and 879x (RS485/Modbus output) that provides switch-point monitoring and continuous density measurement in one device.

2014

Introduction of density monitor type 87x7 with up to 3 microswitches.

2017

Introduction of the integrated density monitor test valve.

2020

Introduction of the integrated insulating gas test and re-filling valve.

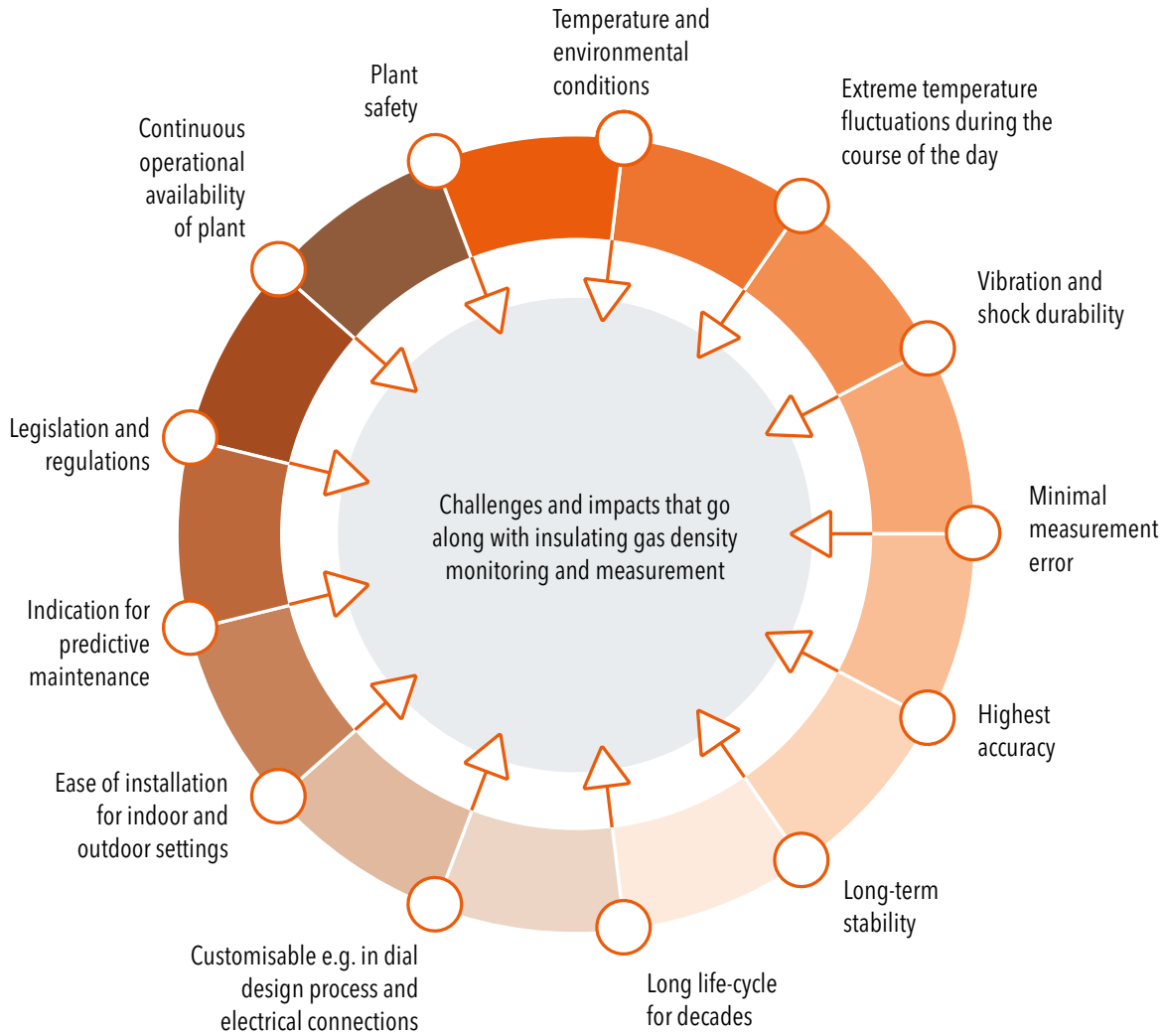
2024

Introduction of the density monitor 8719, marking the start of a new generation of density monitors with large display and advanced reference chamber for future insulating gases.

High-voltage power grid applications for gas density measuring and monitoring

Challenges and impacts for maximum safety and accuracy

Most current conduction parts of high voltage switchgear, circuit breakers and transmission lines are mounted in pressure compartments filled with efficient insulation gases. Sulphur hexafluoride (SF_6) gas is commonly used. Alternative insulation-gas mixtures, that are less harmful to the climate, steadily grow in market share. The insulation strengths of these gases depend basically on the gas density. As the dielectric strength capability of gas-insulated systems is obtained by the gas density, these compartments are filled to several hundred kPa pressure to prevent internal arcing and short circuits even over short distance.



Gas density monitoring plays a key role in plant availability and safety

The operational reliability and safety of high-voltage gear is only guaranteed when the appropriate level of gas density is maintained within the compartments. Leakage would compromise the safety of the switchgear and violate environmental regulations. SF_6 is a strong greenhouse gas and must therefore not leak into the environment. Strict regulations regarding SF_6 emissions (e.g. F-gas Regulation 517/2014) must be met and stipulate a permanent monitoring of gas leakage. This is done with gas density monitors and gas density sensors to trigger safety-related alarms or switching processes and to transmit the status to a data network.
Therefore, continuous density measurement adds several advantages to monitoring of safety alarm trigger points. Real time data allows analysis of the operational availability of the plant and the implementation of inspection windows or predictive maintenance measures.

Highest environmental resistance required

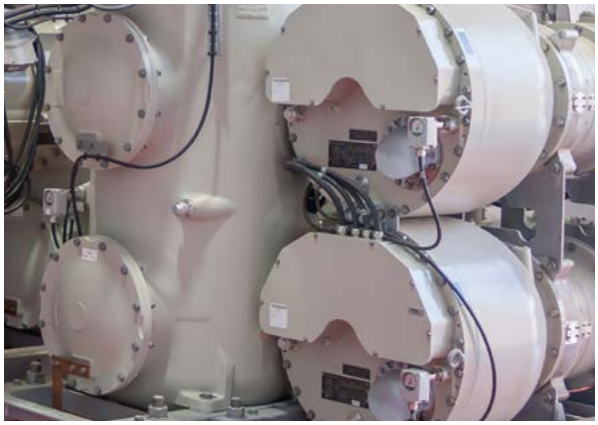
Gas-insulated systems are often installed outdoors. Temperatures between –40°C and +50°C are quite common. In arctic climate zones even temperatures down to –60°C are imposed on the equipment. In addition massive temperature fluctuations, even between day and night, plant shock and vibration have an impact on density monitor and related accessories. However, a long life cycle of density monitoring equipment for several decades is required.

