AIR PILOTS - COMMERCIAL AIR TRANSPORT

SAFETY BRIEFING NOTE 11

[Issued 09 JUNE 2023]

TURBOPROP AIRFRAME ICING RISK

The Context

Turboprop aircraft are relatively underpowered relative to jet types and because of the atmospheric conditions when operating in IMC at typical flight levels, turboprop aircraft often fly where severe airframe icing conditions are most likely to occur. Nowadays, turboprop airframe protection from excessive ice accretion is usually dependent on pneumatic boot leading edge de-icing systems rather than electric or bleed air anti- icing systems. The risk of a loss of control if such aircraft gain an airframe ice loading in flight which exceeds the capability of the de-icing system to remove it continues to be underestimated. Available evidence suggests even experienced turboprop pilots may need an actual encounter with this risk to recognise how easily it can develop into a situation which can be difficult or impossible to recover from. What follows is concerned only with avoiding this risk not how to attempt recovery if it occurs. Of course when departing on a flight where airframe icing is a possibility, it is particularly important that the airframe is completely free of any frozen deposits and that if icing conditions will exist prior to takeoff that anti icing is performed.

Some examples of fully investigated airframe icing events

- In September 2016, the crew of an ATR72-500 which had left Alicante (temperature 20°C) attempted to recommence a climb in icing conditions after 90 seconds of level acceleration but lost control after failing to act before a full stall occurred after 20 seconds and 1700 feet were lost before control was regained. A Degraded Performance Alert as climb rate reduced was ignored.[1]
- In March 2016, an ATR72-500 crew unfamiliar with operation in icing conditions departed Manchester without checking that the airframe was ice free. In icing conditions soon after takeoff, the autopilot could not be engaged and forward control column input beyond trim capability was required to climb safely. Following en-route diversion, the problem was attributed to ice contamination of the horizontal tail plane upper surface.[2]
- In November 2016, a type-experienced ATR72-600 crew climbing out of Bergen continued an IAS autopilot climb in icing conditions even after vertical speed dropped by half in 30 seconds. After eventually deciding to stop the climb, a descent of only 1000 feet was made and applicable procedures were ignored. On reaching the new level, the aircraft stalled as a turn was attempted. Control was lost and only recovered after a 1,500 feet descent at up to 6,500 fpm.[3]
- In October 2014, a Saab 340B making an autopilot VS climb in moderate icing conditions after departing Aberdeen reached the recommended minimum speed for exiting icing conditions but the crew attempted to continue climbing despite the rate varying between 800fpm and "slightly negative". At FL130 it was finally decided to descend to FL110 but a shallow VS descent with the autopilot engaged led to a stall and automatic autopilot disconnection from which the recovery was non standard.[4]

Discussion

The Type Certification process for all transport aircraft which require two-pilot operation approves such aircraft for flight into “known icing conditions” without reference to the severity of ice accretion and no formal definitions apply to the frequent distinction between ‘light’, ‘moderate’ and ‘severe’ icing

[1] see: https://www.mitma.gob.es/recursos_mfom/comodin/recursos/in-020-2017_final_report.pdf
[2] see:https://assets.publishing.service.gov.uk/media/587dfa40ed915d0b12000141/ATR_72-212_A_G-COBO_02-17.pdf
[3] see:https://www.aibn.no/Aviation/Published-reports/2020-16-eng?pid=SHT-Report-ReportFile&attach=1
[4] see:https://assets.digital.cabinet-office.gov.uk/media/55f12b84e5274a151e000007/Saab-Scania_SF340B_G-LGNM_09-15.pdf

conditions. Whilst applicable turboprop aircraft operating procedures will usually support flight in 'moderate' icing conditions - although not necessarily indefinitely - they will almost always explicitly require avoidance of operation in 'severe' icing conditions. Whilst these conditions are most likely to be encountered in winter outside of the tropics, operations in tropical latitudes do not preclude an encounter with icing conditions although since they are more likely to be found within areas of severe convective turbulence which will of necessity be avoided anyway. It is important to be aware that airframe ice accumulation on particular turboprop aircraft types may differ in the same conditions because of differences in their de-icing equipment as well as their individual propensity to pick up ice.

The need to avoid severe icing conditions in the absence of any way of directly knowing that they may be about to be encountered means that apart from any systems which provide explicit alerts, pilots must be able to recognise any continuing degradation of normal aircraft performance whilst in icing conditions. The majority of recorded icing-related loss of control events occur in a climb continued despite significance loss of normal performance. Detecting loss of normal performance is most easily done by monitoring indicated airspeed or rate of climb trends depending on whether the selected autopilot mode is either IAS or VS. Any significant drop in either, especially a rapid one, is a clear indication that the prevailing icing conditions are reaching those associated with severe icing which is incompatible with continued safe flight and must be recognised and responded to. Disengagement of the autopilot may be appropriate but if it remains engaged, very careful mode selection and close monitoring of the results of mode changes is important.

Whilst pilots of turboprop aircraft should be aware that static air temperature and exposure time are key to the rate of ice accretion on the protected areas of an airframe, there is a third factor influencing this, which is the size of the supercooled water droplets which are the source of the ice. In severe icing conditions, these droplets can be up to 100 times larger than the droplet size considered when current aircraft type certification standards deem that safe operation of an aircraft type in known icing conditions is possible. This can quickly result in ice accretion rates which are beyond the capacity of the ice protection system and/or to ice formation further back than the protected leading edge areas.

Safety Recommendations

To Aircraft Operators

- Ensure all pilots recognise icing conditions and the procedures related to them and that they are capable of effective decision making if moderate icing or worse is encountered.
- Consider pre-season refresher training if the exposure to this risk is predominantly seasonal.
- Review relevant procedures and checklists to ensure that they are unambiguous in respect of action required and that if followed they will proactively prevent severe icing encounters.
- Consider making the severe icing procedure a memory drill if this is not the case already.
- Ensure operational flight data monitoring is configured to detect instances where degraded aircraft performance occurs in icing conditions and the response.

To Pilots

- Ensure you know when icing conditions are possible and their potential severity by carefully assessing pre-flight weather forecasts. Note that areas of severe icing within an area of moderate icing are often small and may not trigger the issue of a SIGMET. Note that once any automated 'Ice Detection System' has been activated, a performance-based risk assessment must begin.
- If the en-route forecast gives moderate icing conditions, always be prepared for worse. If necessary be prepared to alter the intended flight path without delay by reducing altitude and/or changing heading whilst maintaining airspeed, setting maximum continuous power and maximum propeller rpm if necessary.
- If icing conditions are expected, the pilot most familiar with icing on the aircraft type should lead the pre-flight brief on recognition, the potential consequences and the necessary responses.
- An automated 'Aircraft Performance Monitor' (the ATR 72 has one) bases its alerts on thresholds met as aircraft performance reduces but all pilots should be monitoring performance anyway.
- Climb in IMC at static air temperatures below 0°C and to as low as -20°C is the most likely time for severe icing but it can also occur during prolonged level flight in the upper part of a Stratocumulus layer - although icing severity is usually less in any cloud with minimal vertical air movement.
- The time exposed to airframe icing can be as important as the relevant severity of the exposure. This means that it cannot be assumed that it is safe to remain for extended periods in conditions which have been forecast and/or assessed as indicative of moderate icing.