January 2005 • NREL/SR-500-36343

Subcontractor Report

The S827 and S828 Airfoils

Period of Performance: 1994 – 1995

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Airfoils, Inc.
State College, Pennsylvania

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Operated for the U.S. Department of Energy
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ABSTRACT

A family of thick, natural-laminar-flow airfoils, the S827 and S828, for 40- to 50-meter, stall-regulated, horizontal-axis wind turbines has been designed and analyzed theoretically. The two primary objectives of restrained maximum lift, insensitive to roughness, and low profile drag have been achieved. The constraints on the pitching moments and the airfoil thicknesses have been satisfied. The airfoils should exhibit docile stalls.

INTRODUCTION

The majority of the airfoils in use on horizontal-axis wind turbines today were originally developed for aircraft. The design requirements for these airfoils, primarily National Advisory Committee for Aeronautics (NACA) and National Aeronautics and Space Administration (NASA) airfoils (refs. 1–6), are significantly different from those for wind-turbine airfoils (ref. 7). Accordingly, several families of airfoils have been designed specifically for horizontal-axis wind-turbine applications, as shown in the following table.

Diameter	Type	Thickness Category	Airfoil			Reference
			Primary	Tip	Root	
2–10 m	Variable speed Variable pitch	Thick		S822	S823	13
10–20 m	Variable speed Variable pitch	Thin	S801	S802 S803	S804	8
	Stall regulated	Thin	S805 S805A	S806 S806A	S807 S808	8
	Stall regulated	Thick	S819	S820	S821	12
20–30 m	Stall regulated	Thick	S809	S810	S811	9
	Stall regulated	Thick	S812	S813	S814 S815	9 and 10
20–40 m	Variable speed Variable pitch	—	S825	S826		14
30–50 m	Stall regulated	Thick	S816	S817	S818	11

An overview of almost all these airfoil families is given in reference 15.

The family of airfoils designed under the present study is intended for 40- to 50-meter, stall-regulated, horizontal-axis wind turbines. The specific tasks performed under this study are described in National Renewable Energy Laboratory (NREL) Subcontract Number AAF-4-14289-01. The specifications for the airfoils are outlined in the Statement of Work.

These specifications were later refined during discussions with James L. Tangler of NREL.

Because of the limitations of the theoretical methods (refs. 16 and 17) employed in this study, the results presented are in no way guaranteed to be accurate—either in an absolute or in a relative sense. This statement applies to the entire study.

SYMBOLS

C_p	pressure coefficient
c	airfoil chord, m
c_d	section profile-drag coefficient
c_l	section lift coefficient
c_m	section pitching-moment coefficient about quarter-chord point
L.	lower surface
R	Reynolds number based on free-stream conditions and airfoil chord
S.	boundary-layer separation location, $1 - s_{sep}/c$
s_{sep}	arc length along which boundary layer is separated, m
s_{turb}	arc length along which boundary layer is turbulent including s_{sep}, m
T.	boundary-layer transition location, $1 - s_{turb}/c$
U.	upper surface
x	airfoil abscissa, m
y	airfoil ordinate, m
α	angle of attack relative to x-axis, deg

AIRFOIL DESIGN

OBJECTIVES AND CONSTRAINTS

The design specifications for the family of airfoils are contained in table I. The family consists of two airfoils, primary and tip, corresponding to the 0.75 and 0.95 blade radial sta-

tions, respectively. (It is recommended that the S818 airfoil (ref. 11) be used for the root region of a wind-turbine blade incorporating this family.)

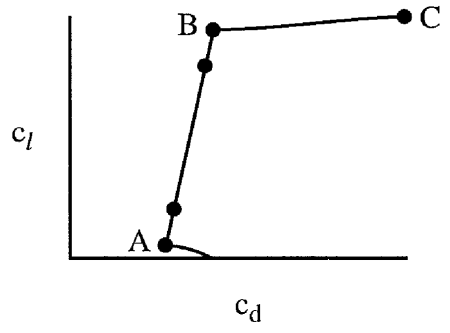
Two primary objectives are evident from the specifications. The first objective is to restrain the maximum lift coefficients of the primary and tip airfoils to the relatively low values of 1.00 and 0.90, respectively. A requirement related to this objective is that the maximum lift coefficient not decrease with transition fixed near the leading edge on both surfaces. In addition, the airfoils should exhibit docile stall characteristics. The second objective is to obtain low profile-drag coefficients over the ranges of lift coefficients from 0.20 to 0.80 for the primary airfoil and from 0.10 to 0.70 for the tip airfoil.

Two major constraints were placed on the designs of these airfoils. First, the zero-lift pitching-moment coefficient must be no more negative than –0.07 for both airfoils. Second, the airfoil thickness must equal 21-percent chord for the primary airfoil and 16-percent chord for the tip airfoil.

In essence, the specifications for these two airfoils are identical to those for the S816 and S817 airfoils (ref. 11) except that all the lift coefficients are reduced by 0.20.

PHILOSOPHY

Given the above objectives and constraints, certain characteristics of the designs are apparent. The following sketch illustrates a drag polar that meets the goals for these designs.



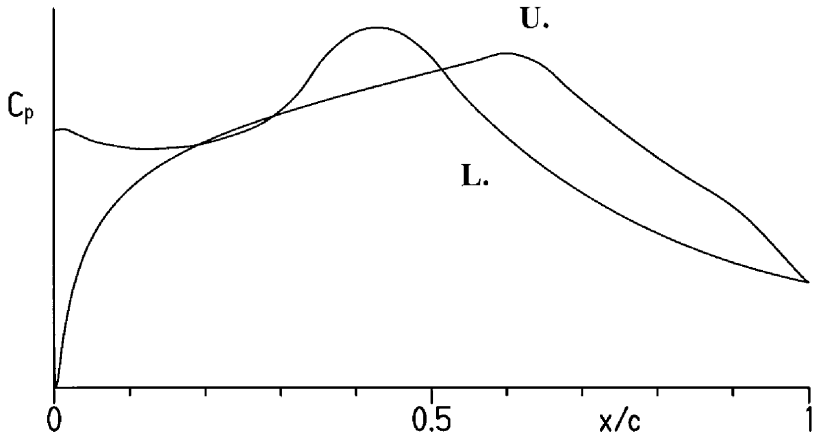
Sketch 1

The desired airfoil shapes can be traced to the pressure distributions that occur at the various points in sketch 1. Point A is the lower limit of the low-drag, lift-coefficient range. The lift coefficient at point A is 0.15 lower than the objective specified in table I. The difference is intended as a margin against such contingencies as manufacturing tolerances, operational deviations, three-dimensional effects, and inaccuracies in the theoretical method. A similar margin is also desirable at the upper limit of the low-drag range, point B, although this margin

is constrained by the proximity of the upper limit to the maximum lift coefficient. The drag at point B is not as low as at point A, unlike the polars of many other laminar-flow airfoils where the drag within the laminar bucket is nearly constant. This characteristic is related to the elimination of significant (drag-producing) laminar separation bubbles on the upper surface. (See ref. 18.) It is acceptable because the ratio of the profile drag to the total drag of the wind-turbine blade decreases with increasing lift coefficient. The drag increases very rapidly outside the low-drag range because the boundary-layer transition point moves quickly toward the leading edge with increasing (or decreasing) lift coefficient. This feature results in a leading edge that produces a suction peak at higher lift coefficients, which ensures that transition on the upper surface will occur very near the leading edge. Thus, the maximum lift coefficient, point C, occurs with turbulent flow along the entire upper surface and, therefore, should be relatively insensitive to roughness at the leading edge.

Because the large thickness of the primary airfoil allows a wider low-drag range than specified, the lower limit of the low-drag range should be below point A.

From the preceding discussion, the pressure distributions along the polar can be deduced. The pressure distribution at point A for the primary airfoil should look something like sketch 2. (The pressure distribution for the tip airfoil should be qualitatively similar.)



Sketch 2

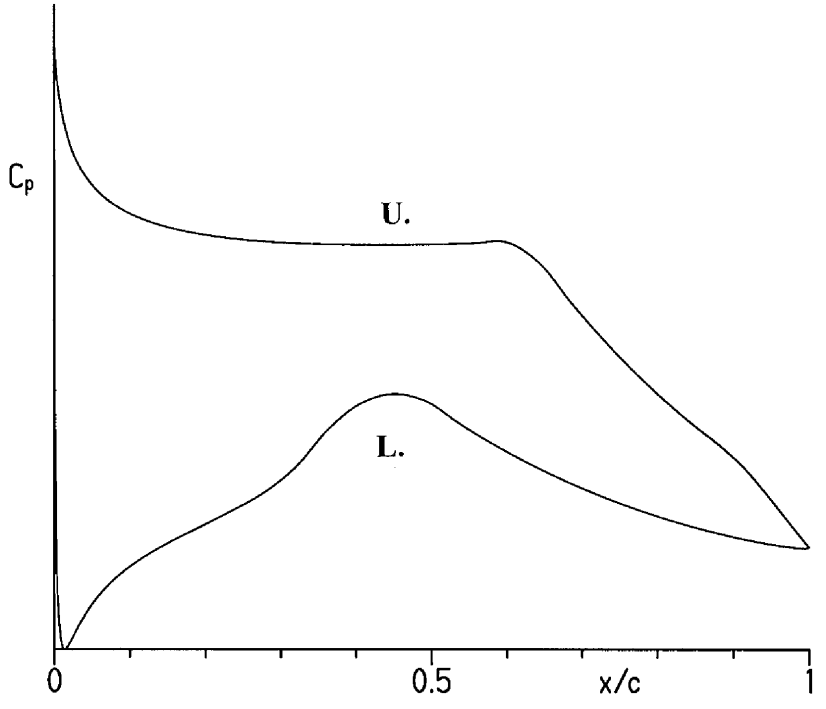
To achieve low drag, a favorable pressure gradient is desirable along the upper surface to about 60-percent chord. Aft of this point, a short region having a shallow, adverse pressure gradient ("transition ramp") promotes the efficient transition from laminar to turbulent flow (ref. 19). The transition ramp is followed by a nearly linear pressure recovery. The specific pressure recovery employed represents a compromise between maximum lift, drag, and stall characteristics. The steep, adverse pressure gradient aft of about 90-percent chord is a "separation ramp," originally proposed by F. X. Wortmann,[1] which confines turbulent separation to

a small region near the trailing edge. By constraining the movement of the separation point at high angles of attack, high lift coefficients can be achieved with little drag penalty. This feature has the added benefit of promoting docile stall characteristics. (See ref. 20.)

A generally favorable pressure gradient is desirable along the lower surface to about 45-percent chord to achieve low drag. The specific pressure gradients employed along the forward portion of the lower surface increase the amount of camber in the leading-edge region while maintaining low drag at the lower lift coefficients. The forward camber serves to balance, with respect to the pitching-moment constraint, the aft camber, both of which contribute to the achievement of the specified maximum lift coefficient and low profile-drag coefficients. This region is followed by a transition ramp and then a concave pressure recovery that produces lower drag and has less tendency to separate than the corresponding linear or convex pressure recovery (ref. 19). The pressure recovery must begin relatively far forward to alleviate separation at lower lift coefficients, especially with transition fixed near the leading edge.

The amounts of pressure recovery on the upper and lower surfaces are determined by the airfoil-thickness and pitching-moment constraints.

At point B, the pressure distribution should look like sketch 3.



Sketch 3

[1]Director, Institute for Aerodynamics and Gas Dynamics, University of Stuttgart, Germany.

Transition is essentially imminent over the entire forward portion of the upper surface. This feature allows a wider low-drag range to be achieved and higher lift coefficients to be reached without significant separation. It also causes the transition point to move very quickly toward the leading edge with increasing lift coefficient, which leads to the roughness insensitivity of the maximum lift coefficient.

EXECUTION

Given the pressure distributions previously discussed, the design of the airfoils is reduced to the inverse problem of transforming the pressure distributions into airfoil shapes. The Eppler Airfoil Design and Analysis Code (refs. 16 and 17) was used because of its unique capability for multipoint design and because of confidence gained during the design, analysis, and experimental verification of several other airfoils. (See refs. 21–24.)

The primary airfoil is designated the S827. The tip airfoil, the S828, was derived from the S827 airfoil to increase the aerodynamic and geometric compatibilities of the two airfoils. The airfoil shapes are shown in figure 1 and the coordinates are contained in tables II and III. The S827 airfoil thickness is 21-percent chord and the S828, 16-percent chord.

THEORETICAL PROCEDURE

The section characteristics are predicted for Reynolds numbers of 2.0×10^6, 2.5×10^6, 3.0×10^6, 3.5×10^6, and 4.0×10^6. The computations were performed with transition free using transition mode 3.0, with transition fixed at 2-percent chord on the upper surface and 5-percent chord on the lower surface using transition mode 1.3, and "rough" using transition mode 9.0, which simulates distributed roughness due to, for example, leading-edge contamination by insects or rain. (See ref. 17.) Because the free-stream Mach number for all relevant operating conditions remains below 0.3, all results are incompressible.

DISCUSSION OF RESULTS

S827 AIRFOIL

Pressure Distributions

The inviscid pressure distributions for the S827 airfoil at various angles of attack are shown in figure 2 and tabulated in the appendix.

Transition and Separation Locations

The variation of boundary-layer transition location with lift coefficient for the S827 airfoil is shown in figure 3 and tabulated in the appendix. It should be remembered that the

method of references 16 and 17 "defines" the transition location as the end of the laminar boundary layer whether due to natural transition or laminar separation. Thus, for conditions that result in relatively long laminar separation bubbles (low lift coefficients for the upper surface, high lift coefficients for the lower surface, and low Reynolds numbers), poor agreement between the predicted "transition" locations and the locations measured experimentally can be expected. This poor agreement is worsened by the fact that transition is normally confirmed in the wind tunnel only by the detection of attached turbulent flow. For conditions that result in shorter laminar separation bubbles (high lift coefficients for the upper surface, low lift coefficients for the lower surface, and high Reynolds numbers), the agreement between theory and experiment should be quite good. (See refs. 21 and 25.)

The variation of turbulent boundary-layer separation location with lift coefficient for the S827 airfoil is shown in figure 3 and tabulated in the appendix. Trailing-edge separation is predicted on the upper surface at all lift coefficients. This separation, which is caused by the separation ramp (fig. 2), increases in length with transition fixed and rough. Separation is predicted on the lower surface at lower lift coefficients. Such separation usually has little effect on the section characteristics. (See ref. 21.)

Section Characteristics

Reynolds number effects.– The section characteristics of the S827 airfoil are shown in figure 3 and tabulated in the appendix. It should be noted that the maximum lift coefficient computed by the method of references 16 and 17 is not always realistic. Accordingly, an empirical criterion should be applied to the computed results. This criterion assumes that the maximum lift coefficient has been reached if the drag coefficient of the upper surface is greater than 0.0150 or if the length of turbulent separation on the upper surface is greater than 0.10. Thus, the maximum lift coefficient for the design Reynolds number of 4.0×10^6 is estimated to be 1.00, which meets the design objective. Based on the variation of the upper-surface separation location with lift coefficient, the stall characteristics are expected to be docile, which meets the design goal. Low profile-drag coefficients are predicted over the range of lift coefficients from below 0 to more than 0.9, which exceeds the range specified (0.20 to 0.80). The drag coefficient at the specified lower limit of the low-drag range ($c_l = 0.20$) is predicted to be 0.0051, which is 36 percent below the design objective. The zero-lift pitching-moment coefficient is predicted to be –0.084, which exceeds the design constraint. However, the method of references 16 and 17 generally overpredicts the pitching-moment coefficient by about 20 percent. Therefore, the actual zero-lift pitching-moment coefficient should be about –0.07, which satisfies the constraint.

An additional analysis (not shown) indicates that significant (drag-producing) laminar separation bubbles should not occur on either surface for any relevant operating condition.

Effect of roughness.– The effect of roughness on the section characteristics of the S827 airfoil is shown in figure 3. The maximum lift coefficient for the design Reynolds number of 4.0×10^6 is unaffected by fixing transition because transition on the upper surface is predicted to occur forward of 2-percent chord at the maximum lift coefficient. For the rough

condition, the maximum lift coefficient for the design Reynolds number is estimated to be 0.99, a reduction of 1 percent from that for the transition-free condition. Thus, the design requirement has been satisfied. The effect of roughness on the maximum lift coefficient increases with decreasing Reynolds number. The drag coefficients are, of course, adversely affected by the roughness.

S828 AIRFOIL

Pressure Distributions

The inviscid pressure distributions for the S828 airfoil at various angles of attack are shown in figure 4 and tabulated in the appendix.

