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Improving Reliability and Reducing Steam Leakage in General Purpose Steam Turbines with Floating Brush Seals

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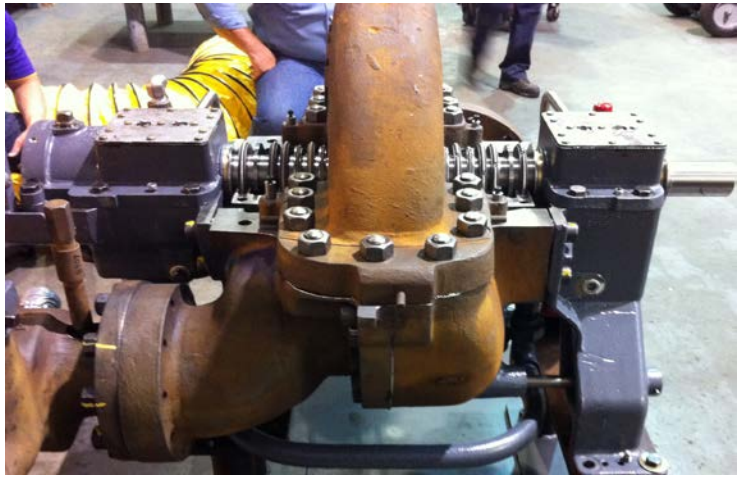
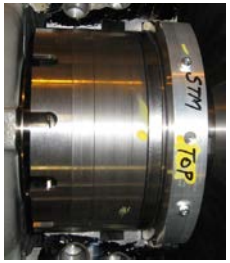
Abstract

This case study examines four different applications where brush seals were introduced into the gland boxes of process steam turbines where conventional carbon rings and mechanical seals were previously applied. The resulting observations and data are presented to highlight the impacts to gland box reliability, steam losses, and bearing life.



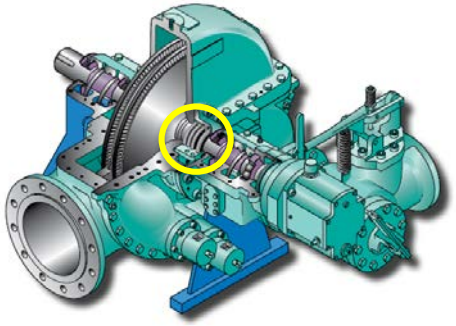


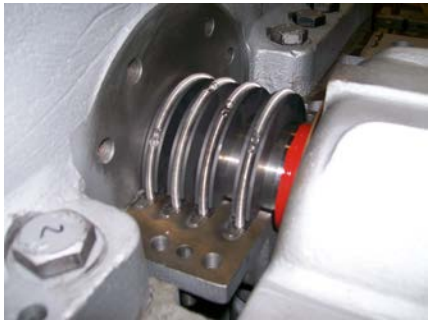
Presentation Outline

- Overview of Gland Box Sealing
- Case Study I: Refinery in Pascagoula
- Case Study II: Refinery in Texas City
- Case Study III: Petrochemical Plant in Port Neches
- Case Study IV: Petrochemical Plant in Golden Triangle
- Conclusions

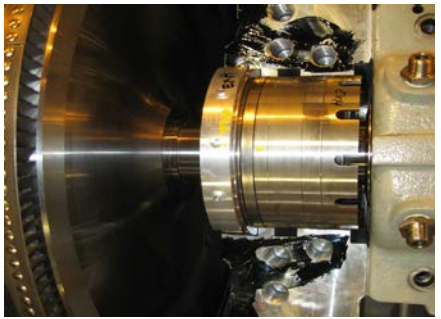
Gland Box Sealing

- Conventional: Carbon Rings
  - Conventional practice
  - 4 to 5 rings typical
  - Tight clearance
  - Easy to install
  - Wear easily
- Upgrade: Mechanical Seals
  - Low leakage
  - Alignment sensitive
  - Sensitive to “wet” steam





