New Compressor Technologies for Emissions Reduction in Shale Gas Applications

Natural Gas STAR Implementation Workshop
November 2015

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Flatrock Compression

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- **Summary of the project findings**
- **Introduction and Background of this application**
- **Test methods & Data Collection**
- **Pressure Packing & Valve Designs Utilized**
- **Study Results**
- **Benefits to Customer & Equipment Owner**

One or both of these technologies are currently applied in a number of recip. compressor applications in units owned or leased by *Natural Gas Star* partners such as DCP Midstream, Targa, EnerVest, Enogex(Enable), Trillium, Kinder-Morgan and others.

Disclaimer: This test and its conclusions as interpreted by the authors, apply only to this specific field application and equipment.

Project Summary

In today's business environment, companies must work smarter, not harder to maintain profitability and meet environmental regulations.

Problem: Shale Gas applications produce heavy liquids & debris, significantly affects compressor life.

- **reduces efficiency & reliability and thus increases operating cost**
  - ✓ **increased number of shutdowns for valve and packing change-outs**
  - ✓ **higher costs for more frequent parts replacement , Increased labor and travel to troubleshoot**
- **increases overall compressor package emissions**
  - ✓ **more compressor blow downs at each shutdown**
  - ✓ **higher wear rates and rod seal damage = higher GHG and oil leakage**
  - ✓ **higher HP/mcfd due to valves = higher fuel used = more exhaust**

Project Summary - *End of 2013, Flatrock commissioned a lifecycle study of (10) GE/Gemini wellhead compressors in the Eagleford Shale (EFS) .*

Goal: To examine how more durable valves & rod seals can better handle heavy liquids & debris.

Results:

- **Reduced # unplanned shutdowns/yr** ***90%***
- **Reduced # replacement valves/yr from 190 to 6.** ***97%***
- **Reduced # replacement 1-1/8" packings/yr from 31 to 1** ***97%***

Project Summary - *cont. Flatrock commissioned study*

To measure and reduce compressor natural gas emissions with same technologies

Results:

- **Reduced number of blow downs Saves 4.8 Mcf/yr =**

***.1 tons CH_4/yr**

- **Unit Packing average leakage rate reduced 19.5scfh or 156 Mcf/yr) =**

***3.3tons CH_4/yr**

- ***Total lost gas $$ savings per Unit @ $3/Mcf =**

$468/yr

Used the EPA Methane online calculator. Actual tonnage is higher for this VOC gas. 1 year is 8000 hours

Introduction - *Flatrock Compression rents compressors for natural gas wellhead & gathering applications .*

