Evaluating the Long-Term Performance of Composite Wear Rings in Centrifugal Pumps

By Robert Aronen Boulden International and Martin Russek, Sunoco

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Mr. Aronen received a B.S. degree (Mechanical Engineering, 1991) from Rose-Hulman Institute of Technology.

Martin Russek, Sunoco: *Martin Russek is a Rotating Equipment Reliability Engineer at the Sunoco, Philadelphia Refinery. He has worked in several rotating equipment reliability roles for Sunoco at their 3 refineries in the Northeast since 1999. He has been responsible for numerous pump, compressor, and turbine upgrades. Prior to his work in the refineries, he was a Systems Engineer and Maintenance Engineer for Public Service Electric & Gas Company. He has a Level II vibration certification and is an INPO certified Systems Engineer.*

Mr. Russek received a B.S. degree (Mechanical Engineering, 1989) from Trenton State College.

Background

- Refinery instituted a reliability improvement program to install composite wear rings as a standard upgrade to all bad-actor pumps
- Initial results were published at 2007 International Pump Users Symposium
- This Case Study provides long-term results after more than 4 years of running time

Program Scope

61 Centrifugal Pumps
Temperatures from 65 ^{o}F (17 ^{o}C) to 475 ^{o}F (246 ^{o}C)
Hydrocarbon, Acid, Amine, Water, Caustic services
Multiple API horizontal and vertical pump types
Intermittent (tank farm, product transfer) and continuous process services

Which Components?

Horizontal Pumps	Vertical Pumps
Stationary wear rings	Stationary wear rings
Inter-stage rings	Bowl bearings
Center-stage bushings	Line-shaft bearings
Throttle bushings	Throat bushings
Throat bushings	

Why Composite Wear Rings?

- No metal-to-metal contact
  - Avoid seizure
  - Survive process upsets
- Reduced Clearance
  - Lomakin Effect
  - Lower vibration
  - Reduced shaft deflection
  - Lower NPSHR

Material Selected: PFA/CF Composite

Key Properties		
Coefficient of thermal expansion (x-y)*	3.1 X 10^{-6} (in/in/^{o}F) 5.6 X 10^{-6} (mm/mm/^{o}C)	ASTM E-831
Temperature Limit*	500 ^{o}F (260 ^{o}C)	ASTM D-648
Limiting PV*	278000 (psi-ft/min) 9.7 (Mpa-m/sec)	Falex test
Chemically compatible with everything in the refinery		
Favorable machining and installation characteristics		

