Operating instructions

for

SF$_6$-Breaker-Analyser

Please read this operating instruction before putting the device into operation. Thus operating faults can be avoided. In case of non observance of the operating instruction the manufacturer cannot assume any liability or warranty.

G.A.S. reserves the right to realize technical changes of the product due to improvements without explicitly mentioning them.

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Important note / Initial operation

All personnel involved in the operation and repair of G.A.S. devices should be specially trained and instructed.

This manual must be read carefully before starting to work with the equipment! G.A.S. does not overtake any liability for damage and disturbances, resulting from neglect or ignorance of the manual's instruction.

The text and graphics do not correspond necessarily to the scope of supply. The figures and/or diagrams do not correspond to the yardstick 1:1.

The actual scope of supply might deviate from special (customized) equipments, the recourse of additional order options or due to newest technical changes concerning the data and references described herein as well as the graphic representations. For questions please contact the G.A.S.-hotline.

G.A.S. reserves the right to realize technical changes of the product due to improvements without explicitly mentioning them.

Initial operation of the measuring device

For the initial operation no special measures must be taken.

Prior to the initial operation the transport protection of SO$_2$-Sensor cartridge has to be removed, the cartridge has to inserted and the gas tubing has to be connected. See chapter 6.1.

For the measurement follow the instructions described in the chapter "Description of the measuring process".

SF$_6$ application and environmental aspects

Since 1900, when SF$_6$ was synthesized for the first time by Moissan and Lebeau, its industrial applications have gradually increased. The remarkable gas inertness and the chemical and dielectric properties caused the General Electric Company in 1937 to suggest its use in electrical equipment. The large-scale employment of SF$_6$ in electrical manufacturing started around 1960 in the U.S.A. and Europe. In that year the first use of SF$_6$ in circuit breakers and switches for high and very high voltages was reported. So far there is currently no suitable substitute for SF$_6$ as an arc suppressant in high and medium voltage electrical switchgear.

To protect the environment it is important to reduce the SF$_6$ emissions, because SF$_6$ is a gas with a global warming potential 22,200 times greater than CO$_2$ and an atmospheric life time of 3,200 years. Thus SF$_6$ is a potent greenhouse gas.

Further SF$_6$ is one of the 6 named gases in the Kyoto Protocol giving reduction targets for 2008 –2012 and beyond that.

Security

The equipment was subject to an endangerment analysis. The construction and execution of the device corresponds to the today's state-of-the-art. The device is reliable in service when operated according to its intended use.

⚠️ **VERY DANGEROUS! Injury or mortal danger!**
The equipment is not certified for the employment in areas with explosive gas air mixtures (zone 0).

The maximum inlet pressure of the device must not exceed 14 bar absolute. Introducing a higher pressure into the device leads to damages of it. For safety reasons the SF$_6$-Breaker-Analyser automatically monitors the outlet pressure and in case of an overpressure (due to a full recycling system or sampling bag) closes the gas inlet and the measurement is aborted.

i Note

The internal inlet valve only opens when executing a measurement. In case of an overpressure at the gas outlet the measurement is aborted and the gas inlet valve automatically closed to prevent further damages.

1.   Introduction

The increased application of SF$_6$ in gas-insulated electrical equipment, such as switchgear or transmission lines, has led to many recent analytical investigations on the stability and decomposition of SF$_6$. Although SF$_6$ shows great chemical inertness it decomposes under electrical stress, in the presence of arcs, sparks or partial discharges. Among the products found are species such as SOF$_2$, SO$_2$F$_2$, SOF$_4$, S$_2$F$_{10}$, SO$_2$, HF, SiF$_4$ and others.

The decomposition of SF$_6$ further depends on gas pressure, electrode materials and the inner surface materials of the equipment. Despite the proven reliability of such components in the electrical power distribution systems, failures occur due to the above mentioned SF$_6$ aging under electrical stress.

The laboratory analysis of decomposition products can be carried out by gas chromatography, gas chromatography/mass spectrometry or infrared spectroscopy. The methods described above are complicated, expensive, require specially trained personnel and can only be done in a laboratory.

Using ion mobility spectrometer (IMS) a good quality assessment of the SF$_6$ in SF$_6$-filled compartment can be achieved on-site. The IMS is calibrated to measure all kind of decomposition products in sum and in combination with a moisture sensor and SF$_6$ percentage sensor a comprehensive monitoring of the SF$_6$ can be achieved. For monitoring the quality of SF$_6$ G.A.S. recommends to use a multi-functional device with a combination of the above mentioned sensors such as the SF$_6$-Analyser, that further allows to implement a Condition Based Maintenance (CBM) via a gas analytical approach (see www.gas-dortmund.de).

The SF$_6$-Breaker-Analyzer is also a multi-functional, modular device which can be configured to test for moisture, decomposition (SO$_2$) and purity of SF$_6$. The base unit contains a computer board for data acquisition and storage, and all necessary hardware to make a physical connection to gas insulated equipment. Users can purchase test cards for specific contaminants. The device will function with one, two or all three cards.
With all three cards installed, the operator simply makes a connection to equipment being tested, and with the push of a button, will receive test values for moisture, decomposition, and purity. The test values are internally compared to the OEM adopted CIGRE B3.02.01 standard for SF$_6$ reuse (or any customer defined value), and a pass/fail indicator will illuminate on the SF$_6$-Breaker-Analyser. All tests values will be stored on internal flash memory – which can later be downloaded to a PC.

When a card requires calibration, the entire device does not need to be returned – simply exchange the card and avoid all downtime.

