How to Develop a Methane Emissions Feasibility and Measurement Study

GMI Middle East Meeting
Washington, D.C.
3 October 2012

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Vice President
ICF International

Agenda

- Measurement study process
  - Desktop study
  - Field study
  - Leak detection
  - Measurement of emissions (methodologies and tools)
- Common sources of emissions
  - Oil and condensate tanks
  - Reciprocating compressor rod packing
  - Centrifugal compressor wet seals
  - Gas powered pneumatic devices
  - Fugitive leaks
- Feasibility study
- Summary of mitigation options
- Partner experience
- Contact and Further Information

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Why Do a Methane Emissions Reduction Feasibility Study?

Emissions may not be readily visible or identifiable without specialized equipment.

These unseen leaks represent significant natural gas losses, reduced operational efficiency, greenhouse gas emissions, and potential safety risks.

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Feasibility Study Process

- Collect basic operation data about facility
  - Equipment and process counts
  - Operational hours
  - Production/throughput volumes
  - Economic parameters
- Perform Desktop Study to estimate emissions
  - Use collected data, along with default values and emission factors
- Perform Field Study to identify and measure emissions
  - Use detection equipment to identify emission sources
  - Use measurement techniques to quantify emissions
- Perform Feasibility Study on options to reduce emissions
- Share project success stories (internally and externally) to propagate ideas

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Performing a Desktop Study

- Purpose: to identify specific facilities to examine for methane emissions reduction opportunities
  - For field verification study scope, timing, and equipment
- GMI and the operating company collaborate to develop an emissions inventory ("desktop study") of representative site(s)
  - Company completes data collection form and/or indicates where default emission factors should be used
  - Identify what sources are potentially the highest methane emitters
  - Generally, sites with highest emitters would benefit most from more comprehensive field measurement studies
- Types of emissions sources include vented, fugitive, and flared

Performing a Desktop Study – Data Collection Form

General Partner Information
Production Data Input Sheet

Reporting Date (MM/DD/YYYY)		
Contact Information	Company name	
	Contact name	
	Contact title	
	Contact email	
	Contact office phone	
	Contact alternative phone	

Project Scope	Describe the scope of the operations to include in the Partner Challenge Study. For example, do you want to include company-wide operations or only operations from a specific location? Attach a diagram of the operations included in this study, if available.

Project Boundaries	Describe the facilities to be included in the Partner Challenge Study. Provide the physical boundaries of each location, explaining boundary points where the facilities in this study interface with other companies, business units, and facilities. Attach a diagram illustrating boundaries, if available.			
	Location	Description of the location	Project boundaries at this location	Throughput in Million cubic feet per day
	SAMPLE Midland, Texas	PF1 production site covering 33 wells routed to a central location with gas/oil/water separators, oil storage, oil pumps, gas compressors, oil pipelines, water pipelines, and gas pipelines.	Lease meters	20 MMcf/day 0.1 MMbbl/day

General Information | Onshore Gas Production | Onshore Oil Production | Offshore Gas and Oil Production | Sheet1

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Performing a Desktop Study – Data Collection Form

ONSHORE NATURAL GAS PRODUCTION

Please answer the following questions for the operations defined in the Project Scope. Enter data as thoroughly as possible for one full calendar year, preferably the latest full calendar year. If a category does not apply to the scope of your project or your company's operations, enter "NA".

WELLS	**Input Field**
Total number of producing natural gas wells:	
→ Number of unconventional gas wells (for example, coal bed methane wells):	
Total volume of gas produced (Million cubic feet per day):	
Natural gas composition (Volume percent methane content in natural gas):	
Total number of gas wells drilled per year:	
Total number of completions for all gas wells:	
→ Number of completions per year that flare gas:	
→ Number of completions per year that vent gas:	
→ Number of green completions per year (Equipment brought on site to recover gas normally vented during clean-up of hydraulic frac jobs):	
Total number of gas well workovers per year:	
→ Number of gas well workovers that flare gas per year:	
→ Number of gas well workovers that vent gas per year:	
Total number of gas well cleanups per year:	
Total number of gas wells with plunger lifts installed to avoid well blowdowns:	
Total number of gas wells using plunger lifts and a programmable logic controller to optimize plunger cycles (smart well automation):	

TANKS / STORAGE	**Input Field**
Total throughput of water storage tanks (Barrels):	
→ Produced water salt content:	

General Information | **Onshore Gas Production** | Onshore Oil Production | Offshore Gas and Oil Produc

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Performing a Field Study – Leak Detection (Infrared Tools)

- Real-time detection of methane emissions
  - Quicker identification of emissions
  - Screen hundreds of components an hour
  - Screen inaccessible areas
- Infrared camera
  - Filters for wavelength at which hydrocarbons absorb visible light
  - Video display and recording capability
- Remote Methane Leak Detector (RMLD)
  - Active infrared technology that produces audible tone when methane is detected

Infrared Camera

Remote Methane Leak Detector

Source: Heath Consultants

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Performing a Field Study – Leak Detection (Hand Held Tools)

- Soap bubble screening
  - Involves spraying a soap solution on small, accessible components such as threaded connections
  - Fast, low-cost leak screening technique
  - Effective for locating loose fittings and connections and for quickly checking the tightness of a repair
  - Operators can screen about 100 components per hour
  - Not suitable for open pipes or vents, or components in sub-freezing or above boiling temperature
- Electronic screening ("sniffer")
  - Device equipped with catalytic oxidation and thermal conductivity sensors designed to detect the presence of specific gases
  - Can be used on larger openings not suitable for soaping
  - Not as fast as soap screening (~50 components per hour)
  - Not suitable for inaccessible components

