7A.3

ORIGINS AND EVOLUTION OF THE ICING INTENSITY DEFINITIONS FOR AIRCRAFT

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1. HISTORICAL DEVELOPMENT

The problem of defining an icing intensity scale has always been complicated by the question of whether the scale should refer to the icing conditions themselves or to the effects on the individual aircraft. Convincing arguments can be made either way. For the former, scales are usually formulated in terms of cloud liquid water content (LWC). For the latter, scales have been invented based on ice accretion rates or performance and handling decrements on the aircraft. LWC's may seem simpler in concept, but in practice are still difficult to estimate or forecast. Until recently, effects on individual aircraft have been regarded as even more formidable to determine, except for a few airplanes where experience has enabled some correlations with indicated icing rates.

1.1 The Original Definitions

The words "trace," "light," "moderate," and "severe" (or "heavy") have been in use for several decades to describe atmospheric icing conditions. The terminology was originally defined in the 1940s by the U.S. Weather Bureau for reporting the amount of ice deposited by frequent icing conditions at the observatory on the summit of Mt. Washington, New Hampshire (Lewis, 1951). For purposes of estimating the amount of ice that may accrete on an airplane flying through similar cloud conditions, the measurements were converted to the rate of accretion on a 3-inch (7.5 cm) -diameter (non-rotating) cylinder, at an "aircraft standard" airspeed of 200 miles per hour (174 kt). See Table 1.

TABLE 1. ORIGINAL ICING INTENSITY SCALE (1940s)

Rate of ice accretion on 3" diam. cyl. at 200 mph (g cm^{-2} per hour)	Weather Bureau scale of icing intensity for mountain stations
0.00 - 1.00	trace
1.01 - 6.00	light
6.01 -12.00	moderate
> 12.00	severe

Direct measurement of ice accretion was a simple way of characterizing clouds for icing conditions. The 3-inch -diameter cylinder served as a standard probe which approximated the leading edge of typical airplane wings and other airframe components where icing is a concern. Thus, the rate of ice accumulation on one of these cylinders could be used to estimate the accumulations on airplanes flying in similar conditions.

The words "trace," etc., served the dual purpose of allowing measured icing rates to be reported in simple, meaningful terms, and at the same time indicating the expected difficulty of flying an aircraft with similar rates of ice accretion. But flight experience began to show that icing rates arbitrarily called moderate in Table 1 often seemed to result in pilots having "severe" difficulty flying the plane.

For meteorologists trying to provide information on existing or forecasted icing conditions aloft, the ice accretion scale is of little use. In-cloud measurements like these are not available for assessing current conditions, and estimates of icing rates elsewhere could only be made with difficulty using statistics from Mt. Washington for similar cloud and weather situations. An alternate scale had to be used where ice accretion rates were replaced by equivalent amounts of supercooled LWC. This is a variable that could be roughly estimated for different cloud types and weather situations. The commonly accepted version is given in Table 2.

TABLE 2. ALTERNATE ICING INTENSITY SCALE FOR FORECASTERS

Supercooled Water Content (g m^{-3})	Intensity
0 - 0.1	trace
0.1 - 0.6	light
0.6 - 1.2	moderate
> 1.2	severe (or heavy)

1.2 *The U.S. Air Force Version (1956).*

By 1956 the preferred reference probe had changed from the 3-inch cylinder to a "small" probe, which was apparently represented by a ½-inch (13-mm) diameter cylinder (Thompson, 1956). No documentation has been found on the thinking behind this change, but perhaps it was reasoned that small probes such as wiper blade arms or other nearby small protrusions were more easily viewed and monitored by the pilots than the wing leading edges.

Table 3 published the relationship between the LWC (which forecasters could try to estimate) and the resulting ice accretion rate on these small probes. This table was evidently prepared by the U.S. Air Force for its

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own use, but it is based on Table 2. Notice that Table 3 modifies the LWC categories of Table 2, with the second category being split into two smaller intervals. The intensity terms have been reassigned too, with both *heavy* and *severe* icing being used separately for the two highest intensities.

