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TKS ICE PROTECTION

Liquid Armor for the War on Icing

By Scott Sherer

There are many people out there who really like snow sports; things like skiing, snowboarding, ice skating, hockey, snowmobiling and all of those other sports that you typically see during the winter Olympics. I'm sure that many aviators enjoy some of these activities as well, and they may actually look forward to doing them, too. I, however, am not one of them.

Sure, every once in a while my wife will make me fly her to Vail to ski, but I'm more likely to head to the bar or a hot tub than I am to hit the slopes. That's not to say that I don't enjoy winter, but as a winter pilot, I view ice, snow and winter rains as impediments to my favorite pastime – flying. As far as I'm concerned, ice belongs in a glass!

Thankfully, my Seneca resides in a hangar, so I don't have to worry about clearing off any snow or ice accumulation before launching. I also have a heavy-duty tug for getting my bird in and out of the hangar quickly, and the Janitrol furnace, along with an assortment of other engine and interior warming contraptions, helps to get my plane warm and ready fast.

However, when the time comes to actually take off and it's cold and grey outside, I do have to think about ice – and for good reason. Here in Wisconsin and in other far north locations, especially those near the Great Lakes, we get ice quite often. While I can usually fly to California and back and never need to turn on my de-icing system, it's an entirely different story within 100 miles of my home plate.

A typical winter ceiling can be 800 to 2,000 feet overcast with tops between 5,000 and 10,000 feet AGL, and more often than not, the wind is strong and the wind chill is very low. The winter cloud in Wisconsin is dark and grey. (I say "cloud" and not "clouds" because we seem to have only one cloud here and it covers the entire state from November well into January!)

Personally, I prefer flying in the grey, as opposed to others who fly only in sunshine. I find that when it's clear and sunny, it is often very cold and windy. As we in Wisconsin say, "If it weren't for the dark, cold, wind and snow, I'd really like winter!"

Anyway, from time to time, I hear pilots say, "I'll just pop up through the clouds to VFR on top." Have you heard that? It's -10°C outside and some well-intentioned but naive winter pilot thinks he'll

turn on his pitot heat and defroster and launch into the grey, ice-laden murk above. "Not to worry, at a 500-feet-per-minute climb rate, I'll be through this in just a couple of minutes," he thinks.

Most of the time, he's right and able to get through it. Then again, every rule has exceptions, and in aviation it's the exceptions that can kill you.

When I take off or land through the winter murk, I have to admit that my forehead and palms get sweaty. Even though my pitot heat, hot props, and heated windshield are on, I always check the wings every couple of minutes for ice build-up. If there's ice on the leading edges of my wings, I'll pop the boots.

Traditional De-icing Boots and FIKI

De-ice boots inflate via air pressure pumps on the engines. For those of you not familiar with this setup, these are the vacuum pumps to which all of your vacuum instruments are connected backwards. The boots and instruments run on pump pressure, rather than vacuum – same thing, only backwards. If you've never heard of this, it's typical for booted airplanes.

I've been in icing conditions at 10,000 feet – even while on my way south to Florida. On one such trip – solid IMC, bumpy ride, and with family in the back – I had one of the pressure (backward vacuum) pumps fail. Down to one functional pump and with ice building on the wings, I could not use the boots, as using just one pump would exponentially increase the risk of blowing the remaining pump. I was already in a pickle, but flying IMC with two blown pumps and no attitude or heading indicators would've been far worse. Flight Into Known Icing (FIKI) certification is great, but try to think about risk reduction when you're in that situation!

Remember, FIKI is a certification for de-icing equipment. My Seneca is FIKI approved, which means that I can legally launch when there's ice in the forecast. On the other hand, it is not intended for extreme icing (and maybe not even for moderate icing), and you can't fly it all day long; it's not designed for that.

So what is it designed for? FIKI is primarily intended to allow you enough time to climb to an on-top or between-layers flight level where there is no ice. It can also be used for landing when you need to descend slowly from cruise altitude to an approach. This latter scenario can be a rather hair-raising ordeal, as you're beginning the descent 100 or so miles out and may end up spending 30 or more minutes flying through ice-laden clouds.

FIKI is good, but it's certainly not a fail-safe. A couple of years ago, a Beech King Air, a FIKI approved, medium-sized turbo-prop aircraft, crashed in Minnesota due to ice. Shockingly, the time from takeoff to an attempted emergency landing was less than 10 minutes. The plane did not make it back.

