Relating Aircraft Icing Intensities

(Trace, Light, Moderate, & Heavy)

to

CFR/CS Part 25, Appendix C

Icing Certification Envelopes

Richard Jeck

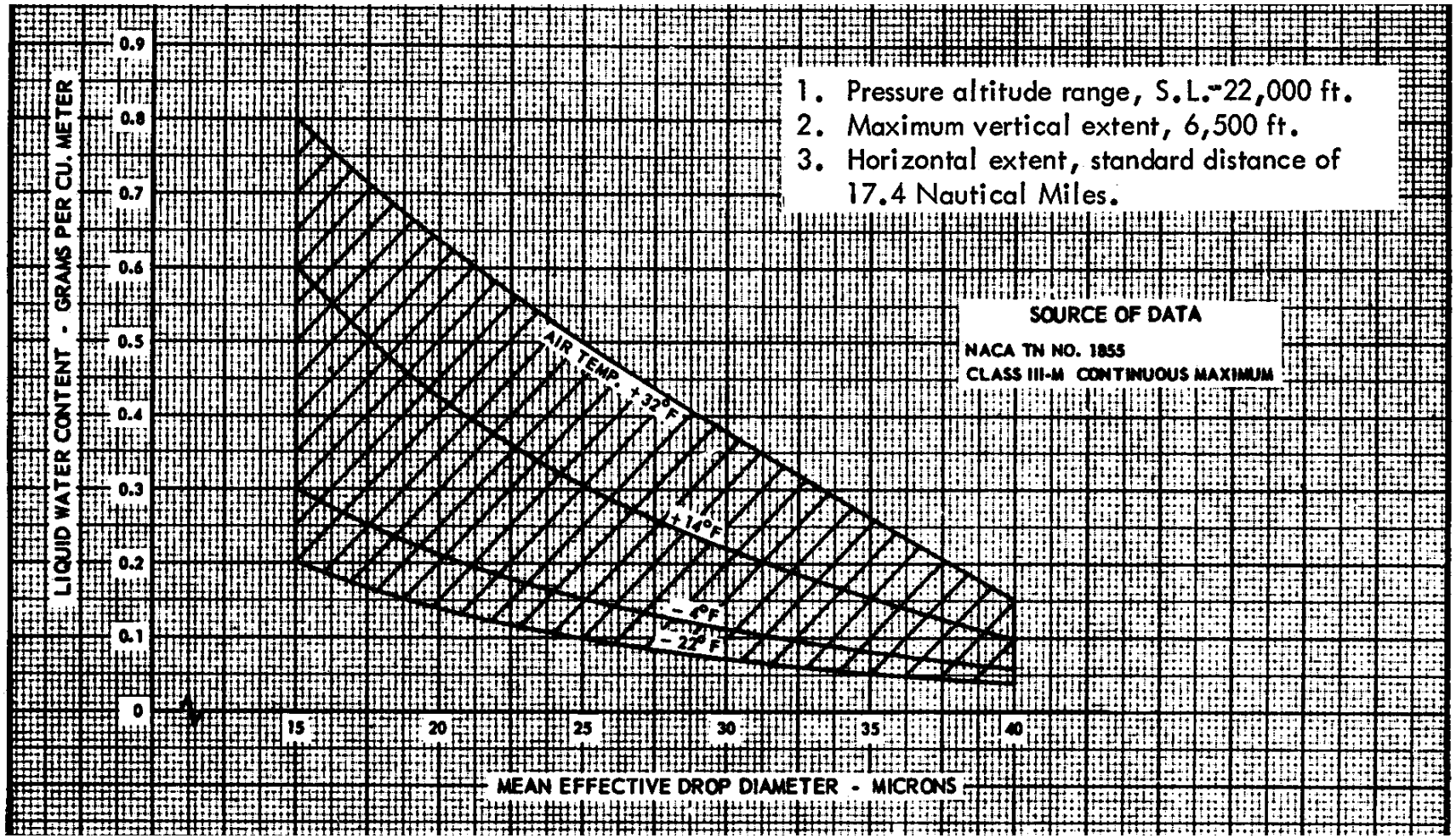
Federal Aviation Administration

Technical Center

CFR/CS 25.1419 ---Ice Protection

"If certification with ice protection provisions is desired, the airplane must be able to safely operate in the continuous maximum and intermittent maximum icing conditions of appendix C."

Appendix C --- Continuous Maximum



Operating Limitations in Icing Conditions (since 1966)

CFR 91.527---General Operating and Flight Rules: Subpart F---Large and Turbine Powered Multiengine Airplanes.

121.341---Operating Requirements: Domestic, Flag, and Supplemental Operations

125.221---Certification & Operations: Airplanes with ≥ 20 Pax or Payload Capacity ≥ 6000 pounds (2730 kg)

135.227---Operating Requirements: Commuter and On-Demand Operations

"Except for an airplane that has ice protection provisions that meet…those for transport category airplane type certification, no pilot may fly---

1) …into known (or forecast) light or moderate icing conditions,

2) …into known or forecast severe icing conditions."

