

WHITE PAPER

# GIVING ICE THE BOOT

Goodrich pneumatic de-icing systems  
enhance safety in icing conditions



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Pneumatic de-icing systems combine low weight, low cost and low power needs with proven performance that enhances safety when encountering icing conditions.

# INTRODUCTION

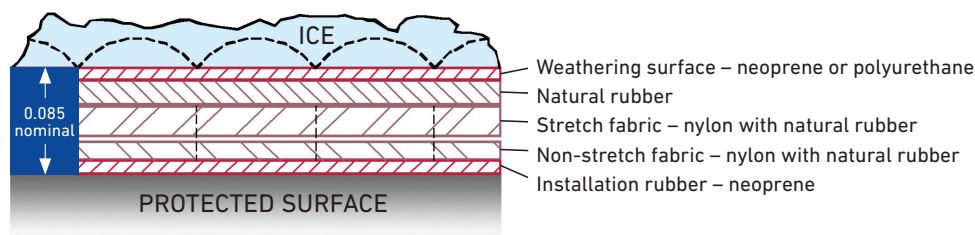
Under certain icing conditions, ice can accumulate rapidly on leading edge surfaces, destroying smooth air flow, increasing drag and decreasing lift. While severe icing has the potential to destabilize an aircraft, the availability of de-icing equipment gives the pilot the tools to combat ice buildup and fly out of icing conditions.

Pilots who fly in regions prone to icing depend on aircraft manufacturers for recommendations on proper operation of de-icing equipment that has been flight tested and certified by the aircraft manufacturer for use on those aircraft. When deciding which type of de-icing system to install on an aircraft, OEMs have a number of choices. The selection is often dictated by the aircraft's size, power, engine type, operating altitude, acquisition and life cycle costs.

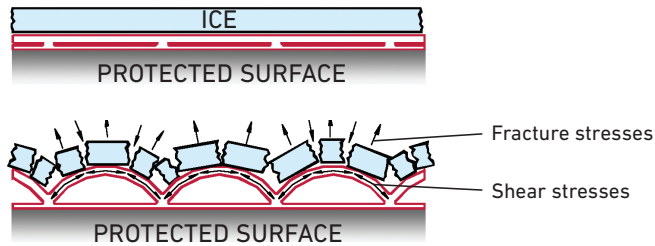
Systems that combat ice accumulation are typically installed on the leading edge of wings, stabilizers and engine air-intake cowlings to prevent or remove ice buildup. Systems vary from inflatable pneumatic boots, to heating systems (engine bleed-air, electric heating elements), to chemical systems (weeping-wing) that weep freezing point depressant liquids. While all of these systems are designed to prevent or dislodge ice buildup on leading edge surfaces and give pilots time to exit the icing environment, pneumatic de-icing boots continue to offer multiple advantages for general aviation, corporate aircraft and commercial turboprops.

This paper examines pneumatic boot de-icing systems and discusses how this type of system enhances flight safety while controlling costs.

### Multi-layer boot construction



### Effects of boot inflation



**Figure 1.** The upper illustration shows the multi-layer construction of a pneumatic de-icing boot. The middle and bottom illustrations show how the inflated narrow tubes of the boot create both fracture and shear stresses that break up and dislodge the ice, allowing the airstream to carry it away. Illustrations not to scale.

## PROVEN PERFORMANCE

Pneumatic de-icing boots were invented in 1930 by Dr. William Geer, a former vice president of research and development for the B.F. Goodrich Company, and were first commercialized on a Northrop Alpha mail airplane in 1932. Then, as today, the ice removal process is much the same. The system consists of inflatable rubber/fabric boots attached to the leading edge of the wing and stabilizers. When ice begins to form on the leading edge, the boot is inflated and cracks the ice off the leading edge, allowing the airstream to remove the ice (see Figure 1). During typical use, the boot is inflated and deflated either manually (pilot activated) or automatically and repeatedly via an electronic timer.

While the basic operating principle of the pneumatic de-icing boot hasn't changed, the boot design and materials have evolved considerably over time. Today's pneumatic de-icing boots feature aerodynamically smooth polyurethane surfaces that both enhance ice removal and improve resistance to rain erosion, sand abrasion and UV/ozone damage. Tube diameters are much smaller (1" versus 3") and inflation and deflation rates are much quicker today — leading to better overall ice removal.