Transition and Separation Locations

The variations of transition and turbulent-separation locations with lift coefficient for the S828 airfoil are shown in figure 5 and tabulated in the appendix. Trailing-edge separation is predicted on the upper surface at almost all lift coefficients. This separation, which is caused by the separation ramp (fig. 4), increases in length with transition fixed and rough. A small separation is predicted on the lower surface at lower lift coefficients. Such separation usually has little effect on the section characteristics.

Section Characteristics

Reynolds number effects.– The section characteristics of the S828 airfoil are shown in figure 5 and tabulated in the appendix. Using the previously described criterion, the maximum lift coefficient for the design Reynolds number of 3.0×10^6 is estimated to be 0.90, which meets the design objective. The stall characteristics are expected to be docile, which meets the design goal. Low profile-drag coefficients are predicted over the range of lift coefficients from below 0 to more than 0.8, which exceeds the range specified (0.10 to 0.70). The drag coefficient at the specified lower limit of the low-drag range ($c_l = 0.10$) is predicted to be 0.0040, which is 43 percent below the design objective. The zero-lift pitching-moment coefficient is predicted to be –0.043, which satisfies the design constraint. Significant (drag-producing) laminar separation bubbles should not occur on either surface for any relevant operating condition.

Effect of roughness.– The effect of roughness on the section characteristics of the S828 airfoil is shown in figure 5. The maximum lift coefficient for the design Reynolds number of 3.0×10^6 is unaffected by fixing transition because transition on the upper surface is predicted to occur forward of 2-percent chord at the maximum lift coefficient. For the rough condition, the maximum lift coefficient for the design Reynolds number is estimated to be 0.89, a reduction of 1 percent from that for the transition-free condition. Thus, the design requirement has been satisfied. The effect of roughness on the maximum lift coefficient

increases with decreasing Reynolds number. The drag coefficients are, of course, adversely affected by the roughness.

CONCLUDING REMARKS

A family of thick, natural-laminar-flow airfoils, the S827 and S828, for 40- to 50-meter, stall-regulated, horizontal-axis wind turbines has been designed and analyzed theoretically. The two primary objectives of restrained maximum lift coefficient, insensitive to leading-edge roughness, and low profile-drag coefficients have been achieved. The constraints on the zero-lift pitching-moment coefficients and the airfoil thicknesses have been satisfied. The airfoils should exhibit docile stall characteristics.

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TABLE I.– AIRFOIL DESIGN SPECIFICATIONS

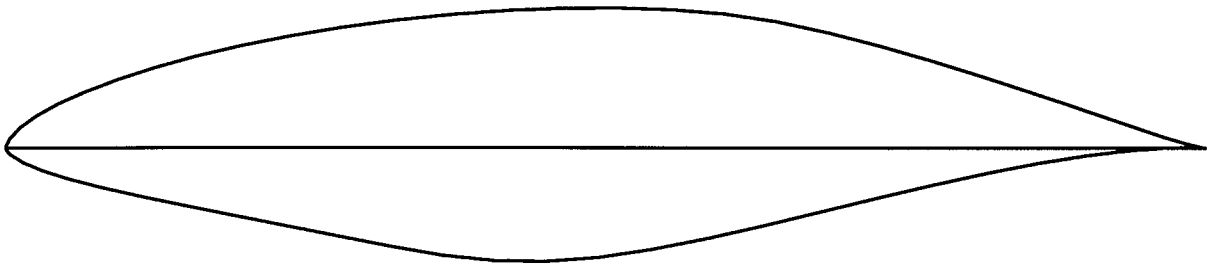
Parameter	Objective/Constraint	
Airfoil	Primary	Tip
Blade radial station	0.75	0.95
Reynolds number	4.0×10^6	3.0×10^6
Maximum lift coefficient	1.00	0.90
Low-drag, lift-coefficient range		
Lower limit	0.20	0.10
Upper limit	0.80	0.70
Minimum profile-drag coefficient	≤ 0.0080	≤ 0.0070
Zero-lift pitching-moment coefficient	≥ -0.07	≥ -0.07
Thickness	0.21c	0.16c

TABLE II.– S827 AIRFOIL COORDINATES

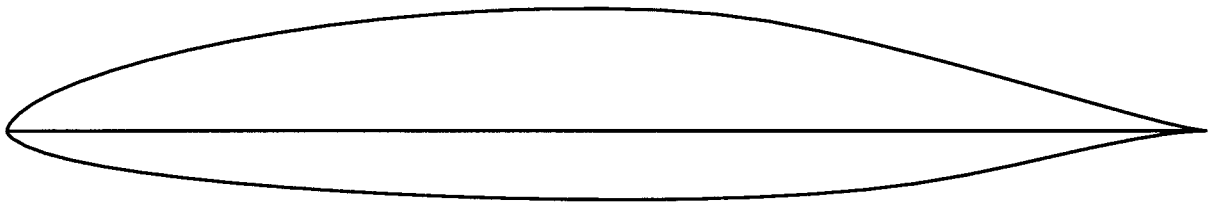
Upper Surface		Lower Surface	
x/c	y/c	x/c	y/c
0.00003	0.00054	0.00010	–0.00098
.00040	.00228	.00075	–.00240
.00327	.00789	.00194	–.00390
.01168	.01688	.00388	–.00572
.02501	.02661	.01440	–.01227
.04304	.03671	.03068	–.01907
.06557	.04692	.05249	–.02597
.09234	.05703	.07952	–.03303
.12305	.06686	.11138	–.04031
.15735	.07623	.14752	–.04794
.19486	.08497	.18727	–.05596
.23516	.09293	.22978	–.06438
.27779	.09996	.27409	–.07310
.32229	.10593	.31892	–.08183
.36815	.11068	.36288	–.08933
.41487	.11409	.40597	–.09376
.46193	.11603	.44906	–.09443
.50881	.11636	.49274	–.09126
.55498	.11490	.53770	–.08456
.59988	.11131	.58417	–.07538
.64347	.10497	.63172	–.06463
.68639	.09591	.67984	–.05305
.72880	.08503	.72787	–.04136
.77025	.07315	.77506	–.03025
.81021	.06086	.82049	–.02035
.84805	.04872	.86316	–.01216
.88305	.03718	.90192	–.00603
.91460	.02643	.93560	–.00204
.94236	.01682	.96306	–.00001
.96586	.00900	.98337	.00052
.98413	.00360	.99581	.00025
.99591	.00078	1.00000	.00000
1.00000	.00000		

TABLE III.– S828 AIRFOIL COORDINATES

Upper Surface		Lower Surface	
x/c	y/c	x/c	y/c
0.00003	0.00053	0.00009	–0.00090
.00038	.00215	.00069	–.00224
.00226	.00609	.00179	–.00364
.00956	.01419	.00481	–.00633
.02173	.02295	.01546	–.01240
.03860	.03202	.03146	–.01840
.05999	.04116	.05264	–.02409
.08569	.05019	.07880	–.02943
.11542	.05894	.10964	–.03438
.14886	.06724	.14480	–.03894
.18564	.07497	.18387	–.04309
.22536	.08199	.22636	–.04679
.26758	.08817	.27176	–.05002
.31183	.09340	.31952	–.05274
.35762	.09756	.36907	–.05490
.40444	.10053	.41982	–.05645
.45176	.10219	.47117	–.05732
.49904	.10241	.52253	–.05746
.54576	.10103	.57329	–.05681
.59134	.09770	.62288	–.05527
.63573	.09180	.67072	–.05275
.67954	.08339	.71627	–.04898
.72289	.07334	.75939	–.04362
.76532	.06246	.80026	–.03672
.80626	.05131	.83903	–.02873
.84507	.04046	.87561	–.02049
.88101	.03029	.90947	–.01301
.91342	.02103	.93959	–.00705
.94187	.01297	.96481	–.00298
.96579	.00665	.98395	–.00080
.98420	.00250	.99592	–.00008
.99595	.00050	1.00000	.00000
1.00000	.00000		

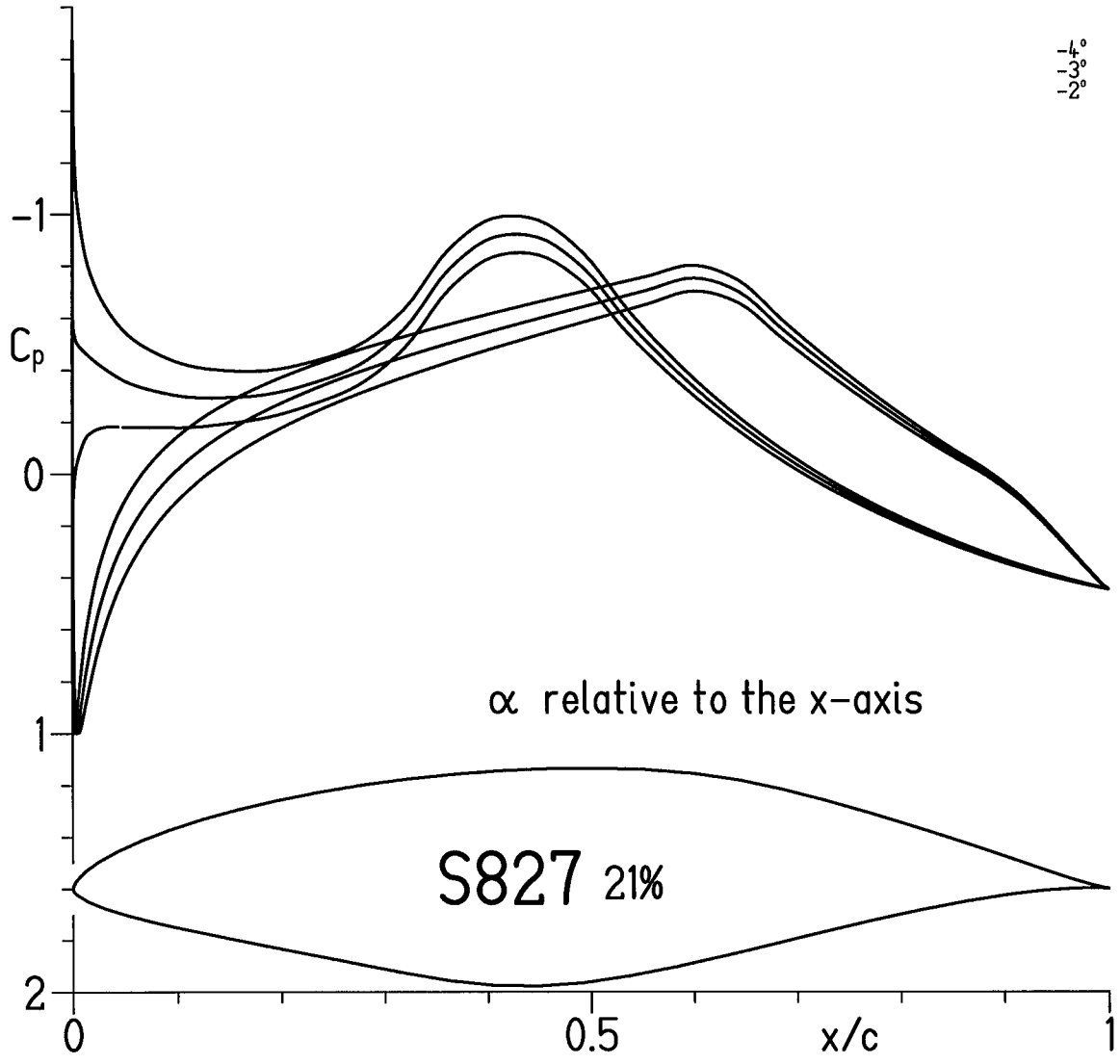


(a) S827.



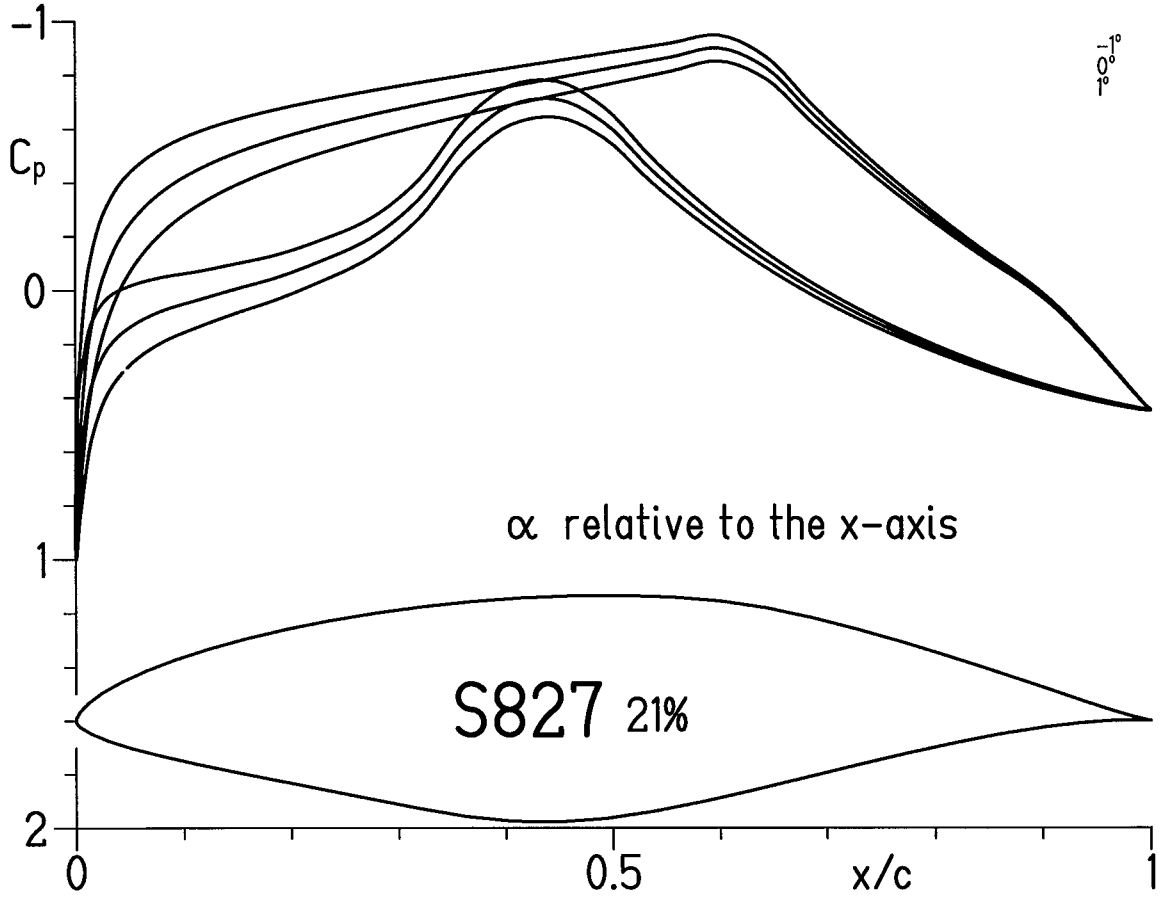
(b) S828.

Figure 1.– Airfoil shapes.



