Ice Prediction Workshop
Test Case Selection

Richard Hann, Isik Ozcer, Alberto Pueyo and Andy Broeren

September 17, 2020

Test Case Selection Process

1st Round Selection

- Test configurations were sorted into three categories:
  - Ice accretion on 3D geometry
  - Ice accretion on 2D geometry
  - Collection efficiency on 3D geometry
- Using the test configurations summarized in Richard Hann's presentation, organizing committee members can indicate:
  - Baseline—simulations performed by all participants
  - Optional—at participants' discretion
  - Consider for future workshop
  - Response deadline was August 24, 2020.
- Richard's task force compiled and sorted the responses.
  - Discussed during August 27, 2020 meeting.

2nd Round Selection

- Next step is to identify specific cases for each configuration.
  - Based upon September 14, 2020 meeting, test cases have been identified—we are here!

Case Selection Criteria

- Distinction is made between “configurations” (i.e. geometries) and “cases”.
  - The number of configurations has been limited to bound the amount of work required to create models and grids and, therefore, encourage the use of 3D icing codes.
  - There could be several cases under a given configuration (selection of which and how many will be part of a second round in the selection process).
- For the baseline cases, at least one configuration for each of the 3 categories is retained.
  - In each category, the most voted configuration(s) were selected
- Optional cases can still be considered as baseline cases candidates for future workshops.

Configurations Summary

Baseline Configurations

- Ice accretion on 3D Geometry
  - 36-inch chord NACA 0012, 30 deg. sweep, AoA = 0 deg.
  - 36-inch chord NACA 0012, 45 deg. sweep, AoA = 0 deg.
- Ice accretion on 2D Geometry
  - 18-inch chord NACA 23012, AoA = 2 deg.
- Collection efficiency on 3D Geometry
  - NACA 64A008 finite swept tail, AoA = 6 deg.
  - Three element airfoil, 36-inch nested chord, AoA = 4 deg.

Optional Configurations

- Ice accretion on 3D Geometry
  - 36-inch chord NACA 0012, 30 deg. sweep
- Ice accretion on 2D Geometry
  - 72-inch chord NACA 23012
- Collection efficiency on 3D Geometry
  - Three element airfoil, 36-inch nested chord, AoA = 4 deg.
  - Axisymmetric inlet at AoA = 15 deg.

Ice Accretion on 3D Geometry

Test Case Summary
Ice Accretion on 3D Geometry

Baseline Test Cases

- Ref. AIAA 2014-2200
- 36-inch chord NACA 0012, 30 deg. sweep, 0 deg. AoA
  - 2 cases, varying temperature
- 36-inch chord NACA 0012, 45 deg. sweep, 0 deg. AoA
  - 2 cases—conditions identical to 30 deg. sweep.

Optional Test Cases

- Ref. AIAA 2020-2814
- 36-inch chord NACA 0012, 30 deg. sweep, 0 deg. AoA
  - 2 cases, each with monomodal drop distribution

ID	Title	Test facility	Year	Data Type	Geometry	Reynolds (millions)	Air speed	MVD µm	LWC g/m3	Temperature	Reference	Vote for baseline 0/1	Vote for optional 0/1	Vote for future workshop 0/1
1	36-inch swept NACA 0012 - complete scallops	IRT	2014	3D Scan	NACA 0012. swept 45, AoA 0	7	200 kts	32.6	0.54	-6.7 C (total)	AIAA 2014 2613	5	5	1
2	36-inch swept NACA 0012 - incomplete scallops	IRT	2014	3D Scan	NACA 0012. swept 30, AoA 4	7	200 kts	15	0.6	-6.7 C (total)	AIAA 2014 2613	7	3	1
3	36-inch swept NACA 0012 - rime	IRT	2014	3D Scan	NACA 0012. swept 30, AoA 4	7	200 kts	15	0.6	-17.8 C (total)	AIAA 2014 2613	5	5	0
4	GLC305 swept wing - complete scallops	IRT	2003	Tracing / Cp	GLC305, tapered, swept 28, AoA 4	4	250 mph	20	0.68	25 F (total)	AIAA 2003 730	2	5	2
5	GLC305 swept wing - incomplete scallops	IRT	2003	Tracing / Cp	GLC305, tapered, swept 28, AoA 4	4	150 mph	20	0.65	25 F (total)	AIAA 2003 730	1	4	2
6	36-inch swept NACA 0012, small K (set of 7)	IRT	2014	Tracings, photos, Cp, ice mass	NACA 0012, swept 30 - 45, AoA 0	3	45 m/s	15	1.5	257 - 269 K (static)	AIAA 2014 2200	6	3	1
7	36-inch swept NACA 0012, large K (set of 5)	IRT	2014	Tracings, photos, Cp, ice mass	NACA 0012, swept 30 - 45, AoA 0	7	103 m/s	32	0.45	257 - 266 K (static)	AIAA 2014 2200	**9**	1	0
8	Helicopter tail rotor in edgewise flow	IRT	2014	3D scans	Bell 206B tail rotor @ 1200,2100 rpm	0.5 - 1	31 m/s	15	0.5	14 F (static)	AIAA 2014 2612	1	0	10
9	Small scale fan	ISU	2018	Photographs, pressure loss	Fan/spinner based on Boeing 18-inch fan rig, @2500 rpm	0.2	15 m/s	20-100	0.5-2.0	-5 - -15 C (static)	AIAA 2018-3013	2	0	9
10	36-inch swept NACA 0012, ref AF2175	IRT	2020	3D scans, ice mass	NACA 0012, swept 30, AoA 0	5	150 kts	20-25	0.6-2.3	-10 - -17.5 C (static)	AIAA-2020-2814	6	2	2
11	15-inch swept NACA 0012, ref AF2175	IRT	2020	3D scans, ice mass	NACA 0012, swept 30, AoA 0	3.5	217 kts	20-25	0.75-1.88	-14 - -25 C (static)	AIAA-2020-2814	5	3	3
12	CRM65 inboard, TG2418	IRT	2018	3D scans, Cp	CRM65 20% semispan section, swept 35, AoA 3.7	21 (full-MAC)	129 kts	25	1	-3.7 C (static)	NASA/CR-2018-219781	4	2	6
13	CRM65 inboard, TG2408	IRT	2018	3D scans, Cp	CRM65 20% semispan section, swept 35, AoA 3.7	24 (full-MAC)	129 kts	25	1	-17.3 C (static)	NASA/CR-2018-219781	3	2	5
14	CRM65 midspan, TH2464	IRT	2018	3D scans, Cp	CRM65 64% semispan section, swept 35, AoA 3.7	22 (full-MAC)	129 kts	25	1	-3.6 C (static)	NASA/CR-2018-219781	5	2	5
15	CRM65 midspan, TH2431	IRT	2018	3D scans, Cp	CRM65 64% semispan section, swept 35, AoA 3.7	24 (full-MAC)	129 kts	25	1	-17.5 C (static)	NASA/CR-2018-219781	5	1	4

Ice Accretion on 3D Geometry

Baseline Cases

36-inch swept NACA 0012, cases from AIAA-2014-2200

30 deg Sweep—suggested baseline cases

Run #	Airspeed m/s	Drop Size microns	LWC g/m^3	Static Temperature K	Icing Time min.	Experimental Ice Mass per Unit Length g/m	Corrected Experimental Ice Mass per Unit Length g/m	LEWICE3D Ice Mass per Unit Length g/m	Experimental Void Density Kg/m^3	LEWICE3D Void Density Kg/m^3	Experimental Ice Shape Area cm^3	LEWICE3D Ice Shape Area cm^3	LEWICE3D Ice Shape Area (ρ_{ice}=917 g/m^3) cm^3	Leading Edge Freezing Fraction
AF2155	45	15	1.50	255	20	787	943	752	505	219	17.6	34.4	8.0	0.76
AF2140	45	15	1.50	264	20	906	906	799	494	186	17.0	43.0	8.1	0.39
AF2138	45	15	1.50	266	20	1170	1178	802	446	172	24.9	46.7	8.0	0.30
AF2139	45	15	1.50	266	20	1191	1191	802	435	172	26.5	46.7	8.0	0.30
AF2141	45	15	1.50	268	20	1113	1113	806	475	161	22.4	50.1	8.0	0.22
AF2153	103	32	0.47	257	5	NA	NA	467	NA	331	7.8	14.4	21.2	0.63
AF2154	103	32	0.47	257	12	827	1145	1176	484	331	21.0	35.5	5.1	0.63
AF2146	103	32	0.47	257	20	1633	1895	1994	538	331	33.5	60.2	12.5	0.63
AF2144	103	32	0.47	262	20	1774	2002	2037	417	308	44.7	66.2	21.5	0.40
AF2148	103	32	0.47	263	2	NA	NA	183	NA	301	4.9	6.1	21.6	0.35
AF2149	103	32	0.47	263	5	NA	NA	475	NA	301	11.8	15.8	2.0	0.35
AF2150	103	32	0.47	263	12	893	1160	1196	491	301	25.7	39.7	5.0	0.35
AF2143	103	32	0.47	263	20	1830	1938	2054	355	301	48.9	68.2	12.6	0.35
AF2142	103	32	0.47	264	20	1814	2060	2079	365	291	49.6	71.4	21.7	0.31
AF2151	103	32	0.47	266	5	NA	NA	477	NA	261	9.3	18.3	22.0	0.22
AF2152	103	32	0.47	266	12	779	1012	1222	557	261	15.4	46.8	5.0	0.22
AF2145	103	32	0.47	266	20	1429	1618	2119	459	261	34.0	81.1	12.7	0.22

