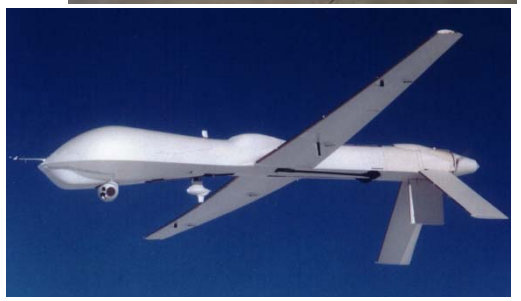
Why Should You Consider a Freezing Point Depressant Ice Protection System?

Icing Certification Present and Future

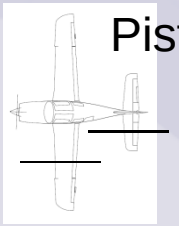
OVERVIEW

- **Presentation Aircraft**
- **Review of Current Icing Environments**
- **Pending Changes to Icing Environments (Appendix O)**
- **Effects of the Addition of Appendix O**
- **Why You Should Consider a Freezing Point Depressant Ice Protection System.**

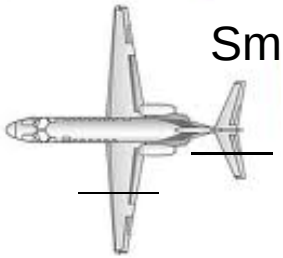


Presentation Aircraft

Piston Single

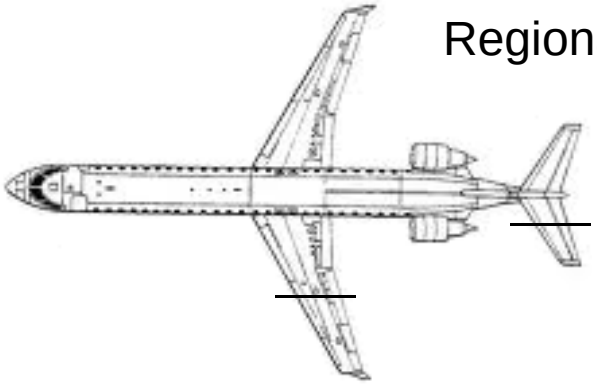


Small Jet

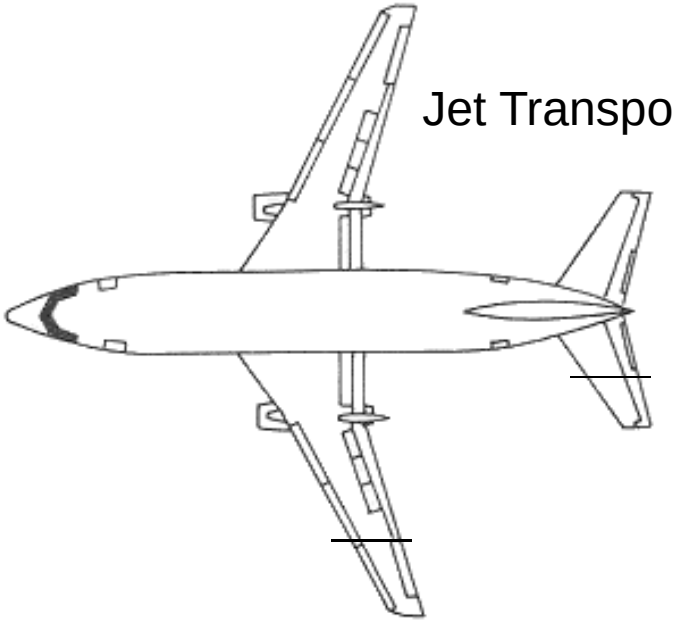


Presentation aircraft used for icing analysis

Regional Jet



Jet Transport



- **Icing analysis was done on the a representative tail and wing section for each aircraft near the marked location**
  - **NACA 23012 used as wing airfoil**
  - **NACA 0012 used for tail airfoil**
  - **Chords estimated for section shown**

