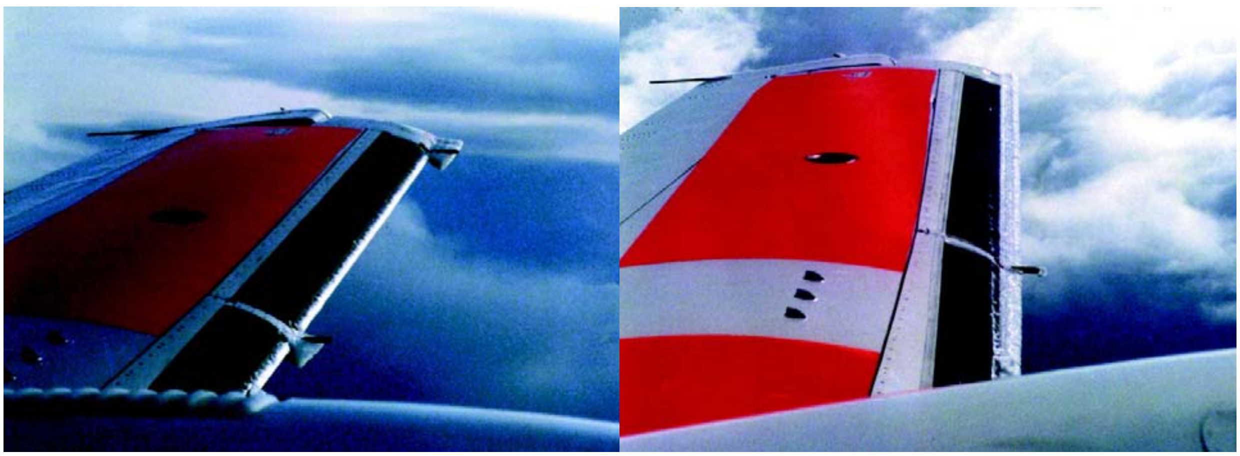
Introduction to Icing Certification

During icing certification potential icing threats are evaluated through analyses and tests to ensure the aircraft can operate safely in icing conditions.

- Ice accumulations on airframes can result in:
  - Loss of control of the aircraft due to:
    - Increased stall speed resulting from the presence of ice on the wing leading edge.
    - Loss of airfoil effectiveness resulting from the presence of ice on the wing and stabilizers' leading edges.
    - Changes in control forces resulting from the presence of ice on the wing and stabilizers' leading edges.
  - Increased drag.



The picture on the left shows ice accretion on the wing during normal operation of the deicing boots. The picture on the right shows ice accretion on the wing following a simulated failure of the deicing boots.

- Ice accumulations on engines can cause damage to the engine as ice is shed. They can affect operation of air scoops by restricting engine airflow and degrading engine performance. Ice accumulations on engines can also cause a loss of power.

- Ice accumulations on propellers can cause loss of thrust, excessive vibration, or damage to the fuselage when ice is removed (shed) by centrifugal force.

The above picture is of an engine intake and propeller icing during flight tests using an icing tanker aircraft.

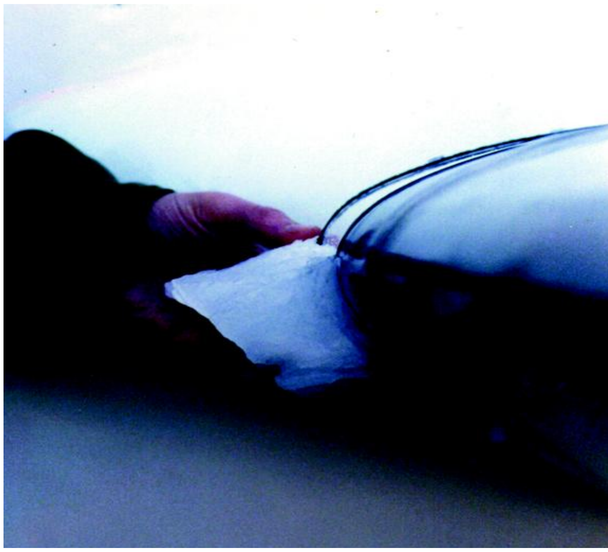
- Ice accumulations on windshields can affect visibility.

