Austin's Very Easy Guide to
Winter Operations

2012 Revision 0

THINGS CHANGE OFTEN! CHECK MY WEB SITE PERIODICALLY TO ENSURE THAT YOU ARE USING THE MOST RECENT VERSION.

Volume 5 in the "Austin's Very Easy Guide" (AVEG) series
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For official information specific to your employer, refer to:
- Your company's operations manual.
- Your company's FAA operations specifications.
- Your company's approved training program.
- Your aircraft's POH or AFM.
- The applicable Federal Aviation Regulations.
- Any relevant FAA Advisory Circulars.
- Standing case law and interpretations published by the FAA Office of the Chief Counsel and/or rulings issued by NTSB Administrative Law Judges.

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2) **Vol. 2 – Austin's Very Easy Guide to On-Demand Part 135 Flight/Duty/Rest Rules**
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6) **Vol. 6 – Austin's Very Easy Guide to Passing Your Part 135 IFR-PIC Checkride**

Although much of the information contained in this series is generic and could potentially apply to many areas of aviation, it is designed specifically as a study aid for those pilots engaged in on-demand Part 135 single-pilot IFR cross-country operations in small reciprocating aircraft. **THIS MATERIAL IS NEITHER ENDORSED BY NOR APPROVED FOR ANY SPECIFIC OPERATOR. IT IS GENERAL INSTRUCTIONAL AND GUIDANCE INFORMATION ONLY!**

Because so many cold-weather operations are equipment-contingent and operator-contingent, this AVEG has been prepared for pilots at Austin's Air Service, LLC., a purely imaginary and completely hypothetical Part 135 operator that flies cargo in ice-protected Cessna 210 Centurions and Beech Barons.

I. Basic Definitions and Explanations

In general, there are two kinds of in-flight icing: **structural (airframe) icing** and **induction icing**, both of which can be extremely hazardous.

A. Induction Icing

In airplanes with fuel-injected engines – such as the Cessna 210 series, which is what we will be using throughout this booklet as an example – **induction icing** refers to ice which forms in an air intake and/or an air filter, blocking the flow of air to the engine. This may happen after flying through heavy rain, for instance, and then into a sub-freezing layer of air. The wet air filter could suddenly become completely frozen, reducing its permeability to near zero. (Carburetor ice is also a form of induction icing, but obviously as 210 pilots we don't have to worry about that!)

To combat the dangers of induction icing, the Cessna 210 utilizes an **automatic alternate engine air source** in the form of a spring-loaded flapper valve which allows air from inside the engine compartment to flow directly into the intake manifold, bypassing the air filter completely. *There is no pilot control for this device*. Suction produced by a blockage (such as ice) overcomes the tension of the spring that normally holds the flapper valve closed. The valve is thus "sucked open" and the engine can breathe. The cylinders are now being delivered warmer, slower-moving air from inside the engine compartment instead of colder, denser, high-speed ram air directly from the primary intake. Therefore, the automatic activation of this device during icing conditions (or any other condition that could obstruct the air filter) can result in a significant loss of engine efficiency, possibly resulting in a degradation of climb and/or cruise performance. The POH warns of a possible 10% loss of power, or up to 1 inch of manifold pressure. (Combined with the additional performance loss caused by structural icing, this could be a real problem.) The *failure* of this device during an induction icing situation, on the other hand, can result in complete engine stoppage. If the engine cannot get air, it will stop running.

B. Structural Icing

Structural icing, sometimes synonymously called "airframe" icing, refers to ice which forms on the wings, propeller blades and other surfaces of the airplane. It increases weight and drag while decreasing lift and thrust. Too much of it will cause a partial or total loss of control.

1. Types of Icing

The FAA currently lists three types of airframe icing with respect to composition: **glaze**, **rime** and **mixed**. It also lists four levels with respect to intensity or rate of accumulation: **trace**, **light**, **moderate** and **severe**. Finally, it lists four types with respect to the nature of the ice formation: **intercycle**, **known** vs. **detected**, **residual** and **runback**.

i. Clear Ice

Glaze ice (sometimes also referred to as "clear" ice) forms when larger water droplets strike the airframe and freeze slowly as they spread, leaving a heavy, translucent, relatively smooth and often somewhat lumpy coating. Clear ice may sometimes be more difficult to see than rime or mixed; it might appear, from certain angles and under certain lighting conditions, as if the wing is simply very shiny or wet. It is often (*but not always*) associated with cumulus clouds (which contain larger water droplets) and turbulent air (because an unstable atmosphere is generally associated with more vertical cloud development).

ii.. Rime Ice

Rime ice forms when smaller water droplets strike the airframe and freeze almost instantly, leaving a rough, granular, milky, porous, brittle surface. It is usually fairly easy to see. It is often (*but not always*) associated with stratus clouds and smoother air. Rime ice typically accretes along the "stagnation line" of an airfoil – the dividing line between air that flows over the top of the wing and air that flows under the bottom of the wing.

iii. Mixed Ice

Mixed ice is a combination of clear and rime ice. Because icing conditions are seldom perfectly consistent as they are in the laboratory, this type is common. Some pilots even feel that *most* ice encountered in the real world is mixed. This may be true. In any case, it is seldom easy to make a definite visual determination. Icing PIREPs are always assumed and understood to be estimations.

2. Levels of Icing

There is much debate about which type of icing is most dangerous. Clear ice adds more weight and causes a greater distortion of the wing shape, but rime ice causes a greater separation of airflow. (In fact, in icing tests, a razor-thin layer of simulated rime ice with the consistency of fine-grain sandpaper caused an extreme loss of aerodynamic efficiency on many higher-performance airfoils.) One thing that all the experts can agree on, however, is that the **rate of accumulation** is the single most important factor in determining how dangerous ice is.

1) Fast-accumulating rime ice is more dangerous than slow-accumulating clear ice.

2) Fast-accumulating clear ice is more dangerous than slow-accumulating rime ice.

