Why Quantify Emission Rates?

- Justification for repair/control costs.
- Prioritization and optimization of efforts?
  - Typically 80 to 90% of emissions contributed by the top 10 leakers at each site.
- Objective performance monitoring.
- Potential to generate marketable GHG credits.
Performance Requirements:

- Reasonable cost.
- Readily available.
- Sufficient accuracy for economic evaluations (e.g., ±25% or better).
Traditional Approaches:

- **Target Applications:**
  - Generally limited to smaller to medium sized equipment components and leak rates.

- **Basic constraints:**
  - Requires easy or supplied access to leaks.

- **Potential Issues:**
  - Composition dependencies.
  - Potential safety issues (H$_2$S or relief events).
  - Backpressure limitations.
  - Detection limitations.
  - High temperature surfaces.
  - Surfaces with heavy ice or frost accumulation.
Traditional Approaches:

- Methods:
  - Bagging
    - Time consuming and costly to apply.
    - Applicable for small to moderate leak rates.
  - End-of-Pipe Capture and Measurement Techniques
    - Calibrated Bag
    - Full-flow flow meters.
  - Hi-Flow Sampler
    - Convenient approach for smaller to medium sized leaks (e.g., 8 to 10 scfm or $29,400 to $36,700/y at $7/mscf).
  - Velocity Probes.
Non-traditional Methods:

- Target Applications:
  - Vent and flare systems.
  - Area, and volume sources.
  - Inaccessible or unsafe to access sources.

- Basic Constraints:
  - Generally more costly and complicated to use.

- Potential Issues:
  - Weather dependent.
  - Susceptible to interferences.
  - Require suitable downwind access (i.e., remote sensing methods).
  - Potentially reduced resolution and accuracy.
Non-traditional Methods:

- Methods:
  - Tracer techniques:
    - In–line tracer methods.
    - Transient response (e.g., ASHRAE building methods).
    - Pollutant-to-tracer ratio technique.
  - Remote plume sensing methods.
    - DIAL ([ftp://public:access@ts.clearstone.ca](ftp://public:access@ts.clearstone.ca)).
    - Back-calculation using atmospheric dispersion models and upwind/downwind monitoring data.
    - AIRDAR.
Non-traditional Methods:

- Methods:
  - Source modeling (i.e., estimation from process operating data and engineering principles):
    - Mass balance and energy balance techniques.
    - Process simulators.
Where should measurement efforts be focused?

<table>
<thead>
<tr>
<th>Major Category</th>
<th>Sub-Category</th>
<th>Typical Leak Frequency (%)</th>
<th>Component Count (% of Total)</th>
<th>% Contribution to Total Emissions</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Recip Comp Units</td>
</tr>
<tr>
<td>Connectors</td>
<td>All</td>
<td>1.2</td>
<td>87.3</td>
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<td>0.3</td>
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<td>Pressurized Stn or Comp Unit</td>
<td>73.5</td>
<td>0.1</td>
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<tr>
<td></td>
<td>Depressurized Recip Comp</td>
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<td></td>
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<td>Orifice Meters</td>
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<td>100.0</td>
<td>100.0</td>
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<tr>
<td>Total Highlighted</td>
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<td>1.7</td>
<td>92.2%</td>
<td>90.9%</td>
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</table>
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.
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 velocity probes.
Blowdown and Vent/Flare Systems:

- Typical Measurement Problems:
  - Low flow velocities.
  - Potentially wet or fouled 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 unstablized product in atmospheric tanks.
    - Malfunctioning vapor recovery systems:
      - Faulty blanket gas regulators or pressure controllers.
      - Fouled vapor collection lines.
      - Leaking roof fittings and seals.
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).
Storage Tanks – Remote Emissions Measurement
Storage Tanks – Unaccounted Losses

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### Best options by source:

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Conclusions on Leak Measurement:

- A selection of measurement techniques is needed.
- Instrumented solutions are the best choice for large potential emitters:
  - Compressor seals.
  - Flare and vent systems.
  - Metering of gas blanketing systems.