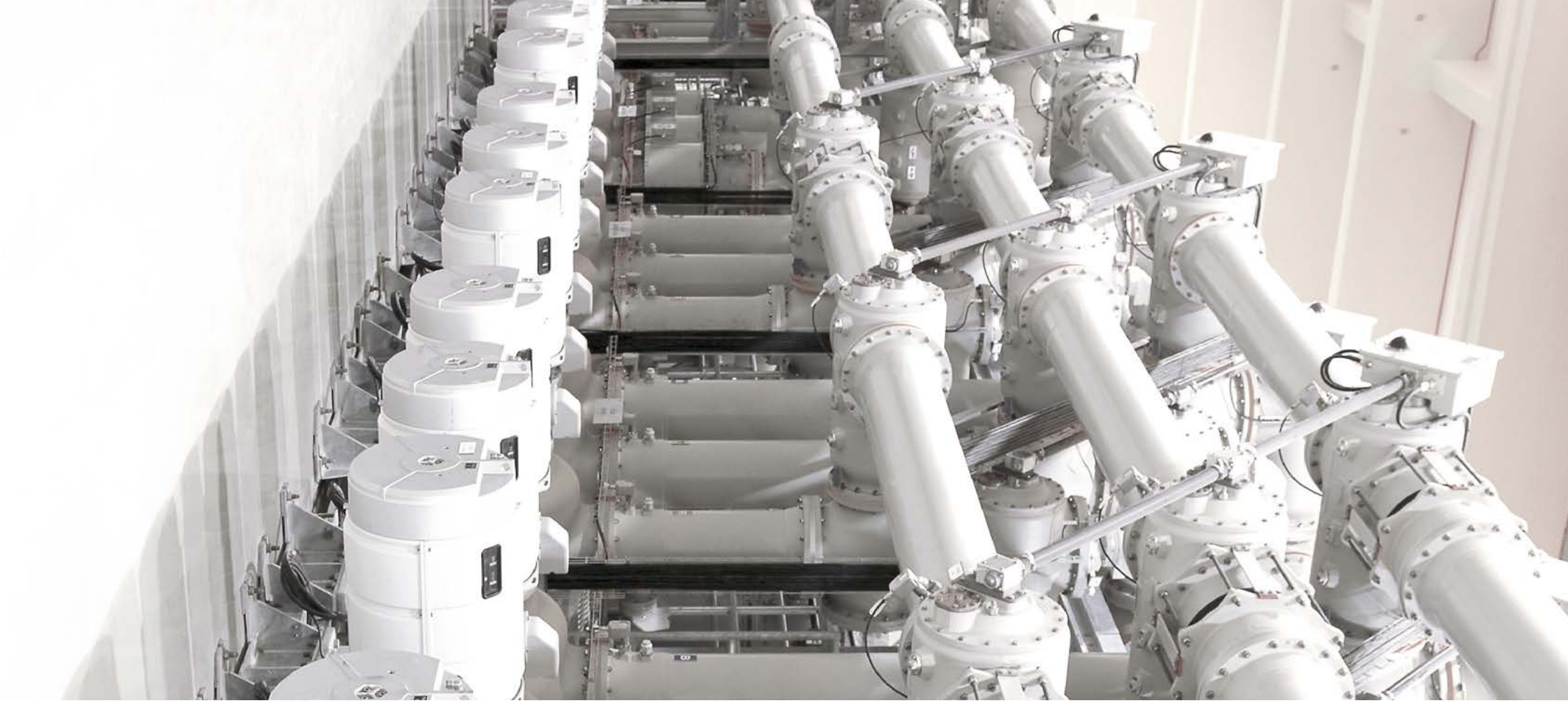
Superior gas density reference chamber and quartz tuning fork principle

Gas density is often indirectly determined by the gas pressure using manometers or pressure sensors. As the pressure in a hermetically closed volume varies enormously with temperature, such devices need temperature compensation, resulting in a source of error. Trafag provides two leading technologies for direct monitoring and measuring of insulating gas density offering the most reliable solutions on the market. Mechanical monitors determine the gas density directly by the reference chamber principle. Gas density sensors employ the electronic quartz tuning fork technology to measure density directly. Both technologies are combined in Trafag's hybrid density monitors.

Typical applications for SF_6 and alternative insulating gas monitoring

- Gas-insulated switchgear (GIS) and switching stations
- Circuit breakers (generator, live and dead tank)
- Gas insulated transmission lines (GIL)
- Gas insulated transformers (GIT)





Gas-insulated switchgear (GIS) 400 kV, Qatar 2009 © Hitachi Energy

Gas density monitoring of alternative insulating gases in SF_6-free switchgear

Alternative insulating gases, or alternative gases for short, are replacing sulphur hexafluoride (SF_6), which has been commonly used in gas-insulated switchgear for many years because sulphur hexafluoride is considered a powerful greenhouse gas. The Trafag product range for gas density monitoring in high-voltage switchgear offers full compatibility with the more environmentally friendly alternative insulating gases.

Although the physical properties of SF_6 make it well suitable for use in gas-insulated switchgear, it is also a powerful greenhouse gas with a massive Global Warming Potential (GWP). For this reason, the use of SF_6 is already massively restricted today and will be largely banned for use in high-voltage switchgear from around 2030 with the F-Gas Regulation in the EU. SF_6 is increasingly being replaced by more environmentally friendly alternative insulating gases. The alternative gases can be divided into two main groups: C_4FN-based insulating gases and air-based mixtures (technical air). The gases in both groups are lighter than SF_6 and have a lower insulating capacity at the same pressure. The chambers of gas-insulated switchgear are therefore filled with significantly more pressure in order to achieve the same insulating properties.

Gas density monitors for alternative insulating gases

The proven reference chamber measuring principle of the Trafag gas density monitors is adopted unchanged for alternative gases. Due to the higher pressures required for alternative gases, the entire measuring system has now been qualified for a measuring range of up to 13 bar (absolute pressure). The main difference to gas density monitors for SF_6 lies in the filling of the reference chamber. This is filled with a gas mixture that represents the isochoric gradient of the alternative gas, i.e. the gradient of the line of the same specific volume (= density) in the pressure-temperature diagram. The switching points and the scaling of the display are adjusted to the effective values of the alternative gas.

Gas density sensors for alternative insulating gases

In addition to being suitable for the higher pressures, the sensor system must also be calibrated for the lower density of the gases. The unique measuring principle of Trafag gas density sensors, which measures the density directly - without detour via pressure and temperature - is suitable for measuring the density of all types of gases. Only the gas mixture specific sensor parameters must be determined once by measurement. These parameters are required for the precise linearization of the output signal and for conversion to pressure at 20 °C, in the case of digital sensors (RS485/Modubus). These parameters are uploaded into the internal chip during the manufacture of the density sensors before calibration.

Operating principles

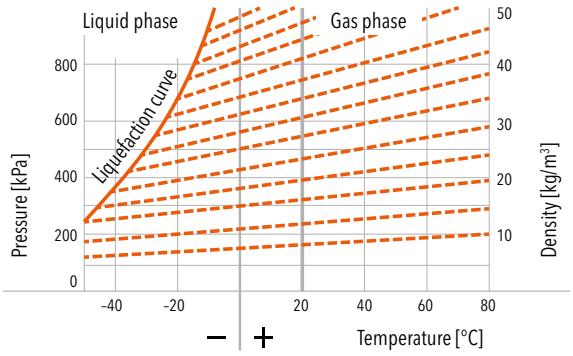
Gas density monitoring with reference gas comparison

The reference gas comparison principle was invented by Trafag in mid 1980s and was continuingly improved. Today it is the leading industry standard for temperature compensated insulating gas density monitoring in applications with high demand for reliability, accuracy, stability and longevity.

