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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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

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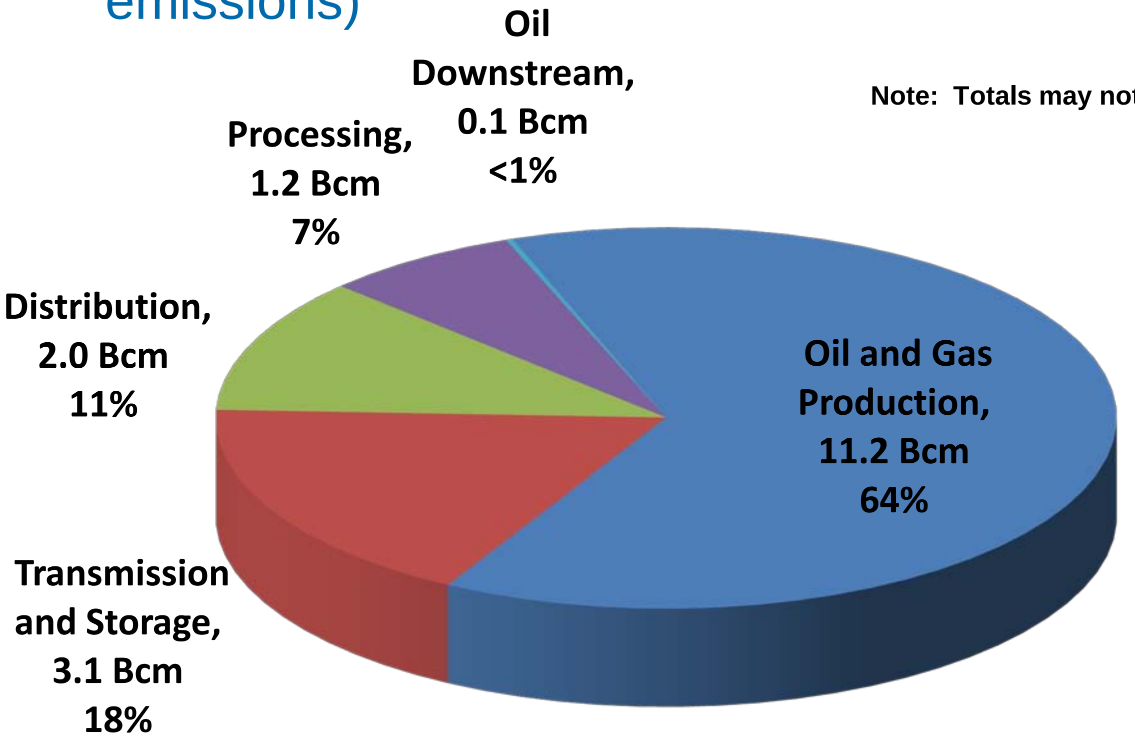
Oil and Gas Methane Emissions by Sector – U.S. Example

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



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

EPA. *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 – 2009.* April, 2011. Available on the web at: epa.gov/climatechange/emissions/usinventoryreport.html.

