

SHOCKWAVE



Electric anti-icing technology comes to homebuilts—and none too soon.

BY JACK COWELL

The Lancair IV-P's sleek lines aren't so much as smudged by the Therm-X installation. Imagine this baby with boots!

In-cockpit weather, XM-sourced product, radar and Stormscope, all help make suitable Experimentals all-weather conveyances. You can therefore avoid thunderstorms in the summer (and other times, as you so choose). But that leaves ice, the big freeze, nasty stuff that can have a seriously degrading effect on the performance of any aircraft.

Certified aircraft have various certified systems, of course, with rubber boots as the old-school solution and “weeping wings” of glycol as the newer-age technology; hundreds of Cirruses are flying with TKS anti-icing equipment.

Now For Experimentals, Too

Finally, there's another option, one being marketed to the high-end Experimentals, called Therm-X. Developed by a division of Kelly Aerospace and an aviation research and development company in Redmond, Oregon, called RDD Enterprises, it's been certified



The Therm-X leading-edge panels might look like a weeping-wing setup from a distance, but those are big volts instead of little glycol droplets doing the work.



The weather out there might be frightful, but with de-icing capabilities, author Cowell's Lancair IV-P is better equipped than most to keep flying all year.

for inadvertent icing encounters on Cessna/Columbia aircraft where it's called E-vade

What Is Therm-X?

Therm-X is an electrical aircraft leading-edge surface de-icing system originally developed by Kelly, a well respected supplier of alternators, regulators and all sorts of other aircraft electrical components. Therm-X has the advantage of no moving parts, minimal maintenance requirements and no need for fluids. It turns electricity into heat, and ice into cold water. Simple as that.

OK, not quite so simple. This new approach uses malleable materials including a graphite foil laminate to create heaters that can be made to fit any GA wing and horizontal stabilizer's length and shape. Electronic heating zones embedded within the laminate are powered by a 75-volt/100-amp alternator. This 7500 watts of energy is digitally controlled to progress through the plane's leading-edge heaters; that is, it is not intended to heat every surface simultaneously, which reduces current demand.

This juice is under the direction of a digital controller that applies power to "parting zones" and "shedding zones." These two areas are divided so that in potential icing conditions, the parting zone is continuously activated (heated) to melt impinging ice. The ice then runs back to the shedding zone, which is kept below freezing, causing the run-back to refreeze and collect as ice.

Every 60 seconds, the controller activates a de-ice cycle where the voltage is increased to the shedding zone so that

the bond between the ice and the shedding zone is broken, and aerodynamic forces blow the ice off of this protected area of the wing's surface. This nuance is important, because though the bond in the shedding zone is weakened, it is not melted as it is in the parting zone. The result is that the ice can be blown off, but it cannot run back.

Once the power is removed from the shedding zone, it quickly cools to below freezing so any new ice can reform on it, and the de-icing cycle starts all over again. Simple right? Then why has no one thought of this before? There are three categorical reasons.

1. The level of efficiency, power and robustness only now available in Kelly's new compact alternators. Until recently, the alternators that could generate the power were large and heavy—not feasible for most GA aircraft. They also failed with disarming regularity under the constant on/off shunt loads that electric de-ice systems imposed. Simulated tests now show that the new alternators have a life expectancy of 1000+ hours under the Kelly/RDD system's loads.

2. Developments in the leading-edge panel components that are sandwiched to make up the heaters themselves. This laminate comprises a flexible, expanded graphite foil that is the electrical and heat-conducting layer. This foil goes between an outer heat conducting layer and an electrically insulating layer. The flexible graphite can be sculpted such that its density and thickness can be varied so that watt densities can also be varied in length and width to accomplish the necessary ice shedding for any GA aircraft.



Electricity for the leading-edge panels is taking up the D-section void.



Each Therm-X panel has different element circuits divided into parting zones and shedding zones. Plus, not all panels are powered simultaneously, reducing peak current requirements.

The flexible graphite is unusually well-suited in terms of surface area to volume for conducting heat and electricity. This means the wattage required is far less than the wattage required by previous attempts at electrical de-icing. Finally, this malleable and thin laminate can conform to leading edges without materially changing their aerodynamic characteristics.

3. Digital technology. Advances in this area have enabled developers to create small, versatile controllers and components that efficiently and effectively

How Much Frost Is Too Much?

Icing not an issue where you live? Don't bet on it. Consider these scenarios:

- Cessna warns that, "0.1 inch of evenly distributed frost on the aircraft's wing could increase the stalling speed by 35%. This roughly doubles the required takeoff run." That much frost is not unusual even in California.
- On a cold, still-air day your airplane is cold-soaked. Gain 20 feet or so of altitude, and the temperature can rise along with the humidity. All of a sudden your windscreen is frosted over and you're IFR at 100 feet AGL.
- Now take the same conditions as above, but crank all the numbers to just a little bit more on the bad side. Instead of just the windows frosting over, you can generate a cloud inside the cockpit.
- "One aileron and a portion of wing had torn off the machine as the pilot accelerated toward cruise speed. The pilot later described aileron flutter followed by departure of the aileron and wingtip. The airplane had been repainted in the spring, and this was the first frost-contaminated flight with the new paint. Apparently the frost was enough to put the aileron out of balance, and that caused the flutter."
- The Lake amphibian had been on the ramp for several days in cold weather. The pilot later reported that he'd felt some resistance in the controls during preflight, but it had gone away. Shortly after takeoff the controls became immovable, causing a non-fatal crash. It was found that leakage from previous water landings had accumulated in the hull and had frozen solid around the cables.

