



Gas Management for the Smart Grid

PN21: Panel Session on Gas Insulated Transmission Line (GIL) and
Mixed Technology Switchgear (MTS)

April 23, 2008

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Agenda

Political Landscape

Reactive Gas Monitoring vs. Proactive Emission Detection

Gas Management

Online Monitoring

MCA – Principle (Computer Aided Signal Analysis)

Gas Management Case Study

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Who we are !

We are the people who have equipped more than 700,000 gas tanks with:

540,000 Gas Density Monitors
120,000 Gas Density Indicators
26,000 Gas Density Switches
18,000 Gas Density Transmitters



Filling, recovering, and purification



Announce the leak



Locate the Leak



Make the operation safe

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Political Landscape

SF₆ is widely used in the T&D industry, because it is an excellent dielectric and has very good electrical arc switching characteristics.

It is chemically inert, non-toxic and non-flammable, making it most suitable for circuit breaker applications.

But, it is a greenhouse gas, GWP UNFCCC Guidelines 23,900 ¹⁾ compared to CO₂

⇒ SF₆ Inventories (manufacturing, use-phase, end of life, IPCC Guideline Vol.3, IPUU)

⇒ Voluntary Commitments (0.5 %/ year of the mass for High Voltage Switchgear)

⇒ Experts say: Typically 0.1 ... 0.3 % / Year

1) F-Gas Regulation 842/2006 EU GWP = 22200, May 2006

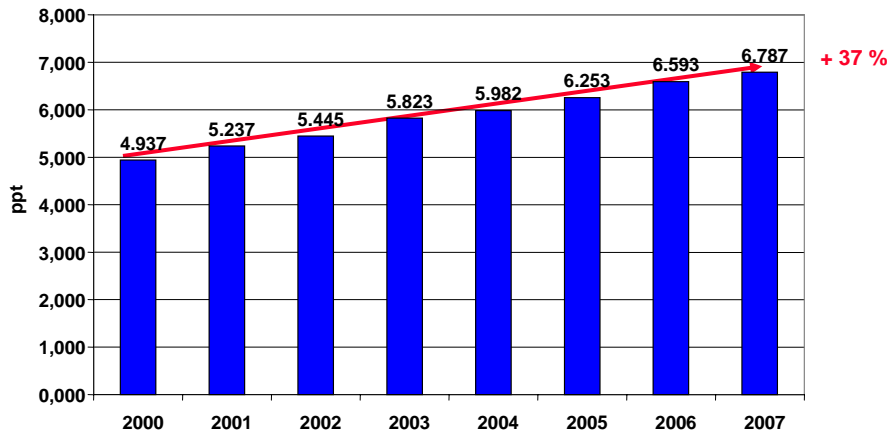
IPCC: Intergovernmental Panel on Climate Change
IPUU: Industrial Processes and Product Use

UN FCCC: United Nations Framework Convention
on Climate Change

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SF₆ Concentration in Germany

SF₆ - Concentration in Germany [ppt]



Source: EPA Data-Center , Langen, Gemany Location: Schauinsland

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Political Landscape – Requiring Condition-Based Monitoring

January 4, 2008

US Government to require mandatory Greenhouse Gas reporting

The US government signed into law the Consolidated Appropriations Amendment on January 4, 2008. This bill provides [funding](#) for and gives the Environmental Protection Agency (EPA) [broad statutory authority](#) for mandatory reporting of Greenhouse Gas emissions (which includes SF₆ gas). [The EPA expects to issue a proposed rule by September 2008.](#)

March 10, 2008

German Federal Office for Environmental Protection
Short-term forecast of 2007 greenhouse gas emissions.

The total output in Germany of all greenhouse gases for the year 2007 was reduced by approximately 24 million tons (-2.4%) in relation to 2006. The emissions of SF₆, however, rose by 6.9 per cent. Measured SF₆ emission concentrations in Germany are up 37% from 2000-2007 and show the continued need to reduce SF₆ emissions.

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Gas Reporting in Germany

In accordance with the voluntary undertaking from summer 2005, manufacturers and operators of electrical equipment using SF6 continue to be committed to recording the quantities of SF₆ used.

The VDN collects this data from the network operators and makes it anonymously available to the Federal Office for Environmental Protection.

The attached survey sheet, which was explained at the VDN 'Infoday' on 19.10.2005 in Fulda, is based on the previous years' survey sheet, with some changes which have been necessitated by the new voluntary undertaking.

