Proposed Special Condition SC-F-62

Flight Instrument External Probes –Qualification in Icing Conditions

Introductory Note

The hereby presented 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.), 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

Icing conditions related contamination of Flight Instrument External Probes is currently regulated through requirement CS 23.1323 (d) for airspeed indicating system and CS 23.1325(b)(3) for static pressure system as follows:

CS 23.1323 (d)
If certification for instrument flight rules or flight in icing conditions is requested, each airspeed system must have a heated pitot tube or an equivalent means of preventing malfunction due to icing.

CS 23.1325(b)(3)
If a static pressure system is provided for any instrument, device, or system required by the operating rules, each static pressure port must be designed or located in such a manner that the correlation between air pressure in the static pressure system and true ambient atmospheric static pressure is not altered when the aeroplane encounters icing conditions. An anti-icing means or an alternate source of static pressure may be used in showing compliance with this requirement

In addition, the CS-Definitions / CS 25 Appendix C define maximum icing conditions within stratiform (continuous) and cumuliform (intermittent) clouds upon which approval of airplane operations in icing conditions is based. Considering clouds containing only supercooled liquid droplet characteristics, CS-Definitions / CS 25 Appendix C provides relationship between mean effective drop diameters, liquid water content and temperature, of the droplets as well as the definition of the icing cloud envelope in terms of horizontal and vertical extent, and altitude w.r.t. temperature.

A significant number of in service events have been reported in relation to flight instrument external probes operation in icing conditions. Even though most of the incident reports involved airspeed fluctuation while in severe atmospheric conditions, temporary loss of airspeed indications has also been experienced. Analysis of the available atmospheric conditions at the time of the incidents showed icing conditions at an unusually high altitude and at a very low temperature. Such events have been reported up to 45000ft and -70°C of Static Air Temperature. It is therefore likely that some of these incidents were due to the presence of ice crystals in the atmosphere. These conditions are outside the environment of CS-Definitions / CS 25 Appendix C.

Pitot tubes are mounted such that they typically are high efficiency collectors of ice crystals.
Encountering high concentrations of ice crystals can lead to the blockage of Pitot probes as the energy required to melt the ice crystals can exceed CS-Definitions / CS 25 Appendix C icing conditions design requirements. Recent incidents evidenced that some failures of the Pitot probe heating resistance may not be seen by the low current detection system on aircraft. In some conditions, an out of tolerance resistance, failing to provide a proper Pitot probe ice protection could not be detected.

A number of events of malfunctioning and/or damage to temperature probes have also been reported and attributed to severe adverse environment encounters and EASA is aware of events due to ice crystal accumulations on angle of attack probes, or other angle of attack sensors.

CS-Definitions / CS 25 Appendix C has been in use since 1964 for selecting values of icing-related cloud variables for the design of in-flight ice protection systems for aircraft. However, glaciated conditions (icing conditions totally composed of ice crystals without supercooled liquid water) and mixed phase icing conditions (condition containing both supercooled liquid water and ice crystals) are not included in the current Appendix C / CS 25 or the CS-Definitions. The ARAC joint Engine and Power Plant Installation Harmonization Working Groups, hereafter referred to as EHWG, drafted a proposed rules addressing FAA 14 CFR Part 25 aircraft turbofan engine installation icing and propeller requirements and Part 33 turbofan engine icing requirements. Included in the EHWG draft rules is a proposed Appendix D to FAA 14 CFR Part 33 defining high ice water content environments in mixed phase and glaciated conditions. The proposed Appendix D to 14 CFR Part 33 has been developed using the history of engine ice crystal in-service events, theoretical models of the atmosphere and atmospheric flight test results (McNaughton FTs). It is intended to be a more representative characterization of the icing conditions that lead to engine events and, based on the recent evidence, appear to cause Pitot probe icing issues.

The Agency followed this proposed regulatory evolution by publishing the NPA 2011-03 which proposes to update large aeroplanes Certification Specifications (CS-25) for flight in icing conditions and in particular a new CS 25.1324 proposing the high ice water content environments in mixed phase and glaciated conditions in a new Appendix P of the CS 25

It should also be noted that compliance to the ETSO qualification standard for electrically heated Pitot and Pitot-static tubes (ETSO-C16a) and for stall warning instruments (ETSO-C54) is not sufficient in itself in demonstrating compliance to the installation requirements of CS 23.1309(a), 23.1323(d), 23.1325(b)(3) and 23.1326. The ETSO C16a specifies free-stream conditions and do not consider the potential installation effects. Depending on the probe design and aircraft installation these installation effects can lead to the Liquid Water Content (LWC) at the probe location being several times greater than the free-stream conditions.

