Mitigation Options for Key Sources
Overview of technologies and practices

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Distribution Emission Mitigation Options

- Compressor emission reductions
  - Rod packing replacement from reciprocating compressors
  - Re-routing wet seal degassing emissions from centrifugal compressors
  - Replacing wet seals with dry seals in centrifugal compressors

- Directed Inspection and Maintenance (DI&M)
Sources of Methane Emissions from Oil and Gas Operations

Oil Production
- Venting of casinghead gas
- Flash emissions from crude oil storage tanks

Natural Gas Production & Processing
- Well completions, blowdowns and workovers
- Reciprocating compressor rod packing
- Venting from glycol reboilers on dehydrators
- Processing plant leaks
- Gas-driven pneumatic devices

Gas Transmission
- Venting of gas for maintenance or repair of pipelines or compressors

Gas Distribution
- Leaks from mains and service lines
- Leaks at metering and regulating stations
- Pipeline blowdowns

Picture courtesy of American Gas Association

Red Numbers are Emissions from Each Sector in U.S.
LDC System Schematic

LDC A Ownership of Distribution Pipelines

LDC A Ownership of Transmission pipelines

Transmission Ownership of Transmission pipelines

Custody Transfer City Gate Station A

Non-Custody Transfer City Gate Station B

Compressor Station A

Compressor Station B

Distribution Network
Compressor Reductions
Methane Losses from Compressors in Distribution

- LDCs use compressors to move gas from custody transfer gates to other sections of distribution system
- Typically reciprocating compressors are in operation
  - Resulting in methane emissions from worn rod packing
- Centrifugal compressors can also be used
  - Resulting in wet seal degassing methane emissions
Methane Losses from Reciprocating Compressors

- Reciprocating compressor rod packing leaks some gas by design
  - Newly installed packing may leak 60 cubic feet per hour (cf/hour)
  - Worn packing has been reported to leak up to 900 cf/hour
- A series of flexible rings fit around the shaft to prevent leakage
- Leakage may still occur through nose gasket, between packing cups, around the rings, and between rings and shaft

![Diagram of Reciprocating Compressor Components](image)
Steps to Determine Economic Rod Packing Replacement

- Measure rod packing leakage
  - When new packing installed – after worn-in
  - Periodically afterwards
- Determine cost of packing replacement
- Calculate economic leak reduction
- Replace packing when leak reduction expected will pay back cost
Cost of Rod Packing Replacement

- Assess costs of replacements
  - A set of rings: $675 to $1,100
    (with cups and case) $2,100 to $3,400
  - Rods: $2,500 to $13,500

Special coatings such as ceramic, tungsten carbide, or chromium can increase rod costs

Source: CECO
Calculate Economic Leak Reduction

- **Determine economic replacement threshold**
  - Partners can determine economic threshold for all replacements
  - This is a capital recovery economic calculation

Economic Replacement Threshold (cf/hour) = \( \frac{CR \times DF \times 1,000}{(H \times GP)} \)

**Where:**
- **CR** = Cost of replacement ($)
- **DF** = Discount factor at interest \( i = \)
- **H** = Hours of compressor operation per year
- **GP** = Gas price ($/thousand cubic feet)

\[ DF = \frac{i(1 + i)^n}{(1 + i)^n - 1} \]
Economic Replacement Threshold

- Example: Payback calculations for new rings and rod replacement
  
  CR = $1,620 for rings + $9,450 for rod
  CR = $11,070
  HR = 8,000 hours per year
  GP = $3/Mcf
  DF @ i = 10% and n = 1 year
  DF @ i = 10% and n = 2 years

  Rings Only:

  \[
  ER = \frac{11,070 \times 1.1 \times 1,000}{8,000 \times 3}
  \]

  \[= 508 \text{ scf per hour}\]

<table>
<thead>
<tr>
<th>Leak Reduction Expected (cf/hour)</th>
<th>Payback (months)</th>
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</thead>
<tbody>
<tr>
<td>55</td>
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Methane Emissions from Centrifugal Compressors

- High pressure seal oil circulates between rings around the compressor shaft
- Oil absorbs the gas on the inboard side
  - Little gas leaks through the oil seal
  - Seal oil degassing vents methane to the atmosphere
- Wet seals leak little gas at the seal face
- Most emissions are from seal oil degassing
- Seal oil degassing may vent 40 to 200 cf/minute

Source: PEMEX
Gas Recovery from Centrifugal Compressors

- Gas capture system currently used by BP on the North Slope of Alaska
  - Wet seal oil degassing emissions recovered with 4 possible destinations for gas
    - Flare
    - Low pressure suction side of compressor
    - Low pressure fuel gas for boiler
    - Compressor turbine fuel
- Recovering gas eliminates cost for conventional retrofit with dry seals
- In distribution, gas may be sent to low pressure section of distribution system
Gas Capture System in Distribution

*Note: New equipment in red*

- Compressor suction/recycle
- High pressure turbine fuel gas
- Gas Demister
- Less gas vented to atmosphere
- Low Pressure Distribution System
- Low pressure fuel gas

*Seal oil is at compressor discharge pressure*
Seal Oil Degassing Pots
First Stage Gas Filter Vessel

This is the first stage gas demister/filter vessel.

