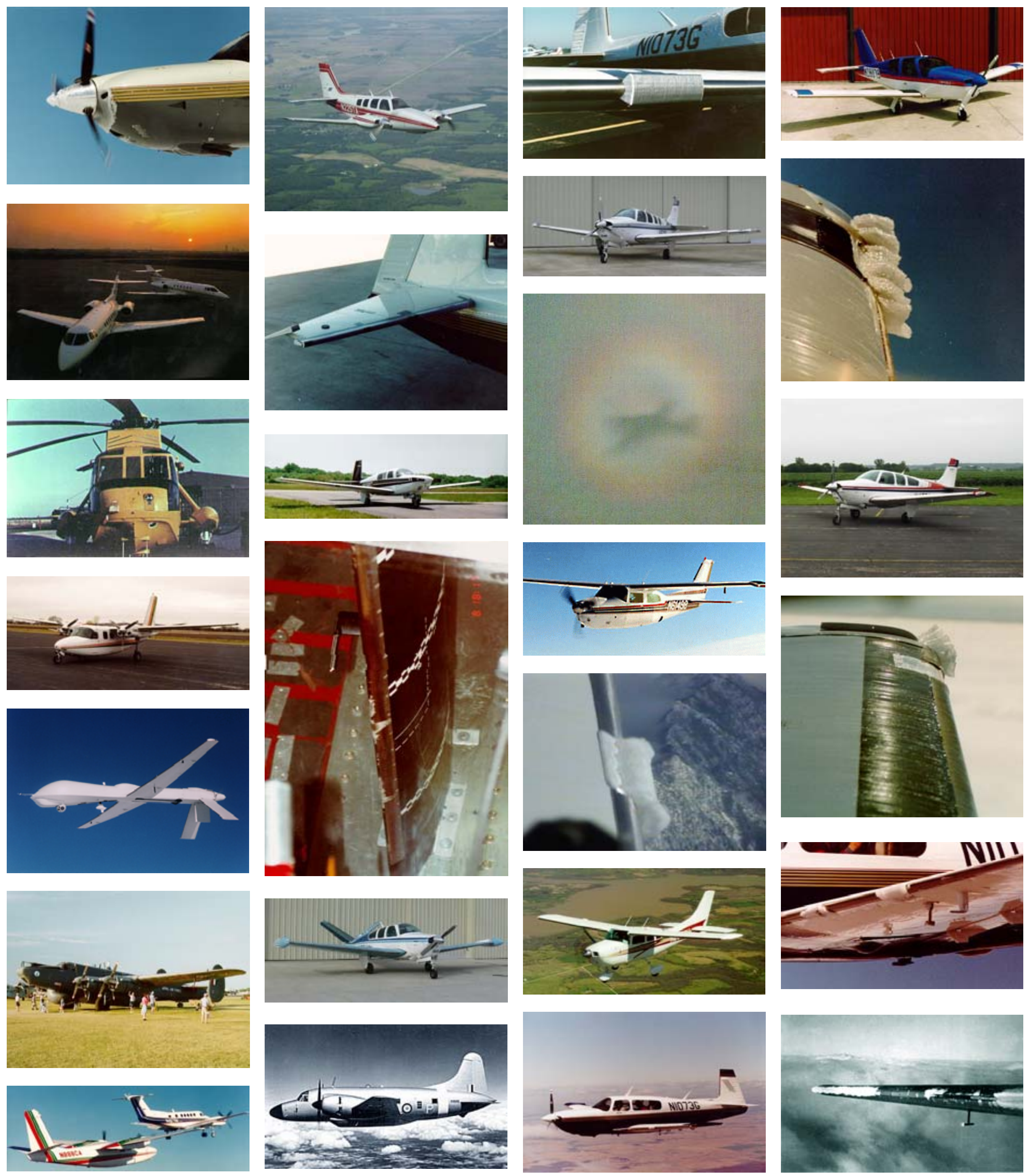
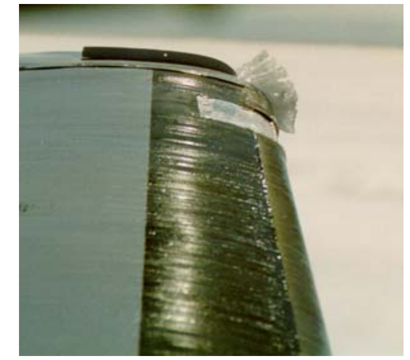
Ice Protection