The SF$_6$-Breaker-Analyser's features are:

- Compact, lightweight
- Low maintenance
- Cost-effective
- Integrated data acquisition and storage
- No consumables
- Highly sensitive
- Automatically validates readings
- Fast test results, typically 5 minutes total
- Modular upgrades
- Battery supply (approx. 8 hours with all sensors)

> **i** Note
>
> **The SO$_2$–sensor has a lifetime of two years. Using the SO$_2$-sensor for more than two years is not recommended as it causes imprecise readings due to <2% per month of signal degradation.**

1.1 Correct use of the SF$_6$-Breaker-Analyser

The SF$_6$-Breaker-Analyser has been designed for measuring parallel SO$_2$, air (or nitrogen) and moisture content in SF$_6$. It is also possible to operate the SF$_6$-Breaker-Analyser with only one or two modules.

Generally the inspected gas is released into the atmosphere. However, appropriate recovery bags or even a discharge recovery system is commercially available to ensure that no SF$_6$-gas is released into the atmosphere.

If the device is intensively used indoor, ensure that the room is always supplied with fresh air. The operation with gas mixtures such as SF$_6$-N$_2$, SF$_6$-CF$_4$. etc. needs as special purity sensor. For this purpose the device has to be specially calibrated.

> **i** Note
>
> **Never close the gas outlet while the device is being operated. Otherwise the measuring process is aborted.**

2. Obligation to exercise due care

The device has been constructed and verified in line and according to the state-of-the-art.
It left our works in perfect condition. The relevant standards and regulations have
been respected and double checked during assembling.

The operator has to ensure that

- the device is only used for the purposes for which it is intended.

- the device is only operated in accordance with the instructions and in good conditions.

- complete and legible operating instructions are available on site.

- only qualified and authorized personnel operates the device.

- this personnel is regularly instructed in safety procedures and environmental protection and that this personnel is fully aware of the complete operating instructions and particularly the safety notes.

3. Technical data

Dimensions: (with handle)

Width (B):	380 mm
Height (H):	185 mm
Depth (T):	440 mm
Weight:	12 kg

Dimensions of the transport case:

Width (B):	670 mm
Height (H):	530 mm
Depth (T):	290 mm
Weight:	20 kg

Technical Specifications		
SYSTEM	Sensor 1	Sensor 2
Connection	SO2-Measuring range	Moisture-Measuring range
Self-sealing quick connector	0 - 10 / 20 / 100 / 500 ppm$_v$ (selectable)	+ 20 to -60 ℃ dewpoint
Pressure	Indication	Indication
0,5-14 bar (gaseous) with automatic flow rate regulation	Resolution: 0.1 ppm$_v$ (0-10,20) and 1 ppm$_v$ (0-100, 500) Temperature compensated	Related to ambient pressure and temperature compensated **in ℃ td, ppm$_v$ and ppm$_w$**
Flow rate	Tolerance	Tolerance
Depending on installed modules	± 1 ppm$_v$ (0-10,20) +/-2% of value	dewpoint +20...-40 ℃: ± 2℃ dewpoint < -40 °C: ± 4 C
Operation	Humidity range	Flow rate
Purge function for tube cleaning Cleaning function with ambient air if necessary (Impurities)	up to 90 % no condensations	20 L/h
Display	Lifetime	Calibration
Graphic Display (240x128 Pixel)	24 months from installation	Every 2 years
		Sensor 3
Supply	Calibration	SF6-Percentage
Lithium-Ion battery with min. 8 h Capacity Rechargeable 100-265 AC V 50/60Hz Battery voltage displayed	not required	0 – 100 Vol. % SF6
Temperature	Maximum zero shift	Tolerance
Storage: -10 to 60 ℃ Operation: 0 to 50 ℃	0,1 ppm$_v$	± 1 % based on SF6-N2-Mixtures
Dimensions	Long-term stability	Flow rate
Enclosure: 380 x 185 x 440 mm (BxHxL)	< 1 % signal degradation per month (linear) < 0.5% (0-500 ppm$_v$)	3 L/h
Weight	Flow rate	
approx. 12 kg	10 L/h	

4.   Standard accessories

1   4 m long PTFE connecting hose with wire sheathing, self-closing stainless steel couplings on both ends

1   Hose connection M20x1.5 (for Coupling DN8)

1   Hose connection M45x2 (for Coupling DN20)

1   Coupling DN 20

1   Coupling DN 8

1   2 m long interface cable RS 232

1   USB adapter / serial 9 poles
        with CD-ROM (software driver)

1   CD-ROM with SF$_6$-Reviewer software and user manual

1   Operating instructions of the SF$_6$-Breaker-Analyser with CD-ROM

1   Transport case

1   Battery charger

1   Instrument's quality test report

1   Battery-module (inserted)

1   SF$_6$-%-module (inserted)

1   Moisture-module (inserted)

1   SO$_2$-module separately (inserted, not connected)

4.1   Accessories available as an option

SF$_6$–Recovery -Kit

SF$_6$-MV-Pressure-Regulator

5. Functional description

5.1 Operation mode of the SO$_2$-sensor

The applied electro-chemical sensor incorporates a gold based, three electrodes and acid electrolyte system.

The introduced SF$_6$ diffuses into the SO$_2$-sensor. Here it reacts at the sensing electrode through an oxidative process, according to the following equation:

Equation 1: **Sensing process**
Sulphur Dioxide   (SO$_2$): $SO_2 + 2H_2O = H_2SO_4 + 2H^+ + 2e^-$

The Counter electrode acts to balance the reaction at the sensing electrode, by means of an oxygen reduction forming water as a consequence.

Equation 2: **Counter reaction:**
Oxygen Reduction: $1/2O_2 + 2H^+ + 2e^- = H_2O$

The two equations represent the overall cell reaction as follows:

$$SO_2 + 1/2O_2 + H_2O = H_2SO_4$$
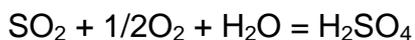
In case of a SO$_2$ presence within the SF$_6$ under inspection, equation 1 changes its electro-chemical potential and electrons are released consecutively. Thus a change of currency is detected and converted to ppm$_v$-values.

