Pressure and Temperature Measurement

SF_6 Emission Monitoring:

State-of-the-Art SF_6 Tracking

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EPA Workshop: Phoenix, AZ

February 4, 2009

www.wika.com/sf6

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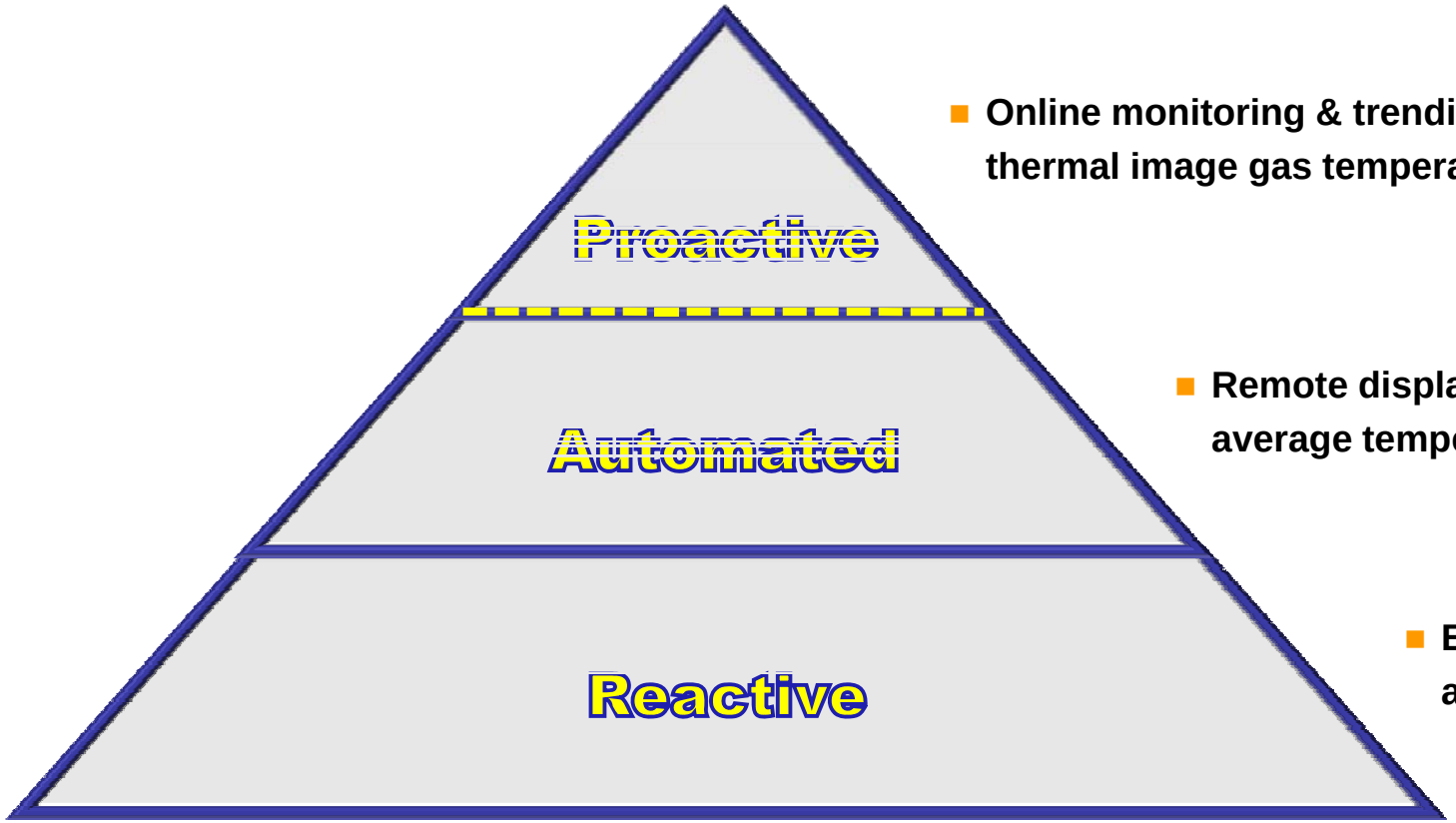
The SF_6 Emission Monitoring Pyramid



- **Online monitoring & trending using thermal image gas temperature**
- **Remote display using average temperature**
- **Event-based using average temperature**

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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.