a product of **Aerospace Systems & Technologies**



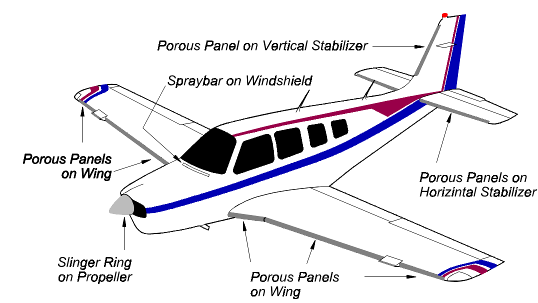
Complete Airframe Ice Protection



TKS Systems

TKS Ice Protection offers a level of ice protection unsurpassed by any other method. It has the major advantage of providing anti-ice capability, as well as de-icing. The end result is an ice protection system that keeps ice off of the aircraft, maintaining aircraft performance in the icing environment. This level of protection, coupled with the ease of use of the system, provides effective, simple ice protection.

The TKS ice protection method is based upon the freezing point depressant concept. An antifreeze solution is pumped from panels mounted on the leading edges of the wings, horizontal and vertical stabilizers. The solution mixes with the super-cooled water in the cloud, depresses its freezing point, and allows the mixture to flow off of the aircraft without freezing.



The system is designed to anti-ice, but it is also capable of de-icing an aircraft as well. When ice has accumulated on the leading edges, the antifreeze solution will chemically break down the bond between the ice and airframe, allowing the aerodynamic forces on the ice to carry it away. This capability allows the system to clear the airframe of accumulated ice before transitioning to anti-ice protection.

A valuable side effect of TKS ice protection is the reduction of run back icing on the wings and tail. Once fluid departs the panel on the leading edge of the surface, it flows aft over the upper and lower surfaces and departs the aircraft at the trailing edge. This run back effect keeps ice accumulation in check aft of the panels, from run back or from impact of larger water droplets. This side effect is a positive benefit in today's environment of concern for ice protection during large droplet encounters.

TKS ice protection systems have been developed for a number of aircraft around the world, with a majority of the recent developments occurring in the United States. Systems have been developed for several general aviation aircraft, from safety of flight (installation) supplemental type certificates (STC) for inadvertent icing encounters, to full known icing certifications.

A Historical Perspective

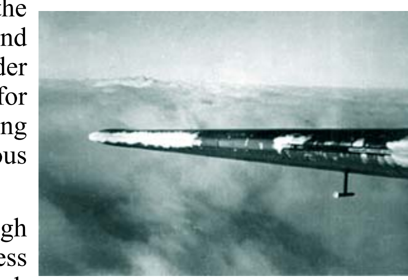
Fluid ice protection started in the 1930's as companies experimented with methods of introducing de-icing fluid at the leading edges of wings. The TKS Ice Protection Systems were developed during World War II, as an ice protection measure that was compatible with armored leading edges. This compatibility was needed for aircraft to deal with the barrage balloon threat. With an armored leading edge, a balloon cable could strike the leading edge of the wing, slide down to an explosive cable cutter, and be severed. A rubber boot on the leading edge was not acceptable, as it allowed the cable to snag the leading edge of the wing and tear it off of the aircraft.

TKS Equipped
Avro Shackelton Bomber

TKS Strip Panels on a DeHavilland Dove

The first TKS systems developed were relatively crude, porous channel systems. Three sides of the channel or tube were solid, with the fourth side made from porous, powdered metal. These strips were placed on the leading edges of the wings and stabilizers as a mechanism to pump glycol solution onto those surfaces. Multiple strips were applied for more fluid coverage of the leading edges.

