Proposed Special Condition on "Stalling and Scheduled Operating Speeds"

Applicable to Airbus A350-941

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 02/04 dated 30 March 2004, 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

The A350, like the A320, A330, A340 and A380 is equipped with a low speed protection system providing a protection against stall that cannot be overridden by the pilot.
The requirements of CS 25 must therefore be adapted to consider this stall protection function.
The practice used for all previous Airbus Fly by Wire aircraft (since A320 up to A380) was to apply the NPA 25F-219 iss2 "flight in icing " on top of SC B-1" stalling and scheduled speeds" for A380 (or SC F-1 for A320), as the basic regulation was not adapted to Airbus fly by wire protected aircraft and needed to be adapted.

In order to apply flight in icing requirements, and to adapt to Airbus Fly By Wire protected A/C design, the following was applied:

- the need for operational speed increase in icing conditions was checked on Vmin1g instead of V_{Clmax}.
- for stall warning requirement, as Stall Warning only appears in case of failure of FCTL system, requirements defined for normal cases were no longer adequate and had to be adapted.

For A350 Type Certification the following Special Condition has been adapted to the new regulation introduced by CS-25 amendment 3 which embodies requirements from NPA 25F-219 iss2.
This Special Condition is similar to special condition issued on the same subject on previous fly by wire Airbus type (see SC B-1 for A380), but as paragraphs 25.103, 25.201, 25.203, 25.207 have been updated to account for new icing considerations introduced in the new paragraph 25.21(g) in CS-25 amendment 3 (supplemented by NPA 2008-05), the previous wording of the Special Condition is changed to embody the new requirements. Those new requirements have been adapted to Airbus Fly By Wire A/C characteristics and highlighted in yellow in the current consultation, in order to provide an equivalent level of safety to the actual CS-25 at amendment 5, which was the principle followed on previous project.
According to CS 25.21g, 25.143 (b)(1), (b)(2), 25.207 (c) and (d) requirements are not to be met in icing conditions.

It should be noted that the Special Condition B-09, related to the generic aspect of "Flight in Icing Condition", is under concurrent public consultation.

Airbus A350-941 - Special Condition

- Stalling and Scheduled Operating Speeds -

0 - Foreword

In the following paragraphs, “In icing conditions” means with the ice accretions (relative to the relevant flight phase) as defined in CS 25 amendment 3 appendix C

1 - Definitions

This Special Condition addresses novel features of the A350 and uses terminology that does not appear in CS 25.
The following definitions shall apply:

- High incidence protection system :	A system that operates directly and automatically on the aeroplane's flying controls to limit the maximum angle of attack that can be attained to a value below that at which an aerodynamic stall would occur.
- Alpha-floor system :	A system that automatically increases thrust on the operating engines when angle of attack increases through a particular value.
- Alpha-limit :	The maximum angle of attack at which the aeroplane stabilises with the high incidence protection system operating and the longitudinal control held on its aft stop.
- Vmin :	The minimum steady flight speed in the aeroplane configuration under consideration with the high incidence protection system operating. See section 3 of this Special Condition.
- Vmin1g :	Vmin corrected to 1g conditions. See section 3 of this Special Condition. It is the minimum calibrated airspeed at which the aeroplane can develop a lift force normal to the flight path and equal to its weight when at an angle of attack not greater than that determined for Vmin.

2 - Capability and Reliability of the High Incidence Protection System

Those paragraphs of CS 25 quoted in reference may be amended in accordance with this Special Condition provided that acceptable capability and reliability of the high incidence protection system can be established by flight test, simulation, and analysis as appropriate. The capability and reliability required are as follows:

1- It shall not be possible during pilot induced manoeuvres to encounter a stall and handling characteristics shall be acceptable, as required by section 5 of this Special Condition.

2- The aeroplane shall be protected against stalling due to the effects of wind-shears and gusts at low speeds as required by section 6 of this Special Condition.