(*but icing conditions are not defined in the regulations!*)

Icing Intensity Definitions in Use since 1964.

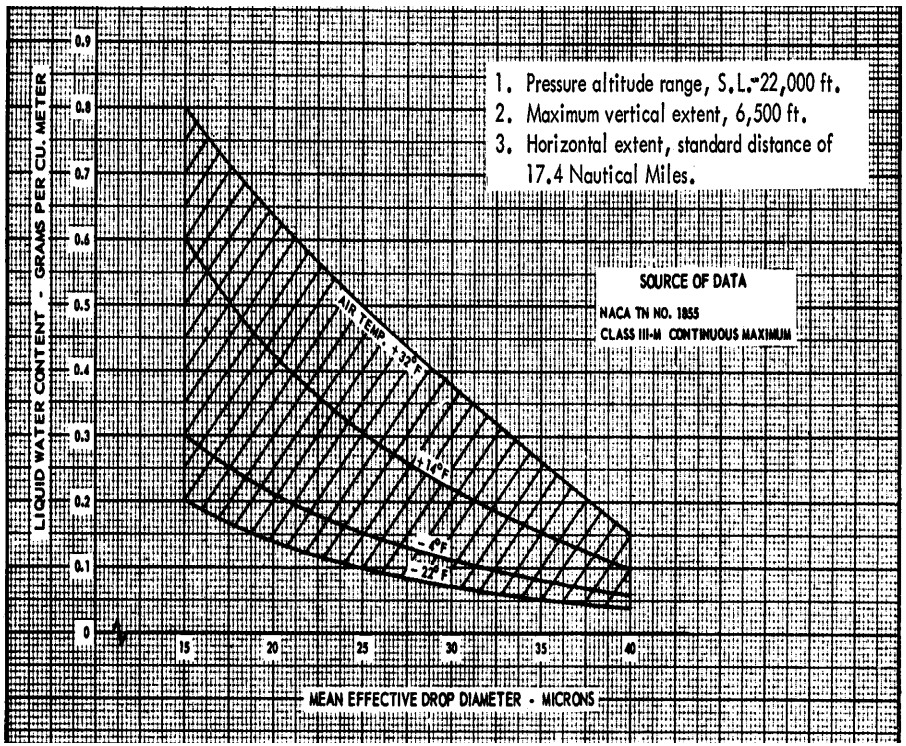
(from the Aeronautical Information Manual (AIM))

Intensity	Definition
Trace	Ice becomes perceptible. Rate of accumulation is slightly greater than the rate of sublimation. It is not hazardous even though deicing/anti-icing equipment is not utilized, unless encountered for an extended period of time (over 1 hour).
Light	The rate of accumulation may create a problem if flight is prolonged in this environment (over 1 hour). Occasional use of deicing/anti-icing equipment removes/prevents accumulation. It does not present a problem if the deicing/anti-icing equipment is used.
Moderate	The rate of accumulation is such that even short encounters become potentially hazardous and use of deicing/anti-icing equipment or flight diversion is necessary.
Severe	The rate of accumulation is such that deicing/anti-icing equipment fails to reduce or control the hazard. Immediate flight diversion is necessary.

(Non-specific rates of accumulation offer *nothing* to measure or compute!)

How do You Relate

This



To This ?

Light The rate of accumulation may create a problem if flight is prolonged in this environment (over 1 hour). Occasional use of deicing/anti-icing equipment removes/prevents accumulation. It does not present a problem if the deicing/anti-icing equipment is used.

