

CRJ-200 Flap actuator tungsten carbide upgrade



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Agenda

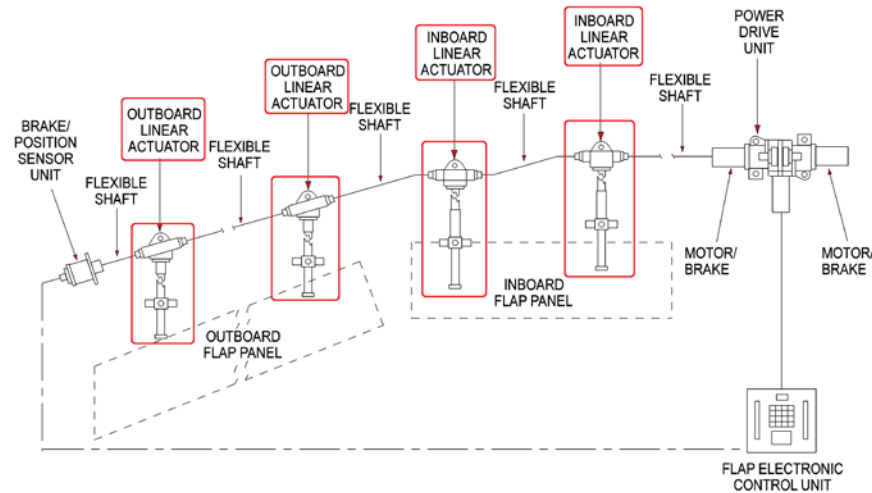
- System summary
- History & field issues
- Solution and validation
- Incorporation into repaired actuators
- Pricing and Contacts
- Questions

Issue/Application

- Platform – CRJ 100/200
- Aircraft problem/impact – Flap system soft jams at low temperature
- Description of problem – Grooving in pinion due to seal wear
- Identify assembly/part number – 852/853/854D100
- Consequence – pinion grooves can lead to contamination of actuator torque absorber brake stack, often resulting in Soft jams during low temperature operation

CRJ200 Flap system – flap actuator location

- A total of (8) flap actuators are used on each CRJ200 aircraft.
- (2) Inboard Linear Actuators provide motion to the inboard flap panels on each wing. – P/N 852D100.
- (2) Outboard Linear Actuators provide motion to the outboard flap panels on each wing. – P/N 853D100, 854D100.



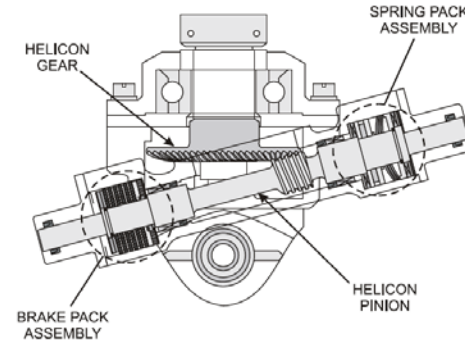
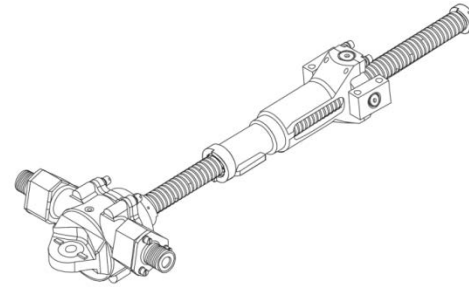
Flap actuator description and operation

Description

- Three configurations of actuators – 852D100, 853D100, and 854D100 – provide mechanical movement of the Wing Flap system
- While each differs slightly, the major functional components in each are analogous

Operation

- A helicon pinion receives torque from the PDU by way of a flex shaft
- The pinion drives a helicon gear, transferring rotary motion of the pinion into linear motion of the ballscrew
- A set of belleville springs and brake plates limits the output force of each actuator



