

Pressure and Temperature Measurement

SF₆ Emission Monitoring:

State-of-the-Art SF₆ Tracking

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www.wika.com/sf6

EPA Workshop 2009: SF₆ Emission Monitoring

State-of-the-Art SF₆ Tracking WIKA **Pressure and Temperature Measurement** The SF₆ Emission Monitoring Pyramid Online monitoring & trending using thermal image gas temperature Proactive Remote display using average temperature Automated Event-based using Reactive average temperature

Overview Reactive Monitoring

- Infrared Camera
- Leak Locators
- Mass Balance (Inventories)
- Flow Measurement
- Temperature Compensated Pressure (Density)

For details, please speak with vendors of these products. We have omitted them due to time constraints.

Pressure and Temperature Measurement

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Pressure and Temperature Measurement

Temperature-Compensated Pressure





- Measured at the tank or inside the control cabinet
- When measured: Constantly, only need to manually take the reading whenever desired

Cost

- No material costs (hermetically sealed & temperaturecompensated monitor/indicator needed)
- Ongoing personnel/misc. costs

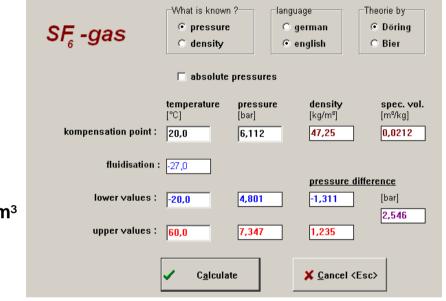
Pros/Cons

- Instruments already required for SF₆-insulated breakers
- Can use Leakage Calculation program to quantify emissions
- Low/no investment cost
- Dials typically with temperature-compensated pressure, not density (conversion by hand or automatic via software)

Temperature-Compensated Pressure

Initial Pressure (Compensated): 90.1 PSIActual Pressure (Compensated): 88.6 PSIInitial Gas Mass 100 %: 11.520 kgTank Volume: 0.240 m³

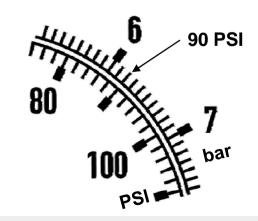
Difference: 0.75 kg/m^3 Lost SF₆ Mass: $0.75 \text{ kg/m}^3 \cdot 0.240 \text{ m}^3$ Lost SF₆ Mass: 0.180 kg



After 3 Years, the conclusion is:

1.6 % in 3 Years is a loss of 0.53 % of the gas mass per year

⇒ Tank lost 60 gr. / yr. or 2.116 oz/yr



WIKA



Pressure and Temperature Measurement

Temperature-Compensated Pressure

🛃 P0078 SF6 Gas Leakage Ca	alculator			
File Language Help				
SF6-Gas Leakage Calculation]	WIKA
Filling pressure (at 20°C)	90.1 psi	Absolute pressure		
Unit filling pressure	psi 💌			
Density at filling pressure	48.0024 g/l			
Nameplate capacity	0 kg		Basis data	
Tank volume known	• Yes • • No		Substation	Main Street
Tank volume	240 I		Substation manufacturer	NoName
			Type of switch	135kv
	Measurement 1	Measurement 2	Customer ID-code	AW-122
Date / Time	01.21.06 10:33 AM	01.21.09 10:33 AM 💌	Inspector	Johnson
Pressure	90.1 psi	88.6 psi	Date	01.21.09 10:33 AM
Unit pressure	psi 💌	psi 💌	Measurement ID-code	1/21/2009JohnsonAW-12;
	Absolute pressure	Absolute pressure		
Density	48.0024 g/l	47.2330 g/l		
Emitted gas mass	184.6541 g	g 💌		
Mass-flow	61.4952 g/yr	g/yr 💌		
Leakage rate	0.53 %/yr			
Calculate	Print	Reset		





Pressure and Temperature Measurement

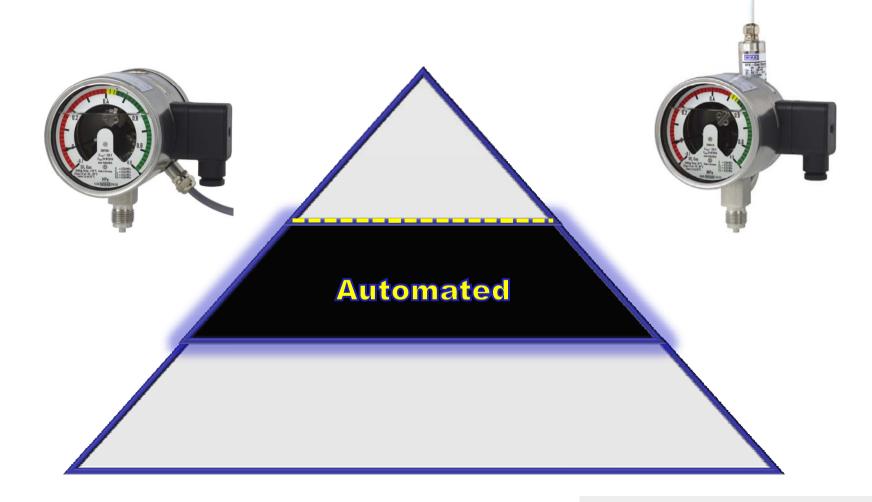
- All processes are time-intense, requiring regular time investment
 - Data has to be measured and information calculated
 - More frequent measurements require additional time commitment
- Up-front investment cost varies depending on the solution
- Not designed to notify of small leaks early-on for proactive maintenance