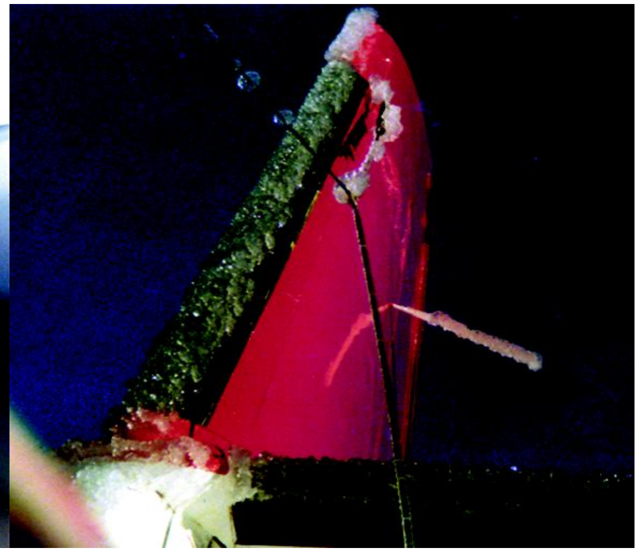
The above picture shows ice accretion on the windshield and wipers following flight in severe icing conditions.

- Ice accumulations, runback, refreeze, or rain/slush spray can affect instruments such as pitot tubes, pressure probes, and stall warning indicators (angle-of-attack sensors).

Part 25 certification permits issuance of a type certificate without approval for flight in icing. Such an airplane is prohibited from flight in known or forecast icing conditions. However, it is not economically feasible to produce a Part 25 airplane that is not approved for flight in icing. Even if the airplane is not approved for flight in icing § 25.1093(b) requires that the turbine engine and its air inlet system must operate in icing conditions. This rule is predicated on the fact that even if an airplane is not certificated for flight in icing the airplane may inadvertently encounter icing. During those encounters the engines must be capable of operating so the airplane can safely exit the icing conditions.

If approval for flight in icing is desired 14 CFR Part 25.1419 requires that the airplane must be able to safely operate in the continuous maximum and intermittent maximum icing conditions of part 25, Appendix C. The aircraft must be protected from ice accumulation on airfoils, control surfaces, engines, propellers, and other flight critical systems by ice protection systems or the aircraft must be able to safely operate with ice accretions. Substantiation for flight in icing approval typically utilizes a combination of analyses, dry air flight tests with and without artificial ice shapes, icing and wind tunnels, tankers, and ultimately flight tests in natural icing conditions.





The picture on the left is of a post flight ice accretion on an unprotected area of the outboard wing leading edge. The picture on the right is of ice accretion on the vertical stabilizer (fin) and horizontal stabilizer following a simulated failure of the deicing boots.

The applicant determines the ice that can accrete on the protected and unprotected surfaces of the airplane while operating in the Appendix C icing conditions.

