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

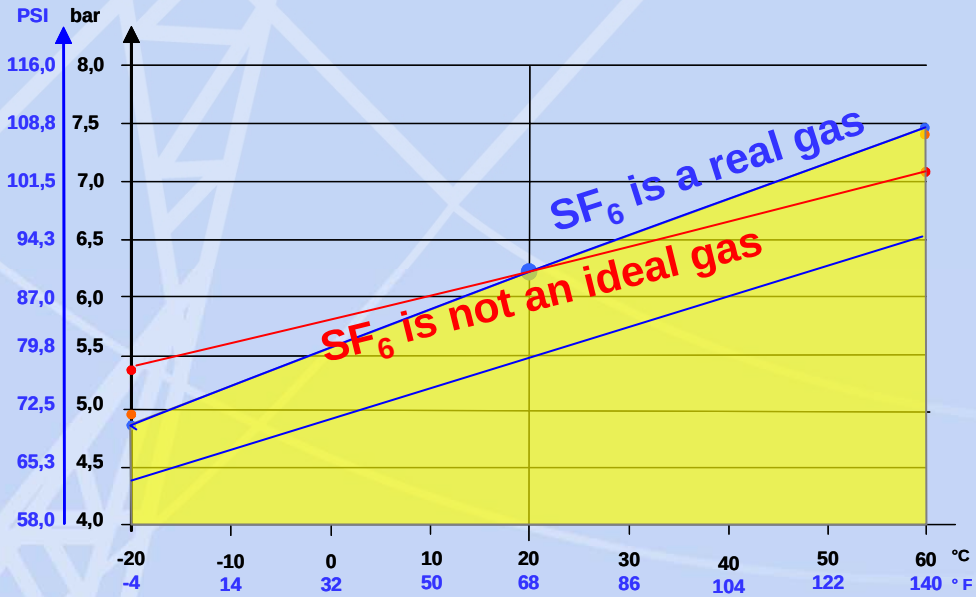
Speaker: Jerome Blackman, EPA

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 :

$$p_1 = p_0 * (1 + \frac{1}{273{,}15\,°C} * \vartheta_1)$$

Real Gas Law (Virial Equation)