36-inch swept NACA 0012, cases from AIAA-2014-2200

45 deg Sweep—suggested baseline cases

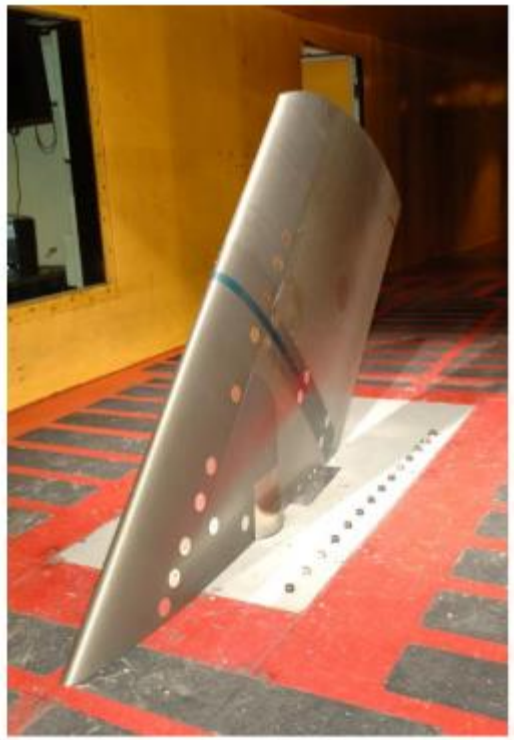
Run #	Airspeed m/s	Drop Size microns	LWC g/m^3	Static Temperature K	Experimental Ice Mass per Unit Length g/m	Corrected Experimental Ice Mass per Unit Length g/m	LEWICE3D Ice Mass per Unit Length g/m	Experimental Void Density Kg/m^3	LEWICE3D Void Density Kg/m^3	Experimental Ice Shape Area cm^3	LEWICE3D Ice Shape Area cm^3	LEWICE3D Ice Shape Area (ρ_{ice}=917 g/m^3) cm^3	Leading Edge Freezing Fraction
AF1790	45	15	1.50	257	380	454	536	325	106	12.3	50.4	5.6	0.80
AF1789	45	15	1.50	259	376	483	546	323	139	13.8	39.2	5.6	0.71
AF1793	45	15	1.50	262	416	491	560	407	138	11.5	40.5	5.6	0.56
AF1788	45	15	1.50	265	536	557	581	380	136	14.5	42.7	5.4	0.41
AF1794	45	15	1.50	265	526	594	581	351	136	14.5	42.7	5.4	0.41
AF1792	45	15	1.50	267	702	706	582	374	132	18.6	44.2	5.6	0.31
AF1791	45	15	1.50	269	534	538	579	380	127	12.6	45.4	5.5	0.20
AF1799	103	32	0.45	257	1476	1582	1440	437	298	34.4	48.3	15.3	0.74
AF1798	103	32	0.45	261	1467	1576	1475	328	275	45.7	53.5	15.4	0.53
AF1797	103	32	0.45	263	1339	1432	1497	283	265	47.8	56.6	15.5	0.43
AF1796	103	32	0.45	265	1340	1438	1539	367	244	38.3	63.0	15.7	0.31
AF1795	103	32	0.45	266	1449	1599	1548	402	230	36.9	67.2	15.7	0.25

36-inch swept NACA 0012, large K (set of 5)—Baseline Cases

b) 30° sweep

Table 2. Experimental and analytical ice shape characteristics for 30° swept NACA 0012 wing.

Run #	Airspeed m/s	Drop Size microns	LWC g/m^3	Static Temperature K	Icing Time min.	Experimental Ice Mass per Unit Length g/m	Corrected Experimental Ice Mass per Unit Length g/m	LEWICE3D Ice Mass per Unit Length g/m	Experimental Void Density Kg/m^3	LEWICE3D Void Density Kg/m^3	Experimental Ice Shape Area cm^3	LEWICE3D Ice Shape Area cm^3	LEWICE3D Ice Shape Area (ρ_{ice}=917 g/m^3) cm^3	Leading Edge Freezing Fraction
AF2146	103	32	0.47	257	20	1633	1895	1994	538	331	33.5	60.2	12.5	0.63
AF2145	103	32	0.47	266	20	1429	1618	2119	459	261	34.0	81.1	12.7	0.22

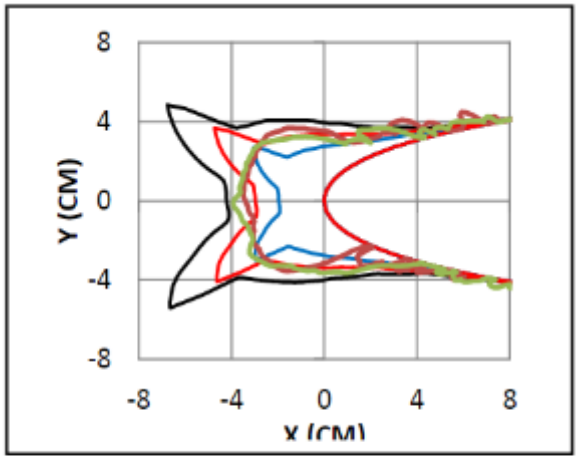


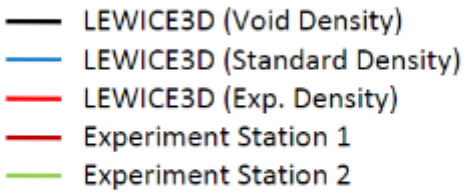
a) 45° sweep

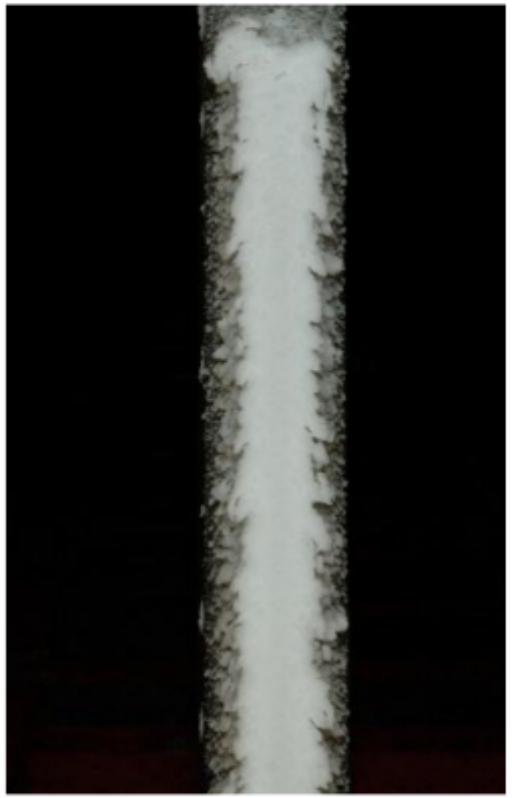
Table 1. Experimental and analytical ice shape characteristics for 45° swept NACA 0012 wing.

Run #	Airspeed m/s	Drop Size microns	LWC g/m^3	Static Temperature K	Experimental Ice Mass per Unit Length g/m	Corrected Experimental Ice Mass per Unit Length g/m	LEWICE3D Ice Mass per Unit Length g/m	Experimental Void Density Kg/m^3
AF1799	103	32	0.45	257	1476	1582	1440	437
AF1795	103	32	0.45	266	1449	1599	1548	402

36-inch swept NACA 0012, large K (set of 5: AF2146)-Baseline



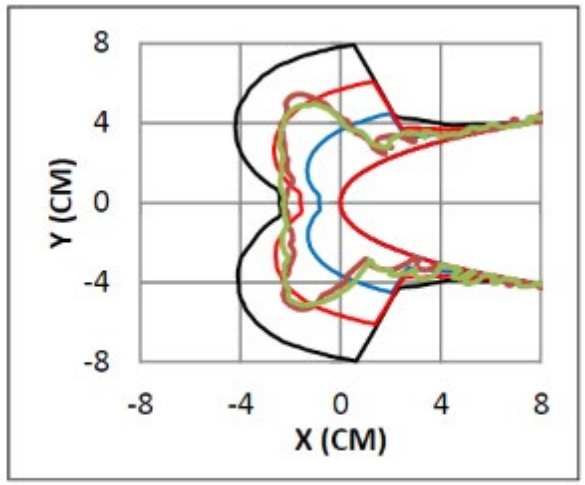


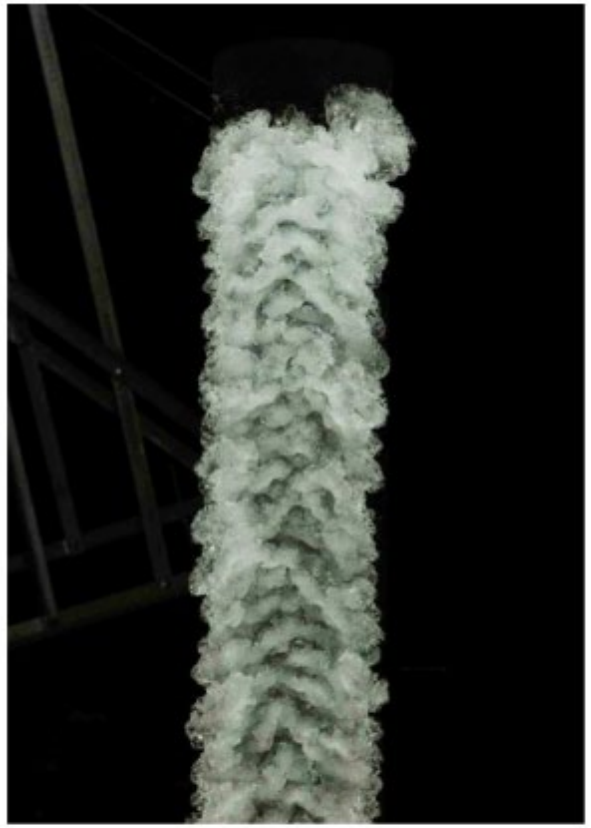


c) static temperature, 257 K; icing time, 20 minutes

Figure 15. Ice shape comparisons for 30° swept wing. Icing conditions: airspeed 103 m/s; liquid water content, 0.47 g/m^3; static pressure, 92321 Pa; MVD, 32 μm.

36-inch swept NACA 0012, large K (set of 5: AF2145)-Baseline

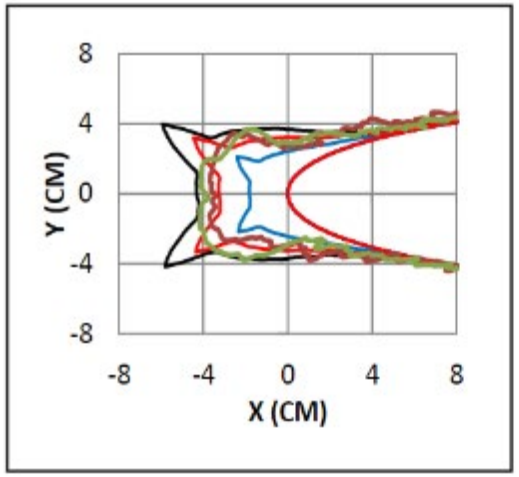




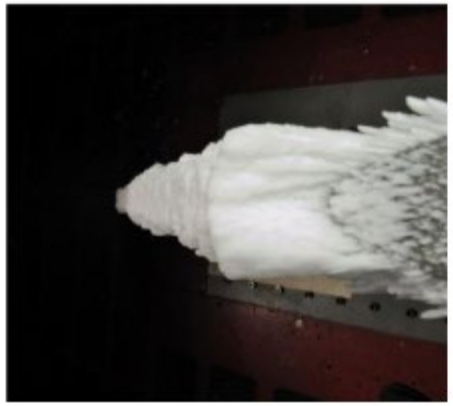
l) **static temperature, 266 K; icing time, 20 minutes**

Figure 15. Ice shape comparisons for 30° swept wing. Icing conditions: airspeed 103 m/s; liquid water content, 0.47 g/m^3; static pressure, 92321 Pa; MVD, 32 μm.

