

**Proposed Special Condition for limited Icing Clearances
Applicable to Large Rotorcraft , CS 29 or equivalent.
ISSUE 1**

Introductory note:

The hereby presented Special Condition has been classified as important 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

To achieve full certification for flight of a rotorcraft in icing conditions, an applicant must demonstrate in accordance with CS 29.1419 that the rotorcraft can be safely operated in the range of continuous and intermittent icing conditions defined in CS 29, Appendix C. FAA AC-29.1419 recognises that the full icing envelope of Appendix C includes an altitude range up to 30,000 ft., which is beyond the normal operating envelope of a helicopter, and permits the use of an altitude restricted envelope to a maximum of 10,000 ft. Although this is still considered an unrestricted icing clearance and no operational restrictions are applied, Appendix C does not cover the full range of conditions likely to be encountered and certain limitations are necessary e.g. flight in mixed conditions or freezing rain/drizzle is prohibited.

Concurrently to full-icing approval Applicants are also seeking approval for "limited icing clearance", exploiting the capability that an unprotected helicopter (cold bladed) may have to operate safely and successfully within a limited set of atmospheric conditions, provided that suitable airworthiness and operational constraints are applied. This capability can be utilised in specific operational situations that allow the helicopter to change flight conditions in order to avoid or vacate atmospheric conditions beyond the demonstrated icing capability. Such a clearance is only envisaged for a Large Rotorcraft certificated in accordance with CS 29, or equivalent, including Category A and IFR approval and operated in accordance with EU-OPS or equivalent operating standards.

Nevertheless CS 29 airworthiness requirements do not include any provisions allowing the possibility of operating in limited icing conditions.

Proposed Special Condition for limited icing clearance

1. Definition of a Limited Icing Clearance

A limited icing clearance is a demonstrated and practical set of atmospheric conditions and airworthiness limitations within which the rotorcraft may be safely operated in icing conditions. The clearance must be defined in terms of parameters readily available to, and observable by, the operating crew and must also allow a safe exit to conditions in which the rotorcraft will de-ice naturally should this prove necessary.

The clearance may typically be limited in terms of some or all of the following:

- Altitude,
- OAT,
- Aircraft Mass,
- Ice severity (Liquid Water Content)
- Airspeed,
- Power required,

- Manoeuvre limitations e.g. maximum bank angle,
- Ice accretion limits on unprotected areas of the airframe (e.g. horizontal stabiliser) when correlated with ice accretion on any part of the airframe directly observable by the operating crew,
- Duration, but only in the context of short term exposure. (See § 2.2)
- Any cockpit displayed parameter requiring the crew to leave icing conditions

Any limited icing clearance must include a means of vacating icing conditions from any point within the declared envelope and demonstration of the subsequent natural de-icing characteristics of the rotor systems and airframe. This would typically be a requirement for a de-icing layer at least 500ft above the surface or safety level, to which the aircraft can descend safely following crew recognition of a declared limitation having been reached.

Note. A de-icing layer is considered to be a band of positive temperature in which the rotorcraft will de-ice naturally and efficiently.

2. Requirements

2.1. Applicability

This requirement is applicable only to large rotorcraft certificated in accordance with CS 29, or equivalent.

Before a rotorcraft can be considered for a limited icing clearance, the following must have been demonstrated:

- 2.1.1 The rotorcraft must comply with the Category A requirements of CS 29.
- 2.1.2 The engine intake must have been shown to be compliant with the icing protection requirement of CS 29.1093(b)(1)(i) considering full icing clearance. See AMC to SC § 2.1.2.
- 2.1.3 The intakes must, further, have been shown to be fully compliant with the snow protection requirements of CS29.1093(b)(1)(ii) or only for level flight and descent phases of flight, but in that case the flight manual shall prohibits flight in snow.
- 2.1.4 The rotorcraft must be approved for instrument flight in accordance with CS 29 Appendix B
- 2.1.5 Instrument and other systems essential for the safety of flight must be provided with ice protection for the full icing envelope as defined in CS29 Appendix C or the AC29.1419 Altitude-Limited envelope. See AMC to SC 2.1.5.

2.2 Compliance Demonstration

Compliance with CS 29 must be assured for the most severe conditions for which approval is sought. In particular, compliance with paragraph CS 29.1419 must be demonstrated except where modified or alleviated by the requirements of this Special Condition.

Flight in icing conditions of lesser severity than specified in CS29, App C, or AC29.1419 may be approved in accordance with the requirements defined in this special condition.

The approval for flight in ice forming conditions must limit the aircraft operation to those conditions which have been demonstrated to be suitable.