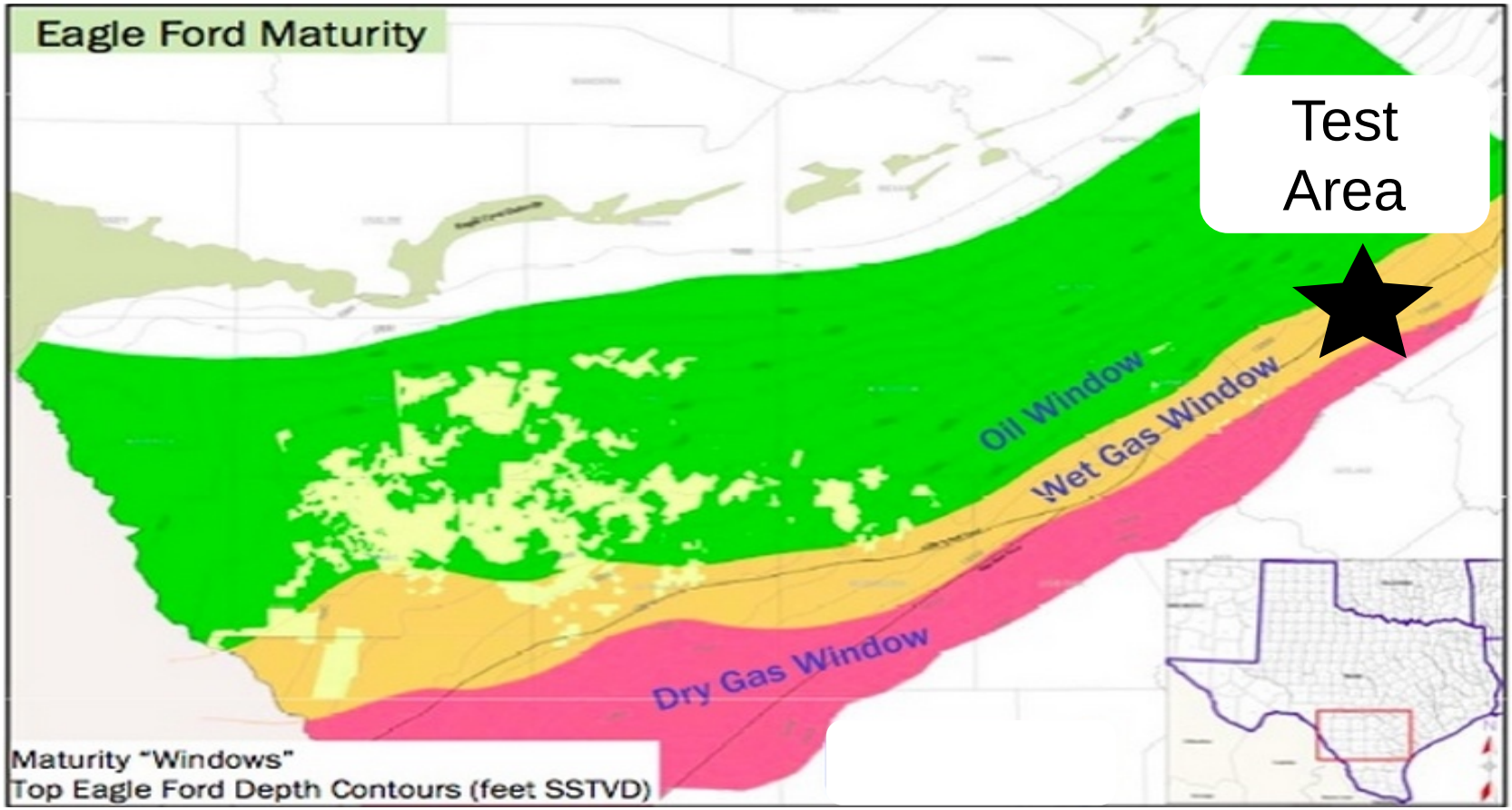
Produced hydrocarbon market prices down 40+%. Unit providers must work efficiently due to reduced rental rates

Their goal is to achieve a 