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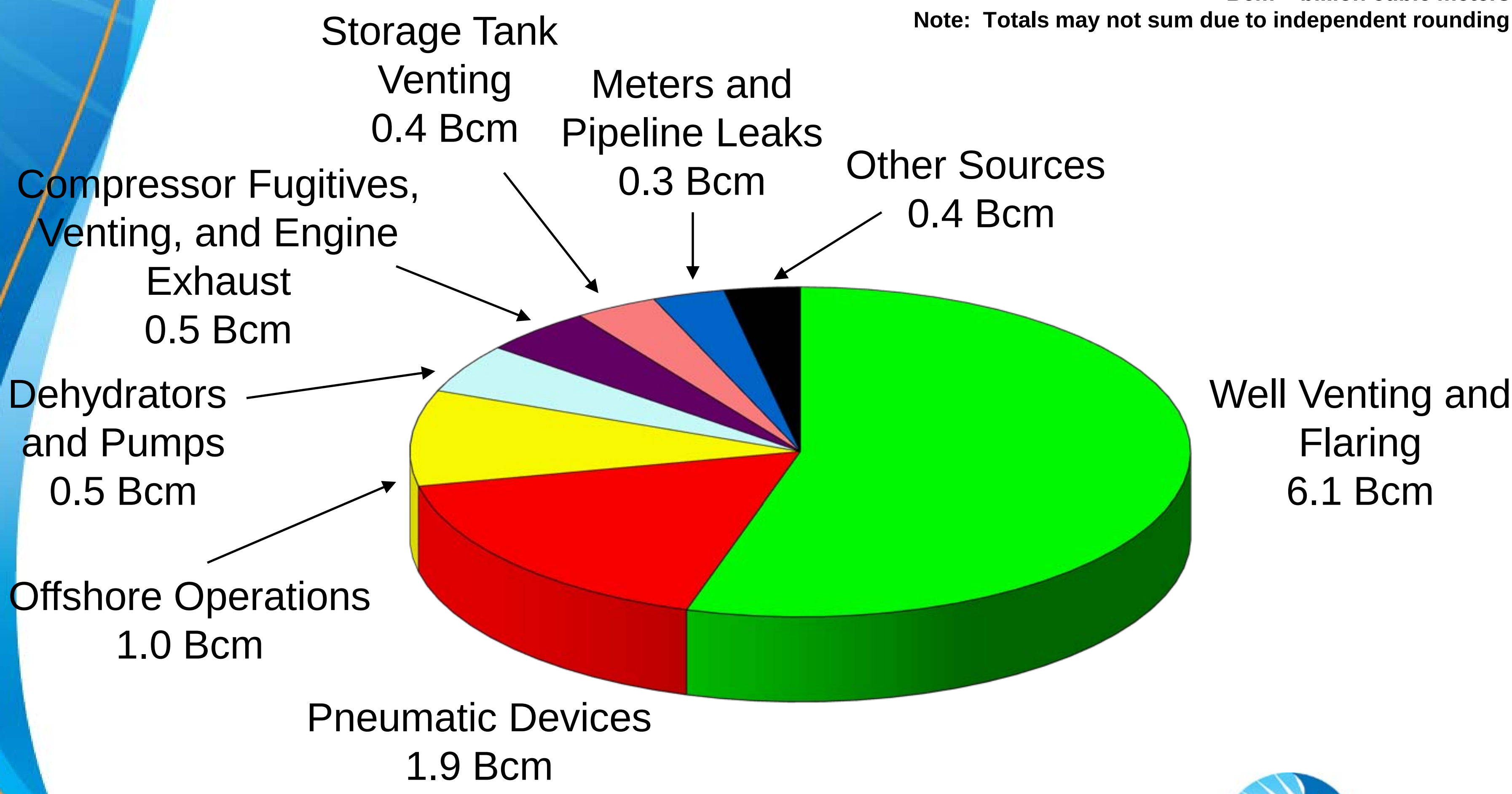
2009 Production Sector Methane Emissions (11.2 Bcm)

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



EPA. *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 – 2009.* April, 2011. Available on the web at: epa.gov/climatechange/emissions/usinventoryreport.html.

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

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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

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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

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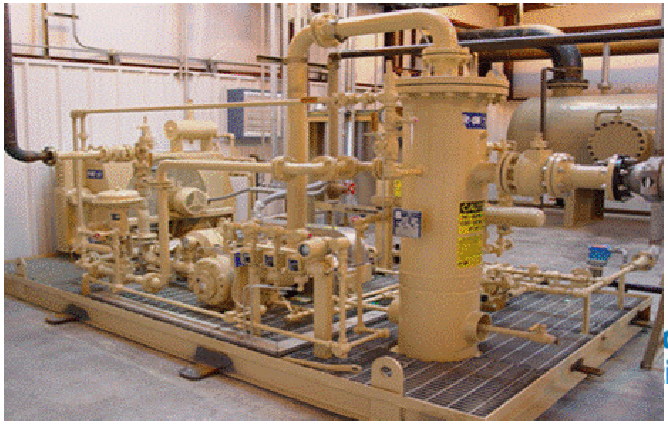
What is the Recovered Gas Worth?