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Performing a Field Study – Leak Detection (Hand Held Tools)

- Toxic vapor analyzer (TVA) and organic vapor analyzer (OVA)
  - Portable hydrocarbon detectors used to detect leaks
  - Both measure the concentration of combustible hydrocarbon at the point of leakage
  - OVA measures the concentration of organic vapors up to 10,000 parts per million by flame ionization detector (FID)
  - TVA measures concentrations up to and far exceeding 10,000 ppm by FID and a photoionization detector (PID)
  - Correlations can be used to estimate leakage

Toxic Vapor Analyzer

- Ultrasound/acoustic leak detection
  - Portable acoustic screening devices that detect the acoustic signal (sound) that results when pressurized gas escapes through a small orifice, such as a through leaking valve
  - Although they do not measure leak rates, acoustic detectors provide relative indication of leak size

Acoustic Leak Detection

Performing a Field Study – Measurement of Emissions

- Equipment- and process-specific quantification is essential to understand both the volume and distribution of emissions
  - Enables prioritization of the most cost-effective projects
- Depending on the source, a variety of methods exist for quantifying source-specific methane emissions
  - Engineering calculations
  - Emission factors
  - Software tools
  - Physical detection and measurement
- Goal is to optimize trade-off between accuracy and level of effort
- Gas composition must be taken into account to estimate methane emissions

Performing a Field Study – Quantification Methodologies

- **Engineering calculations** use operational data and equipment characteristics to perform calculations estimating volume of methane emissions from source
  - Relatively high level of accuracy with relatively low level of effort for variable or cyclic emissions
  - Operational data is typically readily available
  - Appropriate for frequent, geographically dispersed emission sources
- **Emission factors** are average emissions rates for a given source
  - Used in combination with activity factors or operational data
  - Quick method to estimate emissions with relatively low level of effort
  - May not be appropriate for all emissions sources at a facility

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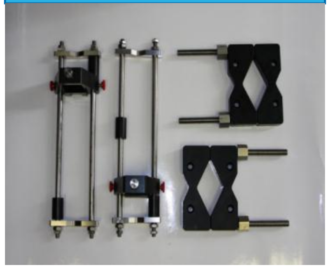
Performing a Field Study – Quantification Methodologies

- **Software tools** use operational data as input for software configured to model methane emissions using equations of state
  - Operational data is typically readily available
  - Actual process may or may not exactly match pre-configured models
  - Applicable programs include:
    - E&P Tank
    - GLYCalc
    - AMINECalc
- **Direct measurement** of emissions using specialized equipment

Performing a Field Study – Direct Measurement Tools

- **High volume sampler**: Variable-flow rate sampling system that provides total capture of emissions from a leaking component
  - Dual-element hydrocarbon detector measures hydrocarbon concentrations in captured air stream
  - Measurable leak rate: 0.001 to 0.2 m^3/min
- **Ultrasonic flow meter**: Two transducers that serve as both ultrasonic signal generators and receivers
  - Difference between the downstream and upstream transit times is proportional to the velocity of the flowing fluid
  - Especially suited for high flow rates or leaks measured over a period of time
- **Turbine meter**: Gas flow through turbine fan measured by an attached flow rate indicator
  - Magnetic pick-up records each turbine rotation which is sent to a recording device and converted to a cumulative flow rate
  - Used for gas flows exceeding 0.28 m^3/min


High Volume Sampler


Ultrasonic Meter


Turbine Meter

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Performing a Field Study – Direct Measurement Tools

- **Vane anemometer:** Emissions pass through a rotating fan to measure the velocity of gas flowing from a vent or pipe
  - Fan revolutions are converted to a flow velocity
  - Volumetric flow rate can be determined by using the cross sectional area of emission source
  - Max measureable flow rate: 17 m^3/min, depending on the diameter of the device
  - Best used with a known cross-sectional area
- **Calibrated bagging:** Bags of known volume (e.g., 3 ft^3 or 0.085 m^3), made from antistatic, non-elastic plastic with a neck for easy sealing
  - Measurement made by timing bag expansion
  - Temperature of the gas is measured to allow correction of volume to standard conditions.
  - Measures leaks greater than 0.28 m^3/min; as large as 6.8 m^3/min

Vane Anemometer

Calibrated Bagging

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Measuring Seal Oil Degassing Vent Emissions with a Vane Anemometer

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Cost and Effectiveness of Physical Detection and Measurement Tools

Summary of Detection and Measurement Techniques		
Detection Techniques	**Effectiveness**	**Capital Cost**
Soap Solution	★★	$
Electronic Gas Detector	★	$$
Acoustic or Ultrasound Detector	★★	$$
TVA (Flame Ionization Detector)	★	$$
Infrared Leak Detection – IR Camera	★★★	$$$
Infrared Leak Detection – RMLD	★★	$$
Measurement Techniques	**Effectiveness**	**Capital Cost**
Calibrated Bagging	★	$
High Volume Sampler	★★★	$$
Rotameter	★★	$$
Ultrasonic Meter	★★★	$$
Source: EPA's Lessons Learned		

