



# Dynamic seals repair solutions and capabilities

**Joe Feula**  
Product sales manager  
Fluid & electrical distribution division

# Agenda

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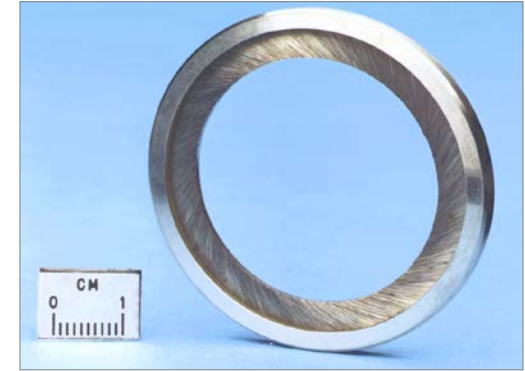
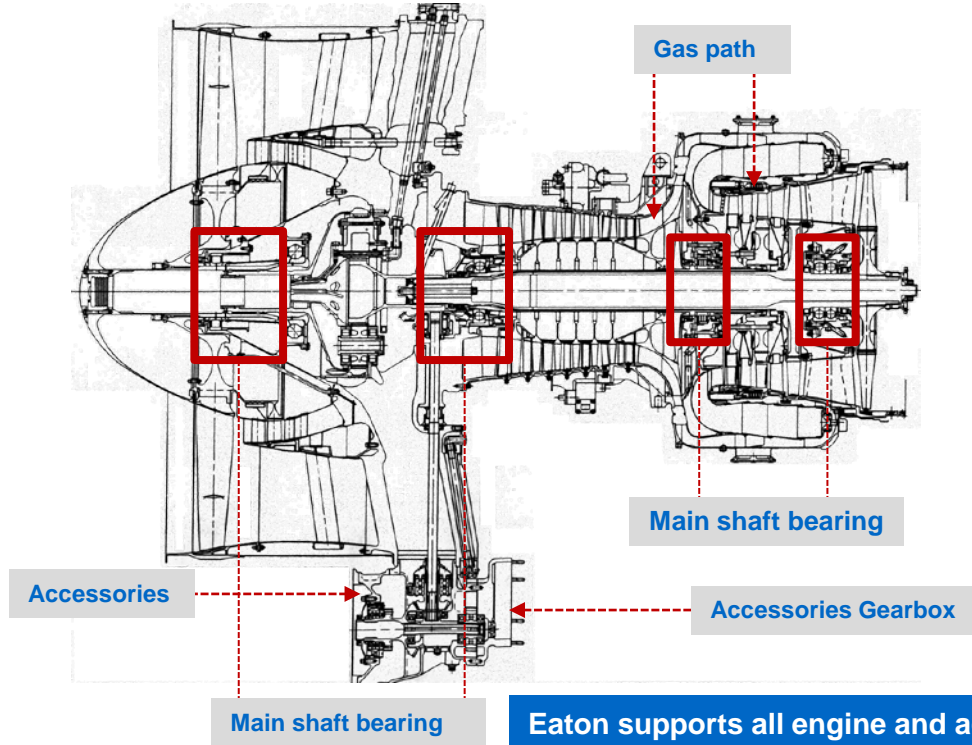
- Overview of dynamic seal products
- Hydrodynamics for sealing solutions and cost savings
- Repairable brush seals for cost savings
- Eaton east providence, RI repair station overview and capabilities
- The benefits of Carbon seal repair with Eaton