- 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 m^3 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

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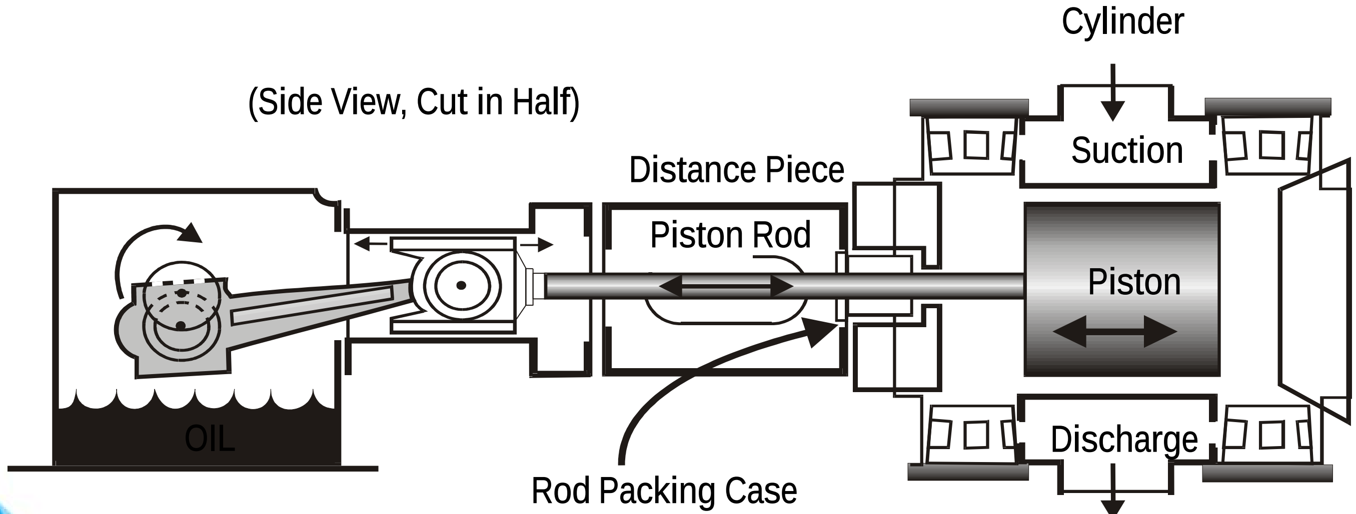
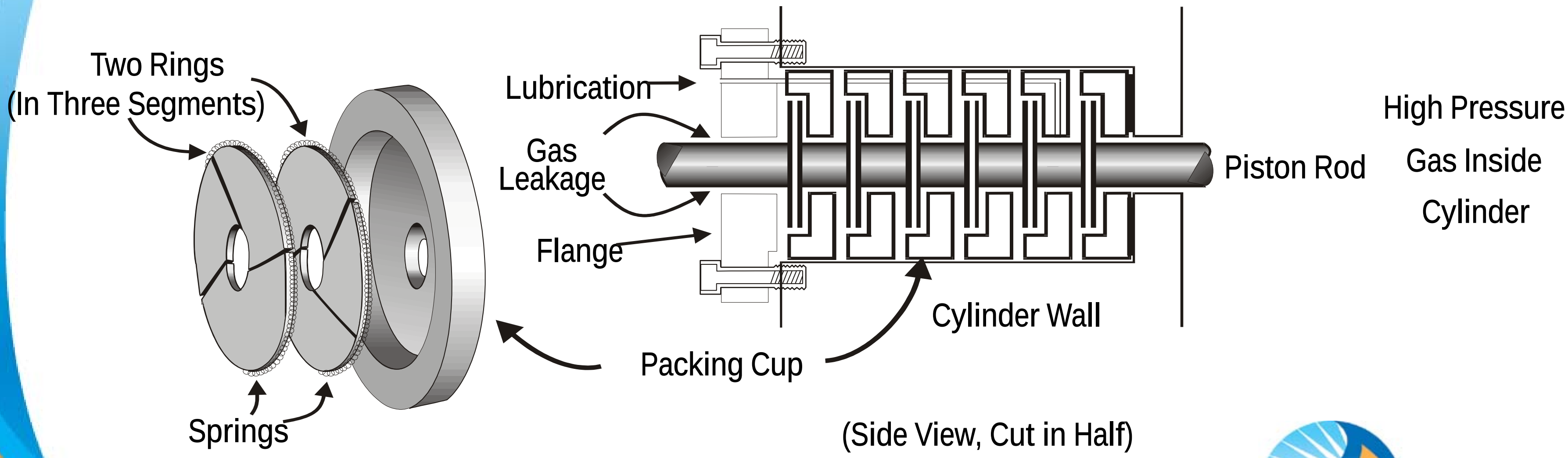
Methane Losses from Reciprocating Compressors

