

Engine Icing Certification: Evolving Research Opportunities



AIRA Icing Research

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Outline

- New Icing Requirements
- Part 25 Appendix X: SLD
- Part 33 Appendix D: Mixed Phase
- Existing Engine Icing Certification Facilities
- Going forward – needs and opportunities
- Conclusion

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New Requirements

The 1994 ATR 72 crash resulted in a NTSB recommendation to:

- Expand the Appendix C icing certification envelope to include:
- Freezing drizzle/freezing rain and,
- Mixed water/ice crystal conditions, as necessary.

In response to the NTSB safety recommendations,

the FAA tasked the Icing Protection Harmonization Working Group(IPHWG)

to develop new rules, along with the Engine Harmonization Working Group(EHWG)

FAR Part 25 Appendix X

- SLD: Supercooled Large Droplets
- Freezing Drizzle > 250 microns
- Freezing Rain > 500 microns
- Not considered an issue for engine icing, except on ground, or taxi
- CPA required, new “table” point: 0.3 g/m^3 , > 100 microns
- Modified Part 33.77 ice slab ingestion

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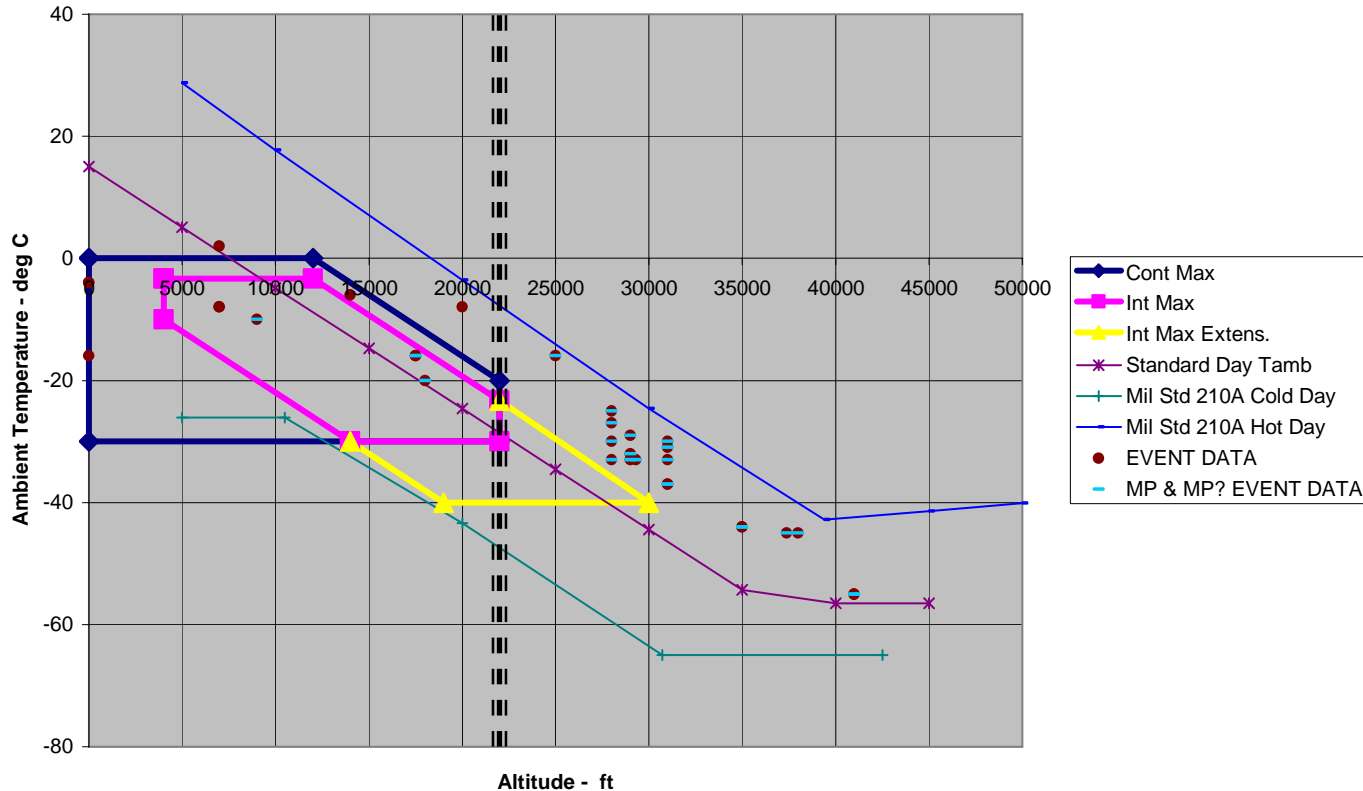
FAR Part 33 Appendix D

- 62 % of 260 icing events outside Appendix C envelope
- Ice Crystals or Mixed Phase
- Serious threat to engine: Surge, flameout or rollback
- New envelope, Appendix D proposed
- CPA required, new “table” point: 0.9 g/m^3 snow
- Method of compliance not currently available