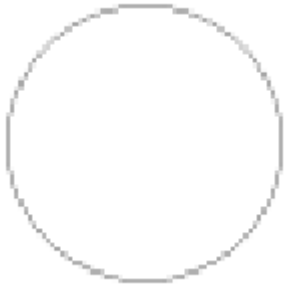
Review of Current Icing Environments

- **FAR 25 (CS 25) Appendix C icing envelopes: Maximum Continuous and Intermittent Maximum**
  - **Maximum Continuous**
    - **Liquid Water Content (LWC) 0.8 to 0.08 grams per cubic meter**
    - **Droplet sizes of 15 to 40 microns**
    - **Temperatures 32° F to -22° F (0° C to -30° C)**
    - **Horizontal cloud extent with a LWC factor of 1 is 17.4 nautical miles (32.22 km)**
  - **Intermittent Maximum**
    - **Liquid Water Content (LWC) 2.8 to 0.2 grams per cubic meter**
    - **Droplet sizes of 15 to 50 microns**
    - **Temperatures 32° F to -22 ° F (0° C to -30° C)**
    - **Horizontal cloud extent with a LWC factor of 1 is 2.6 nautical miles (4.82 km)**

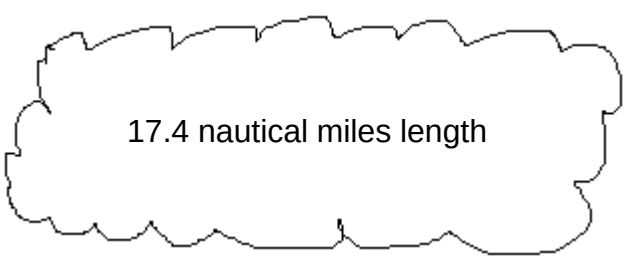
Review of Current Icing Environments

Current FAR 25 (CS 25) Appendix C Maximum Droplet Size

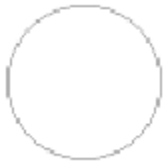
Human Hair (90 Microns)



Maximum Continuous Icing Cloud (40 Microns)



Maximum Intermittent Icing Cloud (50 Microns)



2.6 nautical miles length

Review of Current Icing Environments

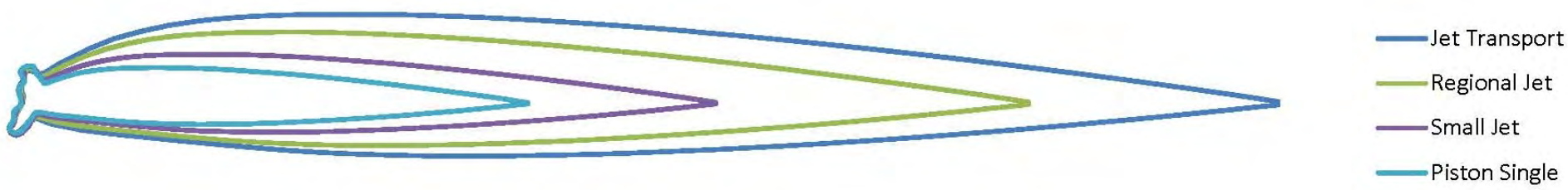
- **Ice shape analysis performed at same conditions for each size of aircraft for comparative purposes**
  - **Liquid Water Content (LWC) of 0.5 grams per cubic meter**
  - **Droplet size of 22 microns**
  - **Temperature of 15.8° F (-9° C)**
  - **AOA of 0°**
  - **Altitude of 22K feet (6705 m)**
  - **Speed of 214 KTAS (110 m/s)**

Aircraft	Wing Chord	Tail Chord
Single Engine	48” (1.2192m)	30” (0.762m)
Business	66” (1.6764m)	48” (1.2192m)
Regional	96” (2.4384)	60” (1.524m)
Transport	120” (3.048m)	120” (3.048m)

