



AEROSPACE INFORMATION REPORT

AIR6226™**REV. A**Issued 2014-10
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Superseding AIR6226

(R) Trimmable Horizontal Stabilizer Actuator Structural Load Path Integrity Monitoring Principles

RATIONALE

Revision A provides an update including information on some civil aircraft recently entered in-service and editorial changes.

TABLE OF CONTENTS

1.	SCOPE.....	4
2.	REFERENCES.....	4
2.1	Applicable Documents	4
2.1.1	EASA Publications	4
2.1.2	FAA Publications	4
2.2	Related Publications	5
2.2.1	SAE Publications.....	5
2.3	Terminology and Acronyms	5
3.	APPLICABLE CERTIFICATION REGULATIONS	5
3.1	List of Applicable Documents.....	5
3.2	CS 25.671 Requirement Description	6
3.3	CS 25.1309(b)(4) and (b)(5) Hidden Failure Considerations.....	6
3.4	CS 25.302 Requirement Description	6
3.5	Additional Considerations	7
4.	SOLUTIONS FOR DETECTING RUPTURE OR DISCONNECTION OF LOADED LOAD PATHS.....	7
4.1	Solution A.....	8
4.2	Solution B.....	8
4.3	Solution C.....	8
4.4	Solution D.....	8
4.5	Solution E.....	8
4.6	Solution F.....	8
5.	DESCRIPTION OF IMPLEMENTED SOLUTIONS	9
5.1	Wide Body Airliners.....	9
5.1.1	Airbus A300B	9
5.1.2	Airbus A310 and A300-600	10
5.1.3	Airbus A330-200/-300 and A340-200/-300	10
5.1.4	Airbus A340-500/-600	11
5.1.5	Airbus A380-800	12

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Documents

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5.1.6	Airbus A350-900/-1000	12
5.1.7	Boeing 787-8/-9/-10	13
5.2	Narrow Body Airliners	14
5.2.1	Airbus A220-100/-300	14
5.2.2	Airbus A318/A319/A320/A321	15
5.2.3	Embraer E170/175/190/195	15
5.3	Executive Jets	16
5.3.1	Bombardier Global Express	16
5.3.2	Bombardier Challenger 300	17
5.3.3	Cessna Citation X	18
5.3.4	Cessna Citation Sovereign	18
5.3.5	Gulfstream G200	19
5.3.6	Gulfstream G280	20
5.3.7	Gulfstream G450	21
5.3.8	Hawker 4000 Horizon	21
5.4	Military Transport Aircraft	22
5.4.1	Airbus A400M	22
6.	NOTES	22
6.1	Revision Indicator	22
Figure 1	Typical fuselage HSA attachment	3
Figure 2	Typical horizontal stabilizer HSA attachment	4
Figure 3	Safety factor versus probability of the failure of the primary load path	7
Figure 4	Airbus A300B upper THSA attachment	9
Figure 5	Airbus A300B lower THSA attachment	9
Figure 6	Airbus A330/A340 upper THSA attachment	10
Figure 7	Airbus A330/A340 lower THSA attachment	11
Figure 8	Airbus A340-500/600 upper THSA attachment	11
Figure 9	Airbus A380-800 upper and lower THSA attachments	12
Figure 10	Airbus A350-900/-1000 upper and lower THSA attachments	12
Figure 11	Boeing 787-8/-9/-10 upper and lower HSTA attachments	13
Figure 12	Airbus A220-100/-300 HSTA load paths	14
Figure 13	Embraer E170/175/190/195 HSTA lower attachment	15
Figure 14	Bombardier Global Express HSTA upper attachment	16
Figure 15	Bombardier Global Express HSTA lower attachment	17
Figure 16	Bombardier Challenger 300 upper HSTA attachment	17
Figure 17	Bombardier Challenger 300 lower HSTA attachment	18
Figure 18	Gulfstream G200 HSTA lower attachment	19
Figure 19	Gulfstream G280 lower HSTA attachment	20
Figure 20	Gulfstream G280 upper HSTA attachment	20
Figure 21	Gulfstream G450 HSA load paths	21
Figure 22	Hawker 4000 Horizon load paths	21

FOREWORD

Many civil or military transport aircraft are fitted with a linear mechanical actuator (screw jack) that achieves the structural connection between the fuselage and the horizontal stabilizer or between the vertical stabilizer and the horizontal stabilizer (HS) for a T-tail. Relatively slow extension or retraction movements of this actuator change the position of the HS, thus performing the pitch trim function of the flight control system of the aircraft. Detachment of the actuator leaving the HS free to rotate around its pivot points is generally Catastrophic; loss of control/immobilization of the HS in any normally encountered position is generally Major as a single event.

Although the screw jack element of the HS actuator (HSA) primarily achieves a structural function, being often sized by static loads rather than loads under movement, it is nowadays considered as flight control equipment including its structural elements. This makes the HSA subject to both flight control system and structural certification regulations.