"Hey, a little frost is no big deal," you say. "I'll go over to the wash rack and rinse it off."

This is definitely a bad idea. Remember your high school physics? Fast flow of air means low-pressure air, and as the pressure drops, so does the temperature. Water on the wing or on the control surfaces could freeze as you accelerate.

So how do the airlines get away with

rinsing off the snow? Not with water. They use a nonflammable, glycol-based deicing fluid. Its viscosity is such that it stays on the wing, thereby insulating the aluminum. But it does melt the snow and is water soluble, so with time it will rinse off.

All that glycol being rinsed into the ground water is not an environmentally friendly practice, so back in 1996 the FAA experimented with a drive-through facility to melt the stuff via infrared heaters. (Envision the biggest upscale sidewalk restaurant in the world) at the Rochester, New York Airport. At last report, it was online and costing about \$100/hour for fuel. That's a lot cheaper than the \$2 to \$4 per gallon price of deicing fluid.

Before we panic and put our airplanes away, let's put this in perspective. Of all the weather-related accidents between 1990 and 2000, only 12% were due to icing. Of that 12%, roughly one-third of them were due to ground accumulation. The hard numbers are also encouraging: Ground accumulation was the cause of only 32 out of 3230 accidents over that 10 years. That's only 1% of weather-related accidents and only 8% of the icing-related accidents.

Consider also that half of those accidents involved pilots with more than 1000 hours. Familiarity breeds contempt.

But what's more sobering is that 52% of the aircraft in icing-related accidents had no ice on the wings. Ice in the carburetor was the culprit. Although this is something all pilots hear about in ground school, it has no real validity until it happens to you. With over half of the accidents being attributed to this, it bears repeating that it is possible for carb ice to form when skies are clear and the OAT is as high as 90° F. All it takes is for the relative humidity to go above 50%.

Consider those numbers carefully. It's 85° F and the relative humidity is 65% ...sounds like a normal summer day in the southeastern United States. You come in low and slow, and all of a sudden it's too low, too slow and too quiet. Think fast! Put full carb heat

on, go for best glide, and hope that rough engine smooths out.

Carb ice is not limited to low power settings either. You can be cruising along and discover that severe carburetor ice buildup may occur at between 20° to 70° F and 60% to 100% relative humidity. That's a pretty wide range.

While fuel injected engines are, by definition, immune to carb ice, they can still be starved for air when the intake or the air filter freezes over. Know where the alternate air intake control is, if one is required. Many times, such a control is not required because the door is spring-loaded; when the main air inlet is blocked, air pressure opens the alternate automatically.

The last 40% of icing-caused accidents are situations where there is ice on the structure. When we hear of an in-flight aircraft icing up, we envision the pilot looking out the window at an inch or two of ice on the wing.

The movies would have you believe that it's the weight that causes our steely-jawed captain to wrinkle his brow. And while the shear mass of the contamination can be a problem, ice on the leading edge will cause the airfoil to stall at a much higher airspeed, so the combination of the two is really at fault here. But even a small amount of ice can raise the stall speed, and rough ice can have a dramatic effect.

What about ice on the tail surface? Is it an issue? The tail is a flying surface, but unlike the wings, which lift the airframe, the tail surface pushes down. When it quits doing its job the airplane goes into a dive. Perhaps this is where the perception of the weight of the ice comes from.

If you feel an immediate loss of control when lowering the flaps, it's probably tail ice. Retract the flaps and plan on a long rollout.

Just remember that although icing is a small number statistically, when it happens to you, the numbers mean nothing.

—Bob Fritz

route the de-icing electricity and run constant self-test cycles to monitor the system and warn the pilot if there is a malfunction.

The Nuts and Bolts

Now that you know what it is and how it works, what's involved in an installation and how much does it cost?

Well, before you can zap the ice, you need the juice. A Kelly Aerospace alternator dedicated solely to the de-icing system produces the necessary 7500 watts of power. In a certified Columbia or an Experimental Lancair IV-P like the test plane, this new belt-driven alternator is mounted between the rear of the engine and the firewall. To make room for it under the extremely tight cowling of a IV-P or ES, the RDD crew removes the original battery, swaps this big 12-volt unit for two much smaller sealed Panasonics, and relocates them in a new spot under each front seat. One more thing: The alternator cannot be used as a backup or for any purpose other than de-icing. So if you want your plane to have backup electric power, a third alternator must be fitted.