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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 & temperature-compensated monitor/indicator needed)***
  - ***Ongoing personnel/misc. costs***
- **Pros/Cons**
  - **Instruments already required for SF_6-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)**

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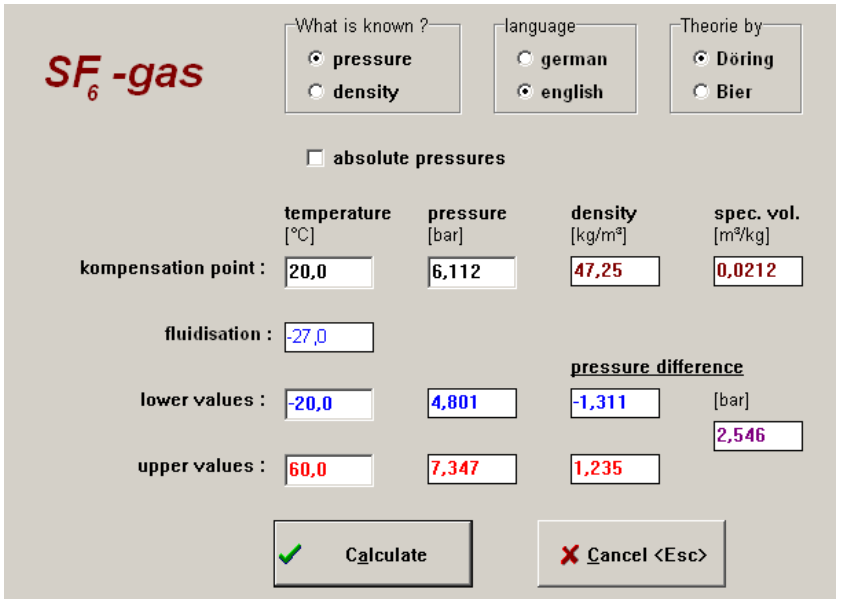
Temperature-Compensated Pressure

Initial Pressure (Compensated) : 90.1 PSI
Actual Pressure (Compensated) : 88.6 PSI
Initial Gas Mass 100 % : 11.520 kg
Tank Volume : 0.240 m^3