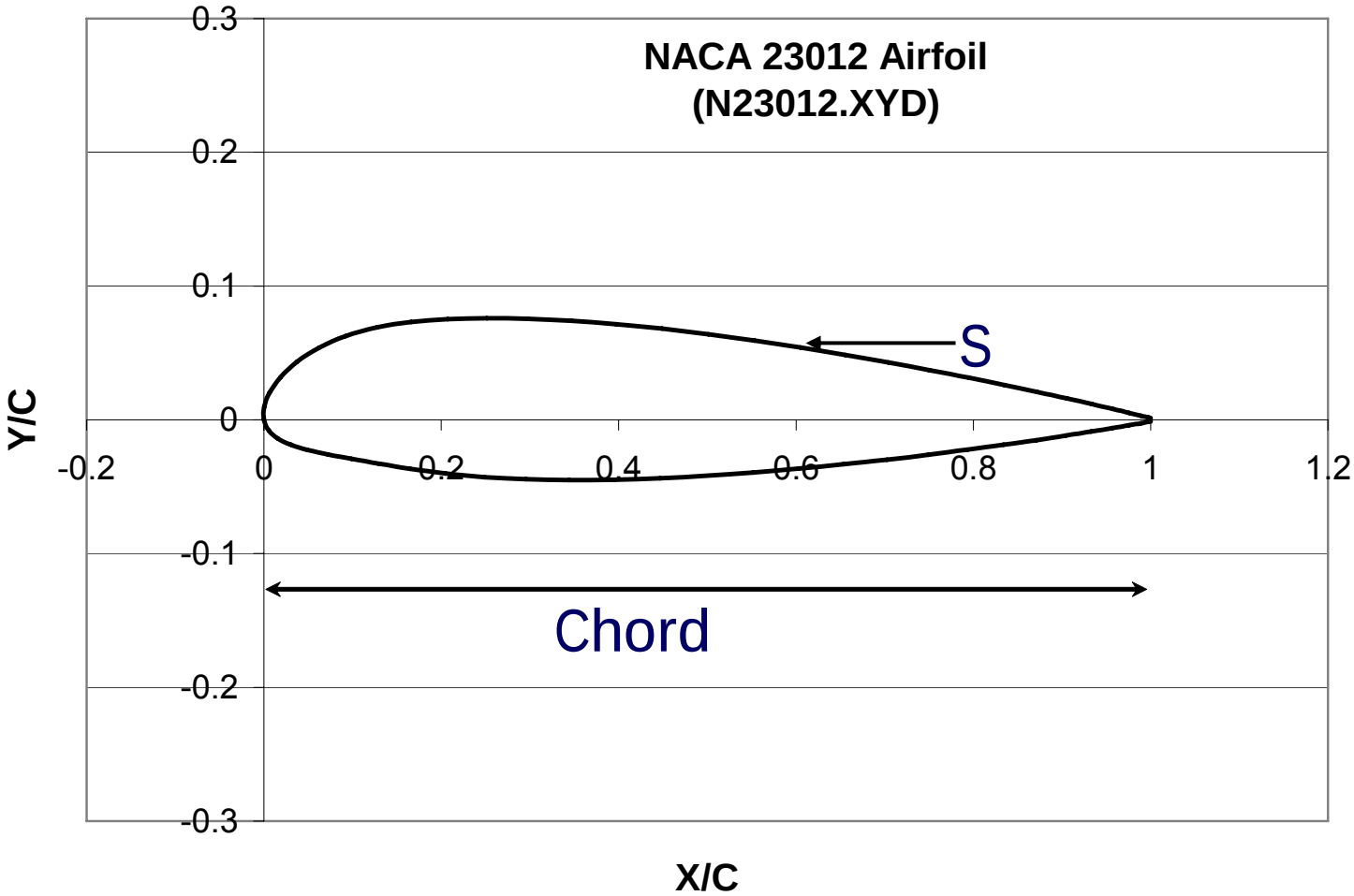
Moderate The rate of accumulation is such that even short encounters become potentially hazardous and use of deicing/anti-icing equipment or flight diversion is necessary.

Severe The rate of accumulation is such that deicing/anti-icing equipment fails to reduce or control the hazard. Immediate flight diversion is necessary.

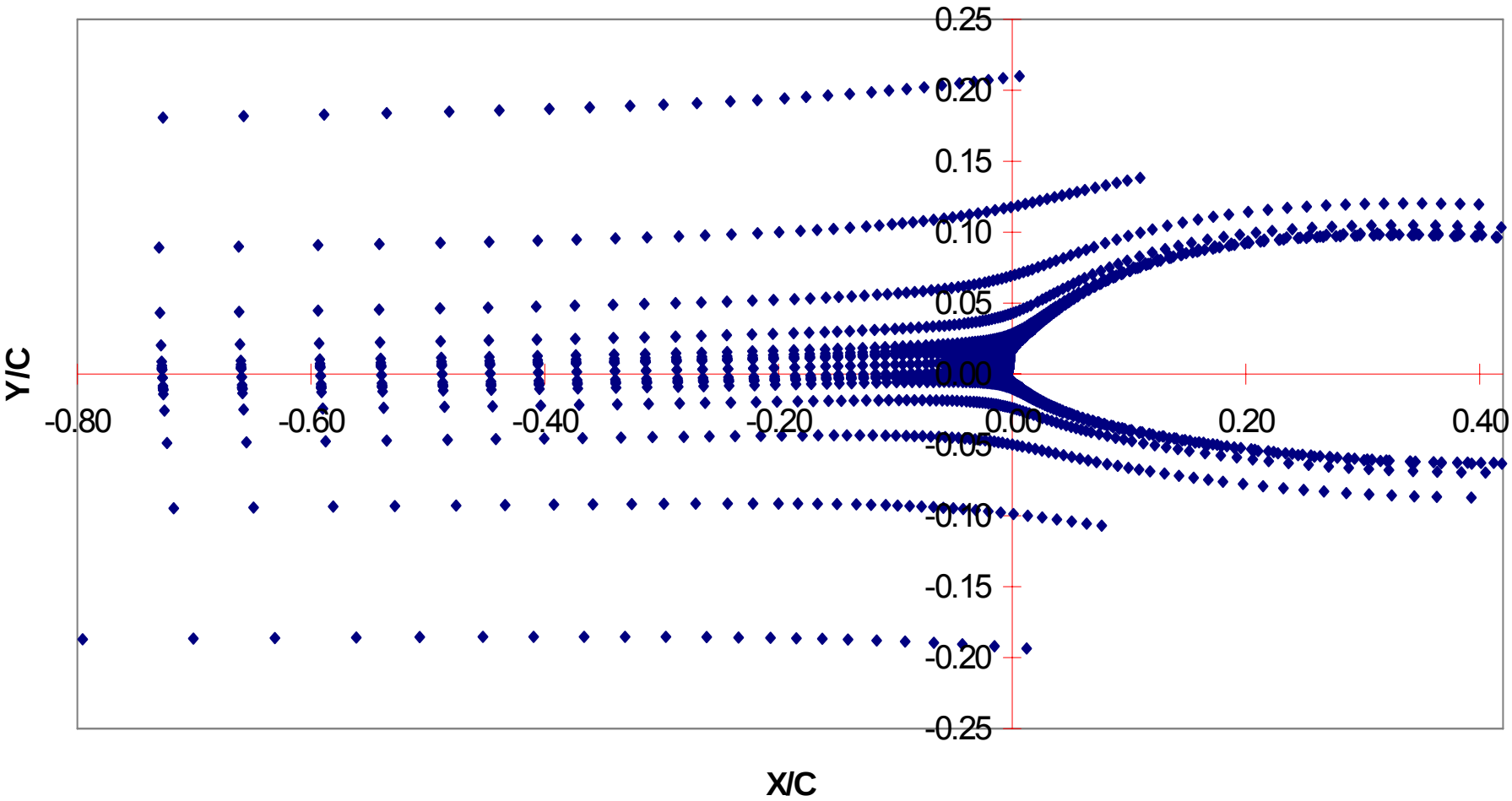
New *Engineering* Icing Intensity Definitions Proposed by the FAA Task 1-B Working Group.