Carbon Rings



Mechanical Seals

Case I: Refinery in Pascagoula

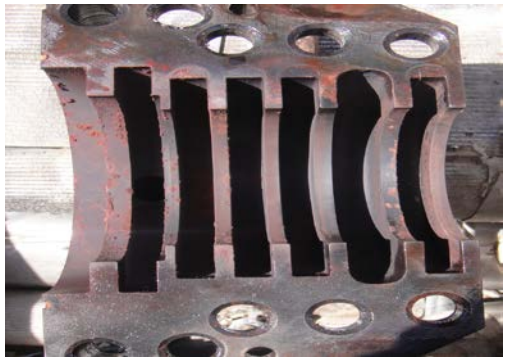
- (2) 825HP steam turbines; parallel operation; 24/7 operation
- (6) ring gland box
- Unit 1B – carbon rings; installed January 2011
- Unit 1C – floating brush seal upgrade; installed August 2015
- Exhaust Back Pressure: 150 psig
- Wet steam

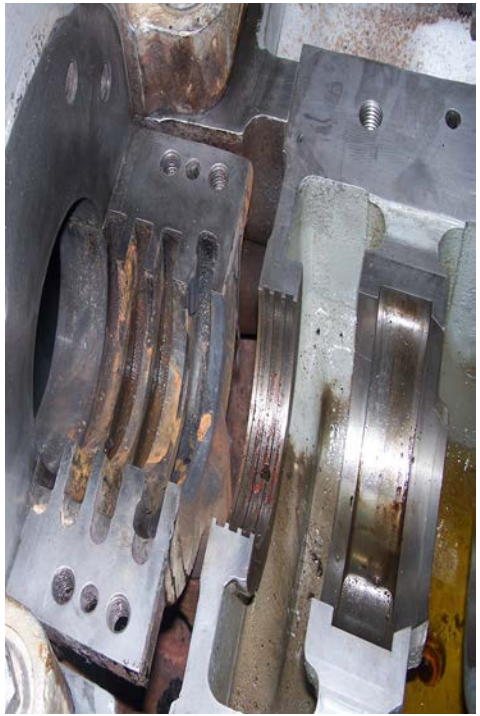
Case I: Problem Statement

- Excessive Steam Leakage
  - Gland boxes
  - Carbon ring wear
- Steam Cross-over to Bearing
  - High Oil Temperatures
  - Oil Contamination
- Environmental and Safety Hazard
  - Visible steam cloud

Case I: Root Cause

- Carbon ring wear
- Steam contamination from rust and hard particles
- Wet steam application accelerated carbon ring wear





Rust and Debris Contaminants

Floating Brush Seals

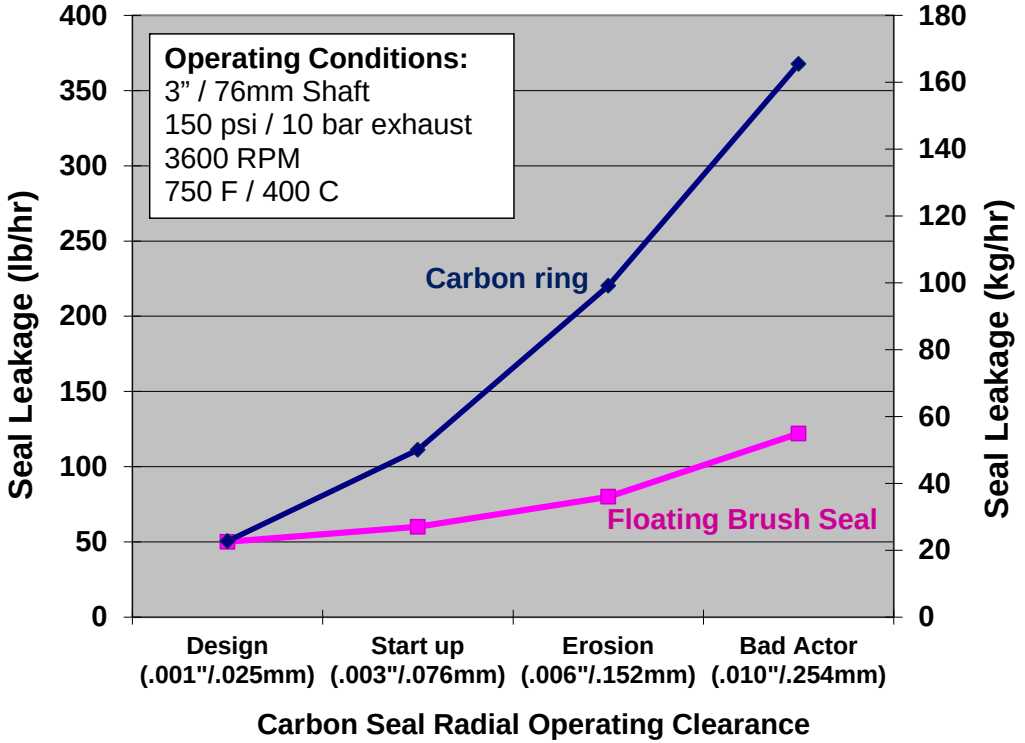
- Densely packed bristles are applied to a carbon ring
- Floating brush seals installed in gland boxes
- Drop-in replacement
- Contacting bristles filter steam contaminants
- Bristles protect downstream carbon rings