Booted airplanes have worked well for decades, but having boots and FIKI approval does not guarantee zero risk. On top of that, boots are terribly expensive so they don't get replaced but maybe once every 10 or 20 years. What if a boot fails in flight? Think of how your airplane is going to handle with one wing clear of ice and the other completely covered. Frankly, I'd rather not.

Bottom line: If you have de-icing equipment on board, FIKI or other, it's a huge improvement over an aircraft with just a heated pitot, but none will guarantee risk-free flight in icing conditions.

The TKS Alternative

So what do you do if you want or need ice protection and your airplane isn't equipped with boots, hot props or a heated windshield?

Well, if you fly a Piper PA-32 (Saratoga) or one of more than 20 other aircraft – including Cessna 182s, 206s and 210s, Beechcraft Barons and Bonanzas, Cirrus SR22s, Mooney M20s and many others – there's another outstanding option for you. It's called TKS.

TKS is a fluid-based freezing point depressant system that coats your aircraft's flight-critical surfaces with an ice inhibiting and eliminating liquid called DTD 406B (often referred to as "TKS fluid" by your local FBO). This ethylene glycol-based fluid chemically prevents the formation of ice in light icing conditions.

Similarly, if ice begins to accumulate or has already accumulated on the plane, the fluid will break down the bond between the ice and the aircraft, allowing natural aerodynamic forces to shed the ice away.

Unlike pneumatic boot systems, there are no boots or air pressure pumps to fail, so there's no risk of the system not working due to a blown pressure pump. Consequently, there's also no risk of losing your flight instruments either. The system is electrically-driven and doesn't require much in the way of power.

TKS is an excellent alternative anti-ice/de-ice system for your aircraft. Of course, we all know that there's no such thing as zero risk, but you can install it on your plane and be as safe in icing conditions as is possible given the dangers outlined above.

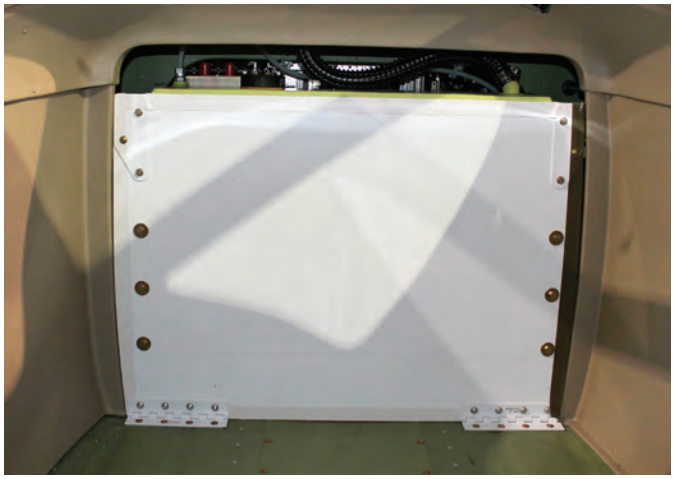
It's worth noting that TKS is not FIKI-approved on all models of aircraft, including the PA-32 and Cessna 182, among others. However, you can still legally install a No-Hazard aftermarket version on your PA-32 whether it is FIKI-approved or not. The difference being, the No-Hazard System for the PA-32 and Cessna 182 only protects critical flight surfaces, unlike other No-Hazard Systems which protect the entire aircraft.

How TKS works

The TKS system is amazingly simple in concept.

First, you have a TKS fluid storage tank that must be strategically

An uninstalled TKS equipment pallet for a Cessna 206. The light green box is the fluid tank.



TKS plumbing is installed aft of the baggage compartment in the Cessna 206. Note how the pallet is installed vertically.

WEIGHT AND ENDURANCE INFORMATION:

Piper Saratoga:

Fluid Capacity: 4.5 Gallons, 2 hours in Normal Mode
Weight without Fluid: 40 pounds
Weight with Fluid: 81 Pounds
Electrical Consumption: 1.5 amps@28VDC in Normal Mode
Specific Models: PA-32-301FT, PA-32-301XTC, PA-32R-301 (HP), PA-32R-301 (SP), PA-32R-301T*

*Also known as Piper Saratoga II HP and TC and Piper 6X and 6XT

Cessna 182:

Fluid Capacity: 5 gallons (2 hours in "Normal" mode)
Weight without Fluid: 40 pounds
Weight with Fluid: 86 pounds
Electrical Consumption: 1.5 amps @ 28V DC in "Normal" mode
Specific Models: 182P, 182Q, R182, TR182, T182, 182S, 182T, T182T S/N 18264296 and up

The TKS system is provided to a number of manufacturers for aftermarket and OEM use. For a list of applicable aircraft, visit: www.caviceprotection.com.

positioned in the aircraft for weight and balance considerations. More specifically, if you have too big a tank, you'll severely cut into your useful load.