Figure 1

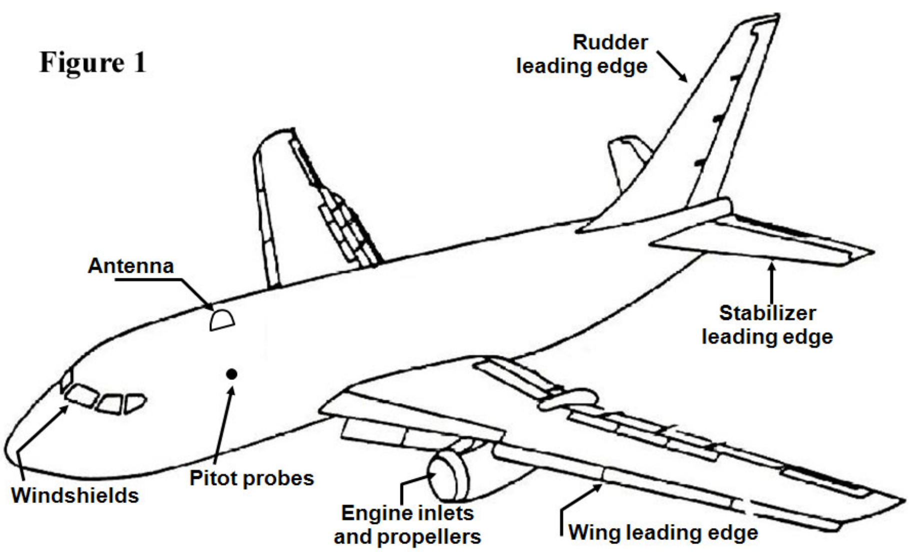


Figure 1 shows the areas of the airframe and engine that may need ice protection.

For protected surfaces there may be accretions present prior to activation of the ice protection system and inter-cycle ice accretions if the ice protection system operates cyclically. Dry air flight tests with artificial ice shapes installed allows airplane performance and handling characteristics to be evaluated in stable dry air conditions with the critical ice shape remaining a constant (i.e., no change of ice accretion due to erosion, shedding, sublimation, etc., as can occur with natural ice shapes). To verify analyses § 25.1419 requires the airplane to be flight tested in measured natural atmospheric icing conditions.

The above picture is of artificial ice shapes (shown in red) on the unprotected areas of the wing leading edges and also simulated runback ice behind the protected leading edges.

Ice protection systems are divided into two main categories:

- Anti-icing: The prevention of ice formation or accumulation on a protected surface either by evaporating the impinging water or by allowing it to run back and off the surface or freeze on areas aft of the protected area.

- Deicing: Removal or the process of removal of an ice accretion after it has formed on a surface.

The most common types of ice protection systems are hot air and pneumatic deicing boots.

- Hot (engine bleed) air.

    - Heat is used either to prevent freezing of water droplets (running wet systems) or evaporate droplets.

    - The heat is typically obtained from the engines. For the descent phase of flight the engine may not be able to produce enough heat for the ice protection system to be fully evaporative.

    - Hot air systems can be operated continuously (anti-icing) or cyclically (deicing)