Description of problem

Historically, two of the largest problem areas for the CRJ200 flap actuators are pinion grooving and insufficient sealing capability

Inner and outer pinion journals require a harder coating to avoid wear during use, which results in early replacement of an expensive part

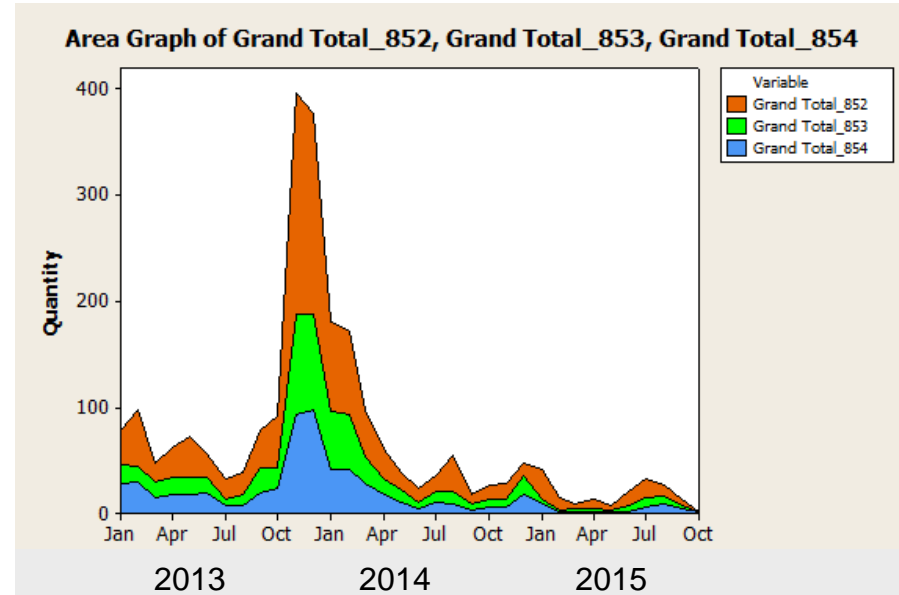
The associated failure mode is leakage through the inner or outer seals. If these seals leak, oil from the gearbox or grease from the flex shaft contaminates the spring pack or brake plates. At low temperatures, the contamination thickens and results in “soft jams”

Grooving is believed to accelerate the leakage failure mode by providing a leakage path through the seals



Description of problem

- Seal restoration program accomplished Oct-Apr of 2014
- Since seal restoration there has been a reduction in the rate of returns to Eaton's repair station



Background

- Why is problem occurring? – Pinion seal is causing grooving on the pinion gear journal
- Validation of the root cause was verified through the evaluation of returned actuators

Why is this problem occurring?

- Over the last several years, the gear set replacement rate has been anywhere between 35-60% of total returns
- In 2015, Eaton saw a significant downtick in the replacement rate which is likely due to:
 - Number of flight cycles on incoming units – between a seal restoration cycle, incoming gear sets in 2015 should be newer in comparison to those seen in 2013 and 2014

CRJ200 Gear Set Shop Findings									
	2013			2014			2015		
Part Number	Grooving	Total Calls	%	Grooving	Total Calls	%	Grooving	Total Calls	%
852SE174-1	349	717	48.68%	130	359	36.21%	7	58	12.07%
853SE174-1/-2	198	337	58.75%	95	224	42.41%	1	14	7.14%
854SE154-1/-2	202	376	53.72%	72	195	36.92%	1	15	6.67%

Description of problem

In Q4 of 2014, Eaton conducted a screening procedure on (45) returned flap actuators.