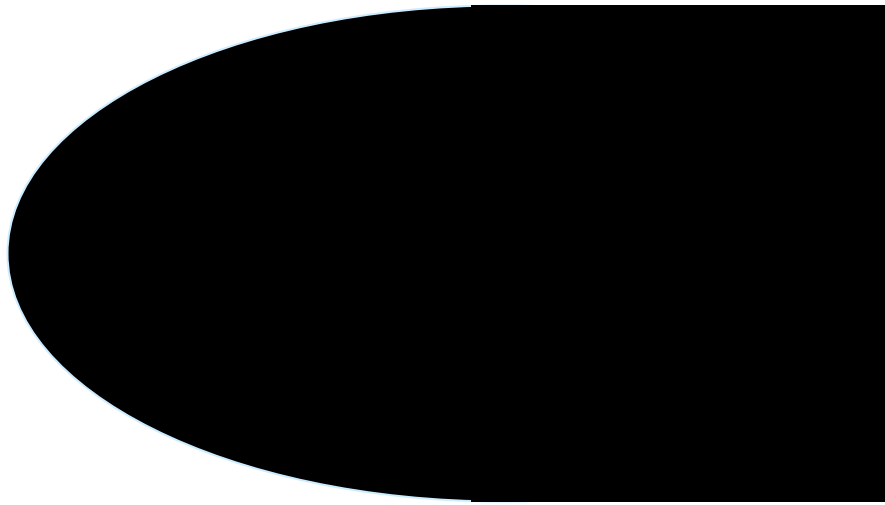
Intensity	**Icing Rate**		
	inches/hr	cm/hr	mm/minute
Trace	< ¼	< 0.6	< 0.1
Light	¼ to 1	0.6 to 2.5	0.1 to 0.4
Moderate	1 to 3	2.5 to 7.5	0.4 to 1.3
Heavy	> 3	> 7.5	> 1.3

(These are *reasonable, measurable and calculable!*)


NACA 23012 Airfoil
(N23012.XYD)
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
Y/C
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
X/C
S
Chord