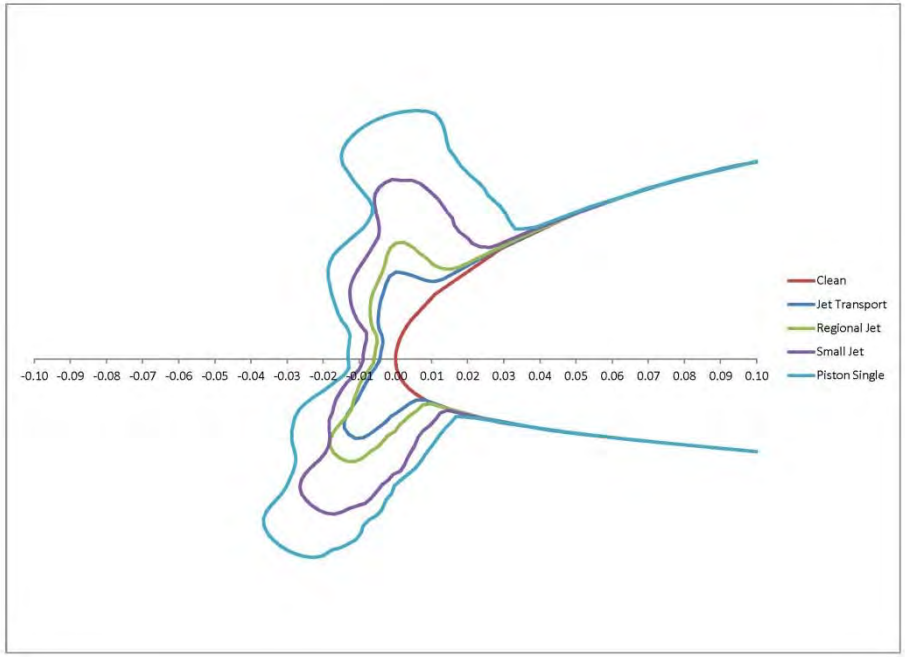
Review of Current Icing Environments

Current 45 Minute Wing Ice Shapes For Example Aircraft

The ice shape remains essentially the same size and shape as the chord length increases



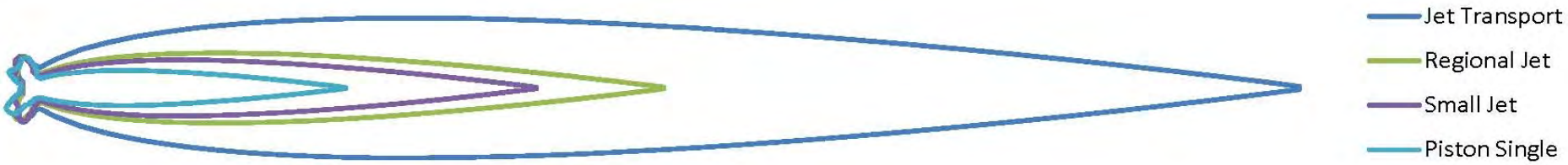
As the airfoil chord length increases, the ice comprises a smaller percent of coverage



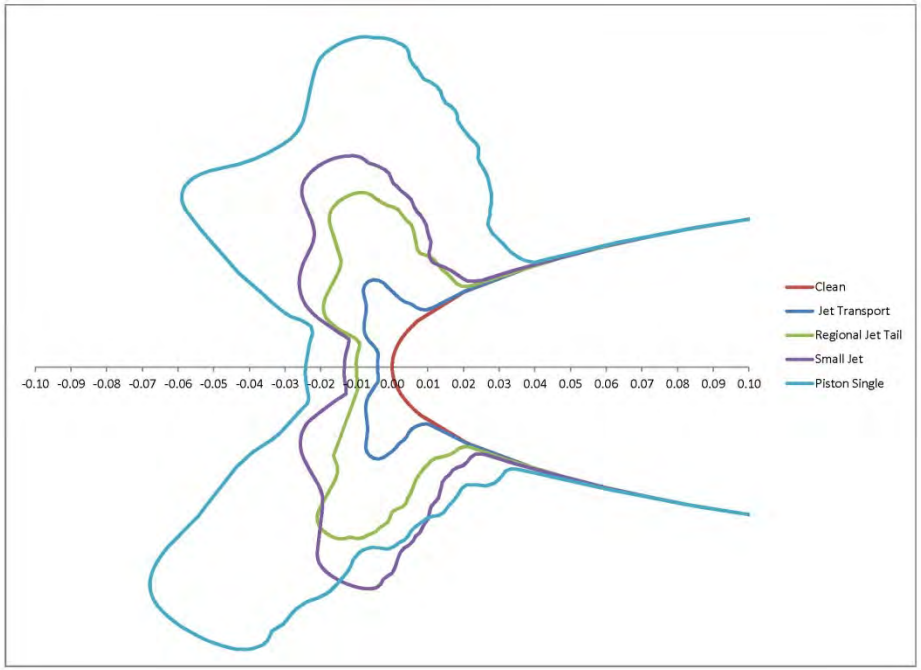
Review of Current Icing Environments

Current 45 Minute Horizontal Ice Shapes For Example Aircraft

The ice shape remains essentially the same size and shape as the chord length increases