NOTE: Case study "Costs of Reactive Monitoring" available at <u>www.wika.com/sf6</u> in the "Gas Management For the Smart Grid" archived presentation **The SF₆ Emission Monitoring Pyramid**

Emission Monitoring Solutions -Automated



Pressure and Temperature Measurement



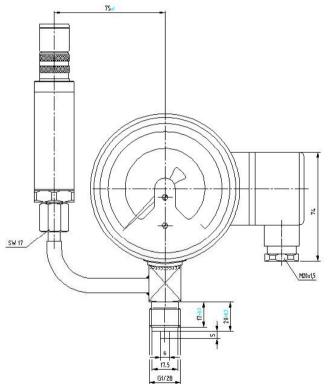
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Emission Monitoring – Automated



Pressure and Temperature Measurement

Emission Monitoring Solutions -Automated



- Measured at the tank with remote signal (density)
- Communicated away from the tank
- Analysis of the raw signal is done manually
- When measured: Constantly
- Cost (New & Retrofit)
 - Low, only change of spec nee ded for instrument

infrastructure changes (wiring/piping/communication)

Pros/Cons

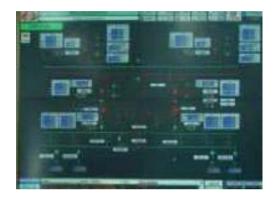
- Information is sent remotely
- Better maintenance planning
- Emission reduction potential through knowledge of actual grid situation
- Quantifying emissions requires personal analysis or custom software
- Change of engineering spec needed

Emission Monitoring – Automated

Automated Emission Monitoring -Illustration





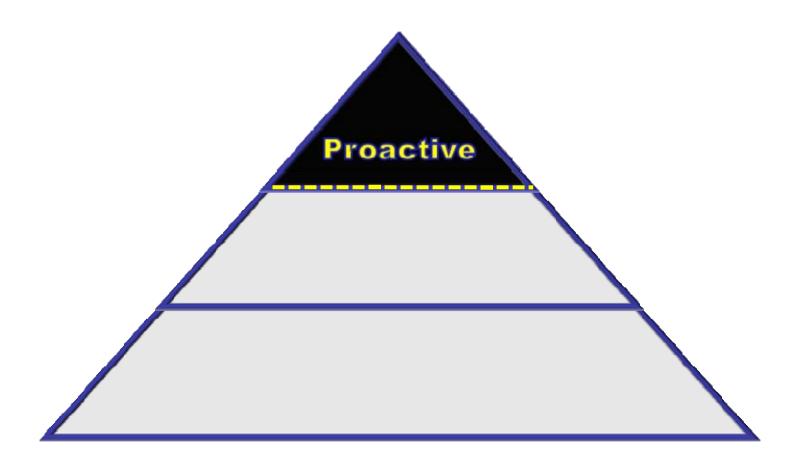




SF6 GAS Der	[kg.f/cm2]	
CB	Section	5.62
Main Bus	Section	5.06
상부E5	Section	5.29
하부DS/ES	Section	5.11

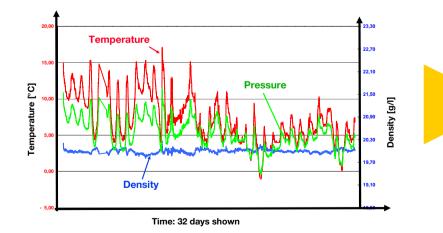
Proactive Monitoring using a SF₆ Gas Management System



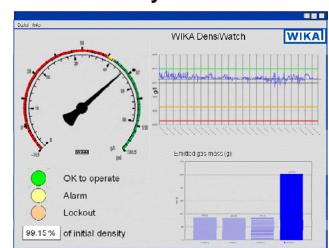


What is a Gas Management System?

- A GMS has core components that operate according to the "MCA-principle"
 - Measurement at the tank (including thermal image of the gas temperature)
 - Communication away from the tank to a remote location
 - Data acquisition and Analysis tools to display real time information



Raw data



Analyzed data





Gas Management Live

48.00 Fill Density 46,00 MAN AN AM M man the provident of the state 34 بالالكلم Transmitter -signal w/trend & LINN 44.00 base lines ٦. 42.00 Alarm Density 40.00 Lockout Density 38,00

NOTE: mount transmitter directly on the tank for best results



Sample Layout of Wireless GMS

3 x GD-10 4 ... 20 mA Tank 1 A/Dconverter Tank 2 **Data-Pitcher** logic Tank n outputs Bay PLC **Wireless** temperature sensor sender **Control Cabinet** 4 ... 20 mA data collection + communication wireless connection **Wireless** receiver **Data-Catcher**





SF₆ Gas Management System

- Measured at the tank with remote signals (density & thermal tank temperature)
- Communicated away from the tank
- Analysis of raw signals minimizes any temperature disbalance (i.e. cabinet heaters) & calculates emission trends
- When measured: Constantly
- Cost (new & retrofit):
 - Change of spec needed for instrument + scope of GMS Communication & Analysis (including possible wiring/piping/communication infrastructure)
- Pros/Cons
 - Proactive grid maintenance possible
 - Emission reduction potential through knowledge of actual grid situation
 - External influences compensated via software
 - Fully customizable for retrofit or new installations (including wireless communication)
 - Change of engineering spec needed
 - Long-term, v alue added mindset needed

The SF₆ Emission Monitoring Pyramid

Reaching the Summit