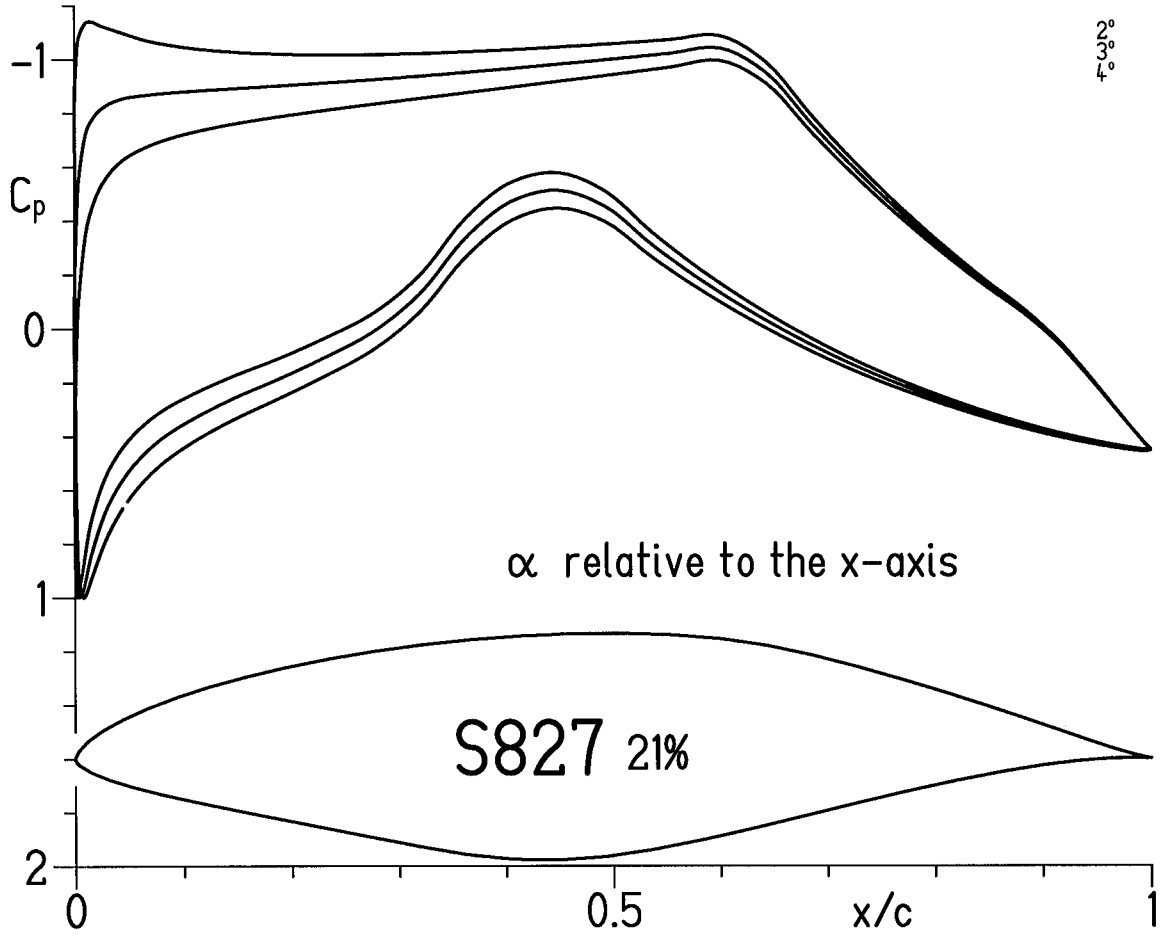
(a) $\alpha = -4°, -3°$, and $-2°$.

Figure 2.– Inviscid pressure distributions for S827 airfoil.



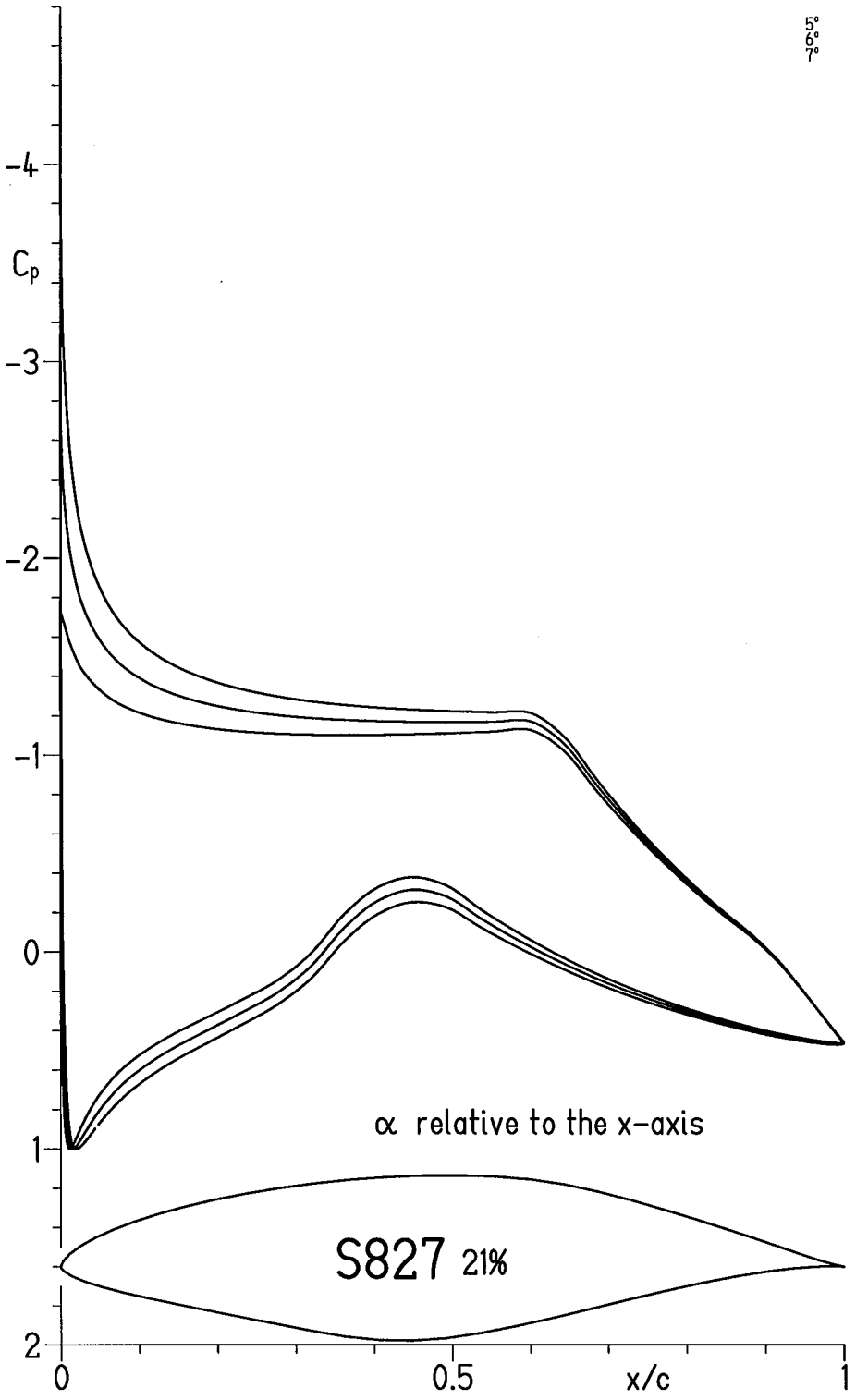
(b) $\alpha = -1°$, 0°, and 1°.

Figure 2.– Continued.



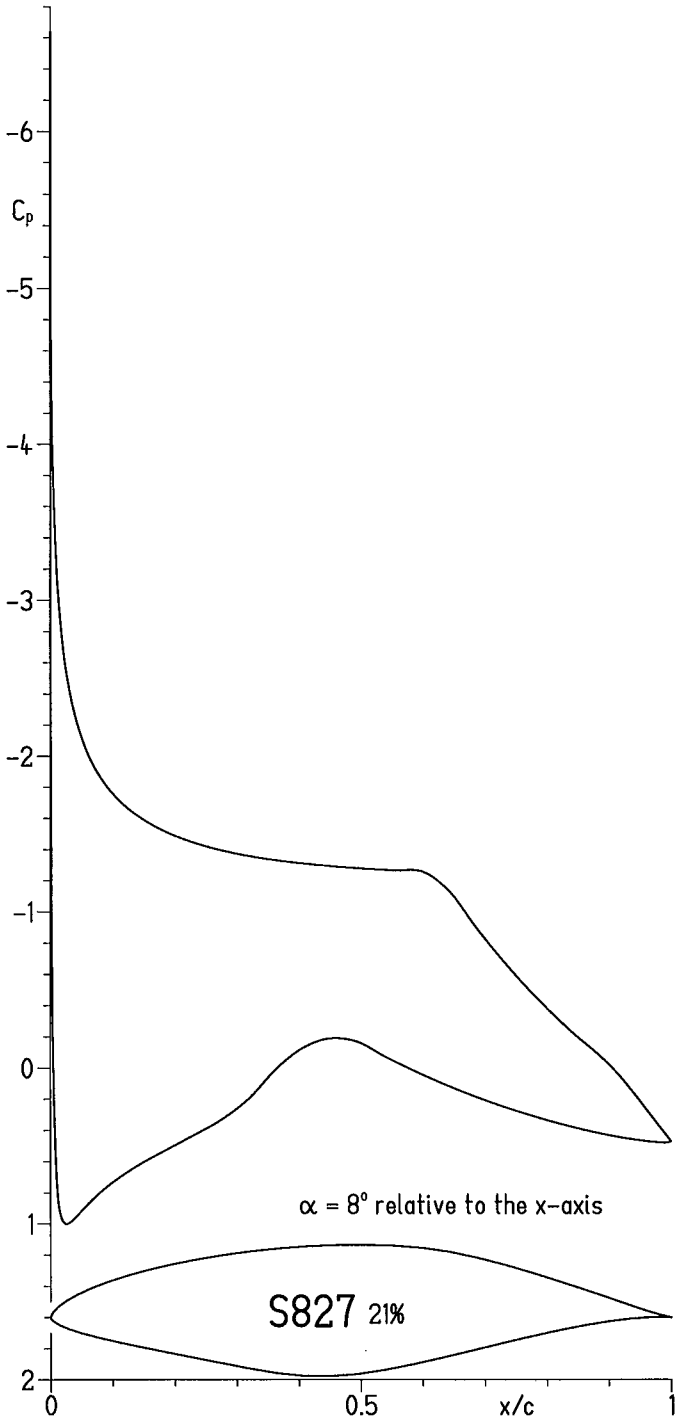
(c) $\alpha = 2°$, 3°, and 4°.

Figure 2.– Continued.



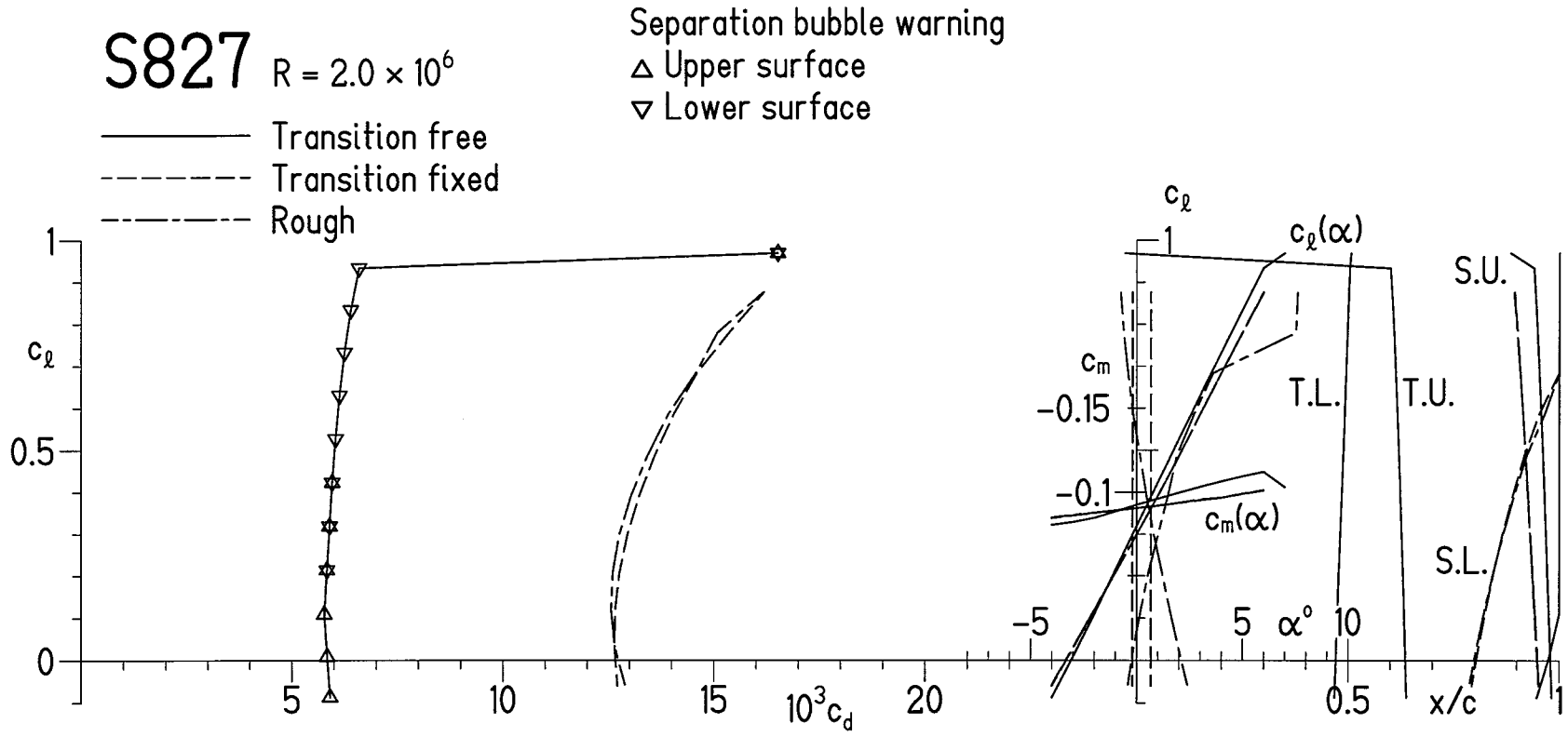
(d) $\alpha = 5°$, 6°, and 7°.

Figure 2.– Continued.



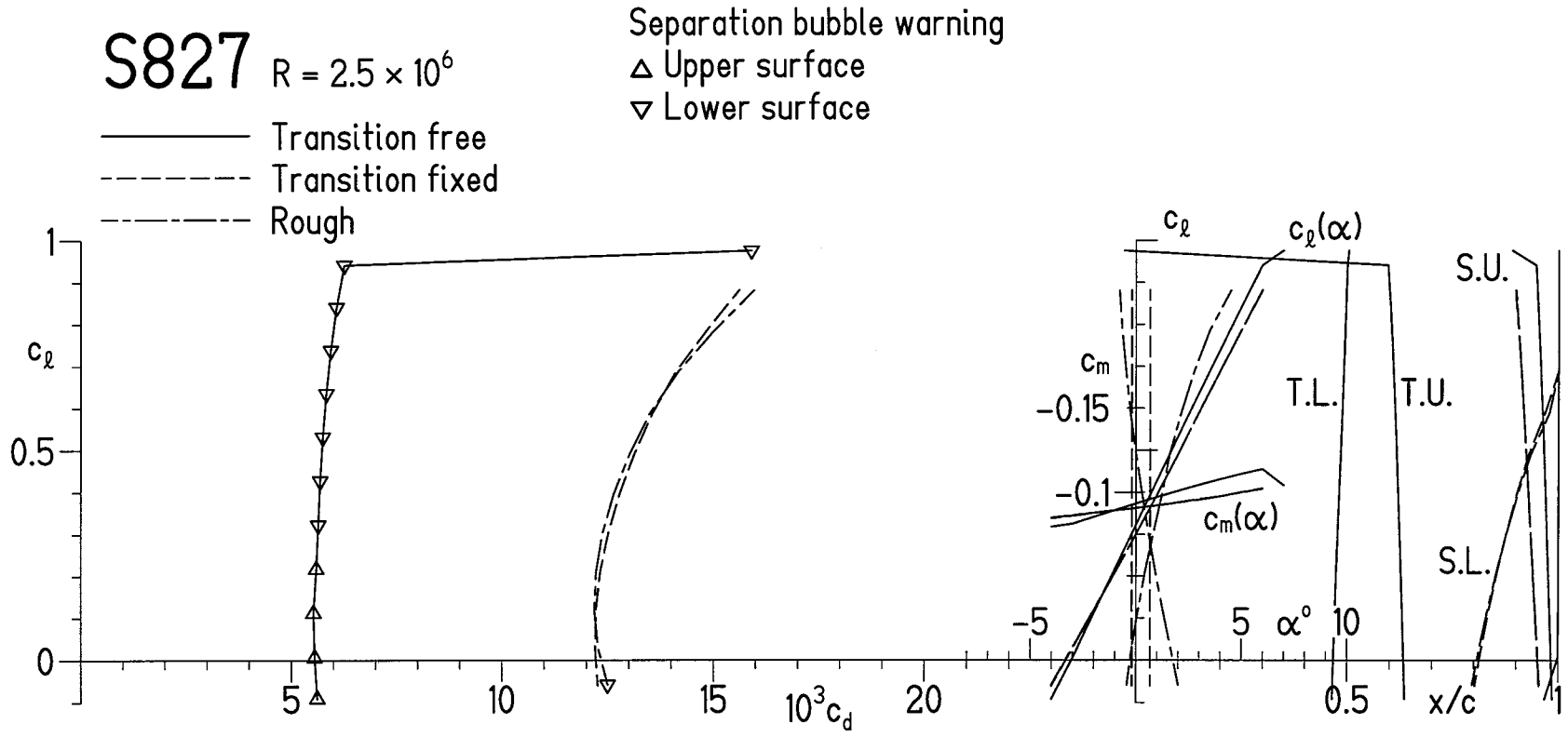
(e) $\alpha = 8°$.

