Identifying SF$_6$ Emissions from High Voltage Electrical Equipment:

SF$_6$ Leak Monitoring Systems

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Live Meeting Housekeeping Items

- Please mute your phone
  – No mute button? Enter *6 on your keypad to mute, *7 to un-mute

- Full Screen mode (F5)

- Q&A session at end of presentation
  – Interactive panels – bottom of console, enter a question or ask!

Speaker: Jerome Blackman, EPA
Agenda

- Importance of Monitoring Equipment for SF$_6$ Gas Leaks
- SF$_6$ Gas Behavior and Common Challenges
- Monitoring Systems - Instrumentation
  - Current industry technology options
  - Advanced technology options
- Questions and Discussion

Speaker: Jerome Blackman, EPA
Importance of Equipment Monitoring

- Research indicates about 7 - 10% of circuit breaker populations may be leaking. Why are SF$_6$ gas leaks a problem for a utility?
  - Can lead to operational inefficiencies and safety hazards
  - Require an unnecessary cost incurred by your company to replace the lost gas
  - Contribute to global warming
- Accurate leak measurement for SF$_6$ emission reduction projects
- Remember, only one component of a full SF$_6$ emission abatement strategy (handling losses and equipment losses)

Speaker: Jerome Blackman, EPA
Measuring Leaks: SF$_6$ Gas Behavior

Ideal Gas Law:

\[ p_1 = p_0 \times \left(1 + \frac{1}{273,15 \degree C} \times \delta_1\right) \]

Real Gas Law (Virial Equation)

\[ p = \rho \cdot R \cdot T \cdot (1 + B_{(T)} \cdot \rho + C_{(T)} \cdot \rho^2) \]

with

\[ B_{(T)} = B_0 + \frac{B_1}{T} + \frac{B_3}{T^3} + \frac{B_5}{T^5} \]

\[ C_{(T)} = C_0 + C_1 \cdot T + C_2 \cdot T^2 \]

\[ B_{(T)}, C_{(T)} \text{ are correction factors} \]

Precise compensation at different density levels requires compensating for different slopes

Speaker: Ron Hoffman, WIKA
Common Challenges

WHAT IS THE PRESSURE?
• Many methods to accurately measure
• Altitude / Barometric pressure may effect

WHAT IS THE TEMP?
• Sun
• Shade
• Rain
• Wind
• Snow
• Gradients

WHAT ARE THE INPUTS?
• Gas input must be controlled
• Manual intervention

Speaker: George Davet, Solon Manufacturing
Current Technology
Current Technology Monitoring Systems

GAUGE/THERMOMETER/CHART
• Low cost
• Requires manual interpretation
• Prone to error
• Not recommended

REMOTE TEMPERATURE SENSOR
• Body location not important
• Temperature sensor follows gas
• Flexible installation options
• Adds cost

INTRINSIC
• Location is important
• More compact
• Simple / less cost
• Same performance as remote when applied properly

Speaker: George Davet, Solon Manufacturing
Current Industry Practices

**ISOLATE TANKS**
- Eliminate connections
- 1/3 gas loss with each leak
- Able to use intrinsic device to lower $

**SETTINGS CLOSER TO FILL PRESSURE**
- Faster notification of leaks
- Current devices are now available with lower deadbands, less contact bounce, & more accuracy
- More sensitive to installation

**BETTER APPLICATION**
- Improved gas systems
- Monitor installation improvements

Speaker: George Davet, Solon Manufacturing

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Advanced Technology
Advanced Technology Monitoring Systems

BCU: Bay Control Unit
DCU: Data Communication Unit
HMI: Human Machine Interface
LAN: Local Area Network
LCP: Local Control Panel
RTU: Remote Terminal Unit
UPS: Uninterruptible Power Supply

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Advanced Technology

Compartment: 3 (Breaker)  Gas Pressure Density
Emission Rate \( \text{mean} \): 0.5 % / Year
Emission Rate \( \text{acc} \): -0.53 % / Year
Volume: 0.240 m³
Mass \( \text{nominal} \): 11.520 kg
Mass \( \text{actual} \): 11.340 kg
Emission Mass: 0.18 kg
Last Inspection: 27.07.2006
Date: 27.07.2007
Status: Pre-Warning

Speaker: Ron Hoffman, WIKA
Current and Advanced Technology: Pros and Cons
Current Technology: Pros and Cons

Advantages in confirming...
- Safe operating condition of a breaker
- Filling process of a breaker
- Actual density in a tank

Disadvantages in design...
- Low emission rate confirmation
- Early leak detection
- High accuracy compensation

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Advanced Technology: Pros and Cons

Advantages in performance features:
- Confirm emissions from gas tanks and can detect leaks early
- Observe current conditions/ operational safety anywhere (web interface)

Disadvantages:
- Current cost
- Availability
- Suitability for gas circuit breakers versus gas insulated substations

Speaker: Jerome Blackman, EPA
Thank you.

Questions, Discussion, Feedback

Speaker: Jerome Blackman, EPA