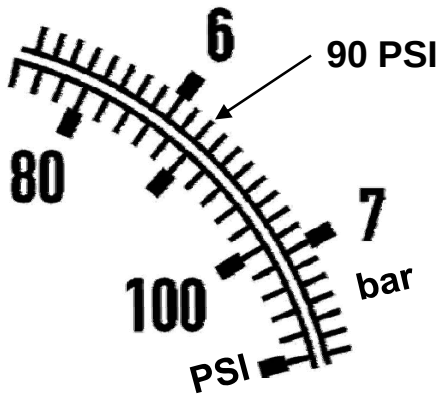
Difference : 0.75 kg/m^3

Lost SF_6 Mass : 0.75 kg/m^3 · 0.240 m^3

Lost SF_6 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**

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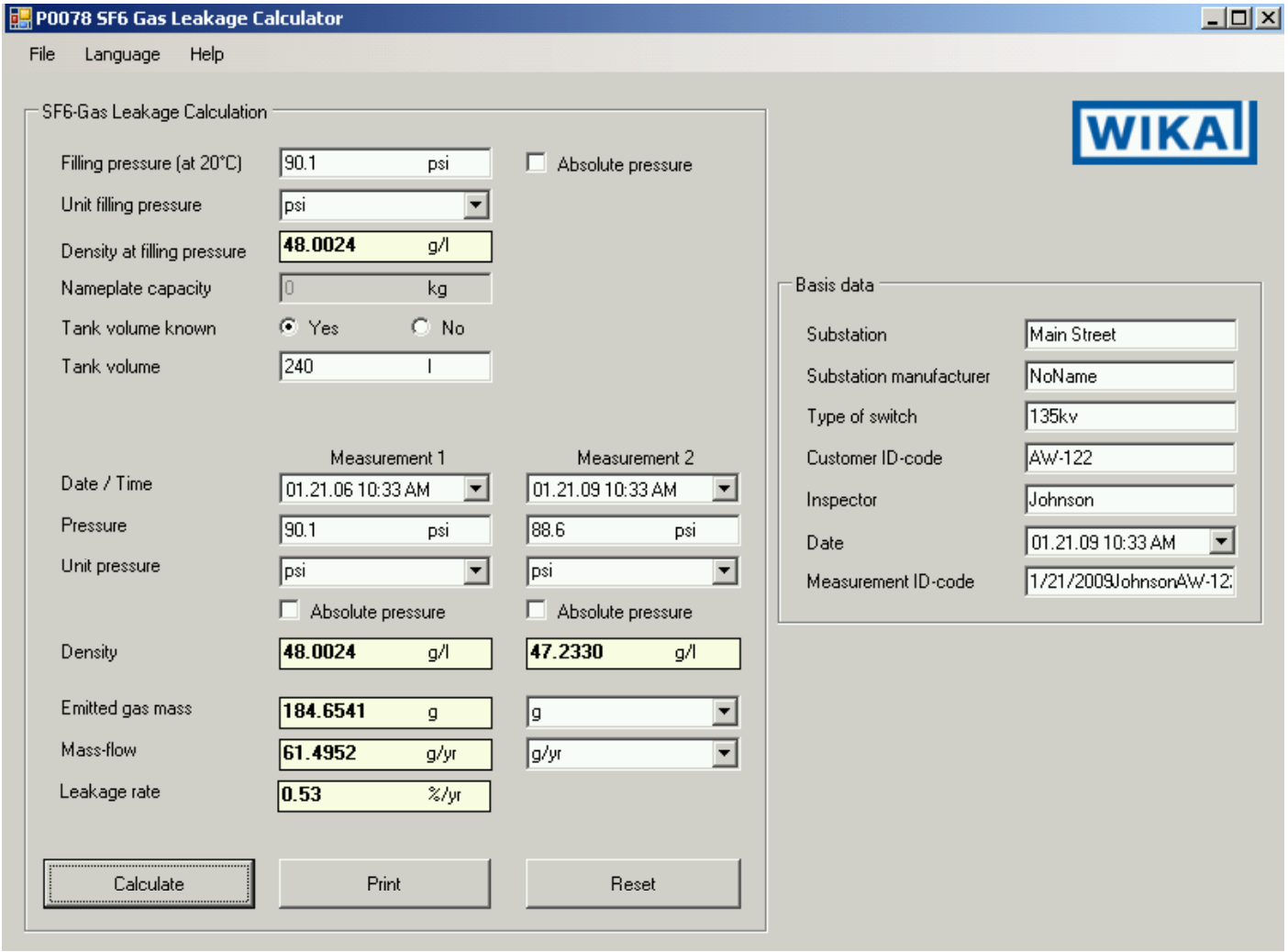
Temperature-Compensated Pressure



Summary Reactive Monitoring

- 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 www.wika.com/sf6 in the “Gas Management For the Smart Grid” archived presentation

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Emission Monitoring Solutions - Automated