The location of the tank is equally important. At 9.2 pounds per gallon, this stuff weighs a lot, and you don't want to bust your flight envelope. The manufacturer's STC takes this into very careful consideration (see "Weight and Endurance Information" sidebar).

With the flip of a switch to the "Normal" position, the fluid is pumped from the tank through your wings' leading edges (and/or your prop and windshield) to prevent ice from adhering to your airplane. This is called anti-ice.

Should you find a growing layer of ice on the plane, you flip the switch the other way to "Maximum" and a higher volume of fluid is pumped. This is the de-ice position and it will hopefully shed already accreted ice from the airplane.

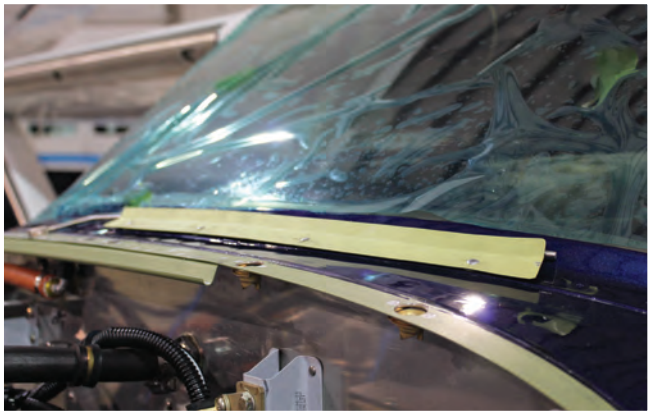
TKS switch panel. If you're entering visible moisture – specifically clouds and fog – and it is cold out, flip the TKS switch to "Normal." If ice is actually forming on the airplane, put it on "Maximum." Again, be sure to keep a close eye on the fluid quantity gauge; it's just as important as fuel if you're IMC and in icing conditions.

Of course, the fluid isn't infinite, so like fuel in your fuel tanks, you'd better have enough TKS fluid aboard for your trip. As such, it's important that you monitor the fluid level as part of your flight planning routine.

As described above, the Normal/Maximum switch on your panel determines the speed of the pump and the volume of fluid it distributes. The fluid is pumped from the tank and through a filter that removes any contaminants. Changing the filter at factory-recommended times will become a crucial part of your annual inspection procedure, so be sure that you discuss this with your A&P at annual time.

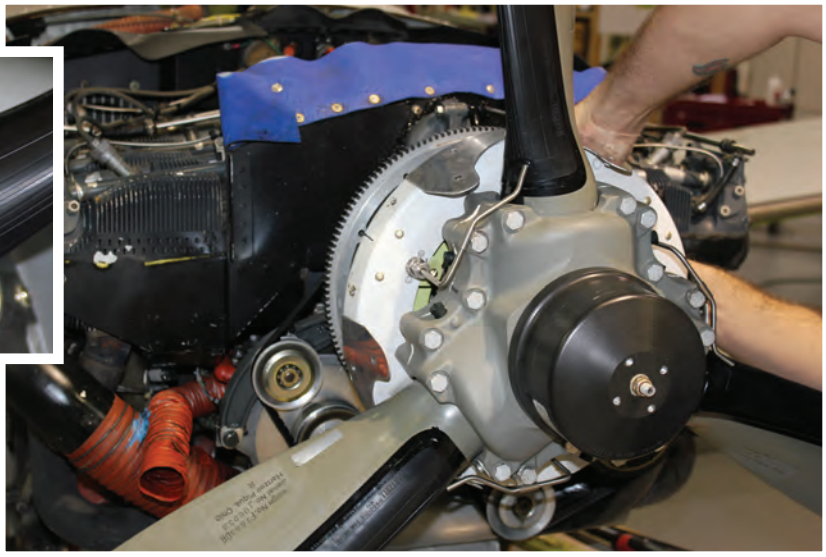
After the filter, the fluid pushes on through nylon tubing and a number of splitters called proportioning units. Usually placed in the wings and tail of the aircraft,

Here you can see a TKS panel installation on the leading edge of a PA-32 wing.

