By Matt Thurber
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Safety

Every few years, a debate erupts about whether the phenomenon of ice bridging is real or something questionable that pilots discuss while hangar flying or warning of the dangers of flying in icing conditions. The issue recently resurfaced at an NTSB public meeting about the icing-related crash of a Cessna Citation 560 in Pueblo, Colo., on Feb. 16, 2005.

The debate centers on an important question: whether pilots should inflate pneumatically operated de-ice boots as soon as ice begins accumulating or allow ice to build (the advice is usually to wait for a quarter to half an inch of ice before inflating the boots).

Conventional wisdom holds that waiting for that quarter to half inch will prevent ice bridging, which the FAA defines in Advisory Circular 91-74 as follows: “This is attributed to the formation of a thin layer of ice which is sufficiently plastic to deform to the shape of an expanded de-icing boot without being fractured or shed during the ensuing tube deflation. As the deformed ice hardens and accretes additional ice, the boot may be ineffective in shedding the ‘bridge’ of ice.”

Tom Bond, chief of the icing branch at NASA’s Glenn Research Center in Cleveland, Ohio, has a more detailed definition of ice bridging: “Anecdotally the belief for ice bridging–and it’s called ‘the ice-bridging myth’–is that in the past experience of pneumatic boot operation and their development over decades, the first boots that were put on airplanes had a very slow rise time to break the ice off the surfaces.

“There was the opinion that if you didn’t have enough ice on the boots when you activated them, that if it wasn’t thick enough, if you didn’t have enough threshold of ice built up, that as the boot got out to its outside perimeter or maximum thickness, the ice might stay out in a shell outside of that perimeter and continue to build up and freeze. The boot would [then] retract, and you would have a bridge of ice over the leading edge where the boot could operate inside that shell but not remove it.”

The NTSB doesn’t believe that ice bridging occurs in aircraft equipped with modern de-icer boots. The Board suggests that pilots should turn on the boots as soon as the airplane enters icing conditions and begins accumulating ice. While some residual ice might cling to the boots between inflation cycles, the NTSB conceded, this disappears during subsequent cycles. The Board also said that it has never investigated any accidents that involved ice bridging.

Inflating boots as soon as ice begins accumulating reduces the aerodynamic penalties that come with allowing a thicker layer of ice to build. This raises a more important question that goes to the heart of the ice-bridging debate: is the risk of not breaking off ice that might turn into a bridge greater or lower than the risk associated with the aerodynamic penalty of ice building to a quarter or half-inch thickness before inflating boots?

It’s interesting to see how different aircraft manufacturers approach this subject in their instructions to pilots. The Cessna Citation 560 Airplane Flight Manual (AFM) tells pilots to wait for ice to build before inflating boots: “The surface de-ice system should be used when ice buildup is estimated to be between one-quarter-inch and one-half-inch thickness. Early activation of the boots may result in ice bridging on the wing. If ice is allowed to accumulate in excess of one inch, boot cycling may not clear it.”

In the section titled Operating Procedures Model 560 Normal Procedures, Approaches, however, Cessna advises pilots not to wait for ice to build first. “When reconfiguring for approach and landing (i.e. flaps extended and gear down), and any ice accretion is visible on the wing leading edge, regardless of thickness, activate the surface de-ice system. Continue to monitor the wing leading

edge for any reaccumulation."

The Raytheon King Air 200 AFM instructs pilots to wait for some accumulation. It reads, "For most effective de-icing operation, allow at least one-half inch of ice to form before attempting ice removal. Very thin ice may crack and cling to the boots instead of shedding. Subsequent cycling of the boots will then have a tendency to build up a shell of ice outside the contour of the leading edge, thus making ice removal efforts ineffective."

Mitsubishi has conducted extensive icing research on the MU-2 as part of an FAA certification review, and the MU-2's AFM requires immediate activation of deicer boots. The manual reads, "At the first sign of ice formation anywhere on the aircraft, or upon annunciation from an ice detector system, whichever occurs first, wing deice switch…ON."

A New Look at Ice Bridging

During the public meeting on the Pueblo crash, NTSB member Robert Sumwalt said, "We've uncovered that once again this ice-bridging issue is still out there. There are still aircraft manufacturers that are not going with NASA and NTSB thinking on shedding the ice at first indication of icing, upon entering icing conditions."

What Sumwalt is likely referring to is a November 1997 NASA-convened conference on ice bridging. NASA's Bond was at that meeting and recalled, "We concluded the same thing as the FAA, that there was no [current] supporting evidence to indicate that ice bridging still existed."

Bond emphasized that NASA has not scientifically studied ice bridging. "NASA holds no position on ice bridging in terms of the scientific 'credibility' of it," he said, "and whether or not it exists in the current fleet operations. We've tested in our icing research tunnel for years and on our icing research aircraft [a de Havilland Canada Twin Otter] and we have never seen ice bridging and have no experience with it. We also never had a scientific program to explicitly explore the phenomenon to try and understand how it occurs," he said.

Nevertheless, Bond added, "All the pneumatic [boot] manufacturers that were asked at the meeting said they have not seen or witnessed that kind of event in any recent history."

One reason that the FAA asked NASA to convene the meeting, Bond said, was that the FAA wanted information to help determine when operators should inflate the boots.

One result of the conference was that the FAA in 1999 proposed a series of airworthiness directives on 19 turbine airplanes–including the Citation 560–regarding ice bridging. The ADs would force manufacturers to change AFMs so that pilots would have to inflate de-ice boots as soon as they begin accumulating ice.

In responding to comments about the proposed AD, the FAA said, "The FAA has reviewed the icing-related incident history of certain airplanes and has determined that icing incidents may have occurred because pneumatic de-icing boots were not activated at the first evidence of ice accretion. As a result, the handling qualities or the controllability of the airplane may have been reduced due to the accumulated ice."

According to the NTSB, Cessna asked the FAA to withdraw the proposed AD for the Citation 560. The manufacturer told the NTSB that the 560 had no problem flying with one-half-inch ice shapes on the airframe during tests it conducted in 1996.

It must be noted, however, that this does not indicate that Cessna either tested for ice bridging or has ever been able to replicate ice bridging, even though it refers to ice bridging in AFMs for the 560 and other airplanes. Cessna declined to comment on any of these issues for this article.

AIN asked boot manufacturer Goodrich if it has an opinion on whether ice bridging occurs, and a spokesman said, "We know there's a lot of discussion about that phenomenon, but we don't have a view one way or another."