★ - Least effective

★★★ - Most effective

$ - Smallest capital cost

$$$ - Largest capital cost

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Common Sources of Emissions

Source	Quantification Methods	Mitigation Option
Emissions from crude oil and condensate storage tanks	Engineering Calculations, Software Tools, Emission Factors, Physical Detection and Measurement	Install Vapor Recovery Units on storage tanks
Reciprocating compressor rod packing leaks	Emission Factors, Physical Detection and Measurement	Economic replacement of rod packing
Centrifugal compressor seal oil degassing emissions	Engineering Calculations, Emission Factors, Physical Detection and Measurement	Replace wet seals with dry seals, Route degassing emissions for alternative uses
Gas powered pneumatic devices	Engineering Calculations, Emission Factors, Physical Detection and Measurement	Replace high bleed devices at end of life or retrofit pneumatic devices to reduce bleed rate
Fugitive leaks	Emission Factors, Physical Detection and Measurement	Directed Inspection and Maintenance

Oil/Condensate Storage Tank Emissions – Infrared Video

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Oil/Condensate Storage Tanks – Quantification Methods

- Combination of direct measurement and engineering calculations
  - Analyze a sample of liquids from low pressure separator and assume all methane dissolved in oil is released to atmosphere
  - Calculate hydrocarbon vapor emissions rate relative to oil throughput (if gas-oil ratio is known)
  - Use Vasquez-Beggs correlation equation
- Software tools
  - E&P Tank
- Emission factors (2012 U.S. Inventory)
  - Crude(<45° API): 0.2 m^3 methane/barrel/year
  - Condensate ($\geq$ 45° API): 3.3 m^3 methane/barrel/year
- Physical detection and measurement
  - IR camera is best (ground or aerial surveillance)
  - Recording/totalizing turbine meter on thief hatch
  - Ultrasonic Meter
    - Especially suited for high flow rates or leaks measured over a period of time

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Reciprocating Compressor Rod Packing Emissions – Infrared Video

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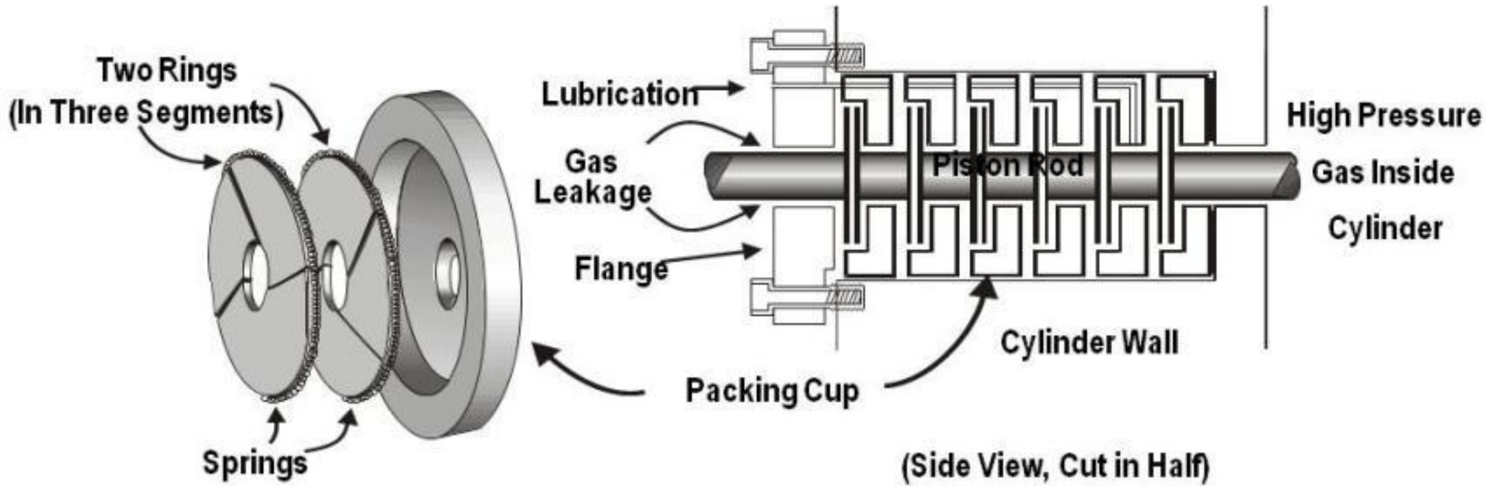
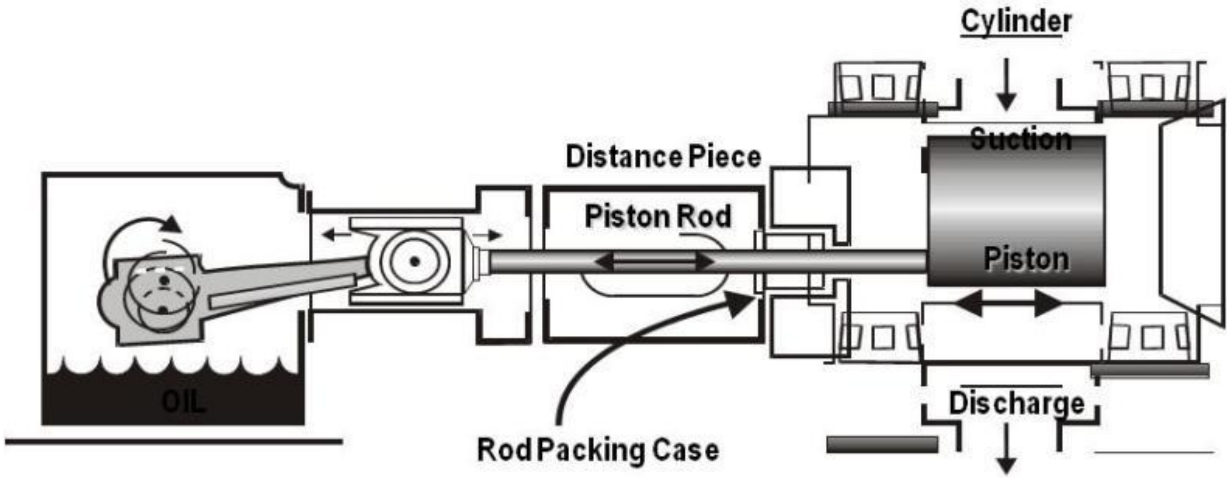
Reciprocating Compressor Rod Packing