36-inch swept NACA 0012, large K (set of 5: AF1799)-Baseline



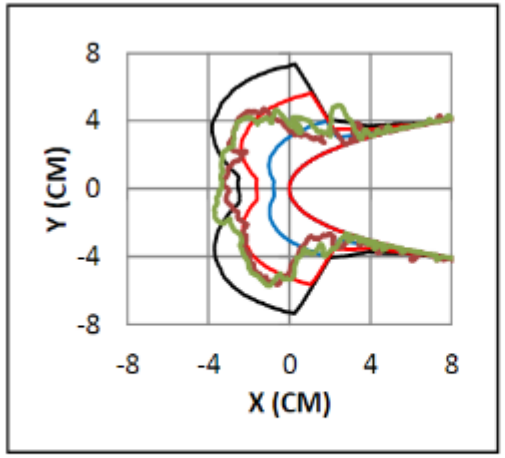
LEWICE3D (Void Density)
LEWICE3D (Standard Density)
LEWICE3D (Exp. Density)
Experiment Station 1
Experiment Station 2

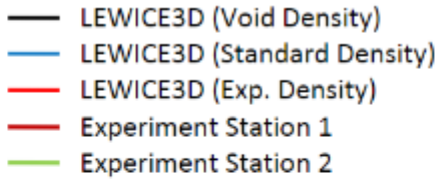


a) static temperature, 257 K

Figure 13. Ice shape comparisons for 45° swept wing. Icing conditions: airspeed 103 m/s; icing time 20 minutes; liquid water content, 0.45 g/m^3; static pressure, 94463 Pa; MVD, 32 μm.

36-inch swept NACA 0012, large K (set of 5: AF1795)-Baseline





e) **static temperature, 266 K**

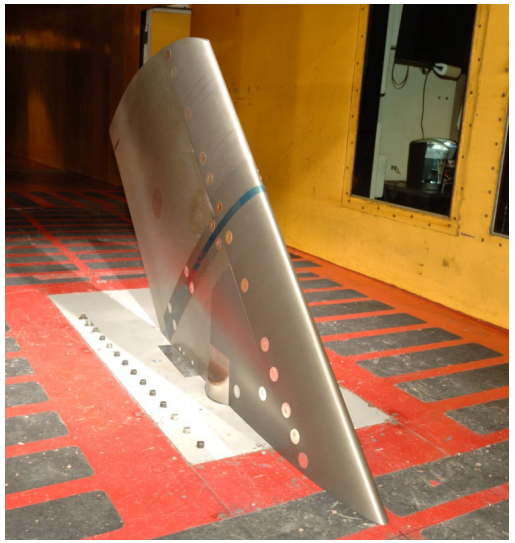
Figure 13. - Concluded. Ice shape comparisons for 45° swept wing. Icing conditions: airspeed 103 m/s; icing time 20 minutes; liquid water content, 0.45 g/m^3; static pressure, 94463 Pa; MVD, 32 μm.

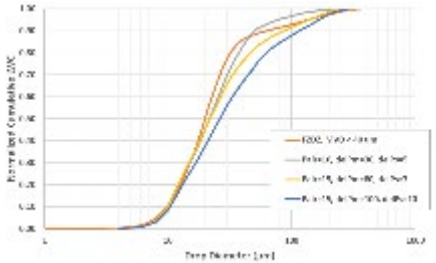
Ice Accretion on 3D Geometry

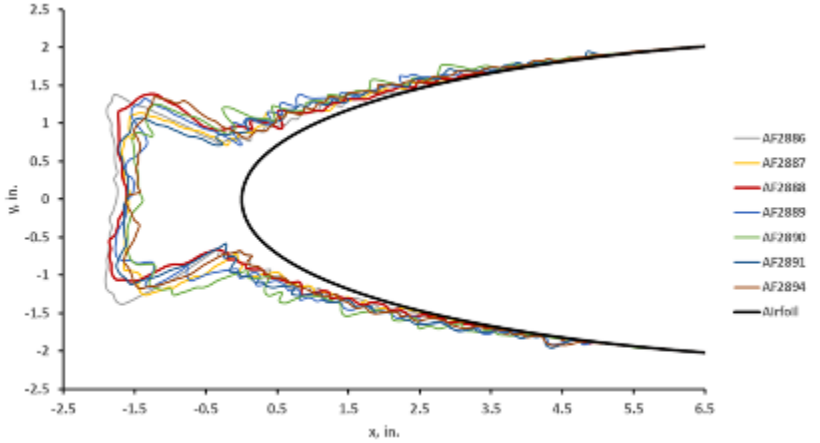
Optional Cases

3D Scanned ice shapes on 36-in swept NACA0012 from NASA IRT—30 deg. sweep

- AIAA-2020-2814







Test Results (*Reference AF2173*)

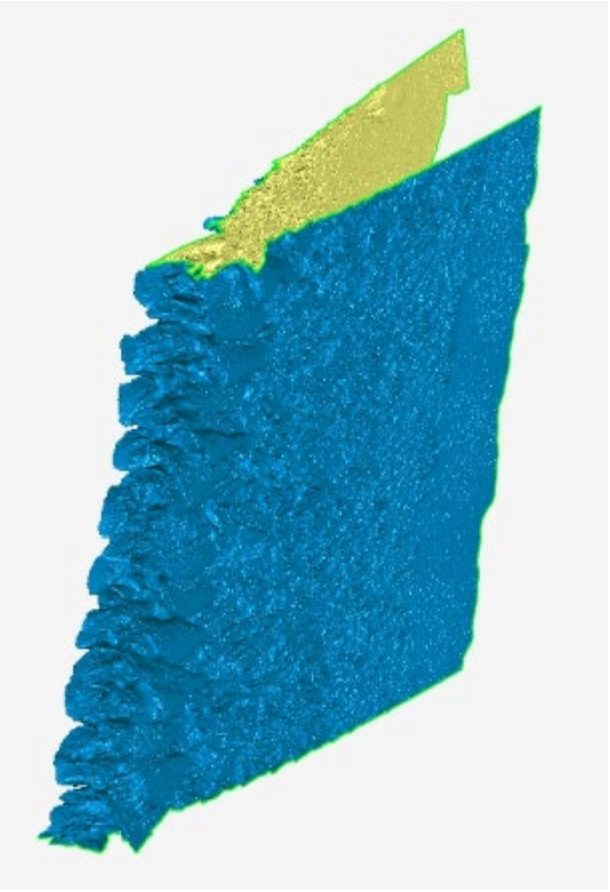
Run Number	V (kts)	MVD (μm)	LWC (g/m³)	Ts (°C)	Tt (°C)	Time (min)	$\beta_0 Ac$	n_0	Mod-1 P_{air} (psig)	Mod-1 delP (psid)	Std P_{air} (psig)	Std delP (psid)	Mass g	Volume in³	ρ_{eff} (g/cm³)
AF2881	224.0	20.00	0.50	-10.0	-3.4	17.7	1.33	0.40	19.4	49.9			365.5	36.1	0.62
AF2882	224.0	21.40	1.12	-15.2	-8.5	7.7	1.33	0.40			15.6	11.6	322.1	28.1	0.70
AF2883	224.0	21.40	1.12	-15.2	-8.5	7.7	1.33	0.40	10.0	30.0	10.0	5.0	340.8	29.0	0.72
AF2884	224.0	21.30	1.54	-17.5	-10.9	5.6	1.33	0.40	15.0	80.0	15.0	7.0	366.7	30.2	0.74
AF2885	224.0	25.00	1.85	-19.4	-12.8	4.4	1.33	0.40	15.0	100.0	15.0	10.0	366.5	29.8	0.75
AF2893	224.0	21.30	1.54	-17.5	-10.9	5.6	1.33	0.40	15.0	80.0	15.0	7.0	346.4	29.7	0.71

Test Results (*Reference AF2175*)

Run Number	V (kts)	MVD (μm)	LWC (g/m³)	Ts (°C)	Tt (°C)	Time (min)	$\beta_0 Ac$	n_0	Mod-1 P_{air} (psig)	Mod-1 delP (psid)	Std P_{air} (psig)	Std delP (psid)	Mass g	Volume in³	ρ_{eff} (g/cm³)
AF2886	150.0	20.00	0.64	-7.5	-4.5	22.5	1.33	0.40	19.5	50.5			368.3	34.4	0.65
AF2887	150.0	21.40	1.43	-12.7	-9.7	9.7	1.33	0.40			15.7	11.7	329.9	29.6	0.68
AF2888	150.0	21.40	1.43	-12.7	-9.7	9.7	1.33	0.40	10.0	30.0	10.0	5.0	351.0	31.4	0.68
AF2889	150.0	21.30	1.96	-15.1	-12.1	7.1	1.33	0.40	15.0	80.0	15.0	7.0	359.3	31.2	0.70
AF2890	150.0	25.00	2.36	-17.3	-14.3	5.4	1.33	0.40	15.0	100.0	15.0	10.0	373.4	31.9	0.71
AF2891	150.0	21.30	1.96	-15.1	-12.1	7.1	1.33	0.40	15.0	80.0	15.0	7.0	384.7	31.9	0.74
AF2894	150.0	21.30	1.96	-15.1	-12.1	7.1	1.33	0.40	15.0	80.0	15.0	7.0	362.1	31.7	0.70

Test Results (*Reference AF2178*)

Run Number	V (kts)	MVD (μm)	LWC (g/m³)	Ts (°C)	Tt (°C)	Time (min)	$\beta_0 Ac$	n_0	Mod-1 P_{air} (psig)	Mod-1 delP (psid)	Std P_{air} (psig)	Std delP (psid)	Mass g	Volume in³	ρ_{eff} (g/cm³)
AF2892	224.0	20.00	0.50	-13.4	-6.8	17.7	1.33	0.60	19.4	49.9			291.2	26.8	0.66
AF2895	224.0	21.40	1.12	-21.7	-15.1	7.7	1.33	0.60			15.6	11.6	307.2	26.1	0.72
AF2896	224.0	21.30	1.54	-25.5	-18.8	5.6	1.33	0.60	15.0	80.0	15.0	7.0	367.0	29.9	0.75
AF2897	224.0	21.30	1.54	-25.5	-18.8	5.6	1.33	0.60	15.0	80.0	15.0	7.0	361.1	29.4	0.75
AF2898	224.0	21.40	1.12	-21.7	-15.1	7.7	1.33	0.60	10.0	30.0	10.0	5.0	323.5	27.6	0.72



Test Case Summary
Ice Accretion on 2D Geometry

Baseline Test Case

- Ref. AIAA 2014-2613
- 18-inch chord NACA 23012, 2 deg. AoA
  - 2 cases, double horn glaze ice and rime ice.

