

## Use of rudder on Airbus A300-600/A310

(extracted from former FCOM Bulletin N°15/1 – Subject N°40)



### Reason for issue

On February 8th, 2002, the National Transportation Safety Board (NTSB), in cooperation with the French Bureau d'Enquêtes et d'Analyses (BEA), issued recommendations that aircraft manufacturers re-emphasize the structural certification requirements for the rudder and vertical stabilizer, showing how some maneuvers can result in exceeding design limits and even lead to structural failure.

The purpose of this Bulletin is to re-emphasize proper operational use of the rudder, highlight certification requirements and rudder control design characteristics.

### Yaw control

#### General

In flight, yaw control is provided by the rudder, and directional stability is provided by the vertical stabilizer. The rudder and vertical stabilizer are sized to meet the two following objectives:

- ▶ Provide sufficient lateral control of the aircraft during crosswind takeoffs and landings, within the published crosswind limits (refer to FCOM Operating Limitations chapter).
- ▶ Provide positive aircraft control under conditions of engine failure and maximum asymmetric thrust, at any speed above  $V_{mcg}$  (minimum control speed - on ground).

The vertical stabilizer and the rudder must be capable of generating sufficient yawing moments to maintain directional control of the aircraft. The rudder deflection, necessary to achieve these yawing moments, and the resulting sideslip angles place significant aerodynamic loads on the rudder and on the vertical stabilizer. Both are designed to sustain loads as prescribed in the JAR/FAR 25 certification requirements which define several lateral loading conditions (maneuver, gust loads and asymmetric loads due to engine failure) leading to the required level of structural strength.

### Certification requirements

For certification in accordance with CS-25/FAR 25.351, loads on the stabilizer and the rudder are defined, considering yawing maneuvers as shown below, for a range of speeds from  $V_{mc}$  (minimum control speed) to  $V_{D/MD}$  (maximum design speed), from sea level up to maximum altitude, and over the full range of aircraft weights and Center of Gravity limits:

1 – With the aircraft in unaccelerated and stabilized straight flight, the rudder is suddenly displaced to the maximum available deflection at the current aircraft speed (*fig 1*).

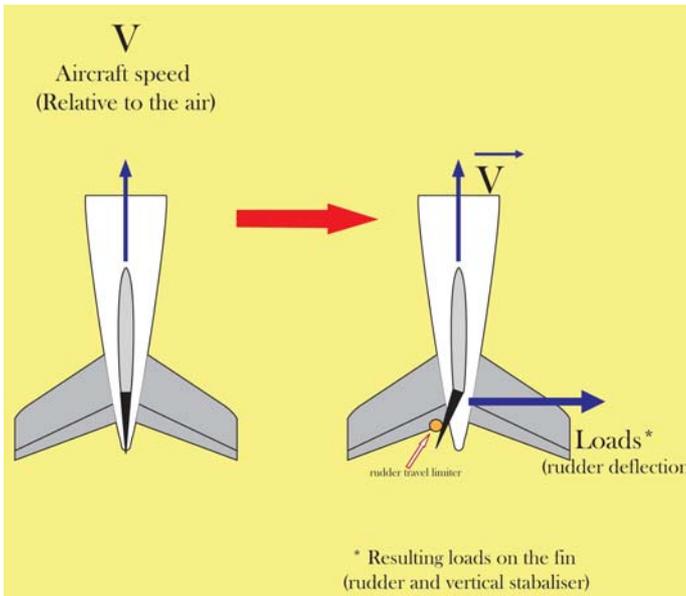


Fig 1

vides the design basis for the vertical stabilizer and rudder. The above loads define the limit loads according to JAR/FAR 25 requirements. These loads correspond to the maximum loads to be expected once in service.

According to CS-25/FAR 25 requirements, the ultimate loads are defined as the limit loads multiplied by a prescribed safety factor of 1.5 unless otherwise specified. The aircraft structure must be able to support limit loads without detrimental permanent deformation and ultimate loads without failure for at least three seconds. Higher loads could lead to structural failure.

**Rudder control**

The rudder surface is controlled by three actuators, commanded by a cable run from the rudder pedals, to which input yaw damping and turn coordination functions are added by the rudder control system.

The rudder travel limiter system, controlled by the Feel and Limitation Computers (FLC), is designed to progressively reduce

2 – With the rudder deflected as shown in Fig 2, the aircraft yaws to the resulting overswing sideslip angle, and then stabilizes at a somewhat smaller steady-state sideslip angle.

3 – With the airplane yawed to the steady-state (static) sideslip angle corresponding to the above rudder deflection, the certification regulations assume that the rudder is released to neutral.