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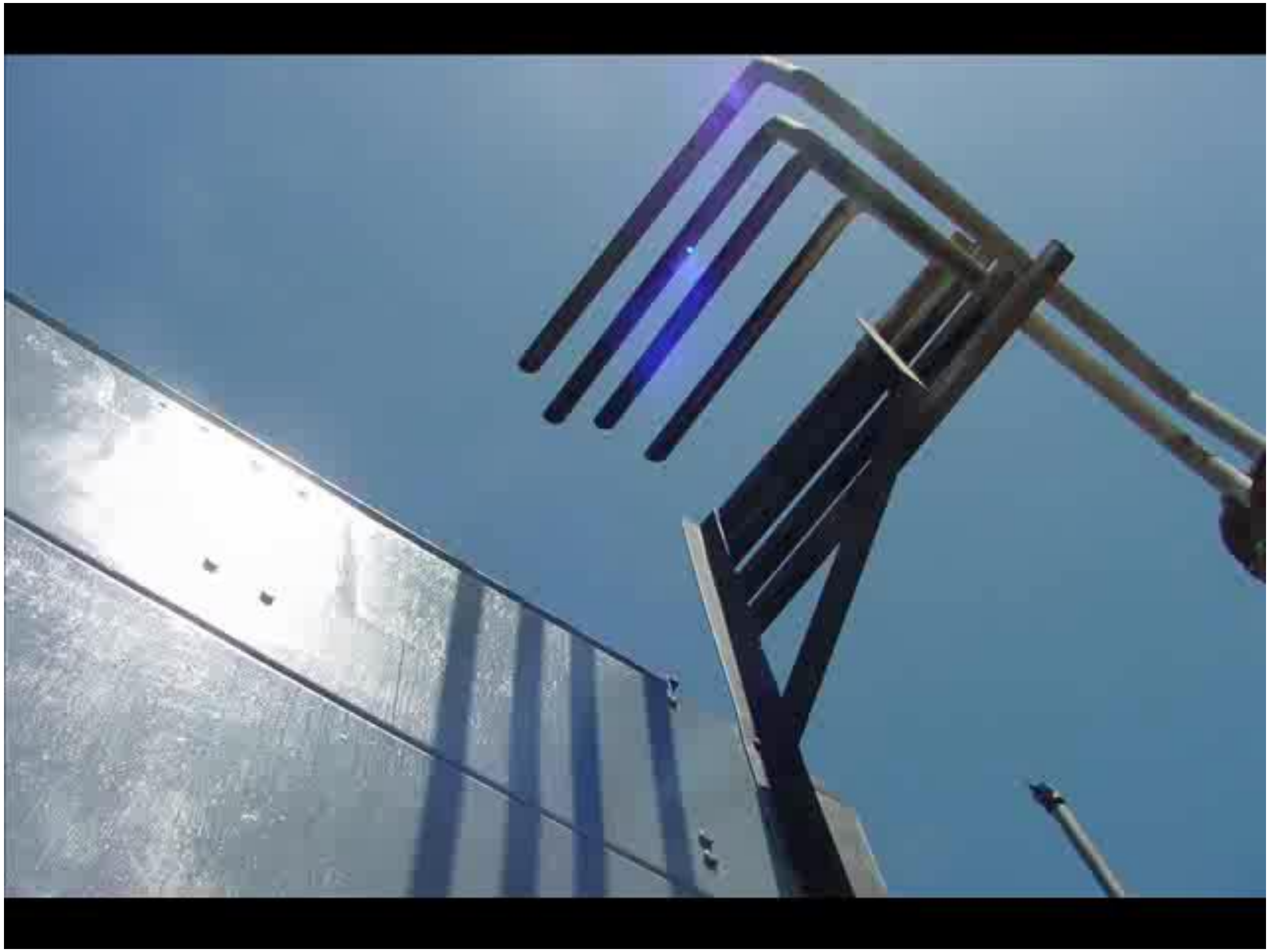
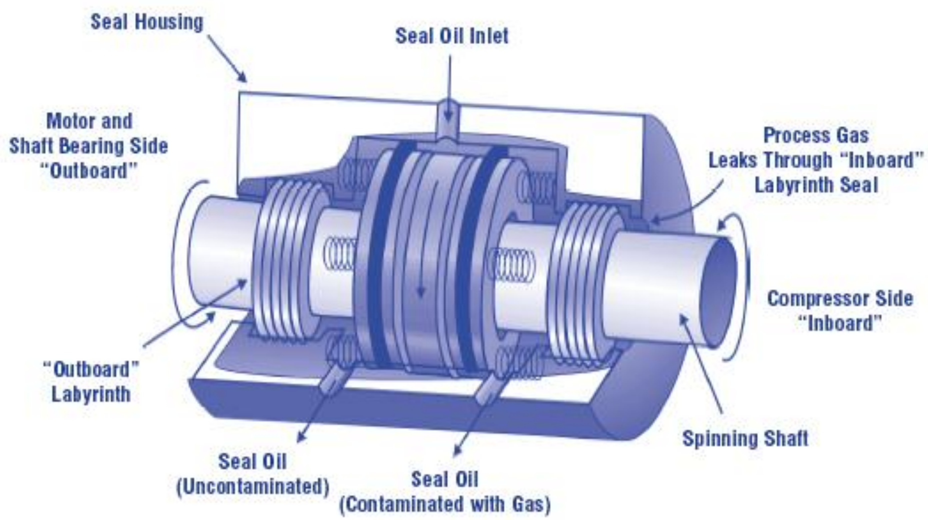
Reciprocating Compressors – Quantification Methods