### ATTRIBUTES OF PNEUMATIC DE-ICING BOOTS

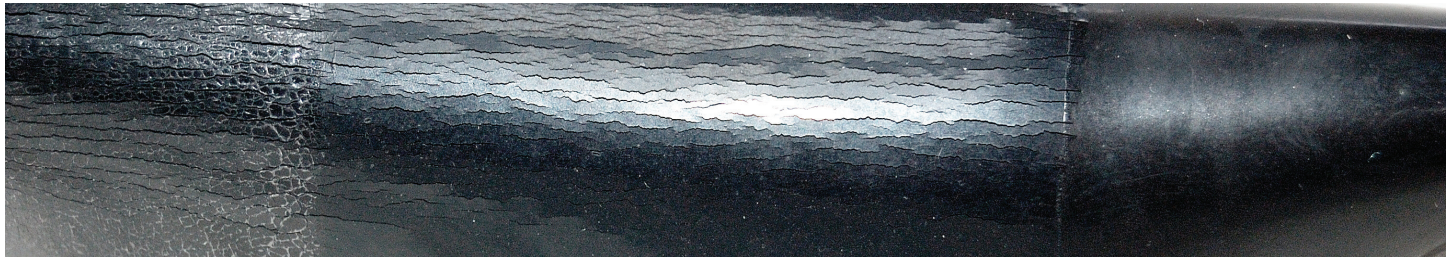
Pneumatic de-icing boots have many advantages in small and medium-size aircraft that make up the bulk of planes flying today (approximately 40,000 aircraft). These attributes should be attractive to pilots, owners and OEMs who are interested in outfitting their aircraft with effective and proven de-icing technology while minimizing installation and operating costs.

**Light weight** – Pneumatic de-icing systems are very lightweight, which is an obvious advantage for small and medium-size aircraft where the extra weight of accessories can make a significant dent in payload capacity. The total weight of a complete pneumatic boot system on a typical twin engine business aircraft is approximately 50 pounds.

**Low power requirement** – Since the power to operate a de-icing system must ultimately come from the aircraft's engine(s), low power draw pneumatic systems save fuel and draw minimal power from the engines. For example, less than one horsepower is drawn off the engines continuously to operate an ejector that provides vacuum hold-down for the boots and assists in deflating them following an inflation cycle. A maximum of one amp of electrical current is required for six seconds at 28 VDC to cycle the inflation valve solenoids. Bleed-air systems and electric heating systems all require more power to operate, making these system types better suited to larger multi-engine turboprop and jet aircraft that have larger airframes and more available power.

**Low cost** – Pneumatic boot systems are a proven and effective de-icing solution and are economical to purchase and operate. Pneumatic systems also have one of the lowest operating costs — even when the cost of maintenance and eventual boot replacement is considered.

**Proven and well-accepted technology** – Pneumatic de-icing systems have been deployed on small and medium-size aircraft for nearly as long as planes have been flying. This technology has proven itself in countless airborne icing encounters worldwide. Today's pneumatic de-icing systems are simple to operate, rugged and effective.



**Figure 2.** Neoprene pneumatic de-icing boot surface material that has been exposed to ozone. The right side was treated with a recommended treatment material.

## BOOT MAINTENANCE

***Durability*** – Like any system on a modern aircraft, a pneumatic de-icing boot requires regular maintenance — such as inspection for cuts or abrasions and treatment with products that preserve the boot material and enhance ice removal. Planes that are hangared regularly and see moderate flight time can often have useful boot life in excess of three years. In general, the life of a pneumatic de-icing boot is affected by the number of annual flight hours and how many times the boots are cycled. Boot life can be greatly extended by use of factory authorized treatment materials.

It has been suggested that exposure to UV light is a primary cause of weathering and deterioration of neoprene surface materials. Rather, it is exposure to ozone that can lead to surface crazing if left untreated. Figure 2 shows a strip of neoprene surface material that has been exposed to ozone. The right end of the strip was treated with a recommended treatment material, Age-Master® No. 1.

The middle portion of the strip was untreated, and the left end was treated with PBS Boot Sealant.

## CONCLUSION

Pilots, owners and manufacturers should give careful consideration to the selection of an appropriate de-icing system. While there are a number of de-icing systems to choose from, pneumatic de-icing boots are a proven and effective technology that is used in a wide variety of general aviation, business and commercial aircraft. They offer significant advantages over other de-icing technologies in the type of aircraft for which they are best suited. Among these positive attributes are light weight, low power consumption, low cost and proven performance. With proper care, pneumatic de-icing boots are designed to provide years of safe operation.



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