Optional Test Cases

- Ref. SAE 2019-01-2022
- 72-inch chord NACA 23012, 2 deg. AoA
  - 2 cases-1 monomodal and 1 bimodal drop distribution, mixed ice.

Ice Accretion on 2D Geometry

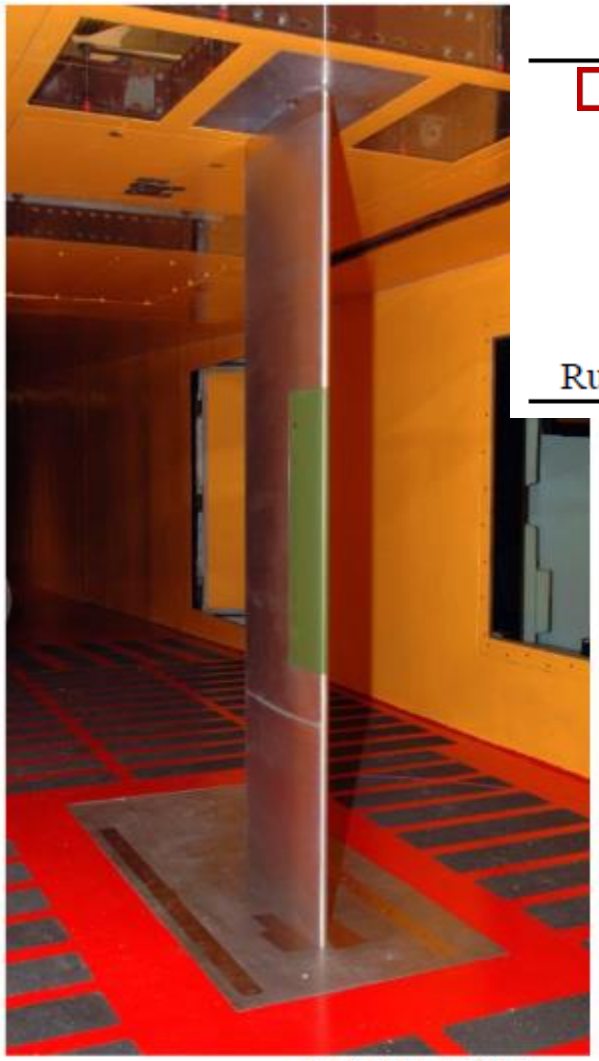
ID	Title	Test facility	Year	Data Type	Geometry	Reynolds (millions)	Air speed	MVD µm	LWC g/m3	Temperature	Reference	Vote for baseline 0/1	Vote for optional 0/1	Vote for future workshop 0/1
16	72-in NACA 23012 (EG1112)	IRT	2016	Tracings, photos, Cp	NACA 23012, straight, AoA 2	15	200 kts	20	0.5	-7.4 C (static)	NASA/TP-2016-218348	4	**6**	0
17	72-in NACA23012, SLD (runs EG2819/EG2820)	IRT	2019	3D scans, ice mass	NACA 23012, straight, AoA 2	15	200 kts	20.8	1.64	-12.6 C (static)	SAE 2019-01-2022	5	**6**	2
18	18-in NACA23012 (ED1978)	IRT	2014	3D scans, cp	NACA 23012, straight, AoA 2	3.5	200 kts	15	0.75	-2.2C (total)	AIAA 2014-2613	**7**	5	0

Selected as optional

Ice Accretion on 2D Geometry

Baseline Case

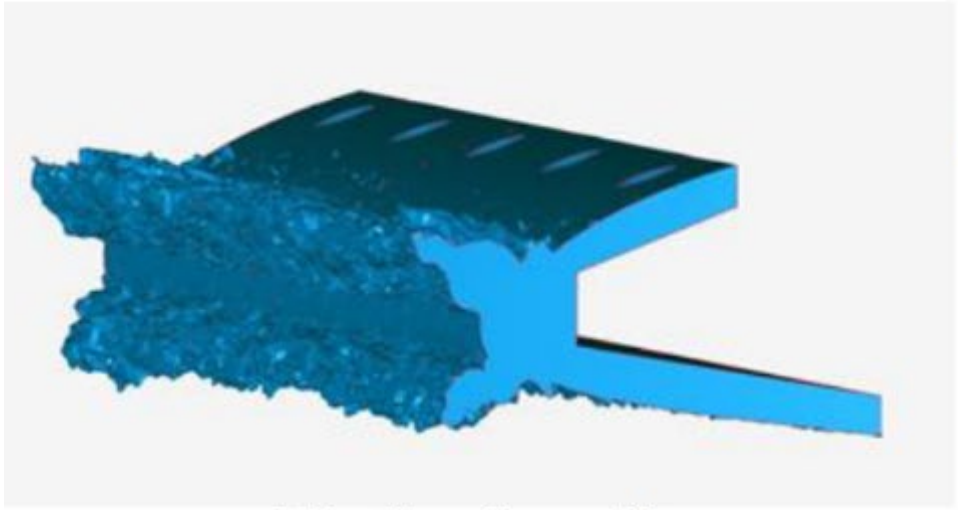
18-in NACA23012 (ED1978) from AIAA 2014-2613



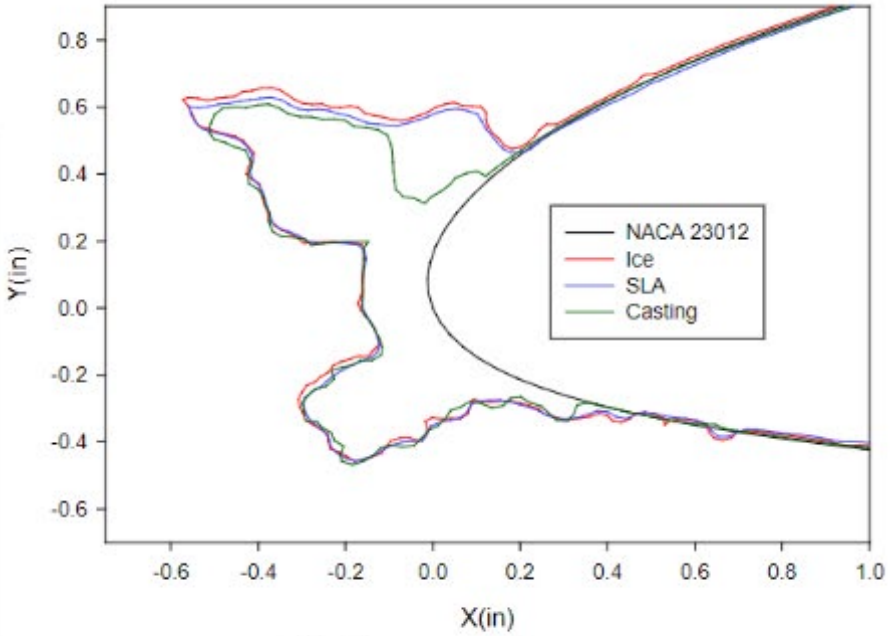
a) NACA 23012

Table 1 Ice shapes tested for straight wing.

Ice Shape	Run Number	α (°)	V (kts)	LWC (g/m^3)	MVD (μm)	T_0 (°C)	Spray (min)
Glaze (Horn)	ED1978	2	200	0.75	15	-2.2	5
Roughness	ED1974	2	200	0.75	15	-2.2	0.5
Roughness	ED1983	2	200	0.4	30	-17.8	1
Rime (Streamwise)	ED1977	2	200	0.4	30	-17.8	5
Rime (Streamwise)	ED1966	5	175	0.3	15	-17.8	5
Runback (Spanwise Ridge)	ED1967	1	175	0.64	15	-4.4	9.5



a) Leading-edge model



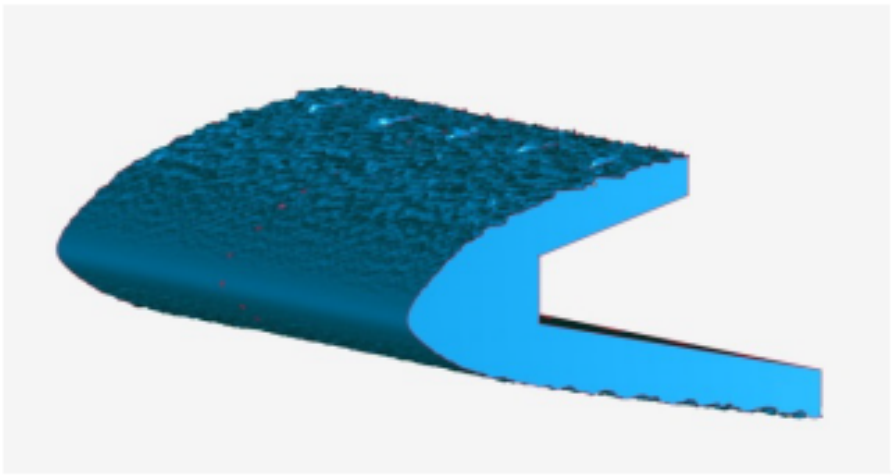
b) Cross section cuts

18-in NACA23012 (ED1978) from AIAA 2014-2613

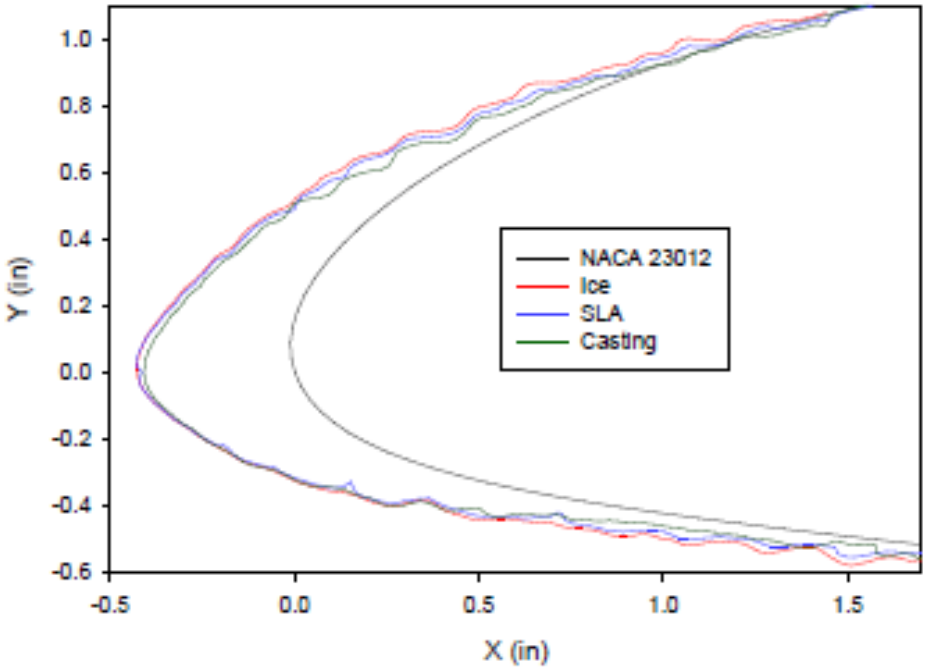
a) NACA 23012

Table 1 Ice shapes tested for straight wing.

