Mitigation Options for Key Sources
Overview of technologies and practices

Distribution Technology Transfer Workshop

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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)

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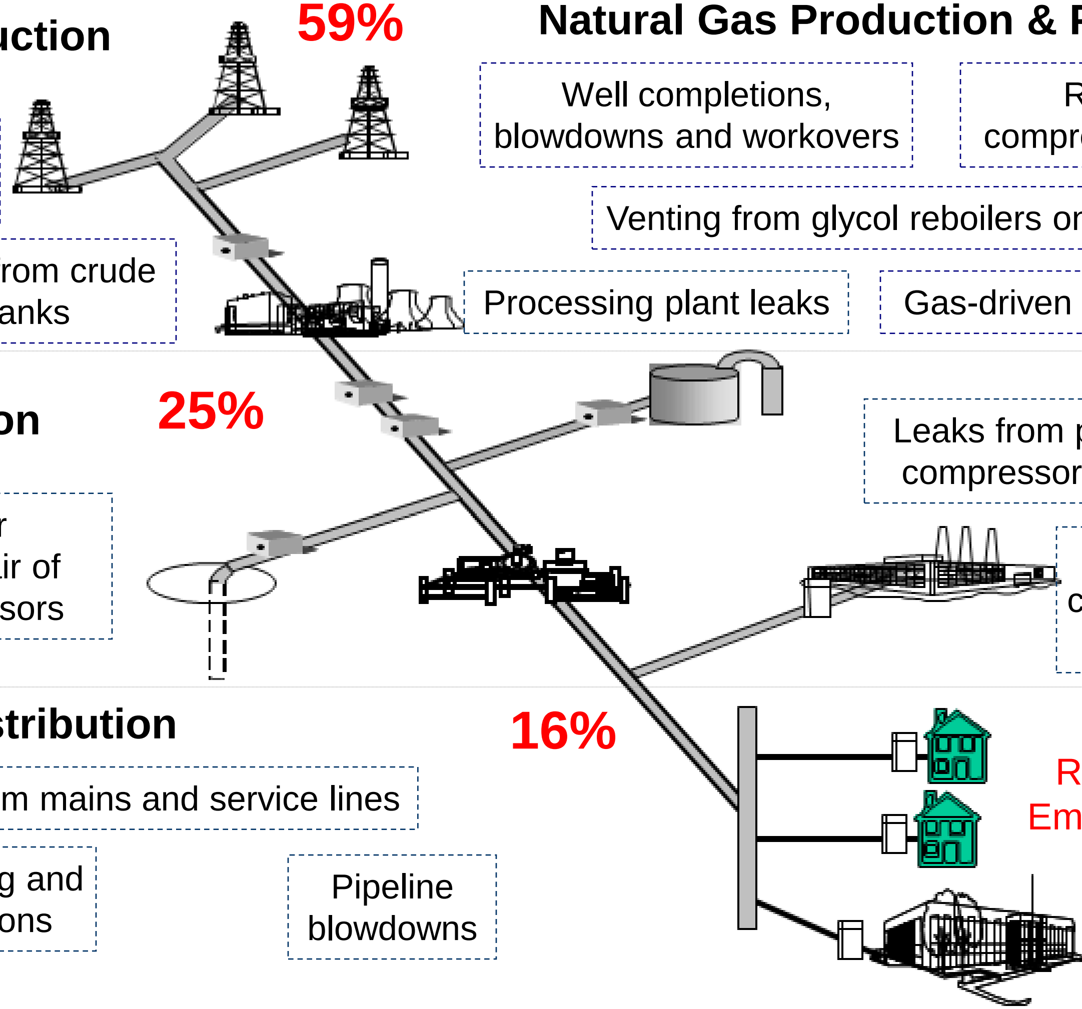
Sources of Methane Emissions from Oil and Gas Operations



Oil Production

59%

- 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

25%

- Venting of gas for maintenance or repair of pipelines or compressors
- Leaks from pipelines, compressor stations
- Centrifugal compressor seal oil de-gassing

