

Large-Drop Ice Accretion Test Results for a Large Scale Swept Wing Model

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AIAA Aviation Forum Virtual 2-6 August 2021

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Outline

- Objectives and Approach
- Experimental Methodology
- Sample Results
- Summary
- Acknowledgements



Objective and Approach

Objective

- Investigate the effect of large MVD conditions on the ice accretion a large-scale, swept wing.

Approach

- Conduct ice accretion testing on full-chord Midspan model section of CRM65 wing in the NASA IRT.
- Use icing scaling parameters to compare small and large MVD cloud conditions.
- Measure ice geometry with 3D scanning technique and compute ice volumes.
- Measure ice mass.

Experimental Methodology

- Ice accretion testing was conducted using full-chord version of Midspan hybrid model based upon CRM65 wing.
- Full-chord model streamwise chord length = 136 inches (~3.5 m).

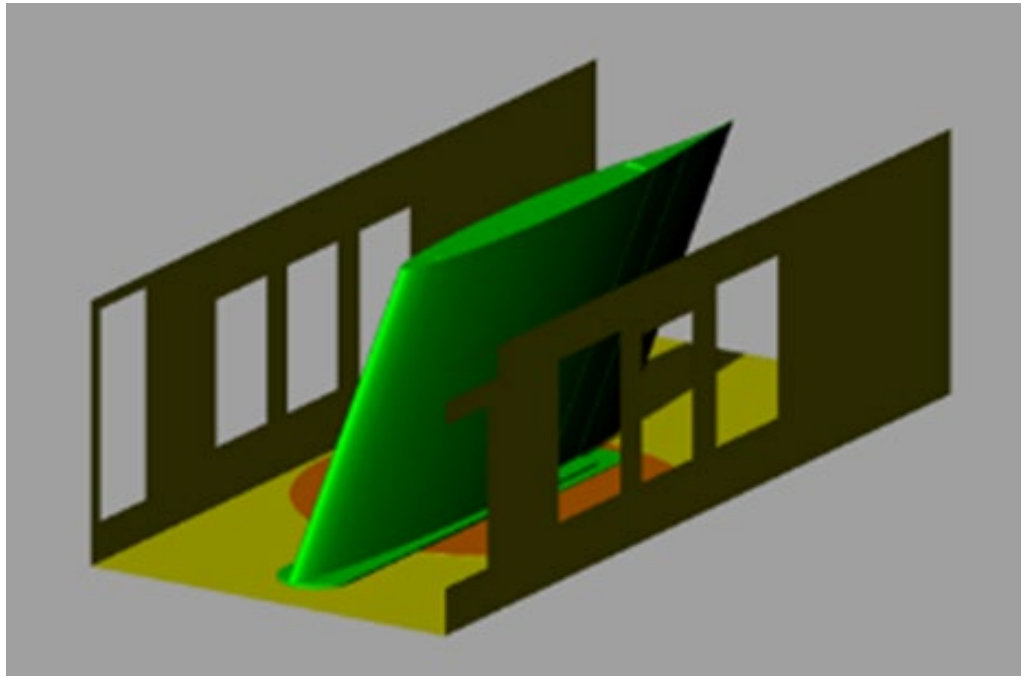


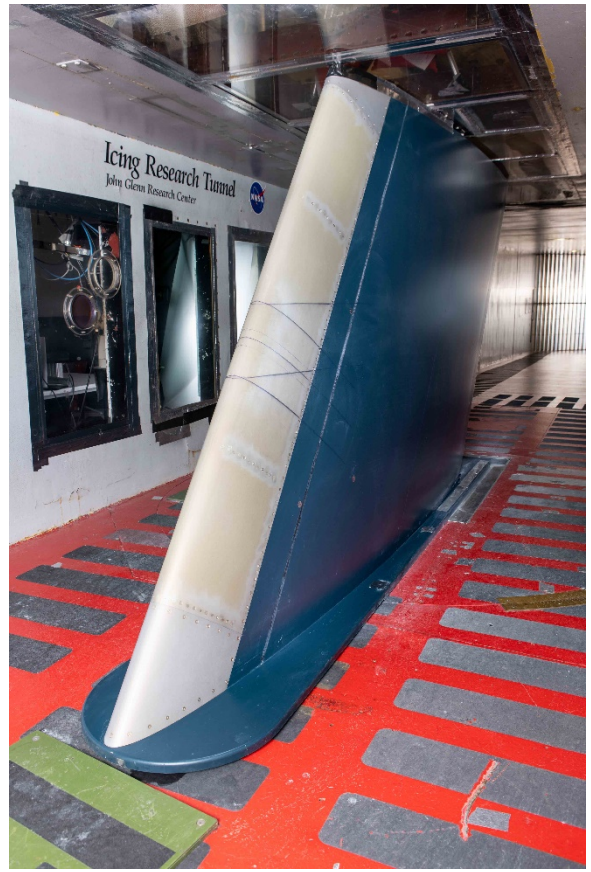
- Companion paper by Lee et al.* compares ice accretion collected on the hybrid and full-chord models under identical icing conditions.

*Lee, S., Broeren, A.P., and Potapczuk, M.G., "Comparison of Ice Shapes on Full-Chord and Truncated Swept Wing Models," AIAA Aviation Forum, 2-6 August 2021, Submitted for Publication.

Experimental Methodology

- Icing tests were performed in the NASA IRT with small and large MVD clouds.
- IRT test section is 6 ft high by 9 ft wide by 20 ft long.
- Model was installed vertically from floor to ceiling.

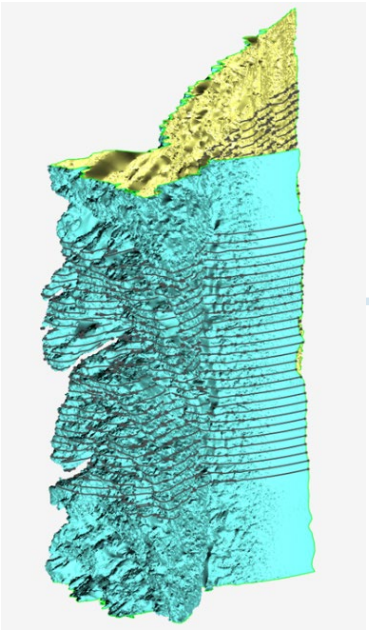


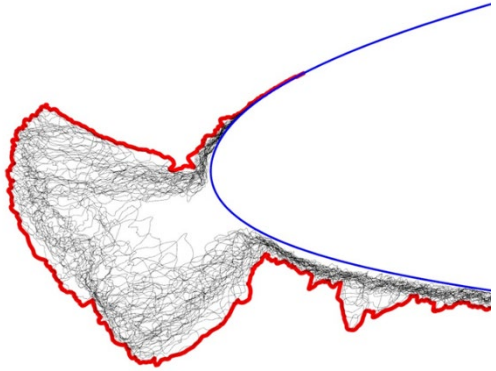


Experimental Methodology

- Ice accretion was documented with photographs and 3D scans.
- 3D scan data were post-processed to provide the Maximum Combined Cross Section (MCCS) and ice volume.







Test Conditions

- All runs had: V = 130 knots, α = 3.7 deg., δ_f = 6.0 deg.