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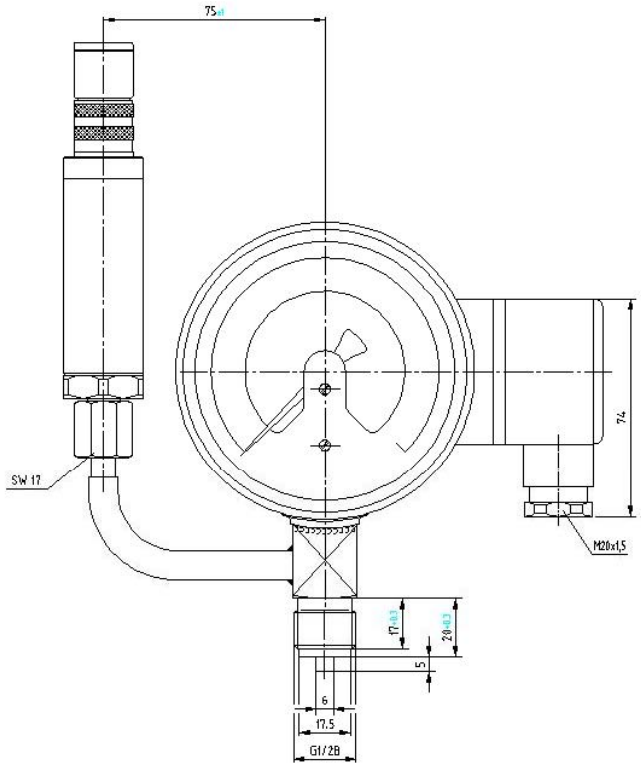
Emission Monitoring Solutions - Automated



- **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 needed 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**

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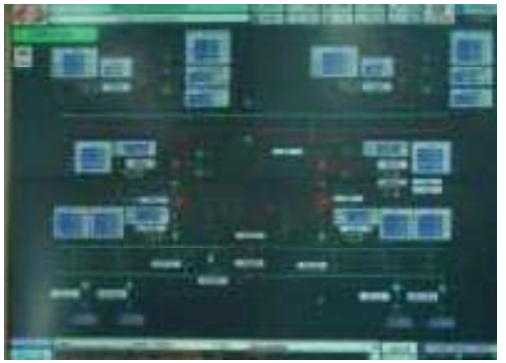
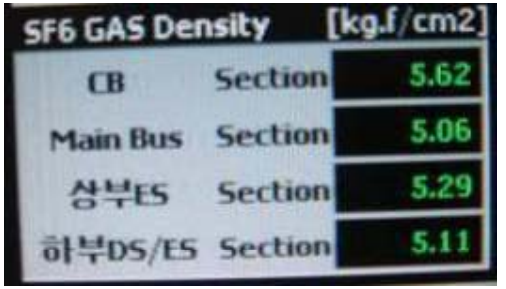
Automated Emission Monitoring - Illustration





