Reducing Emissions from Compressor Rod Packing

Lessons Learned from Natural Gas STAR

Producers Technology Transfer Workshop

Devon Energy Corporation
and
EPA's Natural Gas STAR Program

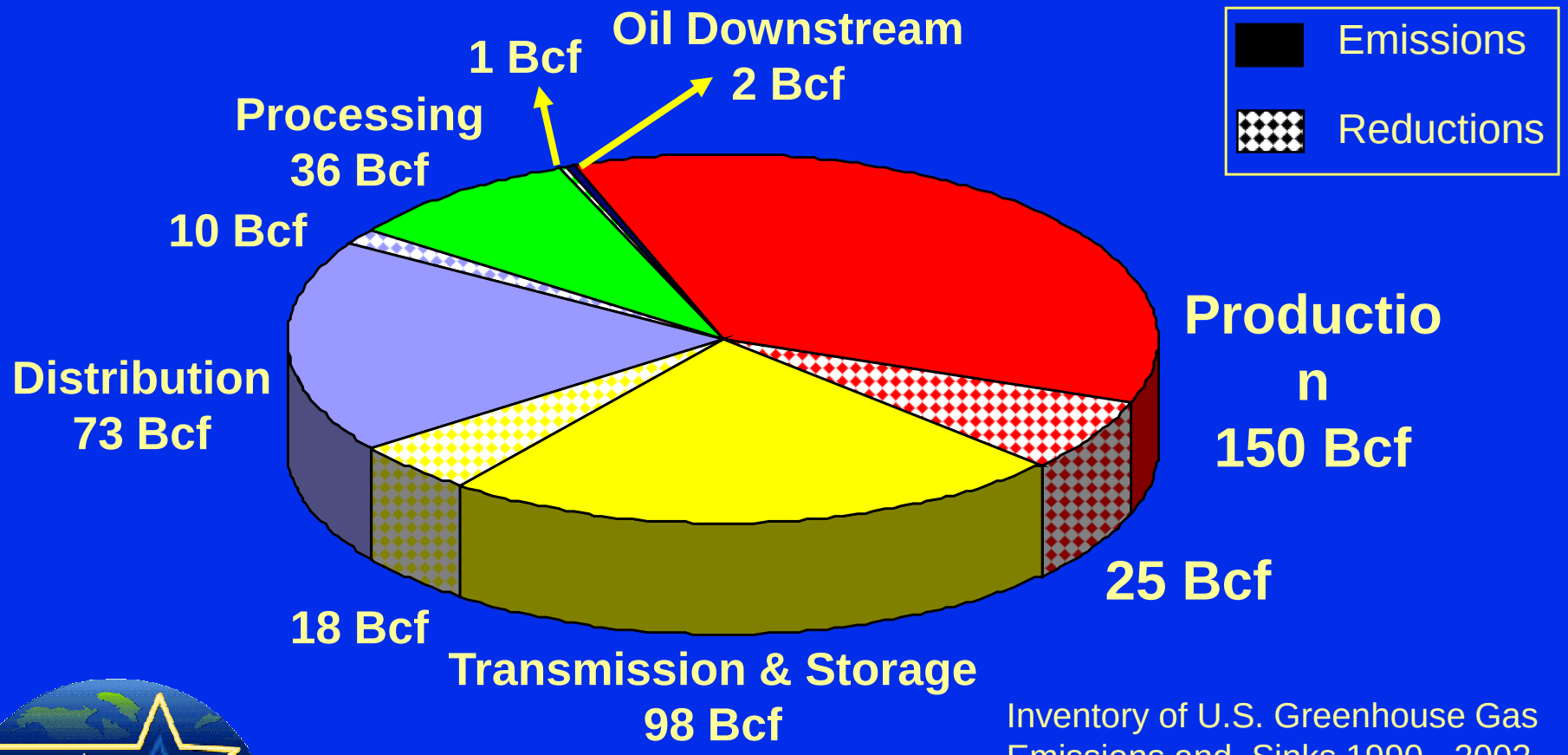
April 20, 2005

Agenda

- Methane Losses
- Methane Recovery
- Is Recovery Profitable?
- Industry Experience
- Discussion Questions

