Special Condition C-xx on Rudder Control Reversal Load Conditions

Applicable to Large Aeroplane category

Issue 1

Introductory note:

The following Special Condition has been classified as an important Special Condition and as such shall be subject to public consultation, in accordance with EASA Management Board decision 12/2007 dated 11 September 2007, Article 3 (2.) of which states:

"*2. Deviations from the applicable airworthiness codes, environmental protection certification specifications and/or acceptable means of compliance with Part 21, as well as important special conditions and equivalent safety findings, shall be submitted to the panel of experts and be subject to a public consultation of at least 3 weeks, except if they have been previously agreed and published in the Official Publication of the Agency. The final decision shall be published in the Official Publication of the Agency.*"

Statement of Issue

Service experience and recent investigation show that regardless of training, pilots may make inadvertent and erroneous rudder inputs. Some cases have included pedal reversals. Accident (AA587) and incident data show some aeroplanes that have experienced such reversals have surpassed the aeroplane's structural limit load and sometimes ultimate load.

In March 2011, the FAA tasked the Aviation Rulemaking Advisory Committee (ARAC) to consider the need to add a new flight manoeuvre load condition to 14 CFR Part 25, subpart C, that will ensure aeroplane structural capability in the presence of rudder reversals and associated build-up of sideslip angles through a defined flight envelope, or to consider if other standards may more appropriately address this concern, such as certain pedal characteristics that discourage pilots from making pedal reversals. The ARAC re-established the Flight Control Harmonisation Working Group (FCHWG) to assist in this task, and EASA participated in this group. The FCHWG concluded in its final report entitled 'Rudder Pedal Sensitivity/Rudder Reversal Recommendation Report' (dated 7 November 2013)[1] that no Part 25 standard can be developed to prevent unintended rudder usage. However, the group was able to develop a standard that accounts for inappropriate usage through a new design load condition.

With no foreseeable way of preventing inadvertent inputs, EASA find it is necessary to issue a Special Condition to ensure that aeroplanes are design tolerant to two rudder pedal doublets. This proposed criteria would be responsive to NTSB Safety Recommendation A-10-119, and would provide more capability to withstand successive rudder pedals inputs.

It is to be noted that some authorities already apply similar requirements for new designs by requiring under §25.601 that applicants for new type certificates show that their design is capable of continued safe flight and landing after experiencing multiple rudder pedal reversals.

[1] The report is available on the FAA website at:
http://www.faa.gov/regulations_policies/rulemaking/committees/documents/media/FCHWG_RPSRR_Complete.pdf

Special Condition C-xx - Rudder Control Reversal Load Conditions

Applicable to Large Aeroplane category

The aeroplane must be designed for loads, considered as ultimate, resulting from the yaw manoeuvre conditions specified in paragraphs (a) through (e) of this requirement from the highest airspeed for which it is possible to achieve maximum rudder deflection at zero sideslip or V_{MC}, whichever is greater, to V_C/M_c. These conditions are to be considered with the landing gear retracted and speed brakes (or spoilers when used as speed brakes) retracted. Flaps (or flaperons or any other aerodynamic devices when used as flaps) and slats extended configurations are also to be considered if they are used in en route conditions. Unbalanced aerodynamic moments about the centre of gravity must be reacted in a rational or conservative manner considering the aeroplane inertia forces. In computing the loads on the aeroplane, the yawing velocity may be assumed to be zero. ~~A pilot force of 890 N (200 lbf) is assumed to be applied for all conditions.~~

(a) With the aeroplane in unaccelerated flight at zero yaw, it is assumed that the cockpit rudder control is displaced as specified in CS 25.351(a) and (b), with the exception that only 890 N (200 lbf) need be applied.

(b) With the aeroplane yawed to the overswing sideslip angle, it is assumed that the cockpit rudder control is suddenly displaced in the opposite direction to achieve the resulting rudder deflection, as limited by the control system or control surface stops, and as limited by the pilot force of 890 N (200 lbf).