The FAA currently lists four levels of in-flight ice: **trace**, **light**, **moderate** and **severe**. (A Notice of Proposed Rule Making presently under consideration suggests removing "trace" from that list, since it implies that no significant hazard exists.)

i. Trace

Ice is perceptible, but the use of de-ice or anti-ice equipment is not necessary unless the condition is sustained over a long period of time (an hour or more).

ii. Light

The use of de-ice or anti-ice equipment is occasionally or intermittently necessary.

iii. Moderate

The use of de-ice or anti-ice equipment is continuously necessary and a diversion and/or altitude change becomes highly advisible.

iv. Severe

Even with the continuous use of de-ice or anti-ice equipment, ice is still accumulating on the airplane. An immediate escape is necessary to prevent a disaster. Never forget: ***Icing can go from trace to severe almost instantly and without warning!***

Strictly from a legal standpoint (specifically §91.527 and §135.227 in our case), you may fly in widespread or localized trace, light, moderate or even severe reported or forecast icing conditions *as long as you are in an airplane which is specifically equipped and/or FAA-approved for it*. This is not the same thing as deliberately flying into what you, as the pilot in command, believes are actual dangerous icing conditions. As we shall see, these are two completely different legal and practical issues. We'll talk more about this shortly.

"What's safe isn't always legal and what's legal isn't always safe!"

3. Other FAA Definitions

"Intercycle Ice" is ice that accumulates on a protected surface (such as the booted leading edge of a wing or stabilizer) between actuation cycles. This term applies to de-ice systems rather than anti-ice systems.

"Residual Ice" is ice which remains attached to a protected surface immediately after the actuation of a de-icing system. Not all ice will be fully and cleanly shed after each actuation cycle; some ice will often remain. It may take multiple cycles to get rid of it all, and in active icing conditions, between intercycle ice and residual ice the wings and stabilizers may never be 100% ice-free.

"Runback Ice" is ice which forms from the freezing (or, in some cases, refreezing) of water leaving a protected surface and flowing – "running back" – onto the unprotected surfaces. Runback ice is very dangerous because once it is present, there is not much you can do to get rid of it, other than flying into above-freezing air! It generally forms on trailing edges and then creeps forward. It is often associated with higher angles of attack – i.e., lower airspeeds and higher flap deflections.

"Treat ice like smoke in the cockpit. *Do* something about it!"
— Richard Collins

C. What Are Icing Conditions?

In order for induction or structural icing to occur in flight or on the ground, two factors must come into play. They are:

1) visible moisture in any form
and (not or)
2) an airplane surface temperature at or below freezing.

"Visible moisture" includes clouds, fog, mist, drizzle, rain or even wet snow.

Notice that the outside *air* temperature does not have to be right at freezing. It can be well below . . . or even slightly above.

Airframe ice can occur when the outside air temperature is slightly above freezing because the airframe itself can be **cold-soaked** to below freezing. This may happen after leaving a colder layer of air and entering a warmer one. Imagine putting a turkey in the freezer until it is frozen solid. Now imagine taking it out of the freezer and putting it in the refrigerator. It will take a long, long time for that turkey to thaw in the refrigerator, won't it? Now consider an airplane that has been flying around in -15° C air for an hour and a half. If it descends into a layer of air that is, say, 2° C, it will not be instantly immune to ice even though the OAT gauge indicates an above-freezing temperature. A cold-soaked airframe may take several minutes or even many minutes to reach the temperature of the surrounding air . . . plenty of time for a deadly amount of ice to form.

A cold-soaked airplane is also vulnerable to ground ice. If you were flying through air that was fifteen degrees below zero for an hour and a half, then when you land at an airport where the surface air temperature is slightly above freezing and mist or drizzle is present ice may form on the airplane while it is parked on the ramp *even though ice is not forming anywhere else!* De-icing may be necessary unless you will be on the ground long enough for the airplane to warm up to the temperature of the surrounding air.

Airframe ice can also occur when the temperature is well below freezing because **supercooled large [water] droplets** (SLD) may be present in the atmosphere. Water can exist in the liquid state even at temperatures far below 0 degrees Celsius because it has the interesting (and dangerous) molecular characteristic that it does not freeze unless it has something to disturb it and/or something on which to crystallize: a nucleus such as a particle of dust or salt. SLD are just what they sound like – large droplets of liquid water at temperatures well below freezing. If you fly through a cloud of them, you could go from having no ice to having so much ice that the airplane is uncontrollable in a matter of only a few seconds!

Try this experiment at home: put a bottle of soda (or beer, I won't make any judgments) in the freezer until it is below the freezing point of water . . . but not yet actually frozen. Then take it out and open the lid. As the bubbles of carbon dioxide begin to come out of solution in the form of a fizzy head, ice will begin to form, starting at the top of the bottle and then working its way down the neck until the whole bottle is frozen solid. It's fascinating to watch. The liquid was already cold enough to freeze. It was just waiting for a disturbance – bubbles, in this demonstration – to trigger the process.

Now you can see why SLD are so hazardous. They will instantaneously freeze when they come in contact with a solid object. If you fly through a cloud of SLD, you can rapidly become coated with a very large amount of ice, perhaps so much that performance and control will be totally lost. Icing reported or forecast as "severe" often involves SLD.

Some pilots have been known to claim that there will be no more icing below a certain magic temperature (-15 degrees Celsius is a commonly heard figure, for example) because there is no more liquid water in the atmosphere. While it *is* true that icing may be less common when it is that cold, there are never any guarantees. Ice, even severe ice, has been reported in extremely cold conditions. SLD have been created in a laboratory environment at temperatures below -40 degrees Celsius! The bottom line to keep in mind is that it is never so cold that icing is no longer a *possibility*.

D. FPD Fluid

"FPD" Stands for "Freezing Point Depressant." FPD fluids are de-icing or anti-icing fluids, designed to prevent the formation of ice and/or remove existing ice from an aircraft. The FAA recognizes four types:

Type I Fluids are unthickened fluids. A Type I fluid forms a very thin film over the aircraft surface. Designed for low-speed aircraft, Type I fluids blow off quickly during the takeoff roll. They are red, red-orange or orange in color. **ONLY USE TYPE I FLUIDS ON AN AIRPLANE SUCH AS A CESSNA 210!**

Type II Fluids are thickened fluids which decrease in viscosity when subjected to shear forces from the relative wind induced during the takeoff roll. They contain a minimum of 50% glycol. Most fluids are clear or pale straw colored.

Type III Fluids are also thickened fluids. They contain a minimum of 50% glycol.