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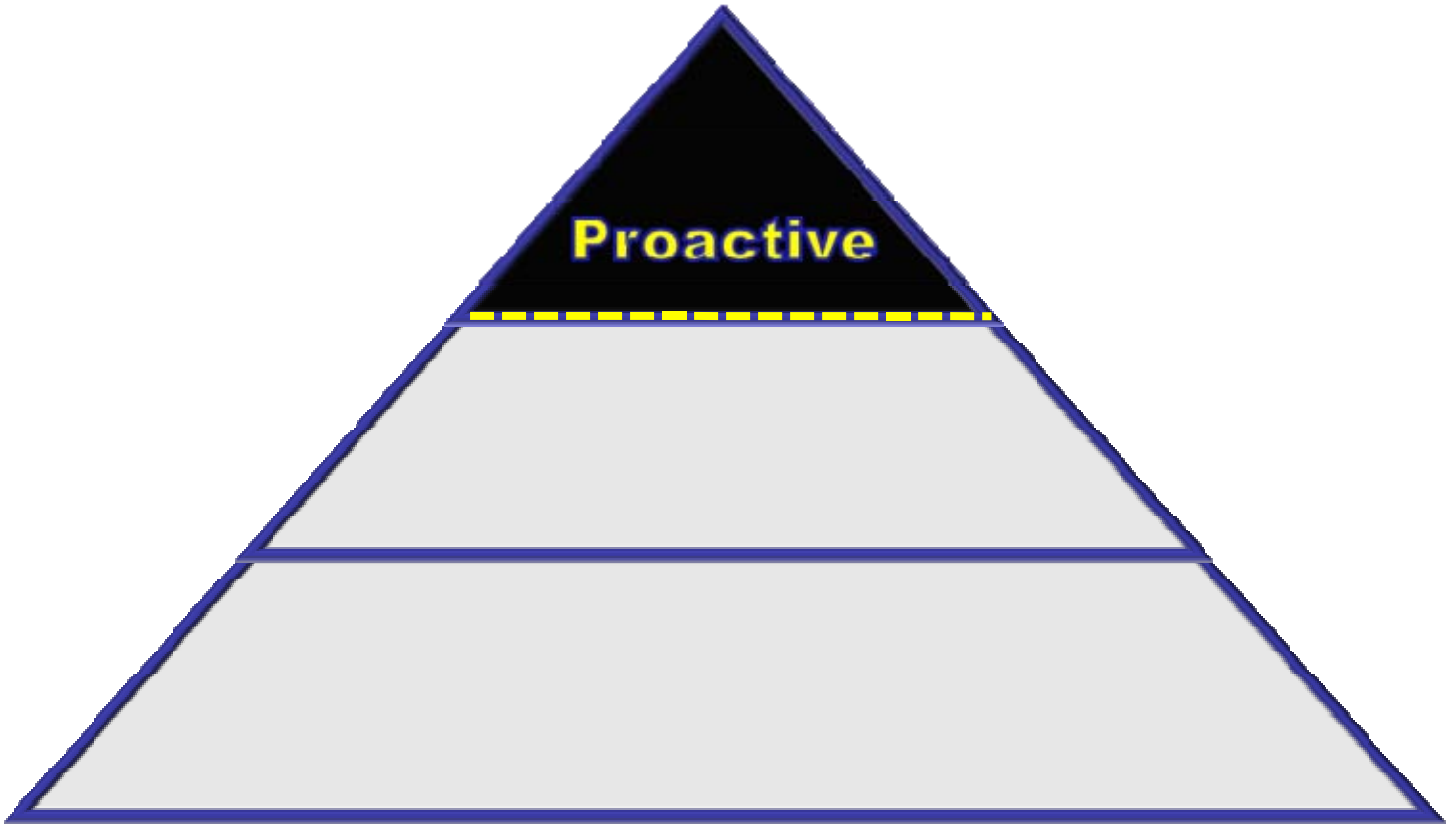
Proactive Monitoring using a SF_6 Gas Management System



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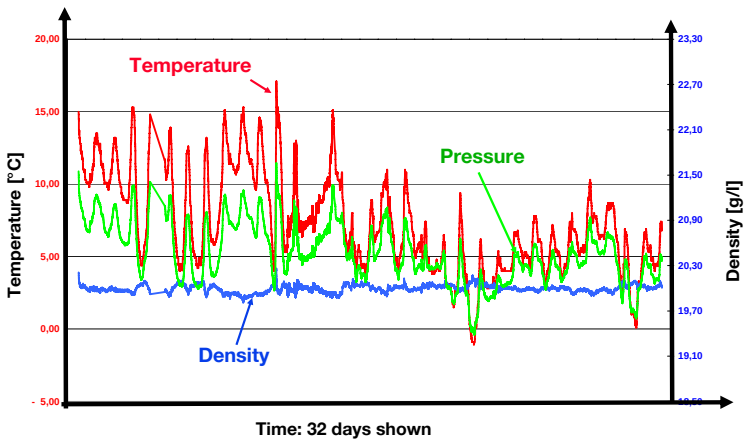
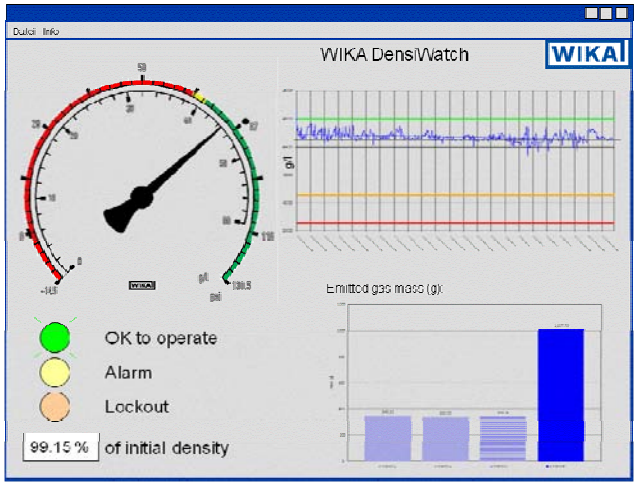
What is a Gas Management System?

