INFLIGHT ICING: THE HANDLING EVENT

By F/O Steve Green (TWA)

On Feb. 21, 1951, a Curtiss C-46 operating at night encountered icing conditions more severe than anticipated. The crew attempted to return to the departure point, but the aircraft was unable to maintain altitude. The crew executed a forced landing alongside a highway in mountainous terrain, destroying the aircraft but incurring only minor injuries.

On Jan. 15, 1977, almost 26 years later, at Stockholm, Sweden, a Vickers Viscount pitched over and entered a vertical dive while on final approach 5 kilometers from the runway. The aircraft hit terrain in a near 90-degree nose-down attitude, fatally injuring all 22 people on board. The Swedish accident was determined to be the result of tailplane stall due to ice accretion.

The Curtiss crew was certainly aware of the effect that ice was having on their aircraft, and that awareness led them to the decision to make an off-airport landing. On the other hand, the Viscount crew was clearly unaware of the effect that ice would have on their aircraft when they configured for landing. This distinction is characteristic of two different types of inflight icing events: the "performance" event and the "handling" event.

The performance event is characterized by drag and lift penalties that predominate and thus appear as reduced airspeed and rate of climb, and a reduced ability to maintain altitude.

The handling event is characterized by changes in the aircraft's stability and control that often appear before the performance penalties become apparent.

Ice accretions can affect the aerodynamic forces and moments responsible for the aircraft's normal stability and control characteristics. A handling event in its mildest form involves changes in the airplane's longitudinal or lateral stability. A handling event in its worst form, and possibly with very little warning, invokes wingtip stall and/or tailplane stall, and for aircraft with manually operated flight controls, critical changes in control surface hinge moment.

Ice-induced degradations in stability and control are always a function of the angle of attack (AOA) of the lifting surface involved, whether it be the wing or the tailplane. Consequently, these degradations typically occur when something has happened to change the AOA, such as changes in configuration, power, or airspeed.

Ice accretions that affect the stability and control of the airplane may be very small and rather unspectacular in appearance. Because of the autopilot's willingness to try to single-handedly manage these disturbances, up to a point, the crew is often unaware of a developing instability or control degradation until the autopilot gives up and hands the pilot a very serious and rapidly deteriorating problem.

The tailplane

In his book *Spitfire: A Test Pilot's Story*, Vickers test pilot Jeffrey Quill observed that, in aerodynamics, "stability can be simply defined as the tendency of an aircraft when disturbed from a condition of steady flight to return to that condition when left to itself. Conversely, instability is the tendency of the aircraft to diverge further away from the condition of steady flight if once disturbed.

"The vital importance to the pilot of having positive stability is obvious," Quill noted. "For instance, if he wishes to raise the nose of his aircraft a small amount...perhaps to aim his guns...but the aircraft itself decides to bring the nose up further than he wants before he has time to check it, he will have great difficulty in aiming."

Quill was instrumental in developing and testing the Supermarine Spitfire during the late 1930s and throughout World War II. The basic Spitfire had marginal longitudinal stability, and Quill and his colleagues expended considerable effort to protect that stability as the airplane evolved.

By itself, instability does not mean the aircraft cannot be flown. But Quill's point regarding difficulty in aiming applies to all forms of precision flightpath control, the kind expected in air carrier operations. In particular, it applies to flightpath control during operations.

Quill goes on to state that providing "a sufficiency of inherent longitudinal stability in an aircraft is therefore an essential task for the designer; and in aircraft of a conventional layout, it is normally obtained by the use of a fixed tailplane at a distance behind the main wing. The effectiveness of the tailplane depends on its aerodynamic qualities and its distance behind the aerodynamic center of the mainplane."

Aerodynamic qualities are precisely the characteristics most affected by structural icing.

The horizontal stabilizer normally operates as an inverted wing. In a steady trimmed flight condition, it must develop low pressure on the underside, creating a nose-up moment that balances the nose-down "pitching moment" produced by the wing as a function of the distance between the center of lift and the center of gravity. If the airplane is upset from this steady condition and pitches above its center of gravity, the stabilizer develops a restoring moment proportional to the extent of the upset. Thus, the farther from trimmed flight the airplane is pitched, the more powerful the restoring moment.

The stabilizer's performance is a function of its local AOA. Because the wake of the wing always affects the tail,

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