The sheet is subdivided into the subject areas:

- Gas used in plants (on site)
- Refilled gas
- Returned gas
- Permanently decommissioned plants

Survey sheet for SF6 quantities
Download: XLS file

Why is Condition-Based Monitoring Important ?

- US Energy Independence and Security Act of 2007 (Title XIII – Smart Grid)
 - Federal funding and support of “modernization” of US T&D infrastructure
 - Detect emerging problems and fix them before they seriously impact the quality of service



The Energy Independence and Security Act

Reactive Gas Monitoring Today



Limitations for Gas Management

Dial markings were never meant to give a reading with high resolution

It is just an annunciator !

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Reactive Gas Monitoring Today – Manual Calculations

Initial Pressure Compensated : 6.200 bar = 89.9 PSI
 Actual Pressure Compensated : 6.100 bar = 88.5 PSI
 Initial Gas Mass 100 % : 11.520 kg
 Tank Volume : 0.240 m³

Density @ 6.200 bar : 47.91 kg/m³ (g/L)
 Density @ 6.100 bar : 47.17 kg/m³ (g/L)

Difference : 0.74 kg/m³

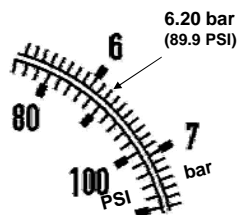
Lost SF₆ Mass : 0.74 kg/m³ · 0.240 m³

Lost SF₆ Mass : 0.178 kg

After 3 Years, the conclusion is:

1.54 % in 3 Years is a loss of 0.51 % of the gas mass per year

⇒ Tank lost 59.3 gr. / yr. or 2.092 oz/yr.



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Reactive Monitoring vs. Proactive Monitoring

Gas Density Monitors ...

- Ensure the safe operation of switchgear
- Control the filling of switchgear
- Show the current density situation



REACTIVE

Gas Management Systems ...

- Measure low emission rates
- Acquire data into a database
- Analyze data
- Calculate trends in real-time
- RESULT: informed decision-making



PROACTIVE

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Proactive Gas Monitoring Today - Online



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Measure / Communicate / Analyze ⇔ MCA Principle