98%+ unit mechanical availability.

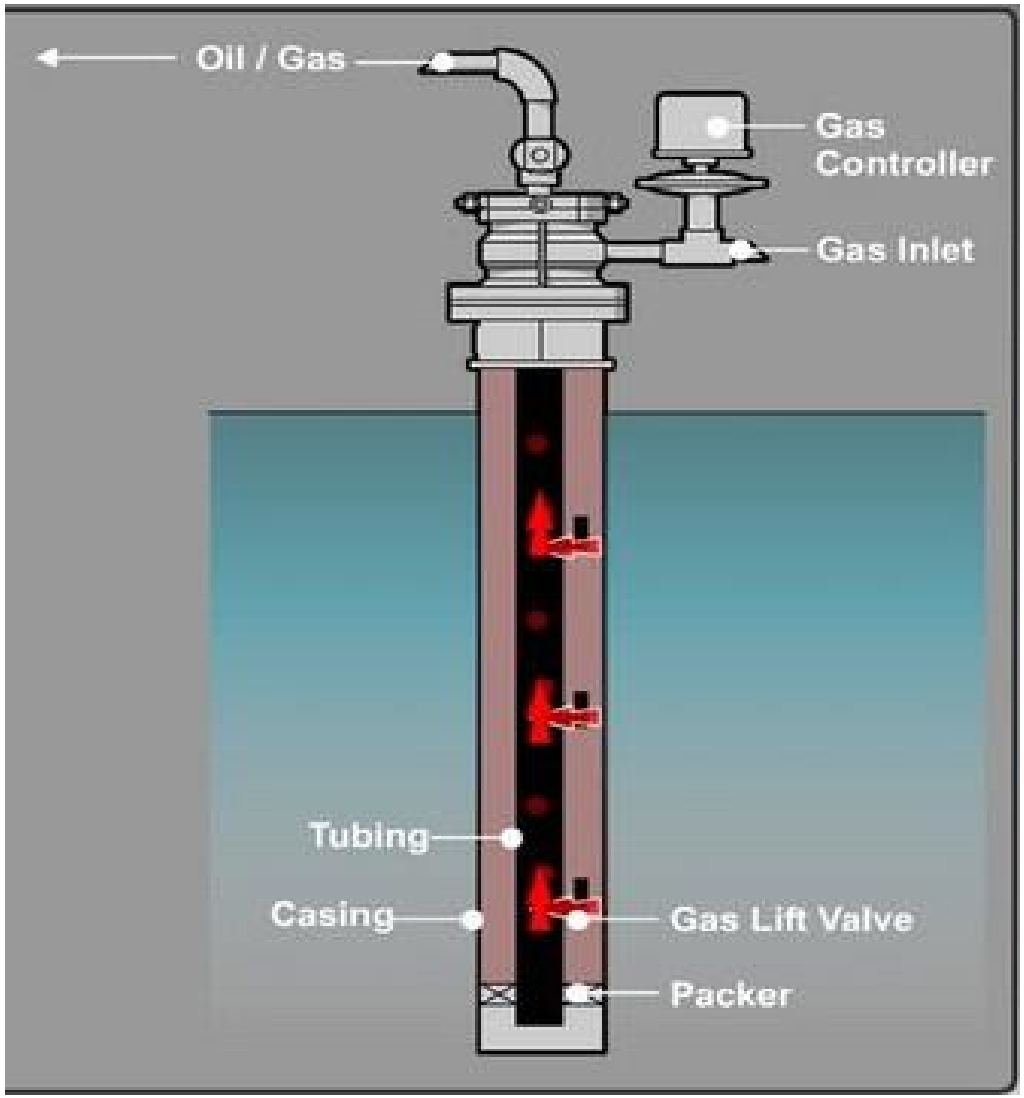
- ✓ **maximize run time between scheduled maintenance**
- ✓ **minimize number of unscheduled shutdowns.**