TKS continued to refine the panels, improving control and distribution of the fluid. Wider porous areas were developed for pumping fluid onto the leading edges, utilizing different porous materials.



Original TKS Strips and Sintered Bronze panels on the Vickers Viking

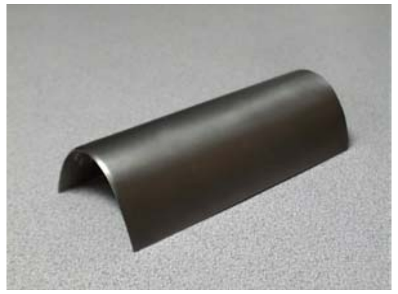
The concept evolved through the 50's, when the first stainless steel panels were developed. Panel porosity was achieved by using material formed from stainless steel mesh. In the early 60's, TKS ice protection was applied to the HS-125 business jet. Since then, every HS-125 produced has been equipped with TKS ice protection.

Cessna Citation SII

In the early 80's, laser-drilled panels were developed and first applied to the Cessna Citation SII as standard equipment. Midway through the decade, development of TKS systems for the single engine, general aviation market in the United States commenced. With the introduction of the system for the Beech Bonanza, the foundation for the development of several general aviation class systems was laid.

System Description

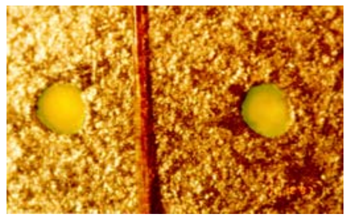
Ice protection with a TKS system is achieved by mounting laser-drilled titanium panels to the leading edges of the wings, horizontal and



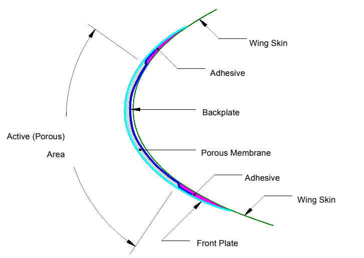
Laser-Drilled Titanium Ice Protection Panel

vertical stabilizers. Secondary fairings or structures such as wing lift struts can be protected in a similar manner. Propellers are protected with fluid slinger rings, and windshields are provided with spraybars.

The outer skin of the ice protection panels are manufactured with titanium, typically 0.7 to 0.9mm thick. Titanium provides excellent strength, durability, light weight, and corrosion resistance. The panel skin is perforated by laser drilling holes, 0.0025 inches in diameter, 800 per square inch. The porous area of the titanium panels is designed to cover the stagnation point travel on the appropriate leading edge over a normal operating environment. This range is typically from best rate of climb at the low end to V_{NO}, maximum structural cruising speed at the high end. Conservative margins are added to this range.



Magnified View of Holes Laser-Drilled Through Titanium



Typical Porous Panel Cross Section

The back plate of a typical panel is manufactured with stainless steel or titanium. It is formed to create a reservoir for the ice protection fluid, allowing fluid supply to the entire porous area. A porous membrane between the outer skin and the reservoir assure even flow and distribution through the entire porous area of the panel.

The porous panels can be bonded or attached as a cuff over a leading edge (typical in STC installations) or built in as the leading edge. Panels are bonded to the airframe with a two-part, flexible adhesive. Most high performance general aviation singles and twins utilize the cuff method.

Two-Speed Metering Pump

Fluid is supplied to the panels and propeller by a positive displacement, constant volume metering pump. The two-speed pump provides two flow rates to the panels and propeller. The low speed supplies fluid for the design point of anti-icing during a maximum continuous icing condition. The high speed doubles the flow rate for removing accumulated ice or providing ice protection for more severe conditions. Flow rates are designed for this level of performance, regardless of the certification basis for the system.