Floating Brush Seal (FBS)

FBS Gland Box Upgrade

Floating Brush Seal Basics

- Rig test comparison
- Carbon clearances based on customer interviews
- Bristle wear rate based on past steam turbine experience
- Brush seal provides a tighter clearance and lower leakage rate



Evaluation of FBS performance

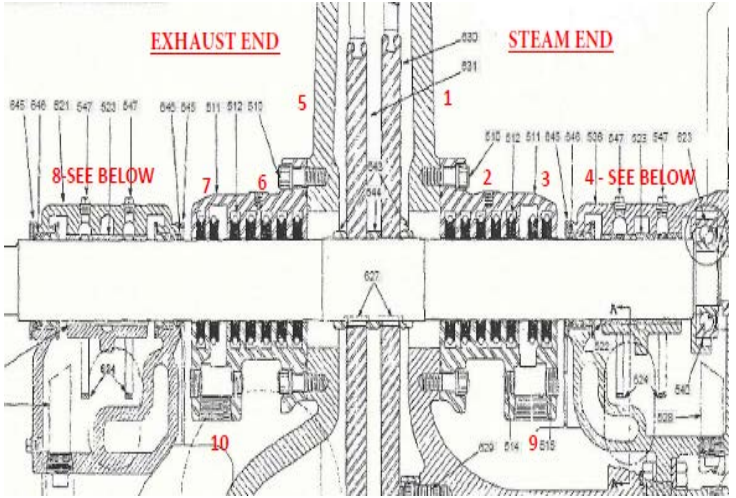
- Two identical units selected
- Turbines lacked instrumentation to measure leakage
- Surface temperatures measured on gland boxes and bearing casings

Unit 1B – Carbon Rings

Unit 1C – FBS Upgrade

Temperature comparison

- Temperature gun used
- FBS upgrade showed 20°F drop
- Higher surface temperature on FBS gland boxes supports lower steam flow to pull heat from gland casing.
- Unable to quantify leakage rate.



						STEAM END GLAND BOX (°F)				EXHAUST END GLAND BOX (°F)			
						1	3	4A	4B	5	7	8A	8B
Unit No.	Gland Box Seal Arrangement (per side)	Seals Installed	Steam Inlet Pressure (psig)	Steam Exhaust Pressure (psig)	Speed	Casing Temp	Last Seal Location	Bearing Cover (Top)	Bearing Oil Temp.	Casing Temp	Last Seal Location	Bearing Cover (Top)	Bearing Oil Temp.
1B	Carbon Rings	1/10/2011	600	150	3709	470	300	**210**	**170**	470	310	**208**	**170**
1C	FBS Upgrade	8/18/2015	600	150	3650	480	410	**190**	**153**	478	380	**168**	**153**