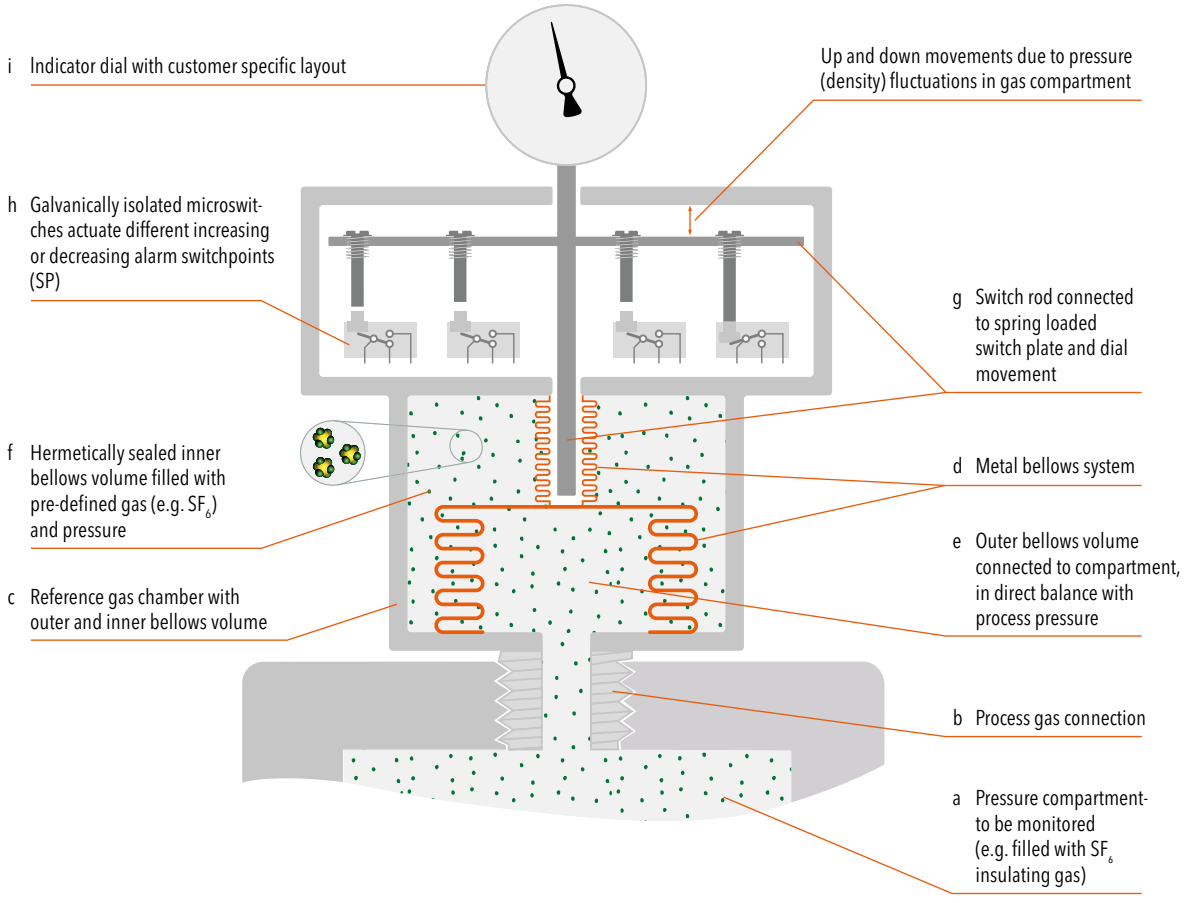
Necessity for temperature independent density monitoring

Density measurement in pressurised, gas-insulated compartments is all about physics. Pressure, density and temperature are in a certain relationship to each other. The relationship is defined by isochores (constant-volume process) for each specific insulation gas. The insulating performance of a gas-insulated compartment is achieved through a defined density which results into a certain pressure at a given temperature. In a closed and tight compartment, the overall density always remains constant, but temperature variations lead to a variation of the system pressure.

Vapour pressure curve: Lines of equivalent gas density of SF_6



Lines exemplary representing constant SF_6 gas density (isochores): Changes in pressure and temperature with constant volume.



Absolute monitoring principle (temperature compensated due to reference principle)
A density monitor is typically directly mounted to the pressure compartment of the high-voltage equipment (a) via a customizable process connection (b). Trafag density monitors are based on a reference chamber (c) incorporating a metal bellows system (d), which is pre-pressurized with the customer specific insulating gas. The metal bellows system allows a direct temperature coupling of the pressure compartment gas and the gas filling in the reference chamber. Ambient temperature changes affect the pressure (isochoric change) in the gas compartment to the same extent as they affect the pressure in the reference chamber. Therefore, the effect of temperature on insulating gas pressure is inherently compensated and a very precise insulating gas pressure @ 20°C (equalling the density), at any temperature, is indicated on a dial face (i). No false alarm is triggered due to temperature-induced pressure changes. Reference gas chamber and pressure compartment are both hermetically sealed systems. Ambient pressure has no influence on the operating principle. Therefore, it is an absolute monitoring principle.

Bellows system actuates microswitches
The pressure, more specifically the density of the insulating gas compartment is compared via the outer bellows volume (e) with the pre-defined density of the hermetically sealed inner bellows volume (f) of the reference chamber. If the density of the gas compartment alters, the bellows system actuates via a switch rod and a spring-loaded switch plate (g) up to four independent microswitches (h). Each microswitch can be factory-calibrated either to increasing or decreasing pressure alarm. That means when the density drops below pre-defined switchpoint (SP) settings, the microswitch contacts gradually close or open. The switchpoint accuracy is factory tested at -25°C, +20°C and 50°C.

Supporting measures for demanding outdoor applications
If the local, environmental effects hamper a direct temperature coupling of pressure compartment (a) and reference gas chamber (c), e.g. outdoor installation with diurnal solar radiation or rapidly changing or extreme weather conditions, specifically designed thermal covers maintain the necessary equality between pressure compartment and reference gas chamber.

Practical example:

Filling pressure (density) of insulating gas compartment: 6.1 bar abs. @ 20°C, pure SF_6

SP1: 5.7 bar abs. @ 20°C, decreasing warning switchpoint for compartment re-filling

SP2: 5.5 bar abs. @ 20°C, decreasing lock-out alarm switchpoint

SP3: 5.5 bar abs. @ 20°C, redundant decreasing lock-out alarm switchpoint

SP4: 6.4 bar abs. @ 20°C, increasing high-alarm switchpoint for compartment overpressure

Factory pre-pressurised inner bellows volume of reference chamber: 5.7 bar abs. @ 20°C, SF_6, hermetically sealed, according to SP1

If the insulating gas compartment pressure (a,e) drops due to leakage, the hermetically sealed inner bellows volume pressure (f) gains impact towards the dropping compartment pressure. The switch rod with the switch plate (g) move down.

While the pressure drops below switchpoint 1 (SP1) at 5.7 bar abs. @ 20°C, the first microswitch changes over and induces first alarm. Usually, the first-alarm indicates that the pressure compartment must be re-filled.

If the pressure drops further, in the example below 5.5 bar abs. @ 20°C, then usually two more, redundant microswitches change over (SP2 and SP3). By default, these switchpoints are used as emergency stop; the operational safety of the system is no longer guaranteed. A fourth microswitch (SP4) e.g. can be used to monitor undesired overpressure conditions during re-filling routines of the pressure compartment. If the pressure rises above 6.4 bar abs. @ 20°C, the microswitch changes over and induces high-alarm.