(c) With the aeroplane yawed to the opposite overswing sideslip angle, it is assumed that the cockpit rudder control is suddenly displaced in the opposite direction to achieve the resulting rudder deflection, as limited by the control system or control surface stops, and as limited by the pilot force of 890 N (200 lbf).

(d) With the aeroplane yawed to the subsequent overswing sideslip angle, it is assumed that the cockpit rudder control is suddenly displaced in the opposite direction to achieve the resulting rudder deflection, as limited by the control system or control surface stops, and as limited by the pilot force of 890 N (200 lbf).

(e) With the aeroplane yawed to the opposite overswing sideslip angle, it is assumed that the cockpit rudder control is suddenly returned to neutral.

Proposed New Acceptable Means of Compliance (for information only)

The following Acceptable Means of Compliance (AMC) are produced to support the understanding of the Special Condition.

However, this part is not subject to public consultation and therefore no comments are expected on the AMC.

"Rudder Control Reversal Design Load Conditions"

1. Purpose. This AMC describes acceptable means for showing compliance with the requirements of the above Special Condition (SC) on Rudder control reversal load conditions. These requirements specify structural design load conditions that apply to the airframe, and that occur as a result of multiple rudder pedal inputs.

2. Related CS 25 Regulations.

a. CS 25.351, *Yaw manoeuvre conditions*.

b. Special Condition, *Rudder control reversal load conditions*.

3. Background.

a. Requirements. CS 25.351, *Yaw manoeuvre conditions*, and SC, *Rudder control reversal load conditions*, specify structural design load conditions that occur as a result of rudder pedal inputs. These conditions are intended to encompass all of the rudder manoeuvre loads expected to occur in service.

b. Yaw manoeuvre conditions. The design load conditions specified in CS 25.351 are considered limit load conditions, and a 1.5 factor of safety is applied to obtain ultimate loads.

c. Rudder control reversal load conditions. The design load conditions specified in this Special Condition are more severe than those in CS 25.351 and include rudder control reversals. These conditions are anticipated to occur very rarely, and so these are considered ultimate load conditions, and no additional safety factor is applied.

d. Overswing sideslip angle definition: Maximum (peak) sideslip angle reached by the aeroplane with the cockpit rudder control displaced as specified in §4.b below.

4. Application of the requirements.

a. General

(1) The aeroplane must be designed for the rudder control reversal load conditions specified in the Special Condition. These are considered ultimate load conditions and, therefore, no additional factor of safety is applied. However, any permanent deformation resulting from these ultimate load conditions must not prevent continued safe flight and landing.

(2) Design loads must be determined as specified in CS 25.321. The load conditions are considered from the maximum airspeed for which it is possible to achieve full rudder deflection at zero sideslip or V_{MC}, whichever is greater, to V_C/M_c. A pilot force of 890 N (200 lbf) is assumed to be applied for all conditions. These conditions are to be considered with the landing gear retracted and speed brakes (or spoilers when used as speed brakes) retracted.

Flaps (or flaperons or any other aerodynamic devices when used as flaps) and slats-extended configurations are also to be considered if they are used in en route conditions.

(3) System effects. System effects should be taken into account in the evaluation of this manoeuvre. For example, fly-by-wire aircraft should be analysed assuming the aeroplane is in the normal control law mode. Any system function used to demonstrate compliance with these requirements should meet the following criteria:

(a) The system is normally operative during flight in accordance with the aeroplane flight manual procedures, although limited dispatch with the system inoperative could be allowed under applicable master minimum equipment list provisions provided MMEL requirements are still complied with, taking into account the rudder reversal pedal inputs as the next critical event under dispatch configuration; and

(b) Appropriate crew procedures should be provided in the event of loss of function. If loss of system function would not be detected by the crew, the probability of loss of function (failure rate multiplied by maximum exposure period) should be less than 1/1000.

(4) Failure conditions. Due to the very low probability of a full rudder pedal doublet event, failure scenarios do not need to be addressed in combination with the rudder control reversal load conditions specified in the Special condition.

b. SC requirements (a) through (e)

(1) Conditions (a) through (e) of the Special Condition are intended as a full displacement pedal input followed by three pedal reversals and return to neutral. Speed should be kept reasonably constant throughout the manoeuvre using pitch control.