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FAR Part 33 Appendix D

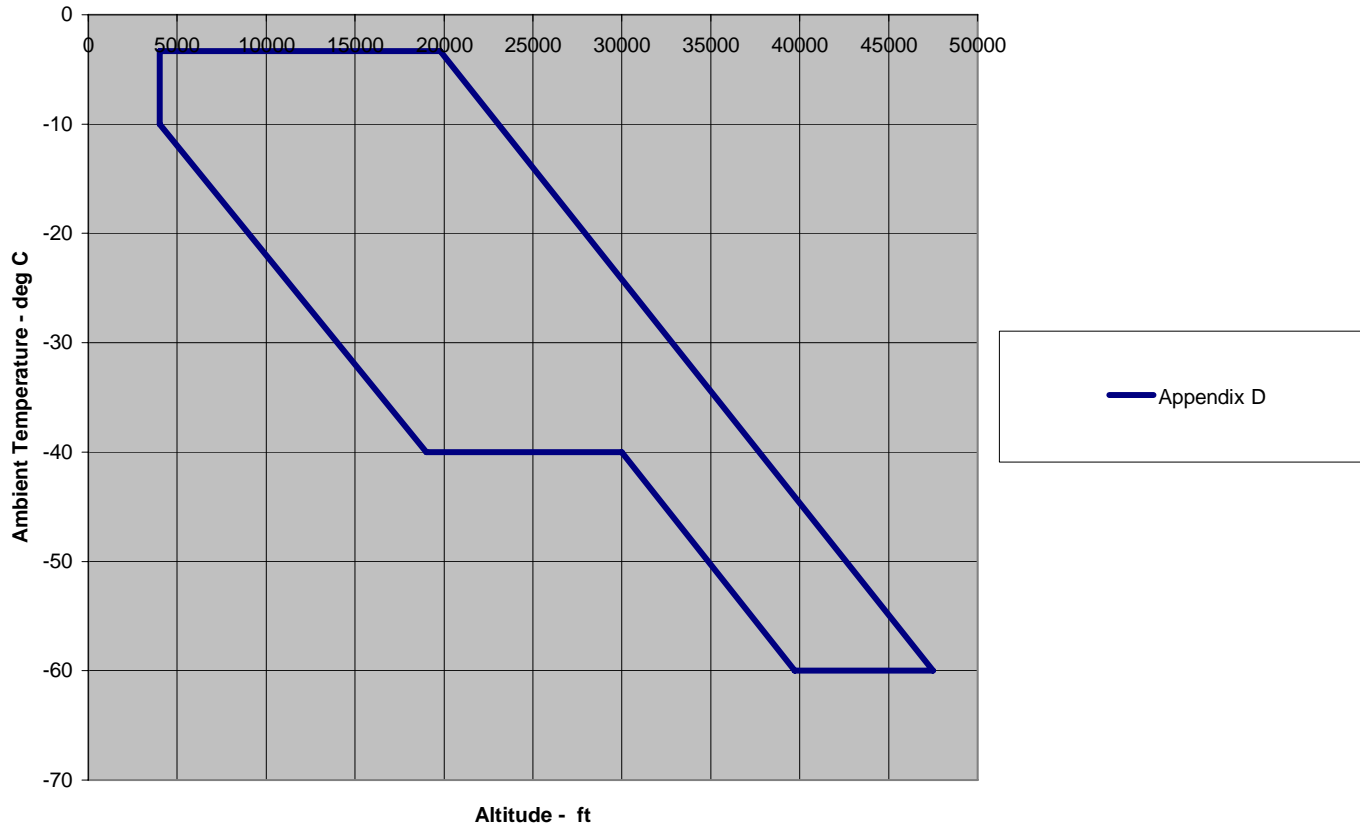
Commercial Service Data Base of Icing Events compared with FAR Part 25 Appendix C Icing Envelope Limits



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FAR Part 33 Appendix D

FAR 33 Appendix D Icing Envelope Limits



Existing Engine Icing Test Facilities

- Sea level:
 - NRC M-7 800 pps max, -25 C
 - GE Peebles (OH): 3600 pps, -8 C
- Sea level refrigerated:
 - McKinley (FL): 250 pps, -40 C
- Altitude:
 - AEDC (TN): 1600 pps, -20 C
 - CIAM (Russia): 600 pps, -20 C
 - CEPR (France) 400 pps, -20 C
 - NRC M-10 10 pps, -20 C TBD



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Going Forward – Needs and Opportunities

Supercooled Large Droplets

- Develop large droplet spray nozzles
- Overcome problem of supercooling of large droplets
- Need modeling of trajectories, ice buildup and shedding for engine inlet and fan blades from SLD and App C
- Develop sea level to altitude transfer function

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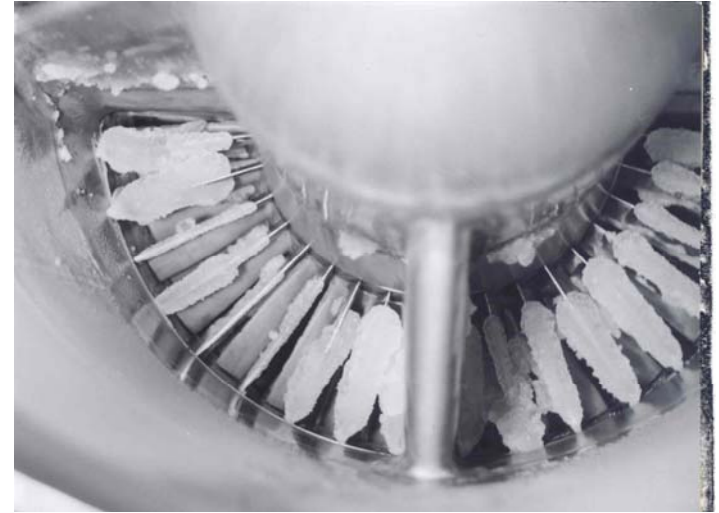
Going Forward – Needs and Opportunities



Mixed Phase

- Determine mixed phase cloud characteristics to better define App D
- Develop ice shaver and/or spray nozzles
- Determine physics of rapid ice crystal buildup within compressor core
- Need modeling of trajectories, ice buildup and shedding for engine internal flow paths

Conclusions



- Lack of specialized icing test facilities worldwide
- Lots of opportunities in engine icing research and technology in the areas of:
 - 1) Certification test facilities for SLD and mixed phase
 - 2) Determination of ice crystal behavior within a compressor
 - 3) Modeling of SLD and mixed phase in an engine environment