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Review of Directed Inspection and Maintenance: Techniques and Technologies for Leak Detection and Quantification.

Oil & Gas Subcommittee. Technology Transfer Workshop

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DI&M: Techniques and Technologies for Leak Detection and Quantification

- Leak Detection
- Importance of quantifying leaks
- Measurement parameters and performance requirements
- Measurement instrumentation
- Compressor seal vents
- Blowdown and vent/flare systems
- Storage tanks
- Final comments, questions

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Leak Definition

- Excessive loss of process fluid past a seal, mechanical connection, cover or defect:
  - Most components have some losses.
  - Compressor and pump seals are usually designed to leak a certain amount to remove heat and debris away from contact surfaces.
- Typical regulatory leak definition:
  - Maximum allowable screening value (e.g., 10 000 ppm).

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Noteworthy Leak Trends

- Most of the emissions are from a few big leaks:
  - Typically, 5 to 10 percent of the leaks contribute >80% of the leakage.
- Most likely sources of big leaks:
  - Compressor seals.
  - Open-ended lines and blowdown systems.
  - Pressure relief valves.
  - Pressure-vacuum safety valves.
  - Tank hatches.
- Least likely sources of big leaks:
  - Valve stem packing systems.
  - Connectors.
- Components in odorized or H_2S service leak less than those in non-odorized or non-toxic service.
- Components in thermal cycling, vibration or cryogenic service have increased leakage.

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Leak Detection – General Requirements

- Minimum detectable leak rate less than or equal to leak definition.
- Quantitative results.
- Rated for use in hazardous locations.
- Portable and easy to use.
- Rugged and weather resistant.
- Suitable for indoor and outdoor use.
- Fast responding real time output.
- Resistant to interferences.
- Cost-effective.

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Leak Detection Options

Organic vapour analyzers

Bubble tests

Ultra-sonic leak detection

Leak Detection Options

Optical Techniques

Visual image of open-ended drain

Infrared image from gas imaging device of open-end drain

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Leak Detection – Bubble Test

- Inexpensive.
- Several times faster than gas sensors.
- Can’t be used on hot components.
- Cannot distinguish between natural gas, air and other gas leaks.
- Provides semi-quantitative results.
- Add anti-freeze agents in cold weather (windshield washer fluid).

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Leak Detection – Portable Gas Sensors

- Well recognized and accepted approach (US EPA Method 21).
- Moderately priced ($1000+).
- Responds differently to different substances.
- Susceptible to fouling and deactivation.
- Some can be heavy and awkward to use.
- Readings affected by wind.
- Not rated for use in freezing weather.

Leak Detection – Ultrasonic Leak Detectors

- Able to screen elevated or difficult to access components.
- Moderate cost ($5000+)
- Generally much faster than Method 21.
- Less sensitive than Method 21.
- Does not distinguish between natural gas, air and other types of gas leaks.
- Limited to use in areas with low background noise in the ultrasonic range.

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Leak Detection – IR Cameras (Thermography)

- Fast and easy to use.
- Easy to check elevated or difficult to access components.
- Provides real-time leak imaging - very effective in communicating leak results.
- Generally less sensitive than a hand held gas sensor but able to more quickly zero in on the major leaks.

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Leak Detection – IR Cameras (Concluded)

- Sees methane, VOCs, CO_2 and steam.
- Expensive ($70,000 to $120,000 US).
- Works best in bright sunlight and warm environments.
- Not effective during rain, snow, sleet, drizzle or fog.

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Why Quantify Emission Rates?

- Justification for repair/control costs.
- Prioritization and optimization of efforts?
- Objective performance monitoring.
- Potential to generate marketable GHG credits and value avoided gas losses.

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Key Measurement Parameters:

- Temperature
- Pressure
- CH_4 Concentration
- Volumetric Flow

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Performance Requirements:

- Practical and safe to use in the field.
- Reasonable cost.
- Readily available.
- Sufficient accuracy for economic evaluations (e.g., ±25% or better).
- Greater accuracy for carbon credit projects (e.g., ± 15% or better).