Background – *Eagleford Shale (EFS)*

EFS is a highly active shale play in S.Texas. An ideal location for field testing in this light oil window (0.75 to 0.80 SG)



Background - *Gas Lift is used to extract oil and NGL*



A gas lift compressor injects natural gas through a tubing-casing annulus to aerate the well fluids and reduce its specific gravity.

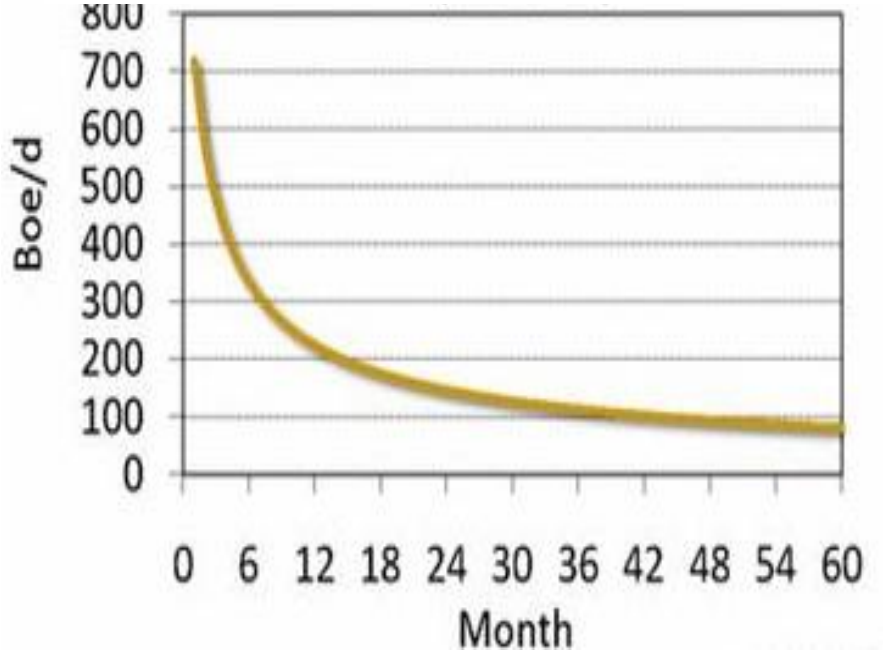
The enhanced formation pressure lifts the lighter fluid column and forces it out of the well bore.

High liquid carry-over ingested by the compressor causes internal damage

Background – *these are often newly Fracked wells*

Produced solids and liquids carry-over typically includes: sand, paraffin, NGL, saltwater, chemicals and frac fluid in varying volumes

Typical production decline curve



Fast declining well gas pressure & flow also affects operating conditions.

Background - *oil field emulsions*

- **Recip compressor cylinder readily mixes oil & liquids (water, hydrocarbon & production chemicals) creating an Emulsion**
- **Types of Emulsion: Water-in-oil; Oil-in-water; Complex/multiple emulsions these will also mix with solids.**

Loose Emulsion

Very Tight Oil Emulsion

Oil-field emulsions are not compressible and will damage compressors.