# Overview of Products



EATON is able to maximize sealing solutions through product breadth

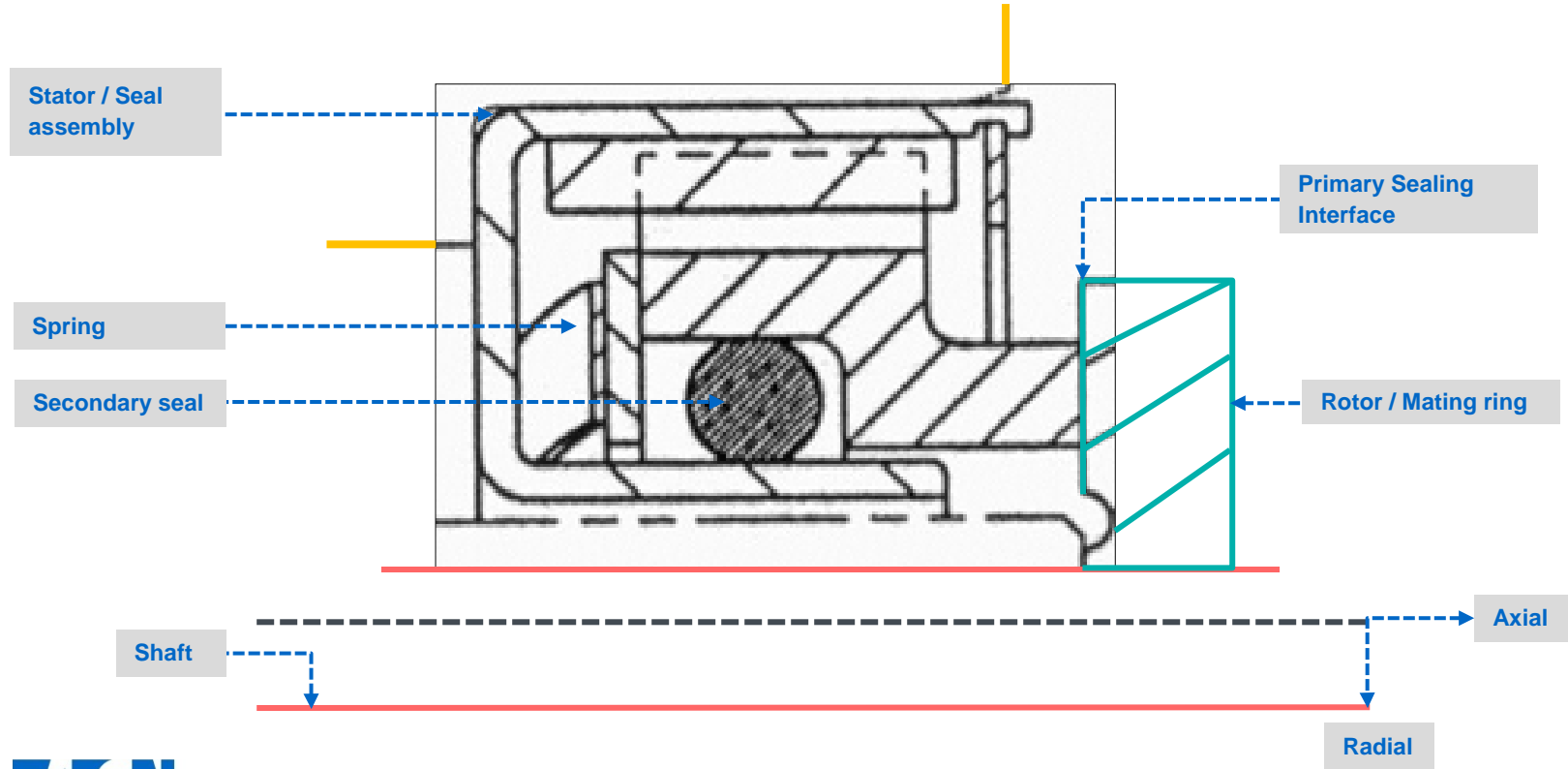
# Where are Eaton seals found?



Gas path

Eaton supports all engine and accessory locations requiring dynamic seals.