Such demonstration must include flight evaluation in actual natural icing conditions.

Flight test results, obtained from artificial icing condition using spray tanker aircraft (HISS), are not acceptable as a complete substitute for testing in natural icing conditions. However, HISS results, limited to test points not found in natural test flight, can be considered accepted if:

- 1) Evidence that HISS flights are representative (or conservative) of natural ice flights is provided.
- 2) HISS and Natural ice flight performed in similar condition must produce same effect on the helicopter or HISS tests must be conservative.

Extrapolation, as a principle, will not be permitted.

The parameters by which the approval will be restricted may include Altitude, OAT, Aircraft Mass, ice severity (Liquid Water Content), Airspeed, Power required, Duration, Manoeuvres limitations and/or ice accretion limits on unprotected areas of the airframe. Where a limit is declared, the relevant parameter must be available to the crew and the limit must be readily observable.

The atmospheric envelope within which continuous (non-time limited) operation in icing conditions is permitted must be established.

Exposure to more severe conditions for a limited time period must also be substantiated to allow sufficient safety margins to exit the icing environment or to cater for transient increase in severity during a period of continuous exposure.

The declared limitations in the Flight Manual Supplement must be within the demonstrated envelope with appropriate margins as required.

2.3 Flight Characteristics

The effect of accretion of ice on the handling, stability, performance and vibration characteristics of the rotorcraft must be established by flight in natural icing conditions and other means of compliance as required.

- 2.3.1 The effect of ice accretion on the handling, stability and vibration characteristics must be established and the rotorcraft must continue to comply with the relevant paragraphs of CS 29.
- 2.3.2 The effect of ice accretion on the performance characteristics must be determined and scheduled in the flight manual supplement. Where this information is provided, the evaluation must include any effect on fuel consumption for flight planning purposes.
- 2.3.3 It must be demonstrated that the rotorcraft can safely enter and recover from autorotation at any stage of rotor icing.
- 2.3.4 All relevant failure cases must be reconsidered taking into account the effect of icing, either by flight test or analysis as agreed by the Agency.

2.4 Flight Loads

Any increase in loads and stresses in critical parts due to ice accretion must not adversely affect the capability of the rotorcraft to meet the structural requirements of CS 29 when the rotorcraft is operated within the established flight limitations associated to limited icing operations. .

The effects of loads increase due to ice accretion must be taken into account in:

- I) The static strength evaluation required by 29.305, by considering a conservative estimate of the amount of ice forming during flight and including the effects of any single failure of the ice detection system to deliver its intended function.
- II) The fatigue and damage tolerance evaluation required by 29.571 and 29.573, by:
 - a. Performing an appropriate flight load measurement program representative of flight conditions associated to operation in limited icing conditions ; and
 - b. Assuming a conservative rotorcraft usage spectrum in limited ice operations during the service life of the rotorcraft; and
 - c. Including the damages due to ice shedding into the threat assessment as requested under 29.573 (d)(3)(iv) and 29.571(e)(4).

Continued compliance with CS 29.629 Flutter and Divergence requirements must be assured for the airframe and rotor in the iced state with reference to AC29.629A, para b(4).

2.5 Systems Functioning

Whilst it is the objective of this special condition to allow limited approval of rotorcraft not equipped with full ice protection systems, any system or item of equipment essential for the safety of flight must be fully protected against full icing envelope.

Additional equipment may be installed , to perform flight in limited icing clearance. For those not essential equipment satisfactory operation must be demonstrated at least throughout the approved limited icing envelope.

See AMC to SC § 2.5.

2.6 Direct Vision Window

Satisfactory functioning of the Direct Vision (DV) window required under paragraph CS 29.773(b)(2) must be assured throughout the approved limited icing envelope.

2.7 Ice Detection Systems

There should be a means identified or provided for determining the formation of ice on critical parts of the rotorcraft which can be met by a reliable and safe natural warning or an ice detection system. Any in-flight icing detection system display(s), status lights, and/or crew alerting messages must be located so that they are within the seated flight crew's forward vision scan area while performing their normal duties. Fixed probes must be located in areas easily scanned by the crew, and must be visible under normal daytime and night time flying conditions. For intended primary detection system specific reliability aspect must be addressed.

2.8 Vacating the Icing Environment

Clear and unambiguous criteria must be established for the crew to determine the need to vacate the icing environment, if environmental or aircraft limits are reached.

Satisfactory procedures for vacating icing conditions following recognition of a limiting condition having been reached must be established and demonstrated. This demonstration must also include demonstration of the satisfactory natural de-icing characteristics of the rotor and airframe.