The study – *Ten 3 stage test Compressors*

Two GE units types: H302 (145hp) & A352 (215 & 325hp)

Pre-test Data

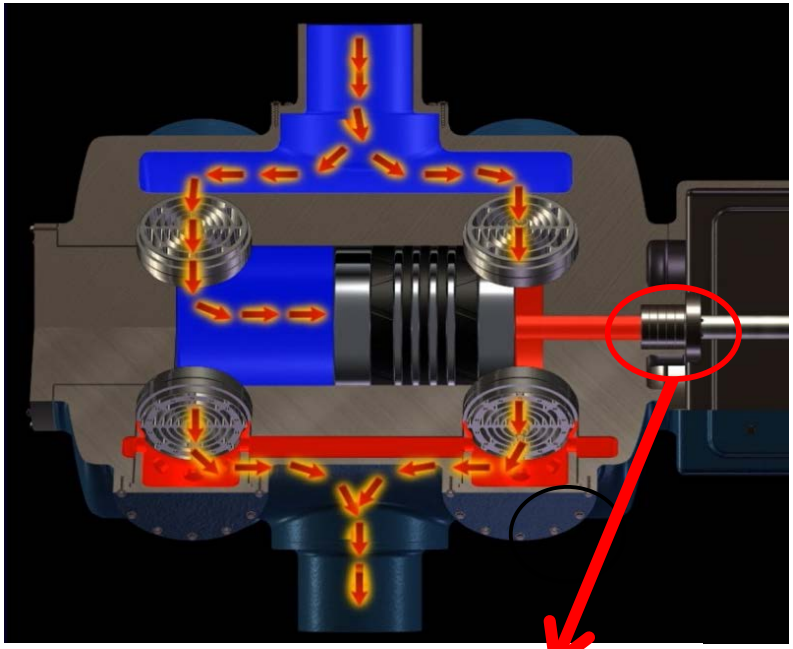
- ✓ maintenance logs, outages, & repair costs reviewed for past 3 years
- ✓ rod packing emissions tests made on typical units
- ✓ established O&M cost basis for valves and packing
- ✓ Testing Team - Flatrock Field techs and Hoerbiger engineers

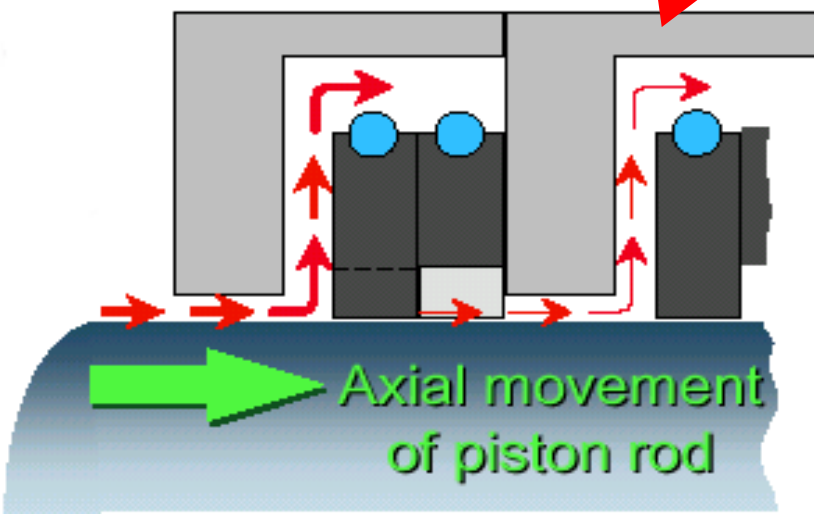
New Compressor Valves & Rod Packing installed

Nov. 2013, quarterly testing commenced tracking:

- ✓ unit status, the event log and operating conditions
- ✓ valve cap temperatures taken to determine valve condition
- ✓ packing case leakage measured

Pressure Rod Packing Sealing





Recognized target leakage rate might be:

***10-12cfh** **(cubic feet/hour/cylinder)**

550 cfday **per Flatrock unit**

or

.011 tonnes **CH4 per day**

<4 tpy(year)

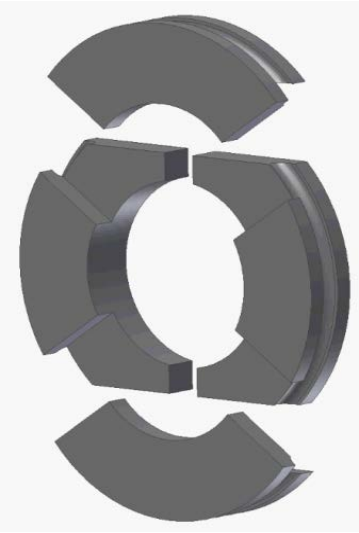
Failed rod packing might see ten+ times acceptable leakage rate