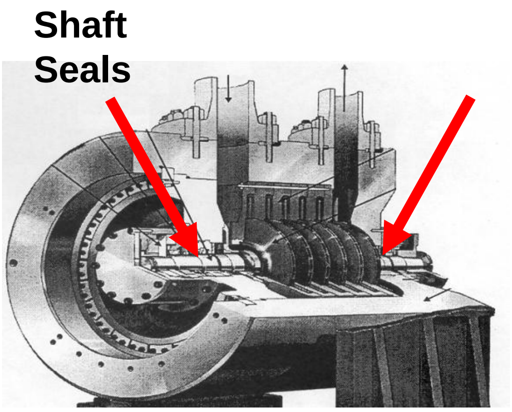
- Considerations of quantification options
  - Rod packing case connected to open-ended line or vent: direct measurement (calibrated bagging, high volume sampler, vane anemometer)
  - Rod packing case not connected to vent:
    - Use emission factor for rod packing, **or**
    - Measurement (high volume sampler) at open distance piece
  - Emissions typically vary with compressor operation mode
    - Need measurement of emissions during both modes to accurately characterize emissions
- Physical detection best done with IR camera, observing entire compressor
- Emission factors
  - Small onshore production compressors: 2.8 thousand m^3 methane/year
  - Large onshore production compressors: 157 thousand m^3 methane/year
  - Processing reciprocating compressor: 115 thousand m^3 methane/year

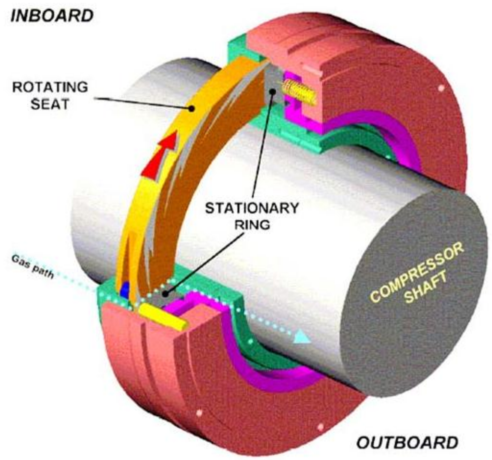
Centrifugal Compressor Wet Seal Degassing Emissions – Infrared Video

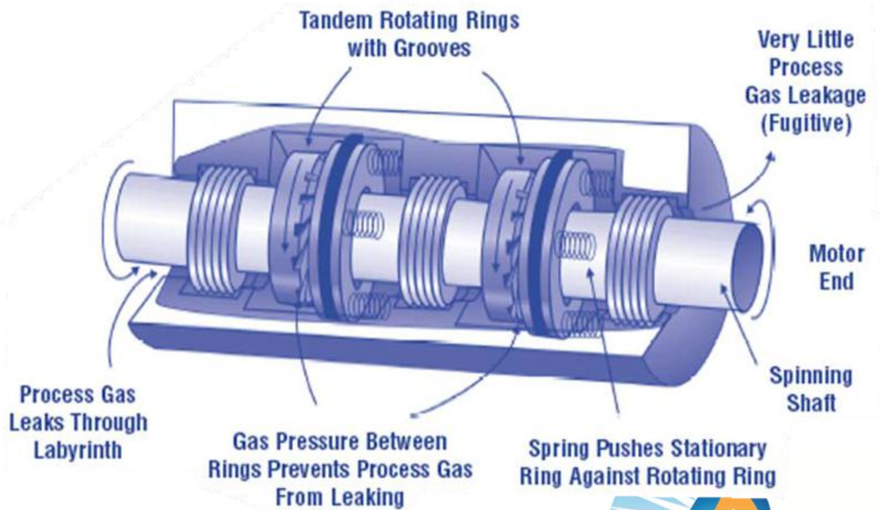


Centrifugal Compressor Wet Seals









Centrifugal Compressor Wet Seals – Quantification Methods

- Emission Factors
  - Centrifugal compressor (wet seals): 600 to 3,000 thousand m^3 methane/year
  - Centrifugal compressor (dry seals): 15 to 90 thousand m^3 methane/year
- Physical detection and measurement
  - Detection of degassing emissions typically at vent located away from compressor unit
  - Vent is normally located in an unreachable area (e.g., roof of building, other high location) so infrared camera is best
  - Degassing emissions can be measured with a vane anemometer, ultrasonic meter, calibrated bagging