Type IV Fluids are enhanced-performance fluids with characteristics similar to Type II when used in 100% concentration during certain weather conditions. Type IV fluid effectiveness is superior to Type II fluids and holdover time is increased by a significant factor under most conditions.

NEVER allow de-icing or anti-icing personnel to apply Type II, Type III or Type IV fluid to your airplane! The thick, sticky fluids will not separate properly from the wings and stabilizers at the airspeeds achieved by a Cessna 210!

Ground de-icing is a procedure by which frost, ice, snow, or slush is removed from the aircraft in order to provide clean, uncontaminated aerodynamic surfaces. A heated mixture of Type I fluid and water is generally used as a de-icing fluid. Typically, the FBO sends over a truck and a line service employee who then applies the de-icing fluid. The pilot prepares the airplane, observes the procedure and then conducts the required checks prior to departure.

Ground anti-icing, on the other hand, is a *precautionary* procedure that provides protection against the formation of frost or ice and the accumulation of snow. This process provides an *estimated* safe time period (known as the **holdover time** or HOT) during which the critical surfaces should remain uncontaminated.

De-icing and anti-icing operations may be (and often are) conducted simultaneously. The term "FPD fluid" is used generically to cover fluid applied for either or both purposes.

Due to the fact that we only use Type I fluids, our holdover time as Cessna 210 pilots is determined by only two factors:

1. **The outside air temperature**
2. **The type of weather condition – i.e., wet snow, freezing mist etc.**

II. Legal Issues Pertaining to Operating in Icing Conditions

A. FAR §135.227 and Company Policy

Section 135.227 of the Federal Aviation Regulations, "Icing Conditions: Operating limitations," addresses the matter of when, where and how a flight may be conducted in icing conditions under Part 135. All Part 135 pilots should be thoroughly familiar with all aspects of this regulation, as well as with your own company's established guidelines which stem from it.

1. Taking Off When Ground Icing Conditions Currently Exist

i. Paragraph (a) of FAR §135.227

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(a) No pilot may take off an aircraft that has frost, ice, or snow
adhering to any rotor blade, propeller, windshield, stabilizing or
control surface; to a powerplant installation; or to an airspeed,
altimeter, rate of climb, flight attitude instrument system, or wing,
except that takeoffs may be made with frost under the wing in the area
of the fuel tanks if authorized by the FAA.
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NOTE 1: The old provision allowing a pilot to "polish the frost smooth" has been removed! The FAA no longer allows pilots to do this.

ii. Paragraph (b) of FAR §135.227

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      (b) No certificate holder may authorize an airplane to take off and no
pilot may take off an airplane any time conditions are such that frost, ice,
or snow may reasonably be expected to adhere to the airplane unless the pilot
has completed all applicable training as required by Sec. 135.341 and unless
one of the following requirements is met:
            (1) A pretakeoff contamination check, that has been established by
            the certificate holder and approved by the Administrator for the
            specific airplane type, has been completed within 5 minutes prior
            to beginning takeoff. A pretakeoff contamination check is a check
            to make sure the wings and control surfaces are free of frost,
            ice, or snow.
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NOTE 2: The other requirements do not apply to us and are not shown here.

NOTE 3: Pay special attention to the FAA's use of very broad language here – "any time conditions are such that frost, ice, or snow may reasonably be expected to adhere to the airplane" – it doesn't matter whether icing is actually being specifically forecast or reported.

§135.227(b)(1) leads us to a discussion of the Approved Ground Icing Program at our imaginary example Part 135 carrier, Austin's Air Service, LLC . . .

ii. The Ground Icing Program at Austin's Air Service, LLC

Austin's Air Service, LLC., has established its own special company program for operating when ground icing conditions exist**. "Ground icing conditions" are conditions in which ice is actively forming on the airplane while it is sitting on the ground.** (Note that this is *not* the same thing as ice which had formed previously but is no longer continuing to form.)

Operationally, this is a very different situation from in-flight icing for one simple reason: **neither pneumatic de-ice boots nor weeping-wing anti-ice systems are effective while the airplane is on the ground!** Ground icing conditions can occur any time there is visible moisture and a surface air temperature near or below freezing. Ground icing can also occur when the airplane itself is cold-soaked to below freezing and visible moisture is present. Visible moisture includes mist, fog, drizzle, rain or wet snow. If any of these exist *and* the outside air temperature (and/or the temperature of the airplane itself) is near or below freezing then ground icing is likely to occur. Frost is also a form of ground icing.

Company pilots are advised to **"REFER TO SECTION XIV [14] OF THE AAS GENERAL OPERATIONS MANUAL (GOM), PAGES 11 - 22, FOR COMPLETE INFORMATION ON OPERATIONS CONDUCTED DURING ATMOSPHERIC CONDITIONS CONDUCIVE TO GROUND ICING."** So let's follow the GOM's instructions:

When you arrive at the airport to begin your duty period and discover that ground icing conditions exist, the first thing that the GOM says you should do is consult the **holdover time table** on page 15 (of Section XIV). Based on 1) the outside air temperature and 2) the type of weather phenomena, the holdover time table tells you *approximately* how much time you will have between getting de-iced and getting airborne. These are the only two factors to consider, because we only use Type I FPD fluid.

Based on that table, if you do not believe that you can safely and realistically do it in the available time, do not even try. De-icing is expensive; don't do it if departure is highly improbable! If, for example, the estimated holdover time is only five minutes, but your ramp is a great distance from the active runway and there is already a long line of airplanes awaiting departure, then it would be pointless to get de-iced anyway. Your airplane would probably get re-contaminated before you could commence your takeoff roll. Call AAS Dispatch and inform them of the situation. They will ask you when you do think you will be able to go, and then you will give them your best guess based on your knowledge of the weather.

If you do believe that you can safely and realistically take off within your holdover time, then call AAS Dispatch and request permission to get de-iced. If permission is granted, call the FBO. The FBO is our "contract agent," approved to conduct de-icing operations for us. ***You may not de-ice the airplane yourself.*** You aren't trained to do this; the FBO line crew are.

It is your responsibility to ensure that the airplane is prepared and configured for the de-icing operation as specified on page 20 of the AAS GOM. For instance, you must install all the covers, chock the wheels and lower the flaps.