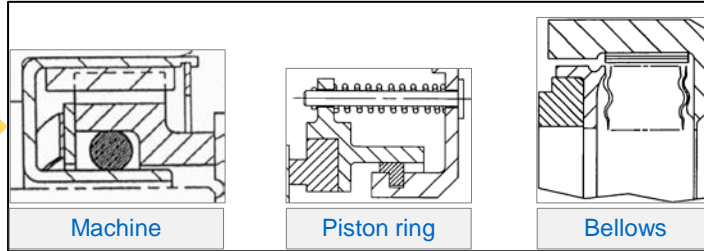
# Carbon seals 101



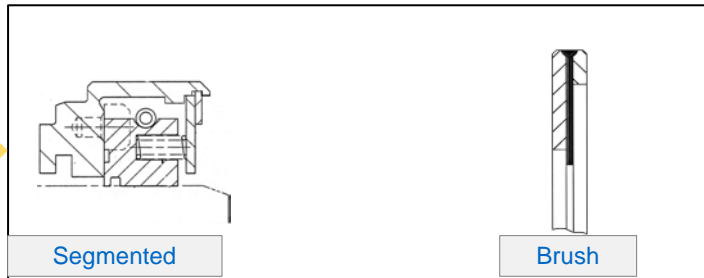
# Carbon seals 101.5

## Contacting

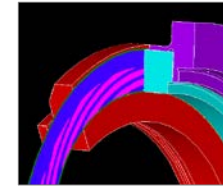
### Axial Seal



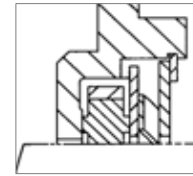
### Radial Seal



## Non-Contacting



Hydrodynamic axial seal



Clearance



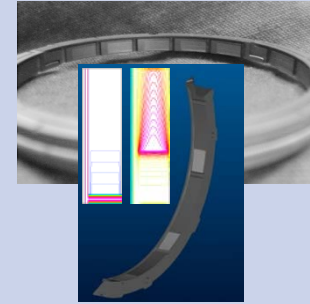
Hydrodynamic radial segmented

Products vary in terms of cost and performance.

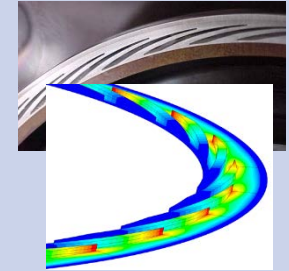
# Hydrodynamic technology

- Highly Engineered Grooves in the primary sealing component provide hydrodynamic pressure
  - Pressure creates “lift” and separates sealing components
  - Carbon face rides on a 50 to 200 μin air film
- Reduce heat generation and torque loss
- Increase seal life and reduce seal leakage

Radial Hydrodynamic

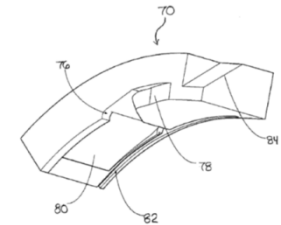


Axial Hydrodynamic



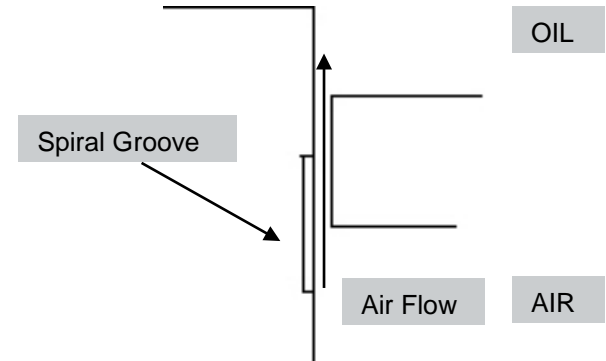
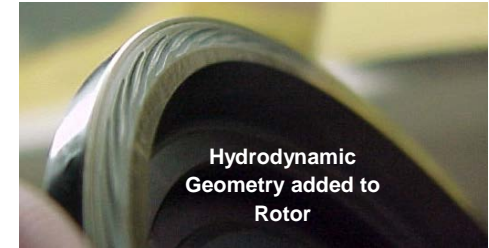
$$\vec{\nabla} \bullet \{ ph^3 \vec{\nabla} p - 6 \mu ph \omega r \theta \} = 0$$

A 3D diagram of a seal assembly showing a carbon seal ring (labeled 1) and a primary sealing component (labeled 2) with a groove. A coordinate system (X, Y, Z) is shown. The equation represents the hydrodynamic pressure field in the seal.



# What are the benefits of applying hydrodynamic features in axial seals?

- The carbon sealing ring is able to lift off from the mating face to ride on a stiff, thin film of air
- During steady state operation there is virtually no contact, thus heat generation and wear is low eliminating the root cause of leakage and coking
- Reduced heat eliminates carburization = reduced leakage = reduced wear = longer time on wing = value to end customer
- Target Platforms
  - NGPF Mainshaft
  - LEAP AGB Carbon Seals
  - PW2000 AGB Carbon Seals
  - GTCP 36-150
  - TFE 731
  - Passport 20 AGB Carbon Seals

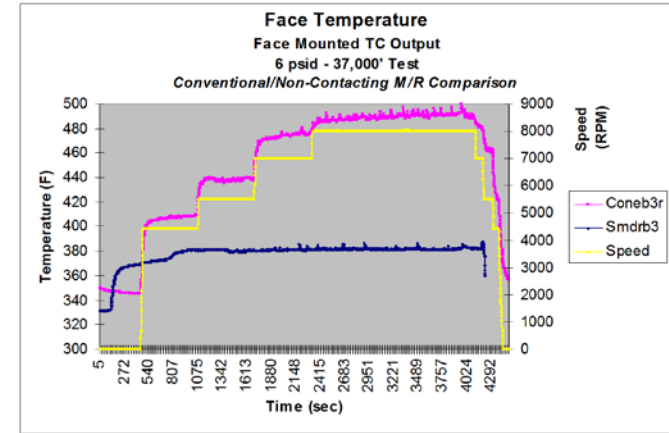


Eaton's axial hydrodynamic technology will be used on new large commercial aircraft engines