Degassing Emissions When Using Recovery System – Infrared Video

CCP MODULE 4905 GT-1809
EXTERIOR VENTS TO ATMOSPHERE

Gas Powered Pneumatic Devices – Infrared Video

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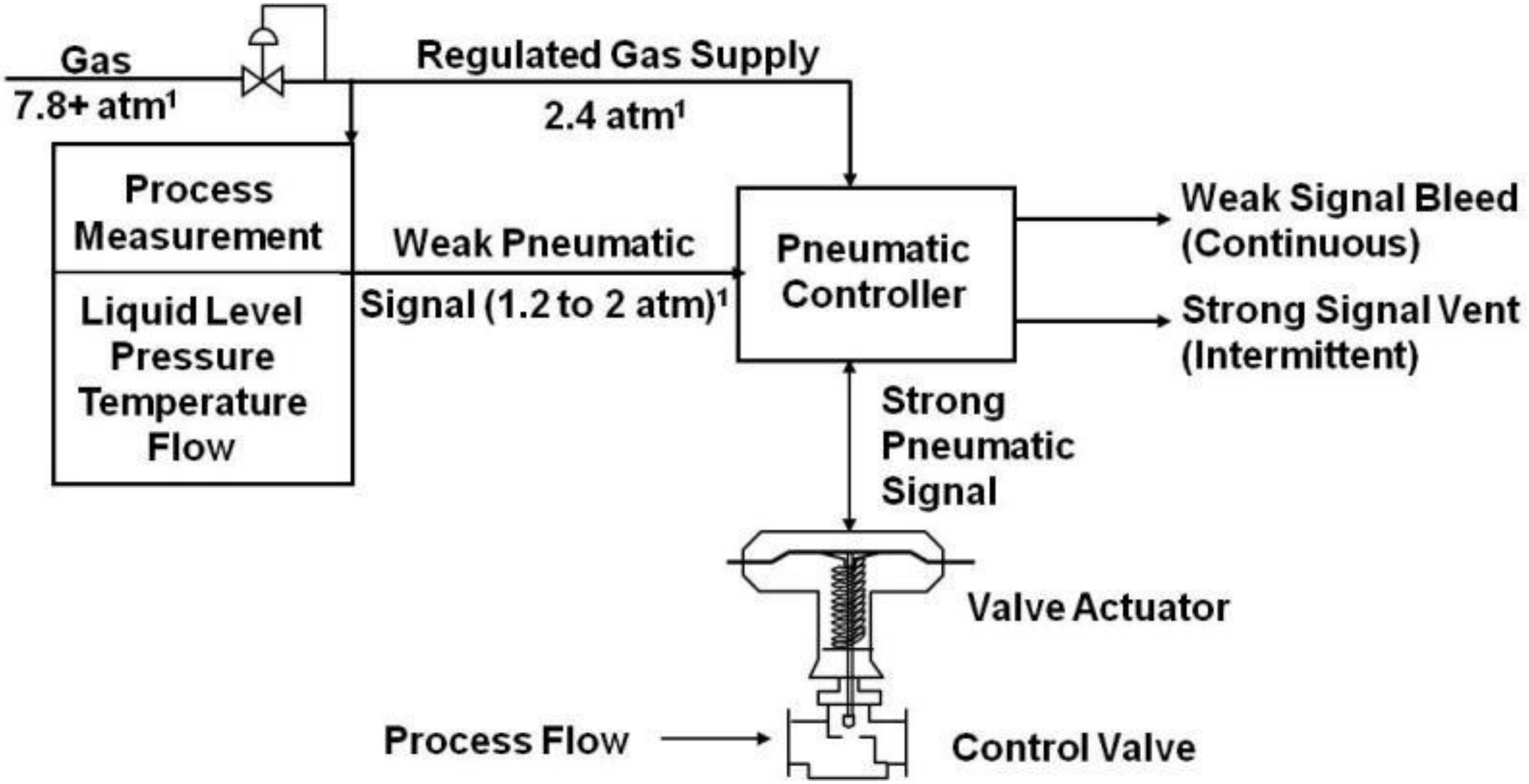
Gas Powered Pneumatic Devices