It is also your responsibility to observe as the contract agent de-ices the airplane. Ensure that the correct de-icing sequence is followed in accordance with the GOM on page 20. (For example, the de-icing begins with surfaces visible from the cockpit, on the theory that if ice re-forms, it will re-form there first, providing the pilot with a possibly life-saving warning.) *Ensure that only Type I FPD fluid is used.*

After the de-icing procedure is complete, you must perform a **pre-takeoff check** in accordance with the GOM. This is a walkaround inspection in which you verify that 1) all ice has been removed from the airplane and 2) no snow, ice and/or slush has been washed, blown or drained into places where it may re-freeze later. Follow the checklist in the GOM on page 21. The pre-takeoff check must be accomplished **after being de-iced and prior to leaving the ramp area.**

Then, within the five minutes immediately prior to commencing your takeoff roll, you must perform a **pre-takeoff contamination check**. This can be a visual check, consisting of an examination of the surfaces visible from the left seat. If any ice has re-formed, you must taxi back to the ramp to either get de-iced again or else abort the flight. See page 22 of the GOM for more on the pre-takeoff contamination check. Note that the term "pre-takeoff contamination check" comes straight from §135.227(b)(1).

If freezing precipitation exists, however, then the pre-takeoff contamination check must take the form of a **tactile** check as explained on page 22 of the GOM. That is, *you must actually get out of the airplane and feel the leading edge of the wing* to ensure that no ice has re-formed. The tactile check is required because clear ice can be difficult to detect visually.

A CAUTIONARY TALE!

The NTSB has adopted a probable cause of the October 10, 2001, accident at Dillingham, AK, in which all 10 people on board a Peninsula Airways Cessna 208 were killed. The airplane crashed shortly after takeoff on a Part 135 flight. The airplane had been parked outside overnight. Investigators were told by other pilots whose airplanes were parked outside overnight that about ¼ -inch to ½-inch of snow and frost covered a layer of ice on their airplanes the morning of the accident. The Cessna was deiced with a heated mixture of glycol and water. However, the NTSB was unable to determine whether the pilot visually or physically checked the wing and tail surfaces for contamination. The ramp supervisor who conducted the deicing told investigators that he believed the upper surface of the wing was clear of ice, but that he did not physically touch the wing and tail surfaces to check for the presence of ice. The Safety Board determined that the probable cause of the accident was an in-flight loss of control resulting from upper surface ice contamination that the pilot in command failed to detect during his preflight inspection of the airplane. Contributing to the accident was the lack of a preflight inspection requirement for Cessna 208 pilots to examine at close range the upper surface of the wing for ice contamination when ground icing conditions exist.

– NTSB Reporter, February 2003

In January 2005, the NTSB issued the following warning:

"It has become apparent that many pilots do not recognize that minute amounts of ice adhering to a wing can result in [severe aerodynamic and control penalties]."

Their alert continued by pointing out that research has shown that fine particles of frost or ice the size of grains of table salt distributed as sparsely as one per square centimeter over an airplane's upper wing surface can destroy enough lift to prevent that airplane from taking off! This is why pilots should exercise extreme caution – the ice might *look* insignificant, but it could be lethal! When in doubt, get de-iced!

2. Flying Into Ice

(c) No pilot may fly under IFR into known or forecast light or moderate icing conditions or under VFR into known light or moderate icing conditions, unless—

(1) The aircraft has functioning deicing or anti-icing equipment protecting each rotor blade, propeller, windshield, wing, stabilizing or control surface, and each airspeed, altimeter, rate of climb, or flight attitude instrument system;

(2) The airplane has ice protection provisions that meet section 34 of appendix A* of this part; or

(3) The airplane meets transport category airplane type certification provisions, including the requirements for certification for flight in icing conditions.

* I.e., an airplane which is FAA-approved for flight into known icing conditions.

We can ignore item (3), obviously, because we do not fly transport-category airplanes at Austin's Air Service, LLC.

Being "approved for flight into known icing conditions" is not the same thing as having a full package of functioning ice protection, but under the new paragraph (c) the FAA allows either option for operating into "known light or moderate icing conditions" under IFR or VFR.

[Paragraph (d) pertains only to helicopters and has been omitted here.]

> (e) Except for an airplane that has ice protection provisions that meet section 34 of Appendix A, or those for transport category airplane type certification, no pilot may fly an aircraft into known or forecast severe icing conditions.

In other words, although it is not necessarily always advisable or recommended, you may fly under Part 135 into an area affected by a SIGMET for severe ice *if* you are in an airplane which is approved for flight into known ice. This part of the regulation has not changed.

SUMMARY:

1) IFR/VFR light or moderate – APPROVAL REQUIRED or ALL EQUIPMENT INSTALLED AND FUNCTIONAL
2) IFR/VFR severe – APPROVAL REQUIRED

Paragraph (e) often causes confusion. Remember that operating in an area affected by a SIGMET for severe ice is not the same thing as deliberately plunging headlong into actual severe icing conditions. Forecasts and reports tend to be pessimistic. The FAA is trusting the pilot to use his or her extensive, detailed knowledge of meteorology, along with experience and judgment, to evaluate whether the flight can be conducted safely. We will return to this topic shortly.

> (f) If current weather reports and briefing information relied upon by the pilot in command indicate that the forecast icing condition that would otherwise prohibit the flight will not be encountered during the flight because of changed weather conditions since the forecast, the restrictions in paragraphs (c), (d), and (e) of this section based on forecast conditions do not apply.

Paragraph (f) basically means that the newest official weather takes legal precedence over the older weather. Remember that the only sources of weather which have any legal (i.e., evidentiary) value are those sources provided by or approved by the FAA or the National Weather Service. Saying "but my friend just flew through that area and he said it was fine" is ***not*** a viable legal defense if you get busted!

Now back to the matter of operating when severe ice is being forecasted or reported. It may be helpful to think of a convective SIGMET as an analogy here. The presence of a convective SIGMET across a large geographic area (peninsular Florida, for example) does not mean that a severe thunderstorm currently covers every single square foot of real estate inside the red box. Instead, it means that there are severe thunderstorms somewhere inside that box. These thunderstorms will vary in size, intensity and movement. It is up to the pilot in command to make an intelligent determination, based on his or her extensive, detailed knowledge of meteorology, along with experience and judgment, to evaluate whether the flight can be conducted safely in that area, and if so what course deviations and/or altitude changes will be necessary.