Figure 2.– Concluded.



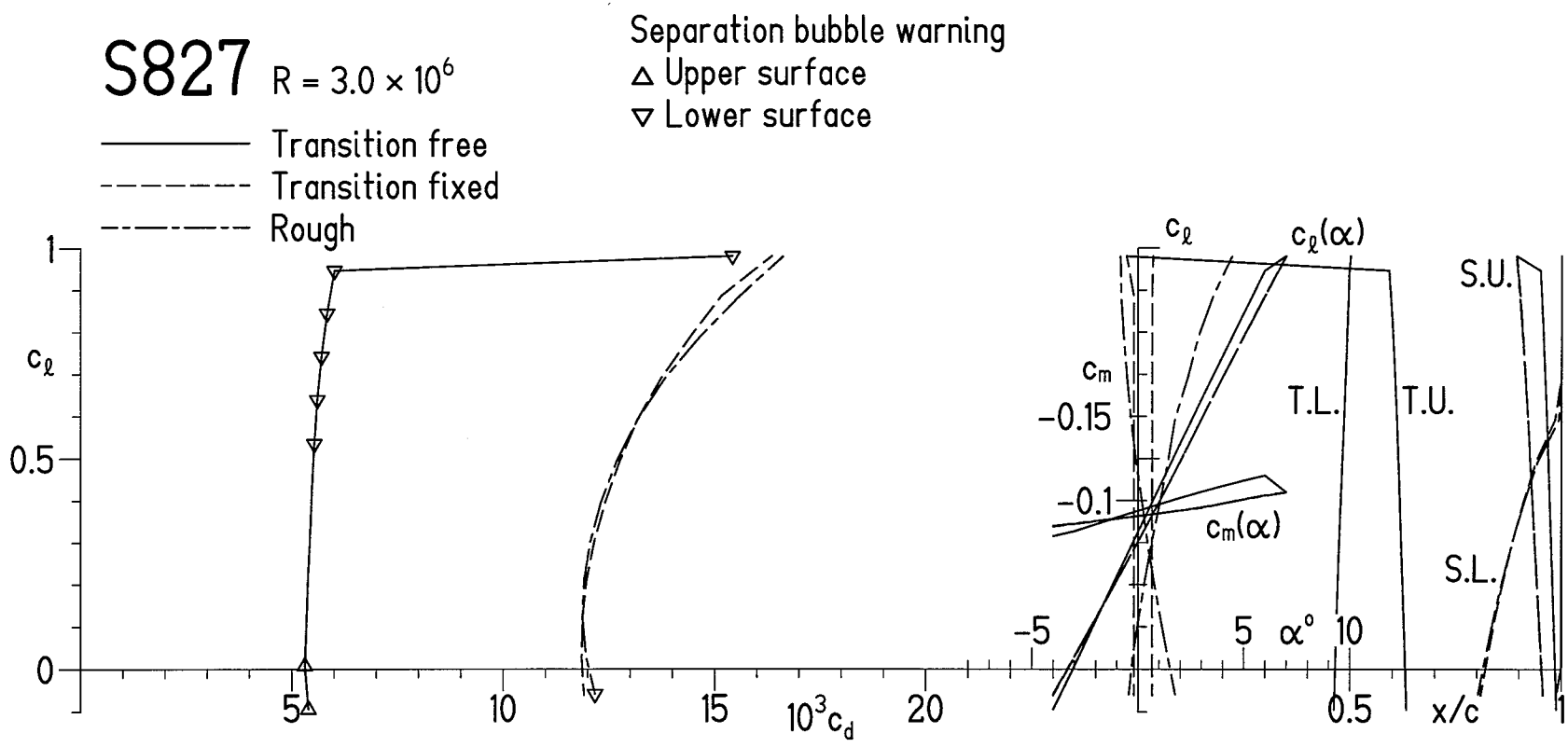
(a) $R = 2.0 \times 10^6$.

Figure 3.– Section characteristics of S827 airfoil with transition free, transition fixed, and rough.



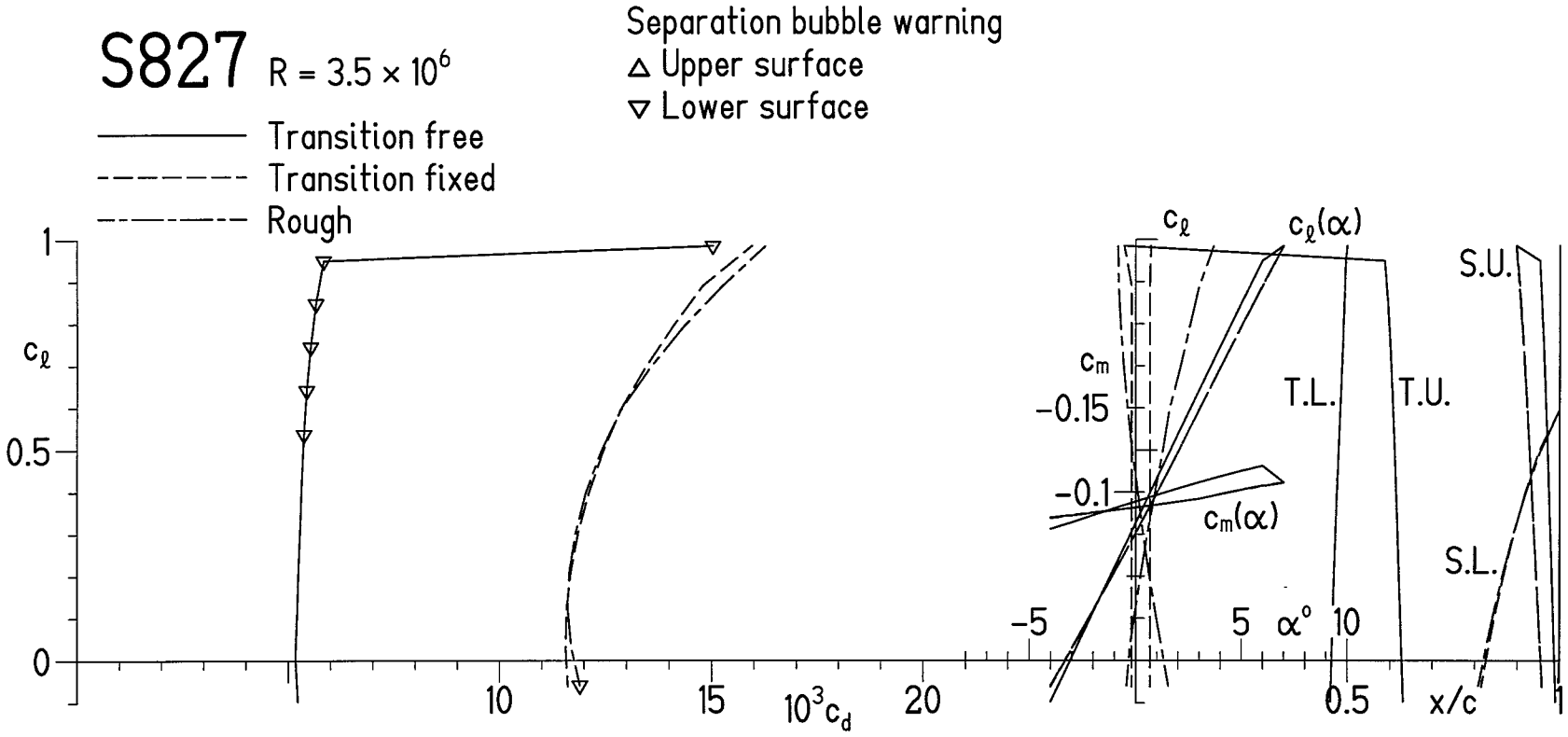
(b) $R = 2.5 \times 10^6$.

Figure 3.– Continued.



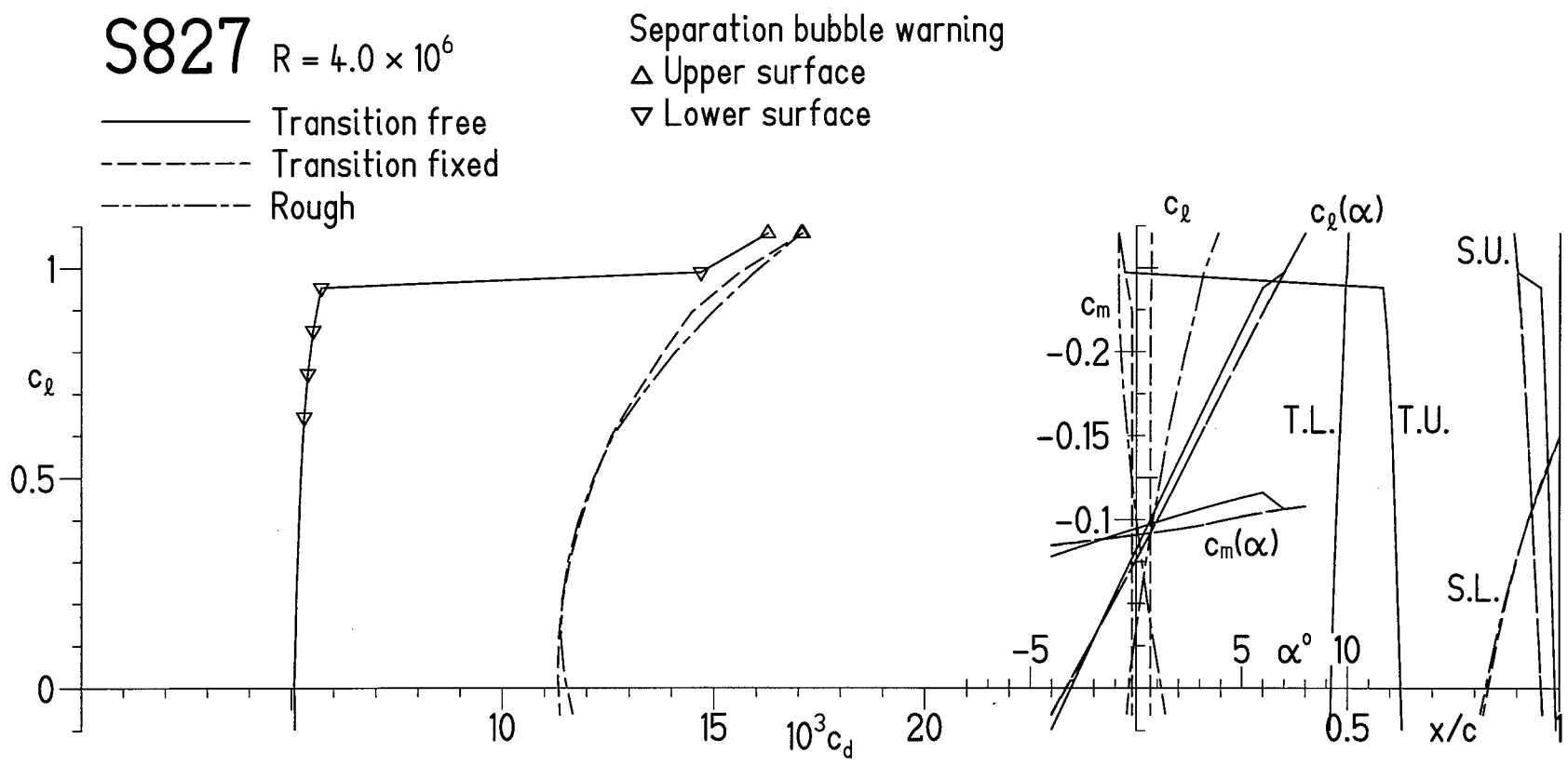
(c) $R = 3.0 \times 10^6$.

Figure 3.– Continued.



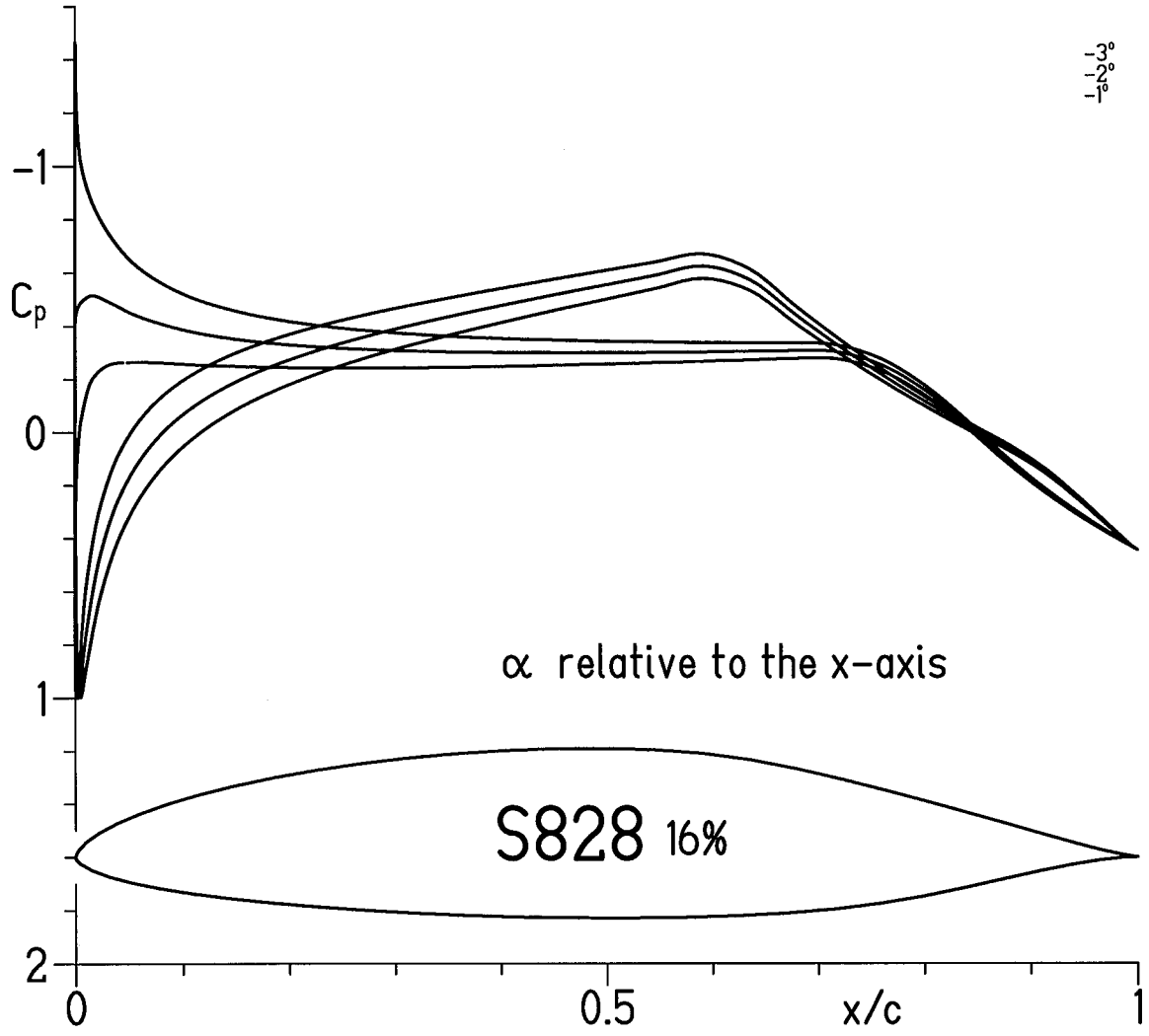
(d) $R = 3.5 \times 10^6$.

Figure 3.– Continued.