For the first time, in Table 3, the effects that pilots generally associated with the different icing terms were included in a column titled "Aircraft Performance Criteria". This table tied together all the various aspects of each icing intensity level---the terminology used to describe it, the effects that the pilot would notice, the LWC that the meteorologists would attempt to forecast, and the amount of ice that would actually be measured (or collected) on a specific probe, if one were available.

TABLE 3. ICING SEVERITY SCALES USED BY THE U.S. AIR FORCE IN 1956

Descriptive Terminology	Aircraft Performance Criteria	Liquid Water Content	Ice Collection Rates on Small Probes	
		($g\ m^{-3}$)	Inches per 10 miles	Miles per ½ inch
Trace	Barely perceptible ice formations on unheated aircraft components	0 to 0.125	0 to 0.09	56 or more
Light	Evasive action unnecessary. (No perceptible effects on performance).	0.125 to 0.25	0.09 to 0.18	28 to 56
Moderate	Evasive action desirable. (Noticeable effects on performance.)	0.25 to 0.60	0.18 to 0.36	14 to 28
Heavy	Eventual, evasive action necessary. (Aircraft is unable to cope with icing situation and extended operation is not possible.)	0.60 to 1.0	0.36 to 0.72	7 to 14
Severe	Immediate evasive action is required. (Aircraft uses climb power to hold altitude, and continued operation is limited to a few minutes.	1.0 or more	0.72 or more	0 to 7

Although the descriptive effects on performance could be used by the pilots of any aircraft, the specific relationship between them and the stated LWCs in this table were said to be for "typical fighter aircraft" (Thompson, 1956). It is not clear how these relationships were established (no documenation has been found so far). The stated connection between the terminology, the effects, and the LWC allowed the forecaster and the pilot to use the same terminology (trace, light, moderate, etc.) unambiguously, at least for a particular class of aircraft. From a numerical estimate of LWC, the meteorologist could issue a forecast of trace, light, etc., icing and the pilots (of the fighter aircraft) would know what to expect. Conversely, when these pilots reported trace, light, etc., icing, the forecaster could translate that back to a range of LWC. This was helpful in judging the accuracy of the forecasts.

It is important to remember that these fighter aircraft were probably not (and still are not) protected against ice accumulation on the wings and tailplane. Thus, the listed effects on performance were real and noticeable and served as a basis for avoidance or evasive action.

1.3 *The National Coordinating Committee for Aviation Meteorology (NCCAM) Version (1964).*

The relationship between terminology and in-flight effects as postulated in Table 3 apparently became popular with pilots in general. By 1964 a national coordinating committee (with representatives from the U.S. Air Force, Army, Navy, Coast Guard, Weather Bureau, FAA, and NASA) agreed on a similar, but revised table, for use by both civil and military aviators in general. This is shown in Table 4. (Mitchell, 1964; Werner, 1973).

TABLE 4. ICING DEFINITIONS ADOPTED BY THE NCCAM IN 1964.

Definition	Accumulation Rate on a Small Probe	Effects on Aircraft	Pilot Response
Trace	½-inch in 80 miles	The presence of ice on the airframe is perceptible, but rate of accretion is nearly balanced by rate of sublimation. Therefore, this is not a hazard unless encountered for an extended period of time.	The use of deicing equipment is unnecessary.
Light	½-inch in 40 miles	The rate of accretion is sufficient to create a hazard if flight is prolonged in these conditions, but is insufficient to make diversionary action necessary.	Occasional use of deicing equipment may be necessary.
Moderate	½-inch in 20 miles	On the airframe, the rate of accretion is excessive, making even short encounters under these conditions hazardous. .	Immediate diversion is necessary, or use of deicing equipment is mandatory.
Heavy	½-inch in 10 miles	Under these conditions, deicing equipment fails to reduce or control the hazard.	Immediate exit from the icing condition is mandatory.

This version was based on Table 3, but the *severe* category in Table 3 was eliminated and the representative ice accumulation rates were replaced by an average value from the last column of Table 3.