Gas Distribution

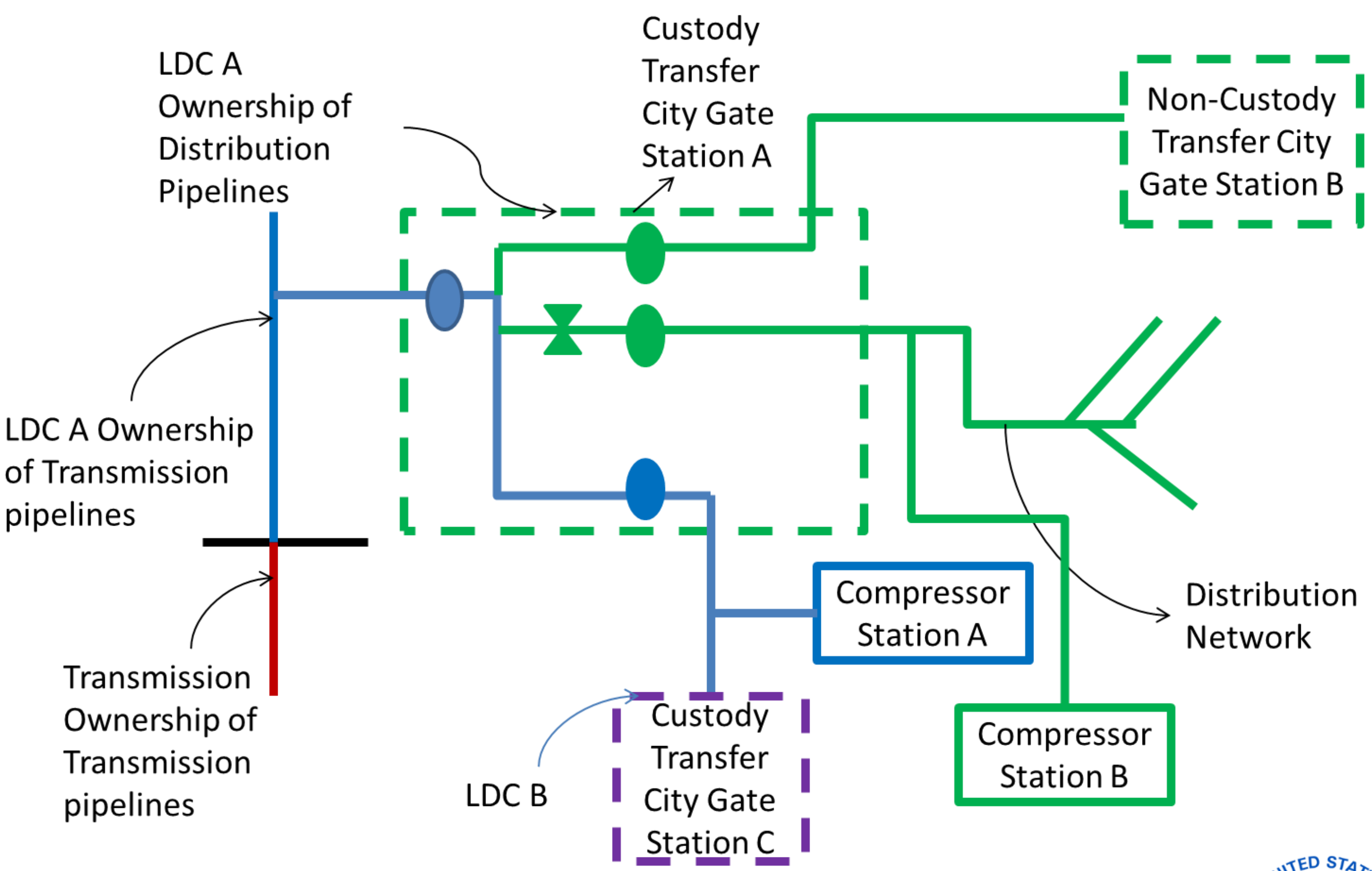
16%

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

Red Numbers are Emissions from Each Sector in U.S.