The applied sensor carries a transmitter board that includes a temperature compensation and a calibration in the specified range.

5.2 Operation mode of the percentage sensor

The measuring principle is based on the evaluation of different velocities of sound of gases. The velocity of sound in the air is about 330 m/s, while it is only about 130 m/s in pure SF$_6$ atmosphere. The velocity of sound measured in the measuring cell is temperature-compensated and converted into SF$_6$-volume content by using a microprocessor.
The measuring results are transmitted to the central processor.

5.3 Operation mode of the moisture sensor

The moisture sensor is based on the absorption of water molecules in a special ceramic material. Only vapour penetrates the covering electrode by diffusion and agglomerate reversibly to the polymer. Therefore, the capacity of the sensor changes, which is registered by the evaluation electronics and is converted into a standard signal. This signal is transmitted to the central processor.

Capacitive polymere

Cover electrode
(vapour permeable

Polymere

Contact spot
(Cover electrode – connection area – wire)

Ground electrode
+ Contact area
(Ground electrode – connection area – wire

Base

$C = f(\%RH)$
$C_{total} = C_0 + C_{\%RH}$
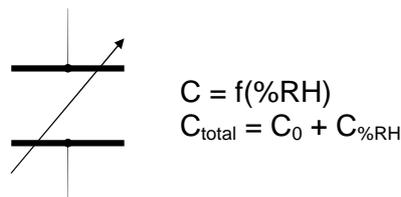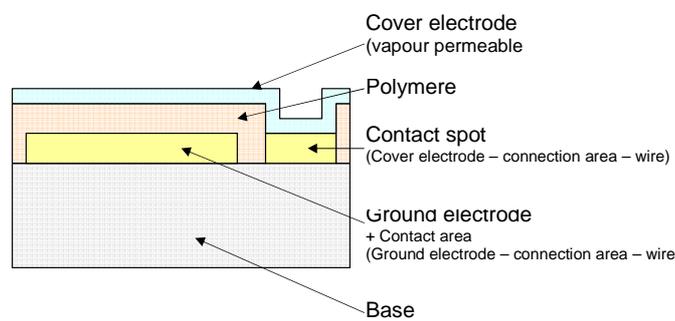
Schematic Diagram of the moisture sensor

5.4 Gas flow diagram
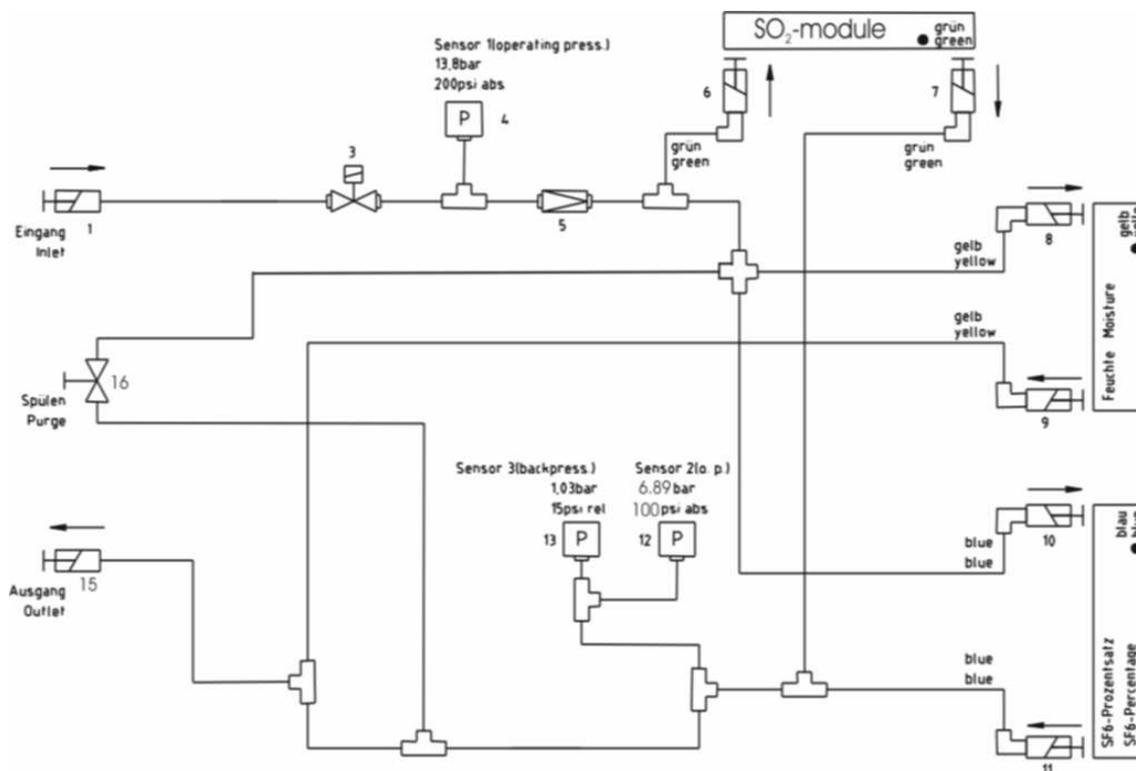
Pos.	Designation
1	Coupling NW 5
3	Solenoid valve
4	Pressure sensor 200 psi abs.
5	Pressure regulator
6	Coupling piece 1/8" inside thread Orifice plate
7	Coupling 1/8" inside thread
8	Coupling piece 1/8" inside thread Orifice plate
9	Coupling 1/8" inside thread
10	Coupling piece 1/8" inside thread Orifice plate
11	Coupling 1/8" inside thread
12	Pressure sensor 100 psi abs.
13	Pressure sensor 15 psi
14	Coupling
15	Rinsing switch

6.   Description of the measuring process

Illustration 6.01

Before starting measuring the transport protection of the SO$_2$-Module has to be removed and the module has to be inserted (See chapter 6.1). As soon as the device is switched on, the start screen appears (ill. 6.02). After a short initialization time the component check follows. The correct function of each component is confirmed or indicated by the "✓"-mark. (ill. 6.03). In case a component is not ready for operation or not inserted it is indicated by a cross. At the end of the successful initialization process, the base menu (fig. 6.04) turns up. All functions of the SF$_6$-Breaker-Analyser are accessible through this menu.