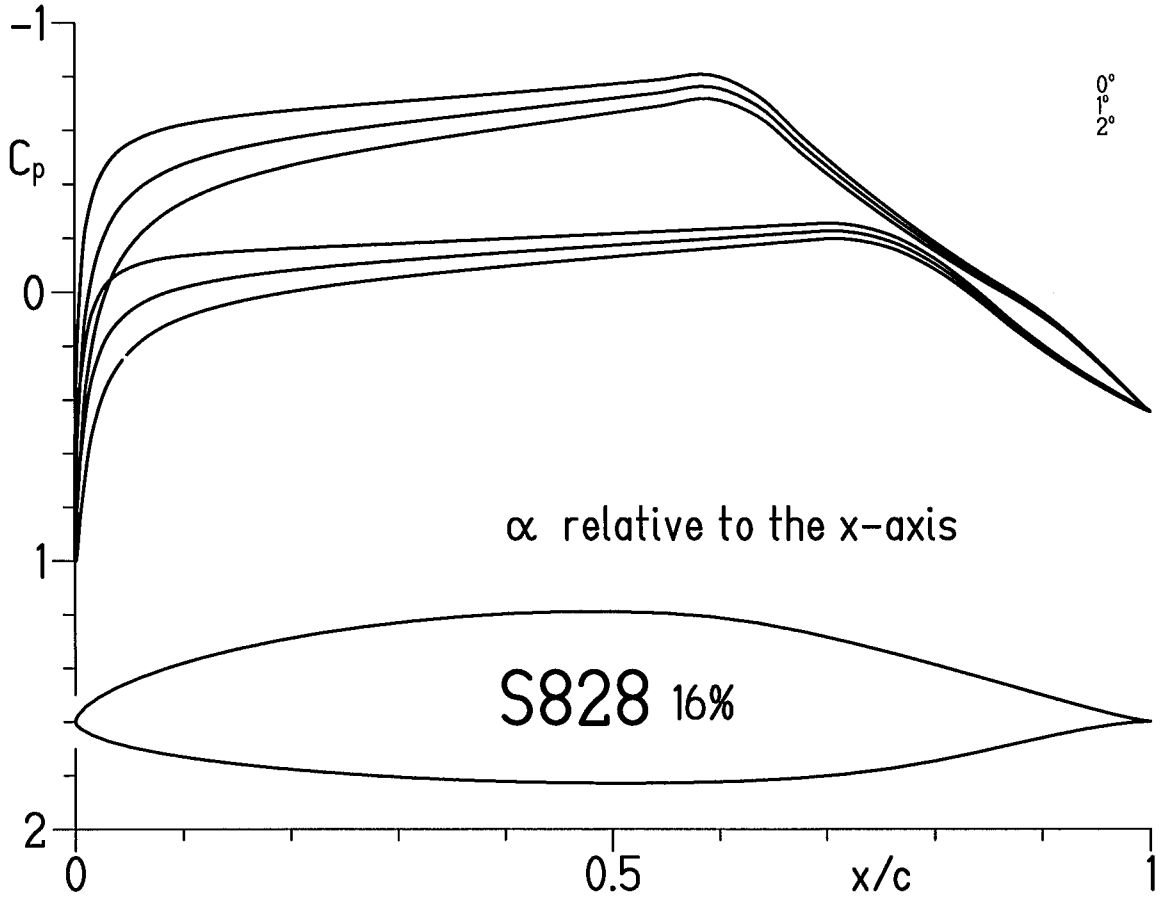
(e) $R = 4.0 \times 10^6$.

Figure 3.– Concluded.



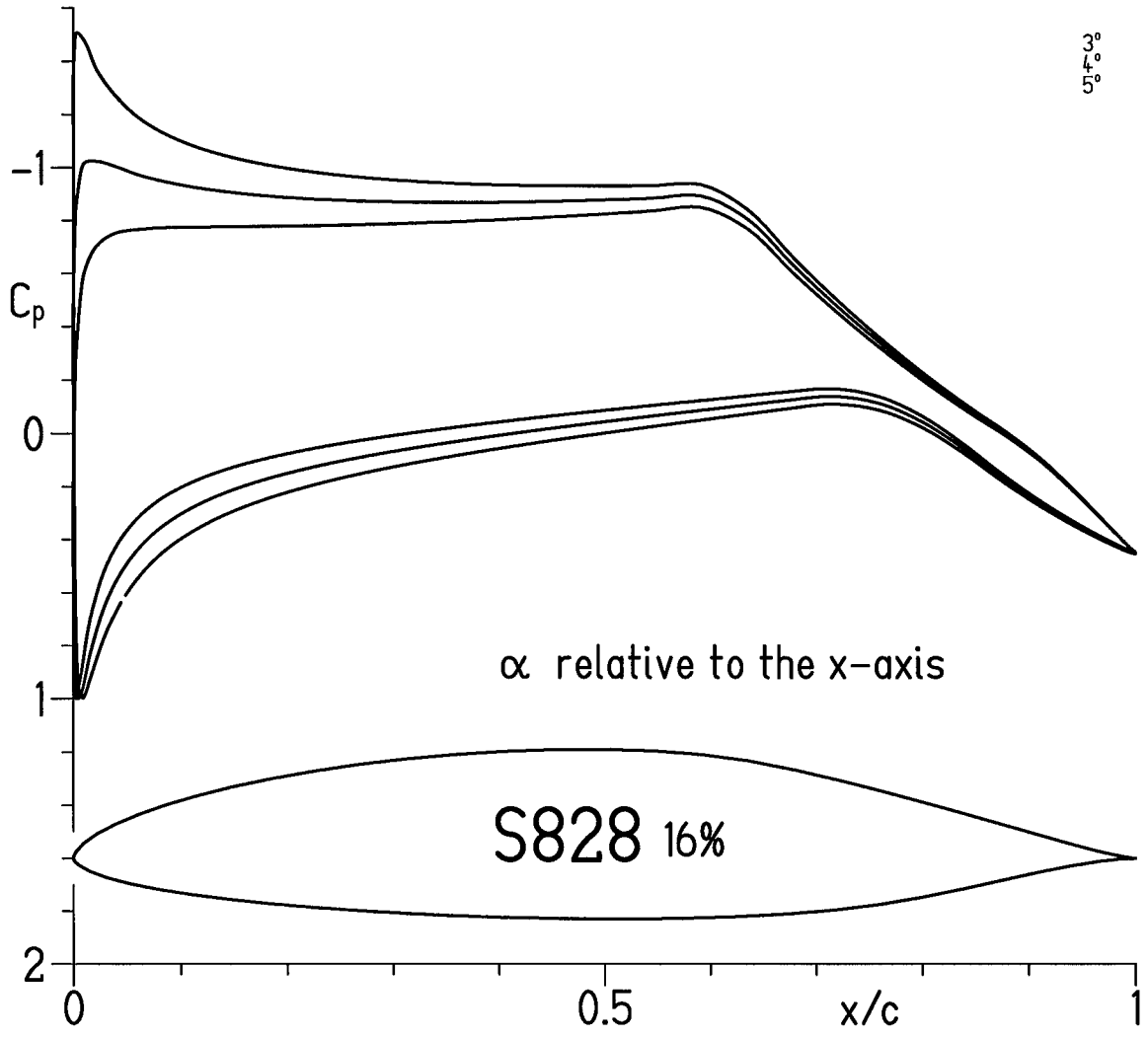
(a) $\alpha = -3°, -2°$, and $-1°$.

Figure 4.– Inviscid pressure distributions for S828 airfoil.



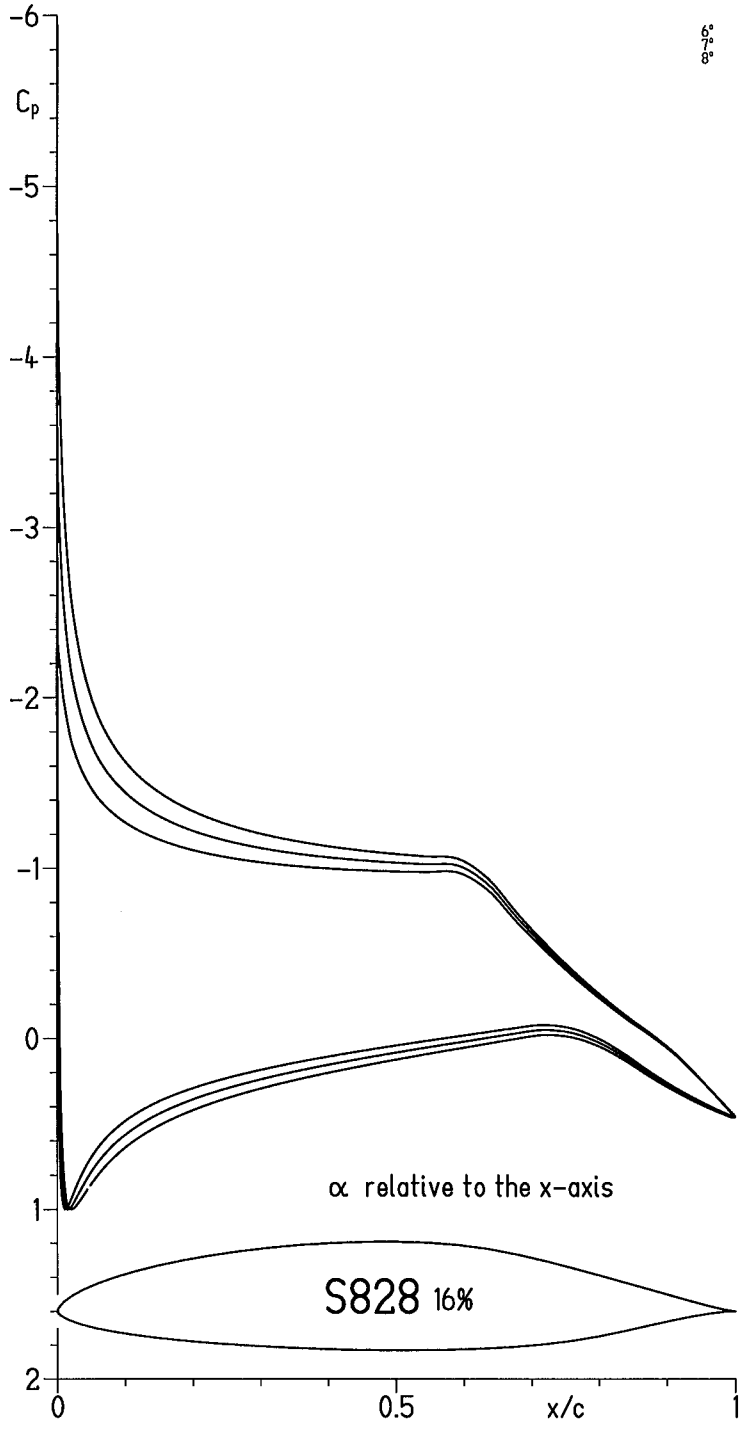
(b) $\alpha = 0°$, 1°, and 2°.

Figure 4.– Continued.



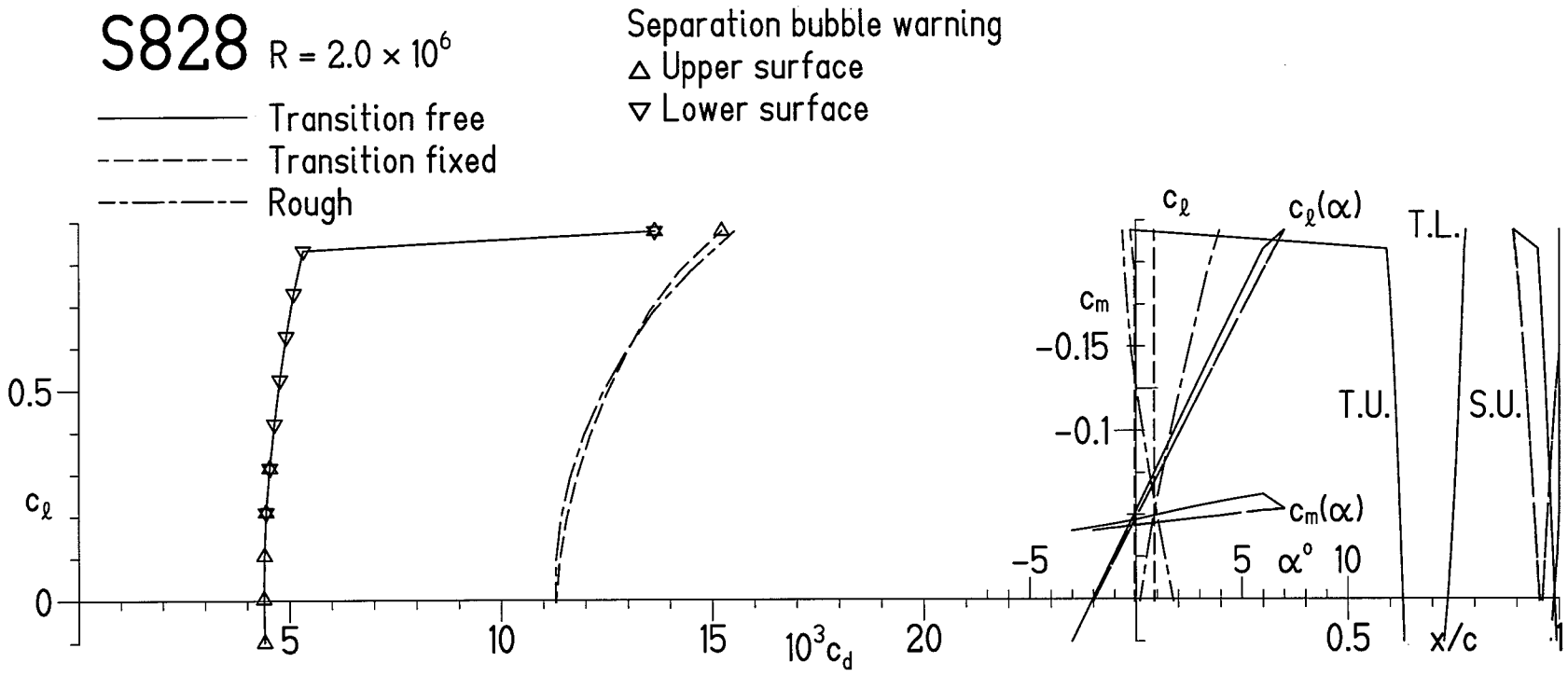
(c) $\alpha = 3°$, 4°, and 5°.

Figure 4.– Continued.



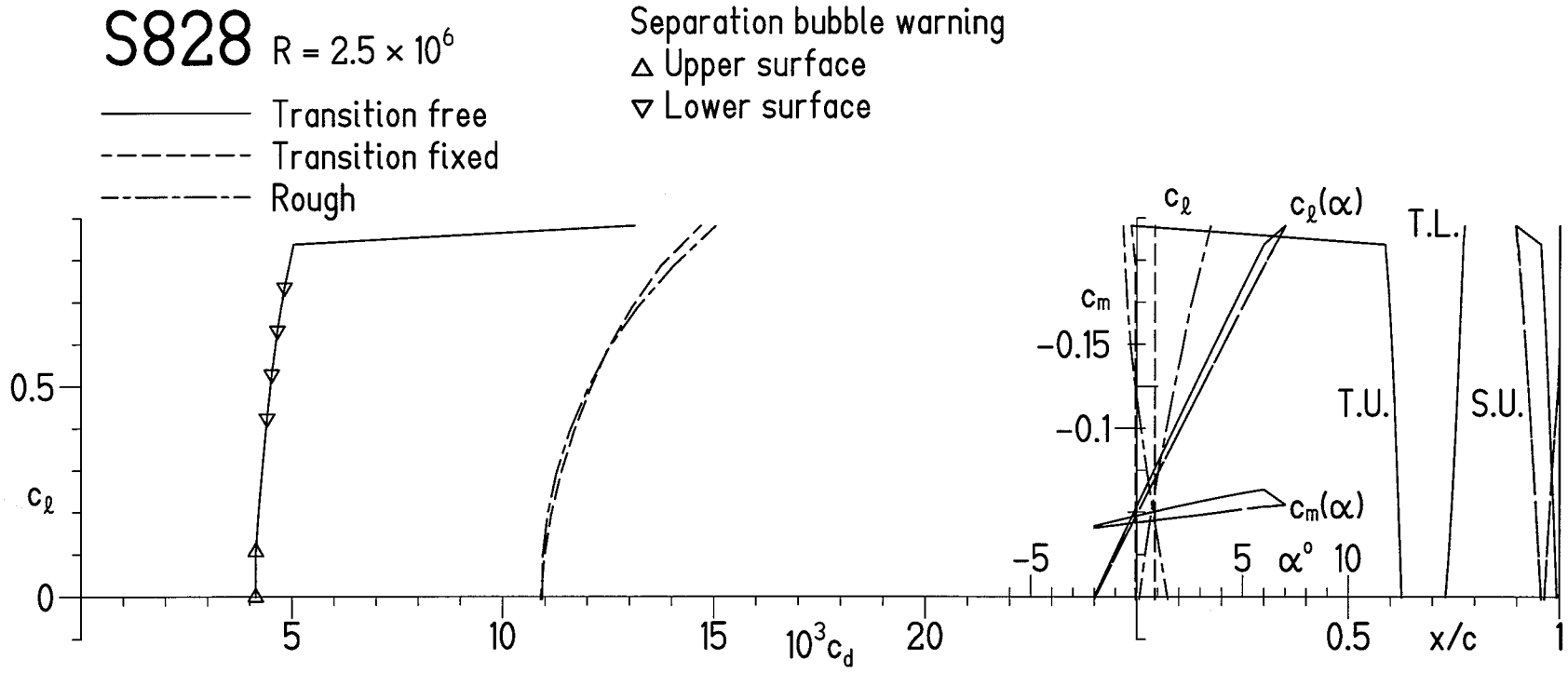
(d) $\alpha = 6°$, 7°, and 8°.