Figure 2

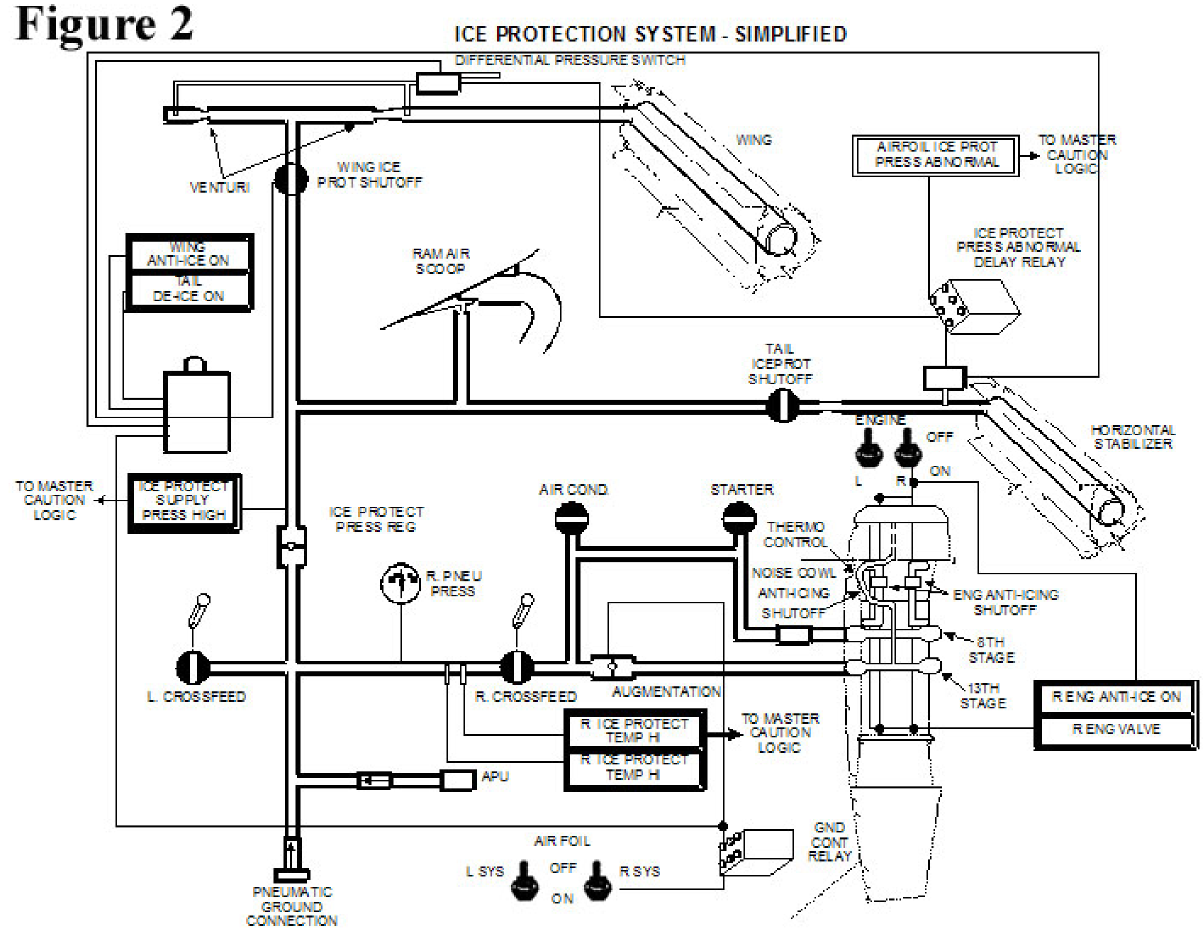


Figure 2 is a schematic of a hot air anti-icing system.

- Pneumatic deicing boots
  - Expandable boots are inflatable devices used to fracture the ice accretions and the airflow helps the ice accretions to shed from the protected surface.
  - Boots are pneumatically driven and inflate either spanwise or chordwise on the wing.

Figure 3

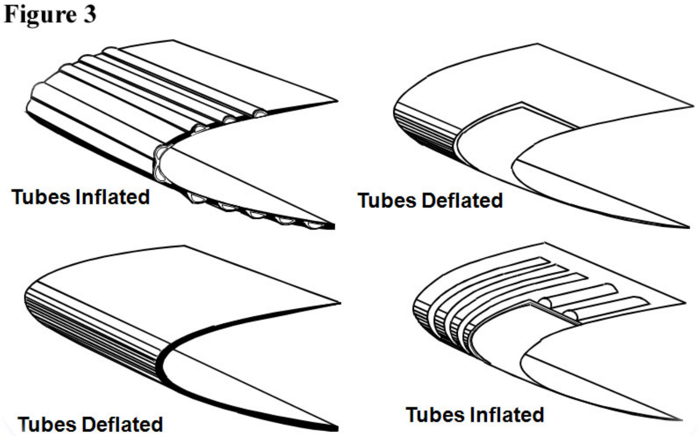


Figure 3 shows deicing boots installed in a spanwise and chordwise orientations and both in the inflated and deflated states.

- Pressure is usually supplied by engine bleed air. Typical operating pressures are 15 to 21 psig.
- Vacuum is required to hold the boots down when not inflated.
- Newer airplanes have automatic boot timers so the boots inflate periodically (typically every 1 and/or 3 minutes) once the system is activated for the initial time. In between the boot activation cycles ice will accrete. This is called inter-cycle ice which may affect the performance and handling of the airplane.

