US EPA’s Natural Gas STAR International: An Overview of Emission Reduction Best Practices

1st Asia Pacific Global Methane Initiative Oil & Gas Sector Workshop

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Don Robinson
ICF International
Agenda

- U.S. Oil & Gas Industry Methane Emissions
- U.S. Production Sector Methane Emissions
- Top Production Sector Fugitive and Vented Methane Emission Sources and Reduction Options
  - Tank Venting
  - Compressor Methane Losses
  - Pneumatic Instrument Venting
  - Dehydrators
- Contacts and Further Information
Oil and Gas Methane Emissions by Sector – U.S. Example

- 2009 U.S. methane emissions from oil and natural gas industry:
  17.7 Bcm (3.8% of total U.S. greenhouse gas emissions)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Bcm</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil Downstream</td>
<td>0.1 Bcm</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Processing</td>
<td>1.2 Bcm</td>
<td>7%</td>
</tr>
<tr>
<td>Transmission and Storage</td>
<td>3.1 Bcm</td>
<td>18%</td>
</tr>
<tr>
<td>Distribution</td>
<td>2.0 Bcm</td>
<td>11%</td>
</tr>
<tr>
<td>Oil and Gas Production</td>
<td>11.2 Bcm</td>
<td>64%</td>
</tr>
</tbody>
</table>

Bcm = billion cubic meters

Note: Totals may not sum due to independent rounding

2009 Production Sector Methane Emissions (11.2 Bcm)

Bcm = billion cubic meters
Note: Totals may not sum due to independent rounding

- Pneumatic Devices: 1.9 Bcm
- Dehydrators and Pumps: 0.5 Bcm
- Compressor Fugitives, Venting, and Engine Exhaust: 0.5 Bcm
- Storage Tank Venting: 0.4 Bcm
- Meters and Pipeline Leaks: 0.3 Bcm
- Other Sources: 0.4 Bcm
- Offshore Operations: 1.0 Bcm
- Well Venting and Flaring: 6.1 Bcm

Top Production Sector Fugitive and Vented Methane Emissions Sources and Reduction Options

- **Tank Venting**
  - Install vapor recovery units and micro turbine generators

- **Methane Losses Reciprocating Compressors**
  - Economic rod packing replacement in reciprocating compressors

- **Methane Losses from Centrifugal Compressors**
  - Replace centrifugal compressor wet seals with dry seals
  - Route seal oil degassing vent and blowdown gas vent to fuel line

- **Pneumatic Instrument Venting**
  - Replace high bleed with low bleed or instrument air

- **Dehydrators**
  - Optimize circulation rate
  - Install flash tank
  - Install electric pump
Tank Venting

- **Problem:** Gas is vented from low-pressure crude oil and gas condensate storage vessels due to flashing, working, and standing losses.

- **Best Management Practices (BMPs):** Vapor recovery towers (VRT) and units (VRU) capture tank vapors using compressors.

Source: Anadarko, VRT
The Heart of a VRU is the Compressor

- Reciprocating and centrifugal compressors are best in dry gas service – NOT vapor recovery
  - Vapor recovered from storage tanks will be “wet” gas (at the liquid saturation point)
  - Wet gas fouls the valves & seals / compromises lube oil

- VRU installations commonly use compressors that work well with wet gas

- Recommended choices
  - Rotary compressors – require electrical power or engine driver
  - Sliding vane or rotary screw compressors
  - Scroll compressors
What is the Recovered Gas Worth?

- Value depends on heat content of gas
- Value depends on how gas is used
  - On-site fuel
    - Valued in terms of fuel that is replaced
  - Natural gas pipeline
    - Measured by the higher price for rich (higher heat content) gas
  - Gas processing plant
    - Measured by value of natural gas liquids and methane, which can be separated
Case Study: Analysis of Methane Recovery from Colombia Tank Battery

- EPA analyzed company-provided operational data to provide Columbia with recommendations for cost-effective methane mitigation
  - Two sources of wasted methane: methane from gas-liquid separator flared and methane from oil-water separator vented
  - Currently importing expensive diesel to supplement grid electricity

**Preliminary proposal**
- Install VRU to capture vented emissions
- Install compressor to increase gas condensate output and improve gas quality
- Install Reciprocating Engine/Generator to burn previously flared gas for electricity

**Estimated Benefits**
- Carbon emissions reduction of 283,000 m³ per year methane or 80,000 TCO2e per year
- 8 Mega Watts (MW) of power generated
- 14 months simple payback and 87% internal rate of return
Methane Losses from Reciprocating Compressors

- Reciprocating compressor rod packing leaks some gas by design
  - Newly installed packing may leak 0.3 to 1.7 cubic meters per hour (m³/hr)
  - Worn packing has been reported to leak up to 25.5 m³/hr
- BMP: economic replacement of rod packing
Reciprocating Compressor Rod Packing

- 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
Solution: Economic Replacement