Small MVD

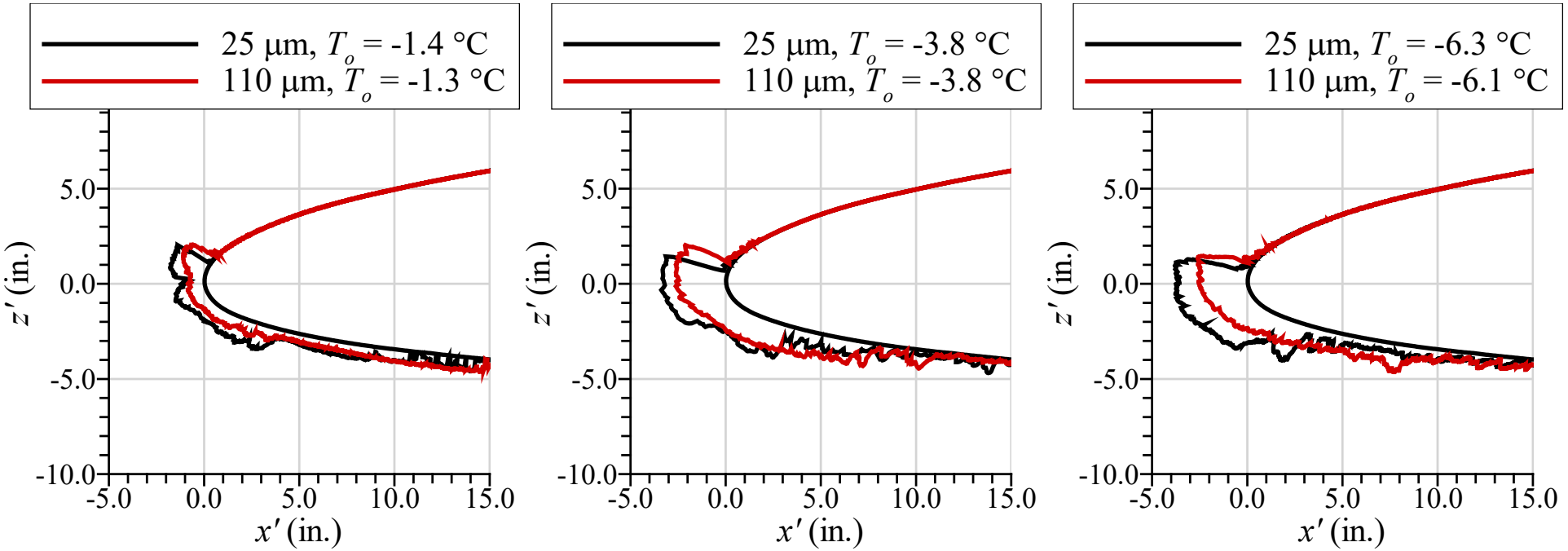
Run Number	T_o (˚C)	T (˚C)	MVD (μm)	LWC (g/m^3)	t (min.)	n_o	$\beta_o A_c$
TJ3379	-1.4	-3.6	25	1.00	29.0	0.12	1.24
TJ3383	-3.8	-6.0	25	1.00	29.0	0.23	1.24
TJ3363	-6.3	-8.5	25	1.00	29.0	0.35	1.25
TJ3397	-8.7	-11.0	25	1.00	29.0	0.45	1.25
TJ3390	-11.2	-13.5	25	1.00	29.0	0.56	1.24
TJ3392	-15.0	-17.2	25	1.00	29.0	0.71	1.25
TJ3395	-23.8	-26.0	25	1.00	29.0	1.00	1.25

Large MVD

Run Number	T_o (˚C)	T (˚C)	MVD (μm)	LWC (g/m^3)	t (min.)	n_o	$\beta_o A_c$
TJ3375	-1.3	-3.5	110	0.60	30.1	0.12	1.24
TJ3384	-3.8	-6.0	110	0.60	30.1	0.24	1.24
TJ3362	-6.1	-8.3	110	0.60	30.1	0.35	1.24
TJ3398	-8.1	-10.4	110	0.60	30.1	0.44	1.24
TJ3376	-10.2	-12.4	110	0.60	30.1	0.53	1.24
TJ3393	-16.1	-18.4	110	0.60	30.1	0.78	1.24
TJ3378	-22.4	-24.6	110	0.60	30.1	1.00	1.24