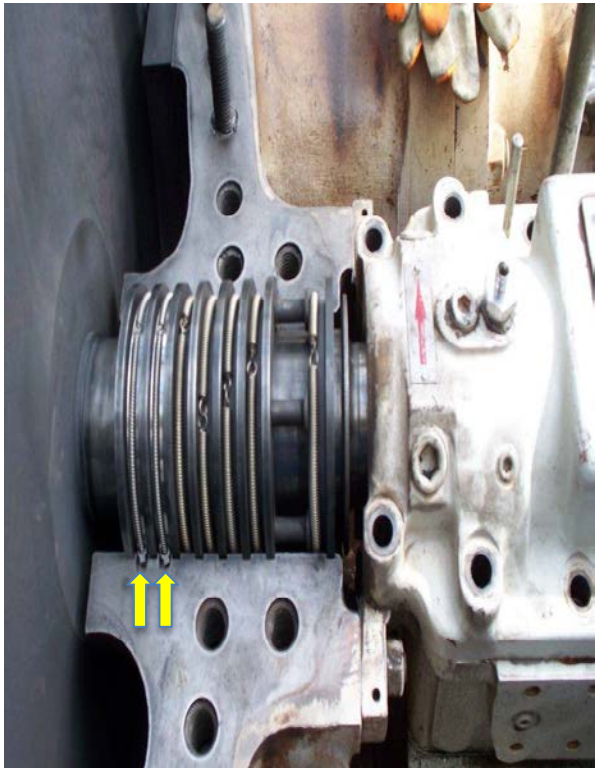
Case II: Refinery in Texas City

- Plant steam study showed gland boxes contributed to 50% of leakage
- 24 month MTBR driven by wet steam and condensate flashing.
- FBS upgrade introduced in 2008
  - MTBR passing 80 months
  - Customer claims 75-80% less leakage
  - Oil temperatures dropped 75-80 °F

FBS Gland Box Upgrade

Case III: Petrochemical Plant-Port Neches

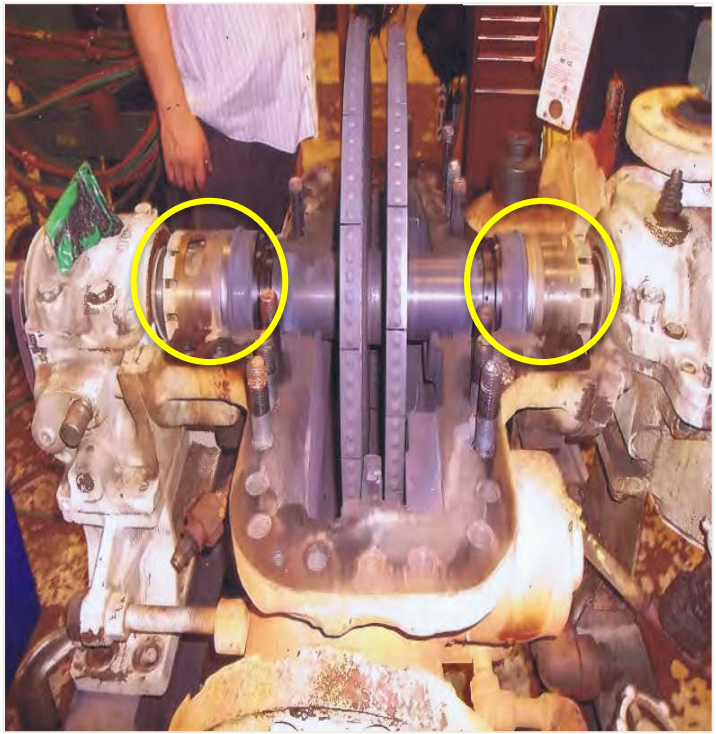
- 24 month MTBR driven by steam contaminates and condensate flashing
- Customer installed eductors to alleviate steam crossover to bearing oil
- FBS upgrade introduced in 2014
  - Eductors disconnected
  - Bleed off pressure reduced to 5 psig
  - Customer claims annual steam savings of $58,000



FBS Gland Box Upgrade

Case IV: Petrochemical Plant-Golden Triangle

- Customer upgraded carbon rings to mechanical seals to increase unit reliability
- Customer reported seal failures from condensate flashing.
- FBS introduced in 2013:
  - Withstanding condensate slugs.
  - Easy to install
  - Less expensive alternative



Mechanical Seal Upgrade

Conclusions

- Operators are seeking to improve gland box reliability
- Steam contaminates and condensate flashing impact carbon ring and mechanical seal performance
- Floating brush seals are an “in-between” alternative which enhance carbon ring performance while offering a more cost effective solution to mechanical seals.
- Upgraded gland boxes with FBS have shown:
  - Increases in MTBR
  - Ability to remove eductors
  - Reduced oil temperatures