# How can airlines and MROs benefit from hydrodynamic repair upgrades?

- Eaton has offered a hydrodynamic design alternative to conventional gearbox seals
- Eaton has had a successful experience for the PW2000, where AGB seals generate high temperatures resulting in coking and leakage



		Face T (°F)		ΔT (°F)
Operating Conditions		Contact Seal	Hydrodynamic Seal	Thermal Improvement
Sea Level	Air Temp: Float	390	220	170
	Air/Oil Temp: 250°F			
Altitude	Air Temp: Float	415	250	165
	Air/Oil Temp: 250°F			

Repair upgrades can incorporate hydrodynamics to increase life and reduce leakage

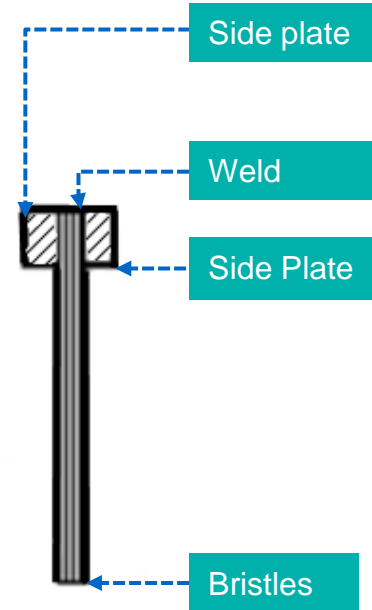
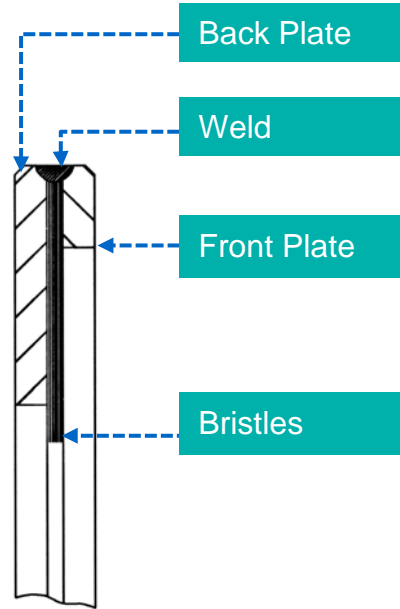
# General brush seal information

- High temperature nickel-cobalt alloy bristles
- Radial seals which may be used in place of traditional labyrinth seals
- Applications in large and small aerospace/gas turbine primary, secondary and tertiary flow gas paths
- Low-hysteresis damping plates allow seals to withstand large radial movements without opening
- Able to manage high temperature, high-speed environments with long life capabilities
- Weighs significantly less than machined labyrinth seals
- 25-30% of labyrinth leakage rates
- Requires less axial space



Conventional brush seals are high performance, but relatively high price...

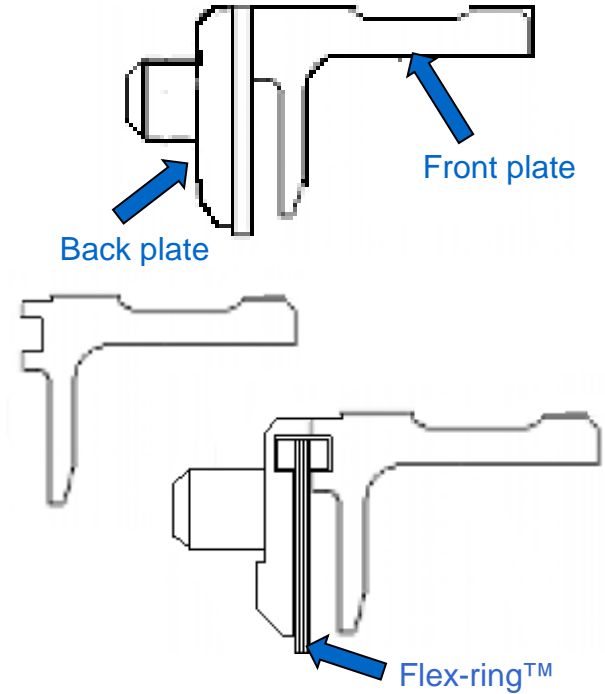
# The Flex-ring™ advantage



The conventional brush seal design, shown above, is not an ideal repairable design since the bristle pack is welded to the high cost side plates. Flex-ring™ design allows for interchangeable low cost bristle packs for repairable designs.