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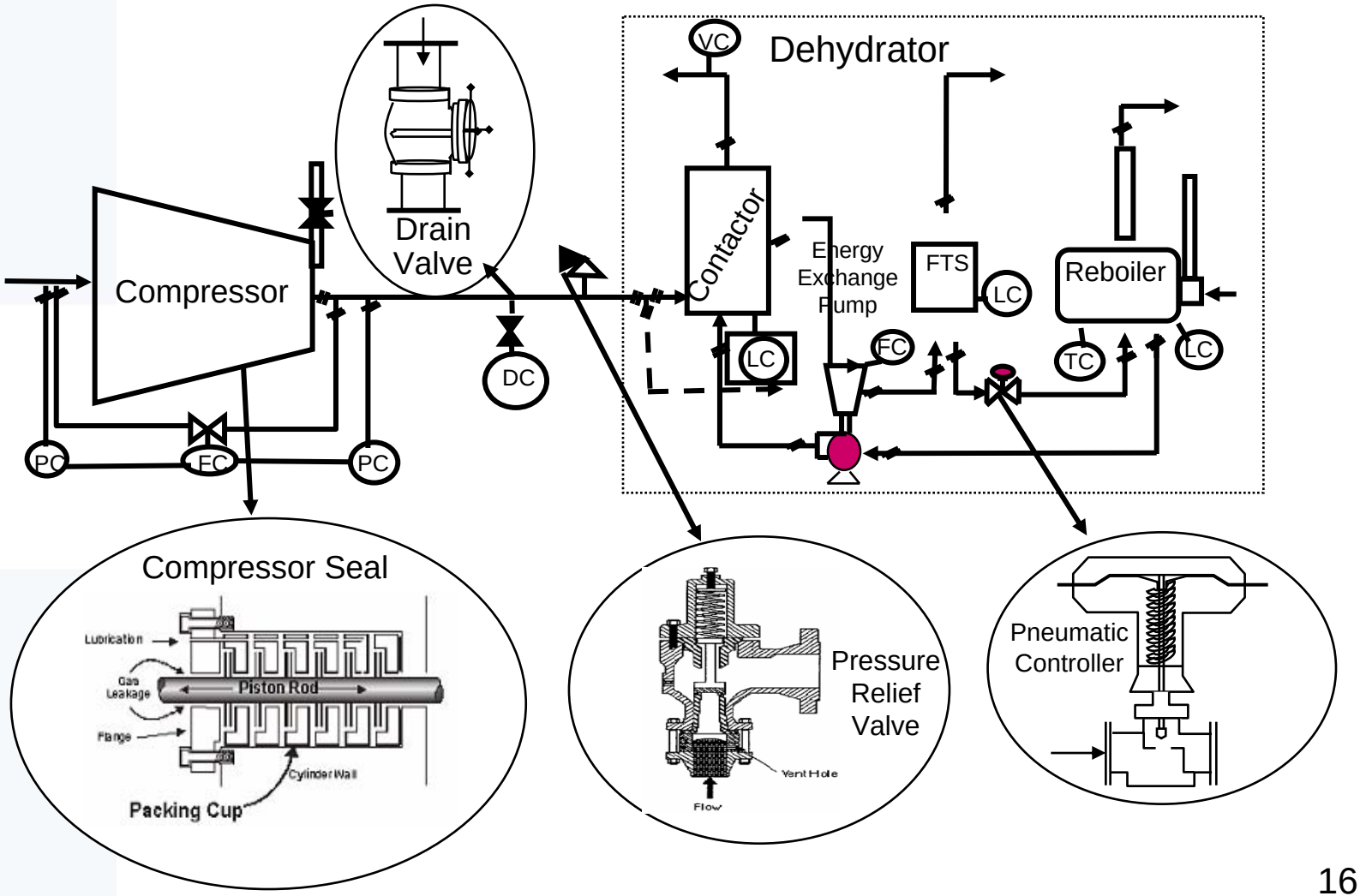
Sources of Methane Emissions



Measurements at the Source

- **Typical Applications:**

✓ Equipment leaks, venting and flaring.

- **Basic constraints:**

✓ Requires easy or supplied access to source.

- **Potential Issues**:

✓ Safety concerns (H2S or relief events).

✓ Backpressure limitations.

✓ High or cold temperature surfaces.

✓ Fouling (e.g., condensing vapor or lube oil mist).