*Source: DuPont™ Vespel® CR-6100

Definitions

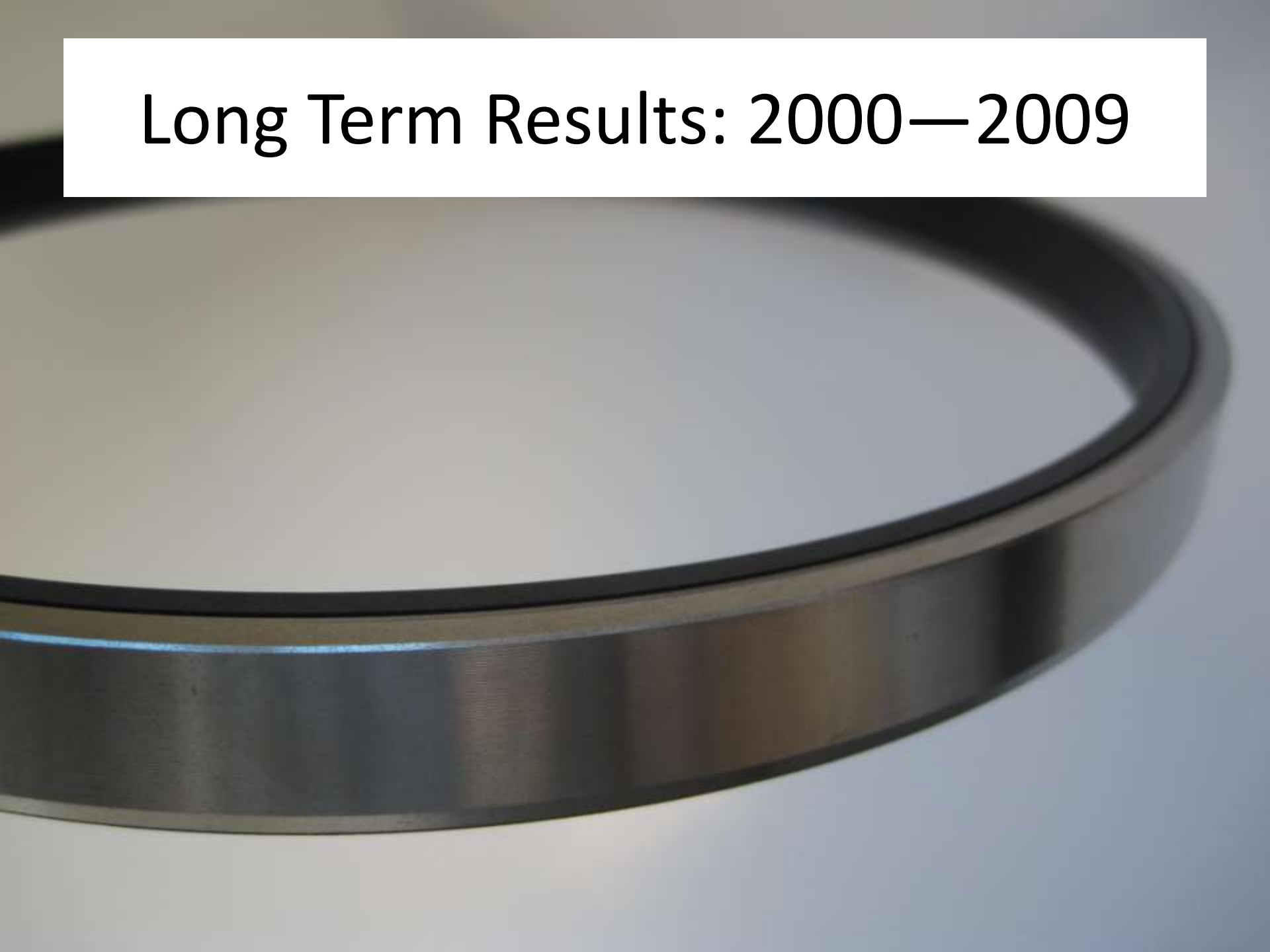
Repair	Any work order—includes seals, bearings, vibration issues, wear ring seizure, inability to make rate, etc… with an associated cost
Overall Vibration	Average of 111 vibration data points from the 25 horizontal pumps within the study population.
LDAR Seal Leaks	Leak Detection and Repair (LDAR) program, which monitors single mechanical seals in VOC (volatile organic compound) services.

Results from Original Study 2003—2006

Factor Studied	**Change**
Number of Repairs	45% Reduction
Overall Vibration	25% Reduction
LDAR Seal Leaks	70% Reduction