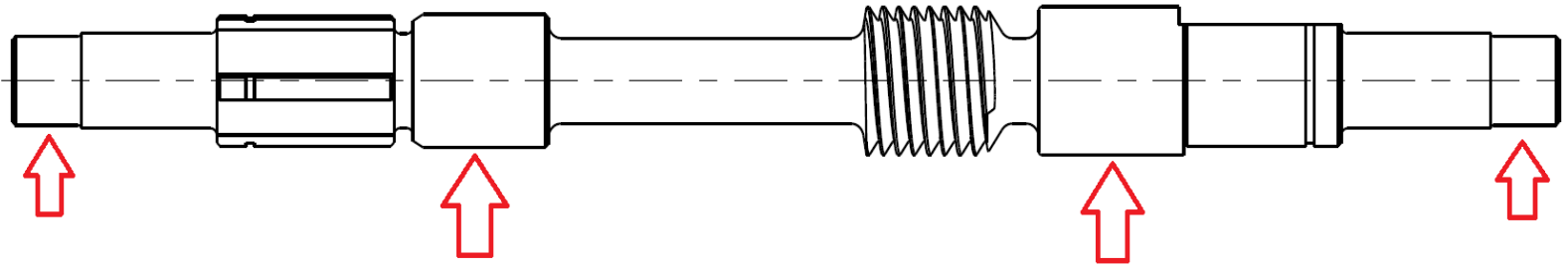
Results indicate no connection between grooving and small leaks, but a strong tie between grooving and large leaks.

- Small leaks had a groove on the corresponding seal journal only 16% of the time. (25 units, Left)
- For large leaks, this number jumped to 72%. (11 units, Right)



Solution

Improved pinion gear wear characteristics through the application of proprietary Tungsten Coating to journal surfaces.



Solution

Wc-co-cr coating improves wear resistance

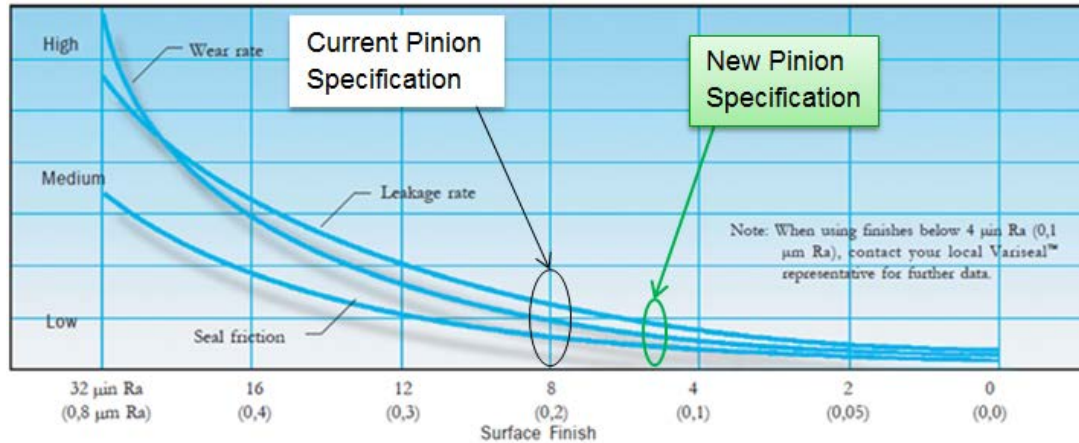
- Increased hardness: +2-5%
 - WC Anticipated = 92.1 HR 15N
 - WC Tested = 94 – 95 HR 15N
 - Chrome = 90.3 HR 15N
 - AMS 6265 Carburized = 87.5 – 88.5 HR 15N

Documented wear improvement from naval research laboratory testing

- Conclusion from wear testing report:
 - “The WC/Co coating outperformed both Electrolytic Hard Chrome and Tribaloy T-800 coatings in both coating wear performance and counter-face wear performance under all test conditions”

Solution

- Pinion inner and outer journals will be coated with a proprietary tungsten carbide coating
- Reduced surface roughness for reduced wear, leakage, and drag torque:
 - Current Pinion: Ra 8 μm Max
 - New Pinion w/ WC: Ra 5 μm Max
- Other surface finish parameters such as Rp, Rz, Skew, and Bearing Ratio defined and controlled additionally to provide improved seal interface