Likewise, a forecast or report of severe icing "out there somewhere" *does not always necessarily* preclude you from flying, although you should certainly exercise extreme caution if you do elect to fly! You may still choose to proceed with the flight if the region or regions of actual severe icing . . .

1) do not lie directly along your planned route of flight,
2) may be overflown or underflown or
3) may be circumnavigated or otherwise avoided. I.e., scattered clouds which can be sidestepped with heading changes.

For example, there might be a SIGMET out for "severe icing in clouds" on a day when there is only a single thin layer of widely scattered clouds that you can easily stay out of.

Or there might be a SIGMET out for "severe icing above 8,000 feet MSL" on a day when your filed altitude is only 4,000 feet.

Or there might be a SIGMET that calls for severe ice along your route and at your altitude that you judge to be excessively pessimistic based on your review of the frontal boundaries, moisture content of the air, freezing levels, PIREPs, cloud bases, cloud tops, lifted index and so forth.

In any of the cases listed above, you absolutely WILL be operating in a geographic area affected by the SIGMET – you will be flying inside the red box – but you might judge this to be safe based on the circumstances. But you will, of course, have to be in an airplane which is approved for flight into known icing conditions in order to take off.

What's safe isn't always legal and what's legal isn't always safe. If you believe there is REAL severe icing along your route and at your altitude and you can neither avoid it nor escape it – DON'T GO, regardless of how your airplane is equipped and regardless of whether it is approved for flight into known ice. It's that simple! (Fortunately, such extreme weather situations are relatively rare – there is usually an "out.")

What does "known ice approved" really mean?

How do you know if your airplane is legal for flight into known ice? If it is, it will have this placard (or one very similar to it) on its instrument panel:

> **This airplane is approved for flight into known icing conditions when all of the required components are installed and operational.**

This means, essentially, that the airplane has been granted a **Supplemental Type Certificate** (STC). An STC is a document issued by the FAA approving an exact modification to a specific model of airframe, engine, propeller etc. An STC is difficult to obtain – it is necessary to go through an expensive and lengthy process to prove that the change will in no way adversely affect airworthiness.

Remember, just having some de-ice or anti-ice equipment – or even a lot of it – does not *necessarily* mean that any given airplane is FAA-approved for flight into known ice. (For example, some Barons have pneumatic de-ice boots but are *not* known-ice approved.) The difference between having de-ice and/or anti-ice equipment and actually being FAA-approved for flight into known ice is rather analogous to the difference between *carrying* a handgun and *having a permit* to carry a handgun; they're not the same thing!

III. Avoiding and Escaping From Ice

First, remember that you can often avoid ice simply by staying above, below or between cloud layers. If you aren't in visible moisture, you won't pick up ice. This might involve some zigging and zagging, but it can certainly be done.

Any time that you fly in known icing conditions, you must have an escape route planned *before* you enter them! When ice is building rapidly and you find your airspeed and altitude suddenly and dramatically decreasing is not the time to be formulating strategy!

Not long ago I heard a Nashville-based pilots telling another pilot with great conviction that "when you hit ice, you should *always* climb." Well, this is just not true.

For example, consider this scenario. You are flying at 9,000 feet MSL with a freezing level at 8,000 feet MSL, cloud tops at 16,000 feet MSL and an MEA at 2,000 feet MSL. A descent makes *much* more sense, doesn't it? You can't climb out of the ice in this scenario, but you can easily descend out of it.

There is no one simple, easy, all-purpose answer. Where escape routes are concerned, ***sometimes*** a climb will be required, ***sometimes*** a descent will be required and ***sometimes*** a change of heading will be required. (That last one is often overlooked. You can, in some situations, flee ice simply by changing direction.) A thorough understanding of the overall weather picture is imperative in order to make a prompt and correct decision.

Here are three general guidelines to help you develop an escape plan beforehand. (These are not hard and fast rules, of course.)

- When the freezing level is below the MEA, a climb or a heading change will be the only remaining options (since you can't descend out of the ice in that situation).
- When the cloud tops are above your service ceiling, a descent or a heading change will be the only remaining options (since you can't climb out of the ice in that situation).
- When the cloud layer is unbroken and many miles wide, a climb or a descent will be the only remaining options (since changing heading will not get you out of the ice in that situation).

Whatever decision you make, you will have to make it fast . . . before the ice narrows your options to one – a rapid descent!

See the example in the special Web training supplement found at:

http://www.austincollins.com/ice.htm

IV. What Does the Term "Known Ice" Mean?

I was at at airport up north once when I heard a pilot-rated mechanic explaining that "known ice means that a pilot flying the same type of airplane at the same altitude and along the same route made an ice PIREP within the previous five minutes." I had to chuckle at that. I'm not sure where he got that idea, but let's take a moment to clear this up.

In the 1974 case of *Administrator vs. Bowen* an Administrative Law Judge for the National Transportation Safety Board (NTSB) issued the following landmark ruling which definitively interpreted the phrase "KNOWN ICE." That interpretation has stood ever since, and it has been consistently upheld. Here it is:

> "We do not construe the adjective 'known' to mean that there must be a near certainty that icing will occur . . . We take the entire phrase to mean that icing conditions are being reported or forecast in reports which are known to a pilot, or of which he should reasonably be aware."

Wow, that's pretty broad language, isn't it? In other words, "known ice" can refer to **forecast ice <u>OR</u> reported ice.**

Let's say you decided to fly a non-equipped or non-approved airplane and had an ice-related incident or accident. If, in retrospect, there appeared to have been any reason to believe that icing was likely along your route and it led to an incident or an accident, the FAA can get you for illegally flying into known ice. They will also get you for careless or reckless flying. So look at *all* the available weather information carefully and if there is ice out there don't go unless you are in an airplane that meets the requirements of §135.227 for the particular situation.

Again, let me strongly reiterate that the only sources of weather information which are considered "official" are those *provided by* or *approved by* the FAA or the NWS. This includes information received from the FSS over the telephone or radio, as well as ASOS, AWOS, ATIS, HIWAS, TWEB et cetera. It also includes surface analysis charts, significant weather prognostic charts, winds and temperatures aloft tables, METARs, TAFs and area forecasts, along with AIRMETs and SIGMETs and all other government-produced or government-endorsed weather products and services.