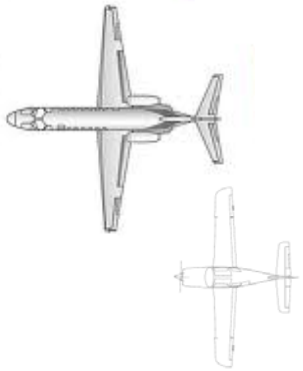
As the airfoil chord length increases, the ice comprises a smaller percent of coverage



Review of Current Icing Environments

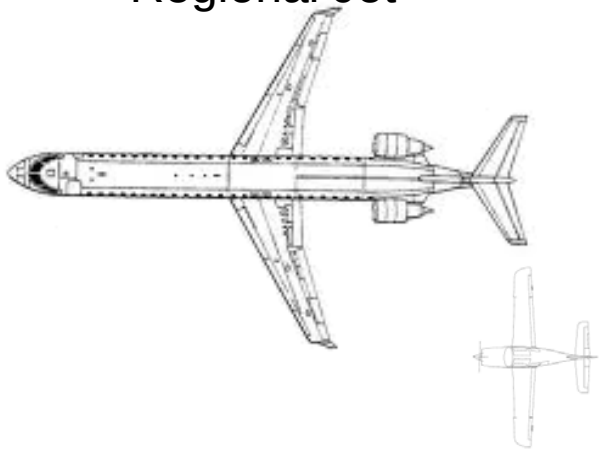
- **As aircraft get smaller, flying through the same icing conditions at the same flight conditions, a greater negative impact on aircraft performance is seen due to the larger percent coverage.**
- **The effect of icing on the Piston Single wing will be similar to the horizontal of Small Jet and Regional Jet. Therefore, the effectiveness of an ice protection system on the Piston Single would also apply to the horizontal of the Small Jet and Regional Jet.**