Reference gas comparison is deployed in the following Trafag devices:

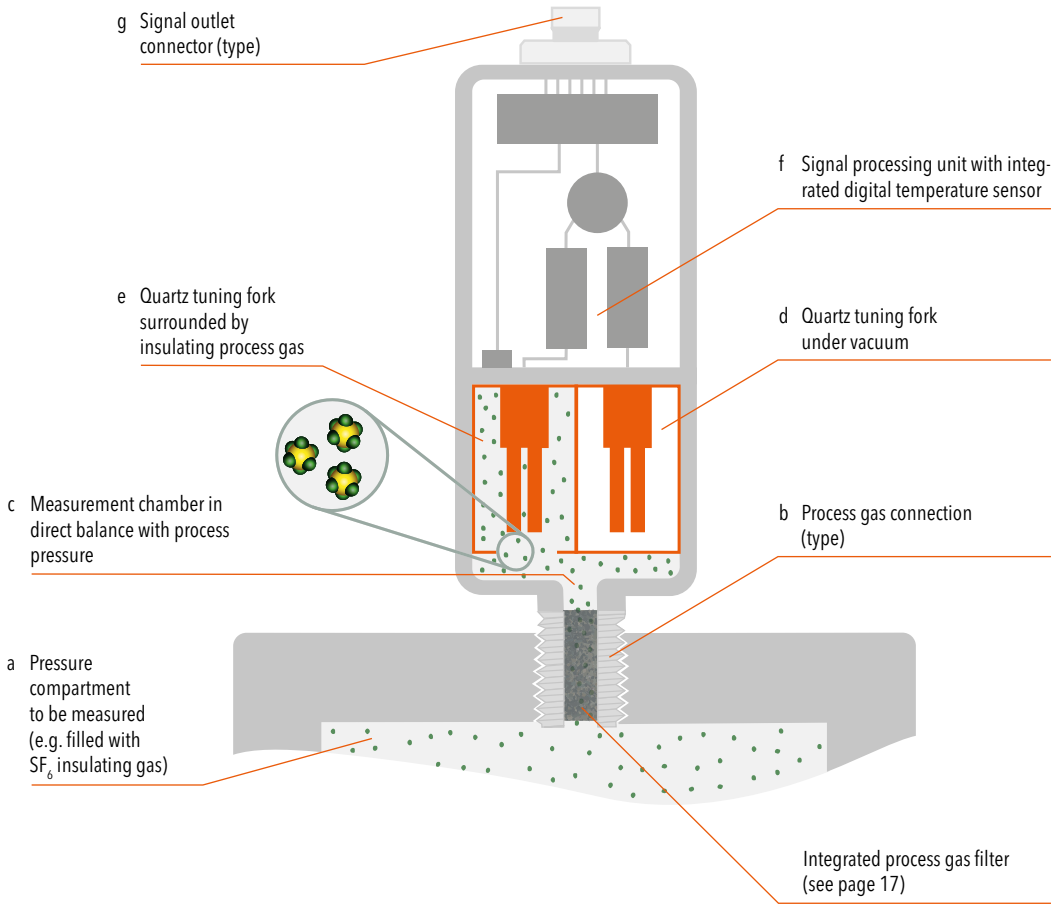
- Gas density monitors 8719, 87x6 and 87x8 see page 20, 22, 23
- Hybrid gas density monitors 878x and 879x see page 26, 27

Electronic absolute gas density measurement with quartz tuning fork

Trafag introduced the quartz tuning fork density measurement technology in the mid 1990s. It is the choice where continuous and long-term drift free density measurement and data acquisition is required. The tuning fork technology is commonly known from its use as the timefrequency standard in clocks. Exposing an oscillating tuning fork to gases of different density lead to a shift and a damping of its resonance frequency. It is a direct density measurement principle.

The density sensor is mounted to the pressure compartment (a) via a customizable process connection (b). Thus, density in the insulating gas compartment and the sensor measurement chamber (c) is in balance. Trafag density sensors use the physics by comparing the constant resonant frequency of a quartz oscillator under vacuum (d) with the resonant frequency of an identical quartz surrounded by the insulating process gas (e).

Gas of different density affects the pre-set resonant frequency of the process gas surrounded quartz tuning fork. The response time for the detection of density changes is less than 10ms. The shift of the resonant frequency is proportional to the density of the insulating process gas. The digital processing unit features an additional temperature sensor (f). The measurement signal is provided on selectable outlet connectors (g).



Electronic gas density measurement with quartz tuning fork is deployed in the following Trafag devices:

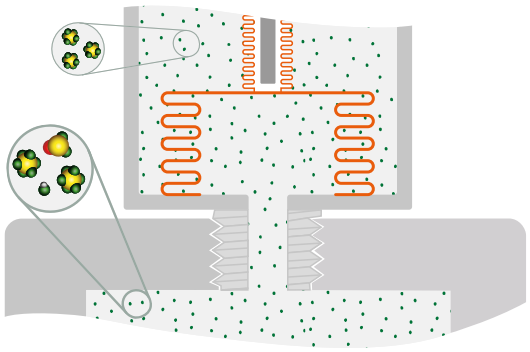
- Gas density sensors 8774 and 8775 see page 24, 25
- Hybrid gas density monitors 878x and 879x see page 26, 27

Countermeasures against aggressive SF_6 by-products

SF_6 is inert during normal use. When electrical discharges occur within SF_6 filled gas compartments, mechanical abrasion, toxic and material-aggressive by-products can emerge. The two main by-products that may occur are hydrofluoric acid and thionyl fluoride. Both can cause long-term damage to improperly selected materials. Abrasion particles can cause sensing element degradation. Trafag deals with it by using suitable materials and additional integrated process gas filters.

Countermeasures for devices with reference gas comparison

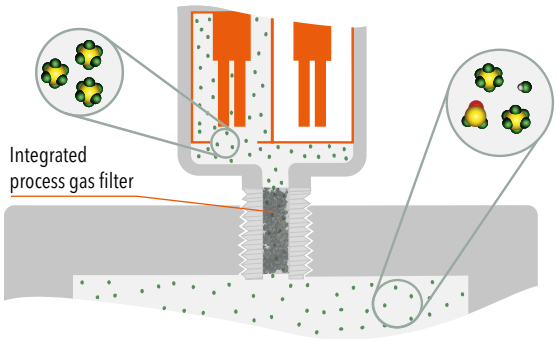
Materials for process gas connection, reference gas chamber and bellows system are specifically selected to withstand hydrofluoric acid and thionyl fluoride. High-alloyed stainless steels 1.4404, 1.4435, 1.4571 (AISI316L, AISI316Ti) are used.



Reference gas chamber, bellows system and process connection are made of stainless steel.

Countermeasures for devices with quartz tuning fork technology

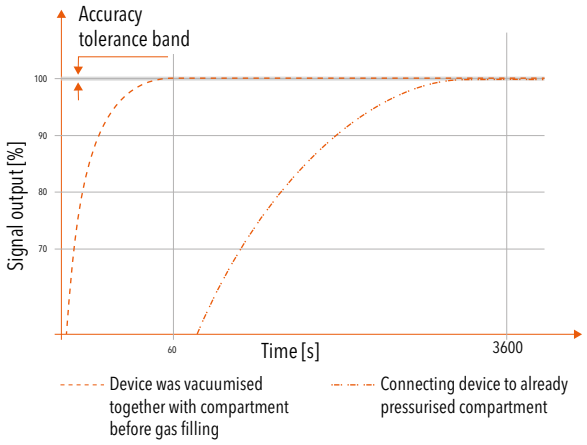
The quartz tuning fork requires advanced countermeasures to repel ingress of aggressive by-products that may occur in insulating gases. Materials for the process gas connection and measurement chamber are specifically selected. High-alloyed stainless steels 1.4404 and 1.4435 (AISI316L) are used. An additional integrated process gas filter protects from fine abrasion particles and absorbs corrosive gases.



Measurement chamber and process connection are made of stainless steel. A process gas filter protects from aggressive by-products.

Response time of the integrated process gas filter of the density sensor

During normal operation, insulating gas density changes are detected in less than 10 ms. The integrated filter element induces a transient response time after installation and initial insulating gas filling. Therefore, a minimised time period for gas equalization between process compartment and the sensor's measurement chamber occurs.



Transient initial response time which is required after installation and gas filling for the sensor signal output to reach accuracy tolerance band.

Product range overview

Monitoring and measurement devices

Trafag's product range of gas density measuring devices splits into three different product groups: The mechanically working Gas Density Monitor, the electronic Gas Density Sensor and the Hybrid Gas Density Monitor, monitoring both mechanically and electronically.
All three types have one thing in common: They are suitable for SF_6 and the complete range of alternative insulating gases.