It does **not** include your own observations, what the people working in Dispatch told you, what the guy at the FBO says over the UNICOM frequency or what you saw on the Weather Channel – although all of those may be useful and valuable sources of information of which you should certainly take full advantage for your own personal benefit.

If you ever have to defend your certificate in court, only the official sources will have any evidentiary value!

Realistically, icing conditions are highly variable, highly unpredictable and highly dynamic. For our purposes, however, Austin's Air Service, LLC defines "Icing Conditions" as any outside air temperature or airplane surface temperature at or below 3 degrees Celsius when any form of visible moisture is present. Use of de-ice or anti-ice equipment (including pitot heat and, in the case of the Baron, fuel vent heat) is mandatory.

Some pilots believe that a PIREP of no ice effectively negates a SIGMET (or an AIRMET or an area forecast) calling for ice. In fact, some pilots even try to be cute by "making themselves legal" through the act of making a no-ice PIREP. ***This does not work.*** The FAA has never bought this argument and it was settled by case law in the 1993 case of *Administrator vs. Groszer*, in which the NTSB ruled that "it is not within [the pilot's] discretion to pick and choose between the SIGMET and anecdotal PIREPs." This is true even when a recent PIREP from the same category, class and type of aircraft in the same area at the same altitude contradicts the SIGMET.

Let's say, for instance, that there is a SIGMET for ice for your route and altitude. A pilot flies through it and reports picking up no ice. ***The SIGMET is still valid.*** The PIREP, while interesting and encouraging, does not cause the SIGMET to go away.

V. Landing With Ice

According to the NTSB, most icing accidents in light aircraft occur *after* the airplane has exited the icing conditions and is maneuvering for landing. While many fatal icing accidents result from a loss of control in the midst of a severe ice encounter, many more occur when a coating of ice causes an airplane's performance to be so badly degraded that a normal landing is impossible after the encounter is over. Ice greatly raises an airplane's stalling speed while greatly reducing its climb rate or even forcing it into a rapid descent. It may also cause a "tail stall," in which the horizontal stabilizer, which normally produces a downward force (which may be loosely described as "negative lift") to balance the weight of the nose, loses its effectiveness and causes the airplane to plummet vertically like a dart. Recovery is difficult at best and impossible at worst.

If you find yourself with ice on your airplane that you are unable to shed, land at a *much higher-than-normal airspeed* on the *longest*, *widest* runway you can reach. If this means diverting to another airport far away, so be it. The POH warns against using more than 10 degrees of flaps, and you may wish to land with no flaps. The danger of a tail stall is reduced with a reduced flap setting. Remember: the airplane's wings or tail may stall at a very high airspeed – even at speeds approaching cruise! And any bank angle at all will further increase this stalling speed.

You might find yourself forced to land so fast that a runway overrun is inevitable. This is still better than finding yourself fully stalled on short final at an altitude of 200 feet. A runway overrun is not likely to kill you; a low-altitude full stall almost certainly will.

The best solution is prevention, however, so try to avoid the whole ugly situation. Don't fly into icing conditions in an airplane without ice protection. And if your ice protection fails in icing conditions, immediately declare an emergency and escape.

When you have encountered icing conditions and/or believe that your airplane's critical surfaces may be contaminated, increase landing distance data from section 5 of the POH by 10% and add at least 11 knots to your final approach speed. Land with only 10 degrees of flaps – or no flaps.

Ice that accumulates on unprotected surfaces of the airplane (such as wingtips, antennae, the prop spinner and so forth) can cause a loss of climb performance of up to 100 FPM. Stall characteristics and low-speed handling will become unpredictable.

VI. Tailplane Icing

Thinner surfaces collect ice more efficiently than thicker surfaces. This is why your VHF radio antenna always ends up looking like a Popsicle. Your horizontal stabilizer is thinner than your wing. Therefore, if you see any ice at all on your wing you can bet you've got more ice on your tail.

The horizontal stabilizer is an upside-down wing; it has a slightly negative angle of incidence. It generates a downward force (which may be loosely described as "negative lift") to balance the weight of the nose. The faster you fly, the more of this downward force it generates, lifting the nose – think of the airplane as a see-saw pivoting around its CG. The slower you fly, the less of this downward force it generates, and the natural nose-heaviness of the plane takes over, lowering the nose. (The airplane is nose-heavy because the center of lift lies behind the CG – if you've loaded the airplane correctly, that is!) This is what makes an airplane stable.

But what happens when ice forms on your tail? Bad things. If the tail stalls, it will be unable to generate the downward force which holds the nose up. The nose will pitch down violently and the airplane will dive into the ground.

A. When are you most in danger from a tail stall?

1) On final approach.

2) At reduced power settings.

3) At higher angles of attack.

4) At higher flap settings.

B. What are the symptoms of a tail stall?

1) Shuddering, buffeting or shaking of the yoke *but not the airframe*. (This is how you tell the difference between a tail stall and a regular wing stall.)

2) "Softening" of the control feel – "mushiness."

3) Difficulty in trimming the airplane.

4) Pilot-induced oscillations. ("Porpoising" up and down.)

5) A sudden, forceful, nose-down pitch change. (Stick forces may be extreme – 100 pounds or more! It has been described as being like having a piano attached to the nose of your airplane.)

C. What is the recovery procedure for a tail stall?

1) Immediately retract the flaps to their previous setting. (In other words, undo whatever you just did.)

2) Apply NOSE-UP elevator input. (This is the exact *opposite* from a wing stall recovery! Be careful, because your reflexive tendency to lower the nose will exacerbate the tail stall, making it deeper and even more violent.)

3) Increase airspeed and power gently, smoothly and cautiously. (Just like with a spin, or a deep wing stall, the sudden addition of a large amount of power in a deep tail stall could make it *worse*!)

VII. De-Ice and Anti-Ice Equipment

At Austin's Air Service, LLC, we have two different systems in our fleet of Cessna 210s which are approved for flight into known ice: TKS and pneumatic boots. The TKS system is primarily intended as *anti-ice*, meaning that it is designed to prevent the formation of ice. The boots are primarily intended as *de-ice*, meaning that they are designed to remove ice that has already formed.