Ice Shape	Run Number	α (°)	V (kts)	LWC (g/m^3)	MVD (μm)	T_0 (°C)	Spray (min)
Glaze (Horn)	ED1978	2	200	0.75	15	-2.2	5
Roughness	ED1974	2	200	0.75	15	-2.2	0.5
Roughness	ED1983	2	200	0.4	30	-17.8	1
Rime (Streamwise)	ED1977	2	200	0.4	30	-17.8	5
Rime (Streamwise)	ED1966	5	175	0.3	15	-17.8	5
Runback (Spanwise Ridge)	ED1967	1	175	0.64	15	-4.4	9.5



a) Leading-edge model



b) Cross section cuts

Ice Accretion on 2D Geometry

Optional Cases

3D Scanned Ice Shapes on 72-in NACA 23012, – SAE 2019-01-2022

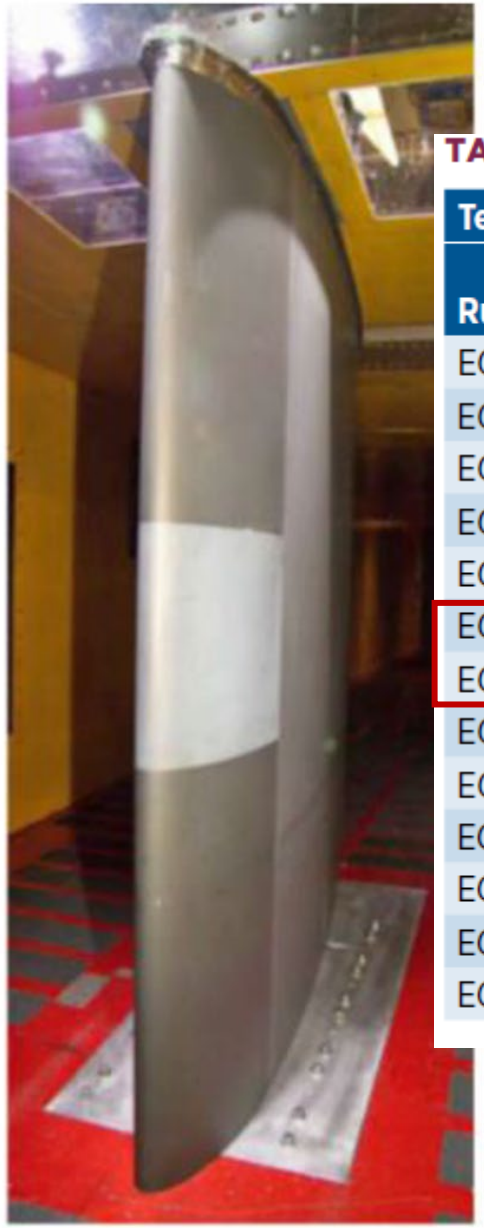


TABLE 2 Test conditions for 72-inch chord, NACA 23012 airfoil model.

Test Conditions											
Run Number	α (deg)	V (kts)	MVD (μm)	LWC (g/m³)	T_t (°C)	T_s (°C)	Time (min)	n_o	P_{air}, *(psig)*	Mod1 DP, *(psid)*	STD DP, *(psid)*
EG2814	5	175	20.8	1.77	-4.7	-8.7	5.20	0.19	15	80	7
EG2815	5	175	20.8	1.77	-4.7	-8.7	5.20	0.19	25.1		22.9
EG2816	2	200	20.8	1.64	-7.3	-12.6	0.59	0.27	15	80	7
EG2817	2	200	20.8	1.64	-7.3	-12.6	0.59	0.27	25.1		22.9
EG2818	5	175	20.8	1.77	-4.7	-8.7	5.20	0.19	15	80	7
EG2819	2	200	20.8	1.64	-7.3	-12.6	6.63	0.27	15	80	7
EG2820	2	200	20.8	1.64	-7.3	-12.6	6.63	0.27	25.1		22.9
EG2821	2	200	20.8	1.64	-26.4	-31.7	4.60	0.72	15	80	7
EG2822	5	175	20.8	1.77	-4.7	-8.7	5.20	0.19	25.1		22.9
EG2823	2	200	20.8	1.64	-26.4	-31.7	4.60	0.72	25.1		22.9
EG2824	2	150	20.8	1.96	-32.1	-35.1	3.50	>.85	15	80	7
EG2825	2	150	20.8	1.96	-32.1	-35.1	3.50	0.85	25.4		23.3
EG2826	2	200	20.8	1.64	-7.3	-12.6	6.63	0.27	15	80	7

3D Scanned Ice Shapes on 72-in NACA 23012, – SAE 2019-01-2022

Test Conditions

Run Number	α (deg)	V (kts)	MVD (μm)	LWC (g/m³)	T_t (°C)	T_s (°C)	Time (min)	n_0	P_{air}, *(psig)*	Mod1 DP, *(psid)*	STD DP, *(psid)*
EG2819	2	200	20.8	1.64	-7.3	-12.6	6.63	0.27	15	80	7
EG2820	2	200	20.8	1.64	-7.3	-12.6	6.63	0.27	25.1		22.9

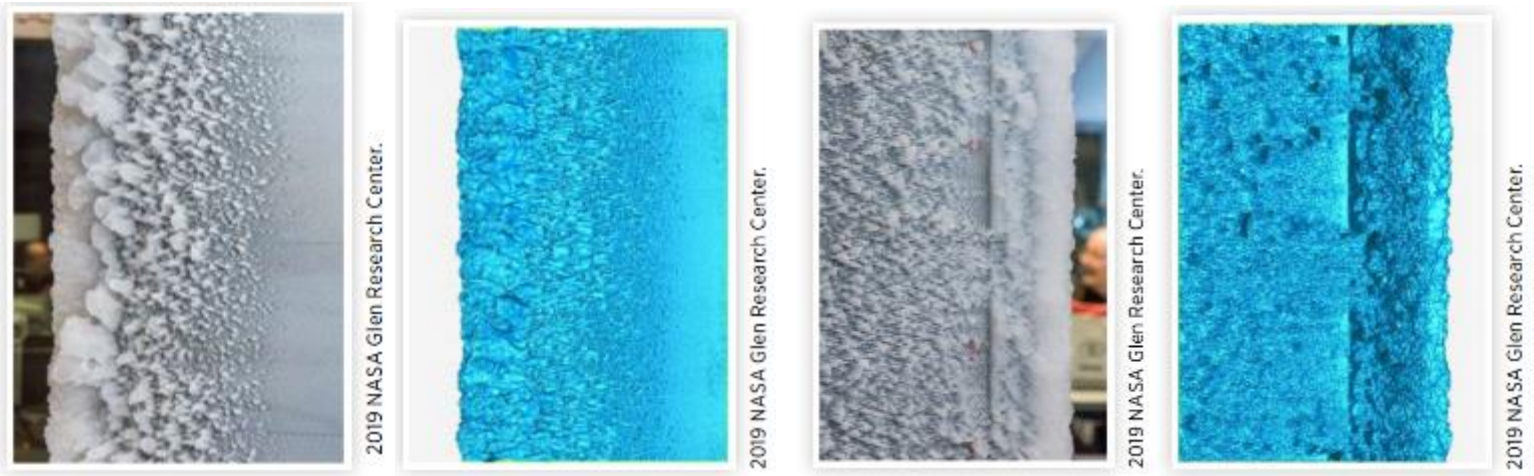
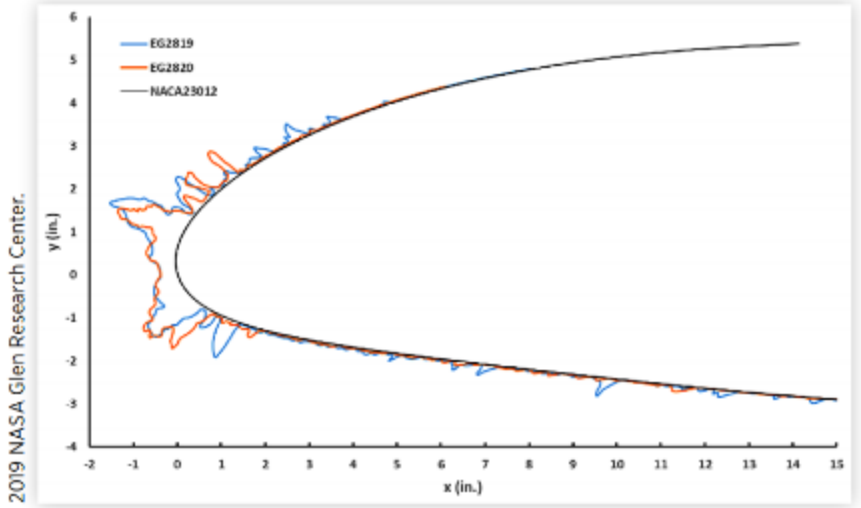


FIGURE 23 Ice shape profiles for runs EG2819 and EG2820 from center line of 72-inch chord NACA 23012 airfoil model.