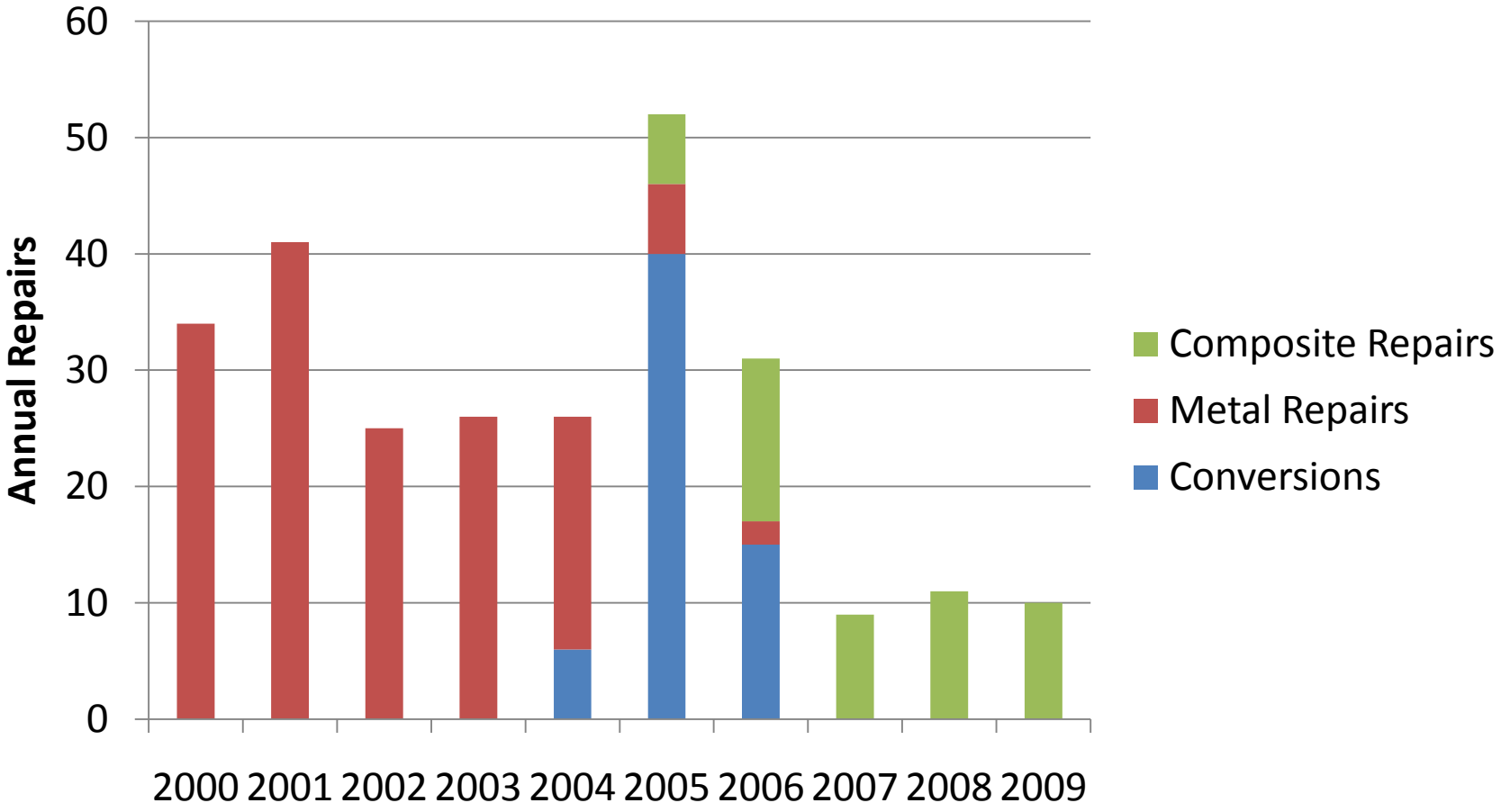
*Source: Aronen, R., Boulden, B., and Russek, M., 2007, "Driving Pump Reliability Forward with Advanced Composite Wear Rings," *Proceedings of the 23rd International Pump Users Symposium*, Turbomachinery Laboratory, Texas A&M University, College Station, Texas, pp. 15-19.