Fig. 6.02
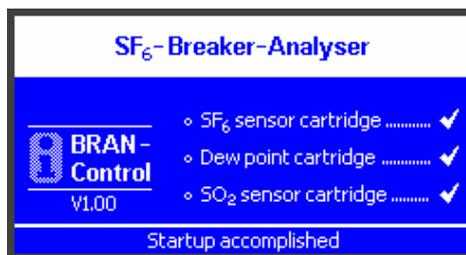
Fig. 6.03

The menu items described under illustration 6.04 can be selected as follows:
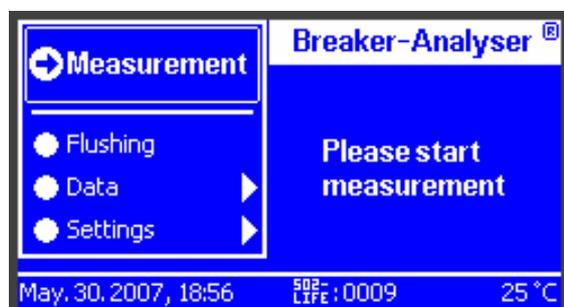
Fig. 6.04

- Measurement:
  In this menu item the measuring process can be started. (see chapter 6.2)

- Flushing:
  In this menu item the flushing of the SO$_2$-module with ambient air after measuring a concentration of SO$_2$ can be carried out. (see chapter 6.3).

- Data:
  This menu item indicates the stored data, which can be deleted and transmitted to a connected computer. See chapter 6.4 and the manual of the SF$_6$-Reviewer software.

- Settings:
  This menu item allows to change the settings of the device and parameters of the measurement (see chapter 6.5 "Settings")

According to the hardware configuration of the device it is possible that not all sensor values are available, which is indicated by the "---" mark for the missing sensor(s). The status bar, which shows the date, the lifetime counter for the SO$_2$ sensor called "SO$_2$-life" and the temperature as well as messages on the status bar of the different processes, is permanently visible on the bottom line of the screen.

i **Note**

As the SO$_2$–sensor has a recommended lifetime of two years the"SO$_2$-life" counts up the lifetime of the installed SO$_2$-module / sensor in daily steps. Approaching the end of the lifetime (670 days (730 minus 60)) the SF$_6$-Breaker-Analyser gives a warning message.

The SF$_6$-Breaker-Analyser is steered via the turning knob on the right side (see ill. 6.01). It is possible to select the desired menu item by turning and to select the control elements by pressing the control elements, which will start the function.

6.1   Insertion of the SO$_2$-module

The SO$_2$-module is delivered inside the SF$_6$-Breaker-Analyser not connected with a transport protection. Before turning on the SF$_6$-Breaker-Analyser remove the two stickers and the rubber foam of the transport protection (blue arrows in figure 6.05). Insert the module and fix the 4 screws of the module (red rings in figure 6.05).

Fig. 6.05

Open the front panel by loosening the screws marked in picture 6.06 and realize the gas connection of the module by plugging the green marked quick connectors onto the SO$_2$-module's adaptors (see picture 6.07).

Fig. 6.06

Fig. 6.07

Shut the front panel again and fix the 2 screws. After switching-on the SF$_6$-Breaker-Analyser, the device recognizes a newly calibrated SO$_2$-module and the lifetime counter of the module is automatically initialised and reset. Its activation is confirmed in the status bar (see figure 6.08).
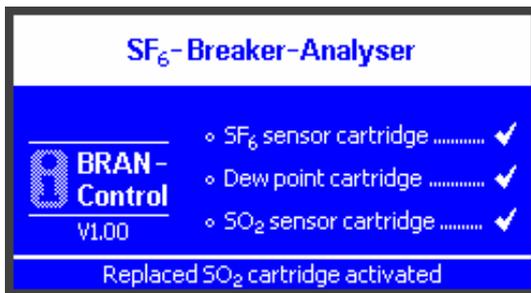
Fig. 6.08 Activation of lifetime counter

6.2   Measurement

Connect the SF$_6$-Breaker-Analyser to the gas compartment to be tested using the 4 m long hose and the corresponding couplings. Assure that the gas outlet on the back plane is not covered or closed or that it is properly connected to a recycling system (see chapter 10) or recovery bag (available at G.A.S., SF$_6$-Recycling-Kit, TEDDLAR, LINDE, etc.).

Procedure:
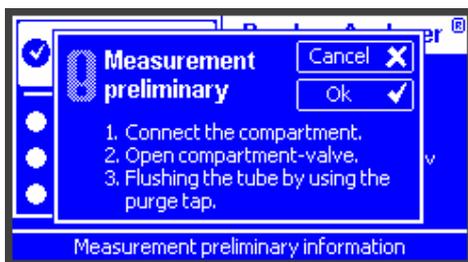
Fig. 6.09
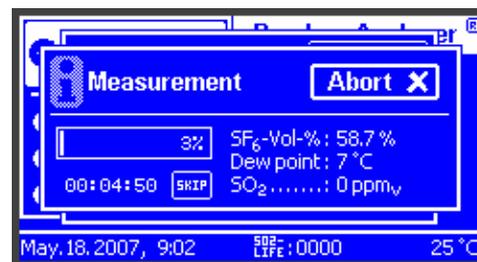
Fig. 6.10

1. To carry out a measurement, click on "Measurement" in the corresponding "Measurement" submenu (see fig. 6.04). The test time of the SF$_6$ gas can be defined by the operator or turned off under the menu point "Settings" (see chapter 6.5). Recommended test time of the SF$_6$-Breaker-Analyser is typically 7 minutes. Turning off a defined test time allows the operator to save the displayed sensor values at any time.

