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NATS Ltd
UK Aeronautical Information Service
Heathrow House
Bath Road
Hounslow, Middlesex TW5 9AT
URL: http://www.ais.org.uk/
Phone: 020-8750 3778 (Editorial)
Phone: 0870-8871410 (Distribution - Tangent Direct)
Phone: 01293-573914 (Content - Flight Operations Policy)

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HELICOPTER HYDRAULIC-POWERED FLYING CONTROLS 'SERVO TRANSPARENCY'

1 Introduction

1.1 Following their investigation into a helicopter accident involving a UK-registered Eurocopter AS350B2 Squirrel, the Air Accidents Investigation Branch (AAIB) recommended that owners and operators of similar helicopters be reminded of the phenomenon of 'Servo Transparency' (Safety Recommendation 2008-068). There were several other notable safety recommendations made within the report which is referenced and linked below.

1.2 The purpose of this Circular is to draw to the attention of such operators the nature of this phenomenon, which may also be known as 'Servo reversibility' or 'Jack stall'. A full description of this feature is provided below through information issued by Eurocopter in their Service Letter 1648-29-03 dated 14 December 2003.

2 The Eurocopter Service Letter

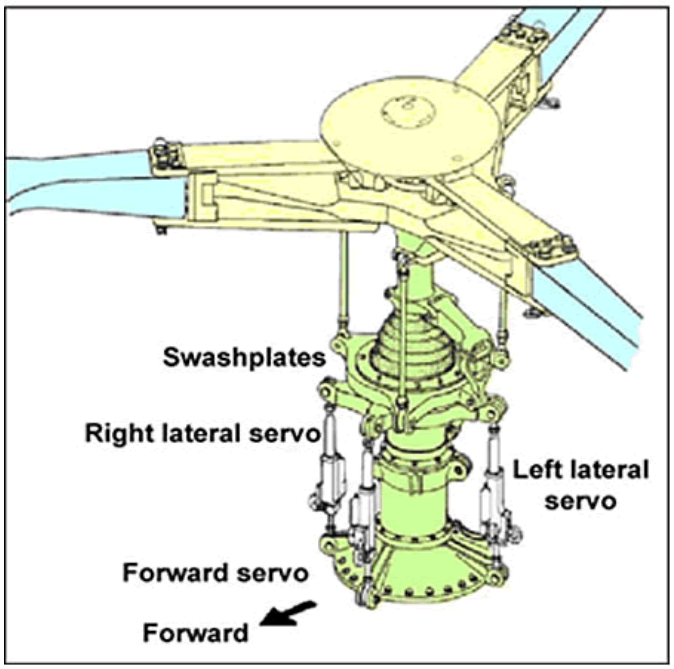
2.1 The content of the Eurocopter Service Letter is reproduced below which, although published for Eurocopter France AS350B, BA, B1, B2, B3, D, AS355E and EC120B models, provides more generic advice for similar types:

> 'This message is being issued as a reminder about the Servo Transparency phenomenon that can be encountered during excessive manoeuvring of any single hydraulic system equipped helicopter, if operated beyond its approved flight envelope. This phenomenon is known variously as Servo Transparency or Servo Reversibility, but is referred to here as Servo Transparency. This aircraft phenomenon occurs smoothly and is not dangerous, if properly anticipated by a pilot during an abrupt or excessive high load manoeuvre such as a high positive g-turn or pull-up. The factors that effect Servo Transparency are airspeed, collective pitch input, gross weight 'G' loads and density altitude'

2.2 What Happens?

2.3 Hydraulic control boost is accomplished by irreversible hydraulic systems which isolate the pilot from the aerodynamic forces of the main rotor by the use of servos. The loads are transmitted from the blades through the pith rods to the swash plate assembly. The hydraulic power system counter-acts these forces through the servos. Since this results in zero control forces, artificial pilot control forces are then created by frictions, springs or force trims. The maximum force the servo actuators can produce is constant and is a function of hydraulic pressure and of the servo characteristics. The system is designed to exceed the requirements of the approved helicopter flight envelope. However, the maximum available power must be limited by design to protect the airframe against overstress, if the approved flight is exceeded. With excessive manoeuvring and under a combination of the above listed factors, the aerodynamic forces can increase beyond the opposing servos forces and Servo Transparency occurs.