Methane Losses from Production

- Production responsible for 42% of methane emissions

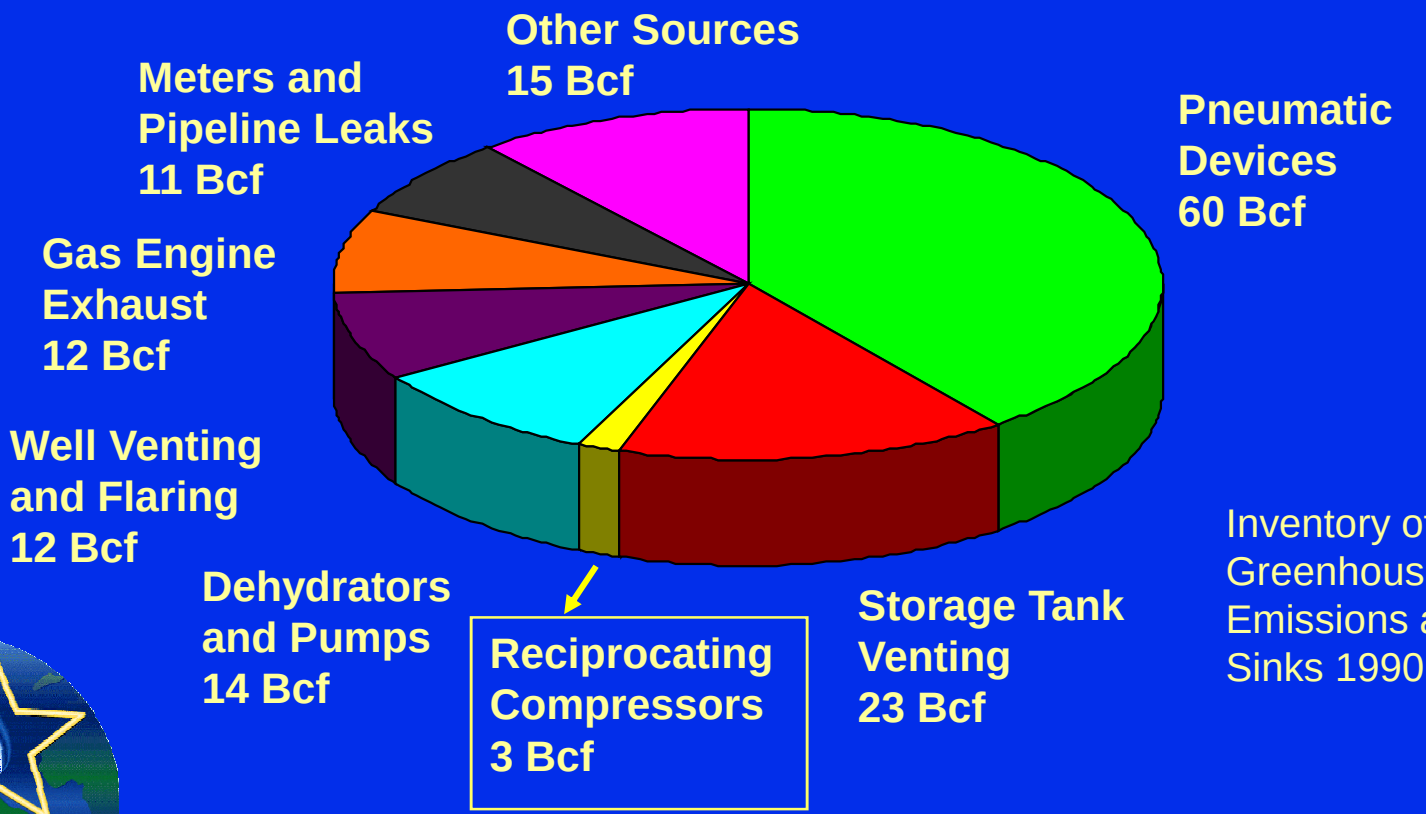


Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 - 2002

Reducing Emissions, Increasing Efficiency, Maximizing Profits