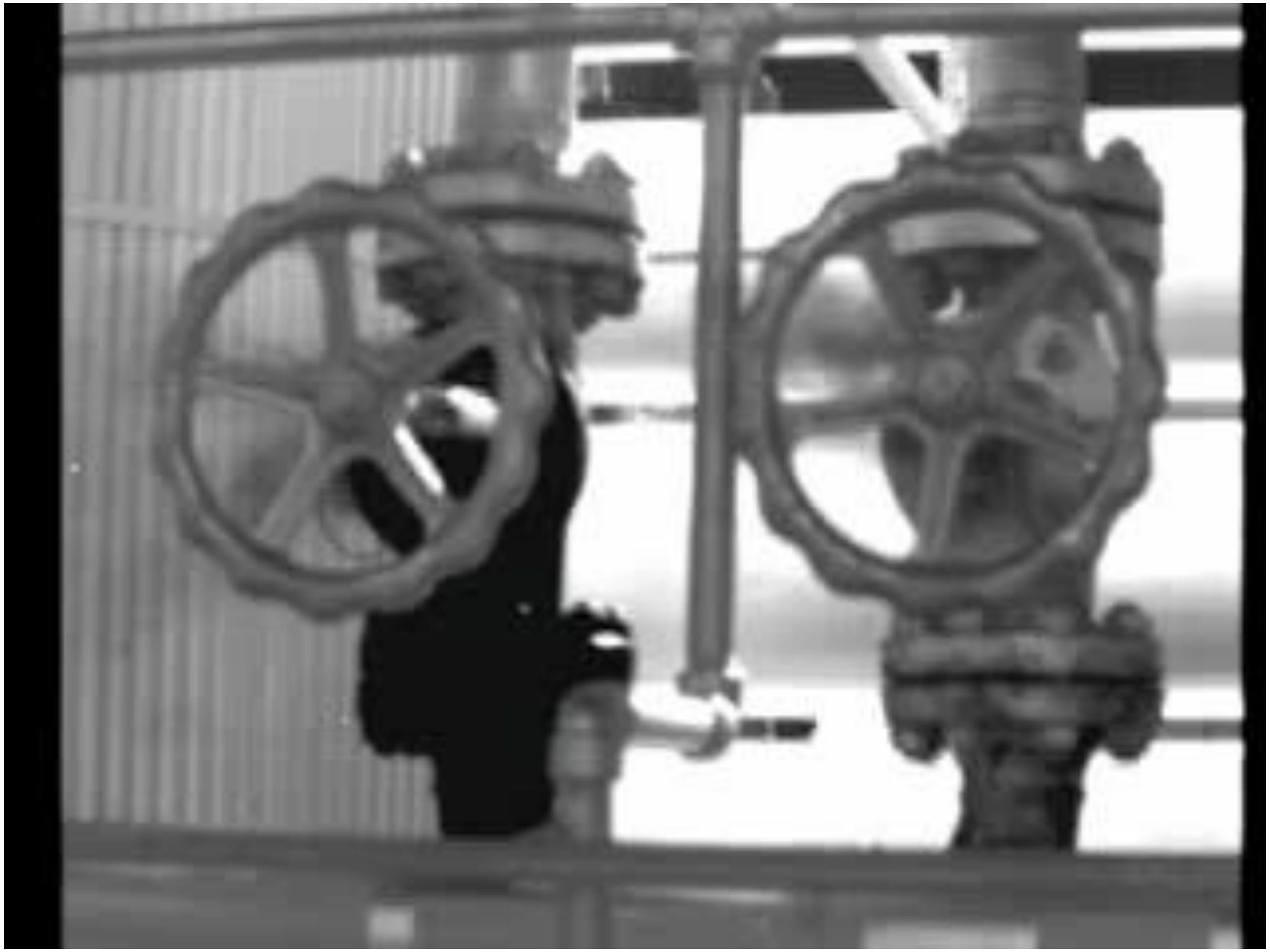


Gas Powered Pneumatic Devices – Quantification Methods

- Engineering calculations
  - Use equipment counts with specific device model bleed rate data as available from manufacturer
- Emission factors[1]
  - Natural Gas Operations:
    - 32.7 m^3 methane per day for high bleed controllers
    - 1.2 m^3 methane per day for low bleed controllers
  - Oil Operations:
    - 9.3 m^3 methane per day for high bleed controllers
    - 1.5 m^3 methane per day for low bleed controllers
- Physical detection and measurement
  - Detection of bleed is typically audible at valve controller
  - Bleed rate can be measured with calibrated bag or high volume sampler
  - Measure bleed rates of several similar type controllers, such as level, temperature, or pressure controllers

[1]Subpart W GHG Reporting Rule

Fugitive Equipment Leaks – Infrared Video



Fugitive Equipment Leaks

Facility Type	Number of Components surveyed Per Site	Leak Frequency (%)	Emissions From All Leaking Sources		Contribution to THC Emissions
			Methane	Value	Top 10 Sources
			(tonnes/year)	($/year)	(%)
Gas Plants	56461	1.7	997	500253	35
	16050	3.5	471	320608	36
	14424	3.0	1412	558665	64
	14174	4.0	1376	553248	36
	11556	3.3	1215	621061	33
	13133	2.5	186	386538	57
	13471	1.2	299	178744	93
	3672	10.3	2334	1262874	77
	5979	0.6	29	11863	93
TOTAL	**148920**		**8320**	**4393854**	
AVERAGE	**16547**	**2.5**	**924**	**488206**	**54**
Compressor Stations	608	5.1	110	61572	90
	4626	1.1	98	49184	83
	3084	0.7	169	98802	95
	6168	1.0	194	103508	64
	1568	4.2	80	33552	80
	224	1.3	0	189	100
	1391	1.9	4	2367	88
	2115	1.8	67	27855	89
	2516	1.1	45	18901	91
TOTAL	**22300**		**767**	**395928**	
AVERAGE	**2478**	**1.5**	**85**	**43992**	**83**
Well Sites	1474	0.2	1	501	100
	1617	1.5	1	351	88
	1797	0.4	1	585	100
TOTAL	**4888**		**3**	**1437**	
AVERAGE	**407**	**0.7**	**0**	**120**	**97**