There are several important things to notice in Table 4.

♦ It was still considered important to tie the definitions to some measurable standard---in this case it was still a "small" probe of some kind, but apparently the relation to LWC was dropped. Nevertheless, the information in the third and fourth columns caused these to be sometimes called "operational definitions." Table 4 is actually a second-hand version, the original documents of the committee have not been found.

♦ The table now seems to accommodate both unprotected and ice-protected airplanes. The "Effects on Aircraft" column still describes what would happen to an airplane without ice protection. As in the 1956 Air Force version, no mention of deicing is made at all in this column, except in the "heavy" category to emphasize the futility of trying to cope with those icing conditions. But the "Pilot Response" column tells the pilot what to do *if* the aircraft has deicing equipment.

♦ A judgement has now been made that even *with* deicing equipment, airplanes generally cannot control heavy icing conditions. The basis for this judgement is not known. Perhaps it was meant to convey the idea that even if deicers could continue to remove ice from the protected parts of the wing and tail, the ice buildup on other (unprotected) parts of the plane would be great enough to cause a dangerous situation.

♦ The "Pilot Response" column does not explicitly mention *anti-iced* (heated wing) airplanes. Either it was assumed that (large) heated-wing airplanes were exempt from icing concerns or the *deicing* equipment was meant to be a generic term for *all* ice protection equipment.

1.4 *The Federal Subcommittee on Meteorological Services[1] Version (1968)*

This successor committee to the NCCAM made some final modifications and recommendations in 1968. These are given in Table 5 (Werner, 1973; Anon., 1969) and are tailored specifically as guidelines for reporting in-flight icing conditions. They combine and refine the wording in the *Effects* and *Response* columns of Table 4, and they make the exposure times a bit more specific by adopting "1 hour" as the threshold of concern for trace and light icing conditions.

[1] Today, this interagency committee is part of the Office of the Federal Coordinator for Meteorology (OFCM) in the U.S. Department of Commerce.

TABLE 5. AIRFRAME ICING REPORTING TABLE ADOPTED IN 1968.

TRACE: Ice becomes perceptible. The rate of accumulation is slightly greater than the rate of sublimation. It is not hazardous even though deicing/anti-icing equipment is not utilized, unless encountered for an extended period of time--over 1 hour.

LIGHT: The rate of accumulation may create a problem if flight is prolonged in this environment (over 1 hour). Occasional use of deicing/anti-icing equipment removes/prevents accumulation. It does not present a problem if the deicing/anti-icing equipment is used.

MODERATE: The rate of accumulation is such that even short encounters become potentially hazardous and the use of deicing/anti-icing equipment or flight diversion is necessary.

SEVERE: The rate of accumulation is such that deicing/anti-icing equipment fails to reduce or control the hazard. Immediate flight diversion is necessary.

There are several things to notice about this latest version.

♦ These definitions required no special measuring equipment, were readily understandable, and were directly related to the seriousness of the effects of icing on any particular aircraft. It is said (Anon., 1969) that these definitions were recommended for use in all Federal Aviation Administration (FAA), Department of Commerce (DoC), and Department of Defense (DoD) handbooks, manuals, and publications. Indeed, these definitions are still in use today (Anon., 2005).

♦ The effects of the accumulations still describe what would happen on an *unprotected* aircraft, but the use of deicing or anti-icing equipment is expected to control at least light icing, if not moderate icing too.

♦ The connection to a standard reference probe has been lost. These were obviously not considered necessary or even available for routine reporting of inflight icing conditions. The definitions have evolved *away* from a measurable reference standard to a qualitative set of guidelines based on vague effects that the pilots can expect to happen. This has the advantage that the above definitions can be used by the pilot of *any* aircraft, and not just for a specific type of airplane. But it means that there is no definable set of icing conditions that constitutes light, moderate, or severe icing. Intensities are now simply relative to the effects on the individual aircraft. It also means that a pilot report from a particular aircraft model has direct meaning only for that model, or similar aircraft. No method is given for translating icing effects to different aircraft.