CS-Definitions / CS 25 Appendix C conditions and ETSO C16a / ETSO C54 does not include mixed phase and ice crystal icing conditions and the operating rules do not prohibit operations in such environment.

There are no specific icing regulations for angle of attack probes, or other angle of attack sensors. CS 23.1309 has been used to address icing of angle of attack probes under some conditions. Section

23.1309(b) requires that equipment perform its intended function under all foreseeable operating conditions. Thus, compliance with CS 23.1309(b) has been used to assess whether the angle of attack systems function properly in the icing conditions for which the aircraft is certificated. Those certifications only include the icing conditions in CS-Definitions / CS 25 Appendix C.

Special Condition SC-F-62 - Flight Instrument External Probes –Qualification in Icing Conditions

1. Replace CS 23.1323(d) and 23.1326 by SC 2 & 3 here below.

2. Flight Instrument External Probes Heating Systems

    Each Flight Instrument External Probes Systems must be heated or have an equivalent means of preventing malfunction due to icing conditions specified in CS-Definitions / CS 25 Appendix C and mixed phase / ice crystal conditions as defined in Appendix 1 of this Special Condition.

3. Flight Instrument External Probes heat alerting systems

    If a flight instrument external probe heating system is installed, an alerting system must be provided to alert the flight crew when the flight instrument external probe heating system is not operating or not functioning normally. The alerting system must comply with the following requirements:

    (a) The alert provided must conform to the Caution alert indications.

    (b) The alert provided must be triggered if either of the following conditions exists:

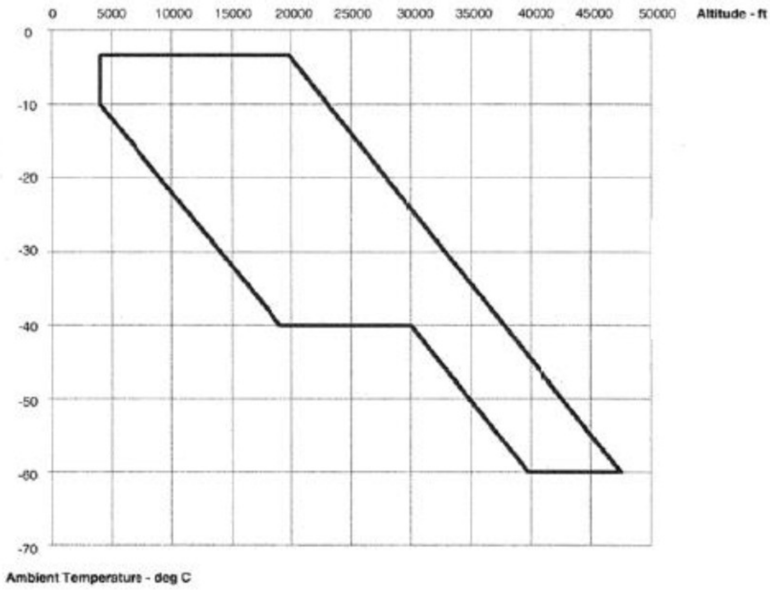
    (1) The flight instrument external probe heating system is switched ‘off’.

    (2) The flight instrument external probe heating system is switched ‘on’ and any flight instrument external probe heating element is not functioning normally.

SC-F-62 - Appendix 1 - Mixed Phase and Ice Crystal Icing Envelope (Deep Convective Clouds)

This ice crystal icing envelope is depicted in the Figure 1.

Figure 1 – Convective cloud ice crystal envelope



Within the envelope, total water content (TWC) in g/m3 has been determined based upon the adiabatic lapse defined by the convective rise of 90 % relative humidity air from sea level to higher altitudes and scaled by a factor of 0.65 to a standard cloud length of 32.2 km (17.4 nautical miles).

Figure 2 displays TWC for this distance over a range of ambient temperature within the boundaries of the ice crystal envelope specified in Figure 1.