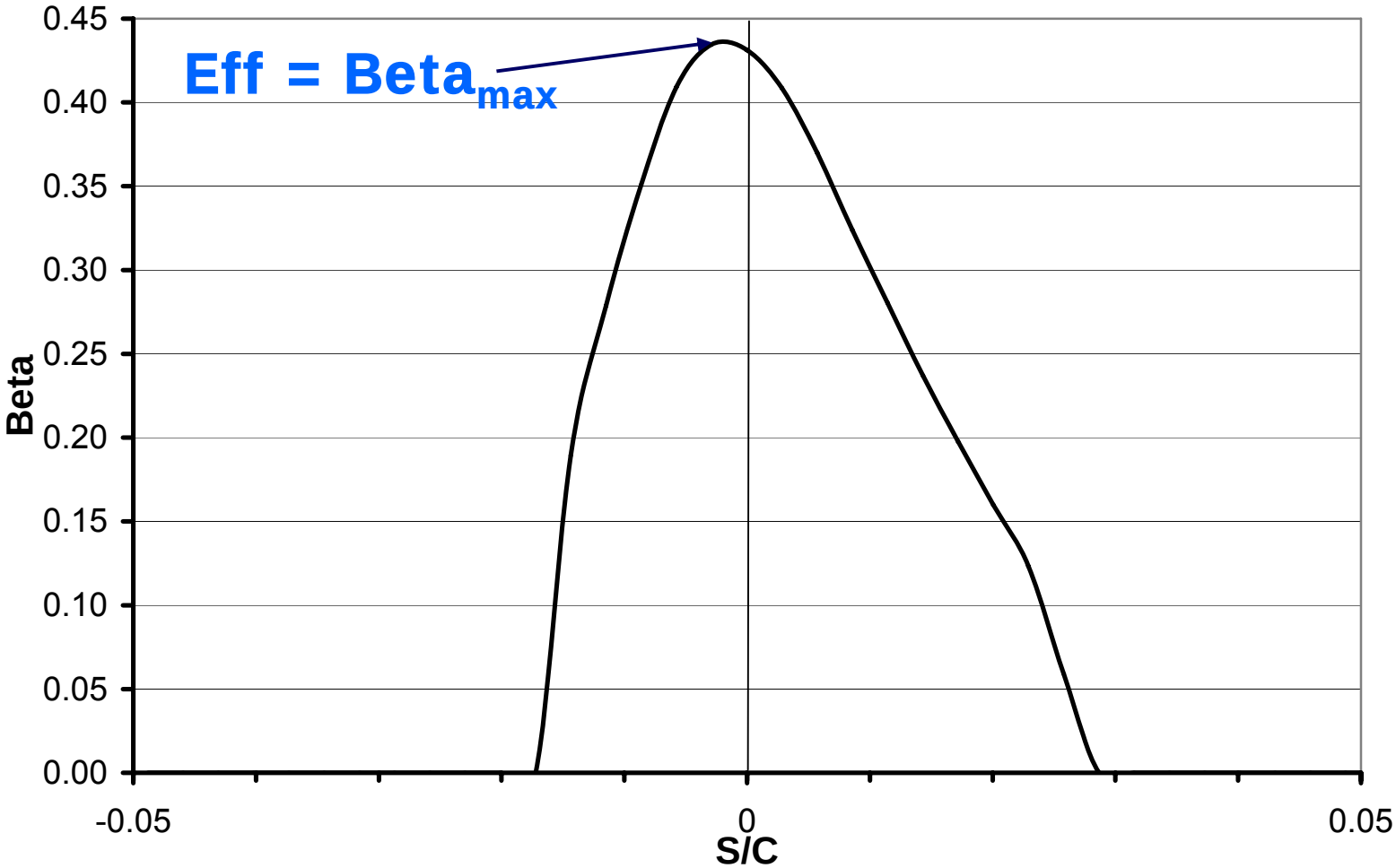
Trajectories for 15 µm drops @ 180 kt





Icing Rate = LWC•Eff•TAS / ρ_{ice}

TAS = 180 kt, MVD = 15 µm



LWC = Icing Rate • ρ / (Eff • TAS)

Example: NACA 23012

chord = 1.22 m

(C-208 “Caravan” outer wing)