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

Raw data



Analyzed data



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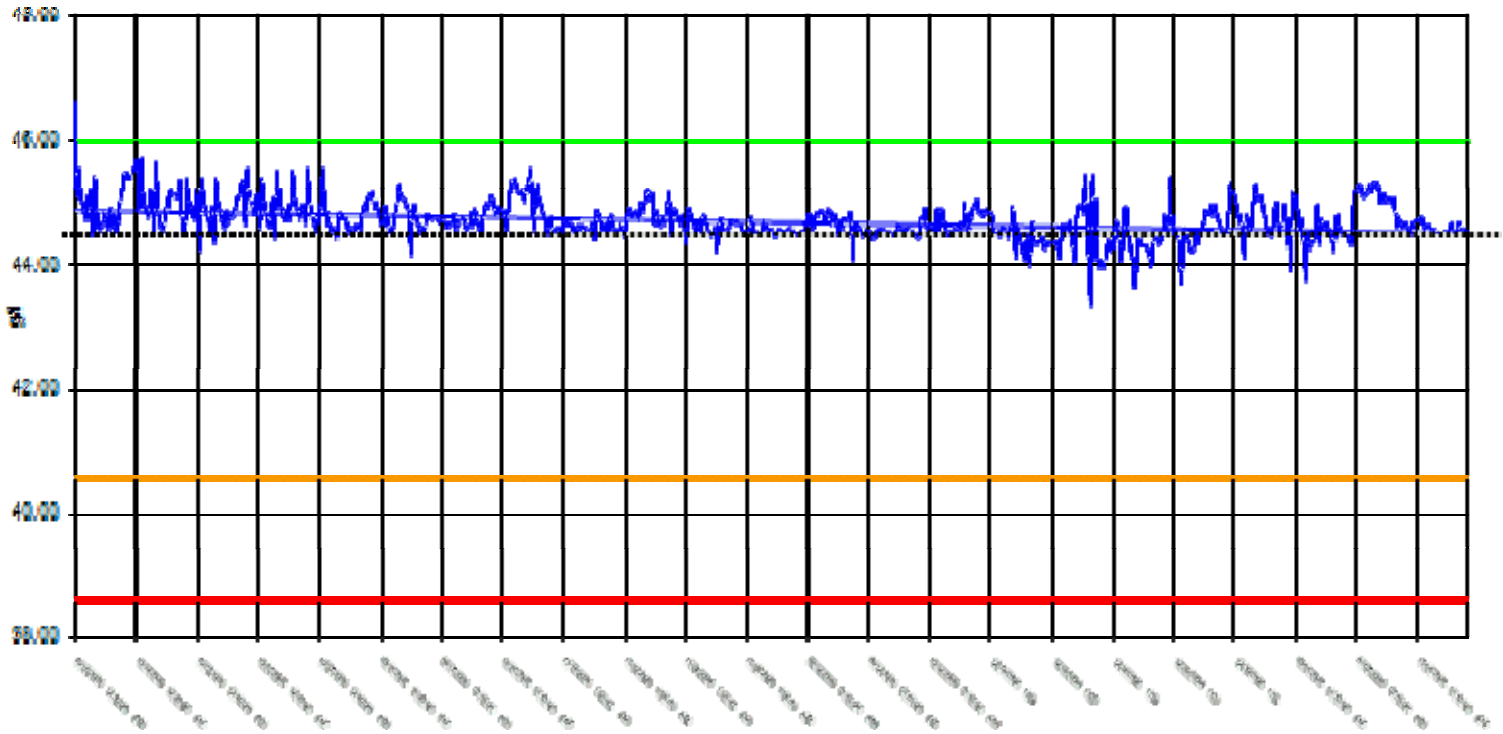
Gas Management Live