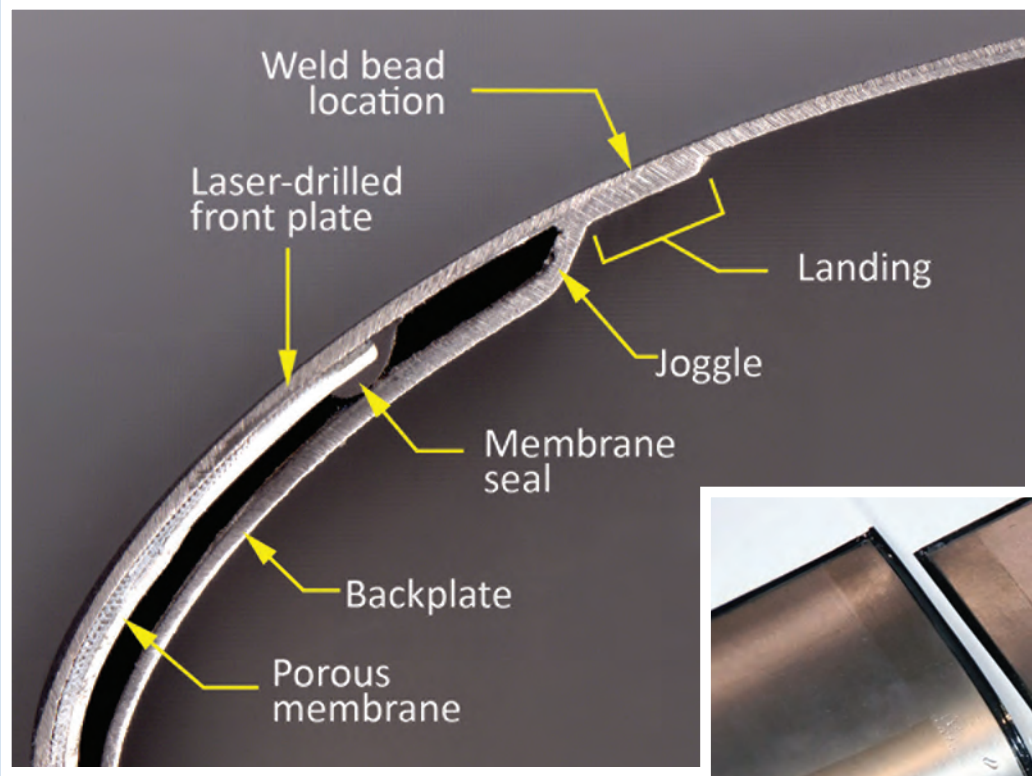


A windshield spray bar installed on a 2016 Cessna T206H.

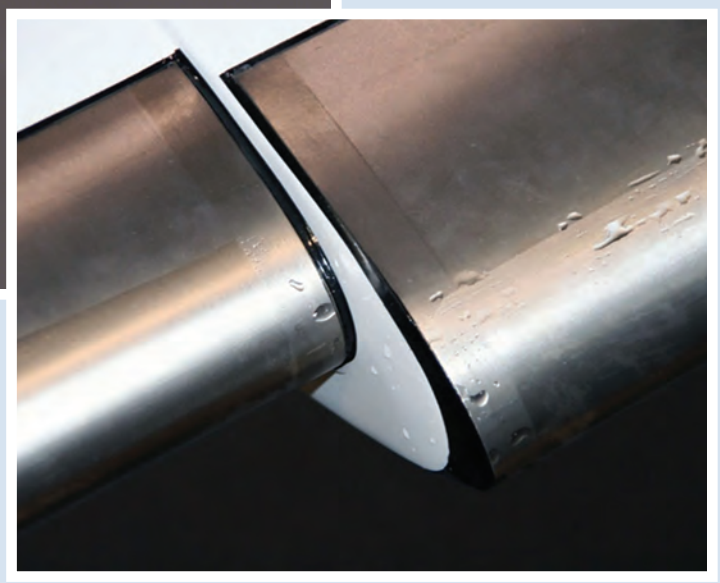
TKS panels are installed on the vertical and horizontal stabilizers of the Cessna 206.



Propeller slinger ring installation on a PA-32. The slinger feed tube delivers fluid to the prop blade.