   After starting "Measurement" and assuring a gas flow, it is recommended to rinse the 4 m long hose immediately by pressing the rinsing knob (purge) at the front panel of the device in order to shorten the subsequent measurement time. Pressing the purge knob for approximately 5 seconds is sufficient to flush out the gas inside the hose.

2. Firstly the "Measurement preliminary" dialog with important pre-requisites for a measurement (fig. 6.09 turns up. All 3 points have to be fulfilled/ carried out before starting a measurement. This implies that a leakage free hose connection between the gas filled compartment and the device has been realized. The maximum inlet pressure of the SF$_6$-Breaker-Analyser is 14 bar. The inlet pressure is indicated in absolute pressure (ambient plus compartment).

3. After initializing the measurement process by confirming the dialog (see 6.09), the test runs automatically and lasts (according to the instrument's settings, see chapter 6.5) some minutes. During the measurement all sensor values and their changes are displayed permanently (fig. 6.10). If the values of the three are under the adjusted criteria for contamination it is possible to skip the remaining measuring time by executing the skip button and show the result of the measurement directly. The final result is displayed at the end of the measurement (fig. 6.11). The indicated values are: SF$_6$-percentage, moisture

and SO$_2$-concentration. Further to that the inlet pressure, the date and time of acquisition as well as the result are shown on the left side of the screen .
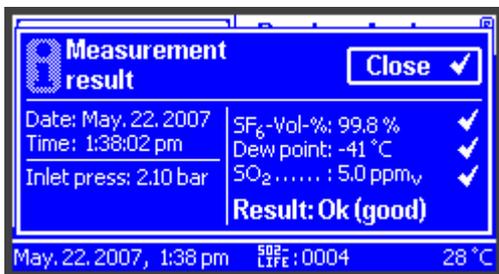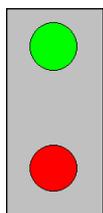

Fig. 6.11

 All implemented sensors are temperature compensated. All sensors work at atmospheric pressure. This should particularly be taken into account concerning the dew point values, which displays dew point values over ice.

Visual data interpretation through the installed LEDs on the front panel:

- "Ok": The values of the SO$_2$-concentration, the moisture and the SF$_6$-percentage are within the set tolerance (see settings, green LED lights up and all sensor values on the screen are marked with a confirmation "✓").

- "Contaminated": The SO$_2$-concentration and / or one of the values for the moisture and the SF$_6$-percentage exceed the set tolerance (see settings, red LED lights up, the sensor(s) is / are marked with a twinkling cross).

- "Undefined": The quality of the measuring data is very bad so that a corresponding evaluation is not possible (red LED lights up).

4. In case "Close" is confirmed the acquired data can be stored in the device.

5. If the user stores the data by clicking "Close", the dialog "Set measurement name" appears. The user is requested to generate a name for the measurement (fig. 6.12). The length of the name is limited to 16 digits (letters or symbols). There is no guideline for the name. Alternatively and to shorten this process, one of the last five names can be used and modified by selecting them by the use of "▼"-symbol..
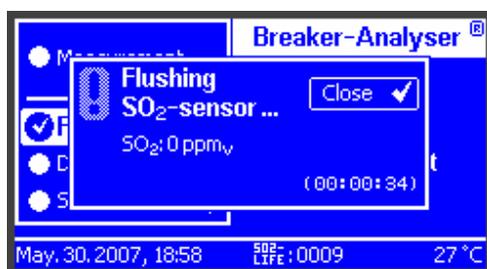

Fig. 6.12

6.3 Purging of the SO$_2$-module

Fig. 6.13

After measuring a SF$_6$ sample with a SO$_2$ concentration above zero the SO$_2$-sensor has to be purged with ambient air to clean and reset the value to 0. Therefore leave the SF$_6$-Breaker-Analyser turned on and execute "Flushing" in the main menu (fig. 6.04). The pump inside the SO$_2$-module starts rinsing ambient air through the SO$_2$-sensor. This process should not be stopped until the SO$_2$-sensor has reached **0 ppm$_v$** again in order to secure a precise reading of the next measurement. The pumping process can be stopped or aborted by pressing "Close" by the operator. The SF$_6$-Breaker-Analyser is again ready for operation.

To secure a longer lifetime and a correct reading the SO$_2$-sensor has to be purged each time a SO$_2$-concentration of > 0 ppm$_v$ is measured.

6.4 Data

The submenu "Data" (fig 6.14), which is reached from the main menu allows to look at stored data (fig. 6.11 and 6.15). Under "Show measurement" the stored data of each measurement can be chosen (fig 6.15). The selected measurement is displayed with all its details (fig.6.11). Measurements can be deleted from the memory by selecting "Delete Measurements".