- Measure rod packing leakage
  - When new packing installed—after worn-in
  - Periodically afterwards
- Determine cost of packing replacement
- Determine economic replacement threshold
  - Partners can determine economic threshold for all replacements
  - This is a capital recovery economic calculation
- Replace packing when leak reduction expected will pay back cost

Economic Replacement Threshold (m³/hour) = \( \frac{CR \times DF \times 1,000}{(H \times GP)} \)

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

\[ DF = \frac{i(1+i)^n}{(1+i)^n - 1} \]
Monitored emissions at two locations
- Unit A leakage as high as 301 liters/minute (18 m³/hour)
- Unit B leakage as high as 105 liters/minute (6 m³/hour)

Installed low emission packing (LEP)
- Testing is still in progress
- After 3 months, leak rate showed zero leakage increase
Methane Losses from Centrifugal Compressors

- Centrifugal compressor wet seals leak little gas at the seal face
  - The majority of methane emissions occur through seal oil degassing which is vented to the atmosphere
  - Seal oil degassing may vent 1.1 to 5.7 m$^3$/minute to the atmosphere
  - One Natural Gas STAR Partner reported emissions as high as 2,124 m$^3$/day

- BMPs:
  - Replace wet seals with dry seals
  - Route blowdown vent to the fuel line
Centrifugal Compressor Wet Seals

- High pressure seal oil circulates between rings around the compressor shaft
- Gas absorbs in the oil on the inboard side
  - Little gas leaks through the oil seal
  - Seal oil degassing vents methane to the atmosphere

Source: PEMEX
Wet Seals Solution: Dry Seals

- Dry seal springs press stationary ring in seal housing against rotating ring when compressor is not rotating
- At high rotation speed, gas is pumped between seal rings by grooves in rotating ring creating a high pressure barrier to leakage
- Only a very small amount of gas escapes through the gap
- 2 seals are often used in tandem
- Can operate for compressors up to 206 atmospheres (atm) safely
Industry Experience – PEMEX

- PEMEX had 46 compressors with wet seals at a production site
- Converted three to dry seals
  - Cost 444,000 USD/compressor
  - Saves 20,500 Mcf/compressor/year in gas
  - Saves 126,690 USD/compressor/year in gas
- 3.5 year payback from gas savings alone
- Plans for future dry seal installations

Source: PEMEX
Pneumatic Instrument Venting

Problem: Process controllers, chemical pumps, and glycol pumps often vent pressurized natural gas used for pneumatic actuation.

BMPs:
- Retrofit high-bleed devices to low-bleed
- Replace natural gas with compressed air
- Use electric or solar powered pumps
Dehydrators: Methane Losses

- Produced gas is saturated with water, which must be removed for long distance gas pipelines
- Glycol dehydrators are the most common equipment used to remove water from gas
  - Most use triethylene glycol (TEG)
- Glycol dehydrators emit methane
  - Methane, Non-Methane Hydrocarbons (NMHC), Hazardous Air Pollutants (HAPs), Benzene, Toluene, Ethylbenzene, Xylene (BTEX) from reboiler vent
  - Methane from pneumatic controllers and glycol circulation pumps

Source: www.prideofthehill.com
**Basic Glycol Dehydrator System Process Diagram**

- **Inlet Wet Gas**
- **Motive Gas Bypass**
- **Dry Sales Gas**
- **Flash Tank**
- **Glycol Contactor**
- **Driver**
- **Glycol Energy Exchange Pump**
- **Lean TEG**
- **Glycol Reboiler/Regenerator**
- **Fuel Gas or Waste Heat**
- **Gas Recovery**
- **Reduced Emissions**
- **Low Capital Cost/Quick Payback**
### Is Recovery Profitable?

#### Economic Analysis of Dehydrator Options Based on Natural Gas STAR Partner Experiences

<table>
<thead>
<tr>
<th>Option</th>
<th>Capital Costs</th>
<th>Annual O&amp;M Costs</th>
<th>Emissions Savings</th>
<th>Payback Period¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimize Circulation Rate</td>
<td>Negligible</td>
<td>Negligible</td>
<td>11 to 1,100 Mcm/year</td>
<td>Immediate</td>
</tr>
<tr>
<td>Install Flash Tank</td>
<td>$6,500 to $18,800</td>
<td>Negligible</td>
<td>35 to 305 Mcm/year</td>
<td>4 to 11 months</td>
</tr>
<tr>
<td>Install Electric Pump</td>
<td>$1,400 to $13,000</td>
<td>$165 to $6,500</td>
<td>10 to 1,020 Mcm/year</td>
<td>&lt; 1 month to several years</td>
</tr>
</tbody>
</table>

¹ Based on gas price of $250/thousand cubic meters (Mcm)

More detail is available on these practices and over 80 others online at:
epa.gov/gasstar/tools/recommended.html

For further assistance, direct questions to:

Scott Bartos
EPA Natural Gas STAR Program
bartos.scott@epa.gov
+1 (202) 343-9167

Don Robinson
ICF International
drobinson@icfi.com
+1 (703) 218-2512