Gas Density Monitors

Absolute SF_6 and alternative gas density monitoring with reference gas comparison

The Gas Density Monitor is based on the principle of reference gas comparison and therefore no temperature compensation is necessary. It works electromechanically and is thus independent of electrical energy supply. Since no recalibration of switchpoints is needed, it operates maintenance-free. The operating temperature ranges are from –60°C up to +80°C.

- Type 8719 New density monitor with large dial see page 20
- Type 87x6 Block type with small dial see page 22
- Type 87x8 Block type for arctic environments see page 23

Gas Density Sensors

Electronic absolute SF_6 and alternative gas density measurement with patented quartz tuning fork

The Gas Density Sensor uses a quartz tuning fork to measure gas density directly – a unique technology patented by Trafag. With the delivery of continuous output signals (analogue or digital) from this electronically operating sensor, Trafag opens new paths for the energy distribution industry. Comprehensive density trend analysis of pressurized compartments is implemented easily.

- Type 8774 with current loop output see page 24
- Type 8775 with digital RS485/Modbus output see page 25

Hybrid Gas Density Monitors

Combined mechanical monitoring and electronic measurement of SF_6 and alternative gas density

The Hybrid Gas Density Monitor combines the advantages of both, the mechanical gas density monitor and the electronic gas density sensor in a compact all-in-one apparatus. With its continuous measurement output it is ideal for insulating gas management trending systems, but it also has a local gas pressure indication and robust switchpoint alarm contacts.

- Type 878x with current loop output see page 26
- Type 879x with digital RS485/Modbus output see page 27

Note: The monitor type x-designation (e.g. 87x6) stands for individual microswitch configuration.
For example, monitor type 8736 contains x = three (3) microswitches.

With the kind support of Swiss Grid

Gas Density Monitor 8719

Gas Density Monitor with switching contacts

The heart of the 8719 gas density monitor is the advanced reference chamber measuring system. This enables a display from vacuum, is fully ready for the future, more environmentally friendly alternative insulating gases and no longer needs to be filled with SF_6 for monitoring SF_6. Further innovations include the large display, which offers optimum readability, the modular design of the connection geometry, which can be flexibly adapted to any installation position, and the integrated connection technology, which enables efficient cabling and installation thanks to pre-assembled plug-in connections.

Features

- Large dial for easy readability
- Exact switching output at all temperatures
- Fully temperature compensated by design
- Suitable for outdoor and indoor applications
- Maintenance free

Technical Data

Monitoring principle	Absolute pressure measuring system with sealed reference gas chamber, no influence due to ambient pressure fluctuations, fully temperature compensated by design
Monitoring range	0 … 1300 kPa abs. @ 20°C
Monitoring output	Floating change-over contact (SPDT)
Quantity of switchpoints	1 ... 5 microswitches
Switchpoint accuracy @ 20°C	± 10 kPa max.
Ambient temperature	-40°C … +80°C -60°C … +80°C with arctic temperature capability option
Protection	IP65 and IP67

Data sheet	www.trafag.com/H72623
Instructions	www.trafag.com/H73623

SF_6-free gas density monitor

The advanced measuring system of the 87x9 generation is based on the same reference chamber principle as the models of the proven 87x6 generation (see page 22). Both the manufacturing processes and the critical elements of the design have been preserved. But the new reference chamber is no longer filled with the same insulating gas as the switchgear, but with a mixture of nitrogen and CO_2, which reflects the isochoric (constant volume) behavior of the system gas. When calibrating the measuring system, the switching points and the scaling of the display are precisely matched to the values of the effective insulating gas in the system.

Easier to read thanks to large display

The large display of the 8719 gas density monitor offers excellent readability across the entire measuring range. The display range is not scaled linearly, but divided into different areas according to their importance in operation and for reading: The operating range, which is crucial for system safety, has the largest proportion of the scale, while the low-pressure and intermediate ranges appear correspondingly reduced.

Operating range

The operating range of the display covers the gas density range in which the system is operated. The reading scale offers a high resolution and reading accuracy here. It ranges from just below the lowest alarm switching point to just above the overpressure alarm switching point.

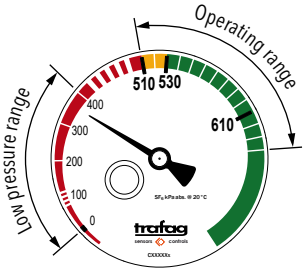
Low pressure range

The low pressure range extends from vacuum to an absolute pressure of around 4 bar. The scale enables good readability in those low pressure measuring ranges that are relevant for transportation and storage pressure - usually between 1.5 and 2 bar absolute pressure - as well as for evacuating the gas compartment.

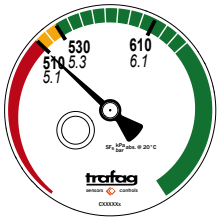
Intermediate range

The range between the operating and low-pressure ranges is not important for maintenance or operation. It has therefore been reduced to the technically necessary minimum on the display scale.

If pressure monitoring is not necessary during transportation and storage, the partial range indicator dial without the low-pressure range can be used. For further simplification, the scaling of the display can be omitted completely, so that a distinction is only made between the green marked operating range and the red marked range outside.



Full range indicator dial according to customer specifications



Partial indicator dial with sectors according to customer specification

Indicator dial with two colour sectors without markings

Gas Density Monitor 87x6

Density monitoring with highest switchpoint accurracy in harsh environments

The mechanical, self-acting gas density monitor 87x6 is based on the superior reference gas principle which is temperature compensated by design. It therefore meets standards of demanding applications over a wide temperature range. Today's full range of insulating gas mixtures can be monitored. This precise and maintenance-free density monitor is equipped with high-performance microswitches and is reliable in operation over decades for indoor and outdoor applications.

Features

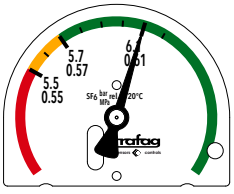
- For SF_6 and variety of alternative mixed gases
- Exact switching output at all temperatures
- No contact bouncing, high shock and vibration stability
- Indoor and outdoor use
- Maintenance free

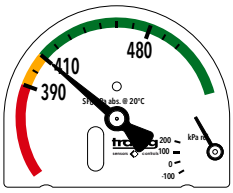
Technical Data

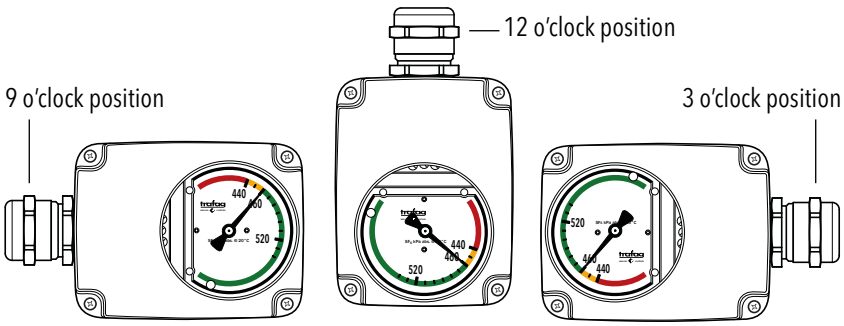
Monitoring principle	Absolute pressure measuring system with sealed reference gas chamber, fully temperature compensated by design
Monitoring range	0 ... 1250 kPa abs. @ 20°C
Monitoring output	Floating change-over contact (SPDT)
Quantity of switchpoints	1 ... 4 microswitches
Switchpoint accuracy @ 20°C	± 8 kPa max.
Ambient temperature	-40°C ... +80°C
Protection	IP65 and IP67

Data sheet	www.trafag.com/H72511
Process connections	www.trafag.com/H72502
Instructions	www.trafag.com/H73511

Trafag provides maximum flexibility in customization for the indicator dial with a full variety of colour codings and pressure units including dual range indication. This also includes rotated dial orientation by 90°/180°/270° to provide best readability for restricted installations.