- Reciprocating compressor rod packing leaks some gas by design
  - Newly installed packing may leak 0.3 to 1.7 cubic meters per hour (m^3/hr)
  - Worn packing has been reported to leak up to 25.5 m^3/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



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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 (m^3/hour) = $$\frac{CR * DF * 1{,}000}{(H * GP)}$$

Where:

$$DF = \frac{i(1+i)^n}{(1+i)^n - 1}$$

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)**

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Industry Experience – Northern Natural Gas (U.S. Transmission Company)

- Monitored emissions at two locations
  - Unit A leakage as high as 301 liters/minute (18 m^3/hour)
  - Unit B leakage as high as 105 liters/minute (6 m^3/hour)
- Installed low emission packing (LEP)
  - Testing is still in progress
  - After 3 months, leak rate showed zero leakage increase

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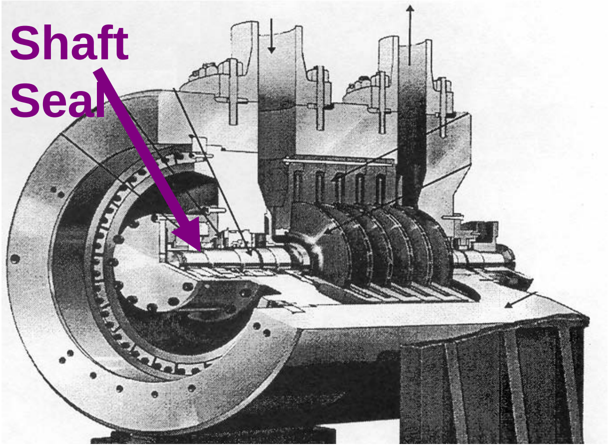
Methane Losses from Centrifugal Compressors

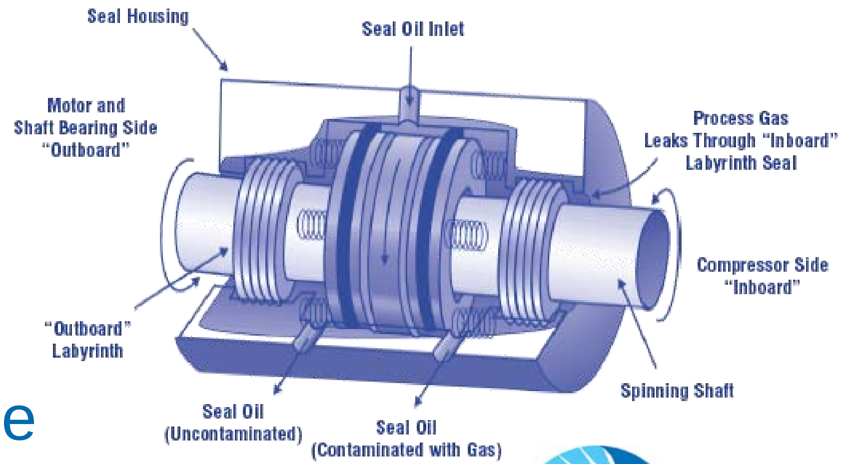
- Centrifugal compressor wet seals leak little gas at the seal face
  - The majority of methane emissions occur through seal oil degassing which is vented to the atmosphere
  - Seal oil degassing may vent 1.1 to 5.7 m^3/minute to the atmosphere
  - One Natural Gas STAR Partner reported emissions as high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