Source: Clearstone Engineering, 2002

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Measurements at the Source:

- Methods:
  - ✓ **Bagging**
    - Time consuming and costly to apply.
    - Applicable for small to moderate leak rates.
  - ✓ **Hi-Flow Sampler**
    - Convenient approach for smaller to medium sized leaks (e.g., 8 to 10 scfm or $25,200 to $31,500/y at $6/mscf).
  - ✓ **End-of-Pipe Capture & Measurement Techniques**
    - Calibrated Bag
    - Full-flow flow meters.
    - Velocity Traverses
  - ✓ **Inline Measurements**
    - Velocity Traverses
    - Tracer Techniques

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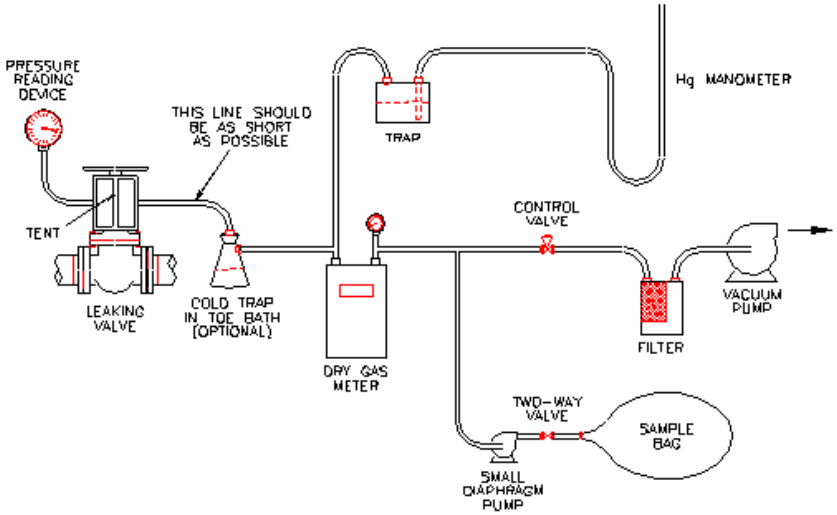
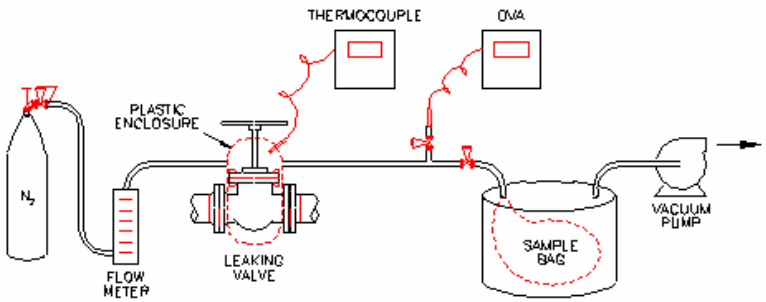
VACUUM METHOD



BLOW-THROUGH METHOD



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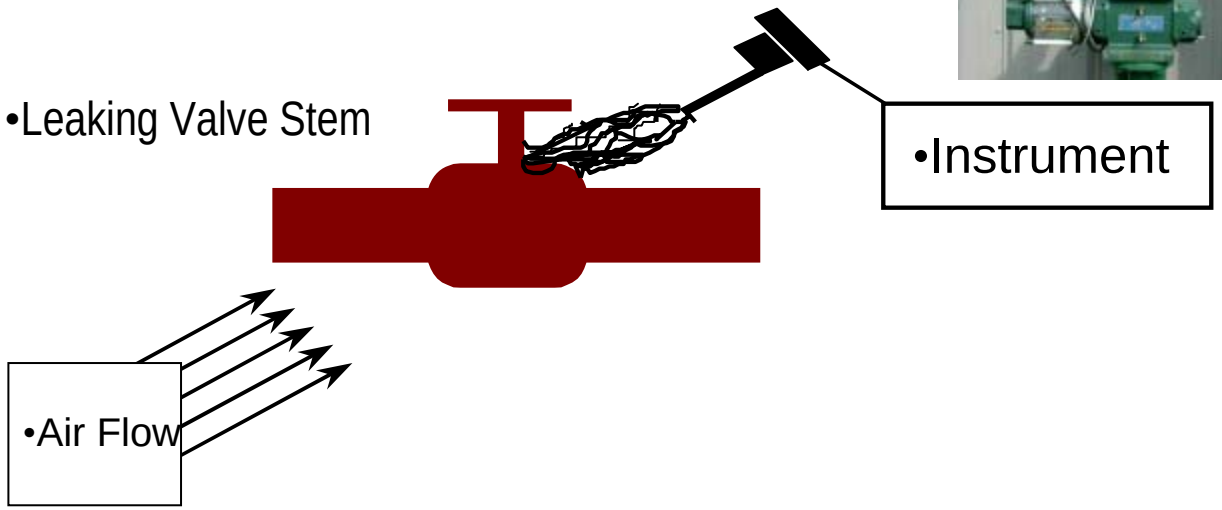
HiFlow Sampler