*lowest leak rate is application specific. See Lessons Learned from Natural Gas Partners, *"Reducing Methane Emissions from Compressor Rod Packing Systems "*

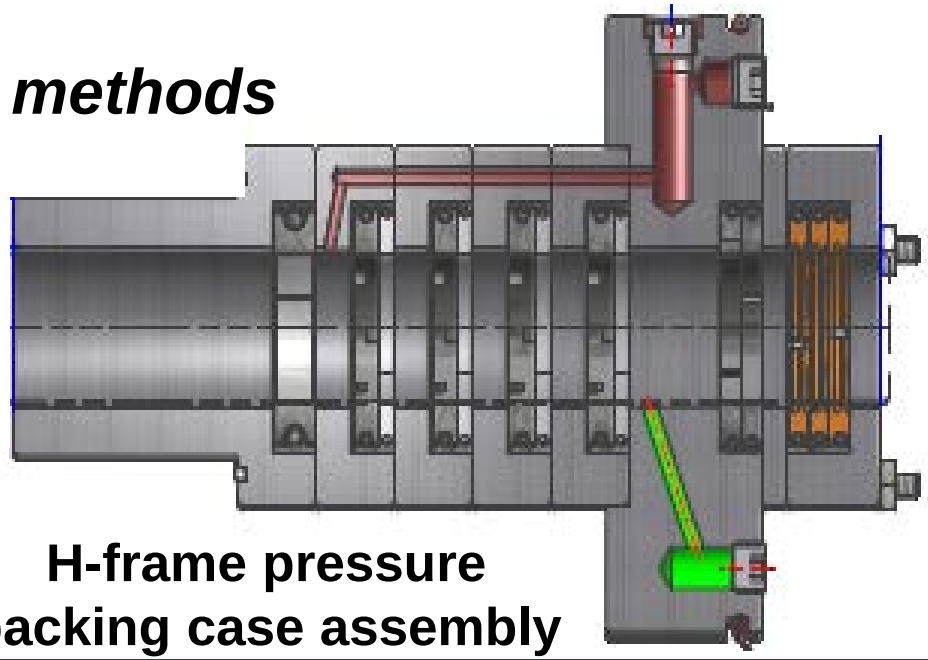
Upgrades to Flatrock units

Increase run time – EPA new limit of 3 years

- ***Replace assembly - new or Certified repair***
- ***Install BCD ring style to improve durability and last the 3+ years***
- ***Installed hardened Piston Rod***
- ***Train to improve installation methods***
  - ✓ ***Requires a proper torquing of the flange bolts***
  - ✓ ***New nose gasket***
  - ✓ ***Gas leakage check***



BCD style ring



H-frame pressure packing case assembly

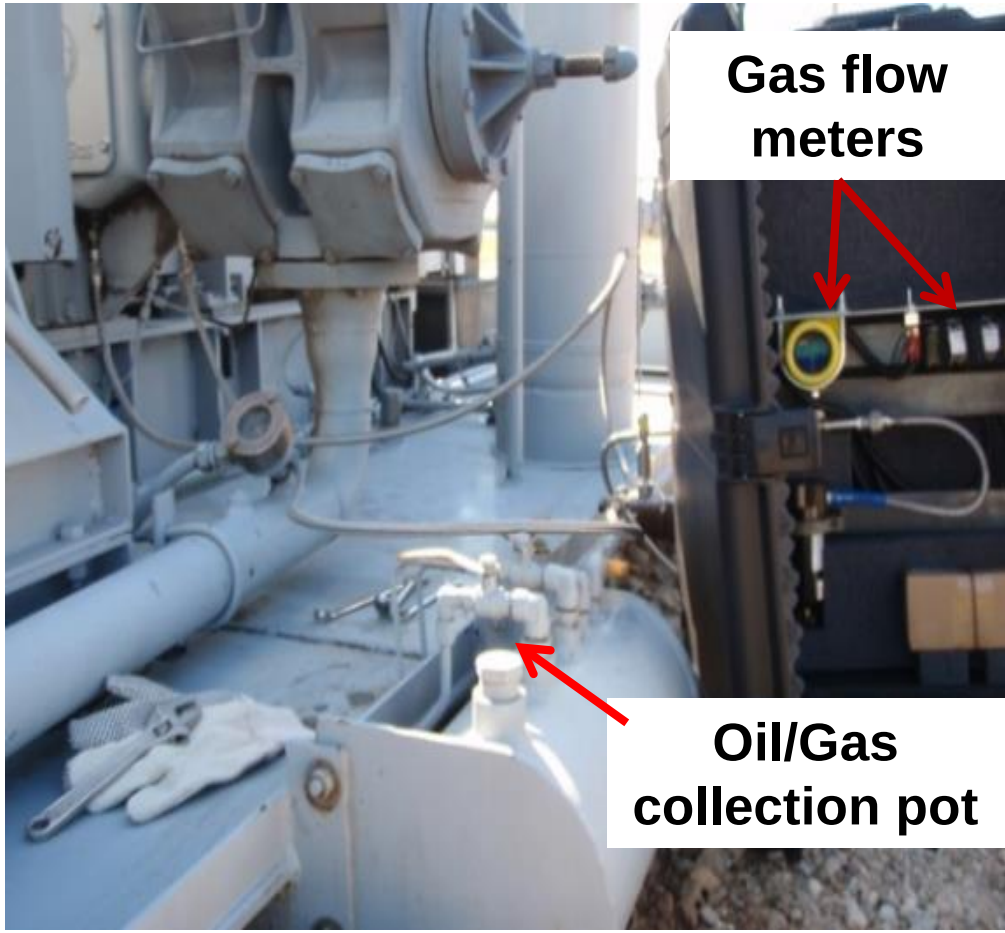
Data Collection -- *Rod Packing leakage*