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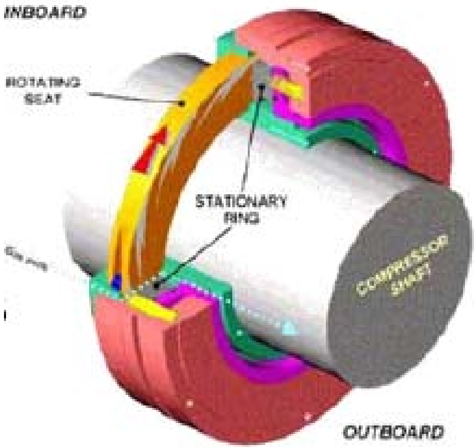
Wet Seals Solution: Dry Seals

- 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



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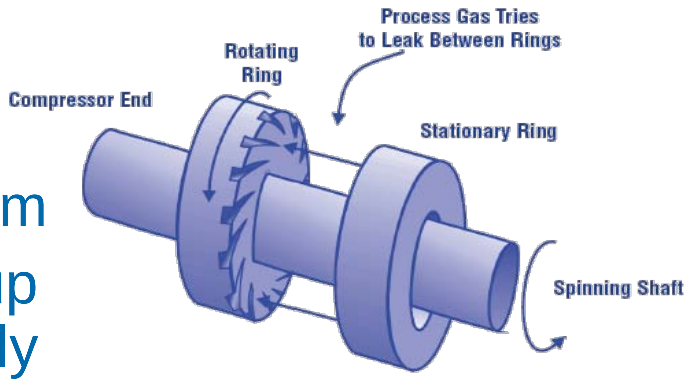

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Industry Experience – PEMEX

- 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

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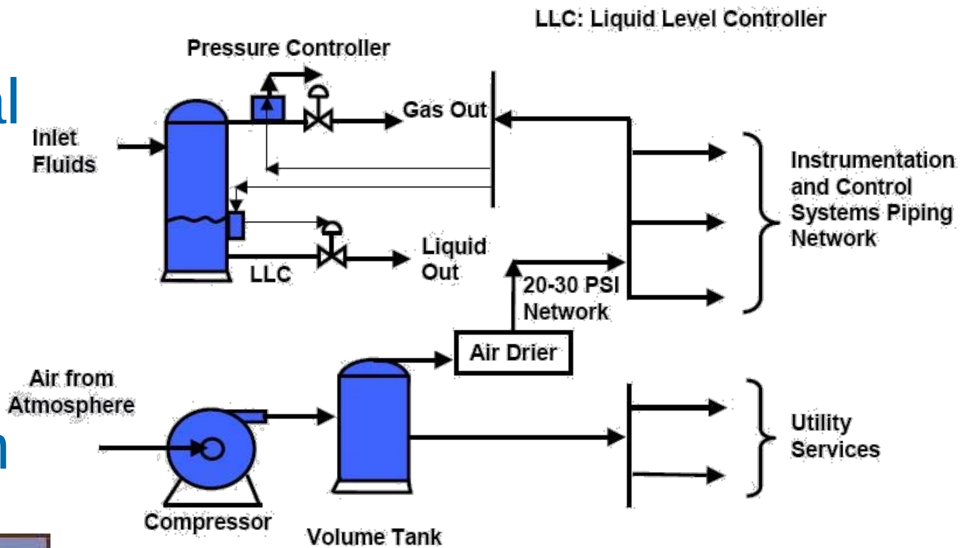
Pneumatic Instrument Venting