> **i** Note
>
> **Please note that only all measurements can be deleted from the internal memory, not single or selected ones.**

The last menu item "Export measurements" starts the "SF$_6$-Reviewer"-mode (fig 6.16), which allows the download of stored data from the compact flash card of SF$_6$-Breaker-Analyser to a connected PC (for this purpose see the user manual of the SF$_6$-Reviewer).
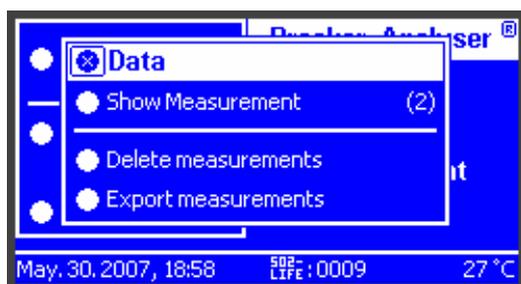
Fig. 6.14
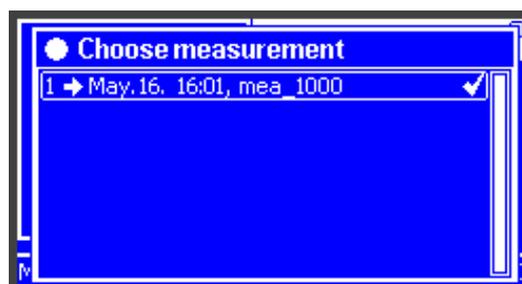
Fig. 6.15

Fig. 6.16

6.5 Settings

Some specific settings are selectable in the "Settings" menu (fig. 6.17). The adjustable values are categorized in "Acquisition", "Date / Time", "Sensors" and "Device".
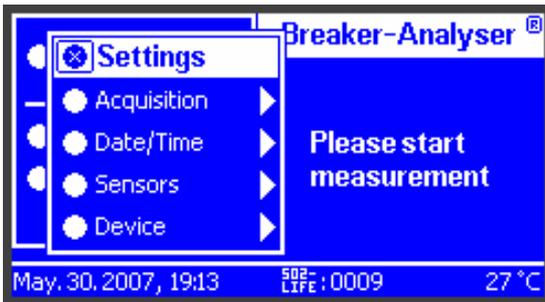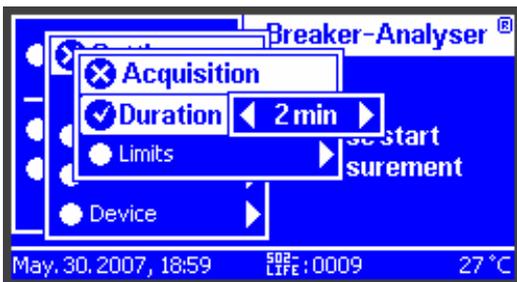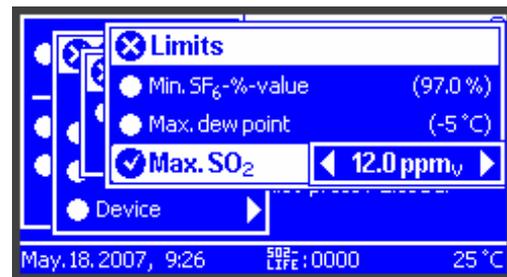

Fig. 6.17

Fig. 6.18

Fig. 6.19

Acquisition (Settings/Acquisition) (fig.6.17)

Concerning the determination of SF$_6$ test values and to operate the SF$_6$-Breaker-Analyser in a correct way, the following points are very important:

o   Duration: The test time can be adjusted or turned off. When operating the SF$_6$-Breaker-Analyser with all sensors, the recommended test time is 7 minutes, as the typical T90 duration for the moisture sensor to measure a dry sample (-45 °C to -55°C) takes this time. Turning off the test time (by using the steering knob) allows to save the acquired and displayed values at any time.

o   Limits (Data acquisition / Limits) (fig. 6.19)
The set values determine how the SF$_6$–Breaker-Analyser interprets the measuring result. In case the SF$_6$ gas under inspection does not fulfil to the following criteria, the SF$_6$-Breaker-Analyser shows the result of a contaminated gas:

- Min. SF$_6$-%-value: The content of SF$_6$–purity is below the set limit.
- Maximum dew point: The humidity content (dew point) exceeds the set value.
- Max. decomp. prod.: The SO$_2$-concentration within the SF$_6$ is exceeded.

The max. tolerable values, recommended in the SF$_6$ Recycling Guide (Revision 2003) of CIGRE (B3. 02 Task Force 01), used as factory defaults, are as follows:

- Min. SF$_6$-%-value: 97 % (or max. 3% for air and CF$_4$)
- Max. dew point: -5 ℃ dew point
- Max. SO$_2$-concentration.: 500 ppmv (2,000 ppmv total max. in equipment)
  12 ppm$_v$ (50 ppmv concerning the re-use)

Fig. 6.20

Fig. 6.21

Date / Time (Settings / Date/Time) (fig. 6.19)

The internal system time is very important for the operation of the SF$_6$-BreakerAnalyser. Synchronisation processes, shutdown and expiration times as well as time indication of measurements are determined by the internal clock. The setting of the system time can be carried out by the following four menu items:

- o Set: Setting of the clock and date. Prior to the setting of time and date the time zone and the time modification should be determined under "Time zone" and "DST automatic". (fig. 6.21)

- o 12 hour clock: In case of a displayed cross, the time output has a 12 hours format, if not, a 24 hours format.

- o DST automatic: Automatic time modification. Many countries shift their time in summer. The installed automatic system realizes the time shift of 1 hour as valid for Central Europe (CEST). In Central Europe the summer time usually starts in the last weekend of March and ends at the last weekend of October, Saturdays at 2:00 a.m. or 3:00 a.m. A displayed cross indicates the activated automatic time modification.
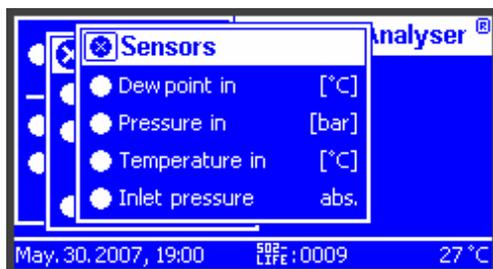
Fig. 6.22

Settings of Sensors (Settings/Sensors) (fig. 6.22)

Following settings of the sensors can be adjusted:

- o Dew point: Dependent on the indicated mode, the moisture is displayed either in °C dew point over ice, ppm$_v$ or ppm$_w$. The selected mode is valid for the output in the base menu.