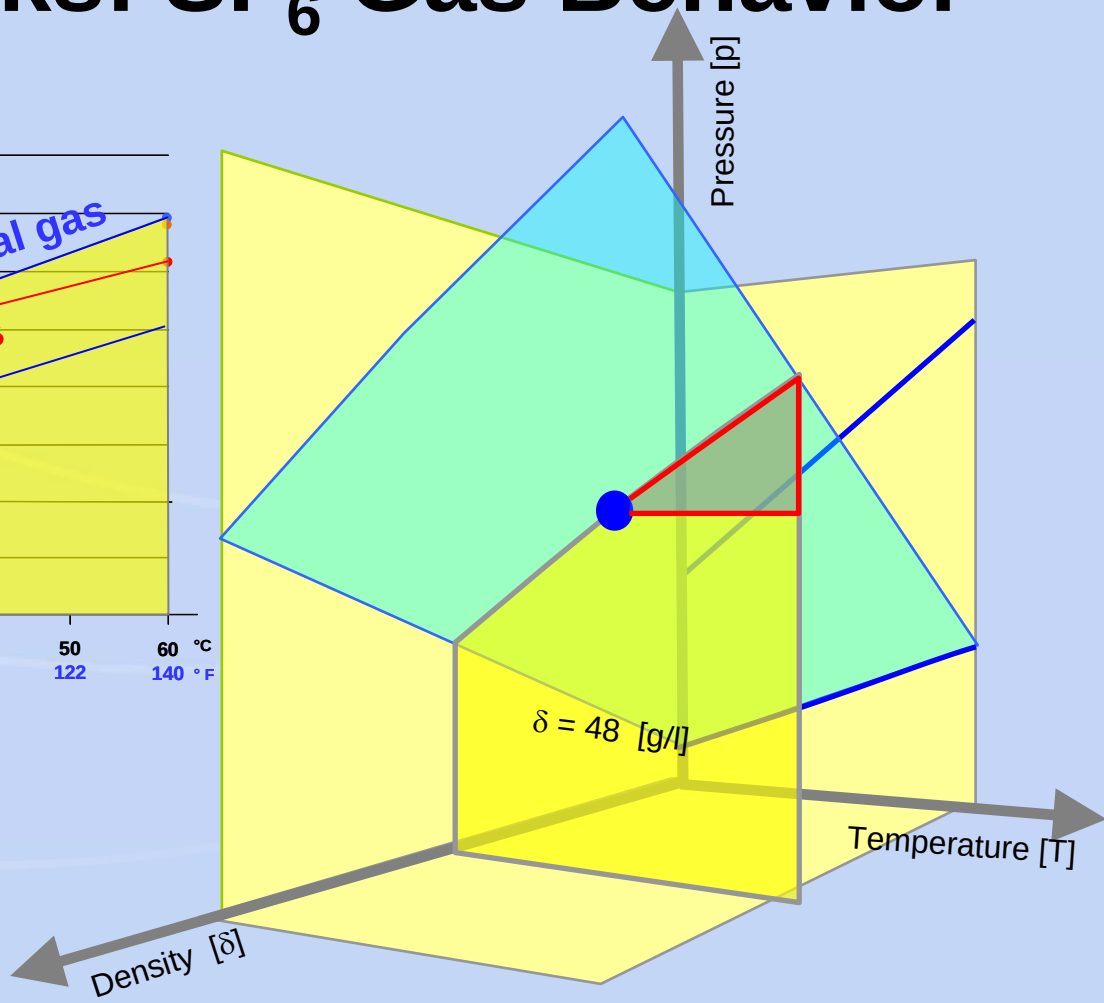
$$p = \rho \cdot R \cdot T \cdot (1 + B_{(T)} \cdot \rho + C_{(T)} \cdot \rho^2)$$

with

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

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

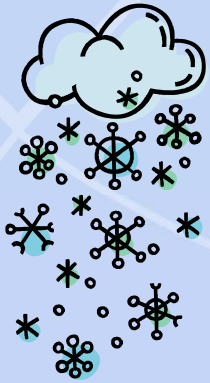
$B_{(T)}, C_{(T)}$ are correction factors

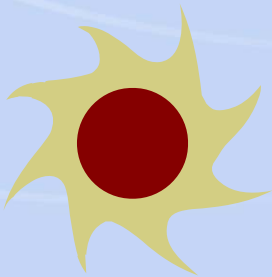


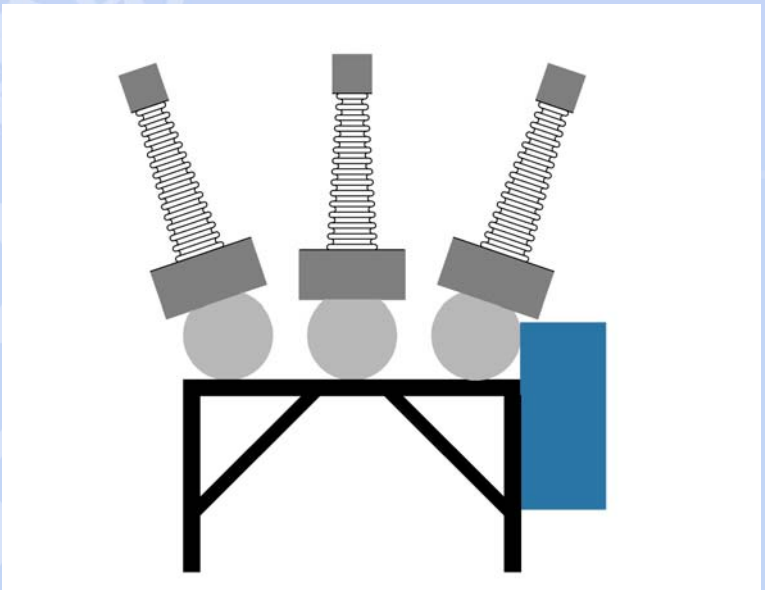
Precise compensation at different density levels requires compensating for different slopes

Speaker: Ron Hoffman, WIKA

Common Challenges







<u>WHAT IS THE PRESSURE</u>?