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



Source: EPA, Instrument air schematic

Source: Anadarko, Solar chemical pump

BMPs:

- Retrofit high-bleed devices to low-bleed
- Replace natural gas with compressed air
- Use electric or solar powered pumps

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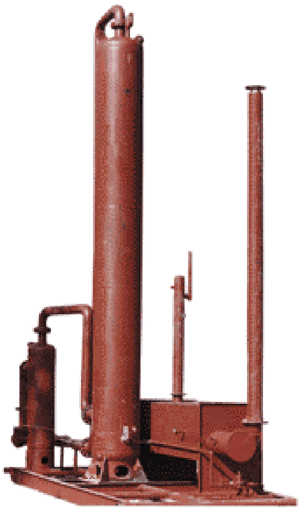
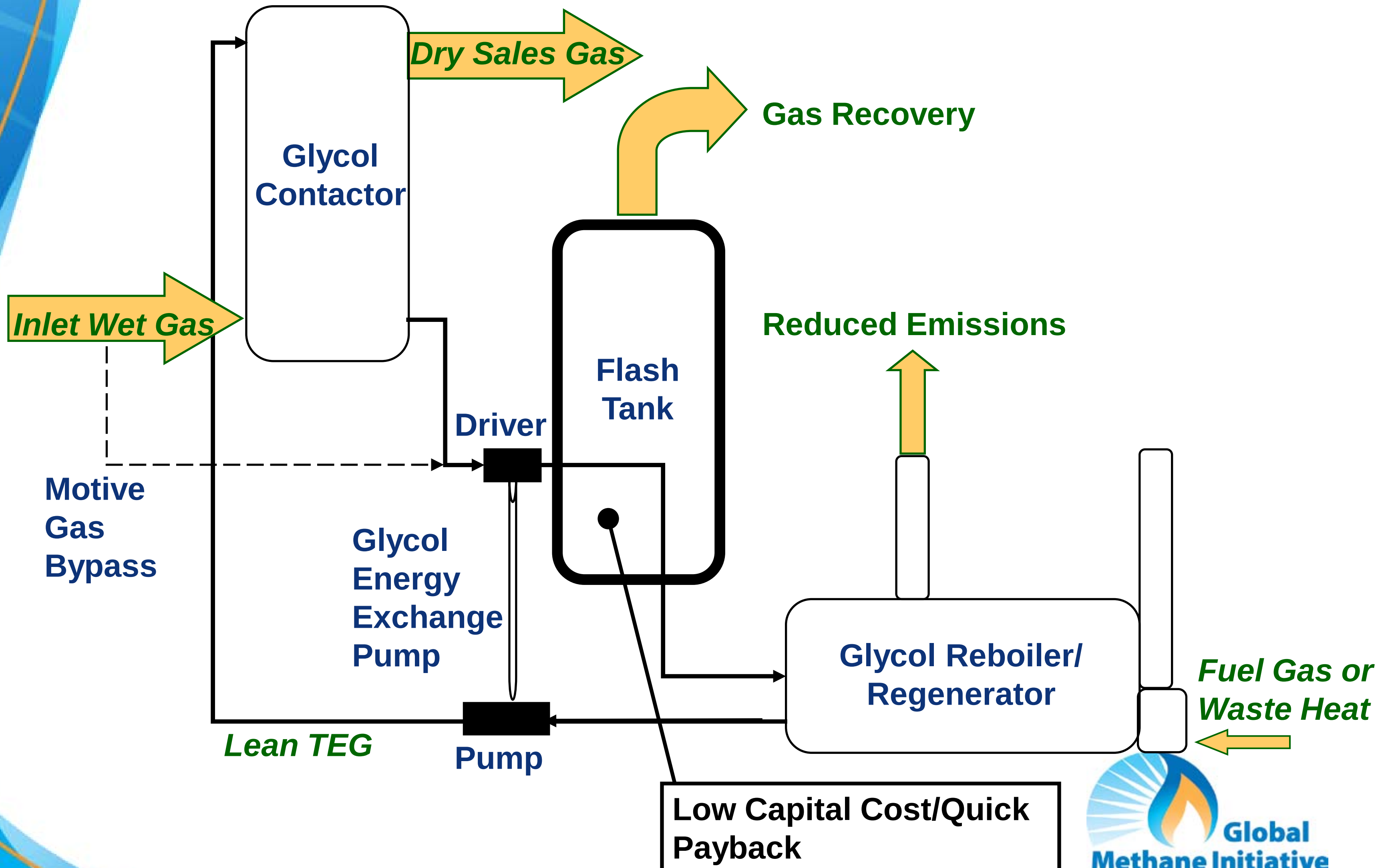
Dehydrators: Methane Losses

