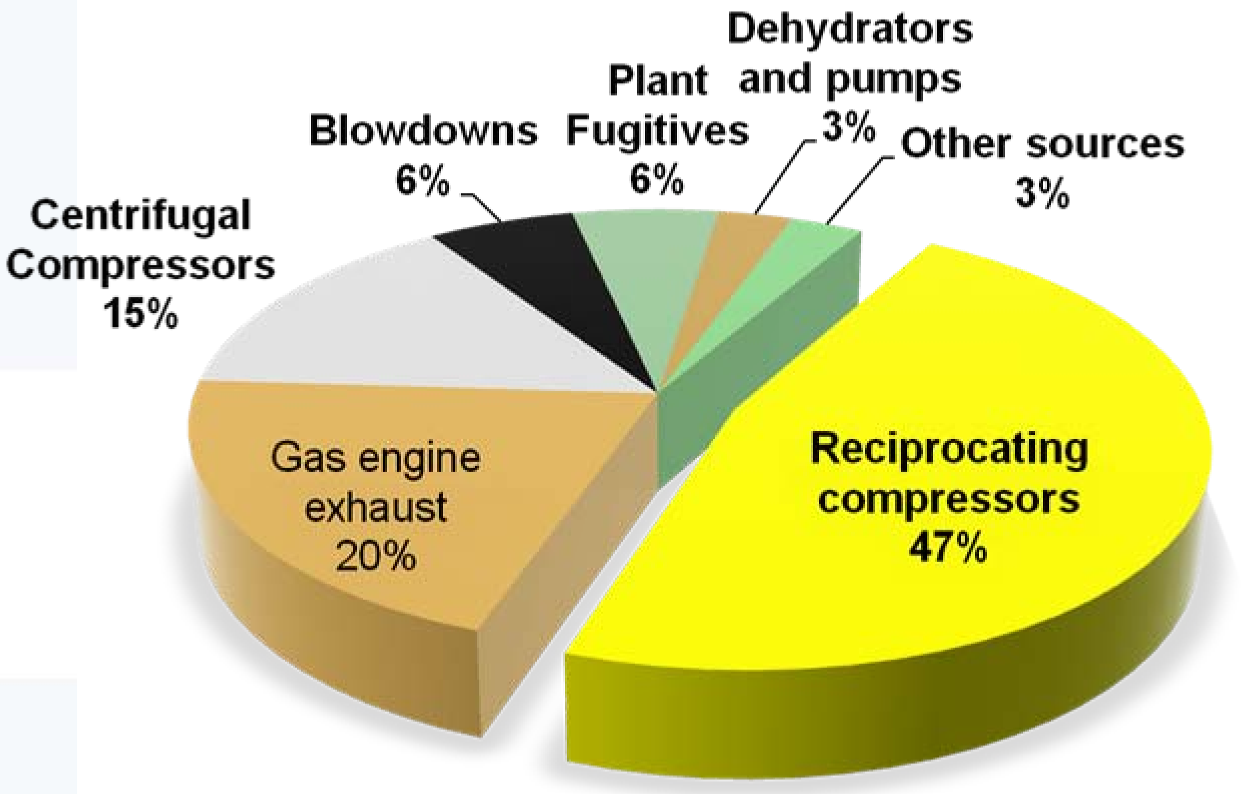
Methane to Markets

Reducing Methane Emissions from Reciprocating and Centrifugal Compressors

Oil & Gas Subcommittee Technology Transfer Workshop

January 28, 2009
Monterrey, Mexico

U.S. Processing Sector Methane Emissions

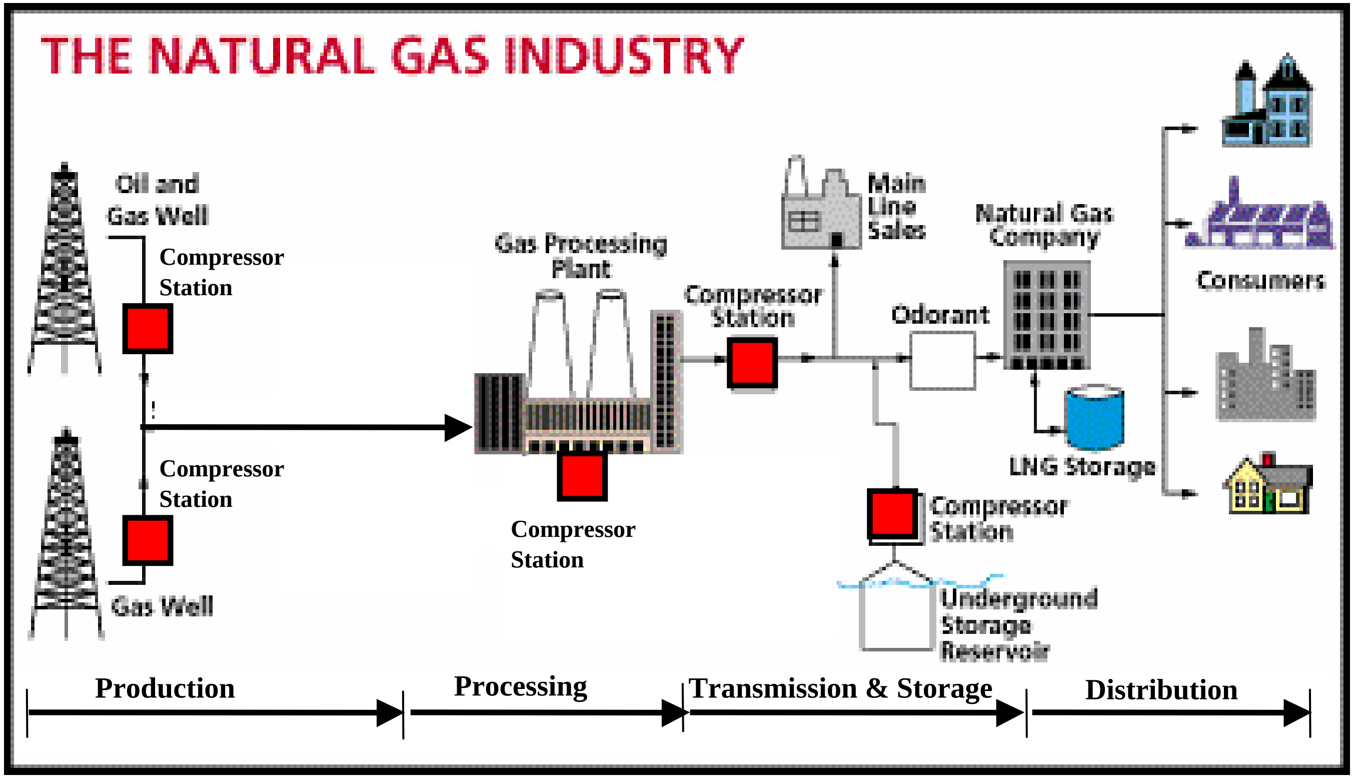


EPA. *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 – 2006.* April, 2008. Available on the web at: epa.gov/climatechange/emissions/usinventoryreport.html

Note: Natural Gas STAR reductions from gathering and boosting operations are reflected in the production sector.

Compressor Methane Emissions
What is the problem?

- It is estimated that methane emissions from compressors in the natural gas industry account for about one fourth of all methane emissions from the natural gas industry