- Many methods to accurately measure
- Altitude / Barometric pressure may effect

<u>WHAT IS THE TEMP</u>?

- Sun
- Shade
- Rain
- Wind
- Snow
- Gradients

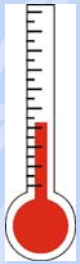
<u>WHAT ARE THE INPUTS</u>?

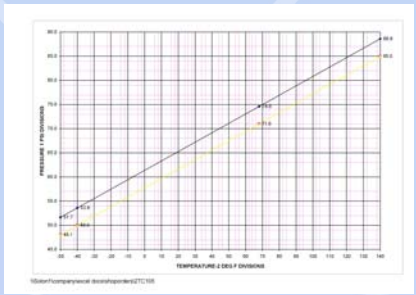
- Gas input must be controlled
- Manual intervention

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

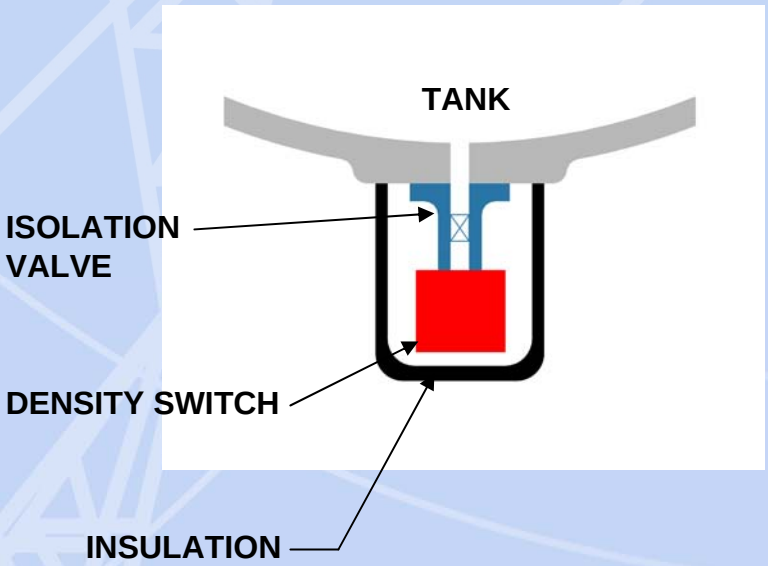
- Body location not important
- Temperature sensor follows gas
- Flexible installation options
- Adds cost

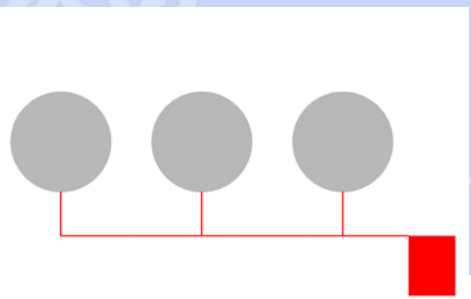
INTRINSIC

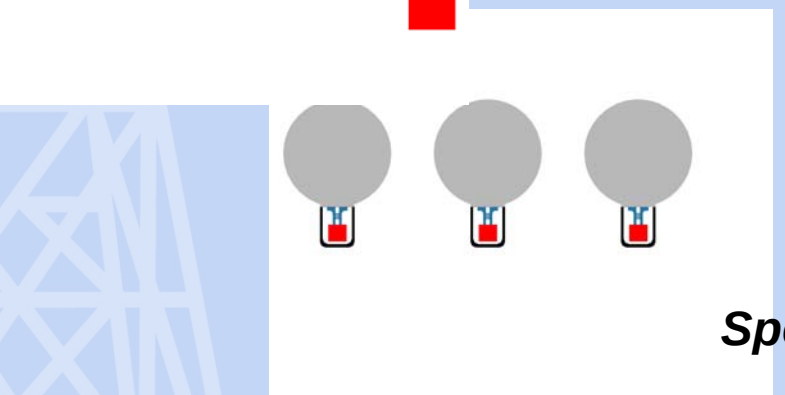
- Location is important
- More compact
- Simple / less cost
- Same performance as remote when applied properly