Methane Losses from Compressor Rod Packing

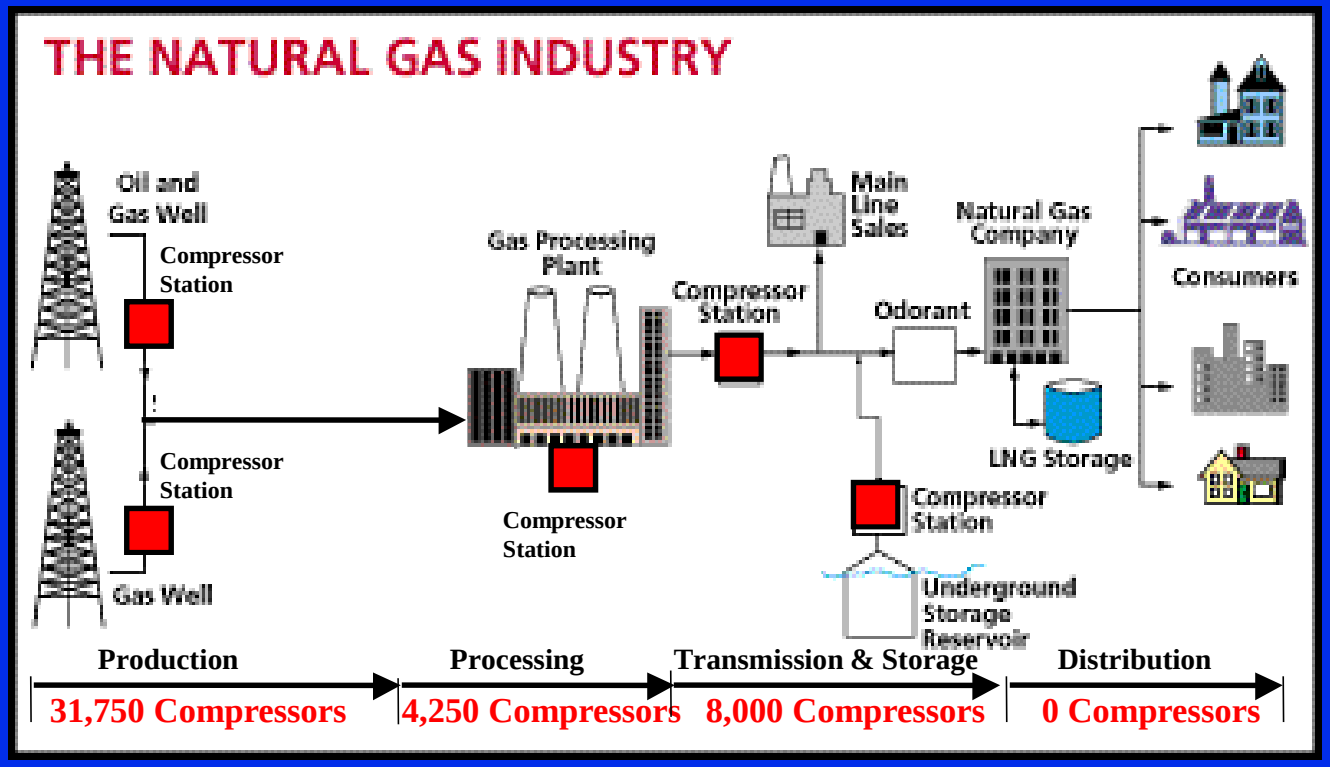
- Reciprocating compressors account for 2% of production sector emissions
  - **Gas lost from rod packing is estimated to be over 350 MMcf/yr costing over $1 million (gas price of $3/Mcf)**



Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 - 2002

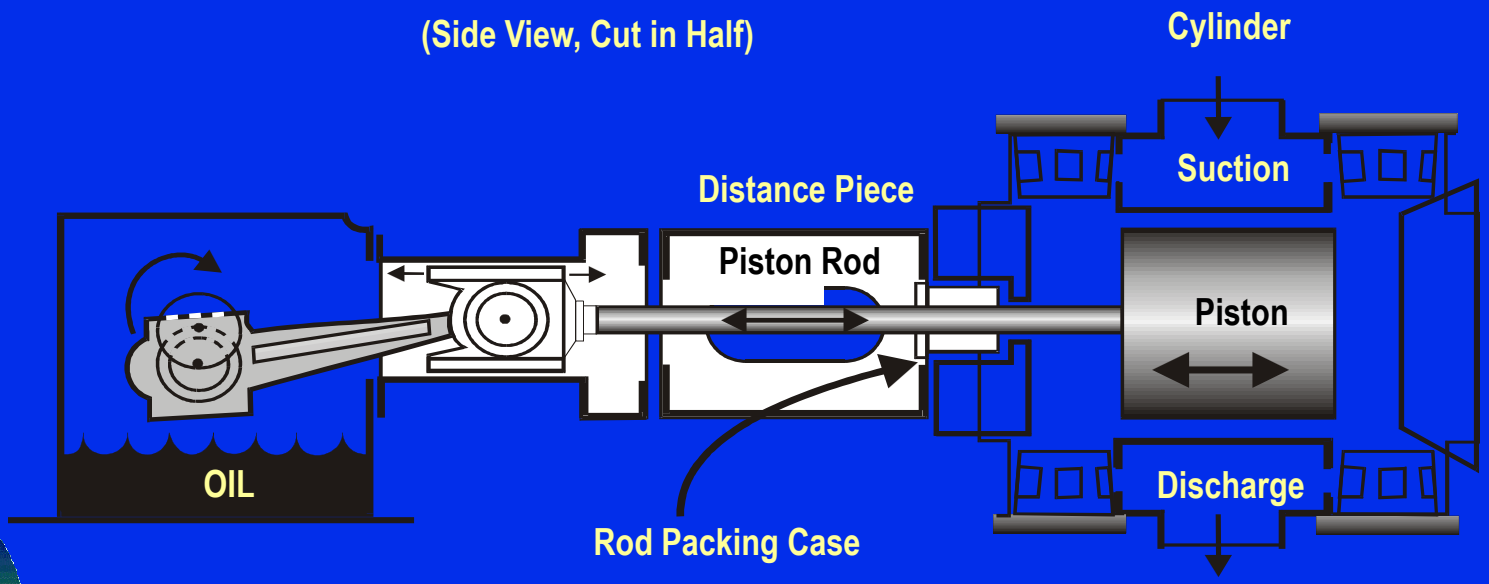
Compressor Rod Packing
What is the Problem?

- Rod packing accounts for 12% of reciprocating compressor emissions in production sector
  - **Over 44,000 reciprocating compressors in natural gas industry**
  - **Over 31,000 compressors in gas production sector**