Long Term Results: 2000—2009



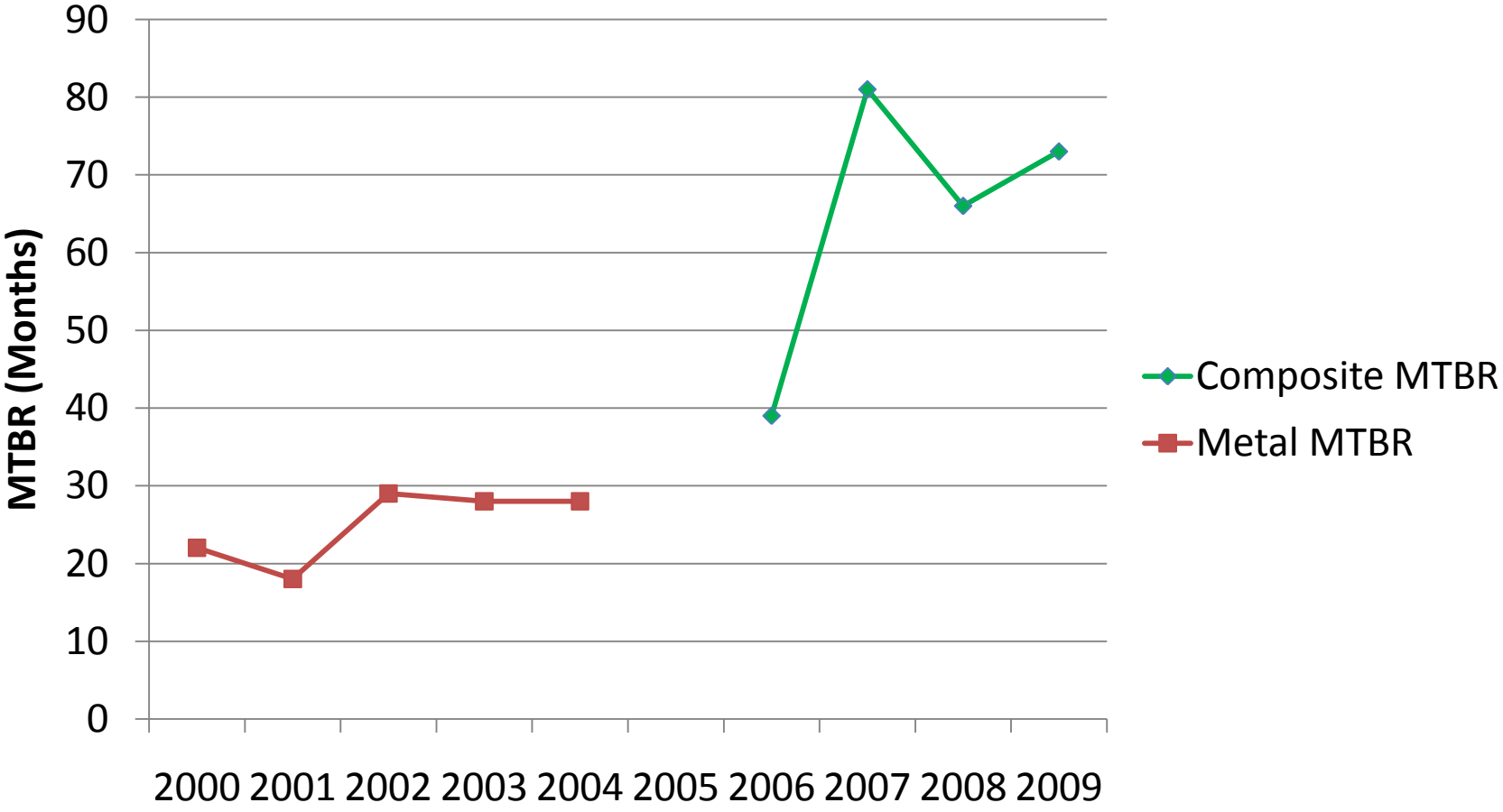
Annual Repairs

(Population 61 Pumps)