1.5 *How the Meteorologists Coped.*

In 1969, a year after these pilot reporting definitions were issued, the U.S. Air Force updated and published its major handbook for forecasting icing conditions (Anon., 1969). In there (page 1-2, paragraph 3b) they wrestle with this problem. Referring to the definitions in Table 5, they say:

> "Although the table is intended for use primarily in the reporting of icing encountered by pilots, the AWS, for standardization purposes, will now use the same definitions in issuing forecasts."

They go on to say,

> "Convention has been to designate icing intensity in terms of its operational effect upon the reciprocating-engine, straight-wing transport aircraft as the standard. For example, the terminology (Table 5, above) applies to the C-54 and C-118 aircraft under "normal" loading and "normal" cruise conditions, and implies the meteorological explanations, based on liquid water content of the cloud, as given in paragraph 29. *Caution must be observed not to state operational effects of icing on other types of aircraft*." (Italics are theirs).

They further explain on page 5-4, paragraph 29c,

> "The (icing) intensities forecast by the subjective rules used in this manual imply these liquid water contents (Table 2, above) and not the actual operational effect upon the aircraft."

Thus, they were uneasy about converting to general-purpose definitions when, to them, the definitions really applied to only two specific airplane models. In addition, the loss of a connection to LWC left them with no other way to forecast the new intensity levels. Their compromise was to acknowledge the definitions imposed by the Federal Coordinating Committee in Table 5, but point out that their forecasts would still have to be based on the liquid water assignments in Table 2. In addition, they were careful to point out that these LWC-based forecasts were still thought to be valid only for C-54 and C-118 airplanes.

2. RECENT CRITICISMS

2.1 *Too Many Definitions*

Subtle confusion still exists, however, because now several sets of definitions are in use simultaneously. Icing forecast rules are still based on Tables 1 or 2, or more often, on various empirical rules derived from accumulated experience with pilot reports. The latter has led to associations of the terms "trace", etc., with different cloud and weather situations based largely on reports from a few specific, straight-winged aircraft types in the 1950s. Although the intent is that "moderate" icing, for example, based on one definition will equate with "moderate" from any other definition, there is a general acceptance that the effects are not the same on all aircraft and that interpretation differs among pilots.

The situation is then that forecasters are issuing estimates of icing intensity based on various rules of choice or convenience, using terminology that they assume is meaningful to aviators. Aviators are interpreting the terminology according to whatever definitions they are familiar with or according to what they feel the effects of the icing will be on their airplane. They may think in terms of leading edge ice accretion, the Table 5 definitions, or they may also interpret the terms ("trace," etc.) rather subjectively, based on their experience or simply on the connotations of the words.

2.2 *No Distinction Between Aircraft*

Icing forecasts are criticized for predicting the *same* intensity for all aircraft, knowing that any given icing condition will affect different aircraft differently, especially for helicopters compared to straight wing aircraft. This failing is largely due to the lack of data on the effects of icing on individual aircraft. It is also a result of using the same words ("trace," etc.) to describe both absolute cloud conditions (Tables 1 or 2) and anticipated pilot reports (Table 5). This situation can be avoided only by describing cloud conditions in terms that will not be confused with Table 5, or by using the Table 5 definitions but tailoring the forecasts to individual aircraft types.

Presently, it is not possible to differentiate between aircraft because there is no generally available information relating LWC intervals to specific effects on individual aircraft. Even if there were up-to-date information available for each aircraft model, naming them all in the general forecasts would be unwieldy if not prohibitive. Possibly, it could be done on an individual basis as part of the preflight weather briefing.

2.3 *Inconsistent With the FAA Icing Regulations*

A discrepancy exists between the definition of severe and the presumption of flightworthiness for aircraft that are certificated for flight in icing conditions. The regulations (14 CFR 135.227(d), for example) permit airplanes to fly in severe icing conditions if they have ice protection equipment that is certificated for icing. However, according to the definitions, severe icing is considered to be impenetrable, even for ice-protected airplanes. The National Transportation Safety Board (NTSB) noticed this too and issued a recommendation as far back as 1981 that the rules in 14 CFR 91.527 and elsewhere be re-evaluated and clarified to ensure that the regulations are compatible with the definition of severe icing.