The wattage is routed to the leading-



High-current wiring is part of the Therm-X installation; proper techniques are critical to the performance of the system.

edge heaters via an assortment of wire conduit, insulated studs and connectors. It's then modulated by a set of heater control modules (HCMs), a group of heat and OAT sensors, and a digital controller. The wire is routed behind the leading edges, and the components are all either contained in the wings, the horizontal stabilizer or the airframe. All that's visible are OAT probes and the smooth silver heater panels.

Power On, Garth

Once power on (it's usually tied to the avionics bus), the combination of electricity and components is managed

by the controller to not only distribute the watts but to systematically self-test the system. To turn it on, you make sure the engine is turning over at 1200 rpm or more and push one button. Integral in that button are three small indicator lights that read "airframe" and "on" in green, and "fail" in red. While the system is going through its 30-second test, the airframe light is steady on and the other two alternatively flash on and off. If all is working properly, the small "on" and "fail" lights go out and the "airframe" light glows a steady, reassuring green.

All the pilot has to do is watch and confirm the system's status. If the lights do not confirm that all is well, you can reset one or both breakers for the controller and/or alternator field circuit and reboot the system. If that doesn't work, your Therm-X is inoperative and must be attended to by a professional.

If you get the usual steady green light, you then can turn the system off knowing that it checked out. The controller will remember that it already has been checked, too, so when your OAT gauge reads 40° F or less—or you inadvertently enter icing conditions—you simply push the button. Because it was pre-tested, the "airframe" and "on" lights go green, and your system is armed and ready. To take advantage of this at-the-ready feature, I've now made turning on and testing the system part of my preflight routine. Be prepared, right?

One additional feature is that in flight with the system operating, the "on" light gives you a quick three-flash green advance notice when current is



Early Columbia (now Cessna) composite aircraft used Therm-X but had initial problems traced to interference between the de-icing system's electrical studs (top) and the internal mesh used to lightning-protect the airframe. An AD was issued, and a fix to return the system to service involved a new kind of connecting stud with a Tedlar insulator (see installed, lower left photo), as well as an initial test before the aircraft is released. This test puts a 1000 volt/50 micro amp current through the system and monitors the result on a scope to ensure there is no mesh contact. Finally, a ground fault sensor is now an integral part of every system, and it immediately kills the electric power if it senses any current flow between the system and the airframe.

GOT WINGS?

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De-icing *continued*

about to be applied to the shedding zone. The flashes are so you're not taken by surprise when a chunk of ice noisily slides off. Neat, simple and user-friendly, right? To be sure, but getting to this point was a bear.

The Joys of Development

At first, everything performed as designed—and then it didn't. Alternators threw off or broke belts. Components tested and worked fine for several hours and then became erratic. Software systems suddenly locked up and stopped working without warning. A failure might occur in one operating hour or 10 hours later, but it did occur.



Cockpit annunciators keep the pilot informed of the system's status.

Clearly, it was a long and expensive 2007 for the Kelly/RDD partnership and, in the process, the patience and good will of adventuresome first customers were sorely tested.

One by one, the mechanical demons were singled out and the mysteries unraveled. In the process, alternator specs and designs had to be changed and HCM mounting locations were found to be extremely temperature sensitive, so where the HCMs were located was critical. For example, the HCM mounting spots that worked perfectly in a Columbia lacked sufficient air circulation and could overheat in a pressurized Lancair IV-P. Result: system failure. But only after several hours of otherwise

normal performance. As you can imagine, troubleshooting this kind of elusive fault was bewildering and exasperating. Finally, the controller and its software brain were painstakingly gone through to clean up redundancies and simplify operating procedures.

All of this took months of trial-and-error bench testing and then weeks more of expensive and extensive flight testing to work out the bugs. Remember, all of this development was on a system that had already been approved in certified Columbia aircraft. Interestingly, according to Kelly and RDD, their Therm-X system's de-icing capabilities always got rid of the bad stuff, but developing it to be robust and reliable in various Experimental aircraft installations was a challenge. Happily, that challenge was met.

Yes, the system is working. In my experience over the course of the last 15 or so hours of operation, it has performed just like the book says—reliably and seamlessly. Because this is now a typical result, complete kits are being shipped—at \$17,995 a pop. Installation cost is on top of that, and RDD supplies a comprehensive manual to guide adventuresome builders. If you want RDD or an RDD-authorized shop to do the installation, figure on an additional \$6000 to \$8000.

Kelly and RDD are now cautiously optimistic about their Therm-X systems. They've sold about 25 as this is being written, and the order book is (finally) building nicely. Furthermore, de-icing systems for Lancair Legacies, Velocities and RV-10s are also in the works.

Now that I have this ice protection, do I still pore over exotic, web-delivered ice forecasting information and avoid ice like the villain it is? You bet I do. Nevertheless, I have seen a bit of rime here and there, and it has departed the airplane just like the Therm-X boys said it would. While it's still strictly a get-out-of-jail card, it's a card I'm mighty glad to have in my metaphorical wallet. †

For more information, visit Kelly Aerospace at www.kellyaerospace.com or RDD Enterprises at www.rddent.com. Find direct links at www.kitplanes.com.

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