- o Pressure: The operator can select between readings in kilo Pascal "kPa", bar "bar" or pound per square inch "psi".

- o Temperature: The operator can select between readings in Celcius "°C" or Fahrenheit "°F".

- o Inlet pressure: The inlet pressure can selectively displayed as a absolute "abs." or relative "rel." pressure.

The factory defaults are in dew point, bar, Celsius and inlet pressure absolute.
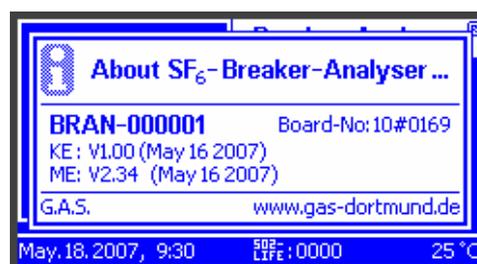

Fig. 6.23

Fig. 6.24

Settings of the Device (Settings/Device) (fig. 6.23)

The following settings of the device can be adjusted:

- o Contrast: The contrast of the LCD.

- o Overheat alarm: The temperature of the SF6-Breaker-Analyser is controlled. In case the internal temperature exceeds the set limit, a warning message is displayed and the instruments additionally gives an audible alarm. For its protection the SF$_6$-Breaker-Analyser is automatically switched-off after some seconds.

- o Info about …: This menu item reveals the serial number of the device and the board as well as the version and revision number of the firmware.

6.6 Shut down

Assure that the hose has been disconnected. Turn off the SF$_6$-Breaker-Analyser by pressing the "Power"-switch on the front panel. For a longer lifetime the SO$_2$ sensor needs some residual humidity when being stored. In order to achieve this, ambient air is automatically pumped through the system for 15 seconds, displayed through a count down. The system will subsequently turn off.

Fig. 6.25

The automatic flushing function is disabled if the device is turned off through the operator within the first 15 seconds after turning on.

7.   Loading battery

The SF$_6$-Breaker-Analyser is equipped with a 5,2 Ah Lithium-Ion battery which allows to operate the device for approximately 8 hours. Internal monitoring of the battery voltage gives warning message if it is low. If not   recharged, the system consecutively executes an automatic shutdown to avoid damages.

To recharge the battery:

1.   Turn off the SF$_6$-Breaker-Analyser.

2.   Connect the power plug connector of the delivered battery charger to the power socket.

3.   Plug the instrument's connector into the socket on the back plane (see picture).

4. Wait until the red charge lamp of the battery charger is extinguished. The battery is charged with a charge current of 2,2 A and a voltage of 16,8V. The maximum charge time of an empty battery is approx. 2,5 hours.

5. Disconnect the plug-ins.

6. The SF$_6$-Breaker-Analyser is again ready for measuring.

8. Exchange, calibration, verification

In case of a sensor breakdown or defect as well as for the calibration or when reaching the end of lifetime (SO$_2$-module), each module can be removed independently from the others. When turning on the SF$_6$-Breaker-Analyser, the system check will recognize the missing module(s). Generally the sensors are stable for several years (besides the SO$_2$-module, see chapter 5.1). However, depending on the frequency of use, storage conditions and treatment, the SF$_6$-Breaker-Analyser should be inspected at regular intervals (recommendation: every 2 years).

8.1 Exchange of modules

Firstly open the front panel by loosening the 2 screws on the top of the front panel like shown in figure 6.06 and let it swing down.
Remove the connecting hoses of the gas input and output (two hoses per module) so that the module to be exchanged can be taken out.

Connections to percentage sensor

Connections to moisture sensor

Connections to SO$_2$-module
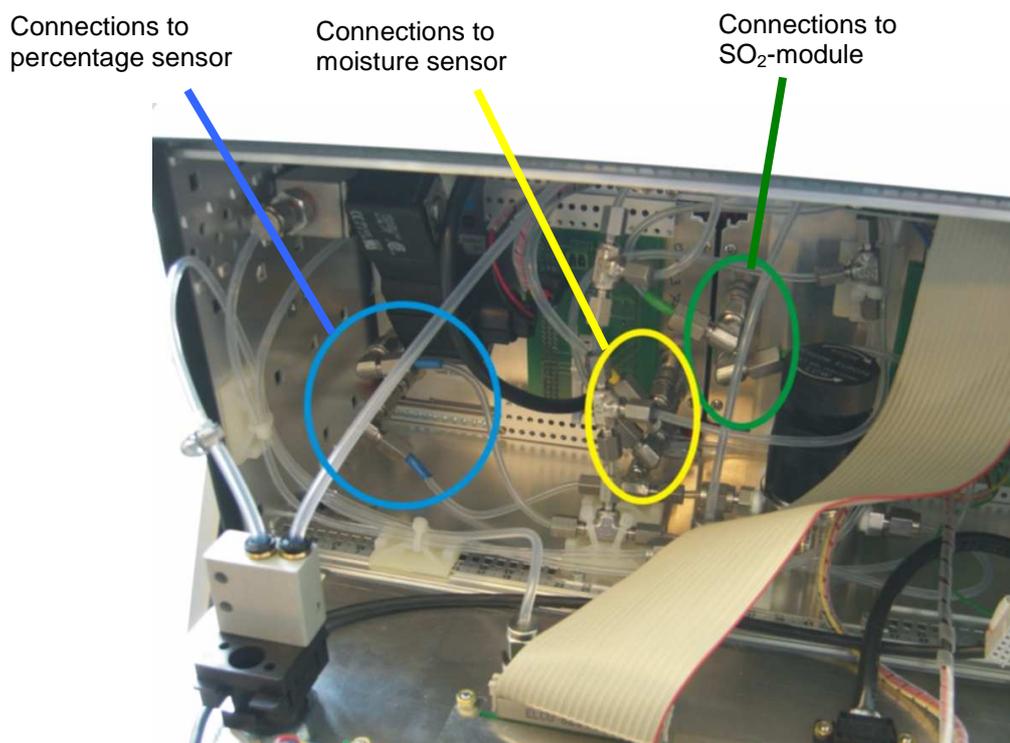
Open the gas connecting couplings (quick release couplings) by pulling back the locking ring. The couplings are tight on both sides so that no air can pour into the system. Consecutively secure the hose end so that it cannot buckle, e.g. by using a wire tie or scotch tape.