NACA23012 Airfoil Test Results

Run Numbers	Mass bimodal (g)	Mass monomodal (g)	Δm (g)	Δm (%)	Volume bimodal (in³)	Volume monomodal (in³)	ΔVol. (in³)	ΔVol. (%)	$\rho_{eff,b}$ (g/cm³)	$\rho_{eff,m}$ (g/cm³)	$\Delta\rho_{eff}$ (%)
EG2819/EG2820	667.0	549.6	117.4	21.4%	52.47	43.07	9.40	21.8%	0.776	0.779	-0.4%

Collection Efficiency on 3D Geometry

Test Case Summary
Collection Efficiency on 3D Geometry

Baseline Test Case

- Ref. NASA TM-2002-211700
- NACA 64A008 finite swept tail, AoA = 6 deg.
  - 1 case: MVD = 21
- Three element airfoil, 36-inch nested chord, AoA = 4 deg.
  - 1 cases: MVD = 21

Optional Test Cases

- Ref. NASA TM-2002-211700
- NACA 64A008 finite swept tail, AoA = 6 deg.
  - 1 case: MVD = 92
- Three element airfoil, 36-inch nested chord, AoA = 4 deg.
  - 1 cases: MVD = 92.
- Ref. NASA CR 4257
- Axisymmetric inlet at AoA = 15 deg.
  - 1 case: MVD = 20.4

ID	Title	Test facility	Year	Data Type	Geometry	Reynolds (millions)	Air speed	MVD µm	LWC g/m3	Temperature	Reference	Vote for baseline 0/1	Vote for optional 0/1	Vote for future workshop 0/1
20	Swept tail	IRT	1997	Collection efficiency, Cp	NACA 64A008 finite swept tail, AoA 6	5	176 mph	21	0.15	291 K (static)	NASA TM 2002-211700	**7**	2	3
21	Axisymmetric inlet	IRT	1989	Collection efficiency, surface Mach	AoA 15, highlight diameter = 15 inches	1	168 mph	20.36		50 F (static)	NASA CR 4257	2	**7**	4

Selected as optional

Collection Efficiency on 3D Geometry

Baseline Case

NACA 64A008 finite swept tail, AoA 6

MVD = 21 microns
Speed = 176 mph
Mach = 0.23
Reynolds = 5.03
Static Temperature* = 291.2 K
Static Pressure* = 83025 Pa

Geometry (test year)	Chord (in)	t_{max} (in)	x/c at t_{max}	V_∞ mph	Re_c Million	AOA (deg.)	MVD (μm)	Re_{MVD}	K	K_0	φ
NACA 64A008 Swept finite span tail (1997)	37.65* (0.956*)	3.01* (0.077*)	0.39	176 (78.66)	5.03*	0.0	11.5	60	0.034*	0.014*	106,514*
							21.0	110	0.114*	0.039*	
							92.0	483	2.186*	0.395*	
						6.0	11.5	60	0.034*	0.014*	
							21.0	110	0.114*	0.039*	
							92.0	483	2.186*	0.395*	

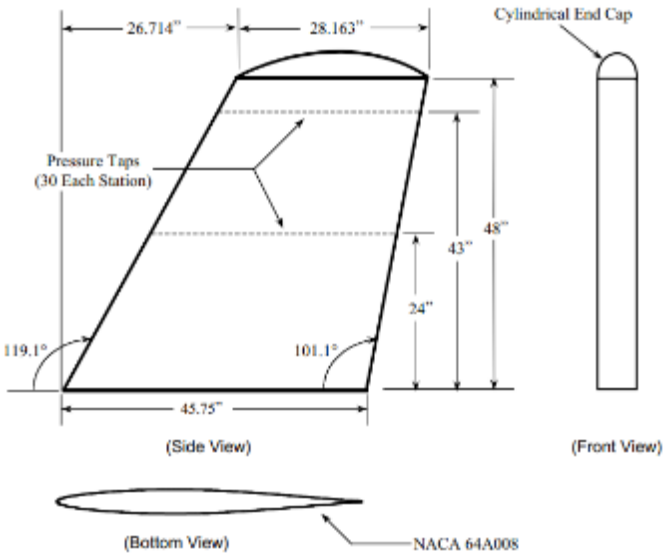
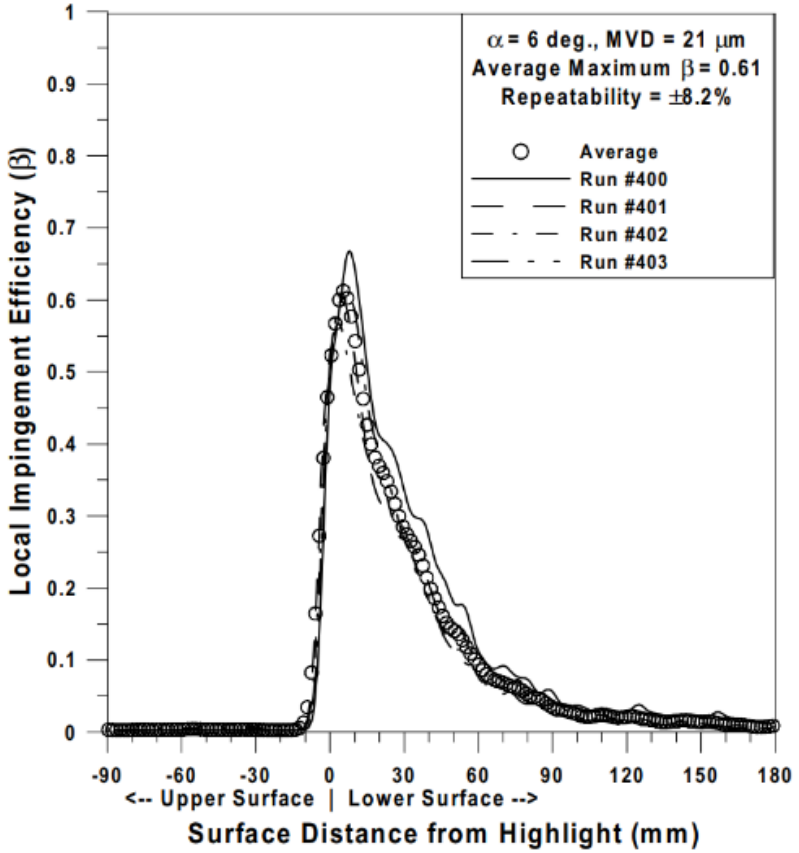
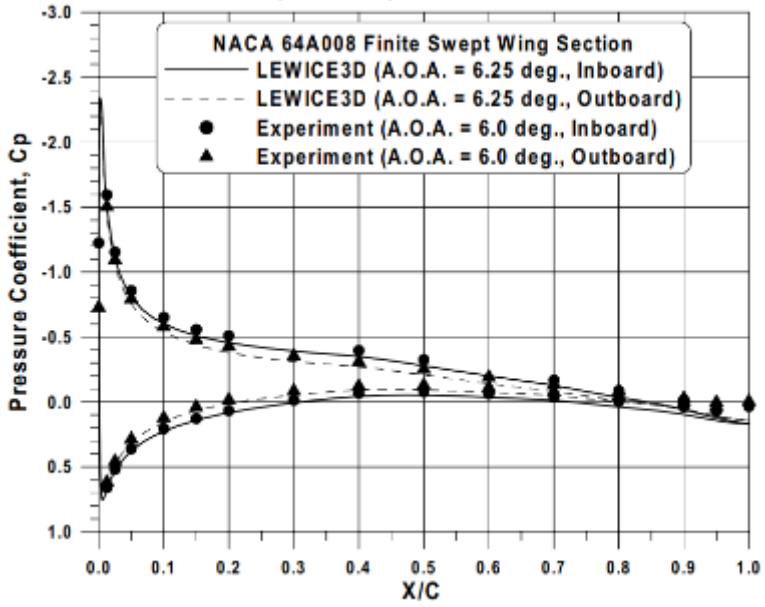


Fig. 14c NACA 64A008 swept tail (3-View Plot).



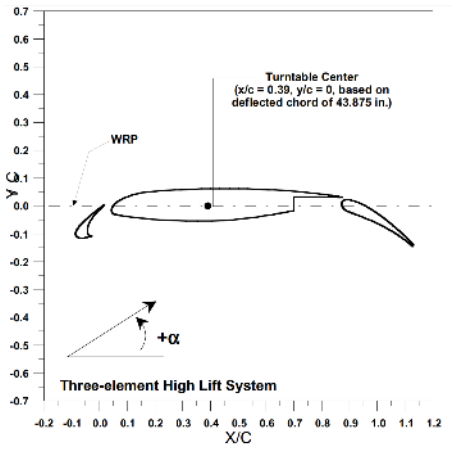


b. α = 6°, M = 0.23, Re = 5.03 million

NASA TM 2002-211700 / NASA-TM-2005-213653

Three-element airfoil at α = 4°

MVD = 21 microns
Speed = 176 mph
Mach = 0.23
Reynolds = 4.9M (deflected chord?)
Static Temperature* = 291.2 K
Static Pressure* = 84337 Pa



Test Model	Number of Surface Pressure Taps	Angle of Attack (α) Flap deflection (δ) (degrees)	MVD (μm)	Average Air Speed	Number of Runs per MVD	Total Number of Runs
Three-element high lift system airfoil (36 in nested chord) Strip Location: Midspan	128	α = 0 4 δ = Landing Configuration	11.5 21 92	176 mph	4	24

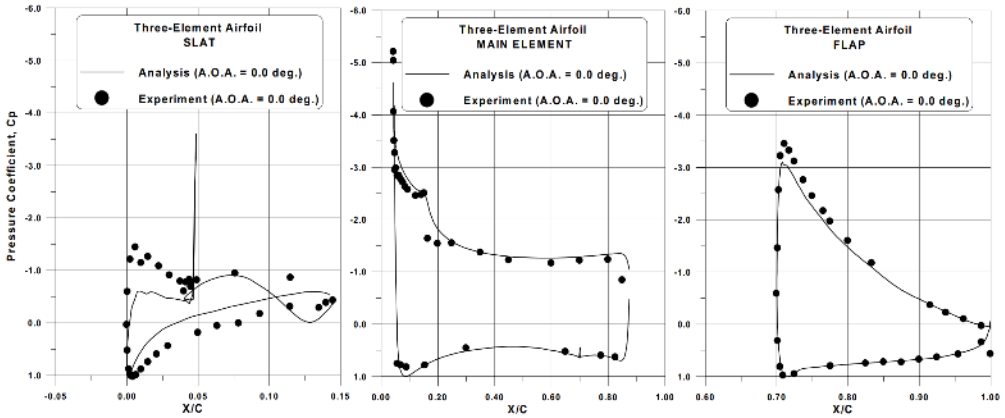
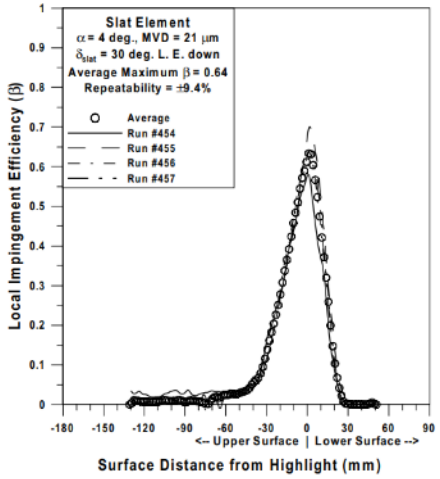
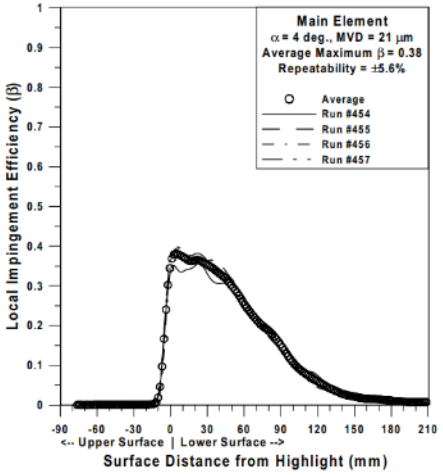
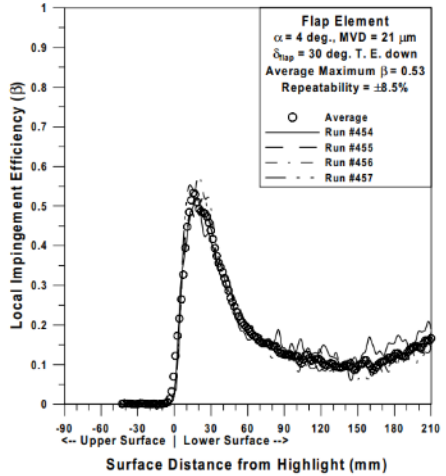


Fig. 81 Comparison of experimental and INS2D pressure distributions for the three-element high lift system; α = 0°, M = 0.23, Re = 4.9 million, landing configuration, slat deflection 30 deg., flap deflection 30 deg.