Speaker: George Davet, Solon Manufacturing

Current Industry Practices







BETTER APPLICATION

- Improved gas systems
- Monitor installation improvements

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

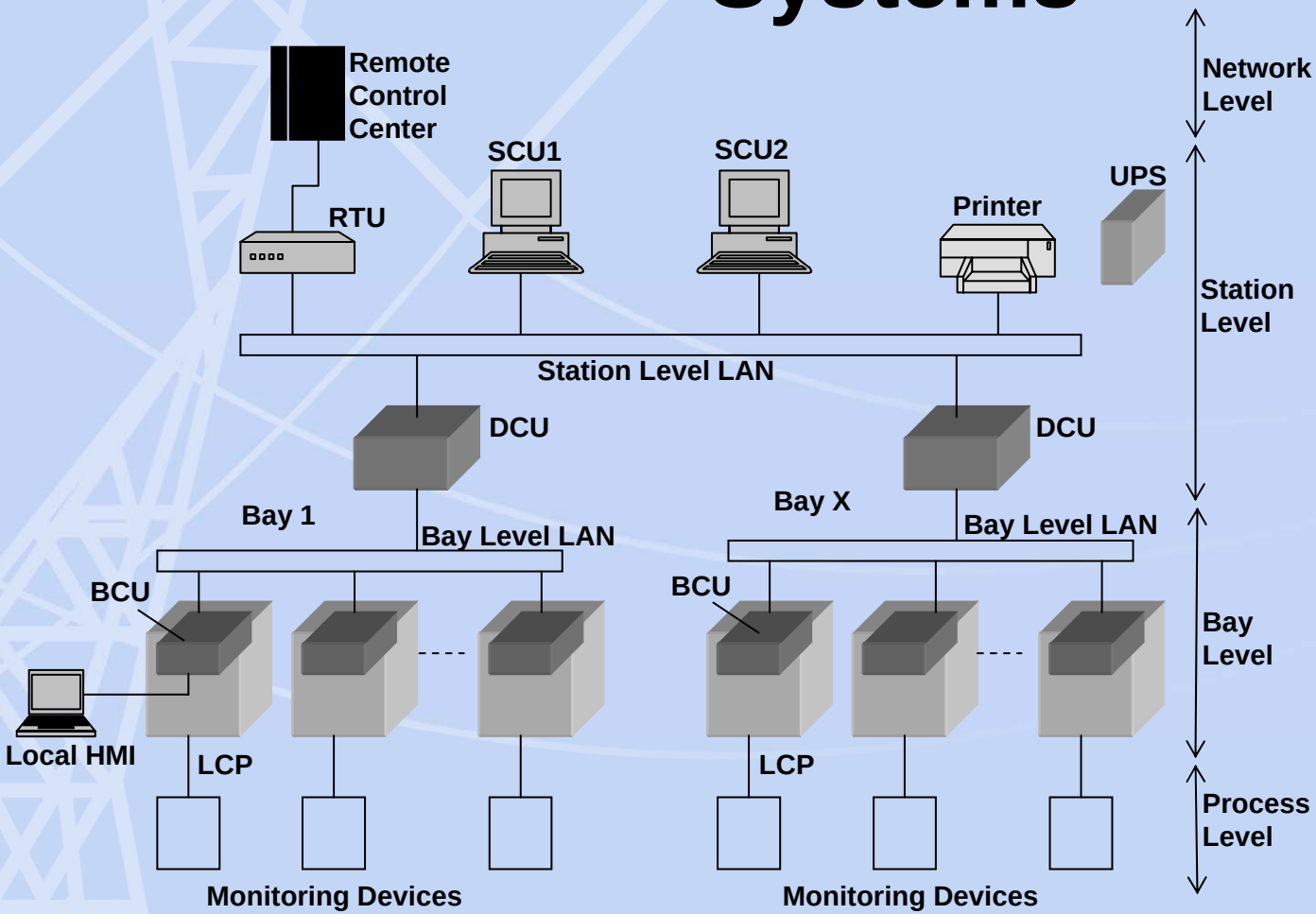
ISOLATE TANKS

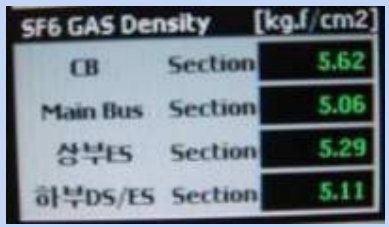
- Eliminate connections
- 1/3 gas loss with each leak
- Able to use intrinsic device to lower $

Speaker: George Davet, Solon Manufacturing

Advanced Technology

Advanced Technology Monitoring Systems