Process - Level

Bay - Level

Network - Level

M

C

A

Permanent Measurement

Communicate the Data

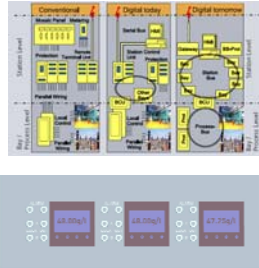
Database Datawarehouse

IEC 61850

Computer
Aided
Signal
Analysis



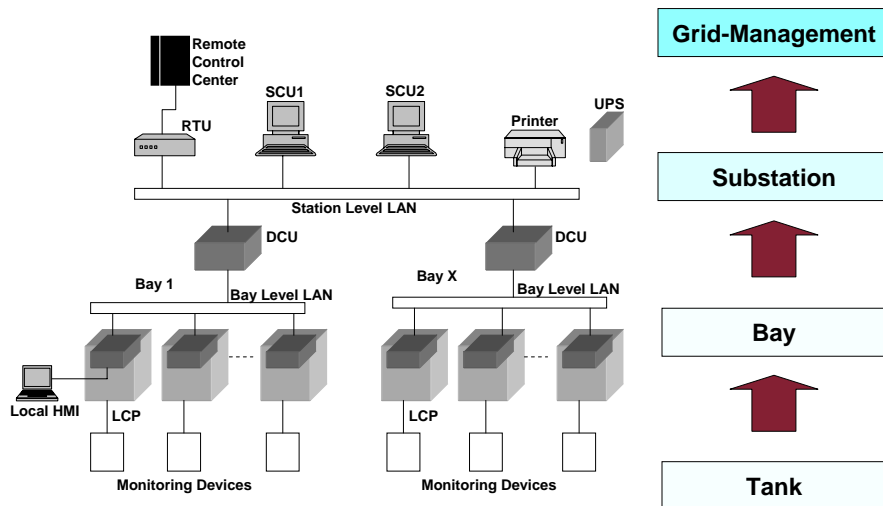
Field Device



Data Acquisition / Communication



Gas Management System: Flow of Information

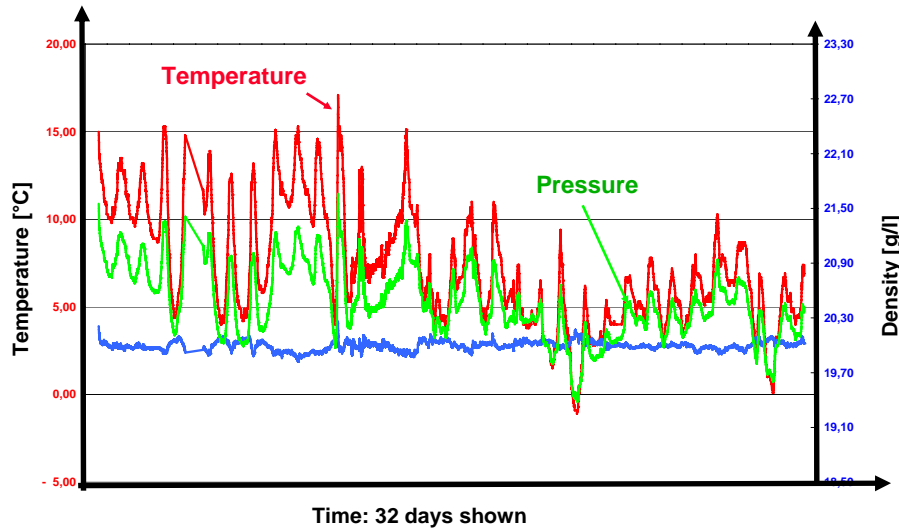


GMS Infrastructure: Customized Software

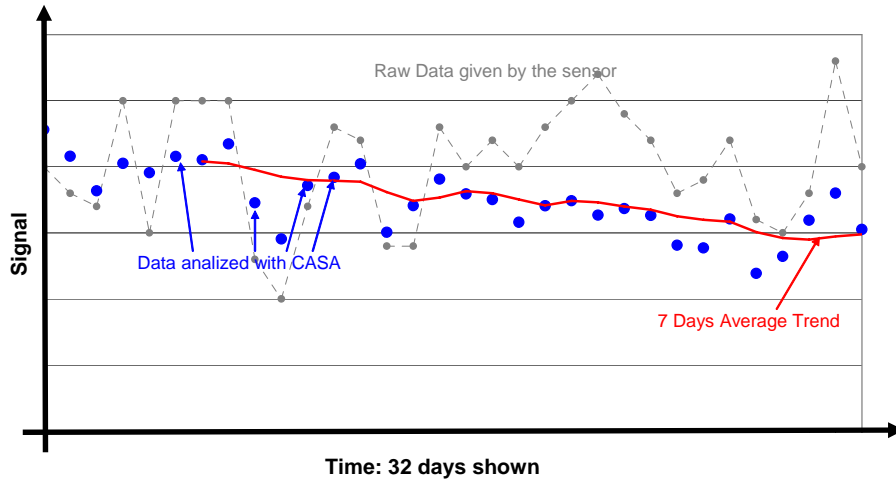
- Display the information needed to:
 - Investigate a leak
 - Prioritize maintenance on critical breakers
 - Calculate emissions for the grid



Raw Data of Measurement

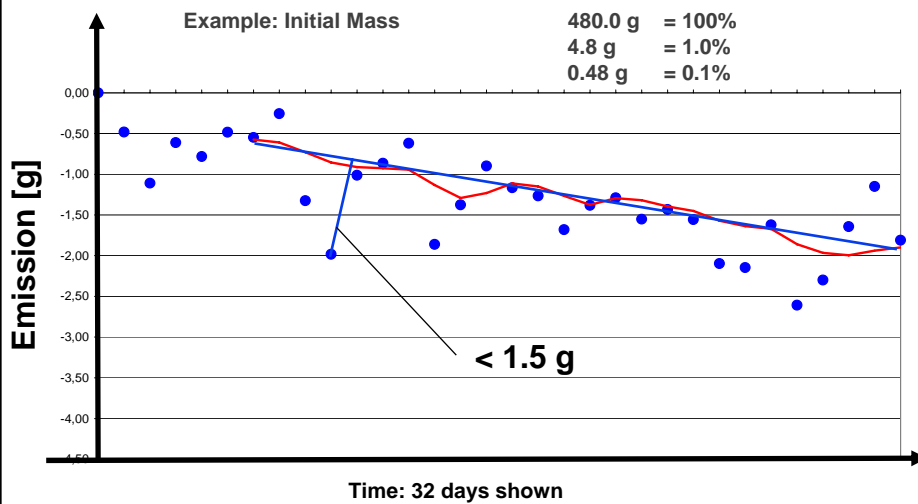


Computer Aided Signal Analysis



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Emission [g] Calculated by CASA



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What can we do with an innovative Concept ?

With a Gas Management System you can...