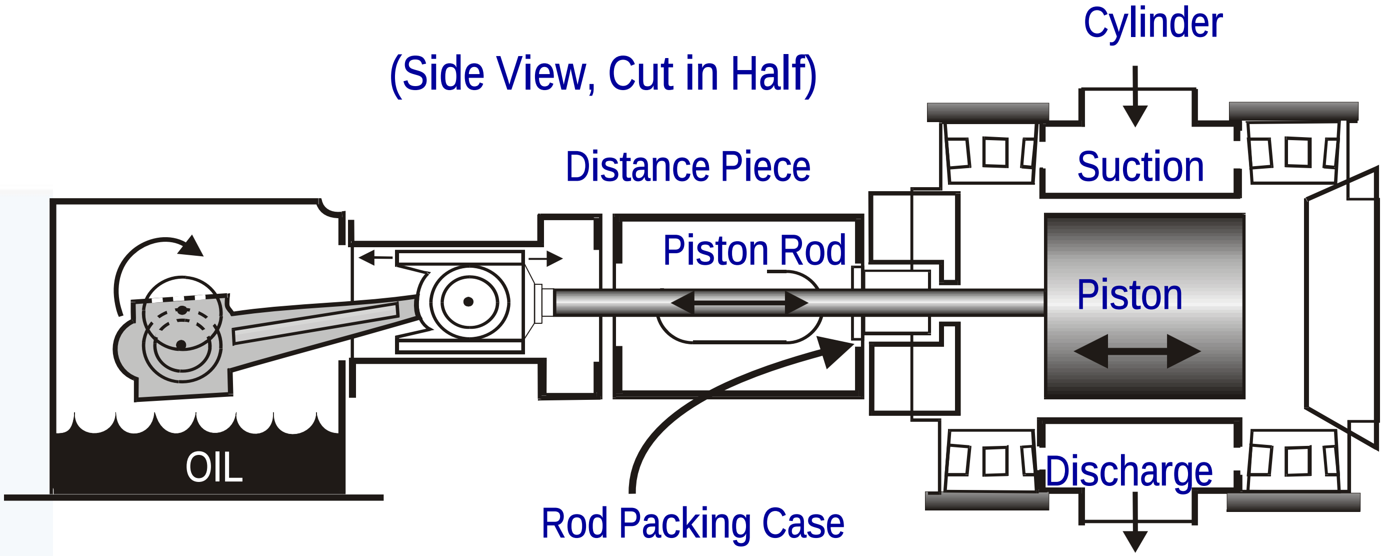


Methane Savings from Compressors: Agenda

- Reciprocating Compressors
  - Methane Losses
  - Methane Savings
  - Industry Experience
- Centrifugal Compressors
  - Methane Losses
  - Methane Savings
  - Industry Experience

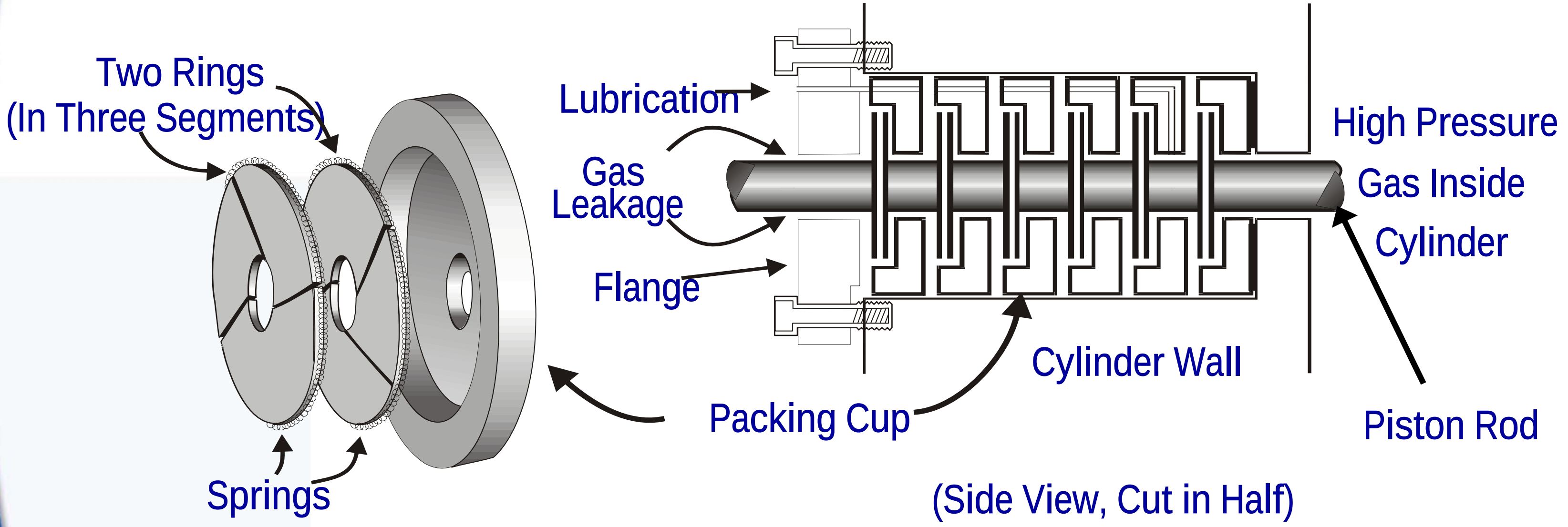
Methane Losses from Reciprocating Compressors

- Reciprocating compressor rod packing leaks some gas by design
  - Newly installed packing may leak 60 cfh
  - Worn packing has been reported to leak up to 900 cfh



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



Impediments to Proper Sealing

Ways packing case can leak

- Nose gasket (no crush)
- Packing to rod (surface finish)
- Packing to cup (lapped surface)
- Packing to packing (dirt/lube)
- Cup to cup (out of tolerance)

What makes packing leak?