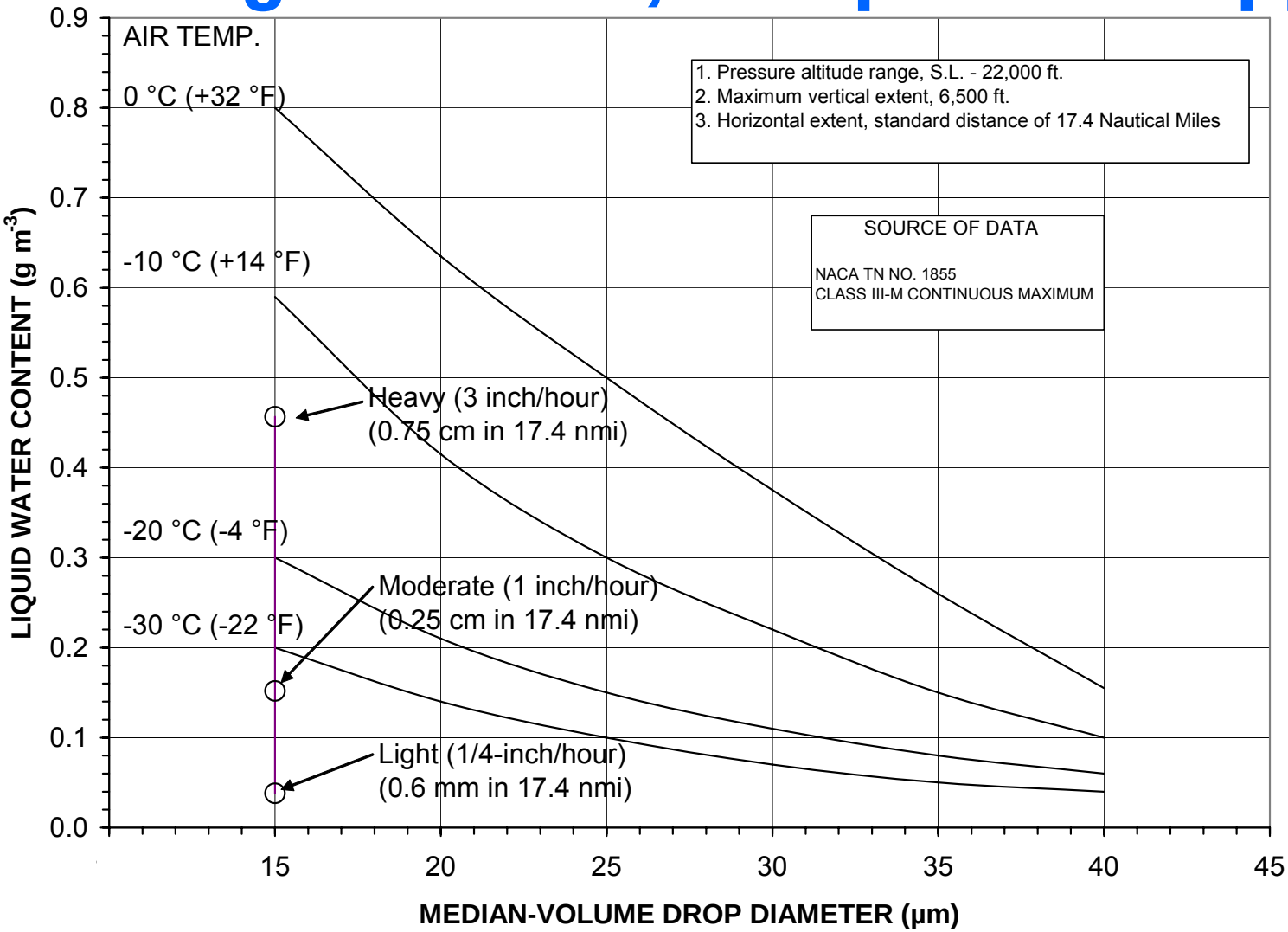
TAS = 180 kt

MVD = 15 µm

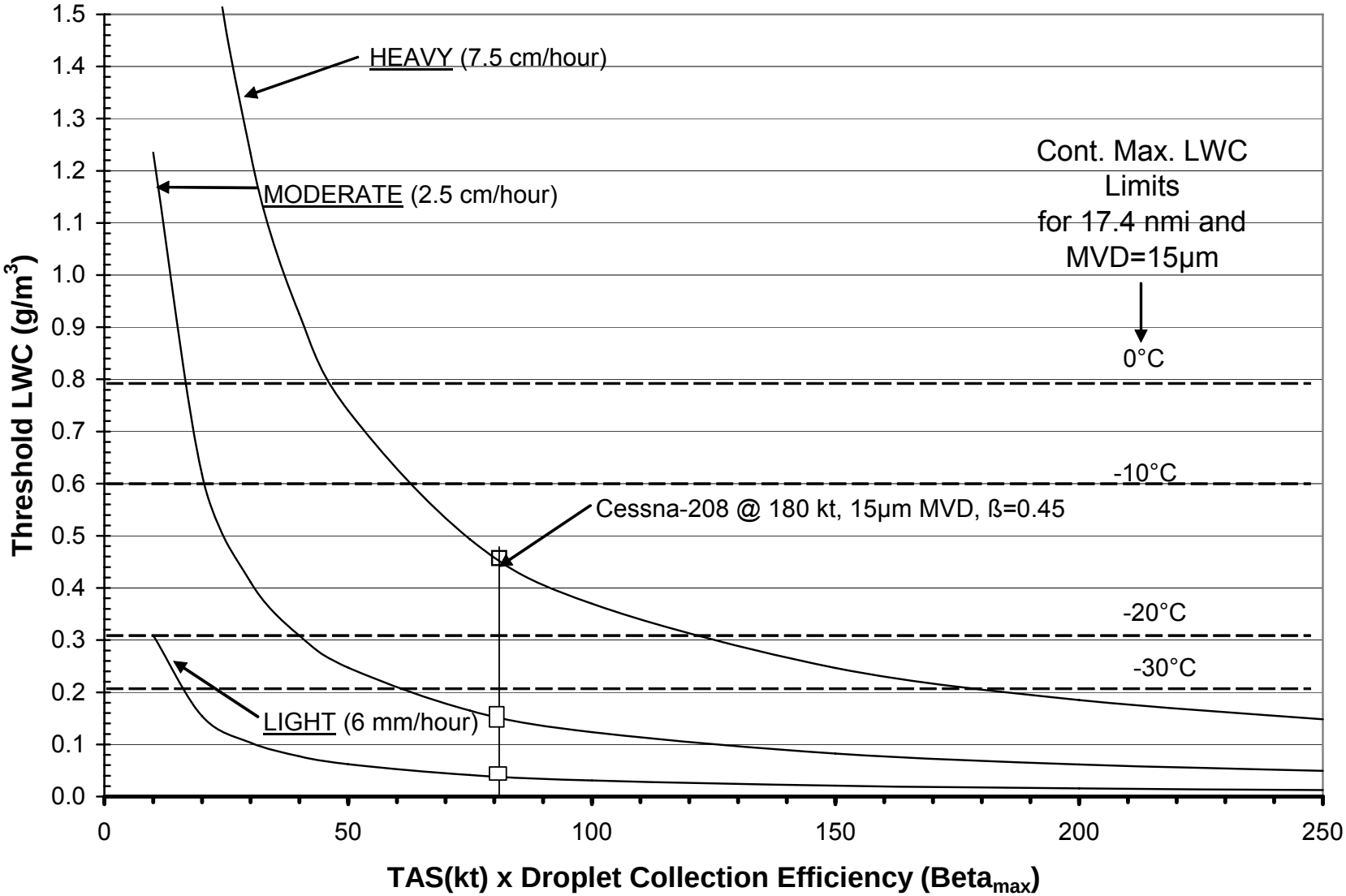
Eff = $Beta_{max}$ = 0.45

Icing Rate Threshold	Required LWC
Light (6 mm/hr)	= 0.04 g/m^3