Here is a person for size reference.

This pipe is NOT the demister/filter vessel.
Second Stage Gas Filter Vessel

This is the second stage, high efficiency gas demister/filter vessel required for turbine fuel gas. It is newly installed and not yet painted.

This is the first stage gas demister/filter vessel (behind a vertical pipe.)
Traditional Solution: Retrofitting/Installing Dry Seals

- **Dry seals:**
  - 30 to 180 cf/hour (0.5 to 3 cf/minute) leak rate
  - Significantly less than the 40 to 200 cf/minute from wet seals
- Very cost-effective option for new compressors
- Significant capital costs and downtime for retrofitting compressors
  - See *Lessons Learned* for more info
- Alternative exists for more cost-effective seal oil degassing and vapor recovery retrofit with less downtime
- Dry seals keep gas from escaping while rotating with the shaft
What is the Problem?

- Gas leaks are *invisible*, *unregulated* and *go unnoticed*
- Fugitives account for most distribution emissions\(^1\)
  - 18 Bcf of from metering and regulator stations in 2011
  - 11 Bcf from other regulator stations in 2011
  - 6 Bcf from customer meter leaks in 2011
- Distribution fugitive methane emissions depend on the technology in use, operating practices, equipment age and maintenance

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What is Directed Inspection & Maintenance?

- Directed Inspection and Maintenance (DI&M)
  - Cost-effective practice by definition
  - Find and fix significant leaks
  - Choice of leak detection technologies
  - Strictly tailored to company’s needs

- DI&M is NOT the regulated volatile organic compound leak detection and repair (VOC LDAR) program
How Do You Implement DI&M?

CONDUCT baseline survey

SCREEN and MEASURE leaks

FIX on the spot leaks

ESTIMATE repair cost, fix to a payback criteria

DEVELOP a plan for future DI&M

RECORD savings/REPORT to Gas STAR
How Do You Detect the Leaks?

- **Screening - find the leaks**
  - Soap bubble screening
  - Electronic screening (sniffer)
  - Toxic Vapor Analyzer (TVA)
  - Organic Vapor Analyzer (OVA)
  - Ultrasound Leak Detection
  - Acoustic Leak Detection
  - Optical Leak Imaging
# Screening and Measurement Summary

## Summary of Screening and Measurement Techniques

<table>
<thead>
<tr>
<th>Instrument/Technique</th>
<th>Effectiveness</th>
<th>Approximate Cost</th>
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<tbody>
<tr>
<td>Soap Solution</td>
<td>★★</td>
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<tr>
<td>Electronic Gas Detectors</td>
<td>★</td>
<td>$$</td>
</tr>
<tr>
<td>Acoustic Detection/ Ultrasound Detection</td>
<td>★★</td>
<td>$$$</td>
</tr>
<tr>
<td>TVA (FID)</td>
<td>★</td>
<td>$$$</td>
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<tr>
<td>Optical Leak Imaging</td>
<td>★★★</td>
<td>$$$</td>
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<tr>
<td>Bagging</td>
<td>★</td>
<td>$$$</td>
</tr>
<tr>
<td>High Volume Sampler</td>
<td>★★★</td>
<td>$$$</td>
</tr>
<tr>
<td>Rotameter</td>
<td>★★</td>
<td>$</td>
</tr>
</tbody>
</table>

Source: EPA’s Lessons Learned Study

* - Least effective at screening/measurement

*** - Most effective at screening/measurement

$ - Smallest capital cost

$$ - Smallest capital cost

$$$ - Largest capital cost
How Do You Measure the Leaks?

- Evaluate the leaks detected - measure results
  - High Volume Sampler
  - Toxic Vapor Analyzer (correlation factors)
  - Rotameters
  - Calibrated Bag
  - Engineering Method

Leak Measurement Using a High Volume Sampler
DI&M by Remote Leak Detection

- The trick has always been finding those few needles in the haystack of leaking components
  - Most large leaks (>3 scf/hr) clearly seen
- Real-time detection of gas leaks
  - Quicker identification & repair of leaks
  - Aerial surveillance applications
  - Screen hundreds of components an hour
  - Easily screen inaccessible areas
Contact and Further Information

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Natural Gas STAR Program:
epa.gov/gasstar/index.html

Recommended Technologies:
epa.gov/gasstar/tools/recommended.html