*Note : Because the aircraft has natural yaw stability, returning the rudder to neutral will also result in returning the sideslip to neutral.*

JAR/FAR 25 requires the above yawing maneuver to be analyzed over the full range of specified conditions. The most severe loads imposed on the vertical stabilizer and rudder are identified. The same analysis is performed for lateral gusts, rolling maneuvers and asymmetric engine failure conditions. The most severe of all these cases and associated loads pro-

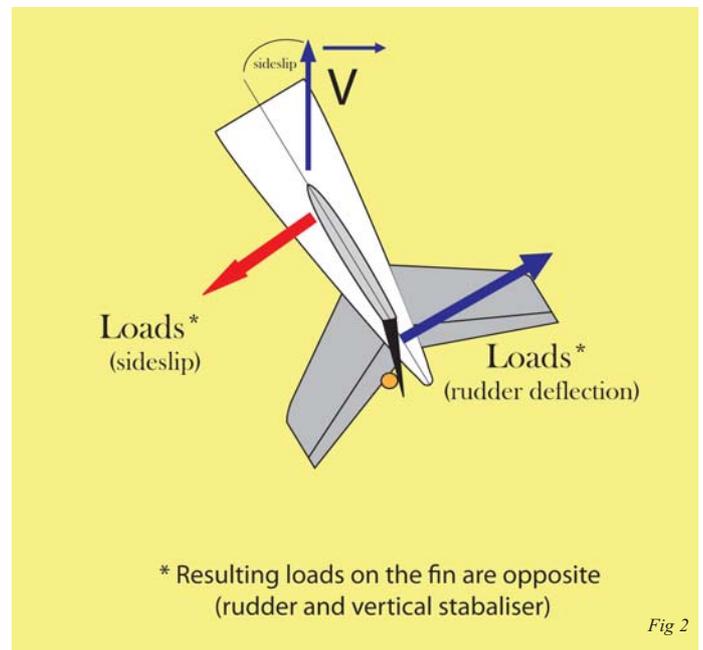


Fig 2

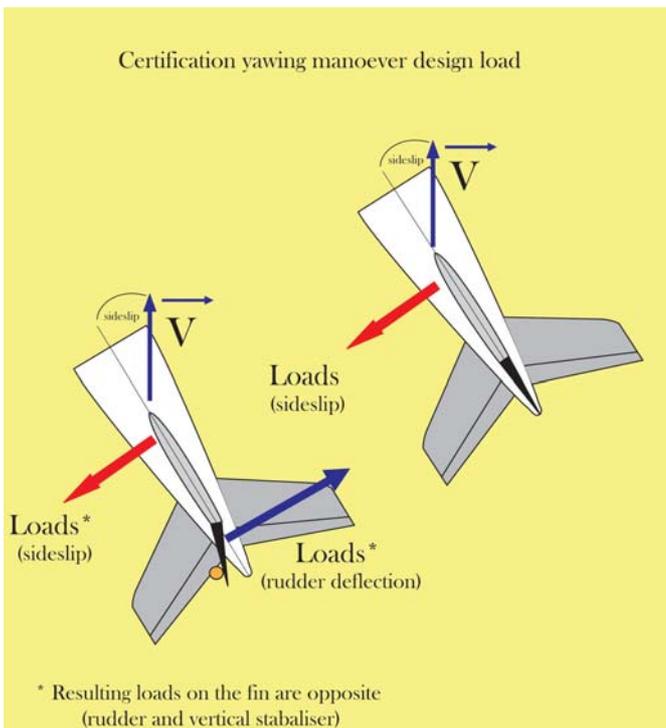


Fig 3

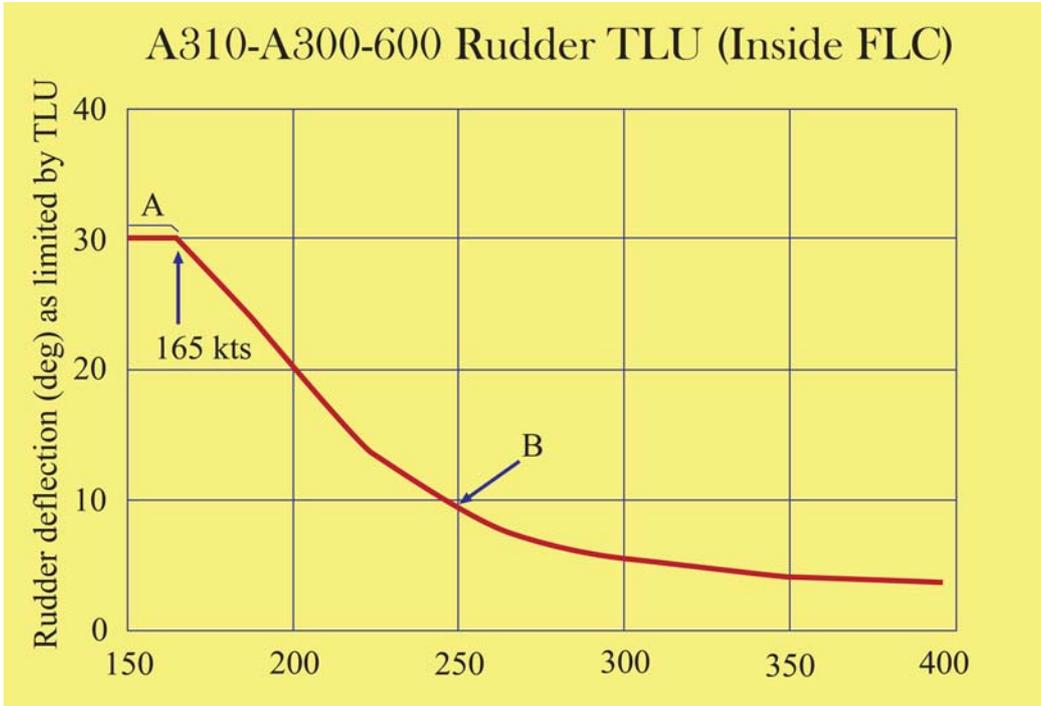
**Caution**

Sudden commanded full, or nearly full, opposite rudder movement against a sideslip can generate loads that exceed the limit loads and possibly the ultimate loads and can result in structural failure.

This is true even at speeds below the maximum design maneuvering speed,  $V_A$ . Certification regulations do not consider the loads imposed on the structure when there is sudden full, or nearly full, rudder movement that is opposite the sideslip.

the available total rudder travel depending on aircraft speed. This provides sufficient yaw control within the entire flight envelope, including engine failure and maximum asymmetric thrust. This also limits the lateral loads on the stabilizer and rudder so that they remain within the certification limits.

Rudder travel is limited as a function of the aircraft speed (IAS), as shown below:



► At low speeds, the rudder deflection required to maneuver the aircraft in yaw is large, and so are the resulting pedal displacement and forces.

► At higher speeds, pedal displacements and forces are smaller.

Therefore, as speed increases, the rudder deflection required by any lateral maneuver (eg, engine failure and maximum asymmetric thrust) decreases, and consequently, so do rudder pedal displacement and associated forces. Rudder pedals displacement is almost linearly proportional to rudder deflection.

Fig 5

Thus, to explain Figs 5&6: The rudder pedal displacement and the resulting pedal forces required to achieve a given rudder deflection are independent from aircraft speed. The rudder pedal limiter will give a direct feel feedback of the allowed rudder travel as a function of speed:

► To start moving the rudder pedals from the neutral position, a minimum force of +/- 10 daN must be applied ("breakout force").

► At low speeds, i.e. up to 165 kt, see ref "A", maximum rudder deflection (30 degrees) is obtained by moving the rudder pedals to their maximum travel which represents a 30 daN force applied on the pedals.