Compressor Seal Vents:

- Causes of Emissions:
  - Seal wear.
- Typical Measurement Problems:
  - Potentially multiple leakage points:
    - Centrifugal:
      - Lube oil degassing reservoir.
      - Seal Vent.
    - Reciprocating compressors:
      - Distance piece and packing case vents.
      - Lube oil drain tank vent.
      - Crank case vent.
  - Potentially large flows.
  - Minimal tolerance to any back-pressure.
  - Fouling due to lube oil mist.

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Compressor Seal Vents:

- Typical Measurement Problems:
  - Oily roof-tops and limited roof-top access.
  - Lack of ports on vent lines.
  - Possibly weather caps on vent outlets.
- Measurement Approaches.
  - Vane anemometers.
  - Diaphragm meters or calibrated bags where some backpressure can be tolerated.
  - Hi-Flow Sampler
  - Quantitative remote sensing methods.
  - Permanent Solutions:
    - Flow switches.
    - Rotameters.

Blowdown and Vent/Flare Systems:

- Causes of Emissions (During Passive Periods):
  - Purge gas.
  - Leakage past the seats of blowdown/relief valves (5 to 10% leak and 1 to 2% of these contribute over 75% of the emissions).
  - Blowdown or drain valves not fully closed.
  - Compressor seals.

- Typical Measurement Problems:
  - Potentially large flows.
  - Difficulty accessing end of pipe.
  - Limited or no suitable ports for insertion of velo probes.

Blowdown and Vent/Flare Systems:

- Typical Measurement Problems:
  - Low flow velocities.
  - Potentially wet or fouling environment inside pipe.
  - Safety concerns (relief episodes).
- Measurement Approaches.
  - Micro-tip vane and thermal dispersion anemometers.
  - In-line tracer tests.
  - Ultrasonic sensors (portable & online).
  - Remote sensing methods.
  - Permanent Solutions:
    - Ultrasonic transit-time flow meters.
    - Flow switches.

Storage Tanks:

- Causes of Emissions:
  - Working and breathing losses.
  - Flashing losses.
  - Unaccounted for contributions:
    - Unintentional Gas carry-through.
      - Leaking drain and dump valves.
      - Malfunctioning level controllers.
      - Inefficient upstream gas/liquid separation.
      - Piping changes resulting in storage of unstablized product.
      - Non-routine storage of unstabilized product in atmospheric tanks.
    - Malfunctioning vapor recovery systems:
      - Faulty blanket gas regulators or pressure controllers.
      - Fouled vapor collection lines.
      - Leaking roof fittings and seals.

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Storage Tanks:

- Typical Measurement Problems:
  - Multiple roof openings.
  - Edge-of-roof access only.
  - Dependence on pump in/out activity and meteorological conditions.
  - Fall protection and potentially confined space training required.
  - Interpretation and extrapolation of results.
- Measurement Approaches:
  - Velocity profiles across openings.
    - Vane anemometers.
  - Tracer techniques.
  - DIAL

- Engineering Calculations
  - API E & P TANKS Model (Flashing, working and breathing losses).

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Partner Experience - PEMEX

- Leak surveys implemented as part of PEMEX collaboration agreement with EPA from 2006 to date.
- Surveyed more than 3,000 components in random chosen sections at 3 major gas processing facilities in Southern Mexico using sniffers, FLIR camera and Hi-Flow Sampler
- Identified leaking rates as high as 2.2 MMcf/year from single components
- Annual methane emissions reduction potential of 200 MMcf/year
- At US$ 5 / Mcf, potential gas savings worth would be US$ 1,000,000 / year
- PEMEX is implementing DI&M program

Source: M2M

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Planned Field Trip:

- View a leak in real time through the view screen of an IR camera.
- Screen the leak using traditional methods:
  - Handheld gas sensor
  - Soap test
- Quantify volume of emission using Hi-Flow Sampler