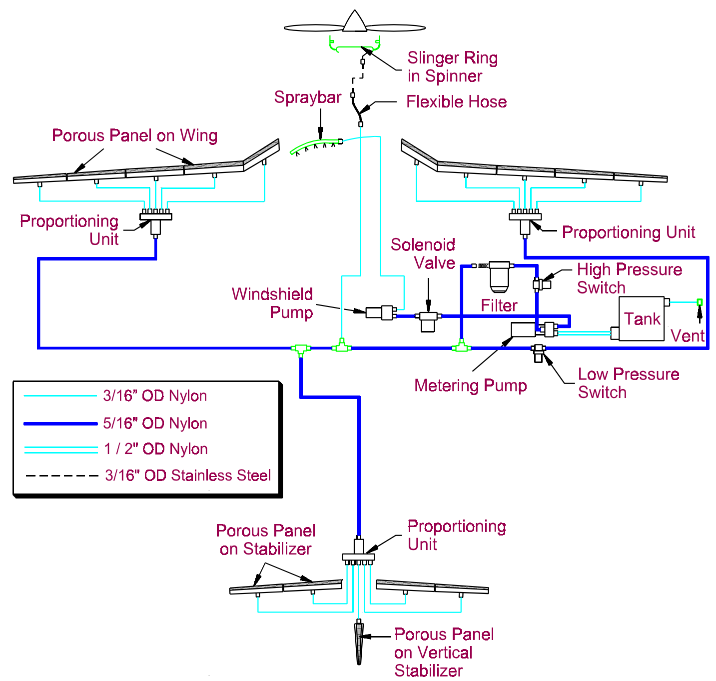
For systems that are not certified for flight into known icing, one metering pump is provided. For systems certified for flight into known icing, two pumps are installed for redundancy. The pumps are individually selectable. Fluid for the windshield spraybar system is provided by an on-demand gear pump. The spraybar may be activated as needed to clear forward vision through the windshield. Similar to the metering pump, one or two pumps are provided depending on the certification basis.

The fluid passes through a microfilter prior to distribution to the porous panels and propeller(s). The filter assures all contaminants are removed from the fluid and prevents a panel blockage.

Windshield Spraybar and Deflector on Mooney

Windshield Pump

A system of nylon tubing carries the fluid to proportioning units typically located in the wings and tail of the aircraft. The proportioning units divide the flow into the volumetric requirements of each panel or device supplied through the unit. Each panel and device is fed again with nylon tubing.