Two measurements were made for each throw:

- ✓ **packing flange vent outlet**
- ✓ **packing case cavity**

Used two calibrated mass flow meters; a high range and a low range.

- ✓ **each point measured separately then totaled**
- ✓ **testing 3 years with 12 readings per unit**



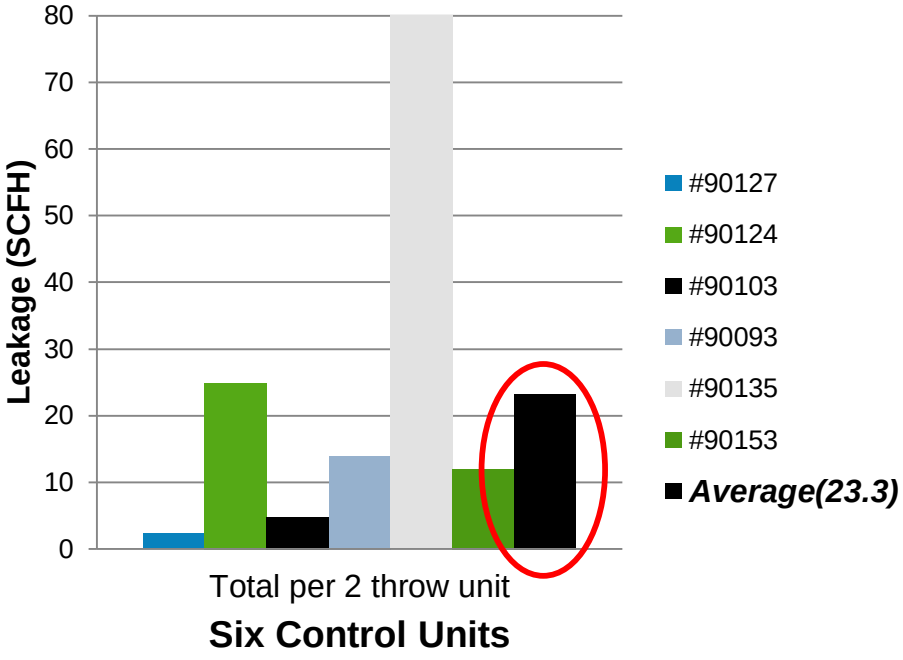
Study Results – *Packing Leakage*

Unit* average leak rate reduction of 19.5 scfh

Old style rings 23.3 scfh

Unit Packing Run-in Leakage

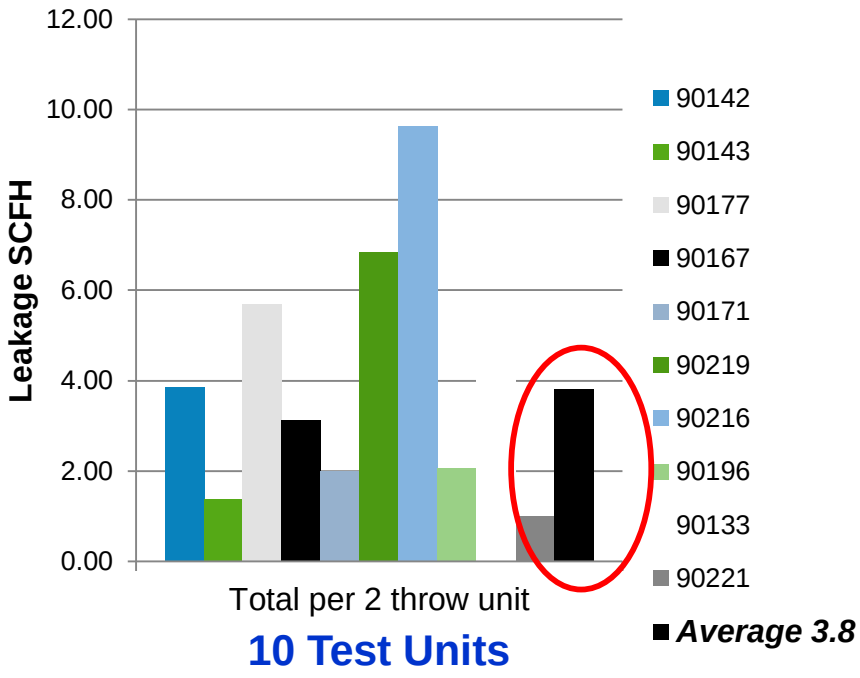
Old Seal Design



BCD style rings 3.8 scfh

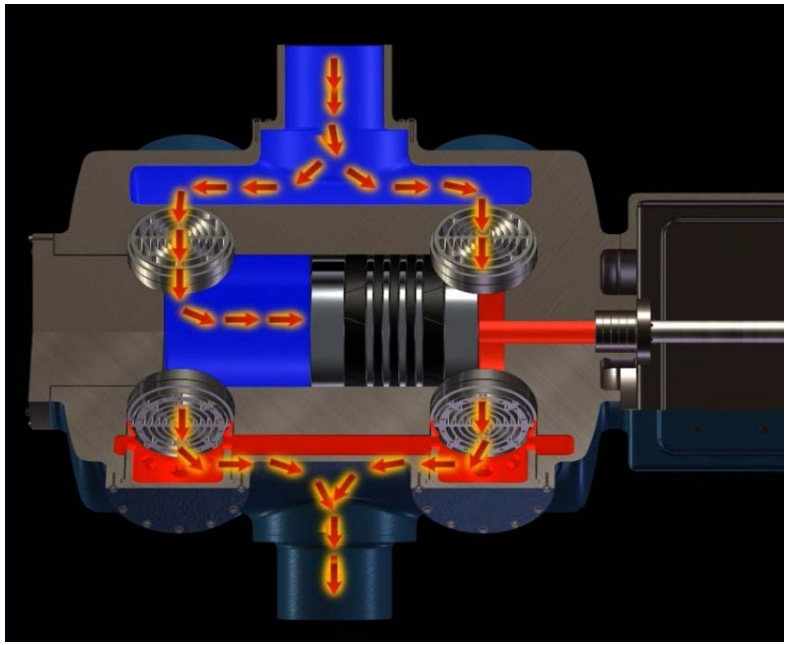
Unit Packing Run-inLeakage

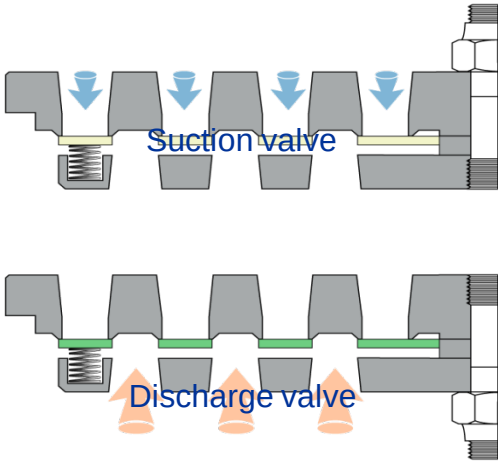
BCD Seal Design



* Total readings of both throws(packings),does not include the one day wear in.

Compressor Valve performance





Compressor valves are the heart of the compressor, opening and closing with each compression stroke.