For dismounting the cartridge loosen the fixing screws of the requested module on the back side of the device and carefully pull out the module using the handle.

| Battery unit | SO$_2$-module | | Gas outlet | Moisture sensor module | | Percentage sensor module |
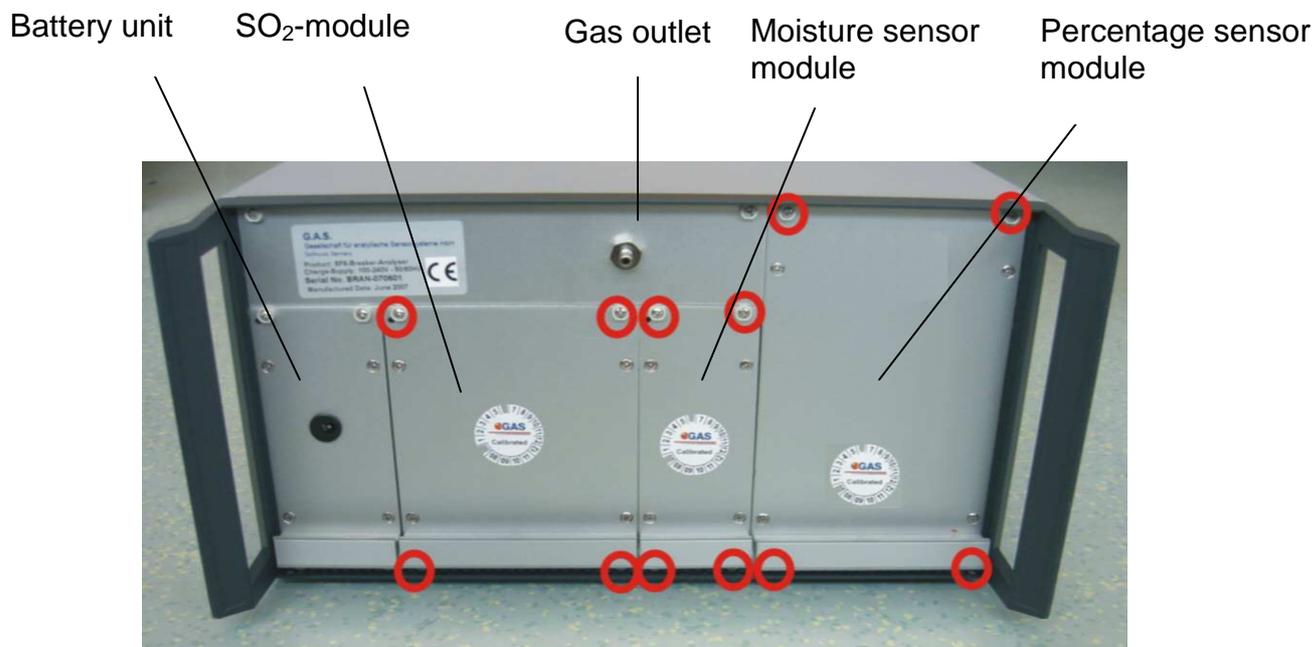
	When returning the modules to the manufacturer use appropriate packing to avoid any transport damage.
Note	

	The calibration and final control in accordance with the company's quality assurance is indicated on each sensor cartridge with month and year on the test badge.

The calibration services for the device is listed below.

Calibration and verification of the complete device
Calibration of the SO$_2$-module (through exchange of SO$_2$-sensor)
Calibration of the percentage sensor module
Calibration of the moisture sensor module

9.   Fault correction

It is not recommended to carry out repair works of the SF$_6$-Breaker-Analyser by yourself. (except for the disassembling of single modules).
Do not carry out any repair or other works on the modules. In case of malfunction return them to the manufacturer.

Messages on the display of the SF$_6$-Breaker-Analyser

During the operation, different messages can appear on the display.
The messages are self-explanatory or mentioned in the above description of the measuring process.
In case unknown error messages appear, particularly in connection with malfunctions contact the manufacturer.

10.   SF$_6$-recovery bags / Discharge recovery system

Legal directives becoming more and more strict and the voluntary self-commitment of the SF$_6$-users also require the collection of used gas even of smallest amounts of SF$_6$, as being discharged during measurements. For this purpose, recovery bags as well as discharge recovery system have been developed.

The SF$_6$-Breaker-Analyser is equipped with a gas outlet at the back plane that can be easily connected to a recovery system like SF$_6$–Recovery-Kit. The internal pressure monitoring of the SF$_6$-Breaker-Analyser executes an automatic abortion of a measurement in case of an overpressure caused by a filled up recovery system in order to avoid an damages to the device and incorrect readings.
This technical design allows the SF$_6$-Breaker-Analyser to be operated with or without recovery bags or a discharge recovery system. Still G.A.S. highly recommends to use such systems for environmental reasons.

According to the standard configuration the outlet is open, which means that the gas is released to the atmosphere. If a recovery bag or system is connected the inspected SF$_6$ is collected in a depressurized condition via the connecting hose. After having reached the maximum consumption capacity of the discharge recovery system, the installed compressor switches on and the collected measuring gas is forwarded into a connected gas cylinder. G.A.S. recommends to use its SF$_6$-Recovery-Kit for collecting and handling the inspected gas properly.

For further details please contact G.A.S..