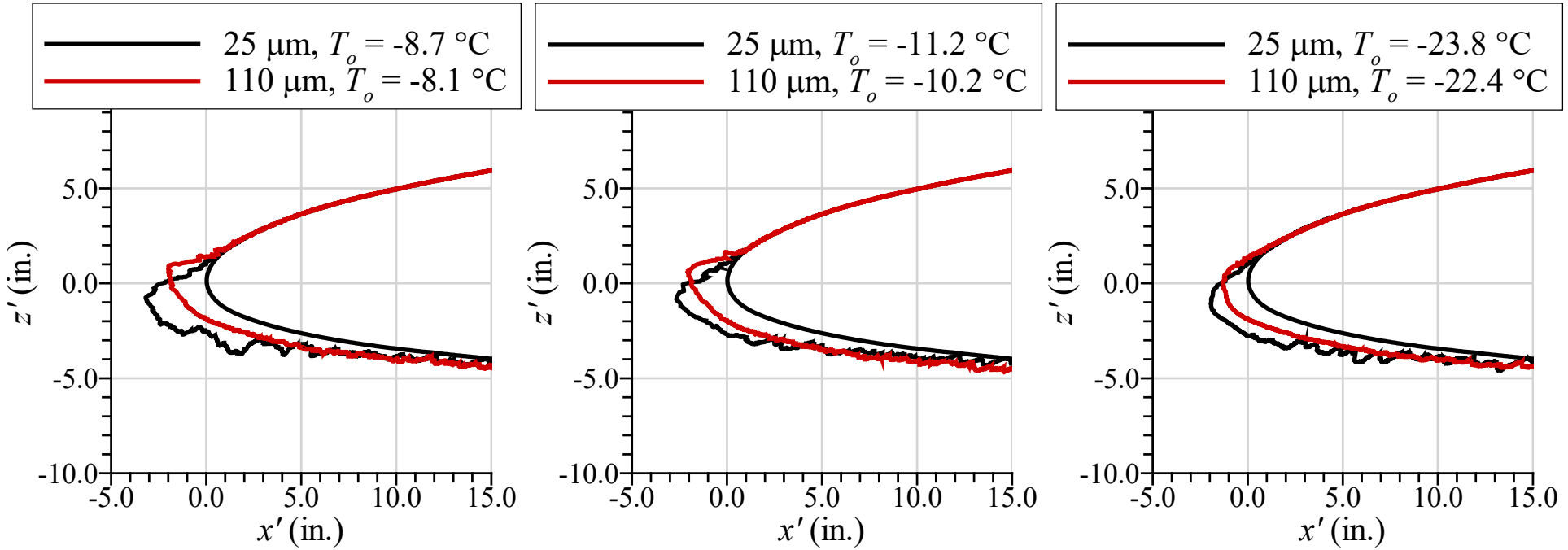
Small and Large MVD MCCS Comparison

- Temperature sweep



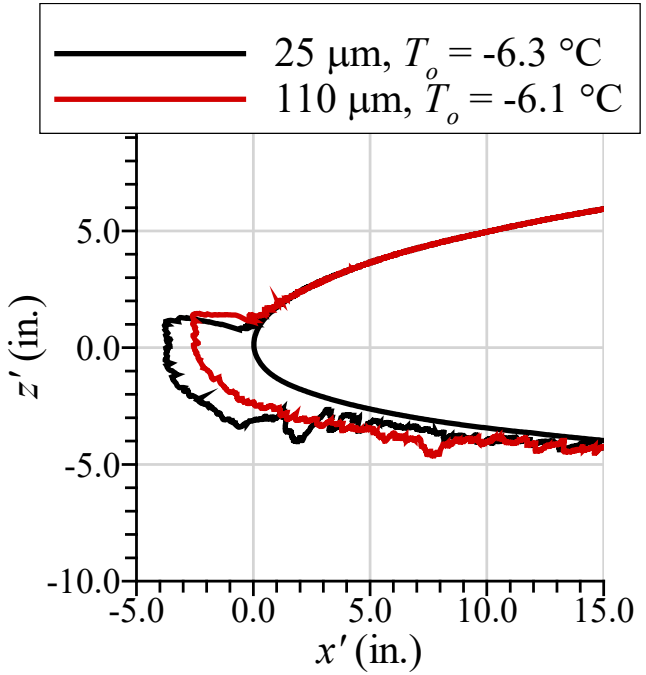
Small and Large MVD MCCS Comparison

- Temperature sweep, con't.