2.4 *The Impact on Instrument Manufacturers*

The present icing intensity definitions (Table 5) contain *nothing* that can be calculated or measured. Therefore, for engineering and forecasting purposes, they are practically useless. If one wished to market an icing rate meter to indicate trace, light, moderate, and severe icing conditions during flight, it would be impossible to do so with these definitions.

Nevertheless, at least one manufacturer has produced an icing rate meter that is calibrated in terms of LWC *and* icing intensity (Anon., 1998). But in order to do this, the manufacturer *had* to go back and base the calibration on a measurable LWC-to-intensity relationship like in Table 2 or 3. In fact, the referenced manufacturer apparently chose to arbitrarily define its own new intensity scale where trace = 0 to 0.25 g m^{-3}, light = 0.25 to 0.5 g m^{-3}, moderate = 0.5 to 1 g m^{-3}, and heavy = 1 to 2 g m^{-3}. This scale is based solely on LWC and not on any correlation with effects of icing on the aircraft. So there is no demonstrable connection between these intensities and those with the same name in Table 5. As a result of these difficulties, the manufacturer has recently decided to replace the words *trace*, *light*, *moderate*, and *heavy*, with simply the words level 1, level 2, etc., on the readout dial of their icing rate meter.

The forecasting and manufacturing concerns described here clearly illustrate a major shortcoming of unquantifiable definitions such as those in Table 5. Engineering applications are forced to ignore these and turn instead to other definitions that are measurable and/or calculable.

3. RECENT PROPOSALS FOR REDEFINING ICING INTENSITIES

3.1 *Based on LWC*

A major deficiency in ongoing attempts to improve the forecasting of aircraft icing conditions aloft has been the inability to come up with a practical measure of icing severity based on LWC alone. Recent attempts have proposed linking some intensity scale to measured or forecasted values of supercooled liquid water content (SLWC) in icing clouds (Politovich & Sand, 1991; Jeck, 1992). But the problem of trying to account for the different response of individual aircraft to the same SLWC was not solved.

3.2 *Based on Rate of Ice Accretion*

A more recent proposal (Jeck, 1998) explores a simple and practical way to overcome the latter problem of individual aircraft response. The idea is to interpret the existing definitions (Table 5) of icing severity (trace, light, moderate, and severe) in terms of how long it takes ice to buildup to a certain small thickness, such as ¼ or ½ inch, on an airfoil (wing or tailplane, for example) during flight in icing conditions. According to the proposal, if an hour or more is required to accumulate ¼ inch of ice, then this will be considered to represent *trace* icing. Light, moderate, and *heavy* icing will mean that 15-60 minutes, 5-15 minutes, and less than 5 minutes, respectively, are required to accumulate 1/4 inch. *Severe* is replaced by the term *heavy* in this scale, which is based solely on rates of accretion and makes no judgment as to the effects of the various rates on the individual aircraft. *Severe* can still be used to describe those rates for which a particular aircraft is unable to cope. Any of these rates of accretion could be severe for one airfoil but not for others. This nicely separates the yet to be determined effects from the basic measurable and calculable quantity—the rate of accretion on a clean airfoil (or other component of interest).

For a given LWC, cloud dropsize distribution, and outside air temperature (OAT), different airfoil sections will have different accretion rates, depending on their individual geometry, airspeed, altitude, and angle of attack. But available, computerized ice accretion codes (Anon., 2001; Wright, 1995) can nowadays easily account for all these variables. These computer models can easily calculate how long it should take for a certain small amount of ice to accumulate on a given airfoil for any specified combination of atmospheric and flight variables.

This scheme has a number of advantages:

- It simplifies the forecasting chore by requiring forecasters to issue only LWC and OAT ranges, not icing intensities themselves. Individual pilots would know from a simple lookup table or graph what intensity is to be expected for their aircraft for the forecasted OAT and LWC range and for their particular airspeed and altitude.