Figure 4

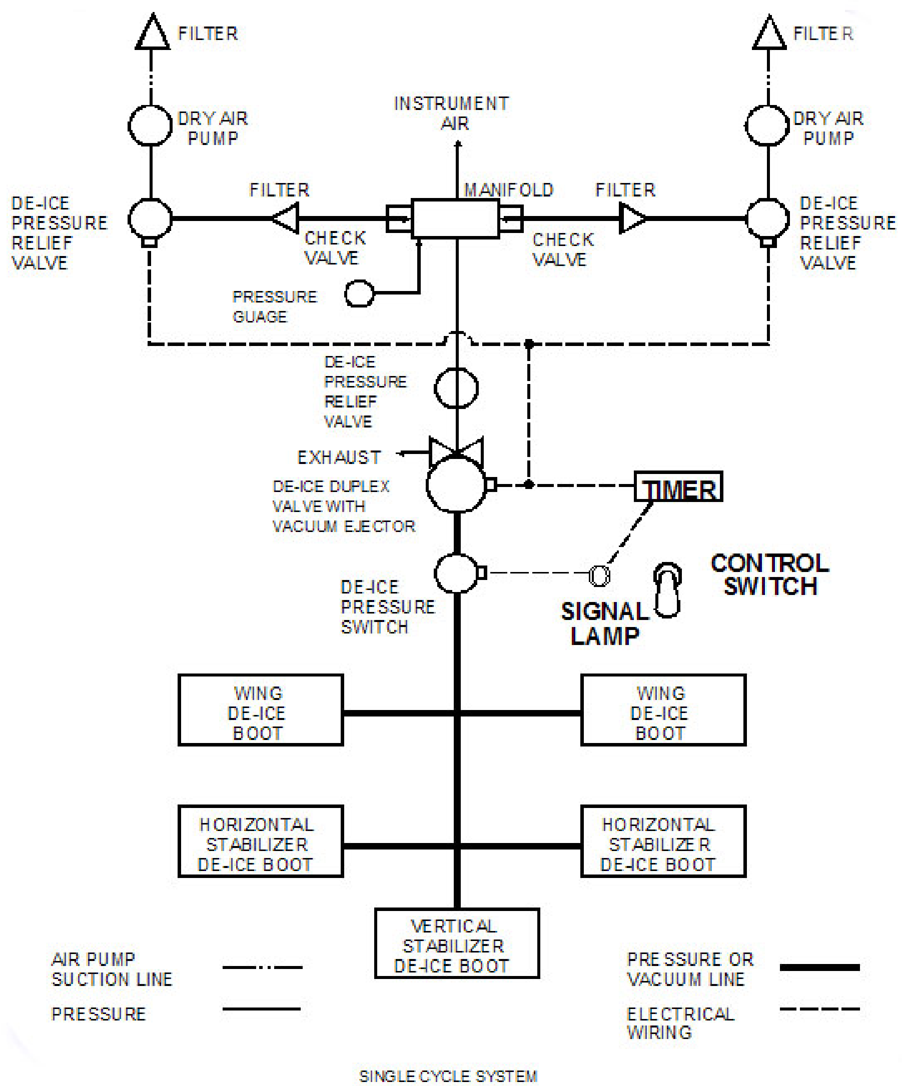


Figure 4 is a schematic of a pneumatic deicing boot system.

As previously mentioned, 14 CFR Part 25.1419 requires that the airplane must be able to safely operate in the continuous maximum and intermittent maximum icing conditions of part 25, Appendix C. These icing conditions address approximately 99% of all aircraft icing encounters. For those severe conditions which exceed the icing envelope identified within Appendix C, safety of flight is predicated on the flight crew's ability to recognize when severe icing is being encountered, and to initiate flight path changes in order to avoid and/or escape these conditions.