Leak Measurement Techniques

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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_2S 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.
    - US EPA (2006): ORS Protocol (www.epa.gov/ttn/emc/prelim/otm10.pdf).
    - DIAL (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?

Gas Transmission Compressor Stations

Major Category	Sub-Category	Typical Leak Frequency (%)	Component Count (% of Total)	% Contribution to Total Emissions				
				Recip Comp Units	Cent Comp Units	Comp Station Yard Piping	Comp Disch Coolers	Total
				(%)	(%)	(%)	(%)	(%)
Connectors	All	1.2	87.3	1.9%	2.8%	3.2%	95.2%	5.7%
Valves	Control Valves	14.6	0.3	4.2%	1.3%	0.0%	0.0%	1.3%
	Block Valves	4.0	10.4	1.7%	4.9%	7.6%	4.8%	5.3%
Open-Ended Lines	**All**	**NA**	**1.3**	**9.0%**	**17.9%**	**46.8%**	**0.0%**	**26.7%**
Pressure Relief Devices	**All**	**14.6**	**0.2**	**6.0%**	**18.0%**	**13.0%**	**0.0%**	**13.4%**
Pressure Regulators	All	16.3	0.3	0.1%	0.2%	0.4%	0.0%	0.2%
Blowdown Systems	**Pressurized Stn or Comp Unit**	**73.5**	**0.1**	**20.2%**	**20.1%**	**14.6%**	**0.0%**	**17.4%**
	Depressurized Recip Comp	73.3	0.0	0.0%	0.0%	0.0%	0.0%	0.0%
	DepressurizedCentr. Comp	61.1	0.0	0.0%	0.0%	0.0%	0.0%	0.0%
Compressor Seals	**Recip**	**86.1**	**0.1**	**57.0%**	**0.0%**	**0.0%**	**0.0%**	**10.0%**
	Centrifugal	**95.2**	**0.1**	**0.0%**	**34.9%**	**0.0%**	**0.0%**	**14.4%**
Flow Meters	Orifice Meters	20.2	0.0	0.0%	0.0%	0.0%	0.0%	0.0%
	Other	2.6	0.0	0.0%	0.0%	0.0%	0.0%	0.0%
Instrument Controllers	All	100.0	0.0	0.0%	0.0%	14.6%	0.0%	5.5%
		Total	100.0	100.0%	100.0%	100.0%	100.0%	100.0%
		Total Highlighted	**1.7**	**92.2%**	**90.9%**	**74.4%**	**0.0%**	**81.9%**

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:

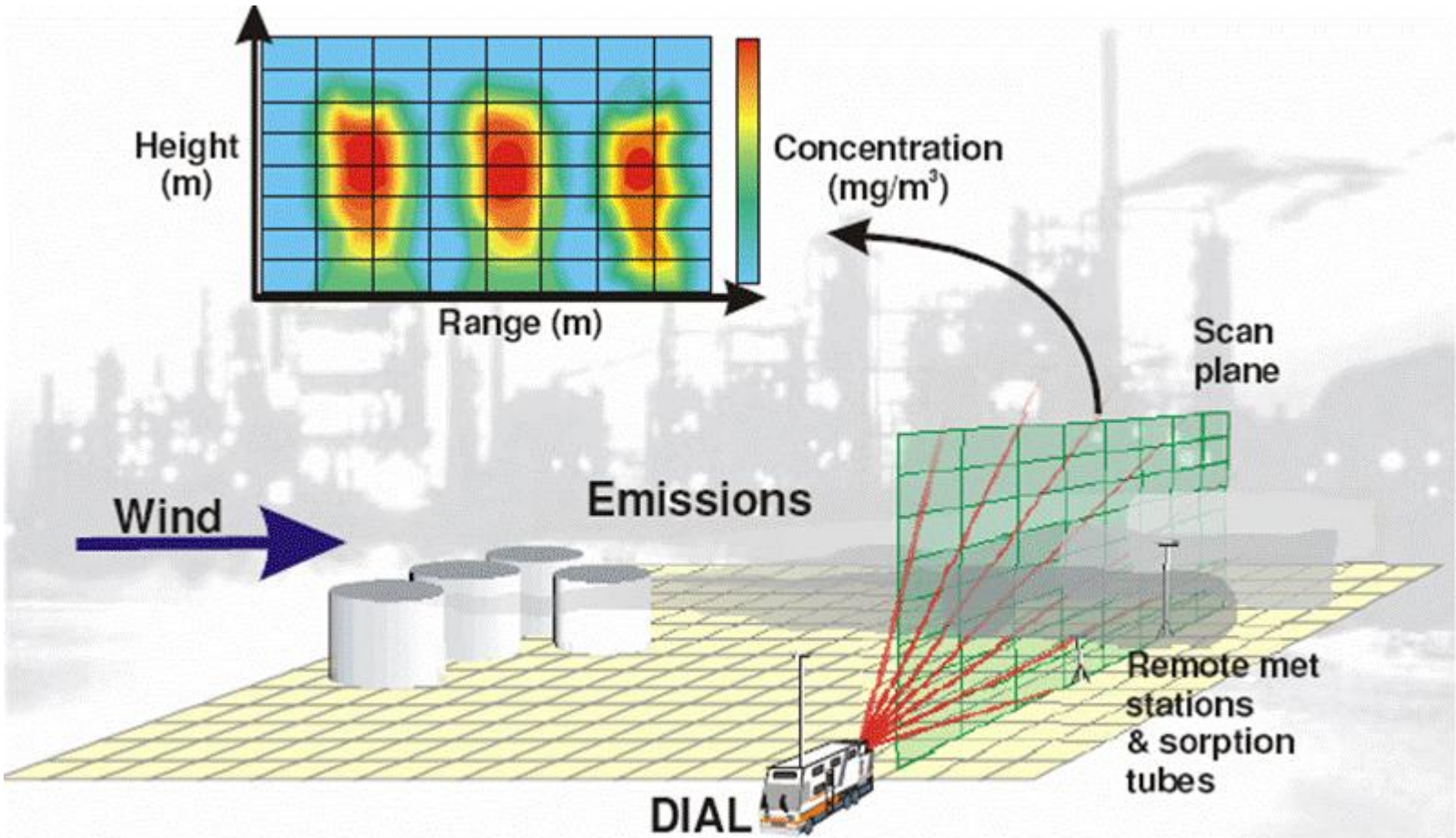
- Causes of Emissions:
  - Working and breathing losses.
  - Flashing losses.
  - Unaccounted for contributions:
    - Unintentional Gas carry-through.
      - Leaking drain and dump valves.
      - Malfunctioning level controllers.
      - Inefficient upstream gas/liquid separation.
      - Piping changes resulting in storage of unstablized product.
      - Non-routine storage of 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.

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

Facility	THC Emissions [$10^3 m^3$/year]	Methane Emissions [$10^3 m^3$/year]	GHG Emissions [tonnes CO_2E/year]	Value of Lost Product [$/year]
Gas Plant #1	NA	NA	NA	NA
Gas Plant #2	NA	NA	NA	NA
Gas Plant #3	1 663	57	813	441 371
Gas Plant #4	NA	NA	NA	NA
Gas Plant #5	95	93	1 325	24 559
Gas Plant #6	NA	NA	NA	NA
Gas Plant #7	NA	NA	NA	NA
Gas Plant #8	4 469	2 651	37 801	1 880 267
Gas Plant #9	NA	NA	NA	NA
TOTAL	**6 227**	**2 801**	**39 939**	**2 346 197**
AVERAGE	**692**	**311**	**4 438**	**260 689**

- **Value of emissions based on a $6.78/GJ for natural, $8.13/GJ for propane, and $9.63/GJ for butane and condensate.**

Best options by source:

Source	Hi-Flow	End-of-Pipe Flow Meters	Velocity Probes	Tracer Methods	Quantitative Remote Sensing	Flow/Leak Sensors
Connectors	X					
Valves	X					
PRVs	X	X				
OELs	X	X	X			
Blowdown Systems		X	X	X		X
Compressor Seals	X	X	X			X
Flare Systems			X	X	X	X
Tanks		X	X	X	X	X
Non-point Sources				X	X	

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.