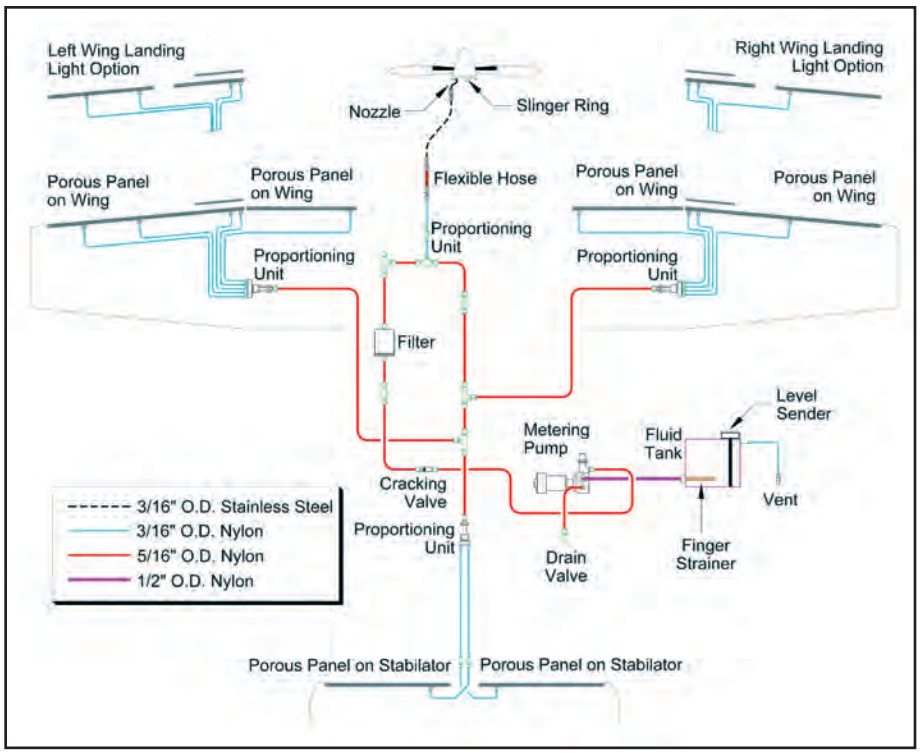


A cross-section of a TKS panel. The front plate is perforated with thousands of laser-drilled holes (800 per square inch) and each is just .00025 inches in diameter. The back plate is then welded to the front plate with a porous membrane sealed between the two panels. This membrane ensures that the fluid is evenly distributed throughout the entire panel.



A close-up view of a laser-welded, porous TKS panel. You can't afford to have even the smallest amount of particulate contamination in the TKS system or it will clog these tiny holes and the system will not work. For that reason, any particulates large enough for the system to fail are blocked by the TKS filter. Bugs or dirt, for example, are not an issue, and though it is possible to have contamination downstream of the filter, that could only happen during installation or maintenance.

TKS installation on a PA-32 propeller.



A TKS system fluid schematic for a Piper PA-32.

TKS Deployment Procedures

1 Preflight the system. Turn the switch to both "Maximum" and "Normal" to listen to the pump. Pumps do fail, but if you're lucky you should hear it on the ground first. Listen for bad bearings grinding away or a sluggish or irregular pump.

2 Remember to turn on pitot heat, cabin heat, defrost and (this is really important) monitor your autopilot. Frequently turn it off while having a firm grip on the yoke. If there's ice accumulation on the airplane and a flight control imbalance, this is the only way you're going to find it.

3 If you think that you're in a potential icing environment, turn the switch to "Normal" and look for an out. This usually means climbing if you're in departure or cruise mode.

4 If you notice ice on the airplane, turn the TKS switch to "Maximum." If you don't catch the icing condition early enough, this may not remove ice from your airplane. Keep an eagle eye out when IMC and it's between +5 and -10°C outside.

5 Increase airspeed by 15 knots if possible. The airplane will stall at a higher airspeed with ice on it.*

these units determine where and how much fluid will be supplied to the respective TKS panels affixed to the leading edges of the plane's wings, wing struts (when applicable) and stabilizers.

The outer skins of the TKS panels are made of titanium and the front panel features miniscule, laser-etched micro-holes from which the TKS fluid is dispersed to coat and protect the various surfaces. The back of each panel is robotically welded to the front panel to create a reservoir of sorts with a porous membrane positioned between the two skins. The panels themselves are typically affixed to the airframe using a supple, two-part adhesive.