# What is the commercial advantage of a Flex-ring™ repairable brush seal?

- Major cost driver are side plates of brush seal
- First repair will salvage one of the side plates and introduce the cavity for the Flex-ring™
- When the repaired seal is returned the next time, both side plates will be salvaged
- No machining of OD required after Flex-ring™ weld
- Can build Flex-ring™ inventory for quick TAT
- Eaton can provide Flex-ring™ or complete repair service through licensing



The repairable brush seal decreases material cost, processes and TAT while maintaining seal performance thus offering a high value solution for the end customer.

# Eaton facilities for dynamic seal repair/upgrade

North America



East providence, RI – USA –  
Center of excellence

Europe

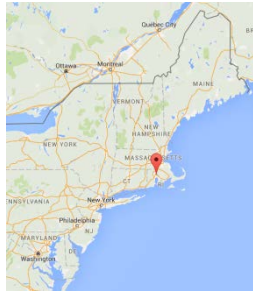


Coignieres, France

The East Providence facility is Eaton's Center Of Excellence for carbon seal design, manufacture and repair.

# Eaton carbon seal repair east providence

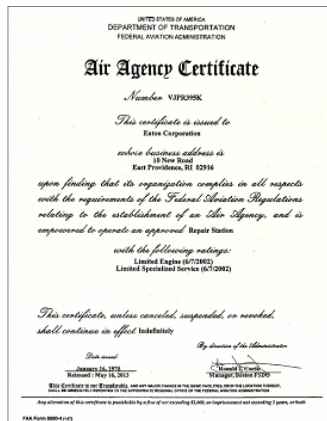
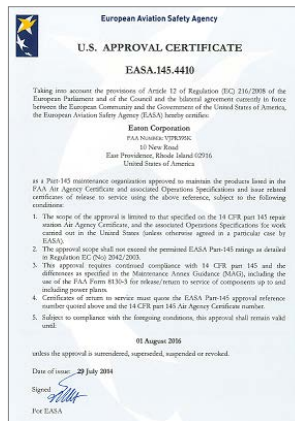
- The seal repair business started in Providence in 1939
- Total Site: 145,000 square feet of floor space
- 45% larger than original Pioneer Avenue Facility
- Room for expansion and new business development
- New manufacturing equipment and streamline layout – same personnel and process.
- Full service FAA Part 145 repair station. FAA / EASA / CAAC / CASE



The East Providence facility and repair station were designed for manufacturing excellence.

# East Providence certifications and approvals

- FAA #VJPR395K
- EASA #145.5437
- CAAC approval #F00100436
- AS9100C and ISO 9001 certified
- AS9100A certified
- NADCAP certified  
(heat treat, welding, EDM)
- Multiple OEM Supplier Qualifications and QMS Approvals (UTC, RR, GE, HON, etc.)



# Current carbon seal repair capabilities

OEM	Engine Model	AGB Repair	Mainshaft Repair
GE Engines	CFM56	X	
	GE90	X	
	CF6-80	X	
	CF6-6	X	
	CF6-50	X	
PW Engines	PW4000	X	X
	PW2000	X	X
	V2500	X	
	JT8D	X	X
	JT3D	X	X

Eaton also offers many other FAA Authorized customized repairs for it's customers.



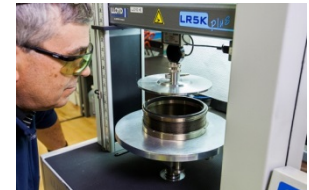
# How do these repair capabilities benefit MROs/airlines?

Customer requirement	Eaton solution
Cost Management	Repair Pricing superior to new replacement spares
Customized solutions	Eaton able to offer repair/upgrade solutions for virtually any carbon seal
Simplified service	<ul style="list-style-type: none"><li>• Problem Solvers / Seal Experts</li><li>• Dedicated and Knowledgeable ASM/TSM with immediate support</li><li>• Quick turn times on repairs.</li></ul>