Picture courtesy of American Gas Association
Values Source: 2013 Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2011

LDC System Schematic



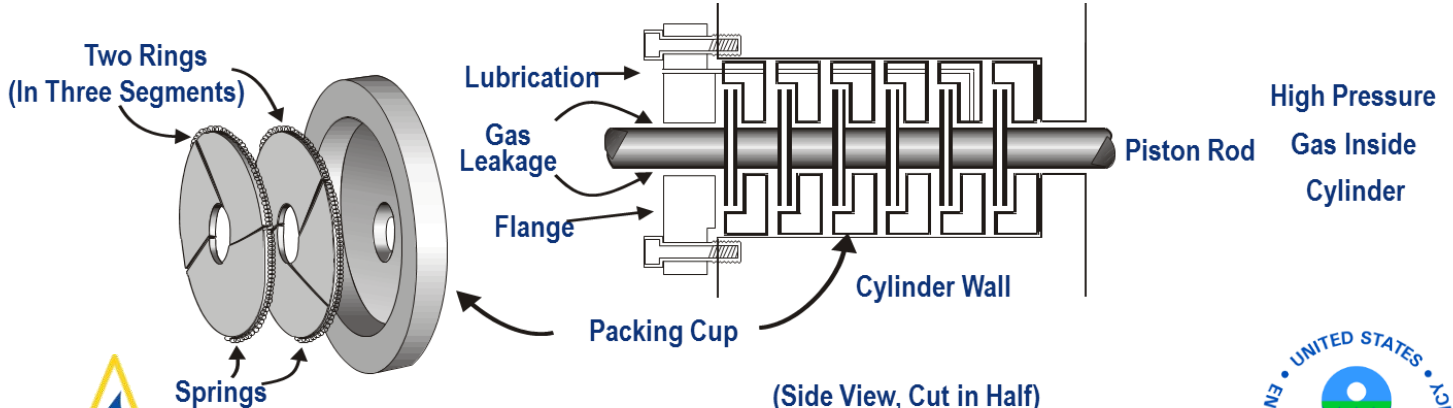
Compressor Reductions

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



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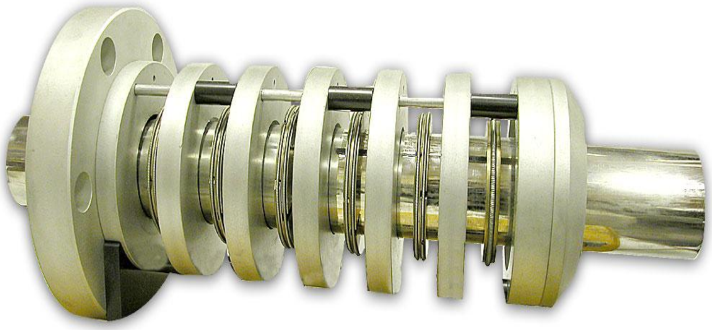
Steps to Determine Economic Rod Packing Replacement

- 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) = $$\frac{CR * DF * 1{,}000}{(H * GP)}$$

Where:

CR = Cost of replacement ($)

DF = Discount factor at interest *i* = $$DF = \frac{i(1+i)^n}{(1+i)^n - 1}$$

H = Hours of compressor operation per year

GP = Gas price ($/thousand cubic feet)

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

One year payback

$$ER = \frac{\$11{,}070 \times 1.1 \times 1{,}000}{(8{,}000 \times \$3)}$$

$$= 508 \text{ scf per hour}$$

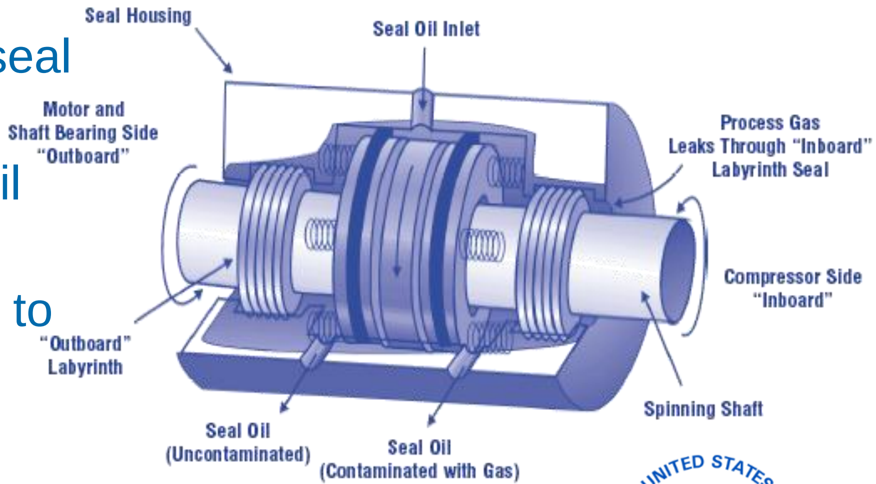
Rings Only:

Leak Reduction Expected (cf/hour)	Payback (months)
55	15
29	28
20	41
16	51

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

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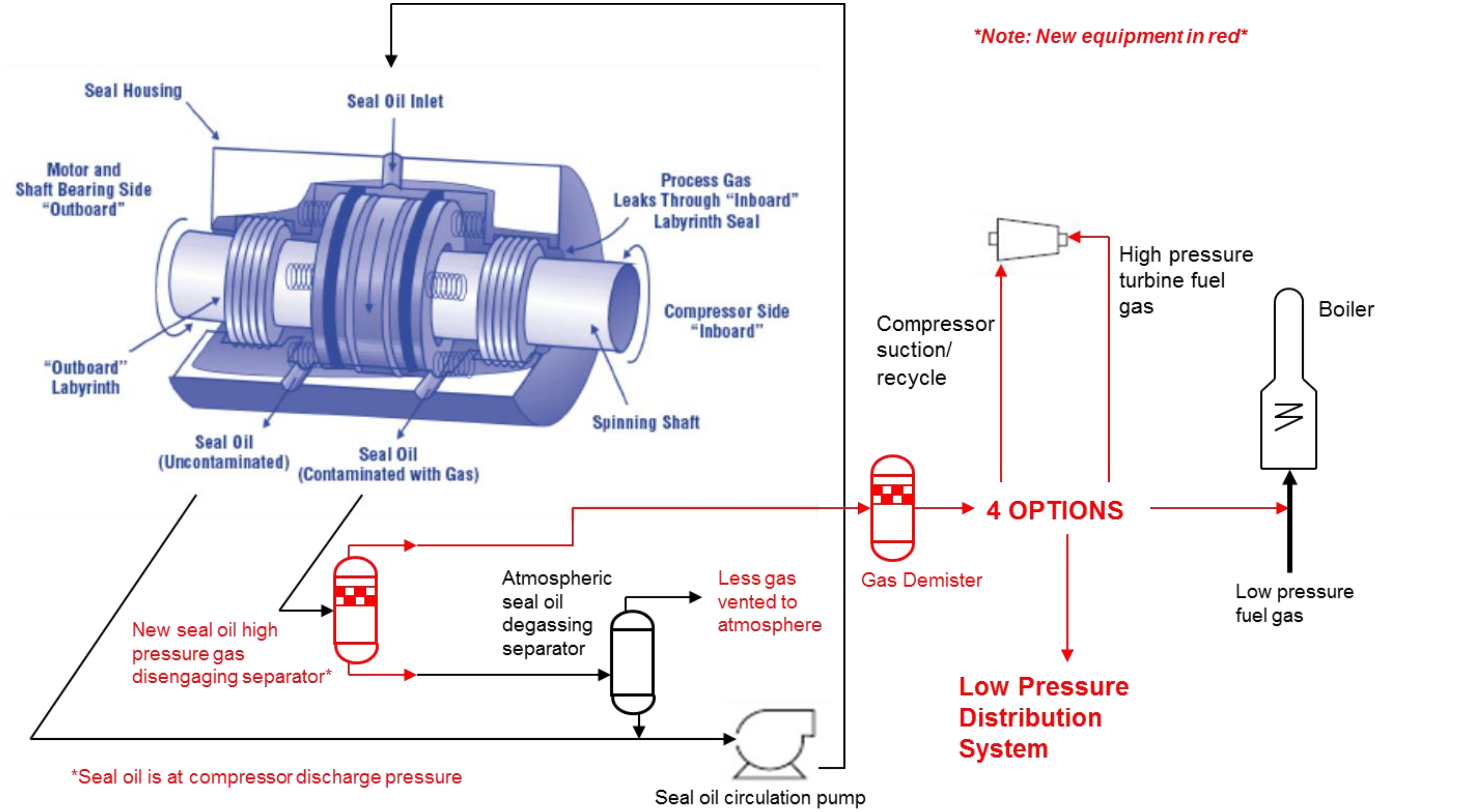
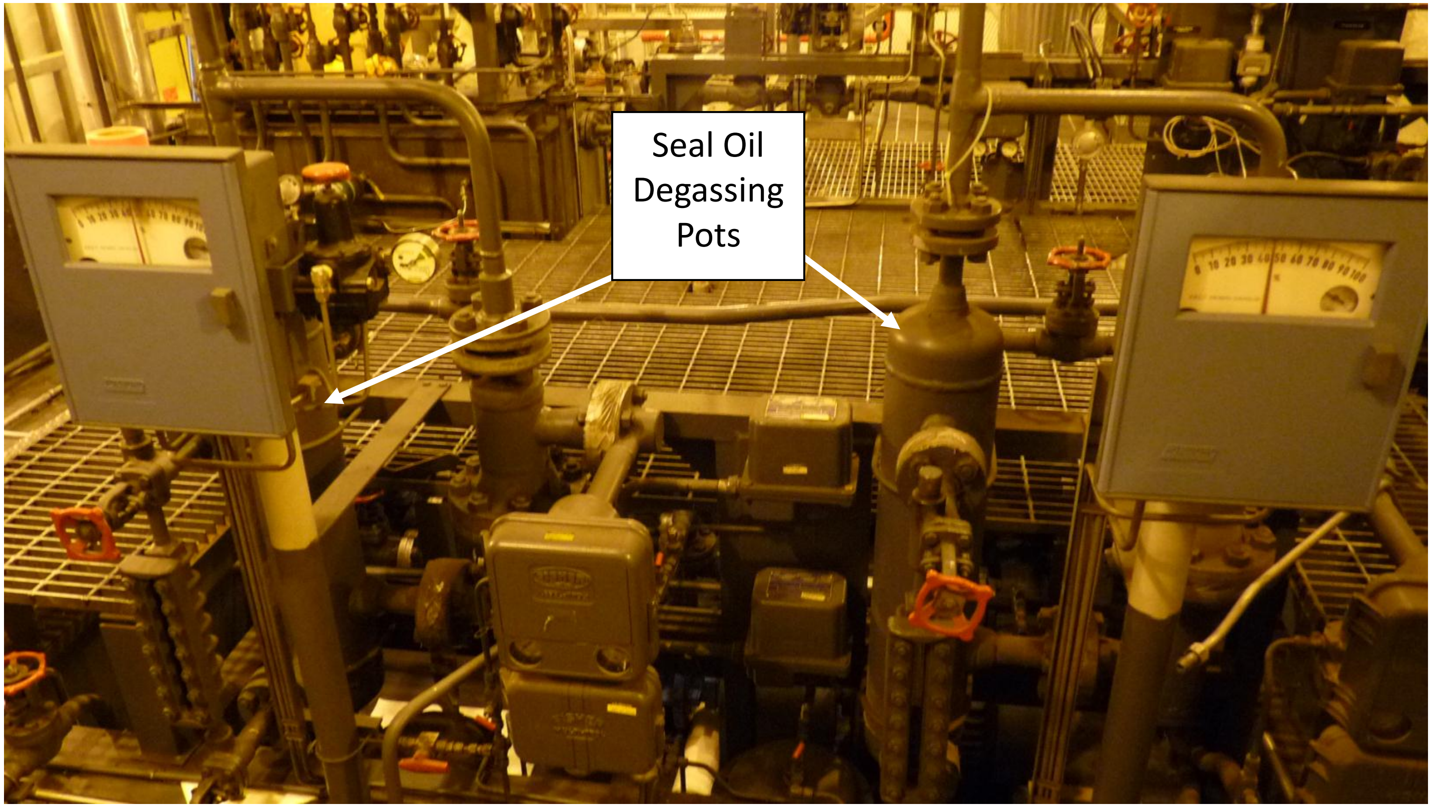
Gas Capture System in Distribution