- Dirt or foreign matter (trash)
- Worn rod (0,0015 in/in ∅)
- Insufficient/too much lubrication
- Packing cup out of tolerance (≤ 0.002mm)
- Improper break-in on startup
- Liquids (dilutes oil)
- Incorrect packing installed (backward or wrong type/style)

Methane Losses from Rod Packing

Emission from Running Compressor	99	cfh-packing
Emission from Idle/Pressurized Compressor	145	cfh-packing
Leakage from Idle Compressor Packing Cup	79	cfh-packing
Leakage from Idle Compressor Distance Piece	34	cfh-packing

Leakage from Rod Packing on Running Compressors				
Packing Type	Bronze	Bronze/Steel	Bronze/Teflon	Teflon
Leak Rate (cfh)	70	63	150	24

Leakage from Rod Packing on Idle/Pressurized Compressors				
Packing Type	Bronze	Bronze/Steel	Bronze/Teflon	Teflon
Leak Rate (cfh)	70	N/A	147	22

PRCI/ GRI/ EPA. *Cost Effective Leak Mitigation at Natural Gas Transmission Compressor Stations*

Steps to Determine Economic 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

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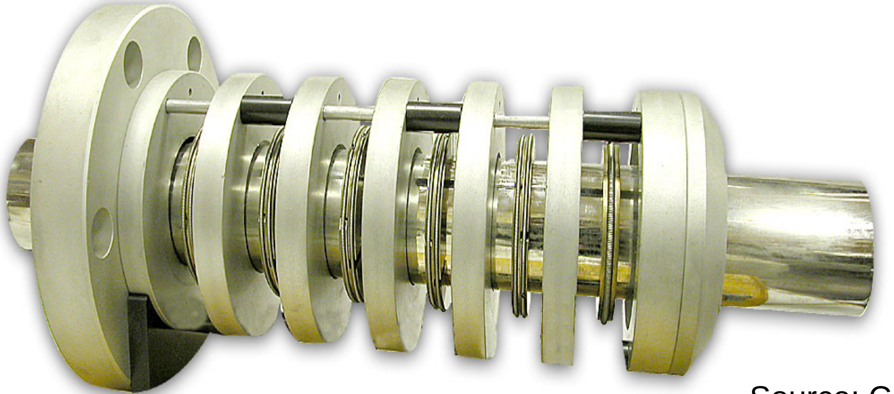
Cost of Rod Packing Replacement

- Assess costs of replacements (US$)
  - A set of rings: $ 135 to $ 1,080
    (with cups and case) $ 1,350 to $ 2,500
  - Rods: $ 2,430 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 (cfh) =

$$\frac{CR \times A/P \times 1{,}000}{(H \times GP)}$$

Where:

CR = **Cost of replacement (US$)**

A/P = **Capital recovery factor at interest *i* *and n years recovery period***

H = **Hours of compressor operation per year**

GP = **Gas price (US$/Mcf)**

Economic Replacement Threshold

- Example: Payback calculations for new rings and rod replacement

CR = \$1,620 for rings + \$9,450 for rod
CR = \$11,070

H = 8,000 hours per year

GP = \$5/Mcf

A/P @ i = 10% , n = 1 year = 1.1

A/P @ i = 10% , n = 2 years = 0.576

Two year payback:

$$ER = \frac{\$11{,}070 \times 0.576 \times 1{,}000}{(8{,}000 \times \$5)}$$
$$= 159 \text{ scfh}$$