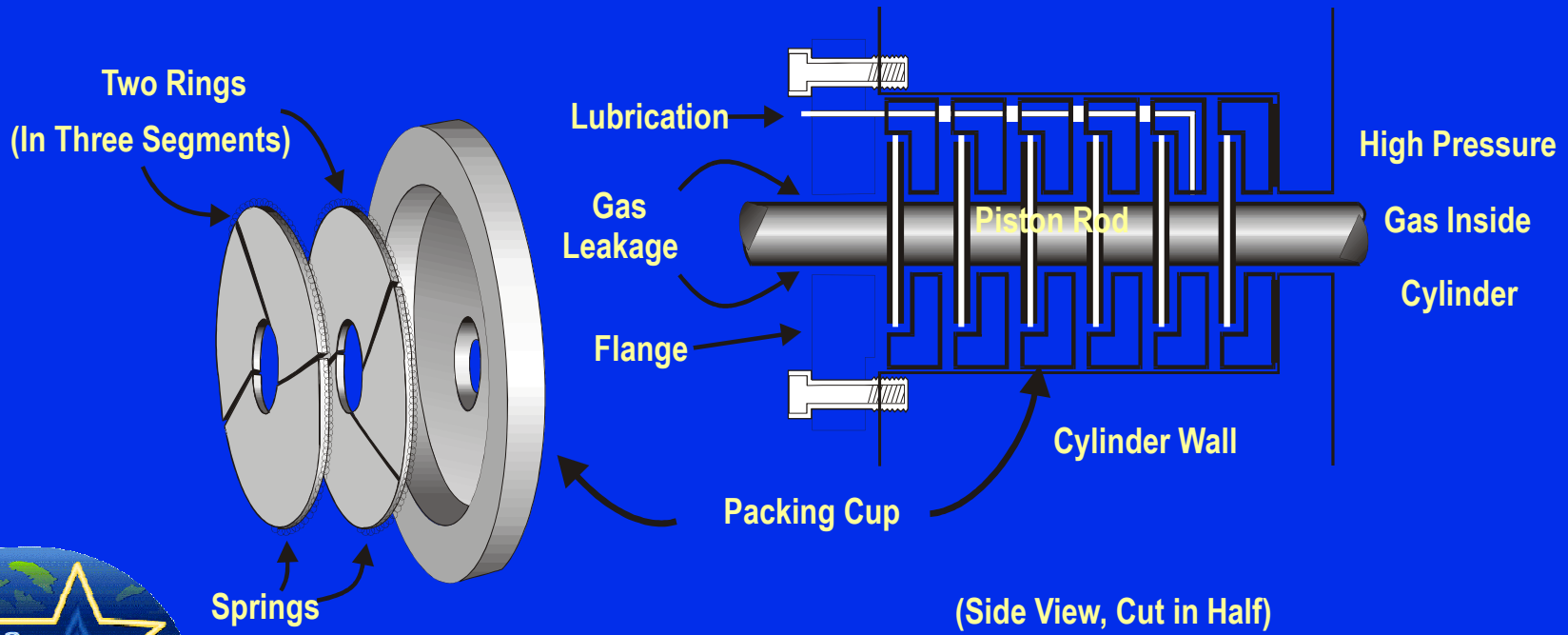
Methane Losses from Rod Packing

- Reciprocating compressor rod packing leaks some gas by design
  - **Newly installed packing may leak 11 cubic feet per hour (cf/h)**
  - **Worn packing has been reported to leak up to 900 cf/h**



Reciprocating Compressor Rod Packing

- A series of flexible rings fit around the shaft to prevent leakage
- Rings held in place by springs and packing cups