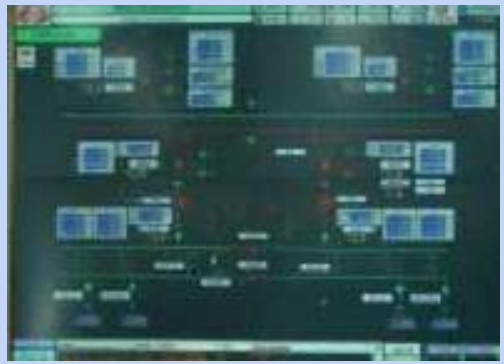


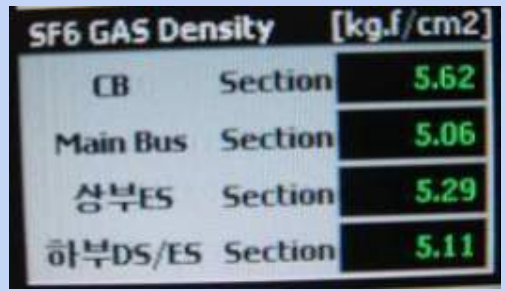
BCU: Bay Control Unit
DCU: Data Communication Unit
HMI: Human Machine Interface
LAN: Local Area Network

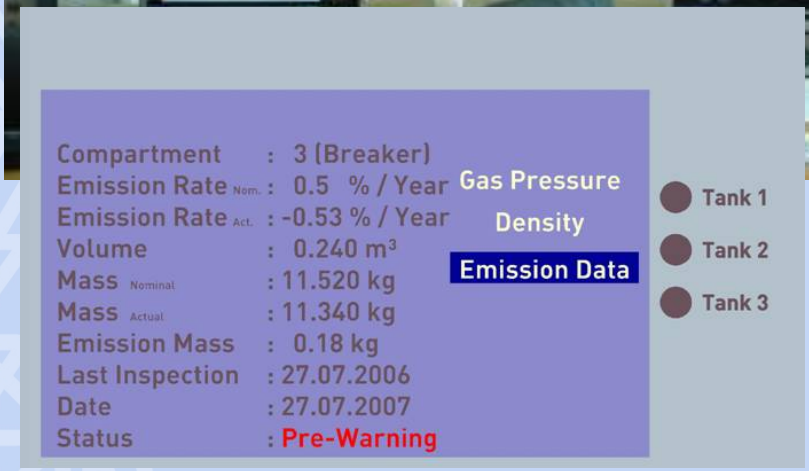
LCP: Local Control Panel
RTU: Remote Terminal Unit
UPS: Uninterruptible Power Supply

Speaker: Ron Hoffman, WIKA

Advanced Technology







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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