# East Providence aftermarket team

## East providence aftermarket contact information:

- Dawn Degnan – Customer Service Manager  
401-473-2324 [DawnCDegnan@Eaton.com](mailto:DawnCDegnan@Eaton.com)
- Judy Rezendes – Sr. Customer Service Manager  
401-473-2337 [JudithTRezendes@Eaton.com](mailto:JudithTRezendes@Eaton.com)
- Josh Duquette – Seal Aftermarket Engineering Manager  
401-473-2284 [JoshJDuquette@Eaton.com](mailto:JoshJDuquette@Eaton.com)
- Vinod Makam – Business Unit Sales Manager – Seals and Ducting  
724-263-0612 [VinodMakam@Eaton.com](mailto:VinodMakam@Eaton.com)
- Joe Feula – Product Sales Manager – America's  
401-473-2414 [JosephAFeula@Eaton.com](mailto:JosephAFeula@Eaton.com)
- Howard King – Repair Station Manager  
401-481-3123 [HowardAKing@Eaton.com](mailto:HowardAKing@Eaton.com)
- Mike Ritter – Plant Manager  
303-460-4023 [MichaelRitter@Eaton.com](mailto:MichaelRitter@Eaton.com)

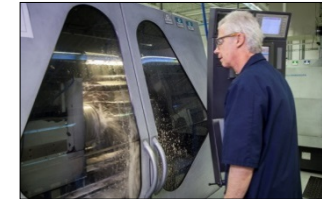


Global Aftermarket Sales Managers  
also available for support.

# East Providence repairs business

## Dedicated to the MRO activity

- **Dedicated area of 13,000 sq ft.**
  - 4 Designated ID/OD Grinding Machines
  - Designated oil soak tanks
  - 5 lathes and Millings machines
  - 2 Vertical Milling Machines
  - Leak Test Bench
  - 4 Lapping tables
  - 5 Designated Ovens
  - 2 computer measuring machines
- **Dedicated Resources:**
  - 1ea Repair Station Manager
  - 1ea Customer Service Managers dealing 100% with our Aftermarket Customers
  - 11ea designated Technicians and Operators
  - 1ea Quality Manager
  - 1 ea shop floor Supervisor
  - 1 ea Designated Manufacturing Manager
  - 1 ea designated Engineering Manager for O&R
  - 2ea Sales Managers on Site
- **Dedicated Inventory of Piece Parts**
  - Kitting process for each reference for easy access and TAT performance
- **Daily collection of repair parts from various forwarders (UPS, Fedex, etc)**



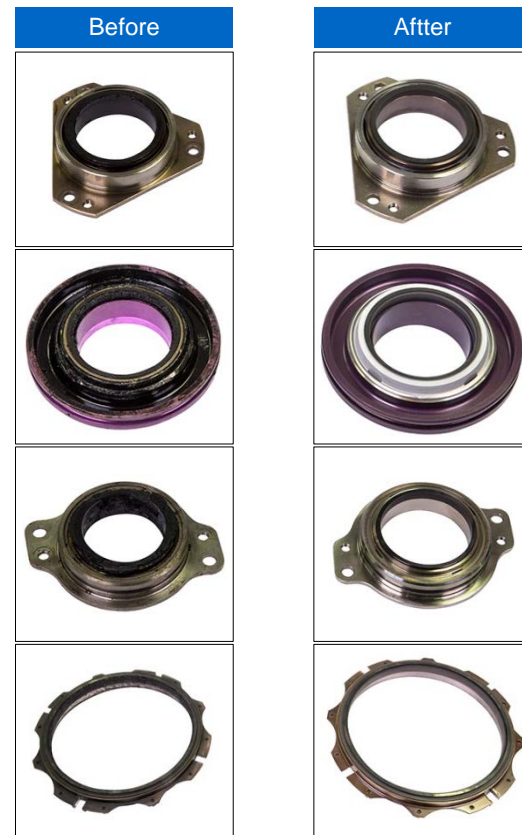
# Seal repair station performance

## 2013 Gearbox seal repairs

- 97% OTD
- 14 Days average TAT
- Over 1,500 CFM56 repairs shipped
- Over 6,000 Gearbox repairs shipped

## 2014 Gearbox seal repairs

- 100% OTD
- 10 Days average  
(Improvements due to inventory increase and staffing,  
also customer pushing from 21 day TAT to 15 days)
- Over 2,000 CFM56 seals shipped
- Over 6,000 Gearbox repairs shipped
- Capability to complete 5 day TAT for overseas customer



# Key takeaways for seal repair...

- Eaton can repair virtually any carbon dynamic seal
- Seal Experts - OEM on many applications
- Problem solvers
- Quick TAT: 8-16 week TAT for development and 10 day lead time thereafter
- Rotable pools can be used to further reduce TAT
- Aftermarket structure and dedicated resources improves overall customer experience



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# Questions/Comments



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