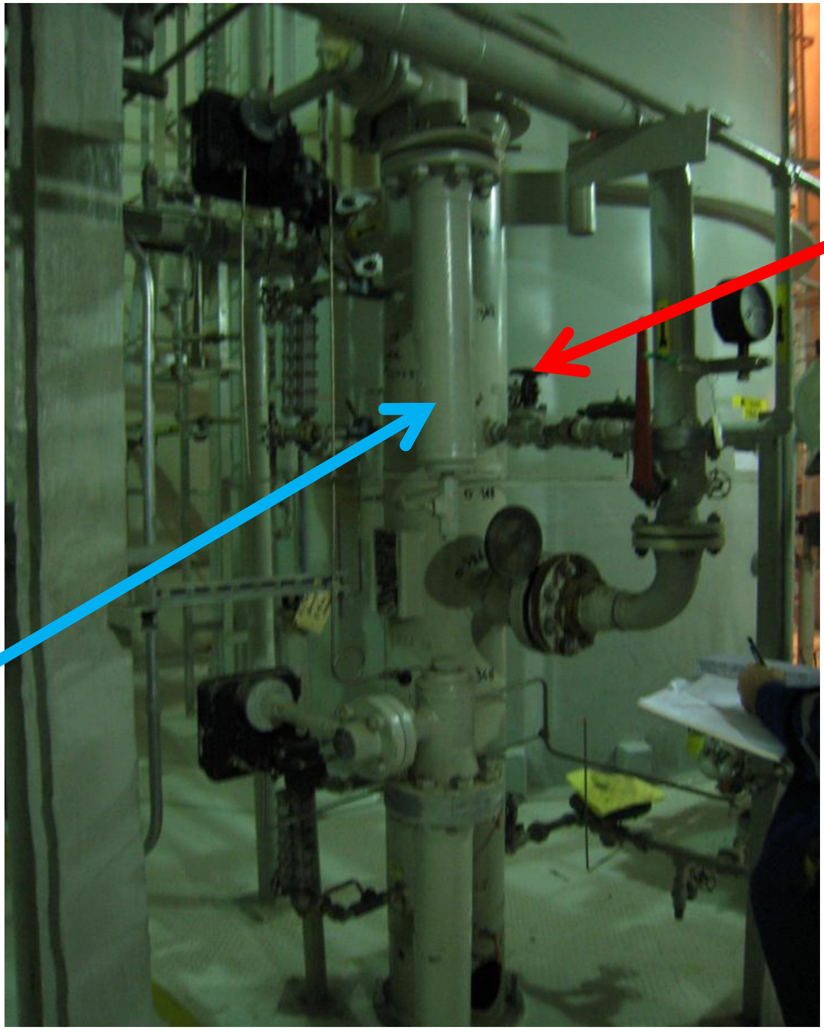


Seal Oil Degassing Pots



First Stage Gas Filter Vessel

This is the first stage gas demister/filter vessel.