Small Jet



Piston Single

Regional Jet

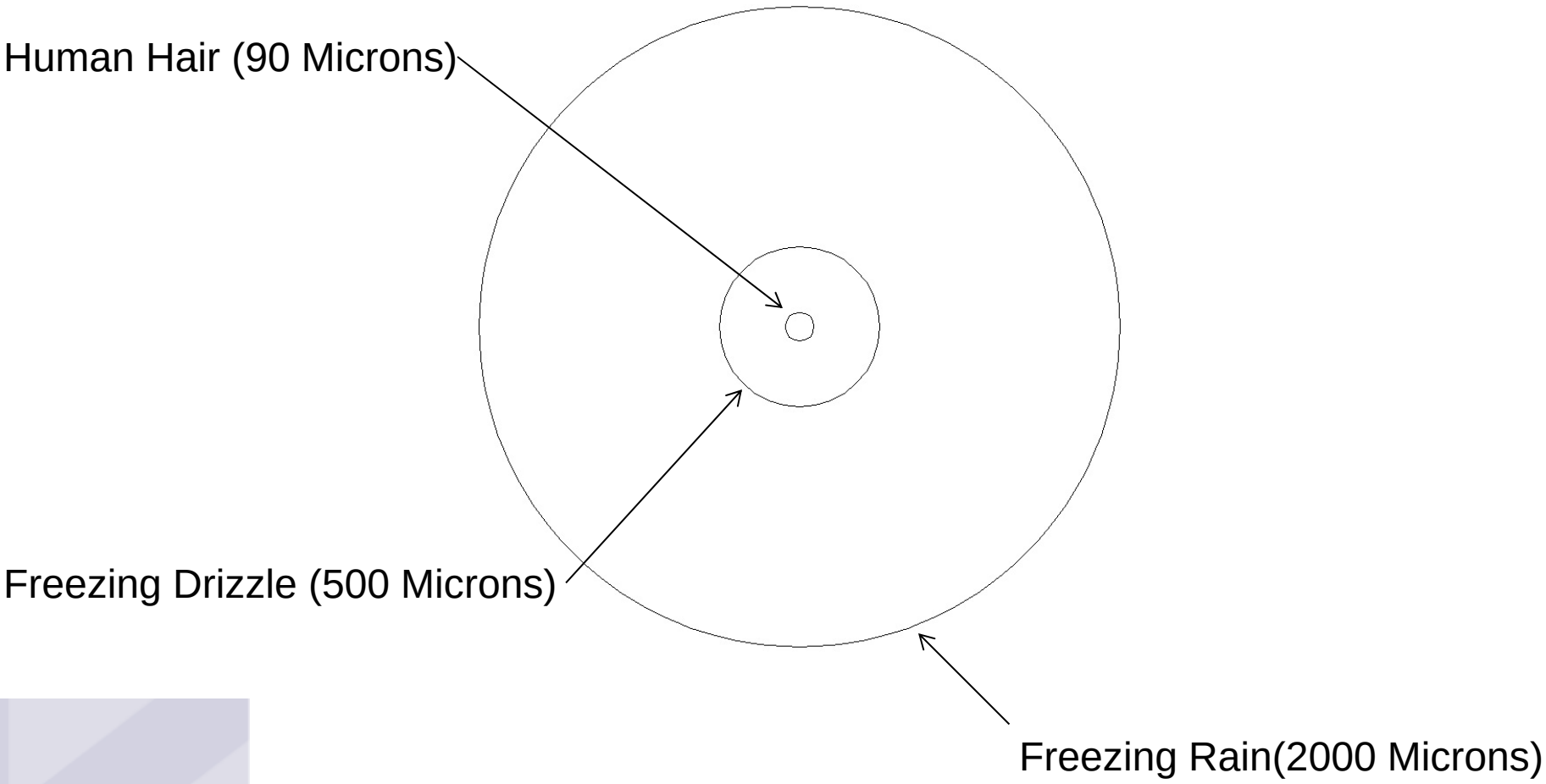


Piston Single

Pending Changes to Icing Environments (Appendix O)

- **FAR 25 Probable Additional Appendix O Icing Envelopes of Freezing Drizzle and Freezing Rain:**
  - **Freezing Drizzle**
    - **Liquid Water Content (LWC) 0.43 to 0.29 grams per cubic meter**
    - **Droplet sizes of 100 to 500 microns**
    - **Temperatures 32° F to -13° F (0° C to -25° C)**
    - **Horizontal cloud extent with a LWC factor of 1 is 17.4 nautical miles (32.22 km)**
  - **Freezing Rain**
    - **Liquid Water Content (LWC) 0.32 to 0.25 grams per cubic meter**
    - **Droplet sizes of 100 to 2000 microns**
    - **Temperatures 32° F to -13° F (0° C to -25° C)**
    - **Horizontal cloud extent with a LWC factor of 1 is 17.4 nautical miles (32.22 km)**

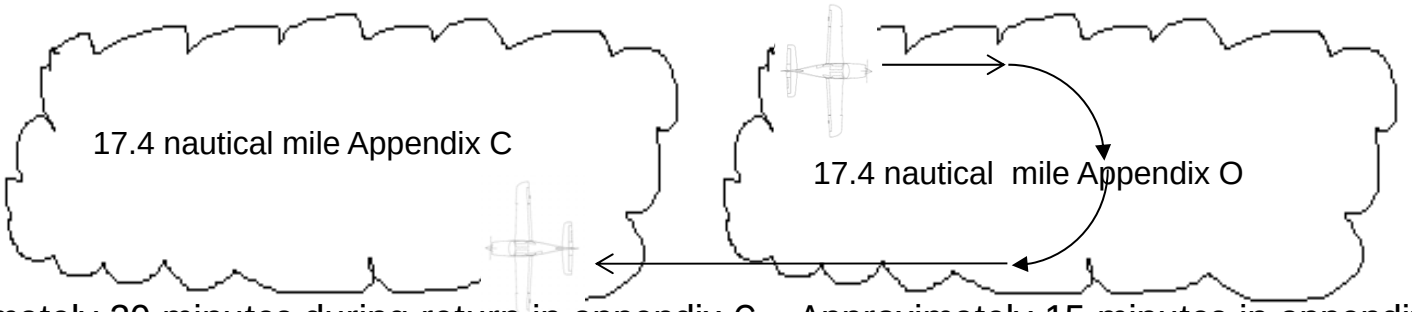
Pending FAR 25 Appendix O Maximum Droplet Size



Effects of the Addition of Appendix O

- **Current proposed methods of certification for the appendix O environment.**
  - **Detect appendix O conditions and then operate safely while exiting all icing conditions (Sec. 25.1420(a)(1))**
    - **Will result in an "exit" ice shape for most ice protection systems**
  - **Safely operate in a selected portion of appendix O conditions, detect when the airplane is operating in conditions that exceed the selected portion, and then operate safely while exiting all icing conditions (Sec. 25.1420 (a)(2))**
  - **Operate safely in all of the appendix O conditions (Sec. 25.1420(a)(3))**