Mod (2.5 cm/hr)	= 0.15 g/m^3
Hvy (7.5 cm/hr)	= 0.46 g/m^3

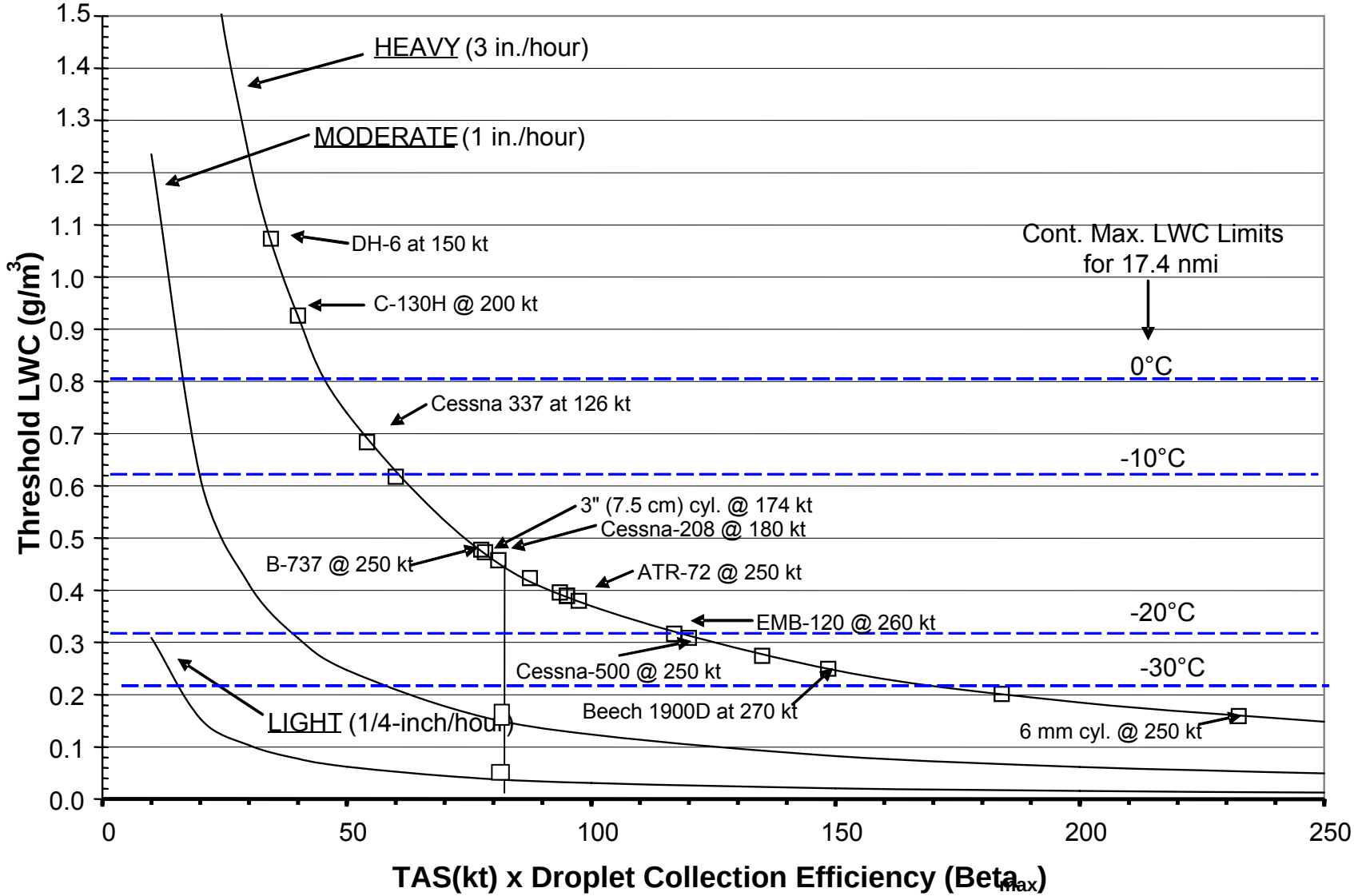
Icing Intensity Thresholds for the C-208 Outer Wing at 180 kt, Compared to App. C