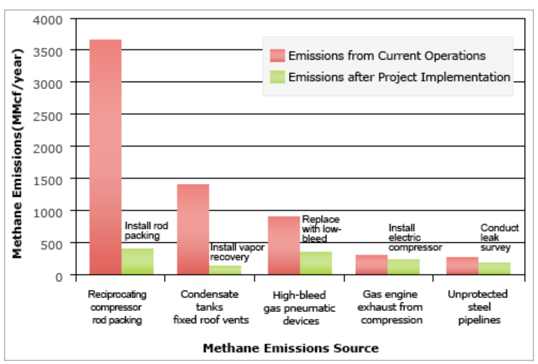
- Value of emissions based on natural gas price of $6.78/GJ

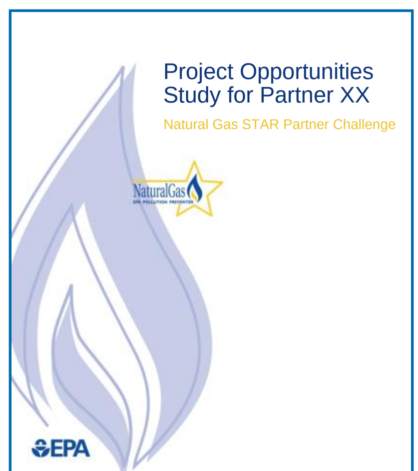
Fugitive Equipment Leaks – Quantification Methods

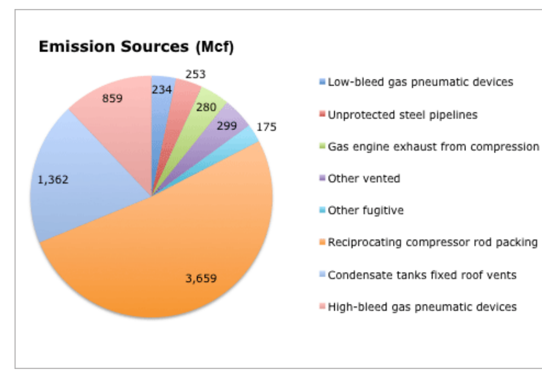
- Emission factors
  - These are provided in the U.S. GHG Reporting Rule (Subpart W)
  - The emission factors are broken out by sector
  - Different emission factors provided depending on whether equipment or component counts are
- Physical detection and measurement
  - Detection is most cost-effective by IR camera
  - Measurement:
    - High volume sampler
    - TVA or OVA and correlation equations for large populations of components in inventories

Feasibility Study – Options to Reduce Emissions

- Analysis that selects specific emissions control technologies for major emissions sources
- Estimates project implementation costs and benefits
- End product is a detailed report that provides:
  - Descriptions of recommended technologies and practices to implement
  - Financial metrics for each project, such as projected net present values and payback periods







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Summary of Mitigation Options

- Installing Vapor Recovery Units on Storage Tanks
- Reducing Methane Emissions from Compressor Rod Packing Systems
- Replacing Wet Seals with Dry Seals in Centrifugal Compressor or Capture Seal Oil Vent Emissions
- Options for Reducing Methane Emissions From Pneumatic Devices in the Natural Gas Industry
- Directed Inspection and Maintenance at Gas Processing Plants and Booster Stations
- Visit the Natural Gas STAR website for more details

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Partner Experience: ONGC Technology Transfer

- ONGC, India's largest oil and gas producer, joined the Natural Gas STAR International (NGSI) in 2007 (first state-owned Partner company)
- EPA and ONGC conducted a series of successful technology transfer workshops at four sites to promote methane mitigation opportunities (December 2007)
- Based on the success of the workshops:
  - Conducted desktop prefeasibility analyses to estimate emissions sources at seven sites
  - EPA and ONGC conducted four onsite measurement studies to assess key methane emission sources and potential mitigation measures (May 2008)
  - Presented measurement study results and recommendations to ONGC Board of Directors (September 2008)
  - Presented at various GMI meetings
    - GMI Partnership-Wide Meeting 2011 (October 2011)
    - GMI Oil and Gas Subcommittee Meeting (April 2012)

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Partner Experience: ConocoPhillips Oil/Condensate Storage Tank VRUs

- Rotary vane VRU's due to wide range of volumes of gas and low discharge pressure
- Project for 9 Tank Batteries
  - Purchase Price for 9 VRU's: $475,000
  - Estimate Install Cost: $237,500
  - Total Capital Costs: $712,500
- Approximate Gas Revenue
  - 1,050 MCFD x $6/MCF* X 30 days = $189,000/ month
  - Payback: < 4 months
  - Installed in 2005 & early 2006; all locations continue to generate incremental revenue and meet environmental compliance goals today

* Value of high-Btu gas in 2005 and 2006

Baker, MT ConocoPhillips VRU installation
Pictures Courtesy of Hy-Bon Engineering

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GMI Partners Embrace the Program

- To date, GMI and Natural Gas STAR Partners have performed numerous desktop and field measurement studies
  - Identified cost effective options to help mitigate GHG emissions and increase revenues
- Contractors such as ICF help companies compile and analyze data
  - To date, ICF has performed over 20 desktop, field, and feasibility studies in 12 countries

Contact and Further Information

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globalmethane.org

Recommended Technologies (Arabic)

epa.gov/gasstar/tools/arabic/index.html

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