Simply Serious - part 2 by John Morris

The last article concentrated on the fuel system of the PC12. This time it will be about the “stuff” that is put into the fuel system. Simple, use the approved fuels (grades) and anti-icing additives.

Most of you have probably never encountered or never knew that fuel icing might be happening while in-flight. I believe I have had that experience one time. I say I believe that was it, because of indications in the cockpit and the corrective actions that I took. After landing there were no apparent indicators, i.e. the pressure differential indicator on the fuel filter. I had the fuel filter removed and inspected for any visible debris but nothing was found. The most likely reason for this is that I was flying from Central America, where fuel storage/additives may not be up to the standards of the United States, back to the U.S. (overwater of course). Makes a person want to learn more. So learn (I) we will.

The approved fuels and anti-icing additives are listed in Section 2 – Limitations. They are Jet A, Jet A1, Jet B, JP-4 plus other Pratt&Whitney approved fuels via latest revised Service Bulletin 14004. Anti icing additives must be used for all flight operations in ambient temperatures below 0° C. Use anti-icing additive conforming to MIL-DTL-27686 or MIL-DTL-85470. Additive concentrations must be between a minimum of 0.06% and a maximum of 0.15% by volume.

Why the different jet fuels and the use of an anti-icing additive?

Let’s start with the difference in jet fuel types. First are the cuts of fuel: Wide-cut [blend of gasoline and kerosene] and kerosene base-types. Wide-cut is now basically Jet B and only used in Canada and Alaska due to its cold climate suitability. It was first used during early turbine aviation days due to greater availability but has some poor qualities. Wide-cut tended to evaporate more quickly at altitude and more importantly it has a low flashpoint, which caused a greater risk of fire during ground handling and aircraft accidents. Kerosene type fuels have a higher flashpoint, meaning the risk is reduced during ground handling and better survivability (fuel related fire) after an accident. The flash point of a volatile liquid is the lowest temperature at which it can vaporize to form an ignitable mixture in air.

For commercial and general aviation, Jet A and Jet A-1 are the fuels of choice. Jet A is only available in the United States and Jet A-1 throughout the (non-communist) world. What's the difference? The only difference is the freezing point. See Fig 1 for technical details but the reason behind the production of Jet A is cost. More Jet A can be produced (cost-wise) since the refining needed for the lower freeze point is eliminated.

Fig. 1

	Flashpoint-Minimum	Anti-Icing Additive (included)	Freezing Point	Weight (at) 15° C - Lbs
Jet A	>38° C	NO	-40° C	6.76
Jet A-1	>38° C	NO	-47° C	6.76
Jet B	-18° C	NO	-58° C	6.36
JP-4*	-23° C	YES	-58° C	6.49
100 LL	-40° C	NO	-58° C	5.97
Water				8.33

Note: Flammable fuels have a flashpoint *below* 38°C. and combustible fuels have a flashpoint *above* 38°C. Meaning combustible fuels are safer for transport and handling prior to, as well as during, aircraft usage. One of the components (or additives) to enhance safe handling is an anti-static to reduce static build up during fuel transfer from various storage mediums.
*JP-4, used primarily by the US Air Force, has been replaced by JP-8 (which contains additional additives including anti-corrosive and anti-static).

Anti-icing additives (Fuel System Icing Inhibitors-FSII) are primarily either EGMME (MIL-DTL-27686) - ethylene or DEGMME (MIL-DTL-85470) - diethylene. EGMME has been certified as a pesticide by the EPA, is more toxic to handle and is considered to have a lower flashpoint. DEGMME has no pesticide-type additive, safer to handle and has a higher flashpoint.

Water present/freezing in the fuel (system)! How is water "still" present in the fuel considering the pre-aircraft fuel tank storage, transport, pumping and sumping requirements done before each flight? What is required to protect the engine and fuel system from the potential effects of fuel icing?

Water may be present as free water or dissolved. Free water can be removed from fuel by adequate filtering and sumping. It can be seen in the fuel as cloud or droplets. Note: Based on current research the “norm” for free water to separate from jet fuel is 1 hour per foot-depth of fuel storage tanks.