The aerodynamic forces in excess of the hydraulic forces are then transmitted back through the control links to the pilots cyclic and collective controls. On clockwise turning rotors, as on the AS350 and EC120, the right servo is the highest loaded when manoeuvring (retreating blade), so servo transparency results in gradually increasing left cyclic control loads required to avoid un-commanded right cyclic motion accompanied by down collective movement due to the general overload on the swash plate assembly. The cyclic and collective control inputs required to counter these control motions may give a pilot who is unaware of this phenomenon an impression that the controls are jammed. If the severity of the manoeuvre is not reduced, the aircraft will roll right and may pitch up. The amplitude of the induced control feedback loads is proportional to the severity of the manoeuvre, but the phenomenon normally lasts less than 2 seconds since the resultant aircraft reaction helps to reduce the factors that contribute to the severity of the manoeuvre and of the Servo Transparency.



2.4 **The Pilots Reaction**

2.5 The pilots reaction to the first indication of control forces feedback should be to IMMEDIATELY reduce the severity of the manoeuvre. Once, developed Servo Transparency will reduce the helicopter speed due to some pitch-up and reduce control loads by included down collective movement, so the servo transparency phenomenon is self correcting. The pilot reaction is to follow the control movement and to allow the collective pitch to decrease (of course, monitor main rotor rpm speed at very low pitch) to reduce the overall load on the rotor system and smoothly counteract the right cyclic tendency to prevent an abrupt left cyclic movement as hydraulic assistance is restored.

Pilots should understand that Servo Transparency is a natural phenomenon for a perfectly flyable helicopter. Basic airmanship should prevent encountering this phenomenon by avoiding combinations of high speed, high gross weight, high density altitude and aggressive manoeuvres which exceed the aircrafts approved flight envelope. It is a basic rule tells (sic) you that it is particularly inappropriate to perform manoeuvres which reach and exceed several aircraft limitations simultaneously.

3 Comment

3.1 It can not be emphasised enough that pilots should ensure that they fly their aircraft within the limits published in the appropriate Flight Manual. If these limits are inadvertently exceeded, structural or handling problems may be experienced in any aircraft, and it is important that any recovery manoeuvre should be carried out smoothly, which may require considerable height to complete.

3.2 The Federal Aviation Administration (FAA) Special Airworthiness Bulletin SW-04-35 on the subject of Servo Transparency makes several recommendations including:

a The pilot should follow (not fight) the control movement. Allow the collective pitch to decrease (monitoring Rotor RPM, especially at very low collective pitch settings) to reduce the overall load. You should be aware that as the load is reduced, hydraulic assistance will be restored and force being applied to the controls could result in undesired opposite control movement. Follow the aircraft limitations in accordance with the Aircraft Flight Manual.

3.3 Pilots may wish to refer to the valuable information contained in the following reports and notices:

AAIB Bulletins 2/2009
http://www.aaib.gov.uk/cms_resources/Eurocopter%20AS350B2%20Squirrel,%20G-CBHL%2002-09.pdf

Australian Civil Aviation Safety Authority (CASA) Airworthiness Bulletin 27-008
http://www.casa.gov.au/wcmswr/_assets/main/airworth/awb/27/008.pdf

CAA Safety Sense Leaflet 17
http://www.caa.co.uk/application.aspx?catid=33&pagetype=65&appid=11&mode=detail&id=1171

FAA Rotorcraft Flying Handbook
http://www.faa.gov/library/manuals/aircraft/media/faa-h-8083-21.pdf

FAA Special Airworthiness Bulletin SW-04-35
http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgSAIB.nsf/dc7bd4f27e5f107486257221005f069d/f015e6e326a1a380808625721f0052ebe1/$FILE/SW-04-35.pdf

National Transportation Safety Board (NTSB) AAB 04/02
http://www.ntsb.gov/publictn/2004/AAB0402.pdf

Transport Safety Board of Canada (TSBC) A05F0025
http://www.bst.gc.ca/eng/rapports-repots/aviation/2005/a05f0025/a05f0025_sec2.asp

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