For added protection, props can be fitted with a traditional fluid "slinger ring," and dependent on whether the TKS Ice Protection system is either No-Hazard or FIKI-certified, the windshield is protected by either one or two on-demand pumps (a backup mode is provided for FIKI-certified systems).

Does it work?

You're darn tootin' it works! When you're on top in the bright sunshine cruising along on your trip and you know that you have to descend to your destination through the grey murk, TKS gives you the peace of mind to know that you can pull it off safely.

Of course, if the forecast mentions moderate (or worse) ice or freezing rain, it's best to rethink your plans, But if the forecast is for light icing and 5,000-foot tops and you have TKS, it's time to get out to the airport and fly!

During my trip to Wichita last year, Cessna gave me a brand-spanking new TTx to fly for a day. I consider the TTx to be the Ferrari of single-engine, fixed-gear aircraft – even more so than the Cirrus and right up there with Mooney. The TTx is sleek, super-fast and it comes equipped with a Garmin G-2000 panel and, of course, a state-of-the-art, FIKI-certified TKS ice protection system.

How much does it cost?

The system itself costs somewhere between $30,000 and $55,000 depending on the application, so TKS is not an inexpensive proposition. However, if you love your airplane and plan to keep it, and ice is a constant threat where you live, then TKS is a very worthy consideration.

As for the fluid, it can be purchased from CAV Ice Protection (www.caviceprotection.com), the TKS manufacturer, and stored in your hangar. Here's a breakdown of current fluid quantity and pricing options with shipping included:

- 2 containers (2.5 gallons each): $115
- 1 container of 5 gallons: $109
- 1 container of 30 gallons: $542
- 1 container of 55 gallons: $795

Is it worth it?

Personally, it's tough for me to justify TKS for my already-booted airplane, but it's certainly much less expensive than the cost of buying a new (or newer) "de-iced" airplane. It may also be a real bargain for someone who is planning to keep their airplane for the next decade or so.

Of course, there are plenty of owners out there who will tell you that the system only needs to work once to be worth the investment. I spoke with one such owner, Jim Berry, who has a TKS system installed on his 1997 Saratoga.

Jim lives in Ohio near Lake Erie so he experiences the same sort of icing conditions I do living in Wisconsin near Lake Michigan, specifically during climb out and descent. The winter clouds top between five and ten thousand feet, so Jim does his enroute flying using VFR on-top. Without de-icing equipment, however, getting there is often a stressful and risky proposition.

Jim has owned his Saratoga for about six years, and four years ago he installed TKS. He has used it more than 20 times thus far and has had no ice accumulation on any of his forays into the frozen grey murk.

According to Jim, the factory install in Kansas was A+. In fact, they noticed a small fuel leak around one of his fuel senders and fixed it during the install. He also said that the user documentation provided by CAV Ice Protection is excellent and the system is easy to use. "You just turn it on 15 to 20 minutes before you need it and it will prime and fill itself," he said.

Jim went on to explain that he will typically turn the system on after engine start and by takeoff it's up and running. "If you accrete ice on the wings and then turn it on, it's too late," he added; "The ice might not come off."

Jim paid around $25,000 for the installation four years ago, so I asked him if he considered his investment a good value. "Absolutely!" he replied. "It's a great value, and I get great safety and peace of mind from TKS."

TKS Ice Protection Systems are available for the following Piper and Cessna aircraft:

Piper:
PA-32-301FT, PA-32-301XTC
PA-32R-301 (HP), PA-32R-301 (SP)
PA-32R-301T

Also known as the Piper Saratoga II HP and TC and Piper 6X and 6XT.

Cessna:
182, 206, 208, 210, 350, 400, TTx

For more information, visit the CAV Ice Protection website at www.caviceprotection.com.

Did you know?

TKS (Aircraft De-icing) Ltd. was formed in 1942 with the merger of the following three companies, each having a specific expertise and each contributing a letter to the TKS moniker:

***T* – Tecalemit, Ltd.** manufactured metering pumps for multi-point lubrication systems. The company designed and produced multi-outlet (6, 10 or 12 outlets depending on the aircraft) metering pumps and filters for the system.

***K* – Kilfrost, Ltd.** specialized in de-icing chemicals and was the primary protagonist for the system in the early stages.

***S* - Sheepbridge Stokes, Ltd.** produced the newly-invented, sintered-powder metal components. The company manufactured the tubes called de-icing strips.

For a complete history of the company, visit **www.caviceprotection.com**.