3- The ability of the high incidence protection system to accommodate any reduction in stalling incidence must be verified in icing conditions

4- The high incidence protection system must be provided in each abnormal configuration of the high lift devices that is likely to be used in flight following system failures

5- The reliability of the system and the effects of failures must be acceptable in accordance with CS 25.1309.

3 - Minimum Steady Flight Speed and Reference Stall Speed

Delete existing CS-25.103 and replace as follows :

CS 25.103 : Minimum steady flight speed and Reference stall speed

(a) The minimum steady flight speed, Vmin, is the final stabilised calibrated airspeed obtained when the aeroplane is decelerated until the longitudinal control is on its stop in such a way that the entry rate does not exceed 1 knot per second.
(b) The minimum steady flight speed, Vmin, must be determined In icing and non icing conditions with :

(1) The high incidence protection system operating normally.

(2) Idle thrust and alpha-floor system inhibited;

(3) All combinations of flaps setting and, landing gear position for which Vmin is required to be determined;

(4) The weight used when Vsr is being used as a factor to determine compliance with a required performance standard;

(5) The most unfavourable centre of gravity allowable; and

(6) The aeroplane trimmed for straight flight at a speed achievable by the automatic trim system.

(c) The one-g minimum steady flight speed, Vmin1g, is the minimum calibrated airspeed at which the aeroplane can develop a lift force (normal to the flight path) equal to its weight, whilst at an angle of attack not greater than that at which the minimum steady flight speed of sub-paragraph (a) was determined. It must be determined in icing and non icing conditions.

(d) The reference stall speed, Vsr, is a calibrated airspeed defined by the applicant. Vsr may not be less than a 1-g stall speed. V_{SR} must be determined in non icing conditions and expressed as:

$$V_{SR} \geq \frac{V_{CL_{MAX}}}{\sqrt{n_{zw}}}$$

where

$V_{CL_{MAX}}$ = Calibrated airspeed obtained when the load factor-corrected lift coefficient ($\frac{n_{zw}W}{qS}$) is first a maximum during the manoeuvre prescribed in sub-paragraph (f) of this paragraph.

n_{ZW} = Load factor normal to the flight path at $V_{CL_{MAX}}$

W = Airplane gross weight;

S = Aerodynamic reference wing area; and

q = Dynamic pressure.

(e) V_{CLMAX} is determined in non-icing conditions with :

(1) Engines idling, or, if that resultant thrust causes an appreciable decrease in stall speed, not more than zero thrust at the stall speed;

(2) The aeroplane in other respects (such as flaps and landing gear) in the condition existing in the test or performance standard in which Vsr is being used;

(3) The weight used when Vsr is being used as a factor to determine compliance with a required performance standard;

(4) The centre of gravity position that results in the highest value of reference stall speed;

(5) The aeroplane trimmed for straight flight at a speed achievable by the automatic trim system, but not less than 1.13 Vsr and not greater than 1.3 Vsr;

(6) Alpha-floor system inhibited; and

(7) The High Incidence Protection System adjusted, at the option of the applicant, to allow higher incidence than is possible with the normal production system.

(8) Starting from the stabilised trim condition, apply the longitudinal control to decelerate the aeroplane so that the speed reduction does not exceed one knot per second.

4 - Stall Warning

Delete existing CS 25.207 and replace as follows:

4.1 Normal operation

If the conditions of paragraph 2 are satisfied, equivalent safety to the intent of CS 25.207, Stall Warning, shall be considered to have been met without provision of an additional, unique warning device.

4.2 High Incidence Protection System Failure

Following failures of the high incidence protection system, not shown to be extremely improbable, such that the capability of the system no longer satisfies items 1, 2 and 3 of paragraph 2, stall warning must be provided and must protect against encountering unacceptable characteristics and against encountering stall.

(a) Stall warning with the flaps and landing gear in any normal position must be clear and distinctive to the pilot and meet the requirements specified in paragraphs (d) and (e) below.

(b) Stall warning must also be provided in each abnormal configuration of the high lift devices that is likely to be used in flight following system failures.