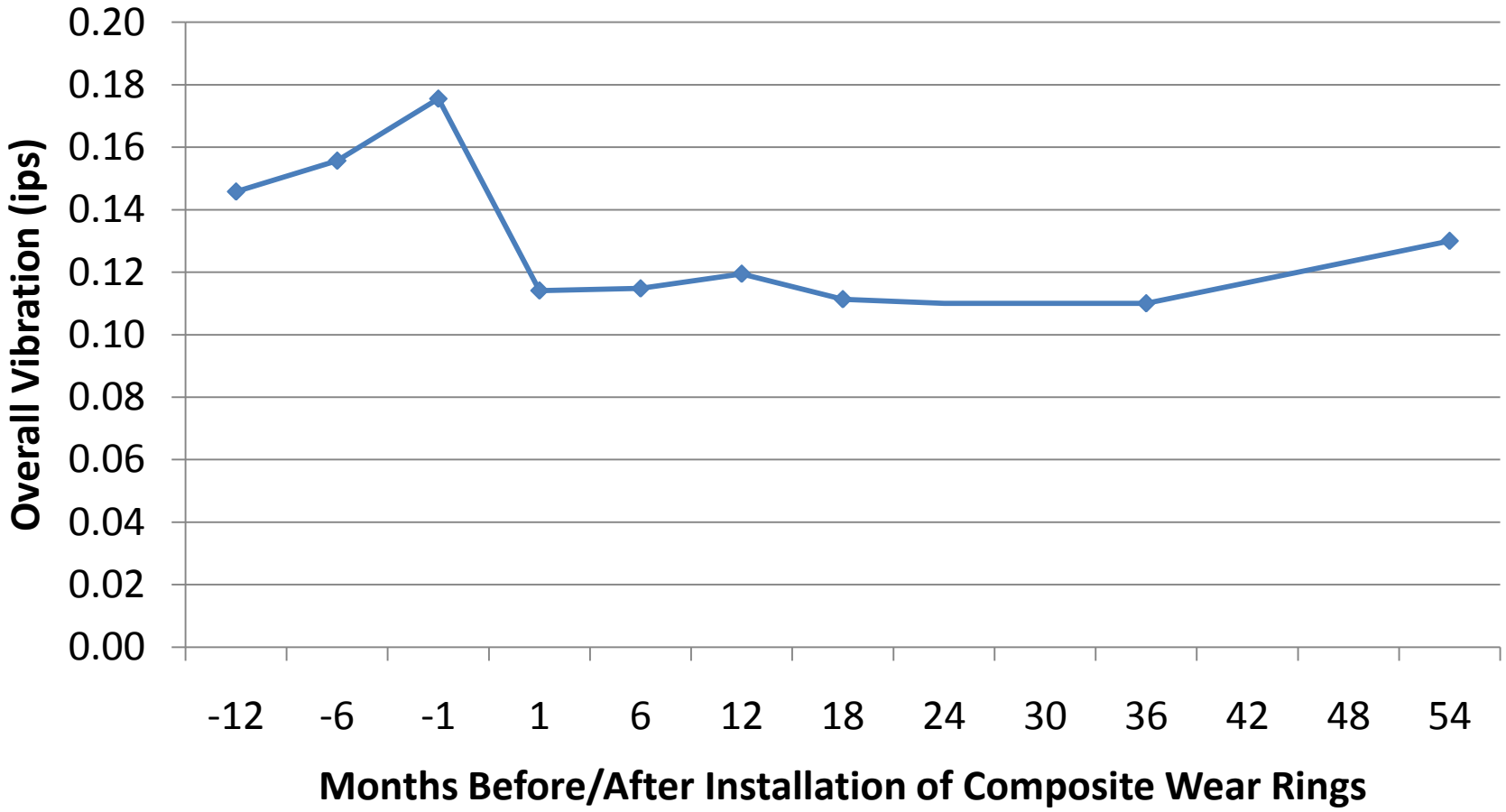
MTBR Before and After

(Population 61 Pumps)