The limitations applicable to the approval must be such that the rotorcraft remains compliant with this SC during the escape, and subsequent natural de-icing process. The effects of ice shedding must be considered.

2.9 Flight Manual

Adequate flight manual information must be provided to ensure safe operation of the rotorcraft. This can be part of the basic Flight Manual or in the form of a Flight Manual Supplement and must incorporate specific icing information in relation to the relevant parts of the basic flight manual.

- Type of Operation. The Flight Manual Supplement must include a statement that the limited icing clearance assumes an ability to vacate the icing environment at any time from within the declared envelope and to de-ice naturally.

A declaration is required that the Supplement does not constitute an operational approval and that operations must be conducted in accordance with the relevant operating regulations addressing flight in icing conditions, such as EU-OPS.

- Limitations. The limitations section must include all additional limitations established during the certification trials e.g. as indicated in para 1 of this Special Condition.
- Normal Procedures. This section must describe the means of determining ice formation and must contain information necessary for safe operation of the rotorcraft in icing conditions. The Equipment required must be listed
- Emergency Procedures. This section must address any emergency procedures specific to the operation of the rotorcraft in icing conditions and any modification of existing emergency procedures due to the operation in icing conditions.
- Performance. The effects of icing on performance information must be presented.

2.10 Safety Approach

The list of equipment and systems used to demonstrate compliance to § 2.7, §2.8 and referred in Flight Manual according to §2.9 shall be clearly established.

The failure to vacate the icing environment if environment or aircraft limits are reached shall be classified according to CS 29.1309 and all systems and equipment involved in that failure condition shall be demonstrated to comply with CS 29.1309

**Acceptable Means of Compliance
to
Special Condition “Rotorcraft Limited Icing clearance”**

1. AMC to SC § 2.1.2: Engine induction system icing

CS 29.1093(b)(1)(i) is applicable also to rotorcraft not certified for flight into known icing conditions. In such case, the FAA AC 29-2C, which is also valid for EASA, allows for the concept of inadvertent entry to ice and a time-limited exposure demonstration is requested. For operation in “limited icing”, as intended within this Special Conditions, for the engine induction system EASA would rather request unlimited exposure in terms of time duration, as it was consistently requested for past applications.

However, in the lack of full compliance with CS 29.1093 (b) (1) (i), EASA may accept additional limitations that could result from engine induction system exposure to full icing envelope, provided that these limitations, when reached, are adequately annunciate to the flight crew to trigger a vacating manoeuvre. The monitoring and annunciating means should be designed in such a way to prevent adverse effects on engine operation or serious loss of power. The monitoring and annunciating means system should consider any additional ice which would be collected on the induction system during the escape manoeuvre.

After leaving the limited icing conditions, the applicant should then demonstrate that while crossing the warm de-icing layer, the induction system would naturally de-ice and the normal operating conditions are restored.

The level of integrity of the monitoring and annunciating system should be commensurate to the criticality of the engine(s) loss or malfunctioning due to monitoring and annunciating system failure according to CS 29.1309(b)(2). Possible common causes due to icing exposure should be taken into consideration in the system safety analysis.

2. AMC to SC § 2.1.5 and SC § 2.5: Essential equipment

The combination of contrasting physical phenomena (like ice accretion and shedding caused by centrifugal and aerodynamic forces) which prevent an “unprotected” rotating blade from being significantly affected from icing conditions, provided that icing parameters remain within a certain envelope, does not apply to other rotorcraft equipment that are exposed to icing. If these equipment are essential for the continuation of a safe flight then it is EASA opinion that, in order to guarantee an adequate level of safety, they have to be protected against full icing envelope. The list of equipment that are essential for the continuation of a safe flight may depend on the aircraft characteristics, the parameters used to define the continuous and time limited icing envelope and the minimum crew. The applicant should propose this list to EASA for agreement as part of the limited icing certification program. The list should take into account that limited icing operations are conducted under IFR rules.

However, as for the engine induction system, EASA may consider acceptable additional limitations for the limited icing envelope that could result from essential equipment exposure to full icing envelope, provided that the reached limitations are annunciate in due time to the crew in order to trigger an escape manoeuvre. The monitoring and annunciating system should consider any additional ice which would be collected on the essential equipment during the escape manoeuvre. Such amount of ice should not lead to any system malfunctioning or misleading indications. The applicant should demonstrate that while crossing the warm de-icing layer, the essential equipment would naturally de-ice and re-gain its normal operation.

The level of integrity of the monitoring and annunciating system should be commensurate to the criticality of the equipment failures (including misleading indications) as a result of the monitoring system failure according to CS 29.1309(b)(2). Possible common causes due to icing exposure should be taken into consideration in the system safety analysis.