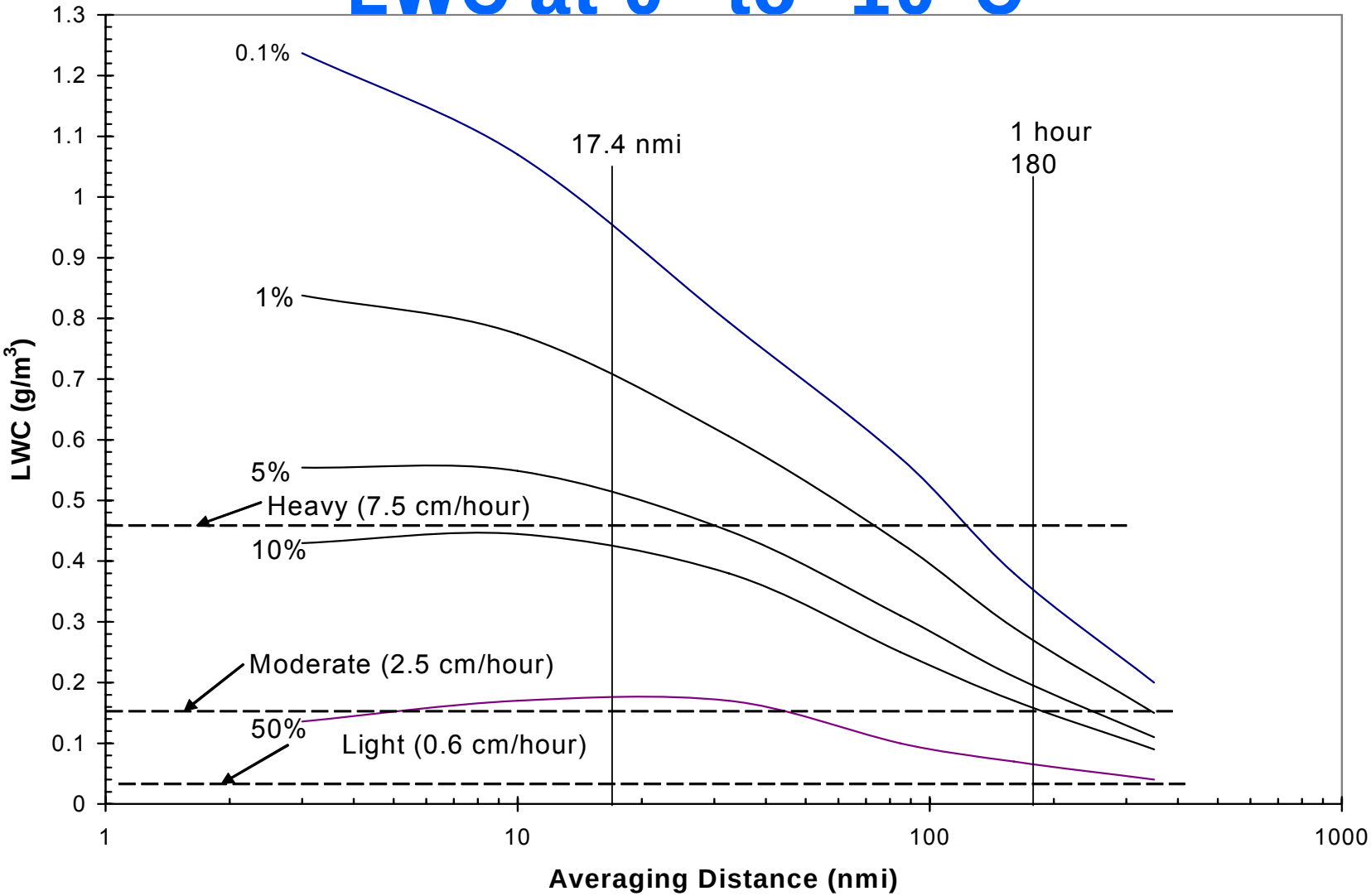
LWC = Icg Rate / (Beta • TAS / ρ)



Universal Curves for Several Airplanes



Natural Probabilities of Finding Required LWC at 0° to -10°C



Summary

- Icing intensity can be related to Appendix C if icing rates are quantified.
- Different airplanes are affected differently, depending on airspeed and wing thickness.
- Heavy icing rates not possible on some airplanes.
- Appendix C covers all icing rates that are possible for a given airplane.