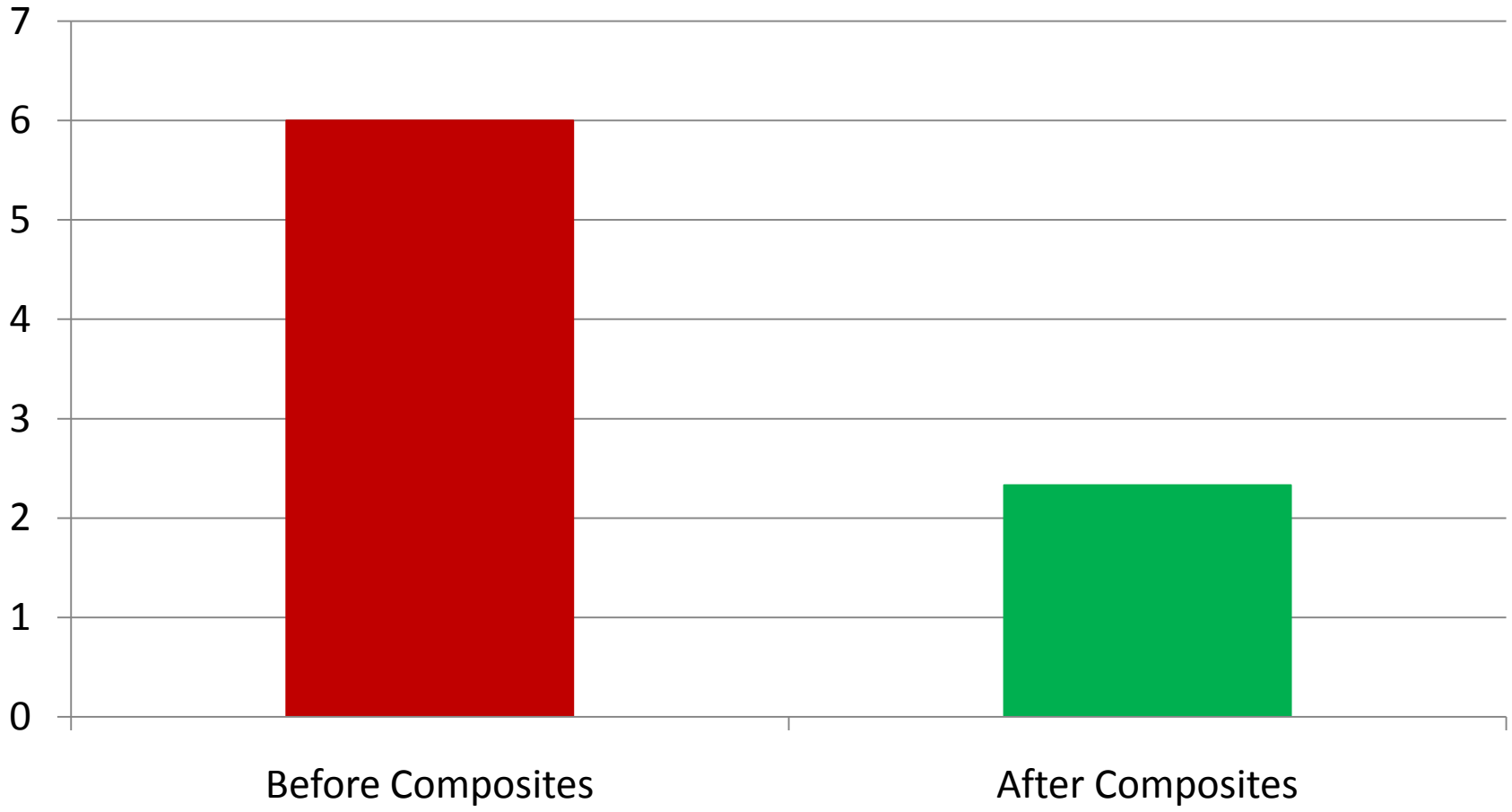
Overall Average Vibration

(Population 25 Horizontal Pumps)



Annual Seal Leaks in VOC Service

(Population of 12 Pumps)