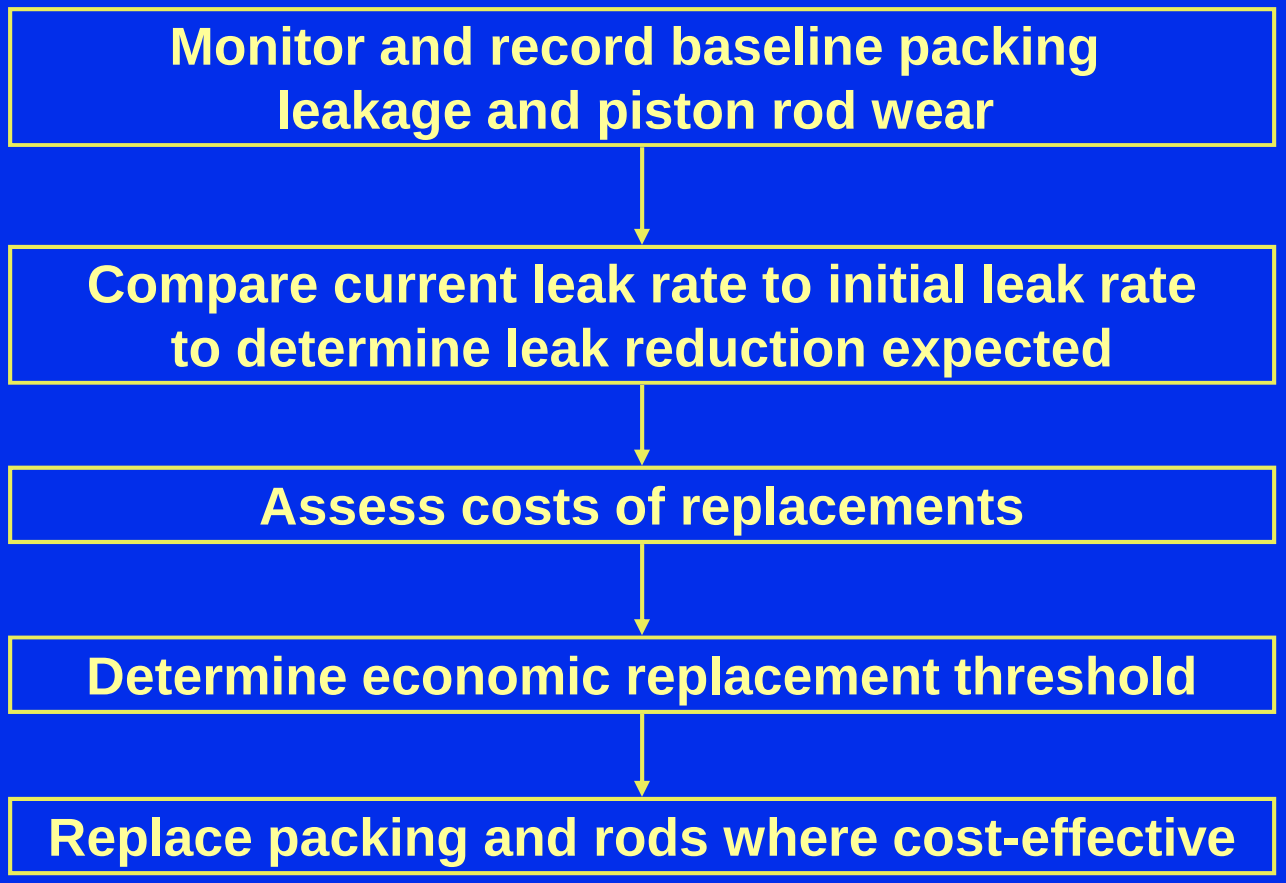
Methane Loss Sources from Rod Packing

- Leakage occurs
  - **Around packing case through nose gasket**
  - **Between packing cups**
  - **Around rings due to movement of the piston rod**
  - **Between rings and piston rod**
- Leaking gases escape either through vents on the packing flange or into the distance piece
- Leakage gradually increases from normal wear of rings and rod

Methane Recovery with Economic Rod Packing Replacement

- Leak rates from rod packing eventually increase to a level that economically justifies packing replacement
  - **Frequency of economic replacement depends on lubrication, rod alignment, rod wear, rod material and economic hurdle-rate**
- Benefits of economic packing replacement
  - **Reduced methane emissions**
  - **Gas savings with lower leakage rates**
  - **Extended service life of compressor rods**

Rod Packing Replacement Decision Process



Establish Baseline Leaks

- Step 1: Monitor and record baseline leakage and rod wear
  - **Measure leaks immediately after installing new seals (or new rods and seals)**
  - **Monitor rods periodically for shaft dimensions and surface roughness when replacing rings**
    - **“Out-of-round” rod seals poorly causing uneven wear and allowing more leakage**
    - **It also causes uneven wear on the seals shortening the life of both seal and rod**

Establish Leak Reduction Expected

- Step 2: Compare current leak rate to initial leak rate to determine leak reduction expected
  - **Leak Reduction Expected (LRE) = Current Leak Rate (CL) – Initial Leak Rate at the last ring/ rod replacement (IL)**
  - **Example: The current leak rate is measured as 50 cf/h, the same component leaked 10 cf/h when first installed**

LRE = 50 cf/h – 10 cf/h
LRE = 40 cf/h

Assess Costs for Economic Rod Packing Replacement

- Step 3: Assess cost of replacements
  - **Packing ring replacement costs depend on the number of cylinders and the type of ring**
    - **Cost of a set of rings: $ 500 to $ 800**
      (with cups and case) $1500 to $2500
  - **Rod replacement costs vary with rod dimension and rod type**
    - **Cost of Piston Rod: $1800 to $3500**
  - **Installation costs roughly equal equipment costs**

Replacement Threshold for Economic Rod Packing Replacement

- Step 4: Determine economic replacement threshold
  - **Economic replacement threshold defines the specific point at which it is cost effective to replace rings and rods**
  - **Discounted cash flow method**
    - **Economic replacement threshold (cfh)**
      = (CR*DF*1,000) / (H*GP)
      where, CR = cost of replacement ($)
      H = hours of compressor operation per year
      GP = gas price ($/Mcf)
      DF = discount factor = $i*(1+i)^n / (1+i)^n - 1$
      i = discount rate or company hurdle rate
      n = payback period selected

Is Recovery Profitable?