As a consequence of the system certification regulations summarized in Section 3, the HSA screw jack is designed as a dual-load path system. Although two separate screw jacks in parallel have been used in the past, the current most popular configuration features two concentric load paths:

- a. The primary load path consists of a rotating screw, generally a ball screw, connected to the fuselage or vertical stabilizer and of a translating ball nut driving the HS.
- b. The secondary load path consists of a tie bar located in the bore of the ball screw.

The secondary load path fuselage or vertical stabilizer attachment includes either a concentric gimbal or a type of spherical bearing where the ball is connected to the tie bar and is concentric to the primary load path gimbal (see Figure 1).

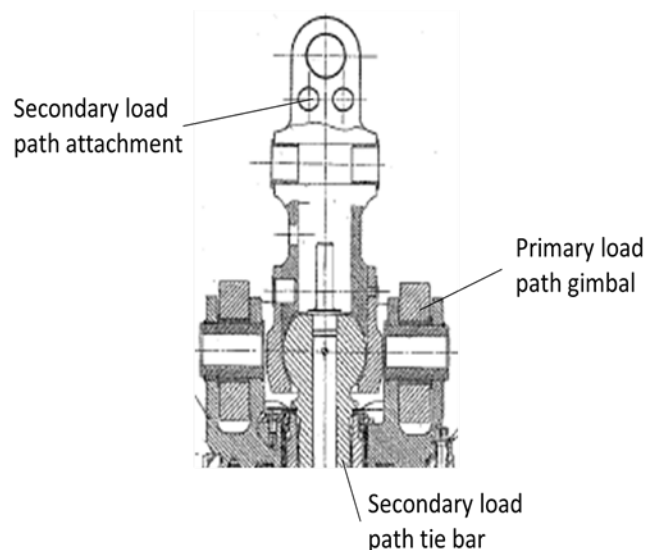


Figure 1 - Typical fuselage HSA attachment

The secondary load path HSA attachment generally includes an inverted thread nut as a backup to the primary load path ball nut and associated connecting parts to the HS (see Figure 2).

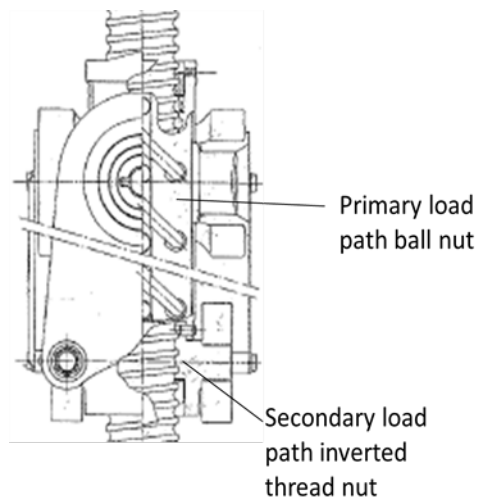


Figure 2 - Typical horizontal stabilizer HSA attachment

The secondary load path is normally unloaded owing to appropriate clearances in the actuator assembly and becomes loaded in the event of a rupture or disconnection of the primary load path.

1. SCOPE

This SAE Aerospace Information Report (AIR) supplies information on trimmable horizontal stabilizer actuator structural load path integrity. It describes the different methods for detecting rupture or disconnection of load paths. It also describes the monitoring principle to compare existing solutions as a reference for its implementation in new aircraft programs.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 EASA Publications

Available from European Union Aviation Safety Agency, Konrad-Adenauer-Ufer 3, D-50668 Cologne, Germany, Tel: +49 221 8999 000, www.easa.europa.eu.

CS-25 Certification Specifications for Large Aeroplanes

The results from the EASA Rulemaking task RMT 25.0049 have been implemented in the CS-25 since Amdt 24 (refer to NPA 2014-02 for details).

2.1.2 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

14 CFR Part 25 Code of Federal Regulations, CFR1.1, Part 25 Airworthiness Standards, Transport Category Airplanes

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Information Report.

2.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 1-877-606-7323 (U.S. and Canada only) or 1-724-776-4970 (outside U.S. and Canada), www.sae.org.

AIR6052 Trimmable Horizontal Stabilizer Actuator Descriptions

2.3 Terminology and Acronyms

Actuators, or sets of actuators, or subsystems driving the entire horizontal stabilizer (HS) of fixed-wing aircraft are referenced according to different terminology, depending on the original equipment manufacturer (OEM). The most common descriptions and acronyms are:

HSA horizontal stabilizer actuator

HSTA horizontal stabilizer trim actuator

HSTS horizontal stabilizer trim system

PTA pitch trim actuator

THSA trimmable horizontal stabilizer actuator

TTA tailplane trim actuator

The following terms and acronyms are also used in this document:

ELSD electrical load sensing device

HS horizontal stabilizer

PLP primary load path

SLP secondary load path

3. APPLICABLE CERTIFICATION REGULATIONS

3.1 List of Applicable Documents

The current applicable regulations for civil aircraft are the 14CFR part 25 and the CS-25, specifically:

25.302 Interaction of Systems and Structure

25.571 Damage-tolerance and fatigue evaluation of structure

25.671 Control Systems

25.1309 Systems

Possible special conditions/issue papers/certification review items (CRI) for a specific aircraft program.