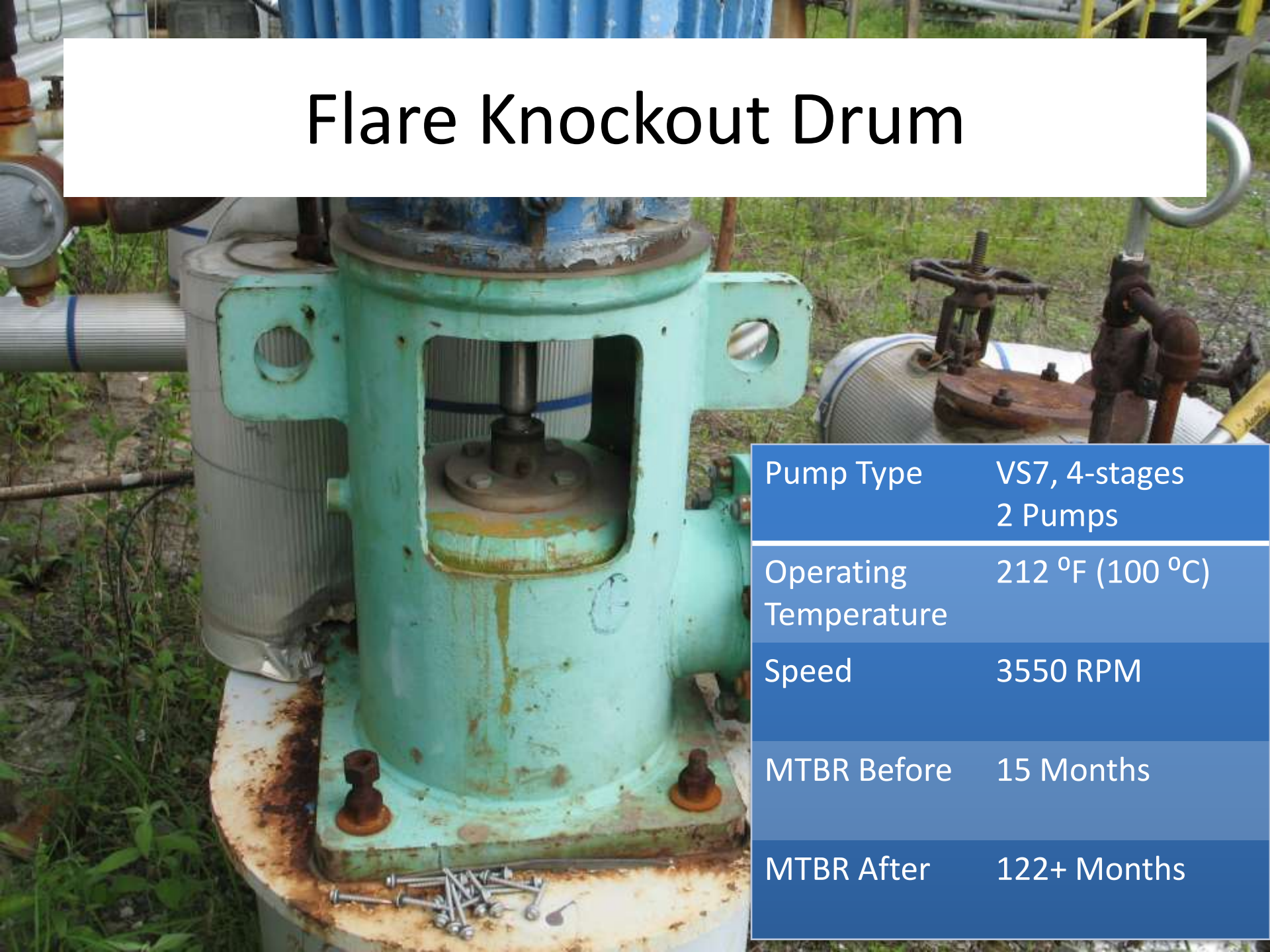
Specific Examples

Boiler Feed Water

Pump Type	BB3 3 Pumps
Operating Temperature	230—250 ^{o}F (110—120 ^{o}C)
Speed	3550 RPM
MTBR Before	15 Months
MTBR After	41 Months*

* One pump had 3 lube oil system failures which were included in calculation, otherwise MTBR would have increased to 163 months

Flare Knockout Drum



Pump Type	VS7, 4-stages 2 Pumps
Operating Temperature	212 ^{o}F (100 ^{o}C)
Speed	3550 RPM
MTBR Before	15 Months
MTBR After	122+ Months

Gasoline Transfer

Pump Type	OH2 4 Pumps
Operating Temperature	Ambient
Speed	3550 RPM
MTBR Before	17 Months
MTBR After	120 Months

Debutanizer Reflux

Pump Type	OH2 2 Pumps
Operating Temperature	100 ^{o}F (38 ^{o}C)
Speed	3550 RPM
MTBR Before	22 Months
MTBR After	107+ Months

Limitations

- In 2005 and 2006 there were some premature composite related repairs—failure soon after start-up due to mechanical interference from reduced clearance
- Pump concentricity standards and checks after assembly were improved to address failures
- Vertical pump shaft bushing minimum clearance was also adjusted to be 0.002” (0,05 mm) larger than 50% of API minimum to avoid assembly issues

Conclusions

- Composite upgrade program improved reliability
- Repairs, vibration levels, and seal leaks decreased
- Reducing clearance requires superior concentricity
- Previous “bad actors” have run more than 5 years with zero failures
- Multi-stage pumps and pumps with start/stop operation showed the largest reliability improvements