(c) The warning may be furnished either through the inherent aerodynamic qualities of the airplane or by a device that will give clearly distinguishable indications under expected conditions of flight. However a visual stall warning device that requires the attention of the crew within the cockpit is not acceptable by itself. If a warning device is used, it must provide a warning in each of the aeroplane configurations prescribed in paragraph (a) above and for the conditions prescribed below in paragraphs (d) and (e) below.

(d) In non-icing conditions stall warning must meet the following requirements:

Stall warning must provide sufficient margin to prevent encountering unacceptable characteristics and encountering stall in the following conditions :

(1) In power off straight deceleration not exceeding one knot per second to a speed 5 knots or 5 per cent CAS, whichever is greater, below the warning onset.
(2) In turning flight stall deceleration at entry rates up to 3 knots per second when recovery is initiated not less than one second after the warning onset.

(e) In icing conditions stall warning must provide sufficient margin to prevent encountering stall and unacceptable characteristics, in power off straight and turning flight decelerations not exceeding one knot per second, when the pilot starts a recovery manoeuvre not less than three seconds after the onset of stall warning.

(f) An aeroplane is considered stalled when the behavior of the aeroplane gives the pilot a clear and distinctive indication of an acceptable nature that the aeroplane is stalled. Acceptable indications of a stall, occurring either individually or in combination are:

(1) A nose-down pitch that cannot be readily arrested
(2) Buffeting, of a magnitude and severity that is strong and effective deterrent to further speed reduction; or
(3) The pitch control reaches the aft stop and no further increase in pitch attitude occurs when the control is held full aft for a short time before recovery is initiated

(g) An aircraft exhibits unacceptable characteristics during straight or turning flight decelerations if it is not always possible to produce and to correct roll and yaw by unreversed use of aileron and rudder controls, or abnormal nose-up pitching occurs.

5 - Handling Characteristics at High Incidence

Delete existing CS 25.201, 203 and replace as follows:

5.1 High Incidence Handling Demonstrations

CS 25.201 : High incidence handling demonstration in icing and non-icing conditions

(a) Manoeuvres to the limit of the longitudinal control, in the nose up sense, must be demonstrated in straight flight and in 30° banked turns with:

(1) The high incidence protection system operating normally.

(2) Initial power conditions of :

I: POWER OFF

II: The power necessary to maintain level flight at 1.5 Vsr1, where Vsr1 is the reference stall speed with flaps in approach position, the landing gear retracted and maximum landing weight

(3) Alpha-floor system operating normally unless more severe conditions are achieved with inhibited alpha floor.

(4) Flaps, landing gear and deceleration devices in any likely combination of positions.

(5) Representative weights within the range for which certification is requested; and

(6) The aeroplane trimmed for straight flight at a speed achievable by the automatic trim system.

(b) The following procedures must be used to show compliance in non-icing and icing conditions :

(1) Starting at a speed sufficiently above the minimum steady flight speed to ensure that a steady rate of speed reduction can be established, apply the longitudinal control so that the speed reduction does not exceed one knot per second until the control reaches the stop

(2) The longitudinal control must be maintained at the stop until the aeroplane has reached a stabilised flight condition and must then be recovered by normal recovery techniques.

(3) Manoeuvres with increased deceleration rates

i) In non-icing conditions, the requirements must also be met with increased rates of entry to the incidence limit, up to the maximum rate achievable

ii) In icing conditions, with the anti-ice system working normally, the requirements must also be met with increased rates of entry to the incidence limit up to 3kt/s

(4) Manoeuver with ice accretion prior to operation of the normal anti-ice system

With the ice accretion prior to operation of the normal anti-ice system, the requirement must also be met in deceleration at 1kt/s up to FBS (with and without alpha floor).

5.2 Characteristics in High Incidence Manoeuvres

CS 25.203: Characteristics in High Incidence

In icing and non-icing conditions:

(a) Throughout manoeuvres with a rate of deceleration of not more than 1 knot per second, both in straight flight and in 30° banked turns, the aeroplane's characteristics shall be as follows:

(1) There shall not be any abnormal nose-up pitching.