A. The TKS System

The TKS system is a **weeping wing** anti-ice system. That means that fluid oozes out, or "weeps," from panels on the leading edges to protect the lifting and stabilizing surfaces. (The abbreviation TKS refers to the company, TKS Limited, a conglomerate of three companies: Tecalemit Ltd., Kilfrost Ltd., and Sheepbridge Stokes, originally formed in Great Britain during World War II to develop anti-icing systems for RAF aircraft.)

1. Components and Function

The TKS system consists of laser-drilled titanium strips with approximately 800 tiny holes per square inch installed on the leading edges of both wings as well as on the vertical and horizontal stabilizers. One of two electric pumps pulls TKS fluid (which is based on ethylene glycol) from a reservoir with a capacity of 6.3 gallons (located in cargo compartment D in the tail of the 210) and pushes it through these porous strips. The relative wind causes the fluid to spread out over the upper and lower surfaces of the wings and stabilizers, preventing the formation of ice.

The pilot may select either main pump 1 or main pump 2 (not both at once) and may also select the **NORMAL** or **MAXIMUM** flow rate. For propeller ice protection, a slinger ring located in the prop hub allows a trickle of fluid to spread over the blades, ejected by centrifugal force onto grooved boots on the first third of the leading edges of the propeller blades. The sprayback from the propeller disk tends to keep the windshield ice-free. An **on-demand spraybar**, however, can be activated by the pilot to clear up any ice that may form on the windshield. The on-demand spraybar is an independent system with its own two pumps, though it draws from the same reservoir as the main pumps. The pilot may activate either windshield pump 1 or windshield pump 2. When the pilot hits the switch, a 3-second burst of fluid covers the windshield, clearing up any ice within a short time but momentarily obscuring forward visibility until the relative wind fully dissipates the fluid about 30 seconds later. (So don't do this right before touchdown!) The windshield pump switch is spring loaded to the OFF position, so after it is released it defaults.

A labeled green indicator light indicates that the selected main pump is running at the MAXIMUM flow rate. (See the diagram on page 18.)

A different labeled green indicator light indicates that the selected main pump is running at the NORMAL flow rate. (See the diagram on page 18.)

If these lights begin to alternately flash red, that means that a LOW PRESSURE condition exists. (See the diagram on page 18.) One or more of the pumps might be clogged or mechanically faulty.

2. Operation of the System

When preflighting a TKS-equipped airplane, turn the system on. Observe TKS fluid dribbling from the full span of all the weeping panels. Fluid should also be trickling from the slinger ring inside the prop hub. (It will not actually spray out; the prop has to be spinning for that to happen.) **Do not fly a TKS-equipped airplane into icing conditions if fluid is not flowing throughout the entire system.** "Dry spots" would translate to unprotected areas!

Always top off the reservoir before any flight into potential icing conditions. **NEVER** fill the reservoir without using the special filter funnel marked "TKS." Failure to use the filter funnel could result in system contamination, which could lead to an in-flight failure of your ice protection!

In flight, **prime** the system by selecting the MAXIMUM flow rate until the red flashing LOW PRESSURE warning lights go out and are replaced by a steady green light. Then switch back to the NORMAL flow rate and leave it there unless the MAXIMUM flow rate is needed. (This is relatively rare. The NORMAL flow rate is almost always adequate.)

The TKS system should always be turned on <u>just prior</u> to entering icing conditions. To conserve fluid, however, do not turn the system on until right before actual icing conditions are met. Conversely, turn the system off as soon as icing conditions are left behind.

When you approach a cloud or a column of freezing drizzle, for example, turn the system on a few seconds *before* penetrating it, priming as described on the previous page. Once you emerge from the other side, turn the system back off again *unless* there is another area of visible moisture coming up ahead. (Obviously this is only when the OAT is near or below freezing.) **Don't** just leave the TKS system on all the time unless you are actually in icing conditions all the time. Otherwise you are wasting valuable fluid. Not only is this very expensive to the company, it also leaves you without fluid when you need it later!

At the NORMAL flow rate, the TKS system provides about **150 minutes of continuous anti-ice protection**. At the HIGH flow rate, the TKS system provides about **75 minutes of continuous anti-ice protection**. In almost all commonly encountered icing conditions, the NORMAL flow rate is perfectly acceptable and quite effective. To conserve fluid, the HIGH flow rate should be used *only* when the NORMAL flow rate fails to prevent the accumulation of ice.

The TKS system does have some limited de-ice capability in addition to its excellent anti-ice capability. It should always be used to *prevent* ice rather than to *remove* ice, however, because if too much ice is allowed to form before the system is turned on the system might not function properly. I.e., the porous strips could be too clogged with ice to allow enough fluid to escape in time to shed the ice which already exists and prevent the formation of new ice before performance and control are lost. <u>*Always* use the TKS system as anti-ice, *not* as de-ice.</u>

If, while using the TKS system in flight, instead of the single green NORMAL or MAXIMUM flow rate indicator light you begin to observe the two red flashing warning lights indicating a LOW PRESSURE condition (probably caused by the failure of one of the two main pumps), *immediately switch* to the other main pump and also change to the MAXIMUM flow rate to re-prime the system. (Once the warning lights go out you may return to the NORMAL flow rate.)

The illumination of the amber HIGH PRESSURE light suggests the need to change the system's filter element. Bring this to the attention of maintenance personnel.

A digital display shows the number of gallons of fluid in the reservoir. Do not trust this display; top off the reservoir and then use time to estimate fluid consumption.

WARNING: Except when necessary for takeoff and landing, when using the TKS system, do not fly the Cessna 210 Centurion at an indicated airspeed of less than 120 knots. Do not extend the flaps more than 20 degrees. THIS IS BECAUSE HIGHER ANGLES OF ATTACK MAY PREVENT THE TKS SYSTEM FROM PROTECTING THE ENTIRE WING! The premature separation of airflow from the wing associated with higher angles of attack can promote the formation of runback ice.

These limitations often confuse pilots because the L model 210 has a maximum full-flap extension speed of 105 knots. (In later models it was increased to 115.) So I would like to clarify this by pointing out that they are two *separate* requirements: you should not fly at an indicated airspeed of less than 120 *regardless* of the flap position – i.e., even if you are operating with zero flaps, you should still not fly slower than 120 (unless necessary for takeoff and landing). Also, you are warned against extending the flaps more than 20 degrees *even when you find that it is necessary* to slow down below 120 for landing – for example, as you are settling into ground effect. Doing this with ice on the wings and/or tail could cause a very sudden, very deep stall and result in an extremely hard landing in a nose-low attitude.