An optional low-pressure indicator monitors conditions aside normal operation e.g. while compartment is filled with transport pressure or being vacuumed.

Gas Density Monitor 87x8

Density monitoring for demanding arctic climate zones

Gas density monitor 87x8 allows to monitor the full range of insulating gas mixtures in demanding artic climate zones and is equipped with up to four high-performance microswitches. The reference chamber is temperature compensated by design and induces an alarm switching signal in the event of insulating gas liquefaction due to extremely low temperatures. This precise and maintenance-free monitor is reliable in operation over decades.

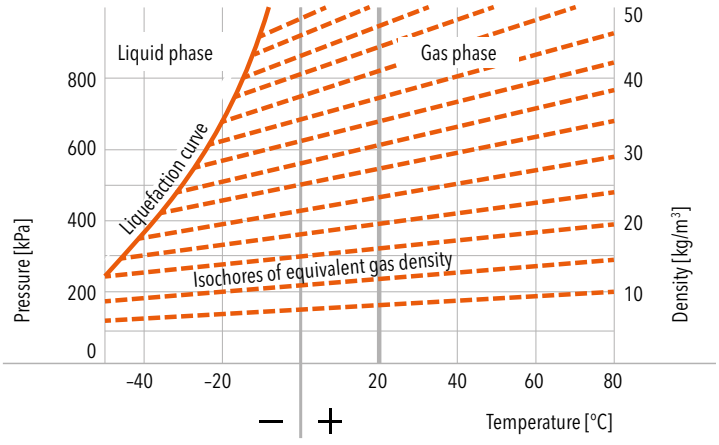
Features

- Exact switching output for artic climates
- Switching signal in case of liquefaction
- For SF_6 and variety of alternative mixed gases
- No contact bouncing, high shock and vibration stability
- Maintenance free

Technical Data

Monitoring principle	Absolute pressure measuring system with sealed reference gas chamber, fully temperature compensated by design
Monitoring range	0 ... 1250 kPa abs. @ 20°C
Monitoring output	Floating change-over contact (SPDT)
Quantity of switchpoints	1 ... 4 microswitches
Switchpoint accuracy @ 20°C	± 8 kPa max.
Ambient temperature	-60°C ... +80°C
Protection	IP65 and IP67

Data sheet	www.trafag.com/H72513
Process connections	www.trafag.com/H72502
Instructions	www.trafag.com/H73513



Arctic climate presents the highest requirements to gas compartment and density monitoring. The main safety aspect is the alarm when the insulating gas may liquefy.

Low temperatures can lead to liquefaction of process gas. Liquefaction causes a rapid pressure-drop that can temporarily trigger an alarm switchpoint. Gas density monitor 87x8 keeps the alarm status until the alarm trigger level is exceeded again while returning to normal condition.

Gas Density Sensor 8774

Continuous density measurement with current loop output

The sensor type 8774 is specifically designed for density measuring of insulation gases. This unique patented sensor technology enables the energy distributing industry to realize comprehensive trend analysis and data acquisition in gas insulated pressure compartments. It measures directly and continuously the gas density providing an analogue current output. Trend analysis helps to detect possible leakages sooner, provides data for preventive maintenance measures and therefore facilitates compliance with greenhouse gas regulations.

Technical Data

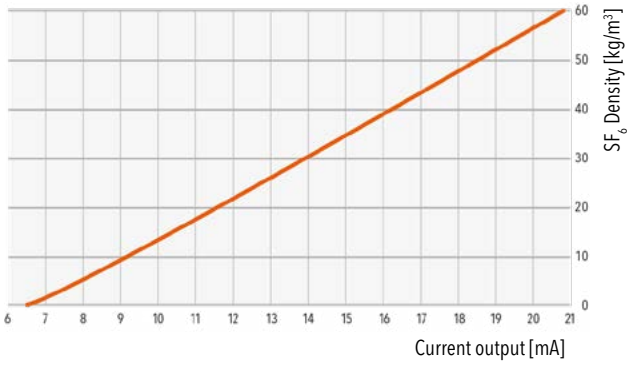
Measuring principle	Oscillating quartz sensor
Measuring range	0 ... 56.1 kg/m^3 or 0 ... 60kg/m^3 0 ... 1100 kPa abs. @ 20°C
Sensor output	6.5 … 20mA current loop
Measuring accuracy	± 1.0 % FS typ.
Ambient temperature	-40°C ... +80°C
Protection	IP65 and IP67

Data sheet	www.trafag.com/H72507
Instructions	www.trafag.com/H73507

Features

- Continuous measurement of SF_6 and alternative gas density
- Current loop output
- Suitable for outdoor and indoor applications
- Long term drift free sensor output signal
- Maintenance free

SF_6 gas density: current loop output



The current loop output has a resolution of 6.5 … 20 mA. Trafag provides conversion formulas for gas density and standardised gas pressure @ 20°C for SF_6 and alternative insulating gases.

Gas Density Sensor 8775

Continous density measurement with digital RS485/Modbus output

The digital sensor type 8775 is specifically designed for density measuring of insulation gases. It is aimed to be integrated into Modbus sensor networks. This unique patented sensor technology enables the power industry to realize comprehensive trend analysis and data acquisition, which helps to detect possible leakages sooner, provides data for preventive maintenance measures and therefore facilitates compliance with greenhouse gas regulations.

Technical Data

Measuring principle	Oscillating quartz sensor
Measuring range	0 ... 60kg/m^3 0 ... 1100 kPa abs. @ 20°C
Sensor output	Gas density [kg/m^3], normalized gas pressure [kPa abs. @ 20°C], gas temperature [K], gas pressure [kPa abs.] @ temperature variable
Measuring accuracy	± 1.0 % FS typ.
Ambient temperature	-40°C ... +80°C
Protection	IP65 and IP67

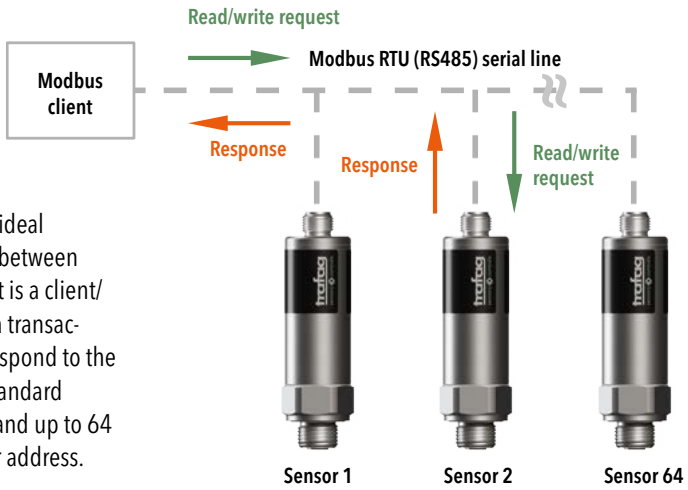
Data sheet	www.trafag.com/H72519
Instructions	www.trafag.com/H73519

Features

- Continuous measurement of SF_6 and alternative gas density
- Digital RS485/Modbus (RTU) output
- Suitable for outdoor and indoor applications
- Long term drift free output signal
- Maintenance free

Modbus communication setting

The open available Modbus protocol is the ideal communication layer for transmitting data between electronic devices over serial RS485 lines. It is a client/server protocol. One client controls the data transactions with multiple servers (sensors) that respond to the client's requests (read or write data). In a standard Modbus serial network, there is one client and up to 64 servers (sensors), each with a unique server address.