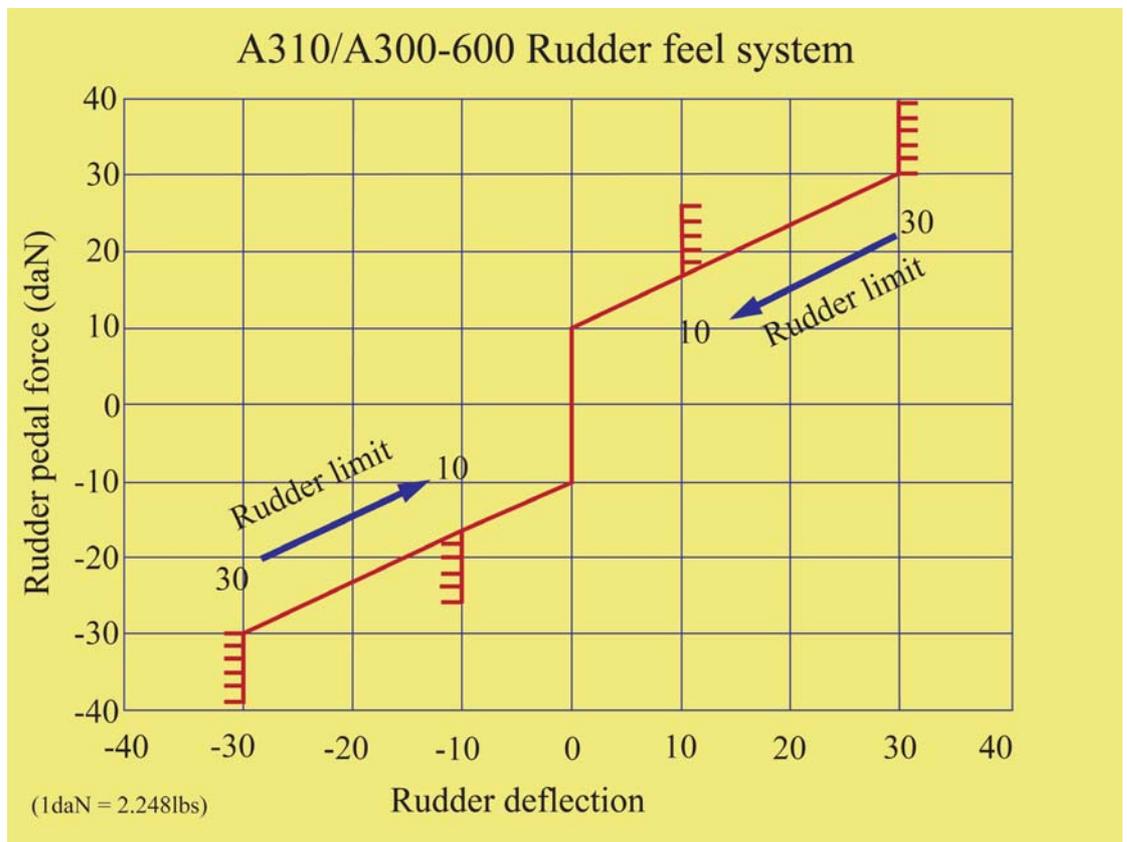


Fig 6

► At higher speeds, for example at 250 kt, see ref "B", the maximum available rudder deflection is reduced to approximately 10 degrees. It is consequently obtained with less rudder pedals displacement which represents a 18 daN force applied on the pedals (60% of the maximum force to reach full pedal travel).

## Operational recommendations

In order to avoid exceeding structural loads on the rudder and vertical stabilizer, the following recommendations must be observed.

### 1. The rudder is designed to control the aircraft in the following circumstances

#### In normal operations, for lateral control

- ▶ During the takeoff roll, when on ground, especially in crosswind conditions;
- ▶ During landing flare with crosswind, for de-crab purposes.
- ▶ During the landing roll, when on ground.

In these circumstances, large and rapid rudder inputs may be necessary to maintain control of the aircraft. Rudder corrections should always be applied as necessary to obtain the appropriate aircraft response. On Airbus aircraft, the rudder control system includes a turn coordination function to achieve acceptable turn coordination.

*Note : At low speed, as deemed necessary, rudder pedals may be used to complement this automatic turn coordination.*

#### To counteract thrust asymmetry

Full rudder authority can be used to compensate for the yawing moment of asymmetric thrust.

*Note : At high speed (i.e. slats retracted), thrust asymmetry (e.g., due to an engine failure) has relatively small effect on lateral control of the aircraft. The amount of rudder required to counter an engine failure and center the sideslip is small.*

#### In some other abnormal situations

The rudder may also be used in some abnormal situations such as:

- ▶ Loss of both yaw damper systems. The rudder may be used as deemed necessary, for turn coordination to prevent excessive sideslip.
- ▶ Runaway rudder trim. The rudder pedals may be used to return the rudder to neutral.
- ▶ Aileron jam. The rudder may be used to initially control the roll.
- ▶ Landing gear unsafe indication (gear not downlocked). When a main landing gear is not downlocked, the rudder may be used to establish sideslip in an attempt to downlock the landing gear by aerodynamic side forces.
- ▶ Landing with landing gear not downlocked. The rudder can be used for directional control on ground.

In all these normal or abnormal circumstances, proper rudder maneuvers will not affect the aircraft's structural integrity.

*Note: In the event of total rudder travel system failure, refer to the relevant RUDDER TRAVEL FAULT procedure.*

#### Rudder should NOT be used:

- ▶ To induce roll
- ▶ To counter roll, induced by any type of turbulence

**Whatever the airborne flight condition may be, aggressive, full or nearly full, opposite rudder inputs must not be applied. Such inputs can lead to loads higher than the limit, or possibly the ultimate loads and can result in structural damage or failure. The rudder travel limiter system is not designed to prevent structural damage or failure in the event of such rudder system inputs.**

*Note: Rudder reversals must never be incorporated into airline policy, including so-called "aircraft defensive maneuvers" to disable or incapacitate hijackers.*

As far as Dutch roll is concerned, yaw damper action and natural aircraft damping are sufficient to adequately dampen Dutch roll oscillations. The rudder should not be used to complement the yaw damper.

*Note: Even if both yaw damper systems are lost, the rudder should not be used to dampen the dutch roll. Refer to the YAW DAMPER FAULT procedure.*

## Recovery techniques from upset situations

Proper use of the rudder, particularly during maneuvers intended to address upset recovery, are emphasized in the Airbus Training Program, supported by the industry-produced 1998 "Upset recovery training aid ". These upset recovery techniques are summarized in Airbus FCOM Chapter Procedures and Techniques (2.02.09).