(2) With the aeroplane in unaccelerated flight at zero yaw, it is assumed that the cockpit rudder control is suddenly displaced to achieve the resulting rudder deflection, as limited by the control system, control stops or pilot force of 890 N (200 lbf). In this context, “suddenly” means as fast as possible within human and system limitations. In the absence of a rational analysis, initial pedal displacement is achieved in no more than 0.2 seconds, and full rudder control reversal displacement is achieved in 0.4 seconds. Alternatively, the applicant may assume the rudder pedal is displaced instantaneously.

(3) The resulting rudder displacement should take into account additional displacement caused by sideslip build-up, and the effects of flexibility should be considered when relevant.

(4) As soon as the maximum overswing yaw angle is achieved, full opposite rudder pedal input is applied. The achieved rudder deflection may be limited by control laws, system architecture, or air loads, and may not be the same magnitude as the initial rudder deflection prior to the pedal reversal. For critically damped aircraft response, maximum overswing yaw angle may be assumed to occur when the sideslip angle is substantially stabilised.

(5) Two additional reversals are performed as defined in (4). After the second reversal, as soon as the aeroplane yaws to the opposite overswing yaw angle, the cockpit rudder control is suddenly returned to neutral.

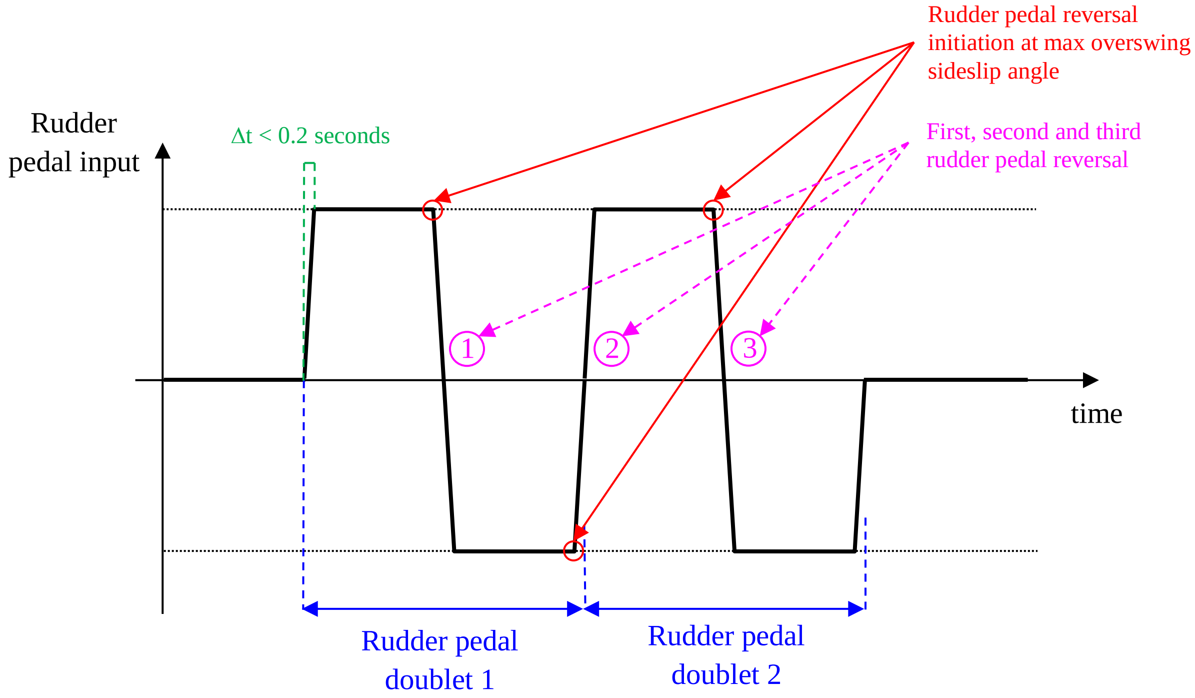

Fig. 1: Illustrative figure of the rudder pedal inputs