NASA TM 2002-211700

Collection Efficiency on 3D Geometry

Optional Cases

NACA 64A008 finite swept tail, AoA 6

MVD = 92 microns
Speed = 176 mph
Mach = 0.23
Reynolds = 5.03
Static Temperature* = 291.2 K
Static Pressure* = 83025 Pa

Geometry (test year)	Chord (in)	t_{max} (in)	x/c at t_{max}	V_∞ mph	Re_c Million	AOA (deg.)	MVD (μm)	Re_{MVD}	K	K_0	φ
NACA 64A008 Swept finite span tail (1997)	37.65* (0.956*)	3.01* (0.077*)	0.39	176 (78.66)	5.03*	0.0	11.5	60	0.034*	0.014*	106,514*
							21.0	110	0.114*	0.039*	
							92.0	483	2.186*	0.395*	
						6.0	11.5	60	0.034*	0.014*	
							21.0	110	0.114*	0.039*	
							92.0	483	2.186*	0.395*	

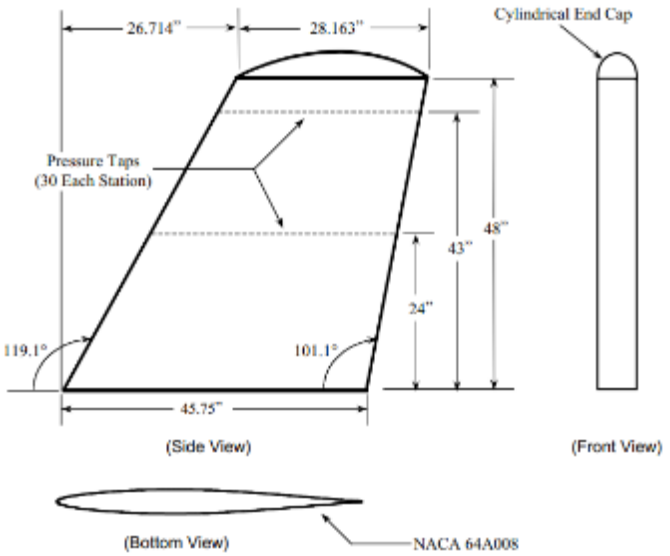
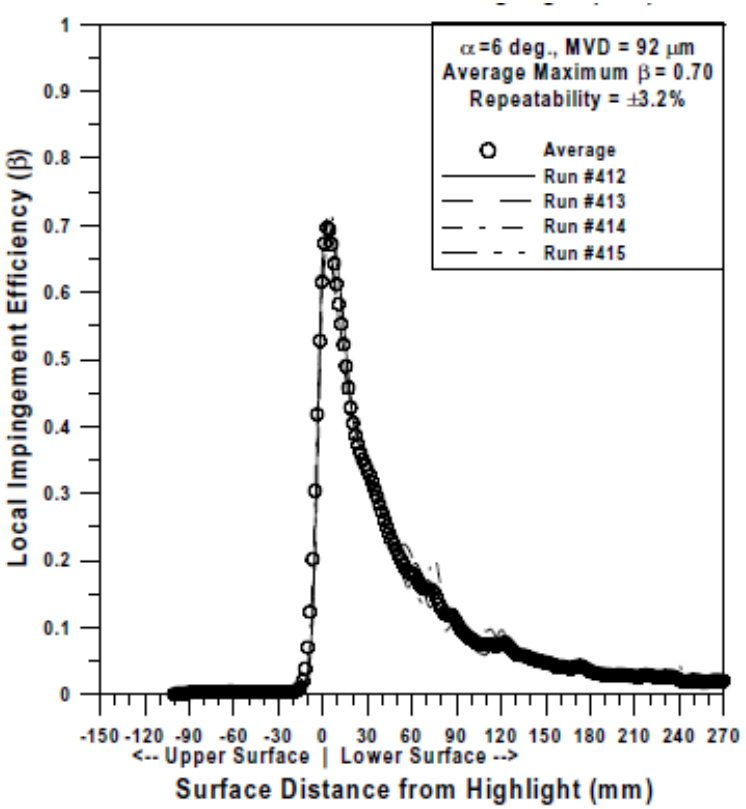
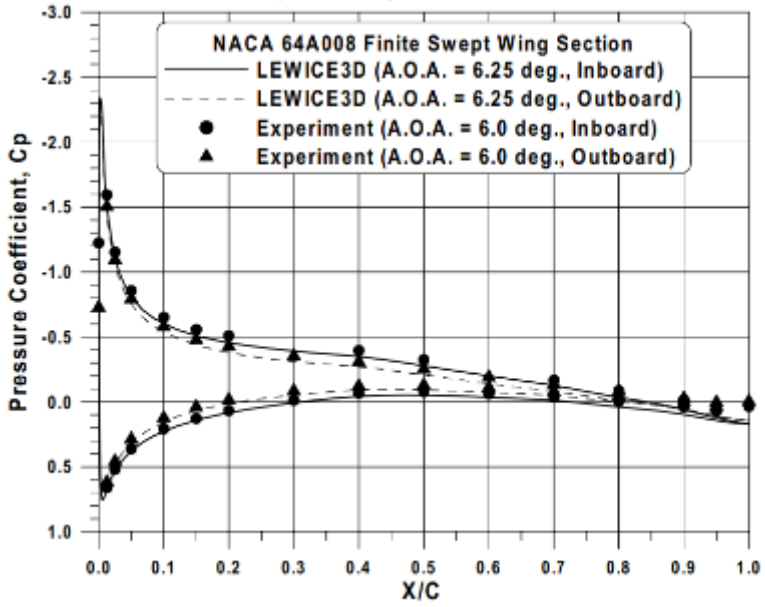


Fig. 14c NACA 64A008 swept tail (3-View Plot).



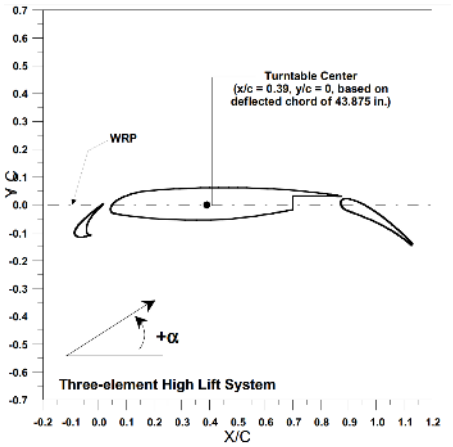


b. α = 6°, M = 0.23, Re = 5.03 million

NASA TM 2002-211700 / NASA-TM-2005-213653

Three-element airfoil at α = 4°

MVD = 92 microns
Speed = 176 mph
Mach = 0.23
Reynolds = 4.9M (deflected chord?)
Static Temperature* = 291.2 K
Static Pressure* = 84337 Pa



Test Model	Number of Surface Pressure Taps	Angle of Attack (α) Flap deflection (δ) (degrees)	MVD (μm)	Average Air Speed	Number of Runs per MVD	Total Number of Runs
Three-element high lift system airfoil (36 in nested chord) Strip Location: Midspan	128	α = 0, 4 δ = Landing Configuration	11.5, 21, 92	176 mph	4	24

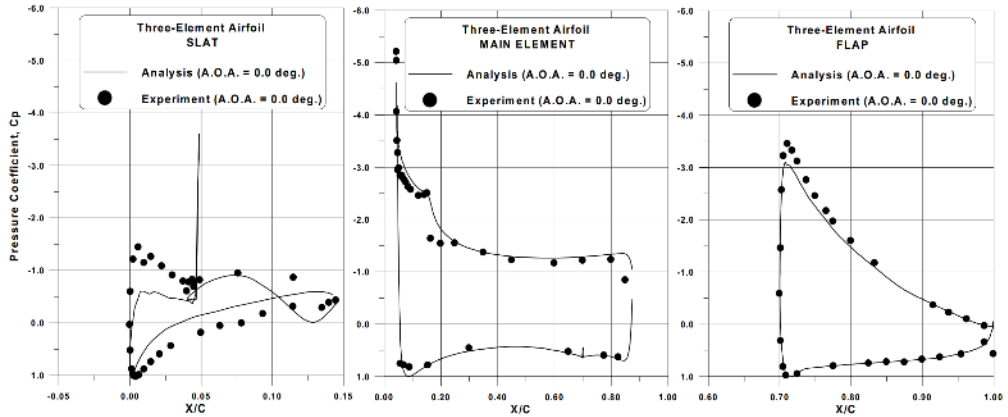
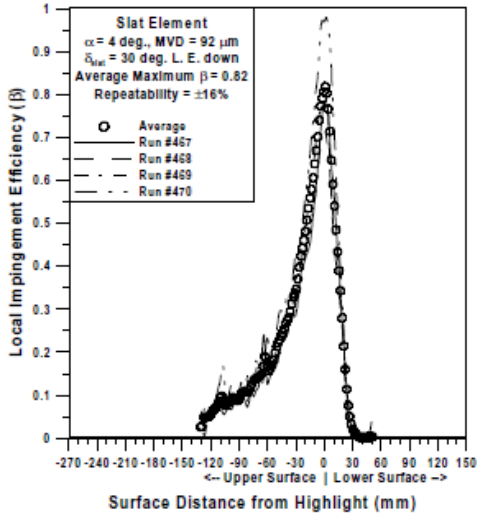
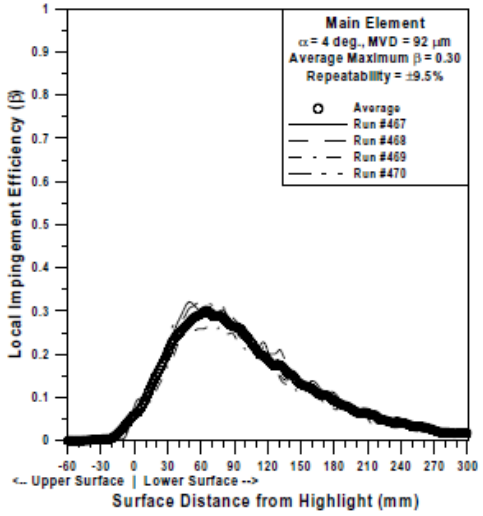
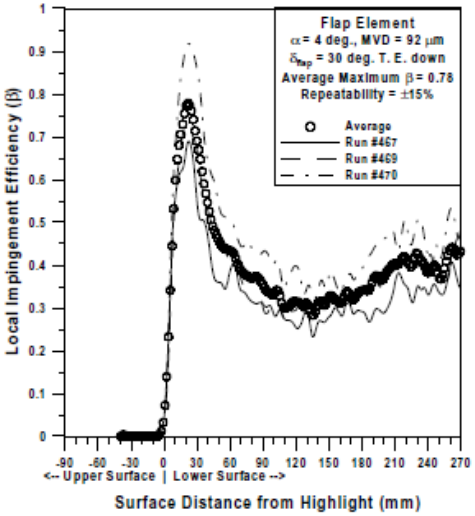


