SAE Aerospace
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AEROSPACE INFORMATION REPORT

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In-Service Reliability Data of Continuously Active Ballscrew and Geared Flight Control Actuation Systems

RATIONALE

The lack of in-service relevant data on unacceptable wear/backlash and jam failure rates of ballscrew and geared flight control actuation systems has been identified as one factor preventing electromechanical actuators from being more thoroughly considered as a primary control surface actuator. This document is written to satisfy this in-service reliability data need.

FOREWORD

The information in this document is compiled from various sources as answers to a survey performed in 2001-2004. It is assumed that these answers reflected the best knowledge of their authors at the time and were expressed in good faith. It is to be highlighted that this informative material has not been submitted to any validation process other than the regular SAE document approval process.

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1. SCOPE

An industry survey has been completed to determine the incidence of jam and excessive backlash in rotary and linear mechanical actuators subject to “primary flight control like” duty cycles. The data is valuable for understanding how existing mechanical actuators behave in service, identifying areas for potential improvement and possibly being used as a reference to support future primary flight control system trade-off studies.

1.1 Purpose

The purpose of this information report is to compile the results of the survey so the data can be made available to the industry as an aid for those specifying, designing, and certifying EM actuators, as well as those developing reliability and safety analyses and reports for these actuators

1.2 Field of Application

This report is written with commercial aircraft flight control system application in mind but the data presented is equally applicable to other aircraft systems or other aircraft categories.

2. REFERENCES

There are no referenced publications specified herein.

3. SURVEY

3.1 Questionnaire

The questionnaire shown in Appendix 1 has been defined as the first step of this data collection process. It was intended to identify:

- the type of equipment,
- some of the applicable requirements, to assess how much the actuator corresponds to the targeted category or to be able to later define sub-categories (ex: size, linear / rotary) if it was found necessary,
- the test experience,
- the relevant in-service reliability data.

3.2 Answers

Complete or partially competed questionnaires have been received from 10 companies, air framers and equipment manufacturers, their data covering 22 applications. From these applications 15 have been found relevant, as control surface actuators used with “primary flight control like” duty cycles:

- 11 Horizontal Stabilizer actuators (8 commercial transports, 2 business jets, 1 military transport)
- 2 Stabilator actuation systems (1 fighter, 1 military helicopter)
- 1 Rudder actuator (business jet)
- 1 Leading edge flap actuator (various fighters)

7 Applications were rejected for being too far from the selection criteria

- 5 Low power, non-surface actuation
- 1 Trailing edge flap actuator
- 1 Helicopter rotor folding actuator

4. SURVEY RESULTS

The following table sums-up the collected data:

TABLE 1 - SURVEY RESULTS

Aircraft Type	Application	Output Type	Accumulated 10^6 Flight Hours	Reported Jams	Reported Excessive Wear
Commercial transport 1	Horizontal Stab Trim Actuator	Ball screw	14	0	0
Commercial transport 2	Horizontal Stab Trim Actuator	Ball screw	21	0	0
Commercial transport 3	Horizontal Stab Trim Actuator	Ball screw	6	0	0
Commercial transport 4	Horizontal Stab Trim Actuator	Ball screw	78.1	0	0
Commercial transport 5	Horizontal Stab Trim Actuator	Ball screw	22.9	0	0
Commercial transport 6	Horizontal Stab Trim Actuator	Ball screw	32.6	0	0
Commercial transport 7	Horizontal Stab Trim Actuator	Ball screw	35.4	5	0
Commercial transport 8	Horizontal Stab Trim Actuator	Ball screw	7.5	0	0
Business jet 1	Horizontal Stab Trim Actuator	ACME	3.6	0	0
Business jet 2	Horizontal Stab Trim Actuator	Ball screw	0.3	0	0
Military transport	Horizontal Stab Trim Actuator	Ball screw	0.4	1	
Military Helicopter	Stabilator Actuator	ACME	2	some	
Fighter	Stabilator Actuator	Ball screw	0.15	0	0
Business jet	Rudder Actuator	Ball screw	0.34	2	
Fighter	Leading edge flap Actuator	Rotary	7	some	

It may be misleading at this stage to consider this partial data as fully representative of the aerospace mechanical actuator population and draw definitive conclusions from it.

However it can be observed that the ball screw Horizontal Stabilizer Trim Actuator population that has accumulated the highest in-service experience appears as the most reliable category with a jamming failure rate of approximately 3×10^{-8} per flying hour.

5. NOTES

5.1 A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

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