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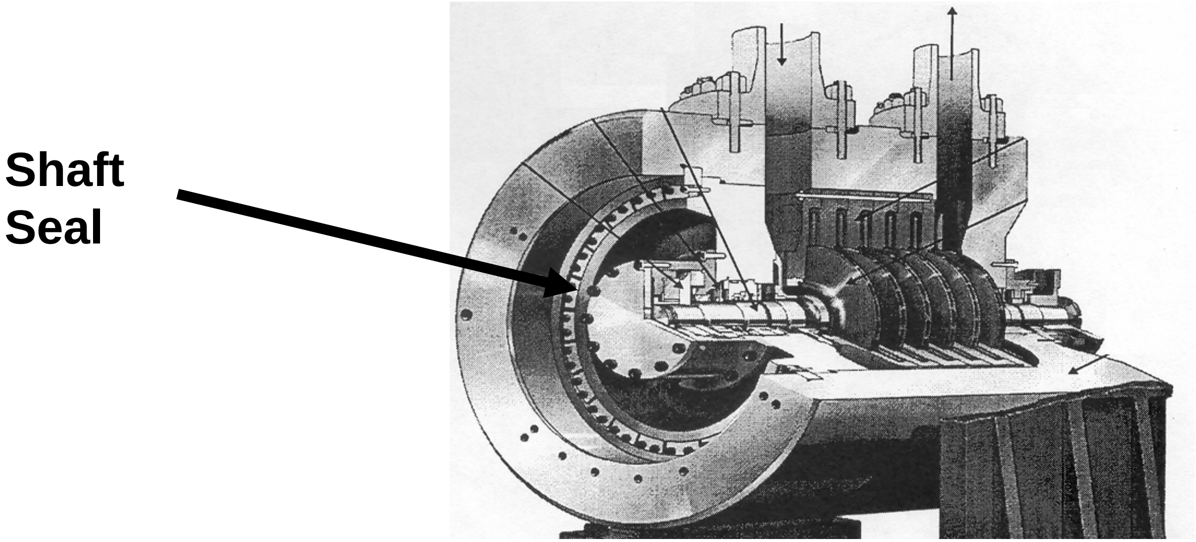
Case Study: Partner Packing Leakage Economic Replacement Point

- Approximate packing replacement cost is US$3,000 per compressor rod (parts/labor)
- Assuming gas at US$5/Mcf:
  - 1.76 cfm =
  - 1.76 x 60 minutes/hour= 105 cfh
  - 105 x 24/1,000 = 2.52 Mcf/d
  - 2.52 x 365 days= 919.8 Mcf/year
  - 919.8 x $5/Mcf = $4,599 per year leakage
  - This replacement pays back in <1 year

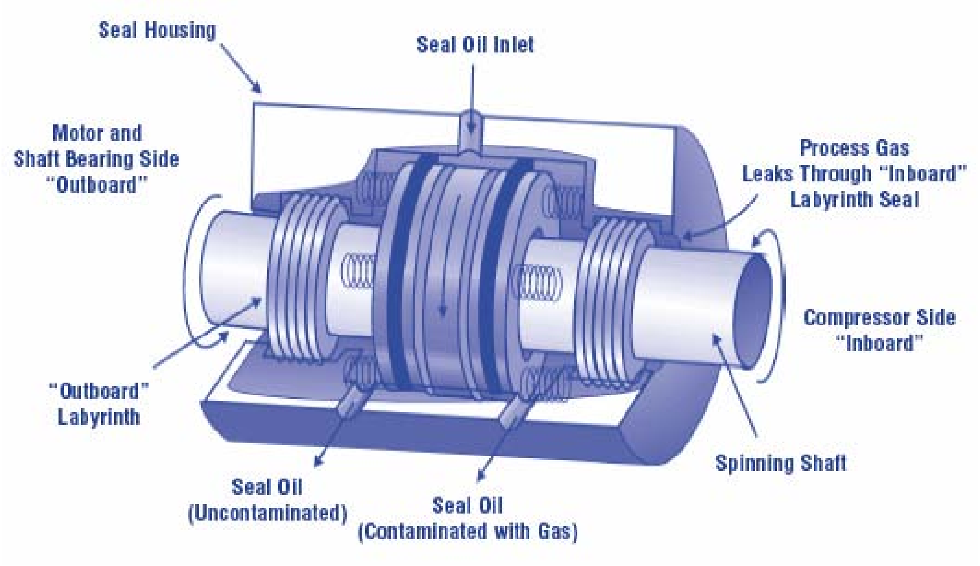
Methane Losses from Centrifugal Compressors