NOTE: mount transmitter directly on the tank for best results

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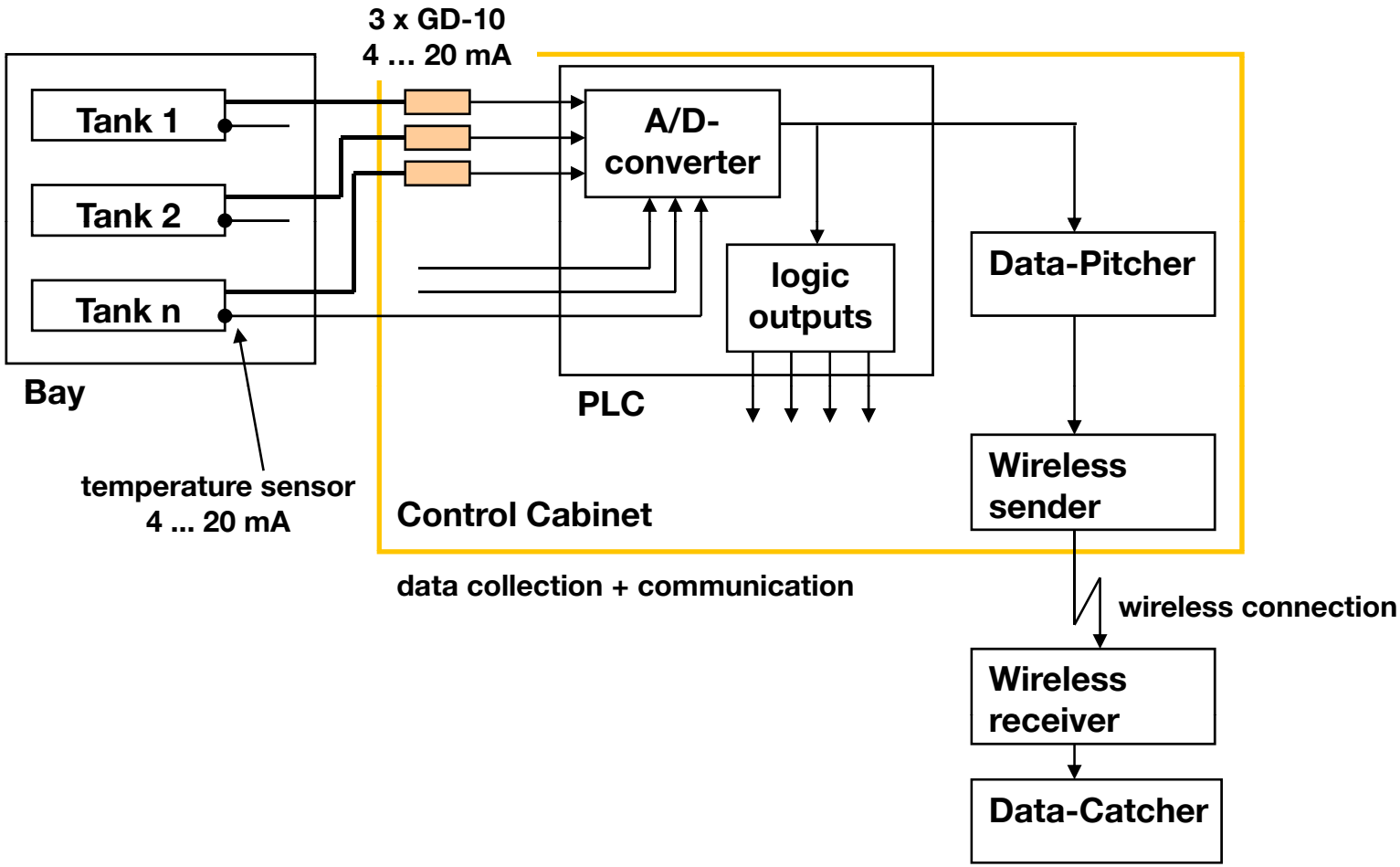
Sample Layout of Wireless GMS