Figure 4.– Concluded.



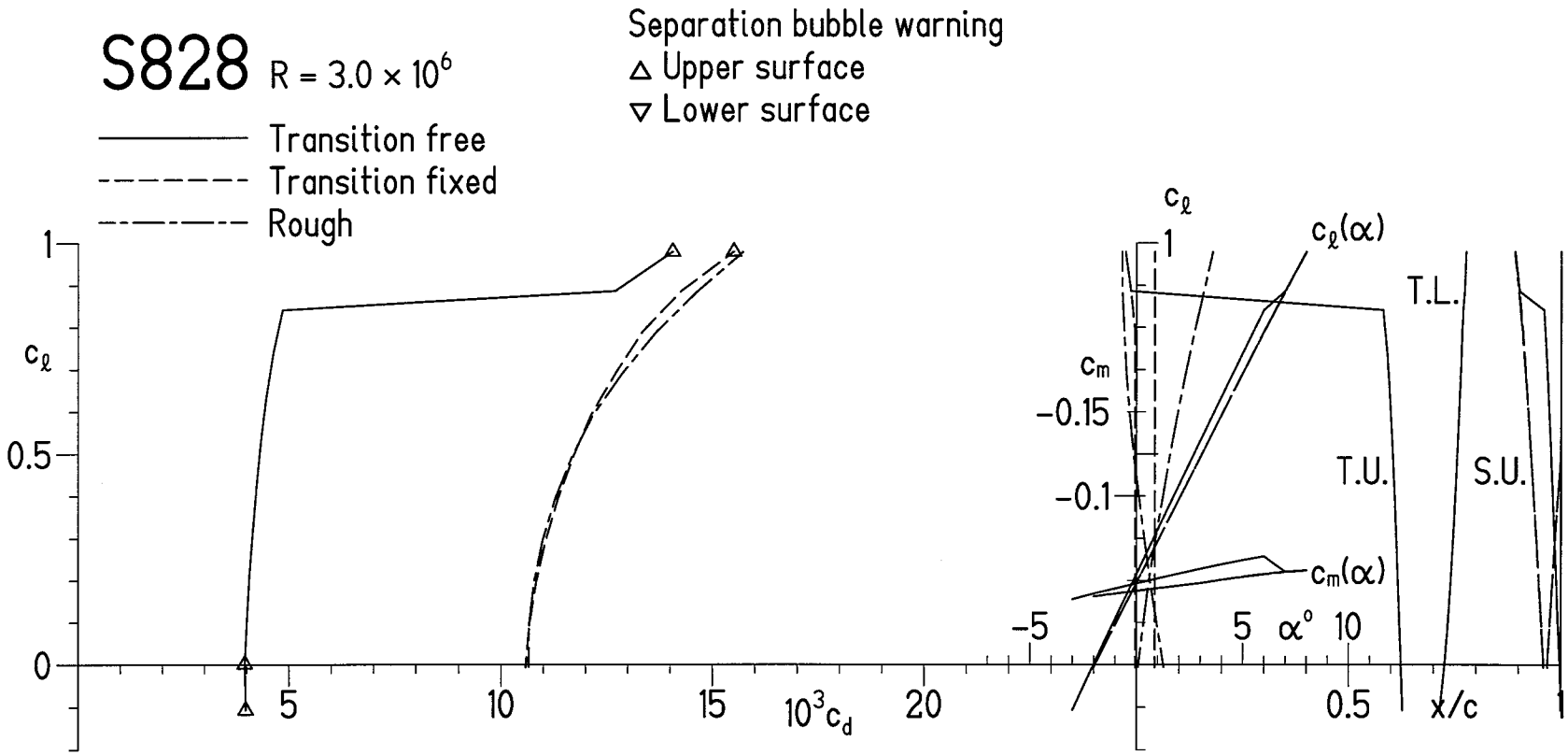
(a) $R = 2.0 \times 10^6$.

Figure 5.– Section characteristics of S828 airfoil with transition free, transition fixed, and rough.



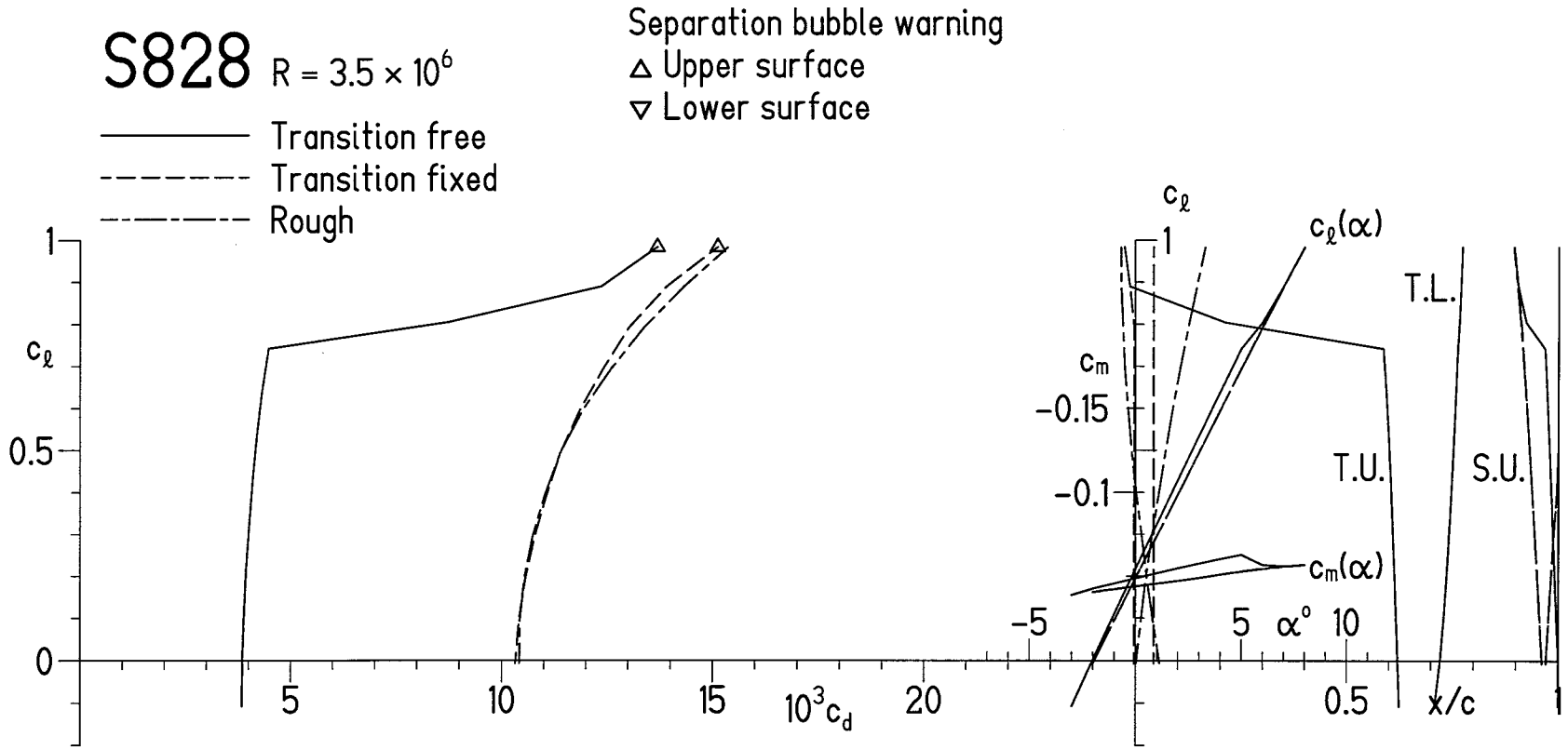
(b) $R = 2.5 \times 10^6$.

Figure 5.– Continued.



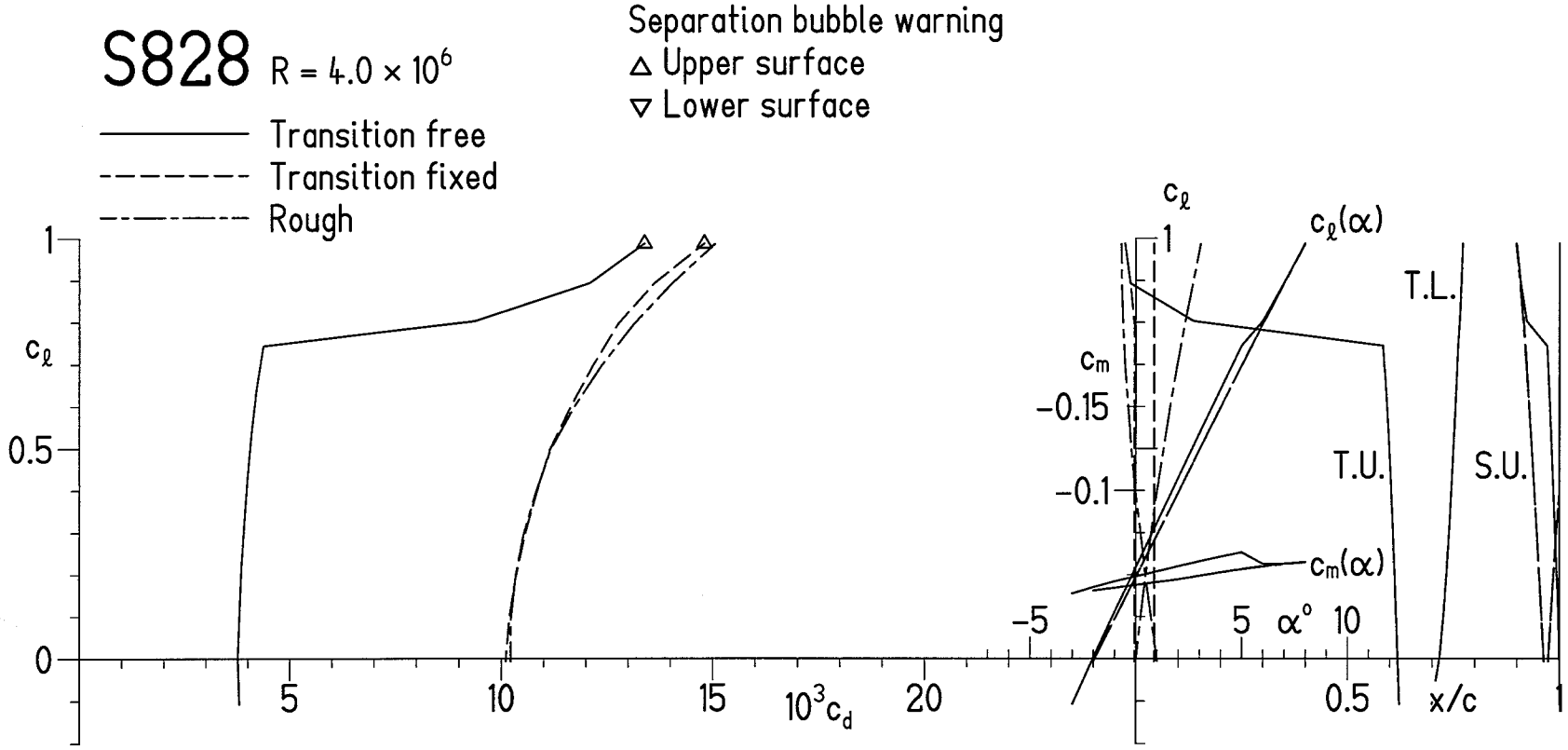
(c) $R = 3.0 \times 10^6$.

Figure 5.– Continued.



(d) $R = 3.5 \times 10^6$.

Figure 5.– Continued.



(e) $R = 4.0 \times 10^6$.

Figure 5.– Concluded.