(2) There shall not be any uncommanded nose-down pitching, which would be indicative of stall. However reasonable attitude changes associated with stabilising the incidence at Alpha limit as the longitudinal control reaches the stop would be acceptable.

(3) There shall not be any uncommanded lateral or directional motion and the pilot must retain good lateral and directional control, by conventional use of the controls, throughout the manoeuvre.

(4) The aeroplane must not exhibit buffeting of a magnitude and severity that would act as a deterrent from completing the manoeuvre specified in § 5.1.a).

(b) In manoeuvres with increased rates of deceleration some degradation of characteristics is acceptable, associated with a transient excursion beyond the stabilised Alpha-limit. However the aeroplane must not exhibit dangerous characteristics or characteristics that would deter the pilot from holding the longitudinal control on the stop for a period of time appropriate to the manoeuvre.

(c) It must always be possible to reduce incidence by conventional use of the controls.

(d) The rate at which the aeroplane can be manoeuvred from trim speeds associated with scheduled operating speeds such as V2 and Vref up to Alpha-limit shall not be unduly damped or be significantly slower than can be achieved on conventionally controlled transport aeroplanes.

5.3 Characteristics up to maximum lift angle of attack

(a) In non-icing conditions:

Manoeuvres with a rate of deceleration of not more than 1 knot per second up to the angle of attack at which V_{CLMAX} was obtained as defined in paragraph 3 must be demonstrated in straight flight and in 30° banked turns with:

(1) The high incidence protection deactivated or adjusted, at the option of the applicant, to allow higher incidence than is possible with the normal production system.

(2) Automatic thrust increase system inhibited
(3) Engines idling

(4) Flaps and landing gear in any likely combination of positions

(5) The aeroplane trimmed for straight flight at a speed achievable by the automatic trim system.

(b) In icing conditions:

Manoeuvres with a rate of deceleration of not more than 1 knot per second up to the maximum angle of attack reached during manoeuvres from 5.1 b)3)ii) must be demonstrated in straight flight with:

(1) The high incidence protection deactivated or adjusted, at the option of the applicant, to allow higher incidence than is possible with the normal production system.

(2) Automatic thrust increase system inhibited

(3) Engines idling

(4) Flaps and landing gear in any likely combination of positions

(5) The aeroplane trimmed for straight flight at a speed achievable by the automatic trim system.

(c) During such manoeuvres, the aeroplane must not exhibit dangerous characteristics , it must always be possible to reduce angle of attack by conventional use of the controls and there shall not be any uncommanded lateral or directional motion and the pilot must retain good lateral and directional control, by conventional use of the controls, throughout the manoeuvre.

6 - Atmospheric Disturbances

Operation of the high incidence protection system must not adversely affect aircraft control during expected levels of atmospheric disturbances, nor impede the application of recovery procedures in case of wind-shear. This shall be demonstrated in non-icing and icing conditions.

7 - Alpha floor

In icing and non icing conditions, the Alpha-floor setting must be such that the aircraft can be flown at the speeds and bank angles specified in 25.143(h) and does not interfere with normal maneuvering of the aircraft.

In addition there must be no alpha-floor triggering unless appropriate when the aircraft is flown in usual operational manoeuvres and in turbulence.

8 – Proof of compliance

Add the following paragraph 25.21 (b):

(b) The flying qualities will be evaluated at the most unfavourable CG position.

9 – Change CS 25.145 (a), CS 25.145 (b) (6) and CS 25.1323(d) as follows:

CS 25.145 (a)	Vmin in lieu of “stall identification”
CS 25.145 (b) (6)	Vmin in lieu of Vsw
CS 25.1323 (d)	"From 1.23 Vsr to Vmin" in lieu of "1.23 Vsr to stall warning speed" and "speeds below Vmin" in lieu of "speeds below stall warning"