Validation test description

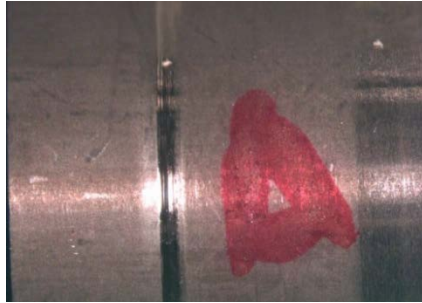
Operate (1) baseline 852D100 unit and (1) tungsten carbide upgrade, alternating every 5,250 cycles between

- Endurance testing (Loaded) –
 - Worst case for leakage – Varying thrust placed on pinion during extend/retract generates pumping action at seal/journal interface to facilitate leakage
- High duty cycle (No Load) –
 - Worst case for wear – Lack of thrust on pinion prevents axial movement at the seal/journal interface, concentrating wear at a single location

Every 5,250 cycles, units were taken out and examined for indications of leakage through the seals and run through an ATP

Photos – chrome and tungsten

Chrome – 21,000 cycles



Tungsten – 39,134 cycles



Test results – tungsten vs. chrome

Chrome baseline

- Actuator Failure: 21,000 Cycles
- Grooving: Several – Depths between 0.0005 and 0.0025". Found on inner seal journals
- ATP Failed: Low Temperature Input Torque (-40 C, Breakaway)
- Root Cause: Leakage through the inner seals

Tungsten upgrade

- Actuator Failure: 39,134 Cycles
- Grooving: None
- ATP Failed: Rated Torque, Torque Absorber Not Activated
- Root Cause: Spalling found on high side of pinion gear teeth. Failure is unrelated to tungsten-coated surfaces

Implementation/proposition value

Mod 1

Only applicable for -19, -21 configurations.
Incorporation of connector gaskets.

Mod 2

Bolt upgrade to allow flex shaft connector
to be secured to bolt heads.

Mod 3

Tungsten carbide coated gear set.

Modification 3

Units upgraded to Modification 3 will incorporate the following tungsten-coated gear set P/Ns

Modification 3

New Gearset P/N	P/N Replaced	Unit P/N (Eaton)	Unit P/N (Bombardier)
852SE192-1	852SE174-1	852D100-23/-25	601R93101-23/-25
853SE192-1/-2	853SE174-1/-2	853D100-23/-24	601R93103-23/-24
854SE192-1/-2	854SE154-1/-2	854D100-23/-24	601R93104-23/-24

Repair vs. replacement

Original tungsten carbide proposal focused on repairing – rather than replacing – gear sets

In June 2015, Eaton found this option to be impractical for the following reasons

- Inability to maintain 30-day turn times with addition of outside processing lead time (several weeks)
 - High cost of low quantity repair would mandate collection of pinions in batches, driving turn times higher still

As a substitute, Eaton will offer gear set replacement, which will provide a longer-lasting product with no added turn time

Pricing

Minor repair	Repair			Overhaul			Material/ New Gearset
Seals only all configurations	852D100-25	853D100-23/24	854D100-23/24	852D100-25	853D100-23/24	854D100-23/24	Gearset replacement
\$3,555	\$7,626	\$7,626	\$7,626	\$12,900	\$12,900	\$12,900	Tungsten carbide
\$3,555	\$7,155	\$7,155	\$7,155	\$11,900	\$11,900	\$11,900	Chrome plated

2 year gearset warranty with purchase of Tungsten Carbide gearset.

Contacts for further questions

- **Regional technical support representatives**

Dwayne Cohen - DwayneCohen@Eaton.com

Dale Carter - dalewcarter@Eaton.com

- **Aftermarket customer sales and support**

Drew Fulkerson - andrewfulkerson@eaton.com



Questions/Comments



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