- Measure low level leak rates
- Show clear emission levels of specific breakers
- Detect leaks early (⇒Forecasts, CBM, SAM concepts assisted)
- Prove commitment / emission rates (by utilities)
- Improve tank filling (tanks are most likely overfilled)
- Issue emission certificate for breakers (competitive advantage for best in class)
- Introduce Emission Trading (CDM – Projects etc...)
- Lay a foundation for nation-wide emission reporting (regulated like cap & trade)

Gas Management Case Study Direct labor savings via GMS

Case Study Assumptions: Infrastructure

- **Typical Utility**
- **Approx. 1050 high-voltage substations**
- **Avg. of 16 SF₆ tanks per substation**

- **25-year time horizon**
- **Maintenance crew of 1 person**
- Labor costs \$36/hr. ¹⁾
(incl. 30% overhead)
- Inflation factored in via labor costs



1) US Bureau of Labor Statistics, 2006 hourly pay figure for Electrical and Electronics Repairers, Powerhouse, Substation, and Relay

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Case Study Worksheet

Costs for Reactive Monitoring – Typical Utility

Service life (in years): 25 years

How many substations do you operate? 1050 substations

How many gas tanks / monitors do you control in one substation (rough figure)? 16 tanks

How often do you take readings from the monitors? Once per 2 months

How many individuals travel as a team to take readings? One

What does a team member cost per hour? \$35.88 USD

How many minutes are needed to get to/from the substation (roundtrip)? 120 minutes

How much time is spent in the substation preparing the job? 30 minutes

How many minutes are spent reading each gas density monitor? 2 minutes

How much time is needed to prepare the follow-up paperwork per substation (documentation)? 60 minutes

Total Lifecycle Times

Driving time: 120 minutes

Organization: 30 minutes

Manual Readings: 32 minutes per substation

Documentation: 60 minutes

Total direct labor cost for reactive monitoring: \$34,094,970 USD

Total direct labor cost for reactive monitoring / substation: \$32,471 USD

Total direct labor cost for reactive monitoring / tank: \$2,029 USD

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Other “hidden costs” of reactive monitoring

- Transportation costs to/from substations
- Unplanned power failures
- Maintenance outages at inopportune times
- Training for new employees due to forecast retirements
- Cost of replacing SF₆ gas
- -
- -
- -
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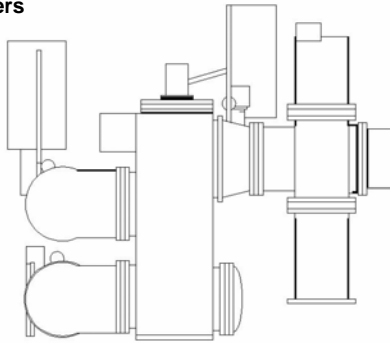
What’s next?

- **Gas Density – Temperature Transmitter Combo**
- **CASA Software Optimization**
- **Pilot Substations to prove the concept**
 - **Europe** ✓
 - **Asia** ✓
 - **Americas** TBD - Who wants to start ?

What else could we do with an innovative Concept ?

Mechanical parameters

- SF₆-density
- Temperature
- Switch position
- Operating time
- Travel curve
- Spring position
- Charging energy
- Charging time

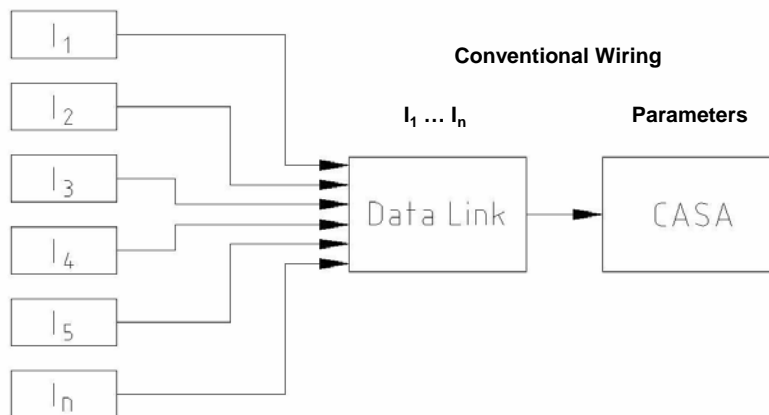


Sketch GIS

Electrical parameters

- Primary voltage
- Primary current
- Motor running time
- Motor current
- Motor voltage
- Auxiliary voltage
- Trip coil current
- Trip coil voltage

What else could we do with an innovative Concept ?



What else could we do with an innovative Concept ?