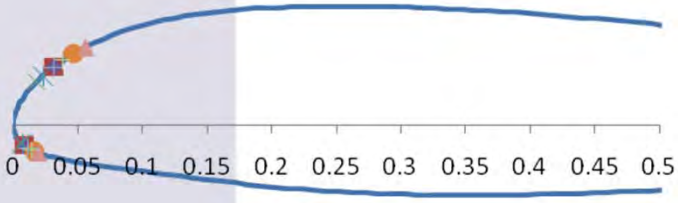
FAA Proposed Detect and Exit Scenario



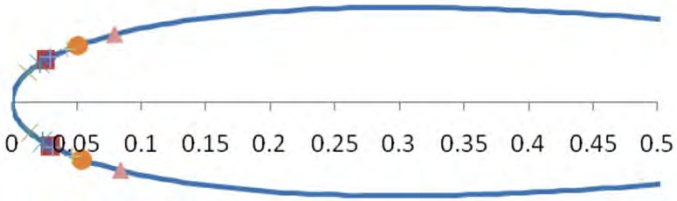
Effects of the Addition of Appendix O

- **Impingement limits greatly increase, requiring ice protection further aft if it's desired to prevent ice shapes from forming**

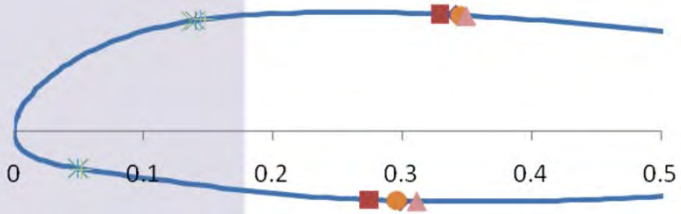
Wing



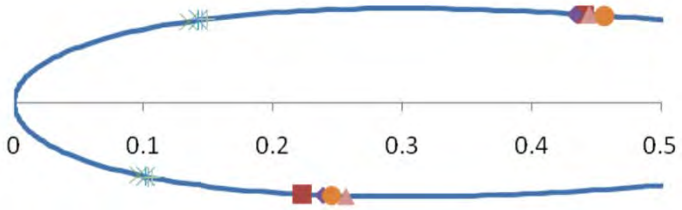
Horizontal



Appendix C
(22 microns)



Appendix O
(1200 microns)



- Transport Impingement Limits
- Regional Impingement Limits
- Buisness Jet Impingement Limits
- Single Engine Impingement Limits
- Transport 10% Beta Limit
- Regional 10% Beta Limit
- Buisness Jet 10% Beta Limit
- Single Engine 10% Beta Limit

Why You Should Consider a Freezing Point Depressant Ice Protection System with the Addition of Appendix O

- **Maintain advantages of a FPD system for Appendix C**
  - **Complete ice protection aft of all protective surfaces (no "inter-cycle", residual, or run back ice shapes)**
  - **Performs as an anti-ice solution within the design envelope and a de-ice system when encountering ice outside of the design envelope. Even in the worse case defined icing environments, a FPD is capable of removing all ice on and aft of the panels after exiting icing conditions.**
  - **Titanium panels can be incorporated as a flush mount to become the leading edge of the protected surface limiting aerodynamic penalties and aesthetic effects.**
  - **Low power requirements.**
  - **Hardware weight alone is comparable to most types of systems.**
  - **Hardware and components (other than the filter/s) are designed to last the life of the aircraft which results in low maintenance costs.**
  - **No change in ice protection performance due to age.**

Why You Should Consider a Freezing Point Depressant Ice Protection System with the Addition of Appendix O

- **Gain advantages of a FPD system for Appendix O**
  - **An appendix C designed system is potentially capable of performing as an anti-ice system in portions of the defined appendix O environment.**
    - **Company investigation on going.**
  - **TKS is capable of clearing all ice, no matter the aft extent, after exiting conditions providing clean surfaces for remainder of flight.**
  - **Can be designed to handle larger portions of the appendix O envelope**
    - **Must determine desired performance versus tank size / fluid quantity / weight.**