- It provides practical and measurable definitions of icing intensity for possible use with FAA rules for operating in icing conditions (14 CFR 91.527 and 14 CFR 135.227) where light, moderate, and severe icing are called out but not defined.

- It permits unambiguous icing pilot reports (PIREPS). It would be universally understood that a report of moderate icing, for example, means that icing conditions are enough to cause ¼ inch of ice buildup on the wing (or tailplane) of the reporting airplane every 5 to 15 minutes, according to the proposed definition. Ideally, the rate of buildup would be monitored by typical onboard icing rate meters calibrated to indicate the rate of buildup on the wing or tail section itself for that particular airplane. This means that anti-iced airplanes can still report icing intensities in accordance with this scheme even though ice may never buildup on the leading edges of the wing or tail. They simply report what the ice detector indicates *would* be building up if there were no anti-icing on that airplane. In the absence of an icing rate meter, pilots will have to estimate the rate of ice buildup. In the old days, pilots of booted airplanes could gauge the icing intensity by how often they had to manually inflate the boots. If it was once every 5 to 15 minutes, that would fit the proposed definition of moderate icing. Today's FAA policy calls for cycling the boots automatically starting with the first sign of icing conditions. In this case, pilots may have to rely on the observed rate of ice accretion on the windshield wipers or on some other surrogate component.

- It provides practical and measurable definitions of icing intensity for gauging the significance of test and certification flights in natural or artificial icing conditions. Depending on the rate of ice accretion, the test can be reported unambiguously as a trace, light, moderate, or heavy icing exposure and everybody would know what that means.

- The definitions are flexible, if necessary or desirable. For example, if icing conditions corresponding to a buildup rate of ¼ inch every 5 minutes or less is considered insignificant for some large, thick-winged airplane, then the intensity thresholds could be changed to some other rate, like ½ inch every 5 minutes. This may be more in line with what heavy icing conditions are thought to be for that airplane. As long as it was generally known that heavy means ½ inch or more every 5 minutes for that airplane, PIREPS from it would still be interpretable.

3.3 *Based on the Effects on the Aircraft*

An FAA-sponsored working group on icing terminology was formed in 1998 to review the definitions of all icing terms used in aviation and to recommend new or modified definitions where suitable. This was in response to Task 1-B of the 1997 FAA In-flight Aircraft Icing Plan (Anon., 1997). It was proposed in that working group that the pilot report (PIREP) format be modified to include an item called a level-of-effect, based on the effects the reportable icing encounter had on the reporting aircraft. This four-level scheme (see Table 6) nicely supplies a type of severity scale, which is independent of, but complements the rate-of-accretion intensity scale. That is, for each aircraft model, each level-of-effect (or severity) category may result from one or more of the icing rate categories, but the correlation does not have to be known ahead of time. In fact, such correlations may naturally become apparent over time as PIREPS accumulate for each type of aircraft.

TABLE 6. EFFECTS OF ICING ON AIRCRAFT

Aircraft Effect (AE)	Speed (See Note 1)	Power (See Note 2)	Climb (See Note 3)	Control (See Note 4)	Vibration (See Note 5)
Level 1	Less than 10 knots loss	Less than 10% increase required	No effect or less than 10% loss	No effect	No effect
Level 2	10-19 knots loss	10%-19% increase required	10%-19% loss rate of climb	No effect	No effect
Level 3	20-39 knots loss	20%-39% increase required	20% or more loss rate of climb	Unusually slow or sensitive response from control input	Controls may have slight vibration
Level 4	40 or more knot loss	Not able to maintain speed	Not able to climb	Little or no response to control input	May have intense buffet and/or vibration

Notes:

1. Speed: Loss of speed due to aircraft icing. This is based on the indicated airspeed which was being maintained prior to encountering ice on aircraft and before applying additional power to maintain original airspeed.

2. Power: Additional power required to maintain aircraft speed/performance that was being maintained before encountering icing on aircraft. Refers to primary power setting parameter, i.e., torque, rpm, or manifold pressure.