Small and Large MVD Comparison

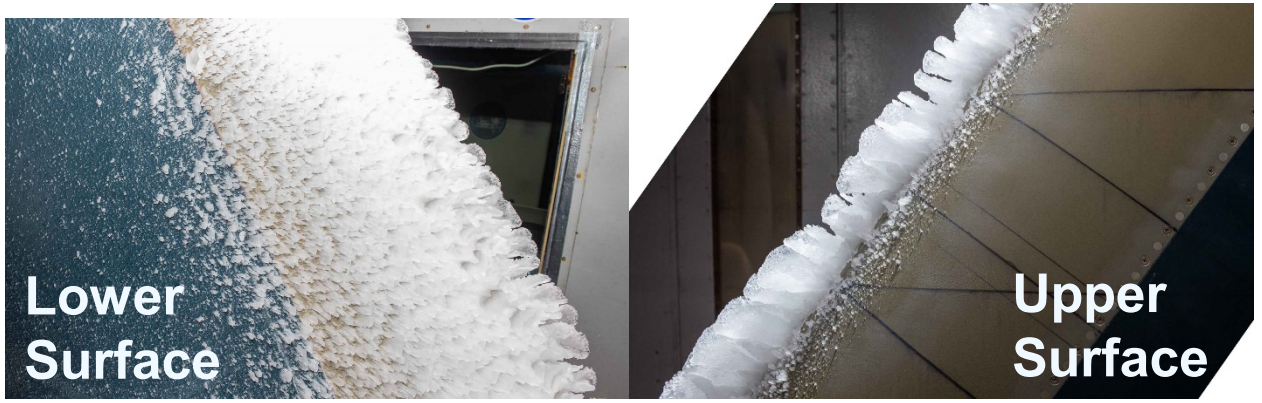
- Matched n_o and $\beta_o A_c$



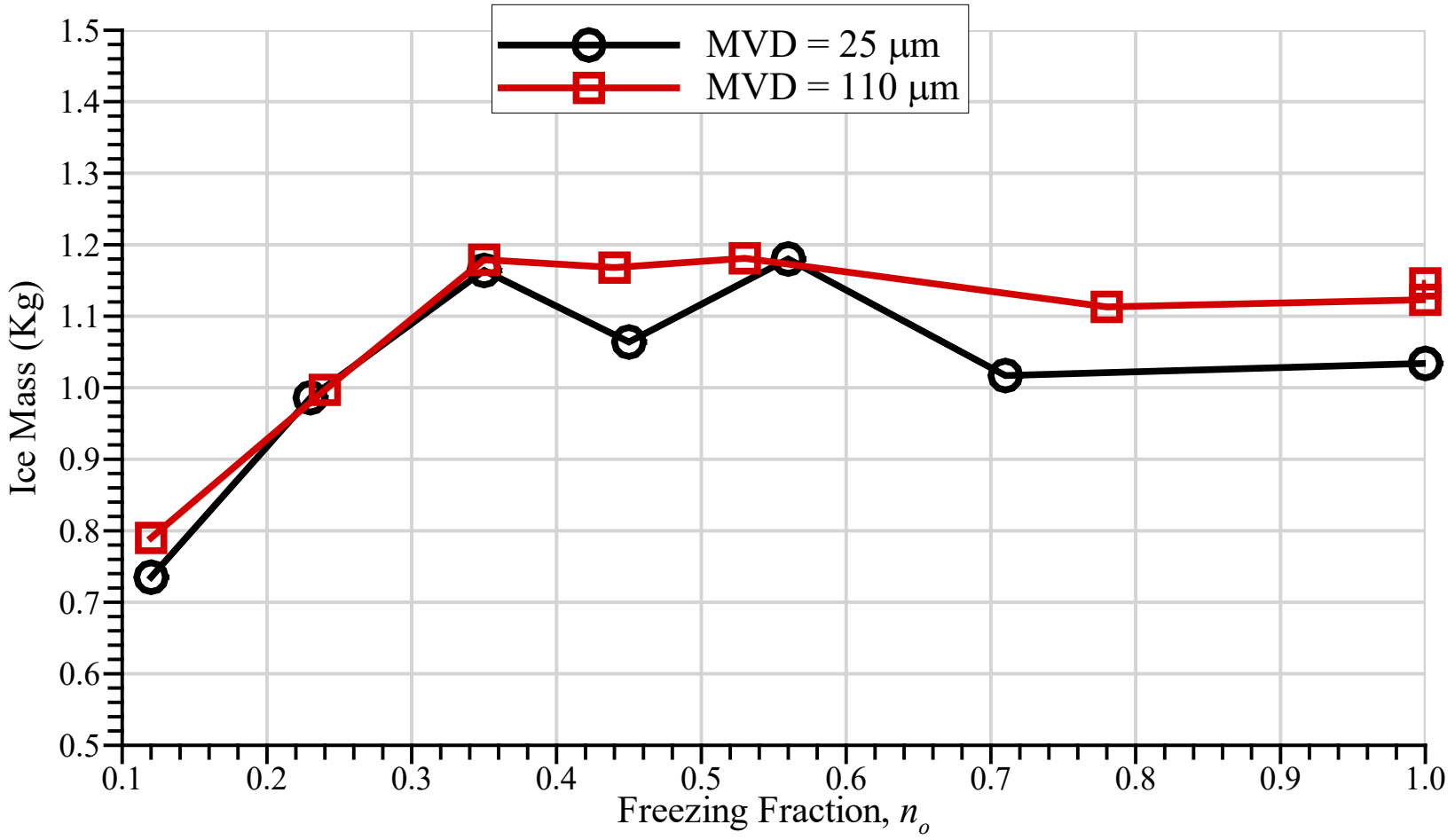
MVD = 25 μm

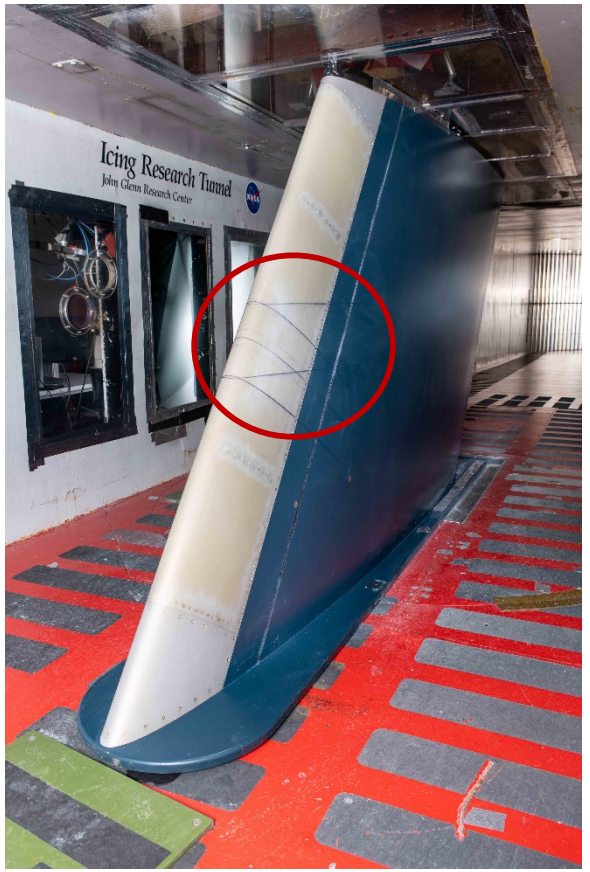


MVD = 110 μm



Small and Large MVD Ice Mass Comparison





Summary

- Comparison between the small and large MVD ice shapes at closely matched values of the scaling parameters showed:
  - Horn thickness of the main ice shape tended to be larger for the small MVD conditions.
  - The large MVD ice shapes were characterized by more ice downstream of the main ice shape.
  - The measured ice mass was approximately equal between the corresponding small and large MVD ice shapes up to a freezing fraction of 0.6. For higher freezing fraction, the large MVD ice shapes weighed more.
- Other results described in the paper:
  - Ice volumes
  - Mass-to-volume ratios (“ice density” or “void fraction”)
  - MVD sweep 50 to 230 μm

Acknowledgements

Test Support:

- IRT staff
- Quentin Schwinn & Jordan Salkin
- Mark Potapczuk

Sponsor Organizations:

- FAA
- NASA - Advanced Air Transport Technology Project

Supporting Organization:

- Boeing