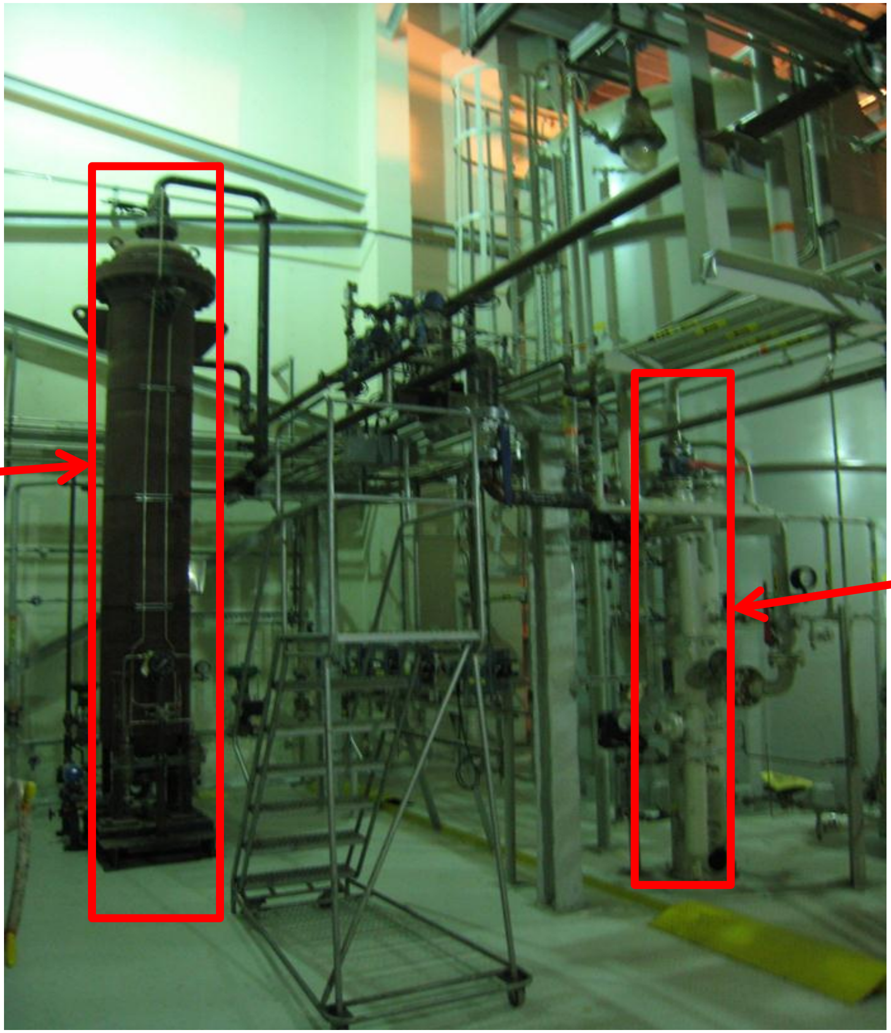


This pipe is NOT the demister/filter vessel.

Here is a person for size reference.

Second Stage Gas Filter Vessel

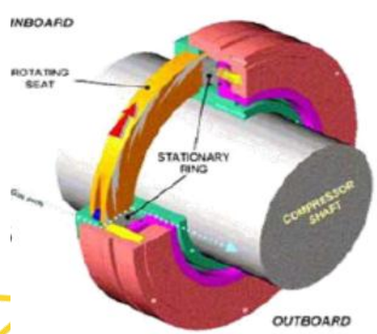
This is the second stage, high efficiency gas demister/filter vessel required for turbine fuel gas. It is newly installed and not yet painted.



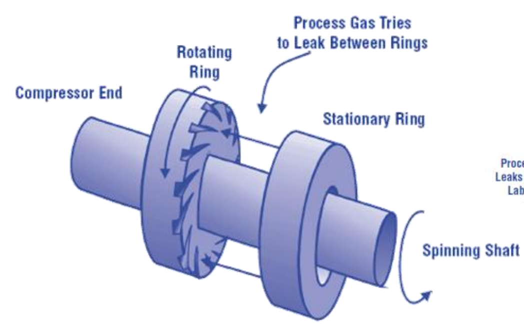
This is the first stage gas demister/filter vessel (behind a vertical pipe.

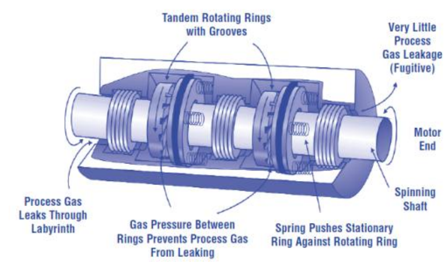
Traditional Solution: Retrofitting/Installing Dry Seals

- Dry seals:
  - 30 to 180 cf/<u>hour</u> (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



Source: PEMEX





Directed Inspection and Maintenance

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

1. Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 – 2011, USEPA, April, 2013

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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 <u>NOT</u> 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

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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

Toxic Vapor Analyzer

Acoustic Leak Detection

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Screening and Measurement Summary

Summary of Screening and Measurement Techniques		
Instrument/Technique	**Effectiveness**	**Approximate**
Soap Solution	★★	$
Electronic Gas Detectors	★	$$
Acoustic Detection/ Ultrasound Detection	★★	$$$
TVA (FID)	★	$$$
Optical Leak Imaging	★★★	$$$
Bagging	★	$$$
High Volume Sampler	★★★	$$$
Rotameter	★★	$$
Source: EPA's Lessons Learned Study		

* - Least effective at screening/measurement

*** - Most effective at screening/measurement

$ - Smallest capital cost

$$$ - Largest capital cost

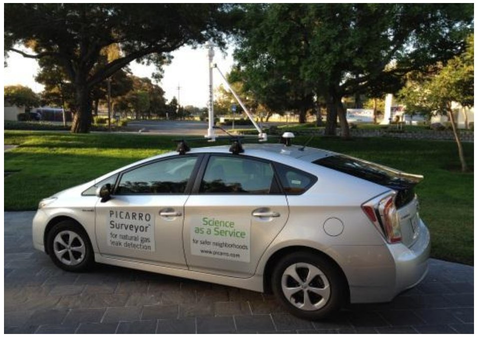
How Do You Measure the Leaks?

- **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



Picarro Engineering Survey Vehicle

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

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