- Centrifugal compressor wet seals leak little gas at the seal face
  - Seal oil degassing may vent 40 to 200 cfm to the atmosphere



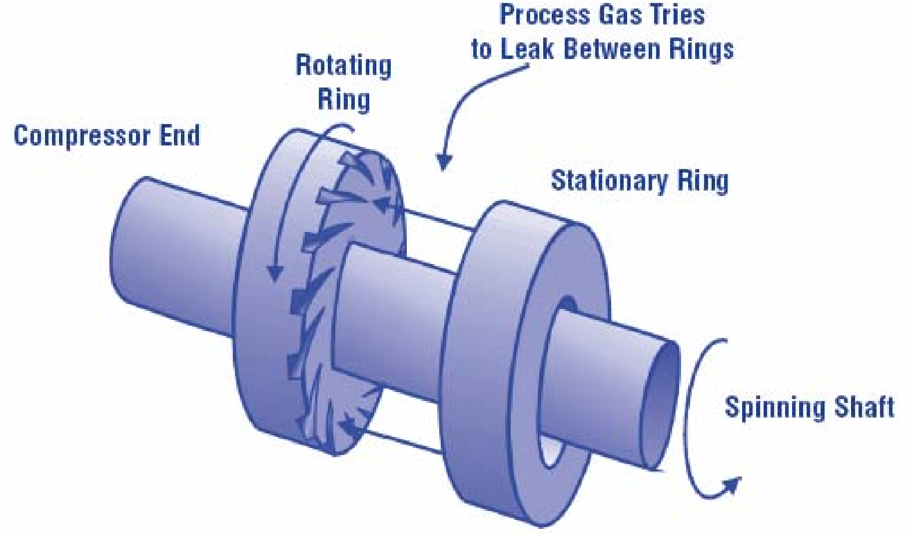
Centrifugal Compressor Wet Seals

- 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



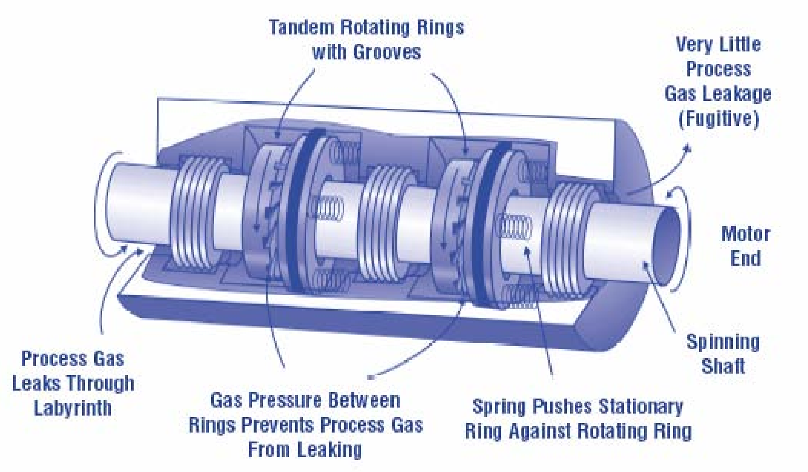
Emissions Reductions with Dry Seals

- Dry seal springs press the stationary ring in the seal housing against the rotating ring when the compressor is not rotating
- At high rotation speed, gas is pumped between the seal rings 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



Methane Recovery with Dry Seals

- Dry seals typically leak at a rate of only 0.5 to 3 cfm
  - Significantly less than the 40 to 200 cfm emissions from wet seals
- These savings translate to approximately $ 88,800 to $472,800 in annual gas value



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Other Benefits with Dry Seals

- Aside from gas savings and reduced emissions, dry seals also:
  - Lower operating cost
    - Dry seals do not require seal oil make-up
  - Reduced power consumption
    - Wet seals require 50 to 100 kiloWatt hours (kW/hr) for ancillary equipment while dry seals need only 5 kW/hr
  - Improve reliability
    - More compressor downtime is due to wet seals
  - Eliminate seal oil leakage into the pipelines
    - Dry seals lower drag in pipelines (and horsepower to overcome)

Case Study

- PEMEX Gas seal substitution program