3. Climb: Estimated decay in rate of climb (ROC) due to aircraft icing, example 10% loss in ROC, 20% loss in ROC, or not able to climb at normal climb speed with maximum climb power applied.

4. Control: Effect of icing to aircraft control inputs.

   Levels 1 and 2. No noticeable effect on response to control input.
   Level 3. Aircraft is slow to respond to control input. Aircraft may feel sluggish or very sensitive in one or more axes.
   Level 4. Little or no response to control input. Controls may feel unusually heavy or unusually light.

5. Vibration/Buffet: May be felt as a general airframe buffet or sensed through the flight controls. It is not intended to refer to unusual propeller vibration (for airplanes so equipped) in icing conditions

Although this information is intended for use by aircraft with approved ice protection systems, this procedure should also be used to report effects of icing encounters on all aircraft.

This chart is to be used for pilot reporting of icing effects ONLY and NOT to be used as a guide for operating in icing conditions.

The effect on an aircraft is to be reported as Level 1, 2, 3, or 4, based on which of the five columns corresponds to the worst perceived effect at the time.

For airplanes equipped with an ice protection system, these effects refer to conditions after operating the airframe ice protection system and with autopilot disengaged.

4. CURRENT STATUS

As a result of the Working Group 1-B deliberations and recommendations, the FAA is considering a new, two-part set of icing intensity definitions for use in PIREPS and in all aviation weather manuals where icing intensity is involved. Part one modifies the wording in Table 5 and adds the icing rates proposed by Jeck (1998) in order to restore measurable and calculable quantities to the definitions. The resulting definitions are shown in Table 7. The *trace* category has been deleted because it is neither forecasted nor used in the regulations (14 CFR 91.527 and 14 CFR 135.227, for example), and to avoid the assertion that trace icing is always harmless. Indeed, the wording “It is not hazardous” has already been removed from the definition beginning with the 2004 edition of the Aeronautical Information Manual (AIM) (Anon., 2005). Part two of the proposed definitions is the level-of-effects already shown in Table 6. These levels would be reported in the remarks section of the icing PIREPS.

TABLE 7. AIRFRAME ICING REPORTING TABLE PROPOSED TO THE FAA IN 2004.

LIGHT: The rate of ice accumulation requires occasional cycling of manual deicing systems** to minimize ice accretions on the airframe. A representative accretion rate for reference purposes is ¼ inch to 1 inch (0.6 to 2.5 cm) per hour* on the outer wing. The pilot should consider exiting the condition.***

MODERATE: The rate of ice accumulation requires frequent cycling of manual deicing systems** to minimize ice accretions on the airframe. A representative accretion rate for reference purposes is 1 to 3 inches (2.5 to 7.5 cm) per hour* on the outer wing. The pilot should consider exiting the condition as soon as possible.***

SEVERE: The rate of ice accumulation is such that ice protection systems fail to remove the accumulation of ice and ice accumulates in locations not normally prone to icing, such as areas aft of protected surfaces and any other areas identified by the manufacturer. Immediate exit from the condition is necessary.****

Notes:
* These rates can be measured by a suitable icing rate meter.

** It is expected that deicing or anti-icing systems will be activated and operated continuously in the automatic mode, if available, at the first sign of ice accumulation or as directed in the Airplane Flight Manual. *Occasional* and *frequent* cycling refer to manually activated systems.

*** It is assumed that the aircraft is approved to fly in the cited icing conditions. Otherwise, immediate exit from any of these intensity categories is required by regulations (14 CFR 91.13(a), 91.527, 125.221, and 135.227).

**** *Severe* icing is aircraft-dependent, as are the other categories of icing intensity. Severe icing may occur at *any* ice accumulation rate when the icing rate or ice accumulations exceed the tolerance of the aircraft. Icing certification implies an increased tolerance to icing intensities up through moderate.

At this writing, these latest definitions are still awaiting publication in the AIM. The definition of severe is practically unchanged and therefore the discrepancy with the icing regulations still exists. Further discussion of this problem and of the history of the icing regulations is given in Jeck (2001).

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