Additional guidance materials are provided in:

The associated Acceptable Means of Compliance (AMC)/Advisory Circulars (AC)

3.2 CS 25.671 Requirement Description

14 CFR Part 25 / CS 25.671(c)(1) and (c)(2) require that the aircraft is shown to be capable of continued safe flight and landing (CSFL) within the normal flight envelope, and without requiring exceptional piloting skill or strength, after the following failures in the flight control system.

- (1) Any single failure, excluding failures of the type defined in CS 25.671(c)(3);
- (2) Any combination of failures not shown to be extremely improbable, excluding failures of the type defined in CS 25.671(c)(3).

3.3 CS 25.1309(b)(4) and (b)(5) Hidden Failure Considerations

14 CFR 25 / CS 25.1309(b)(4) and (b)(5) address latent failures as follows.

- (4) Any significant latent failure is eliminated as far as practical, or, if not practical to eliminate, the latency of the significant latent failure is minimised; and
- (5) For each catastrophic failure condition that results from two failures, either one of which is latent for more than one flight, it must be shown that:
 - (i) it is impractical to provide additional redundancy; and
 - (ii) given that a single latent failure has occurred on a given flight, the failure condition is remote; and
 - (iii) the sum of the probabilities of the latent failures which are combined with each evident failure does not exceed 1/1000.

In addition, the AMC 25.1309 §9.c.6 mentions that:

The use of periodic maintenance or flight crew checks to detect significant latent failures when they occur is undesirable and should not be used in lieu of practical and reliable failure monitoring and indications. When this is not accomplished, refer to paragraph 9.b(6) for guidance.

Paragraph 12 provides further guidance on the use of periodic maintenance or flight crew checks. Comparison with similar, previously approved systems is sometimes helpful. However, if a new technical solution allows practical and reliable failure monitoring and indications, this should be preferred in lieu of periodic maintenance or flight crew checks.

3.4 CS 25.302 Requirement Description

CS 25.302 and its Appendix K address the effects, either direct or as a result of a failure or malfunction, of systems on structural loads. Some control system failures can lead directly to increased loading on the aircraft structure. Other failures can affect the response of the aircraft in subsequent maneuver or gust conditions. The rule addresses these failure conditions by specifying factors of safety (at the time of occurrence and for the continuation of flight) based on the probability of occurrence of the failure mode. The resulting loads are applied not only to the fixed structure but also to the control surfaces and to any element within the control system that reacts to those loads.

According to CS 25 Appendix K the ultimate loads for the secondary load path components shall be SF times the limit loads of the associated primary load path components, the value of SF being determined by Figure 3. Therefore, the typical secondary load path safety factor is 1.

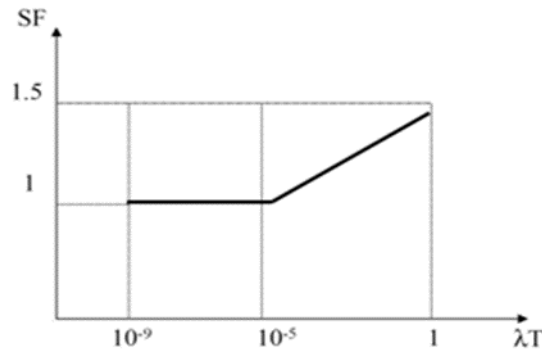


Figure 3 - Safety factor versus probability of the failure of the primary load path

where:

SF = safety factor to be considered for secondary load path components

λ = probability per flight hour of the failure of the primary load path

T = average time spent in failure condition

3.5 Additional Considerations

- a. The secondary (fail-safe) load path (SLP) remains unloaded in normal operation, not to compromise its availability and integrity in the event of a PLP failure. This needs to be assessed/validated considering the worst case of tolerance stack-up.
- b. Failures leading to a full or partial loading of the SLP (i.e., including PLP-SLP load-sharing cases) should be considered and addressed.
- c. The detection of the PLP failure and the annunciation to the crew shall be demonstrated considering the most critical conditions (subject to validation), in terms of aircraft configuration (gross weight, CG), air loads, flight profile, etc.
- d. The qualification of the SLP (normally unloaded) should be commensurate with its expected usage upon failure of the PLP and its design load defined per 14 CFR part 25/CS 25.302 and 25.571. As per point b, full and partial loading cases of the SLP should be considered.
- e. Attention should be paid to how the integrity of the SLP is ensured. An example would be to have a means or periodic inspection resulting from the MSG-3 analysis to check it (ATA MSG-3 is a systematic methodology used in the aviation industry to develop and optimize aircraft maintenance programs (AMPs)).
- f. The safety analysis and testing, as appropriate, should consider the effect of wear (including the worst case of tolerance stack-up), maintenance errors and contamination on the fail-safe features of the actuator.

4. SOLUTIONS FOR DETECTING RUPTURE OR DISCONNECTION OF LOADED LOAD PATHS

The presently in-service fleet shows many different options, not necessarily complying with the most recent requirements. As far as the “historical” designs are concerned, the year of type certification for each aircraft is mentioned. Some devices are covered by patents. The principles of these solutions are the following.