APPENDIX

PRESSURE DISTRIBUTIONS, TRANSITION AND SEPARATION LOCATIONS, AND SECTION CHARACTERISTICS

AIRFOIL S827 21%				-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00
N	X	Y	NUE	CP-DISTR. FOR THE ABOVE ALPHA REL. CHORD LINE							
1	1.00000	0.00000	0.00	0.446	0.446	0.446	0.447	0.448	0.449	0.450	0.452
2	0.99591	0.00078	1.00	0.436	0.435	0.434	0.433	0.433	0.434	0.434	0.435
3	0.98413	0.00360	2.00	0.388	0.386	0.384	0.382	0.381	0.380	0.379	0.379
4	0.96586	0.00900	3.00	0.309	0.305	0.301	0.298	0.295	0.293	0.291	0.290
5	0.94236	0.01682	4.00	0.208	0.202	0.196	0.191	0.186	0.182	0.179	0.175
6	0.91460	0.02643	5.00	0.100	0.092	0.083	0.076	0.069	0.062	0.056	0.051
7	0.88305	0.03718	6.00	0.008	-0.003	-0.014	-0.025	-0.035	-0.044	-0.053	-0.061
8	0.84805	0.04872	7.00	-0.072	-0.087	-0.101	-0.115	-0.128	-0.140	-0.152	-0.163
9	0.81021	0.06086	8.00	-0.167	-0.185	-0.203	-0.221	-0.237	-0.253	-0.269	-0.284
10	0.77025	0.07315	9.00	-0.274	-0.297	-0.319	-0.341	-0.363	-0.383	-0.403	-0.423
11	0.72880	0.08503	10.00	-0.392	-0.421	-0.449	-0.477	-0.504	-0.530	-0.555	-0.580
12	0.68639	0.09591	11.00	-0.521	-0.557	-0.592	-0.626	-0.659	-0.692	-0.724	-0.756
13	0.64347	0.10497	12.00	-0.658	-0.702	-0.744	-0.786	-0.828	-0.869	-0.909	-0.948
14	0.59988	0.11131	13.00	-0.704	-0.753	-0.802	-0.851	-0.899	-0.947	-0.994	-1.040
15	0.55498	0.11490	14.00	-0.653	-0.707	-0.760	-0.813	-0.866	-0.918	-0.970	-1.021
16	0.50881	0.11636	15.00	-0.602	-0.659	-0.717	-0.774	-0.832	-0.889	-0.946	-1.002
17	0.46193	0.11603	16.00	-0.549	-0.611	-0.673	-0.735	-0.798	-0.860	-0.922	-0.984
18	0.41487	0.11409	17.00	-0.494	-0.561	-0.628	-0.695	-0.763	-0.831	-0.899	-0.967
19	0.36815	0.11068	18.00	-0.437	-0.508	-0.581	-0.654	-0.728	-0.802	-0.877	-0.952
20	0.32229	0.10593	19.00	-0.376	-0.453	-0.531	-0.611	-0.691	-0.772	-0.854	-0.937
21	0.27779	0.09996	20.00	-0.312	-0.395	-0.479	-0.565	-0.653	-0.742	-0.832	-0.924
22	0.23516	0.09293	21.00	-0.242	-0.332	-0.423	-0.517	-0.613	-0.711	-0.811	-0.912
23	0.19486	0.08497	22.00	-0.166	-0.262	-0.362	-0.465	-0.570	-0.678	-0.789	-0.902
24	0.15735	0.07623	23.00	-0.079	-0.184	-0.293	-0.406	-0.522	-0.642	-0.766	-0.893
25	0.12305	0.06686	24.00	0.020	-0.093	-0.212	-0.337	-0.466	-0.601	-0.741	-0.885
26	0.09234	0.05703	25.00	0.138	0.014	-0.116	-0.254	-0.400	-0.552	-0.711	-0.877
27	0.06557	0.04692	26.00	0.280	0.147	0.003	-0.151	-0.315	-0.489	-0.673	-0.867
28	0.04304	0.03671	27.00	0.454	0.313	0.156	-0.016	-0.203	-0.405	-0.622	-0.854
29	0.02501	0.02661	28.00	0.668	0.528	0.363	0.174	-0.039	-0.275	-0.535	-0.818
30	0.01168	0.01688	29.00	0.902	0.791	0.637	0.443	0.207	-0.069	-0.386	-0.743
31	0.00327	0.00789	30.00	0.972	0.999	0.945	0.810	0.593	0.296	-0.081	-0.538
32	0.00040	0.00228	30.71	0.345	0.713	0.932	1.000	0.918	0.687	0.305	-0.225
33	0.00003	0.00054	30.96	-0.350	0.280	0.714	0.951	0.991	0.835	0.482	-0.067
34	0.00010	-0.00098	31.21	-1.674	-0.610	0.187	0.714	0.972	0.960	0.678	0.127
35	0.00075	-0.00240	31.46	-1.393	-0.563	0.091	0.569	0.871	0.996	0.944	0.715
36	0.00194	-0.00390	31.71	-1.210	-0.532	0.023	0.454	0.761	0.943	1.000	0.932
37	0.00388	-0.00572	32.00	-1.064	-0.506	-0.035	0.348	0.644	0.851	0.969	0.999
38	0.01440	-0.01227	33.00	-0.804	-0.458	-0.149	0.124	0.361	0.561	0.723	0.849
39	0.03068	-0.01907	34.00	-0.649	-0.406	-0.181	0.025	0.212	0.379	0.527	0.655
40	0.05249	-0.02597	35.00	-0.537	-0.353	-0.180	-0.019	0.132	0.271	0.398	0.513
41	0.07952	-0.03303	36.00	-0.466	-0.319	-0.180	-0.047	0.078	0.196	0.306	0.408
42	0.11138	-0.04031	37.00	-0.417	-0.296	-0.179	-0.068	0.039	0.141	0.237	0.328
43	0.14752	-0.04794	38.00	-0.398	-0.294	-0.193	-0.096	-0.002	0.088	0.174	0.257
44	0.18727	-0.05596	39.00	-0.398	-0.306	-0.217	-0.131	-0.047	0.035	0.113	0.189
45	0.22978	-0.06438	40.00	-0.431	-0.348	-0.267	-0.187	-0.110	-0.034	0.039	0.111
46	0.27409	-0.07310	41.00	-0.492	-0.415	-0.339	-0.265	-0.191	-0.120	-0.049	0.019
47	0.31892	-0.08183	42.00	-0.632	-0.556	-0.481	-0.408	-0.335	-0.263	-0.193	-0.124
48	0.36288	-0.08933	43.00	-0.865	-0.787	-0.710	-0.633	-0.558	-0.483	-0.409	-0.336
49	0.40597	-0.09376	44.00	-0.983	-0.909	-0.835	-0.761	-0.687	-0.614	-0.542	-0.471
50	0.44906	-0.09443	45.00	-0.976	-0.909	-0.842	-0.775	-0.708	-0.642	-0.575	-0.510
51	0.49274	-0.09126	46.00	-0.849	-0.792	-0.736	-0.679	-0.622	-0.565	-0.508	-0.451
52	0.53770	-0.08456	47.00	-0.624	-0.579	-0.534	-0.489	-0.444	-0.398	-0.352	-0.306
53	0.58417	-0.07538	48.00	-0.427	-0.392	-0.356	-0.320	-0.284	-0.247	-0.210	-0.173
54	0.63172	-0.06463	49.00	-0.257	-0.229	-0.201	-0.172	-0.143	-0.114	-0.084	-0.054
55	0.67984	-0.05305	50.00	-0.110	-0.088	-0.066	-0.043	-0.020	0.003	0.027	0.051
56	0.72787	-0.04136	51.00	0.014	0.031	0.049	0.067	0.085	0.104	0.123	0.142
57	0.77506	-0.03025	52.00	0.119	0.132	0.146	0.160	0.175	0.190	0.205	0.221
58	0.82049	-0.02035	53.00	0.206	0.216	0.227	0.238	0.250	0.262	0.274	0.287
59	0.86316	-0.01216	54.00	0.277	0.285	0.294	0.303	0.312	0.321	0.331	0.341
60	0.90192	-0.00603	55.00	0.334	0.340	0.346	0.353	0.360	0.368	0.376	0.384
61	0.93560	-0.00204	56.00	0.377	0.381	0.386	0.391	0.397	0.403	0.409	0.415
62	0.96306	-0.00001	57.00	0.408	0.411	0.414	0.418	0.422	0.427	0.432	0.437
63	0.98337	0.00052	58.00	0.429	0.431	0.433	0.436	0.439	0.442	0.446	0.450
64	0.99581	0.00025	59.00	0.441	0.442	0.443	0.445	0.447	0.449	0.452	0.455
65	1.00000	0.00000	60.00	0.446	0.446	0.446	0.447	0.448	0.449	0.450	0.452

ALPHA0= 3.17 DEGREES CM0=-0.0840 ETA= 1.145

AIRFOIL S827 21%				4.00	5.00	6.00	7.00	8.00	9.00	10.00
N	X	Y	NUE	CP-DISTR. FOR THE ABOVE ALPHA REL. CHORD LINE						
1	1.00000	0.00000	0.00	0.455	0.457	0.460	0.463	0.467	0.470	0.475
2	0.99591	0.00078	1.00	0.436	0.438	0.440	0.442	0.445	0.448	0.451
3	0.98413	0.00360	2.00	0.379	0.380	0.381	0.382	0.384	0.386	0.389
4	0.96586	0.00900	3.00	0.289	0.288	0.288	0.288	0.289	0.290	0.292
5	0.94236	0.01682	4.00	0.173	0.171	0.169	0.168	0.167	0.167	0.167
6	0.91460	0.02643	5.00	0.046	0.042	0.038	0.035	0.032	0.030	0.029
7	0.88305	0.03718	6.00	-0.068	-0.075	-0.081	-0.087	-0.091	-0.096	-0.099
8	0.84805	0.04872	7.00	-0.173	-0.183	-0.192	-0.201	-0.208	-0.215	-0.221
9	0.81021	0.06086	8.00	-0.298	-0.311	-0.324	-0.335	-0.347	-0.357	-0.366
10	0.77025	0.07315	9.00	-0.441	-0.459	-0.476	-0.492	-0.507	-0.522	-0.536
11	0.72880	0.08503	10.00	-0.604	-0.627	-0.650	-0.671	-0.692	-0.711	-0.730
12	0.68639	0.09591	11.00	-0.786	-0.816	-0.845	-0.873	-0.900	-0.926	-0.951
13	0.64347	0.10497	12.00	-0.987	-1.025	-1.061	-1.097	-1.132	-1.166	-1.199
14	0.59988	0.11131	13.00	-1.086	-1.130	-1.174	-1.218	-1.260	-1.301	-1.341
15	0.55498	0.11490	14.00	-1.071	-1.121	-1.171	-1.219	-1.267	-1.314	-1.359
16	0.50881	0.11636	15.00	-1.058	-1.114	-1.169	-1.223	-1.277	-1.330	-1.382
17	0.46193	0.11603	16.00	-1.046	-1.108	-1.169	-1.230	-1.290	-1.349	-1.408
18	0.41487	0.11409	17.00	-1.036	-1.104	-1.172	-1.240	-1.307	-1.374	-1.440
19	0.36815	0.11068	18.00	-1.027	-1.102	-1.178	-1.254	-1.329	-1.404	-1.479
20	0.32229	0.10593	19.00	-1.020	-1.104	-1.188	-1.272	-1.357	-1.442	-1.527
21	0.27779	0.09996	20.00	-1.016	-1.109	-1.203	-1.298	-1.393	-1.489	-1.585
22	0.23516	0.09293	21.00	-1.015	-1.119	-1.225	-1.332	-1.440	-1.548	-1.658
23	0.19486	0.08497	22.00	-1.017	-1.135	-1.254	-1.375	-1.498	-1.623	-1.749
24	0.15735	0.07623	23.00	-1.024	-1.157	-1.293	-1.432	-1.574	-1.718	-1.864
25	0.12305	0.06686	24.00	-1.034	-1.187	-1.345	-1.506	-1.671	-1.840	-2.012
26	0.09234	0.05703	25.00	-1.050	-1.229	-1.413	-1.604	-1.800	-2.002	-2.208
27	0.06557	0.04692	26.00	-1.071	-1.283	-1.505	-1.735	-1.973	-2.220	-2.474
28	0.04304	0.03671	27.00	-1.099	-1.359	-1.633	-1.919	-2.219	-2.531	-2.855
29	0.02501	0.02661	28.00	-1.124	-1.452	-1.802	-2.174	-2.566	-2.980	-3.413
30	0.01168	0.01688	29.00	-1.140	-1.576	-2.051	-2.564	-3.115	-3.702	-4.326
31	0.00327	0.00789	30.00	-1.075	-1.691	-2.384	-3.154	-4.001	-4.923	-5.919
32	0.00040	0.00228	30.71	-0.904	-1.730	-2.703	-3.822	-5.085	-6.490	-8.036
33	0.00003	0.00054	30.96	-0.812	-1.752	-2.885	-4.211	-5.727	-7.431	-9.323
34	0.00010	-0.00098	31.21	-0.694	-1.782	-3.136	-4.756	-6.638	-8.782	-11.183
35	0.00075	-0.00240	31.46	0.309	-0.273	-1.030	-1.963	-3.068	-4.346	-5.794
36	0.00194	-0.00390	31.71	0.739	0.421	-0.021	-0.587	-1.276	-2.087	-3.020
37	0.00388	-0.00572	32.00	0.940	0.792	0.556	0.231	-0.181	-0.681	-1.267
38	0.01440	-0.01227	33.00	0.937	0.987	0.999	0.974	0.912	0.811	0.674
39	0.03068	-0.01907	34.00	0.763	0.851	0.918	0.966	0.993	1.000	0.986
40	0.05249	-0.02597	35.00	0.616	0.708	0.787	0.853	0.908	0.950	0.979
41	0.07952	-0.03303	36.00	0.503	0.590	0.668	0.739	0.801	0.855	0.900
42	0.11138	-0.04031	37.00	0.414	0.494	0.569	0.638	0.701	0.758	0.810
43	0.14752	-0.04794	38.00	0.335	0.410	0.481	0.547	0.609	0.667	0.720
44	0.18727	-0.05596	39.00	0.262	0.332	0.399	0.462	0.523	0.580	0.633
45	0.22978	-0.06438	40.00	0.180	0.247	0.311	0.373	0.432	0.489	0.543
46	0.27409	-0.07310	41.00	0.086	0.151	0.214	0.275	0.334	0.391	0.446
47	0.31892	-0.08183	42.00	-0.056	0.010	0.075	0.138	0.199	0.259	0.316
48	0.36288	-0.08933	43.00	-0.264	-0.194	-0.125	-0.057	0.009	0.074	0.137
49	0.40597	-0.09376	44.00	-0.400	-0.330	-0.261	-0.194	-0.127	-0.062	0.002
50	0.44906	-0.09443	45.00	-0.445	-0.380	-0.316	-0.253	-0.190	-0.129	-0.068
51	0.49274	-0.09126	46.00	-0.395	-0.339	-0.283	-0.227	-0.173	-0.118	-0.064
52	0.53770	-0.08456	47.00	-0.260	-0.215	-0.169	-0.123	-0.078	-0.033	0.011
53	0.58417	-0.07538	48.00	-0.136	-0.099	-0.062	-0.024	0.013	0.050	0.087
54	0.63172	-0.06463	49.00	-0.024	0.006	0.036	0.067	0.098	0.128	0.159
55	0.67984	-0.05305	50.00	0.075	0.100	0.125	0.150	0.175	0.200	0.225
56	0.72787	-0.04136	51.00	0.162	0.182	0.202	0.223	0.244	0.264	0.285
57	0.77506	-0.03025	52.00	0.237	0.253	0.270	0.286	0.303	0.321	0.338
58	0.82049	-0.02035	53.00	0.300	0.313	0.326	0.340	0.354	0.369	0.383
59	0.86316	-0.01216	54.00	0.352	0.362	0.374	0.385	0.396	0.408	0.420
60	0.90192	-0.00603	55.00	0.392	0.401	0.410	0.420	0.429	0.439	0.449
61	0.93560	-0.00204	56.00	0.422	0.429	0.437	0.445	0.453	0.461	0.470
62	0.96306	-0.00001	57.00	0.442	0.448	0.454	0.461	0.467	0.474	0.482
63	0.98337	0.00052	58.00	0.454	0.459	0.464	0.469	0.474	0.480	0.486
64	0.99581	0.00025	59.00	0.458	0.461	0.465	0.470	0.474	0.479	0.484
65	1.00000	0.00000	60.00	0.455	0.457	0.460	0.463	0.467	0.470	0.475

ALPHA0= 3.17 DEGREES CM0=-0.0840 ETA= 1.145

B.L.SUMMARY AIRFOIL S827 21% ALPHA0= 3.165 DEG.
*-WARNING WITH VARIABLE LIMIT ALPHA REL. CHORD LINE

ALPHA(DEG.)	R= 2000000 MU=3.0	R= 2000000 MU=1.3	R= 2000000 MU=9.0
-4.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3615 0.0172 0.0027*	1.0099 0.0484 0.0061	0.8806 0.0474 0.0059
LOWER	0.5321 0.0523 0.0032	0.9664 0.2066 0.0067	1.0205 0.2121 0.0070
TOTAL	CL=-0.087 CD=0.00591	CL=-0.060 CD=0.01272	CL=-0.057 CD=0.01289
	CM=-0.0805	CM=-0.0846	CM=-0.0849
-3.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3641 0.0206 0.0028*	1.0099 0.0533 0.0066	0.9016 0.0524 0.0064
LOWER	0.5290 0.0231 0.0030	0.9664 0.1910 0.0061	1.0071 0.1949 0.0063
TOTAL	CL= 0.009 CD=0.00584	CL= 0.029 CD=0.01265	CL= 0.030 CD=0.01265
	CM=-0.0822	CM=-0.0861	CM=-0.0864
-2.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3669 0.0241 0.0030*	1.0098 0.0583 0.0071	0.9218 0.0576 0.0069
LOWER	0.5256 0.0000 0.0028	0.9664 0.1738 0.0056	0.9901 0.1760 0.0057
TOTAL	CL= 0.109 CD=0.00577	CL= 0.118 CD=0.01266	CL= 0.119 CD=0.01257
	CM=-0.0847	CM=-0.0876	CM=-0.0878
-1.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3700 0.0281 0.0031*	1.0099 0.0635 0.0077	0.9401 0.0629 0.0075
LOWER	0.5220 0.0000 0.0027*	0.9664 0.1551 0.0051	0.9720 0.1556 0.0051
TOTAL	CL= 0.214 CD=0.00584	CL= 0.207 CD=0.01277	CL= 0.208 CD=0.01261
	CM=-0.0886	CM=-0.0891	CM=-0.0892
0.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3735 0.0319 0.0033*	1.0099 0.0688 0.0083	0.9595 0.0683 0.0081
LOWER	0.5180 0.0000 0.0026*	0.9664 0.1340 0.0047	0.9494 0.1325 0.0046
TOTAL	CL= 0.319 CD=0.00590	CL= 0.298 CD=0.01295	CL= 0.299 CD=0.01276
	CM=-0.0924	CM=-0.0905	CM=-0.0906
1.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3770 0.0358 0.0035*	1.0099 0.0741 0.0090	0.9766 0.0737 0.0088
LOWER	0.5138 0.0000 0.0025*	0.9664 0.1101 0.0043	0.9265 0.1070 0.0042
TOTAL	CL= 0.423 CD=0.00596	CL= 0.391 CD=0.01323	CL= 0.391 CD=0.01304
	CM=-0.0962	CM=-0.0920	CM=-0.0920
2.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3807 0.0400 0.0037	1.0099 0.0797 0.0097	0.9918 0.0794 0.0096
LOWER	0.5102 0.0000 0.0023*	0.9664 0.0828 0.0039	0.9056 0.0772 0.0038
TOTAL	CL= 0.527 CD=0.00604	CL= 0.486 CD=0.01360	CL= 0.486 CD=0.01343
	CM=-0.0997	CM=-0.0937	CM=-0.0936
3.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3846 0.0444 0.0039	1.0099 0.0855 0.0105	1.0083 0.0855 0.0105
LOWER	0.5066 0.0000 0.0022*	0.9664 0.0478 0.0036	0.8646 0.0347 0.0034
TOTAL	CL= 0.630 CD=0.00613	CL= 0.585 CD=0.01405	CL= 0.585 CD=0.01392
	CM=-0.1032	CM=-0.0957	CM=-0.0953
4.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3888 0.0490 0.0042	1.0099 0.0918 0.0113	1.0202 0.0920 0.0114
LOWER	0.5033 0.0000 0.0021*	0.9664 0.0000 0.0033	0.8195 0.0000 0.0031
TOTAL	CL= 0.732 CD=0.00625	CL= 0.684 CD=0.01461	CL= 0.683 CD=0.01458
	CM=-0.1064	CM=-0.0967	CM=-0.0967
5.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3936 0.0541 0.0044	1.0099 0.0986 0.0123	1.0305 0.0992 0.0125
LOWER	0.5000 0.0000 0.0020*	0.9663 0.0000 0.0031	0.6234 0.0000 0.0026
TOTAL	CL= 0.834 CD=0.00640	CL= 0.780 CD=0.01537	CL= 0.780 CD=0.01509
	CM=-0.1094	CM=-0.0991	CM=-0.0990
6.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3994 0.0599 0.0047	1.0099 0.1058 0.0133	1.0375 0.1069 0.0137
LOWER	0.4966 0.0000 0.0019*	0.9664 0.0000 0.0029	0.6196 0.0000 0.0024
TOTAL	CL= 0.933 CD=0.00660	CL= 0.876 CD=0.01619	CL= 0.875 CD=0.01616
	CM=-0.1122	CM=-0.1013	CM=-0.1010
7.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	1.0268 0.1143 0.0147*	1.0268 0.1143 0.0147*	1.0411 0.1151 0.0151*
LOWER	0.4931 0.0000 0.0018*	0.9638 0.0000 0.0027	0.6157 0.0000 0.0023
TOTAL	CL= 0.969 CD=0.01652	CL= 0.969 CD=0.01747	CL= 0.968 CD=0.01738
	CM=-0.1030	CM=-0.1030	CM=-0.1028
8.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	1.0409 0.1239 0.0166*	1.0409 0.1239 0.0166*	1.0414 0.1240 0.0166*
LOWER	0.4893 0.0000 0.0017*	0.9638 0.0000 0.0025	0.6118 0.0000 0.0021
TOTAL	CL= 1.060 CD=0.01823	CL= 1.060 CD=0.01909	CL= 1.060 CD=0.01872
	CM=-0.1043	CM=-0.1043	CM=-0.1043
9.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	1.0412 0.1339 0.0182*	1.0412 0.1339 0.0182*	1.0415 0.1339 0.0182*
LOWER	0.4851 0.0000 0.0016	0.9638 0.0000 0.0023	0.6080 0.0000 0.0020
TOTAL	CL= 1.149 CD=0.01977	CL= 1.149 CD=0.02055	CL= 1.149 CD=0.02023
	CM=-0.1055	CM=-0.1055	CM=-0.1055
10.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	1.0413 0.1452 0.0200*	1.0413 0.1452 0.0200*	1.0416 0.1453 0.0200*
LOWER	0.4801 0.0000 0.0015*	0.9358 0.0000 0.0022	0.6045 0.0000 0.0019
TOTAL	CL= 1.235 CD=0.02149	CL= 1.235 CD=0.02219	CL= 1.235 CD=0.02192
	CM=-0.1062	CM=-0.1062	CM=-0.1062

