EASA
European Aviation Safety Agency

EASA DIFT Workshop
–
Related Type Certification Requirements

Cologne, 23 March 2015

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Flight Handling Requirements

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Flight Handling Requirements

CS 25.143 & 23.143 General

- (a) The aeroplane must be safely controllable and manoeuvrable during …
  - (1) Take-off;…..

- 25.143(b) It must be possible to make a smooth transition from one flight condition to any other flight condition without exceptional piloting skill, alertness, or strength

Flight Handling Requirements

- Maximum control forces permitted (CS23.143 and CS25.143):

Force, in newton (pounds), applied to the control wheel or rudder pedals	Pitch	Roll	Yaw
For short term application for pitch and roll control – two hands available for control	334 (75)	222 (50)	–
For short term application for pitch and roll control – one hand available for control	222 (50)	111 (25)	–
For short term application for yaw control	–	–	667 (150)
For long term application	44,5 (10)	22 (5)	89 (20)

- 25.143(e) Approved operating procedures or conventional operating practices must be followed when demonstrating compliance with the control force limitations for short term application that are prescribed in sub-paragraph

Aeroplane Flight Manual

- **CS 23.1581 and 25.1581 General**

(a) *Furnishing information.* An aeroplane Flight Manual ……must contain the following:

…. (2) Other information that is necessary for safe operation because of design, operating, or handling characteristics……

- **CS 23.1585 Operating procedures**

(a) For all aeroplanes, information concerning normal, abnormal (if applicable) and emergency procedures and other pertinent information necessary for safe operation and the achievement of the scheduled performance must be furnished, including:

(1) An explanation of significant or unusual flight or ground handling characteristics;…

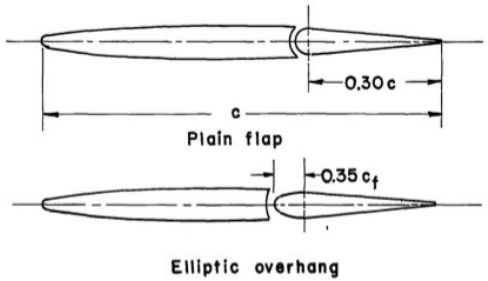
- **CS 25.1587 Performance information**

(b) Each aeroplane Flight Manual must contain the performance information computed under the applicable provisions of this CS–25 ….within the operational limits of the aeroplane, and must contain the following:

…..(5) An explanation of significant or unusual flight or ground handling characteristics of the aeroplane.

Likely Most Affected Configurations

- Manual control (no hydraulic assist)
- Surfaces where hinge moments reduced by aerodynamic balancing
  - Horn Balance
  - Hinge Overhang
  - Servo Tab



Hinge Overhang

Servo Tab

Horn balanced rudder

Horn balanced aileron

Control Surface and System Loads (for CS-23/25 Aircraft)

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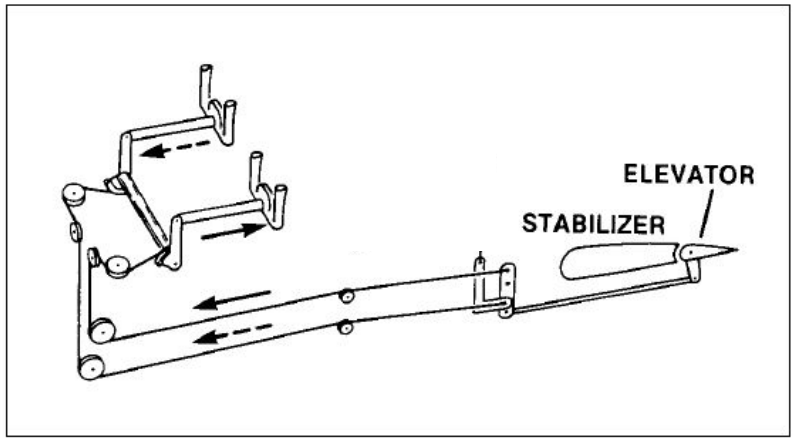
Introduction

- Focus in this presentation on:
  - CS-23/25 conventional aircraft
  - Reversible (unpowered) flight control systems
  - Longitudinal control systems (including elevator surface) without tabs
  - Aerodynamic loads / pilot forces (not fatigue, not flutter,…)
  - Symmetrical (up/down) conditions
  - Nominal conditions, not (system or structural) failure conditions (e.g. jamming)



CS-23/25 Control Surface and System Requirements

- **CS 23/25.391 & CS 23/25.395**
  - Longitudinal control systems (including elevator surfaces) must be (mainly) designed for loads resulting from the following conditions:
    - balanced conditions
      - manoeuvring load factor
    - pitch manoeuvers
      - checked / unchecked
    - gust / turbulence
      - in-flight
      - on ground
    - Not more than maximum pilot effort (see next slide)
    - Not less than minimum pilot effort (see next slide)

CS-23/25 Control Surface and System Requirements

- **CS 23/25.397** Control System Loads
  - Minimum and maximum pilot forces (limit load):

Elevator:

Stick.....	743 N (167 lbf)	445 N (100 lbf)
Wheel (symmetrical) .	890N (200 lbf)	445 N (100 lbf)
Wheel (unsym-metrical) [5]	.....	445 N (100 lbf)

Control	Maximum forces or torques	Minimum forces or torques
Elevator: Stick	1112 N (250 lbf)	445 N (100 lbf)
Wheel (symmetrical)	1335N(300 lbf)	445 N(100 lbf)
Wheel (unsymmetrical) †		445 N (100 lbf)

(maximum forces to be increased when MTOW > 5000 lbs)

  - Dual control systems:
    - Pilots operating in opposition
    - Pilots operating in same direction
    - For both cases, in general, 75% of individual pilot force is applied

CS-25 Control Surface and System Requirements

- Are design loads exceeded?

(ref. CS 23/25.143 – maximum control force permitted for short term application)

Force, in newton (pounds), applied to the control wheel or rudder pedals	Pitch
For short term application for pitch and roll control – two hands available for control	334 (75)
For short term application for pitch and roll control – one hand available for control	222 (50)

- As long as compliance with CS 23/25.143 is maintained, there is a considerable margin with even the minimum limit pilot forces of CS 23/25.397
- So far, no indication of structural limits being exceeded in the “anti-icing” events (no structural failures/deformations)

Summary / Conclusions

- Control surfaces and systems are designed for loads resulting from a number of (nominal) conditions, such as manoeuvre / gust conditions, and minimum and maximum pilot force conditions
- In addition, failure conditions such as jamming need to be considered
- Although the aerodynamic load distribution on the elevator may be affected (hinge moment increase) due to the presence of the anti-icing fluid, loads from these (other) conditions are still expected to exceed the loads occurring during the take-off rotation condition
- Situation will however continue to be monitored and re-evaluated when necessary

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Flight Control Systems (CS-23/25 Aircraft)

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CS-23/25 Flight Control System Requirements

- Control Surfaces – Design and Construction
  - CS 23/25.651 requires Limit Load Testing of Flight Control Surfaces including Flight Control System interface (e.g. horn, fitting,…). Applicable loads are derived from 23/25.391.
  - CS 23/25.657 ensures robust design of flight control surface hinges.
  - Hinges must withstand loads parallel to the hinge line as given in 23/25.393.

Do we have adverse in-service experience with regards to flight control surface designs caused by Aircraft de-/anti-icing products?

CS-23/25 Flight Control System Requirements

- Control System – Design and Construction
  - CS 23/25.671(a) request the control system to operate with ease, smoothness and positiveness. Flight control system behavior/response varies due to:
    - Operational Characteristics (e.g. speed, altitude, attitude, CG,…)
    - System failures / malfunctions
    - Environmental Conditions
    - Flight Control Surface Contaminations
  - CS 25.671(c) requires the flight control system to be fault tolerant against single failures, combination of failures and jamming conditions.

CS-23/25 Flight Control System Requirements

- Control System – Design and Construction
  - CS 23/25.681 requires the entire flight control system (incl. supports, brackets,…) to be limit load tested against the most severe loading condition.
  - CS 25.683 requires that the entire flight control system to be operational tested with 80% limit loads when subject to pilot effort.
  - CS 23.683 requires that the entire flight control system to be operational tested to limit air or pilot loads, whatever is less.

Summary / Conclusion

Flight Control System design requirements and compliance demonstration relies on correct load assumptions.

Repercussions of flight control surface contamination on surface balance, aerodynamic loads,… should be evaluated to ensure safe operation for the approved flight/operational envelope.

Subpart F - Equipment (CS 23 and 25)

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CS23.1301 and 1309

- **CS 23.1301** Function and Installation

  Each item of installed equipment must :

(a) Be of a kind and design appropriate to its intended function;

(c) Be installed according to limitations specified for that equipment

(d) Function properly when installed.

- **CS 23.1309** Equipment, systems and installations

  Each item of installed equipment must :

(a) Each item of equipment, each system, and each installation

(1) When performing its intended function, may not adversely affect the response, operation or accuracy of any

(i) Equipment essential to safe operation; or

(ii) Other equipment unless there is a means to inform the pilot of the effect

- **Equipment/Systems susceptible to be exposed to de/anti-icing fluids shall operate as intended and ensure a safe operation**

CS23.1419 and its link with AC 23.1419

- **CS 23.1419** Ice Protection
  - **AMC 23.1419** Ice Protection

    Acceptance of FAA AC 23.1419-2 as AMC to CS 23.1419

    The AC23.1419-2 (Certification of part 23 Airplanes for flight in icing conditions) lists potential issues related to the use of ground deicing fluids : Performance/Longitudinal Control/Vibration & Controllability/Freezing of Control.