Dissolved water is water that has been absorbed by the fuel. It cannot be seen and cannot be separated out of the fuel by filtration or mechanical means. Water is very slightly soluble in jet fuel, and conversely, jet fuel is very slightly soluble in water. The amount of water that jet fuel can dissolve increases with the aromatics content of the fuel and temperature. Fuel in contact with free water is saturated with water, i.e., the fuel has dissolved all the water it can hold. A typical water-saturated kerosene-type fuel contains between 40 and 80 ppm dissolved water at 21°C (70°F). If the temperature of the fuel increases, it can dissolve more water. Conversely, if the temperature of water-saturated fuel decreases, some of the water dissolved in the fuel will separate as free water. In other words, the colder the fuel the faster the dissolved water becomes free water and is then subject to freezing.

FAR Part 33 [Turbine Engines] 33.67 Fuel Systems, (4)(ii), states: “That the fuel system is capable of sustained operation throughout its flow and pressure range with the fuel initially saturated with water at 80°F (27°C) and having 0.025 fluid ounces per gallon (0.20 milliliters per liter) of free water added and cooled to the most critical condition for icing likely to be encountered in operation. However, this requirement may be met by demonstrating the effectiveness of specified approved fuel anti-icing additives, or that the fuel system incorporates a fuel heater which maintains the fuel temperature at the fuel strainer or fuel inlet above 32°F (0°C) under the most critical conditions”.

The PT6A-67B/P has a fuel/oil heat exchanger that meets the heat specification of the FAR. Pilatus also requires the use of fuel anti-icing additives when operating (flight) below 0° C ambient which additionally satisfies the other portion of the FAR.

FAR 23.955 Fuel Flow (f) [Turbine Engine Fuel Systems-condensed]. Each turbine engine fuel system must provide at least 100 percent of the fuel flow required by the engine under each intended operation condition and maneuver, (1) Be shown with the airplane in the most adverse fuel feed condition (with respect to altitudes, attitudes, and other conditions) that is expected in operation.

The PC12 fuel system covers this last FAR with the dual boost pumps and the by-pass of fuel filter and low-pressure engine driven pump since the next destination of the fuel (as it pertains to icing) would be the fuel/oil heat exchanger, which would protect the high-pressure engine driven pump from damage.

Of course the operator of the aircraft should insure that proper maintenance of the fuel system is maintained and that the Pilot in Command samples the fuel system before each flight to ensure that the fuel is free of water and other contaminants.

It is apparent that even with all of the pre-flight measures, from storage facilities to fueling trucks, water is still going to be in the fuel. So either the fuel is kept warm, in-flight, via a fuel heat system or an anti-icing additive is included to reduce the likelihood of fuel icing. Most general aviation aircraft do not incorporate a fuel heating system due to various factors relating to system design/functionality, cost, weight, etc. So either the jet fuel used already has a satisfactory freeze point (Jet A-1), incorporates an FSII additive that brings the fuel to a satisfactory freeze point (JP-4) or FSII will be added before use of the fuel (Jet-A).

Fuel system icing inhibitors (FSII) work by combining with any free water that forms to lower the freezing point of the mixture so that no ice crystals are formed. However, if the mixture of the FSII in incorrect, either from poor application during fueling or dilution of mixture due to not including FSII during some re-fueling, fuel icing can occur before the approximate freeze point designation. According to PRIST®, the addition of “DiEGME” (their registered active ingredient) will lower the freezing point to -46° C when correctly mixed between 0.10% and 0.15% by volume.

Can we, as pilots, do anything more to help ensure that the minimum amount of free water may be present before a flight? How about fueling the aircraft at least one-hour before flight and sumping before the aircraft is moved, which will agitate the water with the fuel. Or have the aircraft moved and fueled at least an hour before flight for sumping purposes. However, something to definitely keep in mind is the temperature at the time of fueling and the altitude of the ensuing flight. As earlier noted warmer fuel can hold more dissolved water (undetected) so that it will be possible for more free water to be present once at a flight level, after a period of time of much colder air temperatures.

By all accounts as long as we adhere to the approved jet fuel types and application of approved anti-icing additives fuel icing should not present a danger to safe flight operations. But we must always be aware of the unexpected, and be properly prepared through knowledge and continuing training.

“A safe pilot is always learning”

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ACFT Services provides training ONLY for all PC12’s, no other aircraft.