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World-Class Military Support

CEF INDUSTRIES, LLC

A Dramatic New Approach To The C-130/L100 Wing Flap Actuators

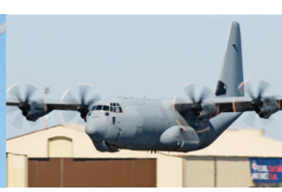
- **Improve Service Life**
- **Maintain Interchangability at the Gearbox Level**
- **Reduce Cost**

Background

CEF Industries new C-130/L100 Wing Flap Actuators, PIN 8445M1 (inboard) and PIN 8446M1 (outboard), are the result of extensive research, engineering, and testing. Market research at various C-130/L100 operators and overhaul facilities indicated a need to improve the service life of the ballscrew. The main contributor to short service life is the operating environment. Excessive wear between the ballnut and ballscrew is the primary cause for early removal. This result can generally be traced to a salt spray, sand, dust, and vibration environment. Heavy corrosion of the ballscrew shaft and torsion bar, as well as of flaking of chrome plating was noted on many short hour units. Given the aircraft design, protection of the flap actuator from the environment is not possible.

Older configurations of the ballscrew assembly (pre C-130J) have chrome plated ballscrew shafts and ballnuts. While thin dense chrome plating does have good wear properties, corrosion resistant properties are minimal, and thread geometry does not permit even deposition of plating. Examination of chrome plating thickness reveals only a trace of plating at the root of the thread and only at the crest is the desired thickness achieved. Thickness variation is an inherent limitation of electroplating thread forms. Corrosion resistance at the thread root is severely limited, and fabrication of the precision thread form required to maximize the ballscrew actuator efficiency is inhibited. Additionally, hard chrome plating has a hexavalent microstructure and tends to be highly stressed, resulting in poor structural integrity of the chrome and marginal adhesion to the base metal. Consequential flaking of the chrome plating and exposure of the base metal is likely.

Field samples revealed evidence of chrome flakes trapped by the lube acting as an abrasive agent, dramatically increasing the wear rate. Instances in which the balls were reduced diametrically by more than .010" were not uncommon. Flaking generally starts at the root of the thread form and proceeds up the thread wall. Some field specimens exhibited severe corrosion at the spline end of the torsion bar as a result of chrome plating breakdown.



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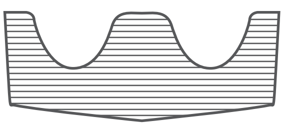
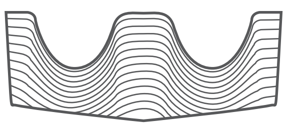
- STAINLESS STEEL Precision Thread Rolled Ball Screw
- STAINLESS STEEL Torsion Bar with Twice the Length or Engagement
- Heat Treated Electroless Nickel Plated Ball Nut
- STAINLESS STEEL Recirculating Balls
- STAINLESS STEEL Output Shaft Couplin
- Heavy Duty Wipers

Ballscrew Shaft

To meet design objectives, several materials were evaluated. A highly specialized stainless steel was selected because of excellent corrosion resistance properties, anti-galling properties, and work hardening properties. To exploit these properties and insure a consistent thread accuracy, the thread form is developed by precision thread rolling. A larger ball diameter is used to decrease the wear rate and achieve static load requirements. The thread rolling process increases the structural integrity of the shaft as shown.



Machined Ballscrew Shaft



Rolled Thread Ballscrew Shaft

Recirculating Balls

Hardened balls made of 52100 steel and 440C stainless were evaluated in both "all load ball" and "load ball-spacer ball" configurations. The 440C stainless was selected based on clearly superior life test results.

Wiper

Extensive evaluations were performed on alternatives to the conventional felt wiper. However, the felt wiper proved to be superior to polymers and elastomers and was therefore retained in the design, with an increase in section height for heavy duty performance.

Ballnut

Corrosion resistant materials were not suitable for the ballnut as the nut must withstand approximately 15 times the wear of the ballscrew shaft. The base material selected is conventional high carbon alloy steel (9310) surface hardened to Rockwell “C" 58. To maximize corrosion resistance and wear characteristics the ballnut is plated with a specialized high phosphorous electroless nickel and then subsequently heat treated. The uniform coating delivered by the electroless method minimizes chipping or flaking due to inconsistent plating thickness, while preserving the integrity of the precision thread form.

Torsion Bar

To improve the corrosion protection and meet the design requirements of this critical component, PH13-8MO, a precipitation hardening stainless steel, was selected. This material allows hardening to the degree necessary to handle stress from repeated twisting. To improve design safety and reliability the spline coupling is more than two times longer than previous designs and 30% greater in diameter than previous designs. This coupling area of the actuator assembly is very susceptible to retention of moisture and corrosion problems. The output shaft which couples the torsion bar to the actuator was also changed to this same high reliability material.

Part Number	Description
8445M1	Flap Actuator Assembly *(inboard)*
8446M1	Flap Actuator Assembly *(outboard)*
8545M1	Ballscrew/Yoke Assembly *(inboard)*
8546M1	Ballscrew/Yoke Assembly *(outboard)*

Results

AFTER... the ballscrew shaft was subject to TWO full life cycles, with only the replacement of balls and wipers... The NEW design had nearly immeasurable wear, no corrosion, and was completely serviceable.

AFTER ... formal qualification testing, audited by Lockheed, perfomed side by side with the chrome plated design... The NEW design had far less corrosion, negligible shaft wear and significatly less ballnut and ball wear.