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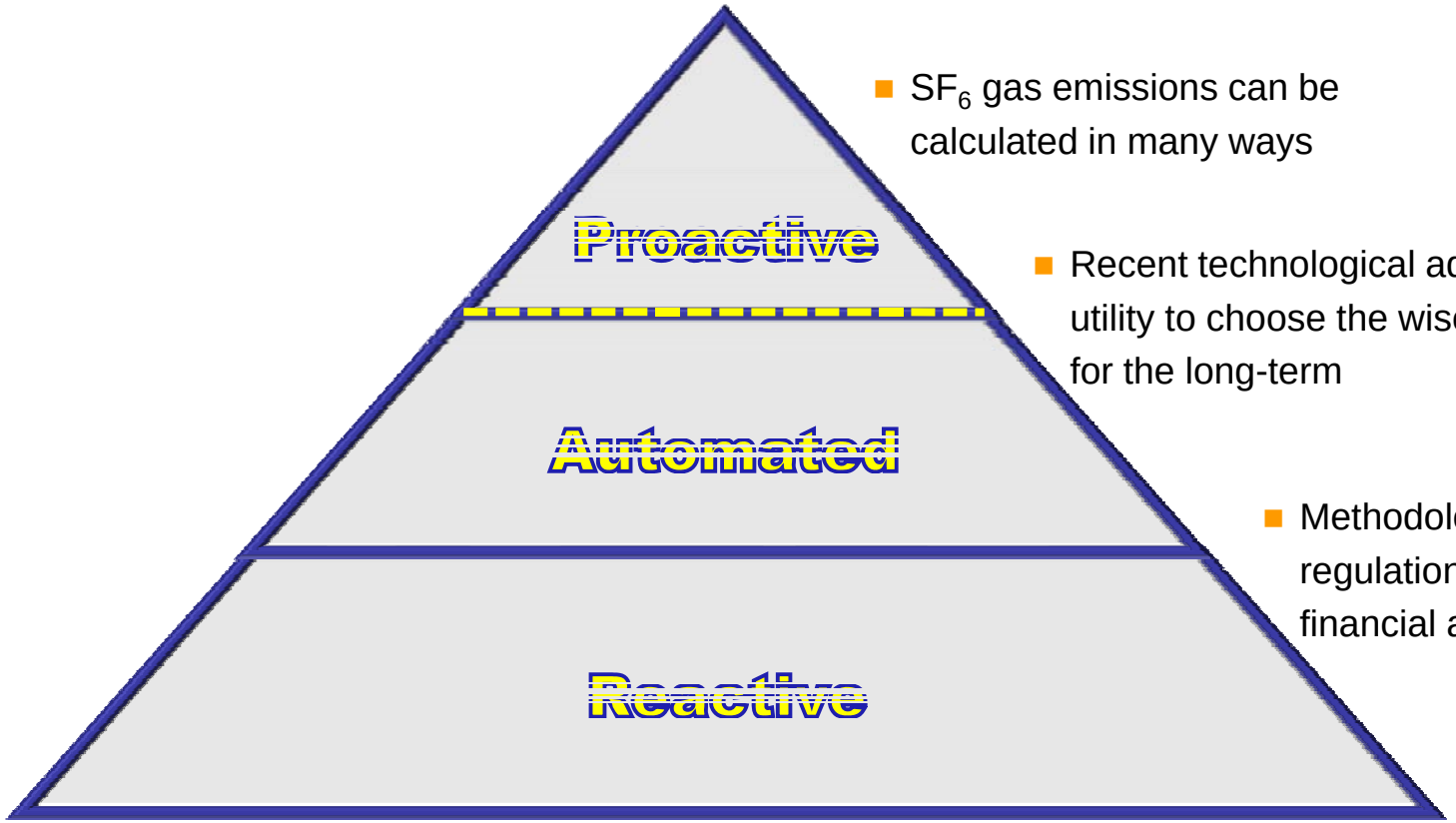
SF_6 Gas Management System

- **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**

Reaching the Summit



- SF_6 gas emissions can be calculated in many ways
- Recent technological advances enable a utility to choose the wisest way to invest for the long-term
- Methodology decisions depend on regulations as well as available financial and personnel resources