- **High reliability requires steady conditions, but life is affected by:**
  - ✓ **pressures, rises in temperatures**
  - ✓ **increase in weight of the median**
  - ✓ **loss of seal due to solids**

- **Efficiency requires maximum open areas through the valve**
  - ✓ **Open porting**
  - ✓ **Proper timing of opening and closing**

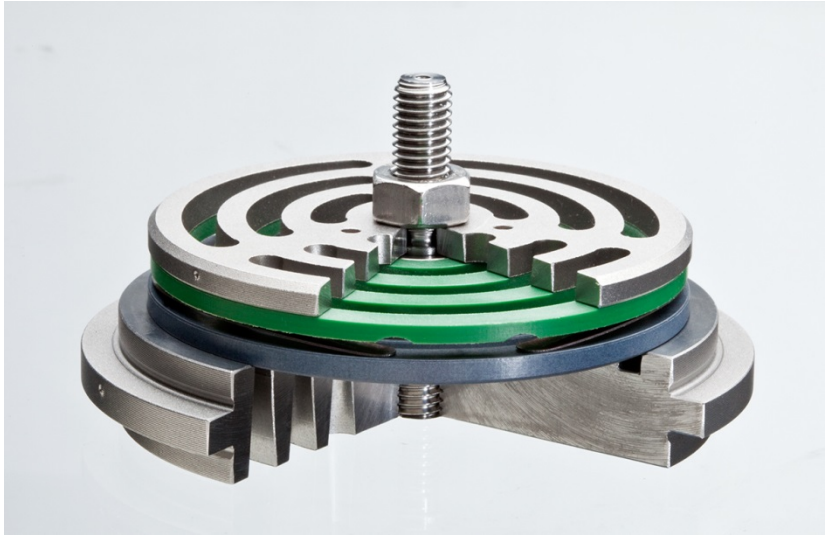
Valve Design – *CPs Valve*

Test confirmed

- **improved gas flow with lower flow resistance**
- **self cleaning was evident**
- **ease of cleaning in the field**

Results are now 3 years and counting with the original valves.

Increased runtime between failures/shutdowns by 97%.



Annual valve inspections – *2014 & 2015*

Retainer and valve with paraffin wax buildup

Valve Seat before & after hand clean up

Study Results – *Operating Hours*

Valves and packing on most units now over 15,000 hours

Unit	CPs Qty	Install Unit Hours	Last Site Visit Date	Confirmed CP Hours
90219	6	2343	9/1/2015	14181
90171	4	10495	9/1/2015	13039
90177	4	37026	9/1/2015	12896
90143	4	49560	9/1/2015	12843
90221	6	26313	8/24/2015	12578
90142	8	37575	7/7/2015	10696
90133	4	0	7/29/2015	8991
90196	6	31535	7/7/2015	8673
90167	4	49553	8/6/2015	4847
90216	6	19135	7/21/2015	4835

Future implementation

Compressor	Hp Rating	New Design Valve & Packing Cost Estimate	Pay back (years)
H302 – 3 stg	145	$7,000	4.8
A352 – 3 stg	215	$9,000	1.8
A352 – 3 stg	325	$14,000	1.4

Based on the program results, the packing and valve replacement is planned for:

1. Any compressor experiencing multiple overload conditions caused by liquid or debris carryover

2. All A352 compressors

Summary - *Study Results*

- **Significant reduction in O&M outages & $/Hp-year for 10 test units' valves & pressure packing vs standard components.**
- ***Greatly extended runtimes are still being experienced. Now exceeding 15,000 run hours***
- **Reduced number of shutdown/blowdowns can add up to high emissions**
- **Pressure packing gas leakage after a short start-up/wear-in *dropped from 24 to 3 scfh*; a 19.5 reduction in GHG/VOC emissions from one unit!**
- **Valve and packing upgrades are cost affective, especially when addressing "special" situations where liquids & debris common.**

Benefits to Producer

- **Increased profitability from consistent and stable process operations.**
- **Reduced engine exhaust and GHG emissions**
  - ✓ **Reduces compliance issues**
  - ✓ **Enhances company GHG reduction goals**
- **Reduced packing leakage keeps more gas & lubricating oil in compressor**
  - ✓ **increases saleable/useable gas, even at 3.00 $/MCFD**
  - ✓ **minimizes the on-site handling/disposal of liquid hydrocarbons (oil).**
- **Improved equipment reliability provide a better utilization of assets & personnel**

Benefits to Equipment Owner

- **Increased profitability from consistent high unit availability**
- **Reduced labor, travel and maintenance costs with longer lasting wear parts.**
- **Low cost retrofit of new technology to existing legacy compressors will give faster paybacks.**
- **Reduced after hour callouts increases profitability and safety.**
- **Improved unit reliability optimizes personnel utilization increasing routine maintenance activities.**
- **An improved overall work environment, gives fewer “surprises” increasing employee morale.**

Questions?

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