- *"…Evaluation of above issues are not required for showing compliance to 14 CFR 23.1419….however… airplane manufacturer may want to consider during certification to prevent re-designs after type certification if it is anticipated operators will use ground deicing/anti-icing fluids…"*

AC 23.1419

- *"…The following paragraphs summarize methods that have been used by manufacturers in previous projects to address these issues. They are provided to assist airplane manufacturers in evaluating fluids for their specific designs…"*

(1) Design : analysis of collection sites / drainage features

(2) Airplane performance : Back to back T/O test with or without fluid to determine the lift decrement due to fluid at liftoff

- LIFT LOSS DECREMENT : 5.24% and 8 % had been respectively considered acceptable for jet powered and propeller powered airplanes.
- LIFT COEFFICIENT DECREMENT : A 6% has been considered significant.

(3) Controllability

- Control power and control force during rotation at the scheduled Vr.
- Control power and control force during rotation at 10 knots or 7%, whichever is less, below the scheduled Vr
- Controlability test after lift off

AEO :± 40º bank angle changes, ± 0.5g or stall warning

OEI : ± 30º bank angle changes, +1.3/-0.8g or stall warning

(4) Fluids : The airplane manufacturer should evaluate the type and brand of fluids to be approved for the airplane.

(5) Airplane Systems: Any adverse effect on aircraft systems should be noted

AC 23.1419

AFM

(1) Fluids. The type and brands of fluid approved, along with any minimum outside air temperature limitation, should be in the Limitations section.

(2) Limitations. Procedures modified as a result of ground fluids should be in the Limitations section.

(3) Procedures. Pre-flight or post-flight inspection and cleaning of areas in which fluid residue is shown to occur.

(4) Performance. Any increases in takeoff distance due to takeoff speeds increased above the established threshold should be presented in the Performance section.

CS25.1301 and 1309

- **CS 25.1301** Function and Installation

(a) Each item of installed equipment must :

(1) Be of a kind and design appropriate to its intended function;

(3) Be installed according to limitations specified for that equipment

- **CS 25.1309** Equipment, systems and installations

(a) The aeroplane equipment and systems must be designed and installed so that:

(1) Those required for type certification or by operating rules, or whose improper functioning would reduce safety, perform as intended under the aeroplane operating and environmental conditions.

- **Equipment /Systems susceptible to be exposed to de/anti-icing fluids shall operate as intended and ensure safe operation**

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Next Steps (CS 23 and 25 Aircraft)

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Next Steps

- The wind tunnel testing performed within the scope of the DIFT research project confirmed the potential hazard of increased stick forces during rotation at take-off:
  - for aircraft with reversible longitudinal flight controls
  - when thickened deicing/anti-icing fluids are applied

- Consequently, EASA consider to take the following next steps …

Next Steps

- EASA to discuss in relevant fora (e.g. SAE G12 on “Aircraft Ground De-icing Committee”) on the opportunity to evolve SAE AMS1428 standard (thickened fluid) con consideration of the identified effects during fluid qualification.

Next Steps for Continued Airworthiness

- EASA consider to publish a SIB (Safety Information Bulletin) summarizing the main conclusions of the DIFT research and encouraging Operators to report related events to the responsible TCHs,NAAs and EASA.

Next Steps for Continued Airworthiness (cont.)

- EASA consider to draft a corresponding CARI (Continued Airworthiness Review Item) to request detailed information from TCHs for potentially affected aircraft types. Relevant information needed by EASA would be:
  - Number of occurrences related to increased control forces after application of fluids per aircraft type reported to the TCH and associated occurrence reports
  - Operational data about frequency of applying thickened deicing/anti-icing fluids on the aircraft fleet, if available (e.g. number of flight cycles / take-offs performed with deicing/anti-icing fluids applied)

    => TCHs may review data from a suitable operator with regular operation under ground icing conditions performing FDM to get details on the hazard of increased stick forces for their aircraft type.
  - Information on actions taken by the TCH to identify or mitigate effects of deicing/anti-icing fluid application on aircraft performance and/or handling qualities (e.g. testing performed, AFM procedures, etc.)

Next Steps for Type Certification

- EASA consider to initiate a Rulemaking task to require demonstration of adequate take-off operation with de-icing/anti-icing fluids by means of CS-23 / CS-25 amendment. (Long Term Action – ToR for RMT.0118 planned for Q3/2015)

- EASA may consider to draft Special Condition(s) to be applied to upcoming Type Certification programmes for CS-23 / CS-25 aircraft with reversible longitudinal flight controls to require demonstration of adequate take-off operation with de-icing/anti-icing fluids to support operational use of these fluids for the new aircraft types. (Short Term Action) - (similar to FAA Policy No PS-ACE-23-05/PS-ANM-25-10)

Next Steps for Type Certification (cont.)

Alternatively to the above short term action…

- EASA may consider to draft additional AMC/GM in a Certification Memorandum to be applied to upcoming Type Certification programmes for CS-23 / CS-25 aircraft with reversible longitudinal flight controls to require demonstration of adequate take-off operation with de-icing/anti-icing fluids to support operational use of these fluids for the new aircraft types.

but …

EASA aims to coordinate its actions with FAA and TCCA.

and

Final decision will be taken after completing the assessment of relevant available information.

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Thank you for your attention!

Any questions….?

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