- Step 5: Replace packing and rods when cost effective
  - **Example:**

Rings Only

Rings:	$1,200
Rod:	$0
Gas:	$3/Mcf
Operating:	8,500 hrs/yr

Leak Reduction Expected (cfh)	Payback Period (years)
52	1
27	2
19	3
15	4
12	5

Rod and Rings

Rings:	$1,200
Rod:	$7,000
Gas:	$3/Mcf
Operating:	8,500 hrs/yr

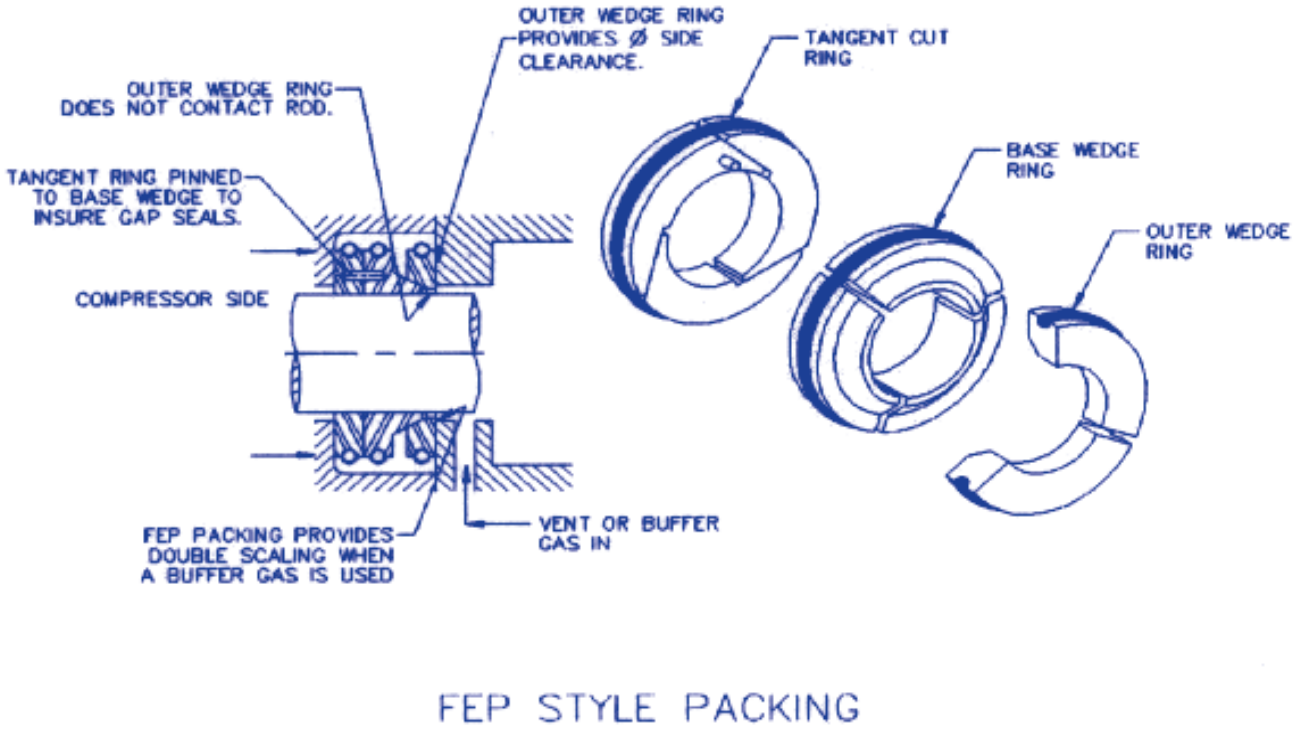
Leak Reduction Expected (cfh)	Payback Period (years)
354	1
185	2
129	3
101	4
85	5

Based on 10% interest rate
Mcf = thousand cubic feet, cfh = cubic feet per hour

Industry Experience on New Rod Packing Material and Coatings

- New packing materials can improve the life and performance of equipment
  - **Carbon impregnated Teflon® rings cost almost the same as bronze rings but last about one year longer**
    - **Other factors like proper installation, cooling and lubrication play an important role**
  - **Piston rods coated with tungsten carbide or chromium increase service life of rods**
  - **Axially loaded packing installed in one of the last two cups reduces emissions**

Axially Loaded Three Ring Rod Packing



FEP STYLE PACKING

Source: Compressor Engineering Corporation

Discussion Questions

- What is your practice on replaced rod packing in reciprocating compressors?
- How can the Lessons Learned study be improved upon or altered for use in your operation(s)?
- What are the barriers (technological, economic, lack of information, regulatory, etc.) that are preventing you from implementing this technology?