Hybrid Gas Density Monitor 878x

Combined density monitoring and measurement with current loop output

The hybrid gas density monitor combines self-acting monitoring with high-performance microswitches and continuous density measurement of insulating gases in one device. It covers demanding applications and maintains highest accuracy over a very wide temperature range. Trend analysis helps to detect possible leakages sooner, provides data for preventive maintenance measures and therefore facilitates compliance with greenhouse gas regulations. This precise and maintenance-free hybrid density monitor is reliable in operation over decades for indoor and outdoor applications.

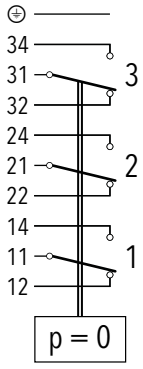
Features

- For SF_6 and variety of alternative mixed gases
- Exact switching output at all temperatures
- Continuous density measurement
- Current loop output
- High shock and vibration stability
- Maintenance free indoor and outdoor use

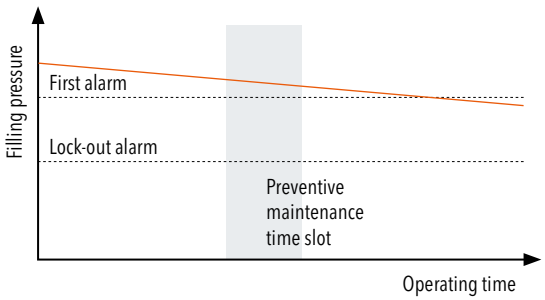
Technical Data

Monitoring principle	Absolute pressure measuring system with sealed reference gas chamber, fully temperature compensated by design
Measuring principle	Oscillating quartz sensor
Monitoring range	0 ... 1250 kPa abs. @ 20°C
Measuring range	0 ... 56.1 kg/m³ 0 ... 1250 kPa abs. @ 20°C
Output signal	Floating change-over contact (SPDT)
Quantity of switchpoints	1 ... 3 microswitches
Sensor output	6.5 ... 20 mA current loop
Switchpoint accuracy @ 20°C	± 8 kPa max.
Measuring accuracy	± 1.0 % FS typ.
Ambient temperature	-40°C ... +80°C
Protection	IP65 and IP67

Data sheet	www.trafag.com/H72511
Process connections	www.trafag.com/H72502
Instructions	www.trafag.com/H73511



Density monitoring is based on up to three galvanically isolated microswitches that actuate different alarm signals.



Density measurement is provided via 2-wire current loop output. It provides essential trend information of potential gas losses or gear status and therefore allows to determine preventive maintenance measures.

Hybrid Gas Density Monitor 879x

Combined density monitoring and measurement with digital RS485/Modbus output

The hybrid gas density monitor combines self-acting monitoring and continuous density measurement of insulating gases in one device. The digital RS485/Modbus output allows the parameterisation of gas density, gas pressure and gas temperature output data. Trend analysis helps to detect possible leakages sooner, provides data for preventive maintenance measures and therefore facilitates compliance with greenhouse gas regulations. This precise and maintenance-free hybrid density monitor is reliable in operation over decades for indoor and outdoor applications.

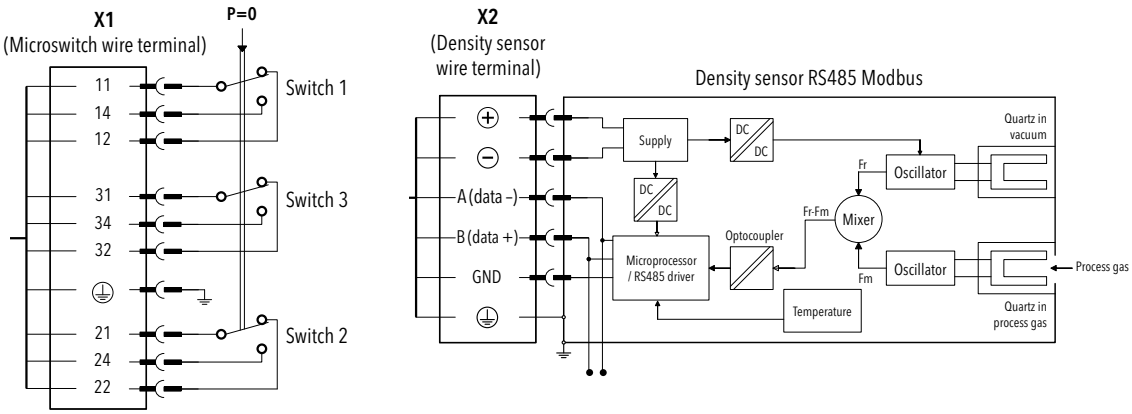
Features

- For SF_6 and variety of alternative mixed gases
- Exact switching output at all temperatures
- Continuous density measurement
- Digital RS 485/Modbus (RTU) output
- High shock and vibration stability
- Maintenance free indoor and outdoor use

Technical Data

Monitoring principle	Absolute pressure measuring system with sealed reference gas chamber, fully temperature compensated by design
Measuring principle	Oscillating quartz sensor
Monitoring range	0 ... 1250 kPa abs. @ 20°C
Measuring range	0 ... 56.1 kg / m^3 0 ... 1250 kPa abs. @ 20°C
Output signal	Floating change-over contact (SPDT)
Quantity of switchpoints	1 ... 3 microswitches
Sensor output	Gas density [kg/m^3], normalized gas pressure [kPa abs. @ 20°C], gas temperature [K], gas pressure [kPa abs.] @ temperature variable
Switchpoint accuracy @ 20°C	± 8 kPa max.
Measuring accuracy	± 1.0 % FS typ.
Ambient temperature	-40°C ... +80°C
Protection	IP65 and IP67

Data sheet	www.trafag.com/H72517
Process connections	www.trafag.com/H72502
Instructions	www.trafag.com/H73520



Density monitoring microswitches and sensor data signal are separated by independent wire terminals.

Integrated test and service valve for gas density monitors

Additional test and service valves integrated into the gas density monitors simplify the safety-related inspection of the switching contacts and maintenance during continuous operation, and filling valves with a large cross-section enable the gas tank to be filled or emptied quickly. To ensure optimum accessibility, the process and electrical connections are offered in various arrangements, i.e. with angles of 0°, 90°, 180° and 270°..

Direct access to the gas compartment of the switchgear is required for the maintenance and inspection of gas density monitors in gas-insulated high-voltage switchgear. For this purpose, additional valves are often installed between the system and the gas density monitor. The main disadvantages of these separate valves, apart from the costs, are the additional connection points, which can lead to leakage, and the increased space requirement. As the importance of maintenance and testing is increasing and at the same time network operators are expecting ever greater efficiency, Trafag offers optional integrated valves for the current gas density monitors and hybrid gas density monitors: Test valves to check the compartment switching points of the gas density monitor as well as service valves for sampling and refilling the insulating gas and filling valves with a large cross-section to quickly fill or empty the entire insulating gas. The test valve and the service or filling valve can also be integrated into the gas density monitor in combination.