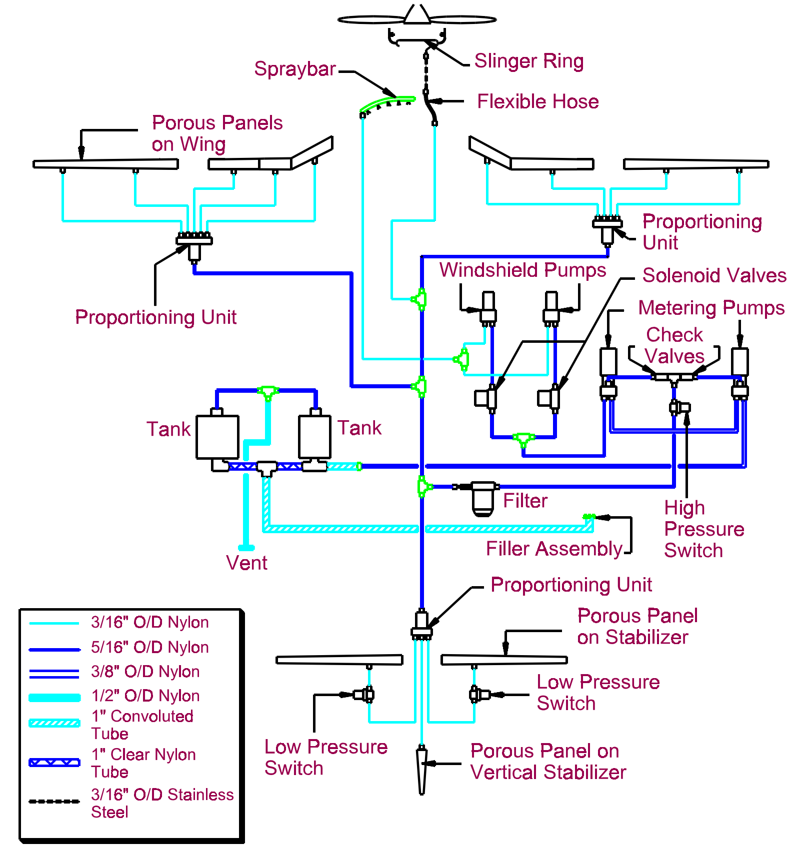


Typical Installation STC TKS System Schematic (Beech A36 Bonanza)

Each system is provided with a fluid reservoir that ensures a minimum ice protection endurance when filled. All systems are designed for a minimum anti-ice endurance of 2.5 hours. The endurance can be increased dependent on available volume for the reservoir and weight constraints on the amount of carried fluid. For the high performance single, the design fluid quantity typically falls in a range of 6 to 7.8 gallons.

Known Icing Style Control Panel

The system is operated and monitored through a control panel in the cockpit. All modes of operation and selection for the metering and windshield pumps are controlled through the panel. Coupled to a float sensor in the reservoir, the remaining quantity of fluid is displayed.



Typical Known-Ice STC TKS System Schematic (Mooney)

The operational state of the system may also be monitored with the panel. One very important aspect of TKS ice protection is its inherent low power consumption. Little demand is placed on the aircraft's electrical system by the TKS system. A 28-volt TKS system will typically draw 1.5 Amps of current during normal operation. Complete airframe ice protection is provided for a fraction of the power consumption of a resistance heating device on the airframe.

System Weight

The weight of a TKS ice protection system for a high performance, single engine aircraft will typically fall between 35 to 40 pounds without fluid. The final value is dependent on the size of the aircraft, the coverage and size of the leading edge panels, and the configuration of the mechanical components. Systems with components individually mounted tend to be lighter that pallet-based systems, because of the added weight of the pallet framework. The tradeoff is weight versus ease of installation of these components.

Fluid weight depends entirely on the quantity carried. At a weight of 9.2 pounds per gallon, fluid weight falls in the range of 55 to 70 pounds. This weight can, however, be eliminated in non-icing seasons by draining the fluid tank or not replenishing it.

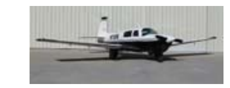
Ice Protection Fluid

The active element of any TKS system is the antifreeze solution. In most instances, three fluids have been approved for use in TKS systems certified in the United States, but one is typically used. This fluid is commonly known as AL-5, manufactured to the British specification DTD 406B.

The fluid is a relatively simple mixture consisting of three parts: 85% ethylene glycol, 5% isopropyl alcohol, and 10% de-ionized water by volume. The fluid weighs 9.2 pounds per gallon. Simple as it is, the fluid is well-filtered before distribution to remove even the smallest contaminants that could adversely affect the operation of a TKS system. The fluid is available from a number of manufacturers in the U.S. and is readily available at a number of fixed-base operators throughout the country.

Systems Available in the United States

Since 1987, the following systems have been certified by STC in the United States and are available to customers:

Aircraft Manufacturer		Model
Beech (Raytheon)		**All model 33 and 36 aircraft, S35 through V35B**
Mooney		**M20J, M20K, M20M, and M20R**
Cessna		**U206F and U206G**
Cessna		**P210, (T)210L, (T)210M, and (T)210N**
Socata		**TB20 and TB21**
Commander Aircraft (Known Ice)		**114B and 114TC**
Cessna (Known Ice)		**P210, (T)210L, (T)210M, and (T)210N**
Aero Commander (Rockwell) (Known Ice)		**500B, 500U, and 500S**
Beech (Raytheon) (Known Ice)		**Baron B55, C,D,E 55, 58**
Mooney (Known Ice)		**M20K, M20M, M20R and M20S**

For more information, or to order your TKS System, contact:

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Check out our website
www.weepingwings.com

(brochures\general\4-page general flyer)

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