Fig. 81 Comparison of experimental and INS2D pressure distributions for the three-element high lift system; α = 0°, M = 0.23, Re = 4.9 million, landing configuration, slat deflection 30 deg., flap deflection 30 deg.







NASA TM 2002-211700

Axisymmetric inlet at α = 15°

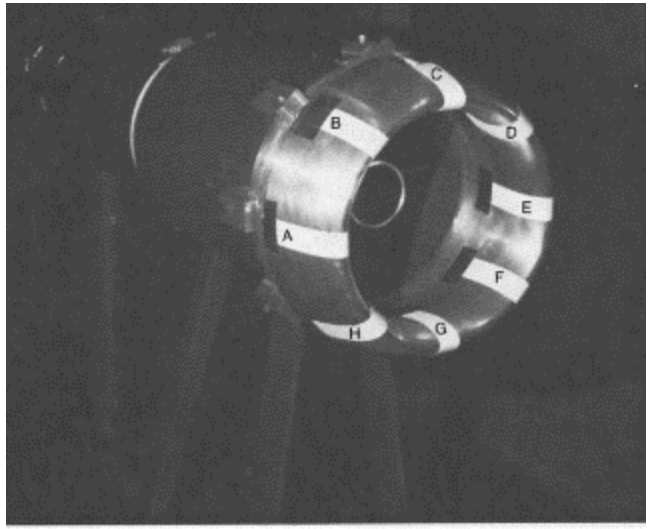
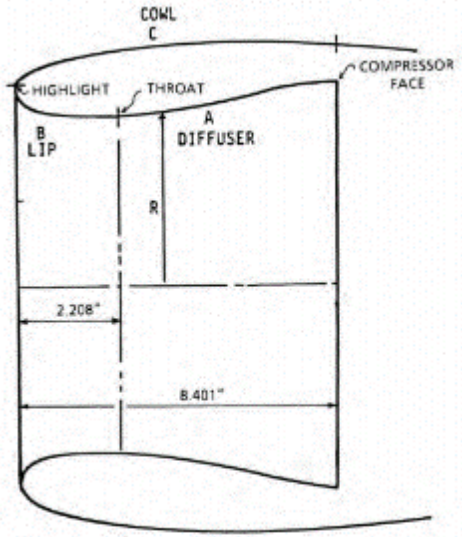


FIGURE 3.22

BLOTTER STRIP LOCATIONS ON AXISYMMETRIC INLET FOR α = 15°.

MVD = 20.36 microns
Speed = 168.9 mph
Mach = 0.2328



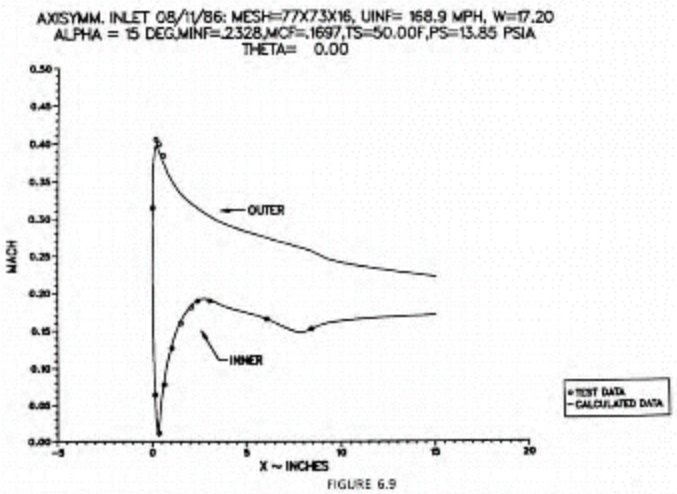
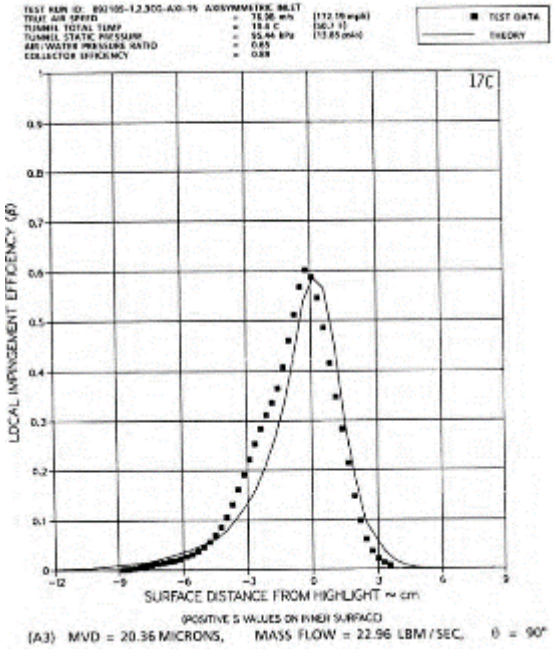
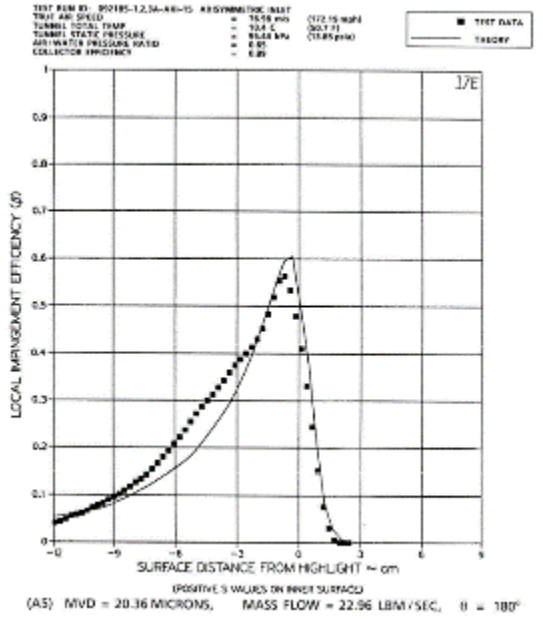
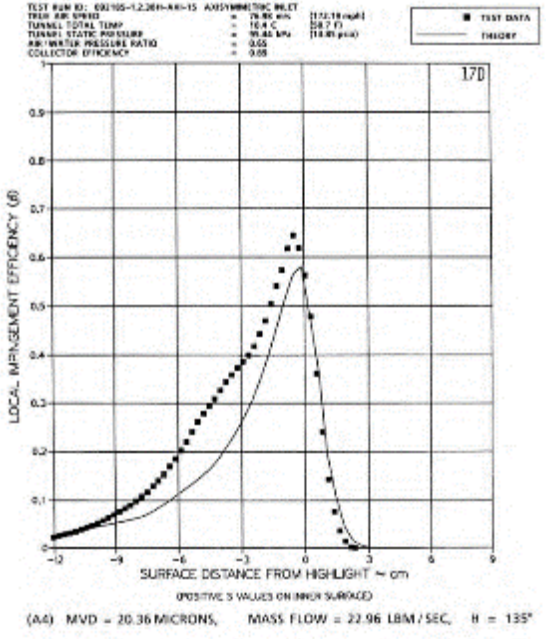


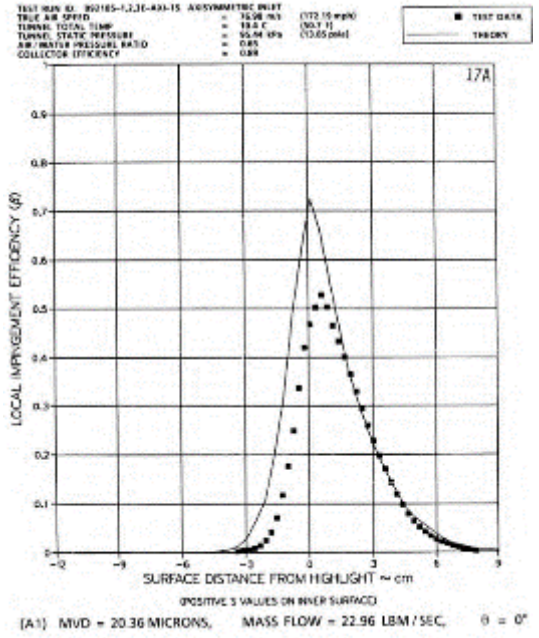
FIGURE 6.9

EXPERIMENTAL AND ANALYTICAL SURFACE MACH NUMBERS FOR AXISYMMETRIC INLET (B1) W = 17.20 LBM/SEC (PAGE 6 OF 17).









Test Case Summary

Category	Configuration	Baseline	Optional
Ice Accretion on 3D Geometry	NACA 0012, 30 deg sweep	2	2
	NACA 0012, 45 deg sweep	2	0
Ice Accretion on 2D Geometry	18-inch chord NACA 23012	2	0
	72-inch chord NACA 23012	0	2
Collection Efficiency on 3D Geometry	NACA 64A008 finite swept tail	1	1
	Multi-element airfoil	1	1
	Axisymmetric inlet at $\alpha = 15°$	0	1