Manage your TKS fluid intelligently. The system is useless if the pilot allows it to run out of fluid in flight. At our bases where TKS-equipped airplanes are kept, we also maintain a supply of TKS fluid. Refill the reservoir as often as necessary.

TKS-equipped 210s may utilize dual or high-capacity alternator configurations. Take the time to familiarize yourself with the electrical system.

The TKS control panel looks like this:

(*Photograph by Austin Collins.*)

The normal flow rate is selected (on the right) and the "NORMAL" green light is illuminated, indicating a normal flow rate. The display indicates that four gallons of TKS fluid remain in the tank. The on-demand spraybar for the windshield is in its default spring-loaded center/off position. Main pump one is currently selected for the wings, stabilizers and propeller slinger ring. The amber "HIGH PRESSURE" warning light is not illuminated. All indications show that the system is operating normally.

Operate the TKS system on the ground prior to flight. This serves two purposes: it allows you to check its function as described on page 16 and it also fully primes the system. (If the system is not fully primed before departure, it could take a dangerously long amount of time for fluid to begin flowing while flying in actual icing conditions.)

If the selected main pump failed, the "NORMAL" and "MAXIMUM" lights would begin to alternately flash red.

Notice that this airplane is equipped with a standby alternator. The toggle switch for it is in the on position.

B. De-Ice Boots

Be aware that just having boots *alone* is not enough to automatically make an airplane ice-approved.

In order for a booted 210 to be approved for flight into known ice, it must have the complete package of ice protection, all of the required components must be functional **and** the FAA must have approved that particular aircraft installation. *Having some de-ice or anti-ice equipment on any airplane does not automatically mean that that airplane is approved for flight into known ice.* (If it is approved, there will be a placard on the instrument panel which so states. See the example placard on page 11.)

1. Required Components

1) Pneumatic boots along the *full length* of the leading edges of both wings as well as the horizontal and vertical stabilizers.

2) Electrically heated boots on the propeller blades.

3) A hot plate for the windshield.

4) Either a big (95-amp or 100-amp) alternator or a dual or standby alternator system.

5) An ice detection light, mounted on the left side of the engine cowling, which shines on the leading edge of the left wing.

6) Heat for the pitot tube and stall warning vane.

7) A high-capacity vacuum pump (because it is also used to inflate the boots).

2. Operational Considerations

Pneumatic boots do have one major inherent disadvantage. They can only *remove* ice that has formed on the airplane. They cannot *prevent* the formation of ice. In other words, some performance *will* be lost.

Cycle the boots as often as necessary to keep the wings ice-free. Do not mistake **residual ice** for **ice bridging** or **intercycle ice.** Residual ice is ice that is left over (not shed) after an inflation cycle. It often takes two or three (or more) inflations to shed all ice. Intercycle ice is ice which forms between boot inflations. In active icing conditions, between intercycle ice and residual ice the wings and stabilizers may never be 100% ice-free. Residual ice and intercycle ice are often mistaken for ice bridging. Ice bridging supposedly occurs when the boots are inflated “too early” and a “shell” of ice forms over the boots, rendering subsequent inflations useless. All modern scientific evidence strongly suggests that there is no real danger posed by ice bridging. Pilots who think they are seeing ice bridging are probably actually seeing residual ice.

Aeronautical engineers and aircraft equipment manufacturers have never been able to reproduce significantly observable ice bridging in flight or in wind tunnel tests. The FAA and the NTSB recommend cycling the de-ice boots **early** and **often**. Begin using the boots at the first sign of ice and continue to use them as frequently as needed.

The POH supplement for the known-ice equipment warns that an accumulation of even ½ inch of ice on the leading edges of the wings can result in a loss of up to 500 FPM in rate of climb, a loss of up to 30 knots in cruising airspeed and an increase in stalling speed of up to 15 knots! There is no such thing as “a little ice.” Again, cycle **early** and **often**. Don’t wait until there is an inch or more of ice before cycling the boots . . . you could lose control of the airplane before the ice is shed.

To operate the boots, press the spring-loaded switch marked DE-ICE PRESS and then release it. The boots will inflate in an 18-second process – first the tail, then the inboard wing, then the outboard wing – about 6 seconds each. A pressure indicator light will go on while the boots are cycling. The system may be re-activated about six seconds after the indicator light goes out. If the indicator light never comes on, something may be wrong with the system.

Remember that while the hot plate will prevent the formation of ice on that small rectangular section of the windshield that it protects, ice may still form all over the rest of the windshield, rendering it opaque and significantly reducing forward visibility.

CHECKING FOR ICE

The ice detection light should be used for a maximum of one minute for functional checks or to look for contamination.

For night operations, the light should be used:

1) **Once every 15 minutes when not in icing conditions as defined on page 13.**
2) **Once every 5 minutes when in icing conditions as defined on page 13.**

Day or night, surfaces with a narrow cross-section (such as an OAT probe or a doorstop) are excellent visual indicators of ice accumulation, because they accumulate ice more rapidly than surfaces with a wider cross-section.

(*Photograph by Austin Collins.*)

(*Photograph by Austin Collins.*)

Never use your de-ice or anti-ice equipment as a tool of complacency.

Even in a fully protected and ice approved airplane, it is always a good idea to exit icing conditions if possible.

Using the Boots to Stay Alive

Aircraft manufacturers, NASA, the FAA and the NTSB, based on their extensive research and numerous accident investigations, all strongly urge pilots to activate the de-ice systems EARLY and continue to use them as OFTEN as necessary to dislodge ice! DO NOT WAIT! Many fatal accidents have taken place because the PIC waited too long to activate the de-ice system. I know this will probably be a controversial topic for a long time, but that's the most authoritative regulatory and procedural guidance available today.

For an example of an air disaster caused by waiting too long to inflate the pneumatic de-ice boots, read this article (Myth #5):

http://www.austincollins.com/art4.jpg
http://www.austincollins.com/art5.jpg

Fly safely!