- 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



Is Recovery Profitable?

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

Option	Capital Costs	Annual O&M Costs	Emissions Savings	Payback Period[1]
Optimize Circulation Rate	Negligible	Negligible	11 to 1,100 Mcm/year	Immediate
Install Flash Tank	$6,500 to $18,800	Negligible	35 to 305 Mcm/year	4 to 11 months
Install Electric Pump	$1,400 to $13,000	$165 to $6,500	10 to 1,020 Mcm/year	< 1 month to several years

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

Source: EPA Natural Gas STAR Lessons Learned Document "Optimize Glycol Circulation and Install of Flash Tank Separators in Dehydrators" and "Replacing Gas-Assisted Glycol Pumps with Electric Pumps" (http://www.epa.gov/gasstar/tools/recommended.html)

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Contacts and Further Information

- 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:

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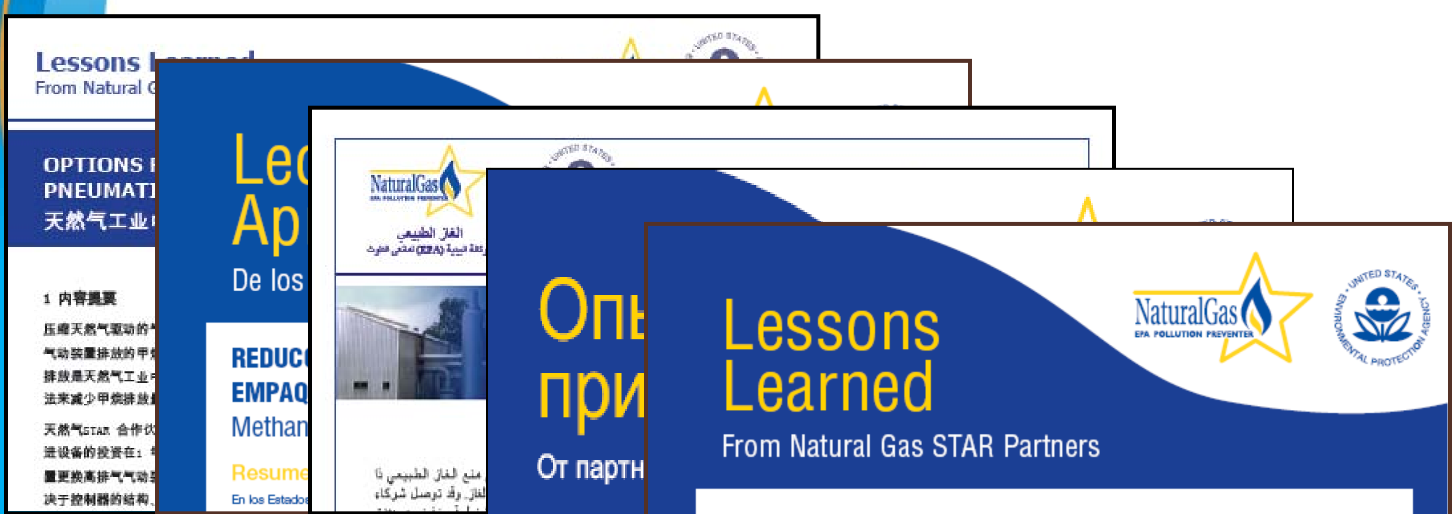

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