Simple, safe and efficient maintenance processes thanks to integrated valves

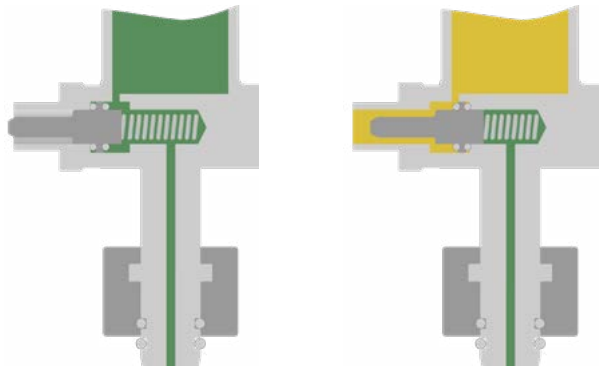
Without a test valve, the gas density monitor would have to be removed from the system to check the switching points. Every disassembly and assembly process involves the risk of components being mixed up, incorrectly connected or damaged during transportation to the test equipment. All these risks are eliminated by integrating the valve directly into the gas density monitor.

The more compact design of the integrated valves not only saves space in installation and makes access easier, but the shorter overall length also reduces the distance between the mass of the gas density monitor and the mounting point. A short lever arm to the vibrating masses is particularly important for switching operations that can cause strong vibrations. The compact design of the integrated valve reduces the load on the gas density monitor caused by vibrations, thereby reducing the risk of wear, damage and malfunctions such as contact bounce.with the patented, direct integration of valves in the density monitor for checking the switching points, for sampling, for refilling insulating gas and for direct emptying and filling of the gas compartments.

In addition to the insulating gas SF_6, more environmentally friendly alternative gases are increasingly being used on high-voltage switchgear, as the use of SF_6 on new systems is being increasingly restricted and will be completely banned throughout the EU in the next few years. To prevent confusion, the cover caps of the valves integrated in the Trafag gas density monitors are marked in the usual colors: Orange for SF_6, green for alternative insulating gases C_4FN and blue for air mixtures. Just like the gas density monitor itself, the valves are also designed for a specific gas, both in terms of pressure resistance (alternative insulating gases require a significantly higher pressure than SF_6 for equivalent insulating properties) and the sealing materials used. Trafag offers a safe and elegant solution for the reliable operation and efficient maintenance of high-voltage switchgear with the patented direct integration of valves in the gas density monitor for checking the switching points, for sampling, for refilling insulating gas and for emptying and filling the gas compartments.

Integrated test valve

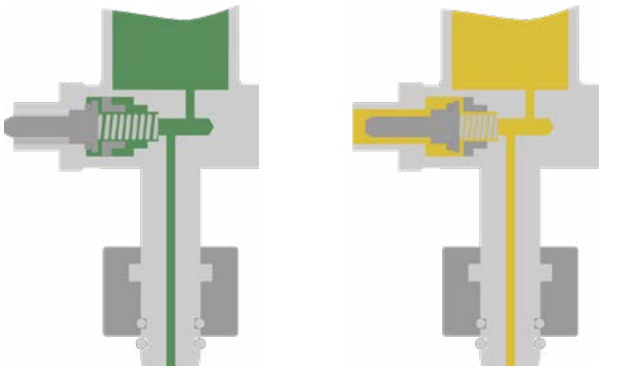
The integrated test valve allows the switching points of the density monitor to be checked when installed. An external test device can be connected via a standardised DN8 connection. For the test procedure, the valve closes the opening to the gas chamber and opens the connection to the DN8 connection. Once the test of the switching points of the density monitor and, if applicable, the signal of the density sensor installed in the hybrid density monitor has been completed, the valve is switched back to the normal position and the line to the DN8 connection is closed again. The test device can now be removed.



Normal operation | Monitor test mode

Integrated maintenance valve DN8
Integrated filling valve DN20

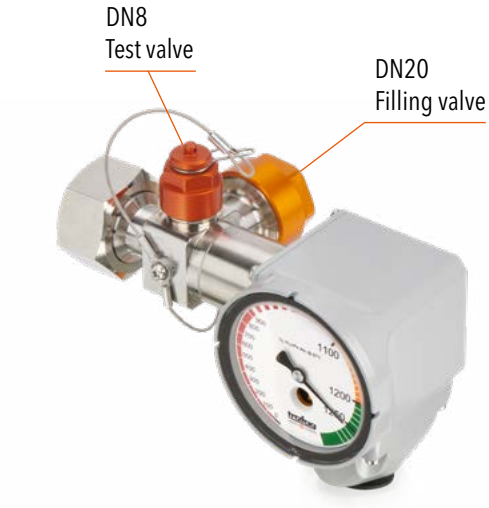
The integrated maintenance valve DN8 is used, if samples of the insulating gas need to be taken for maintenance purposes or gas in the compartment needs to be refilled. By opening the valve, the connection to the compartment is established while the connection to the gas density monitor is maintained. Once the maintenance work has been completed, the valve is reset to its normal operating state and the external modules can be disconnected. The integrated filling valve DN20 provides the same functionality as the maintenance valve DN8, but with a massively larger flow cross-section for initial filling and replacing the entire insulating gas in the compartment.



Normal operation | Process gas test and re-fill mode

Combined variants of test valves and filling valves

In addition to the individual valve variants, Trafag also offers the combined integration of test valve and filling or refilling valve, as in most systems, in addition to refilling or complete filling and maintenance work that affects the insulating gas in the system, the density monitors must also be checked. The combined valves integrated directly into the connection of the density monitor even save additional connection points.
Both the individual valves and the combinations can be ordered in various different arrangements to ensure optimum accessibility to the connections and the density monitor itself, depending on the installation position.

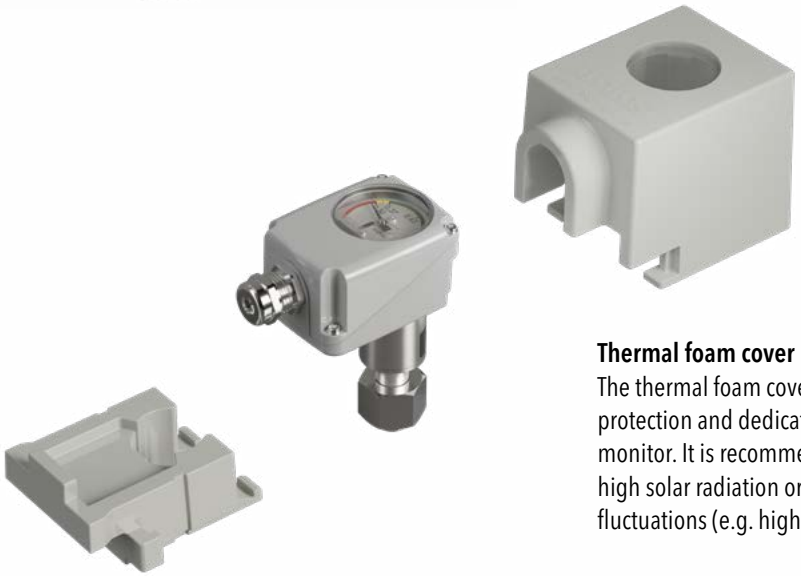


trafag sensors controls

Sheltering options

For demanding environmental conditions

Weather protection cover with separate thermal insulation ring
The weather protection cover is aimed for long-term element protection of the density monitor. The insulation ring for the probe housing increases thermal inertia in moderately changing climates. The probe housing is the lower part of the monitor where the reference gas chamber and the oscillating quartz sensor are located.



Thermal foam cover
The thermal foam cover is aimed for long-term element protection and dedicated thermal inertia of the density monitor. It is recommended for outdoor installations with high solar radiation or extreme diurnal temperature fluctuations (e.g. high altitude, arctic, desert).

Compartment immersion process connection
The compartment immersion is an intank pressure connection installation that is aimed to match continuously process gas and monitor probe temperature. This allows to further minimize a temperature disbalance between reference chamber and gas tank. A bayonet fitting with integrated stop valve allows installation while process compartment is pressurised.

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Industriestrasse 11
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+41 44 922 32 32
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