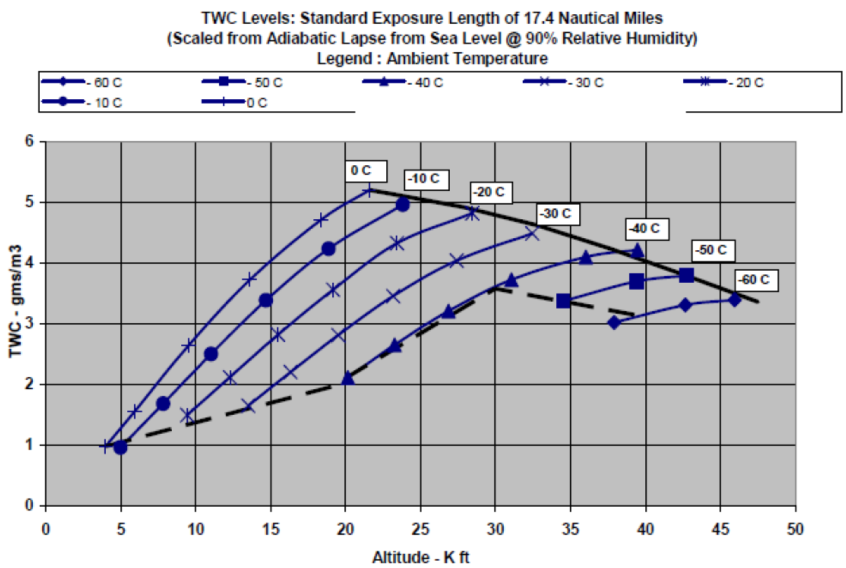


Figure 2 Total Water Content

Ice crystal size median mass dimension (MMD) range is 50 - 200 microns (equivalent spherical size) based upon measurements near convective storm cores. The TWC can be treated as completely glaciated except as noted in the Table 1.

Temperature Range in ° C	Horizontal Cloud Length	LWC – g/m3
0 to -20	</= 50 miles	</=1.0
0 to -20	Indefinite	</=0.5
< -20		0

Table 1 Supercooled Liquid Portion of TWC

The TWC levels displayed in Figure 2 represent TWC values for a standard exposure distance (horizontal cloud length) of 32.2 km (17.4 nautical miles) that must be adjusted with length of icing exposure (see Figure 3).

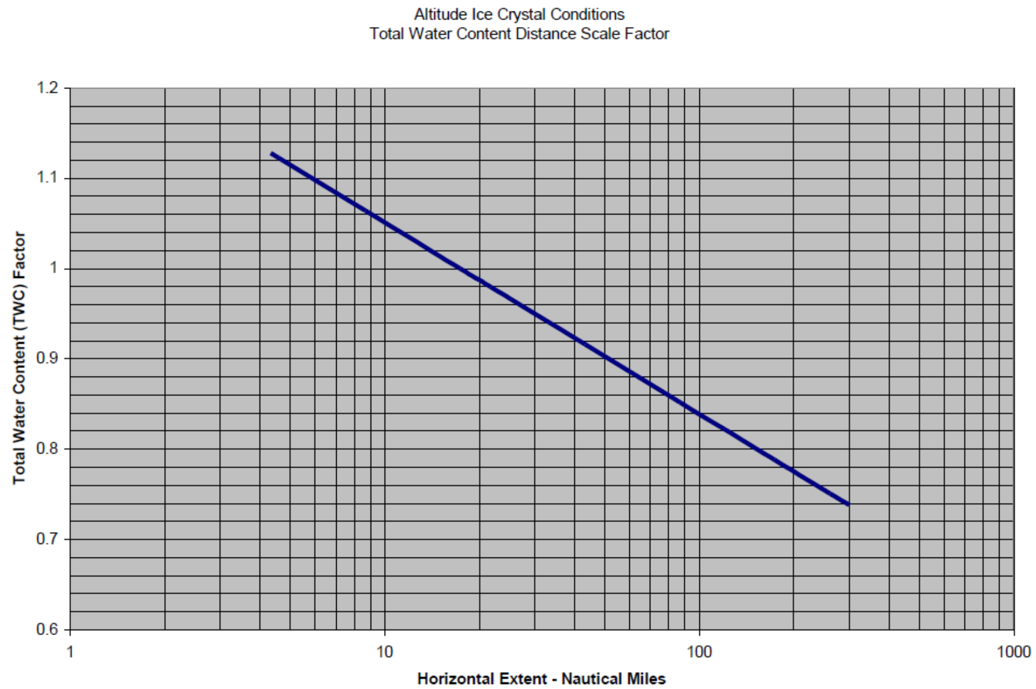


Figure 3 Exposure Length Influence on TWC