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B.L.SUMMARY AIRFOIL S827  21%  ALPHA0=  3.165 DEG.
 *-WARNING WITH VARIABLE LIMIT  ALPHA REL. CHORD LINE

ALPHA(DEG.) R= 2500000 MU=3.0      R= 2500000 MU=1.3      R= 2500000 MU=9.0
-4.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.3643 0.0138 0.0025*  1.0099 0.0456 0.0059  0.8997 0.0449 0.0057
   LOWER 0.5349 0.0321 0.0031   0.9664 0.1980 0.0064  1.0216 0.2041 0.0068*
   TOTAL CL=-0.091 CD=0.00561   CL=-0.060 CD=0.01227  CL=-0.058 CD=0.01250
         CM=-0.0796             CM=-0.0846             CM=-0.0849
-3.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.3670 0.0170 0.0027*  1.0099 0.0504 0.0063  0.9180 0.0498 0.0062
   LOWER 0.5319 0.0010 0.0029   0.9664 0.1822 0.0059  1.0103 0.1865 0.0061
   TOTAL CL= 0.006 CD=0.00555   CL= 0.028 CD=0.01220  CL= 0.030 CD=0.01227
         CM=-0.0813             CM=-0.0861             CM=-0.0864
-2.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.3701 0.0204 0.0028*  1.0098 0.0553 0.0068  0.9363 0.0548 0.0067
   LOWER 0.5287 0.0000 0.0027   0.9664 0.1647 0.0054  0.9949 0.1674 0.0055
   TOTAL CL= 0.112 CD=0.00552   CL= 0.118 CD=0.01222  CL= 0.119 CD=0.01218
         CM=-0.0854             CM=-0.0877             CM=-0.0878
-1.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.3735 0.0242 0.0030*  1.0099 0.0604 0.0074  0.9537 0.0599 0.0073
   LOWER 0.5252 0.0000 0.0026   0.9664 0.1454 0.0049  0.9787 0.1465 0.0050
   TOTAL CL= 0.217 CD=0.00559   CL= 0.208 CD=0.01232  CL= 0.209 CD=0.01222
         CM=-0.0894             CM=-0.0892             CM=-0.0893
 0.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.3770 0.0278 0.0031   1.0099 0.0656 0.0080  0.9697 0.0653 0.0079
   LOWER 0.5214 0.0000 0.0025*  0.9664 0.1237 0.0045  0.9594 0.1231 0.0045
   TOTAL CL= 0.323 CD=0.00563   CL= 0.300 CD=0.01251  CL= 0.300 CD=0.01237
         CM=-0.0933             CM=-0.0907             CM=-0.0907
 1.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.3806 0.0314 0.0033   1.0099 0.0708 0.0087  0.9847 0.0706 0.0086
   LOWER 0.5172 0.0000 0.0024*  0.9664 0.0992 0.0041  0.9383 0.0969 0.0041
   TOTAL CL= 0.428 CD=0.00568   CL= 0.394 CD=0.01277  CL= 0.394 CD=0.01264
         CM=-0.0971             CM=-0.0922             CM=-0.0922
 2.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.3843 0.0353 0.0035   1.0099 0.0762 0.0094  0.9996 0.0761 0.0093
   LOWER 0.5131 0.0000 0.0022*  0.9664 0.0703 0.0038  0.9200 0.0658 0.0037
   TOTAL CL= 0.532 CD=0.00575   CL= 0.490 CD=0.01312  CL= 0.490 CD=0.01302
         CM=-0.1008             CM=-0.0940             CM=-0.0939
 3.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.3882 0.0395 0.0037   1.0099 0.0818 0.0101  1.0132 0.0819 0.0101
   LOWER 0.5093 0.0000 0.0021*  0.9664 0.0315 0.0035  0.8920 0.0212 0.0034
   TOTAL CL= 0.635 CD=0.00583   CL= 0.589 CD=0.01357  CL= 0.589 CD=0.01351
         CM=-0.1043             CM=-0.0959             CM=-0.0956
 4.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.3925 0.0438 0.0039   1.0099 0.0877 0.0109  1.0233 0.0880 0.0111
   LOWER 0.5059 0.0000 0.0020*  0.9664 0.0000 0.0032  0.8613 0.0000 0.0031
   TOTAL CL= 0.738 CD=0.00594   CL= 0.688 CD=0.01412  CL= 0.688 CD=0.01417
         CM=-0.1077             CM=-0.0976             CM=-0.0975
 5.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.3975 0.0484 0.0042   1.0099 0.0942 0.0118  1.0324 0.0948 0.0121
   LOWER 0.5025 0.0000 0.0019*  0.9663 0.0000 0.0030  0.8247 0.0000 0.0029
   TOTAL CL= 0.840 CD=0.00607   CL= 0.786 CD=0.01485  CL= 0.785 CD=0.01502
         CM=-0.1109             CM=-0.1001             CM=-0.0999
 6.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.4038 0.0537 0.0045   1.0099 0.1011 0.0128  1.0386 0.1022 0.0133
   LOWER 0.4991 0.0000 0.0018*  0.9664 0.0000 0.0028  0.7742 0.0000 0.0027
   TOTAL CL= 0.941 CD=0.00626   CL= 0.882 CD=0.01562  CL= 0.880 CD=0.01596
         CM=-0.1138             CM=-0.1023             CM=-0.1020
 7.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 1.0268 0.1093 0.0142   1.0268 0.1093 0.0142  1.0412 0.1101 0.0146
   LOWER 0.4956 0.0000 0.0017*  0.9638 0.0000 0.0026  0.6287 0.0000 0.0022
   TOTAL CL= 0.976 CD=0.01591   CL= 0.976 CD=0.01685  CL= 0.975 CD=0.01681
         CM=-0.1041             CM=-0.1041             CM=-0.1039
 8.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 1.0409 0.1186 0.0160*  1.0409 0.1186 0.0160*  1.0415 0.1187 0.0160*
   LOWER 0.4920 0.0000 0.0016*  0.9638 0.0000 0.0025   0.6241 0.0000 0.0021
   TOTAL CL= 1.067 CD=0.01757   CL= 1.067 CD=0.01842  CL= 1.067 CD=0.01809
         CM=-0.1055             CM=-0.1055             CM=-0.1055
 9.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 1.0412 0.1281 0.0175*  1.0412 0.1281 0.0175*  1.0416 0.1282 0.0176*
   LOWER 0.4880 0.0000 0.0015   0.9638 0.0000 0.0023   0.6194 0.0000 0.0020
   TOTAL CL= 1.157 CD=0.01906   CL= 1.157 CD=0.01982  CL= 1.157 CD=0.01954
         CM=-0.1068             CM=-0.1068             CM=-0.1067
10.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 1.0413 0.1391 0.0193*  1.0413 0.1391 0.0193*  1.0417 0.1392 0.0193*
   LOWER 0.4834 0.0000 0.0014   0.9358 0.0000 0.0021   0.6146 0.0000 0.0018
   TOTAL CL= 1.244 CD=0.02071   CL= 1.244 CD=0.02140  CL= 1.244 CD=0.02116
         CM=-0.1075             CM=-0.1075             CM=-0.1075
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B.L.SUMMARY AIRFOIL S827 21% ALPHA0= 3.165 DEG.
*-WARNING WITH VARIABLE LIMIT ALPHA REL. CHORD LINE

ALPHA(DEG.)	R= 3000000 MU=3.0	R= 3000000 MU=1.3	R= 3000000 MU=9.0
-4.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3668 0.0113 0.0024*	1.0099 0.0433 0.0057	0.9121 0.0428 0.0056
LOWER	0.5374 0.0168 0.0030	0.9664 0.1910 0.0062	1.0218 0.1973 0.0066*
TOTAL	CL=-0.094 CD=0.00539	CL=-0.061 CD=0.01191	CL=-0.059 CD=0.01217
	CM=-0.0788	CM=-0.0846	CM=-0.0849
-3.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3697 0.0144 0.0026*	1.0099 0.0481 0.0062	0.9298 0.0476 0.0060
LOWER	0.5345 0.0000 0.0028	0.9664 0.1748 0.0057	1.0126 0.1795 0.0059
TOTAL	CL= 0.007 CD=0.00531	CL= 0.028 CD=0.01185	CL= 0.030 CD=0.01196
	CM=-0.0818	CM=-0.0861	CM=-0.0864
-2.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3731 0.0177 0.0027	1.0098 0.0529 0.0067	0.9466 0.0525 0.0065
LOWER	0.5313 0.0000 0.0027	0.9664 0.1571 0.0052	0.9985 0.1602 0.0053
TOTAL	CL= 0.114 CD=0.00535	CL= 0.118 CD=0.01187	CL= 0.119 CD=0.01188
	CM=-0.0859	CM=-0.0877	CM=-0.0879
-1.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3766 0.0210 0.0028	1.0099 0.0579 0.0072	0.9628 0.0575 0.0071
LOWER	0.5279 0.0000 0.0025	0.9664 0.1373 0.0048	0.9837 0.1389 0.0048
TOTAL	CL= 0.220 CD=0.00539	CL= 0.209 CD=0.01197	CL= 0.210 CD=0.01191
	CM=-0.0900	CM=-0.0892	CM=-0.0893
0.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3801 0.0249 0.0030	1.0099 0.0630 0.0078	0.9776 0.0627 0.0077
LOWER	0.5242 0.0000 0.0024	0.9664 0.1152 0.0044	0.9671 0.1152 0.0044
TOTAL	CL= 0.325 CD=0.00544	CL= 0.302 CD=0.01215	CL= 0.302 CD=0.01206
	CM=-0.0939	CM=-0.0908	CM=-0.0908
1.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3836 0.0284 0.0032	1.0099 0.0682 0.0084	0.9903 0.0680 0.0083
LOWER	0.5202 0.0000 0.0023	0.9664 0.0897 0.0040	0.9478 0.0880 0.0040
TOTAL	CL= 0.431 CD=0.00548	CL= 0.396 CD=0.01241	CL= 0.396 CD=0.01231
	CM=-0.0978	CM=-0.0924	CM=-0.0924
2.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3873 0.0321 0.0034	1.0099 0.0734 0.0091	1.0046 0.0734 0.0091
LOWER	0.5159 0.0000 0.0022*	0.9664 0.0594 0.0037	0.9289 0.0556 0.0036
TOTAL	CL= 0.535 CD=0.00553	CL= 0.493 CD=0.01275	CL= 0.493 CD=0.01268
	CM=-0.1016	CM=-0.0942	CM=-0.0941
3.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3913 0.0359 0.0035	1.0099 0.0788 0.0098	1.0166 0.0789 0.0099
LOWER	0.5118 0.0000 0.0021*	0.9664 0.0147 0.0034	0.9124 0.0056 0.0033
TOTAL	CL= 0.639 CD=0.00561	CL= 0.593 CD=0.01318	CL= 0.593 CD=0.01318
	CM=-0.1052	CM=-0.0960	CM=-0.0957
4.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3958 0.0402 0.0038	1.0099 0.0845 0.0106	1.0259 0.0848 0.0107
LOWER	0.5082 0.0000 0.0020*	0.9664 0.0000 0.0031	0.8822 0.0000 0.0031
TOTAL	CL= 0.742 CD=0.00571	CL= 0.692 CD=0.01375	CL= 0.692 CD=0.01383
	CM=-0.1086	CM=-0.0983	CM=-0.0982
5.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.4010 0.0446 0.0040	1.0099 0.0906 0.0115	1.0339 0.0913 0.0118
LOWER	0.5047 0.0000 0.0018*	0.9663 0.0000 0.0030	0.8570 0.0000 0.0029
TOTAL	CL= 0.845 CD=0.00584	CL= 0.790 CD=0.01443	CL= 0.789 CD=0.01466
	CM=-0.1119	CM=-0.1008	CM=-0.1007
6.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.4079 0.0496 0.0043	1.0099 0.0973 0.0124	1.0397 0.0984 0.0129
LOWER	0.5013 0.0000 0.0017*	0.9664 0.0000 0.0028	0.8223 0.0000 0.0027
TOTAL	CL= 0.946 CD=0.00601	CL= 0.887 CD=0.01517	CL= 0.885 CD=0.01559
	CM=-0.1149	CM=-0.1031	CM=-0.1029
7.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	1.0268 0.1053 0.0138	1.0268 0.1053 0.0138	1.0413 0.1061 0.0141
LOWER	0.4978 0.0000 0.0017*	0.9638 0.0000 0.0026	0.7778 0.0000 0.0025
TOTAL	CL= 0.981 CD=0.01543	CL= 0.981 CD=0.01636	CL= 0.980 CD=0.01662
	CM=-0.1050	CM=-0.1050	CM=-0.1048
8.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	1.0409 0.1144 0.0155*	1.0409 0.1144 0.0155*	1.0415 0.1144 0.0155*
LOWER	0.4943 0.0000 0.0016*	0.9638 0.0000 0.0024	0.6360 0.0000 0.0021
TOTAL	CL= 1.073 CD=0.01706	CL= 1.073 CD=0.01790	CL= 1.073 CD=0.01760
	CM=-0.1065	CM=-0.1065	CM=-0.1065
9.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	1.0412 0.1235 0.0170*	1.0412 0.1235 0.0170*	1.0417 0.1236 0.0171*
LOWER	0.4904 0.0000 0.0015	0.9638 0.0000 0.0022	0.6312 0.0000 0.0019
TOTAL	CL= 1.163 CD=0.01849	CL= 1.163 CD=0.01925	CL= 1.163 CD=0.01900
	CM=-0.1078	CM=-0.1078	CM=-0.1078
10.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	1.0413 0.1341 0.0187*	1.0413 0.1341 0.0187*	1.0417 0.1342 0.0188*
LOWER	0.4861 0.0000 0.0014	0.9358 0.0000 0.0021	0.6258 0.0000 0.0018
TOTAL	CL= 1.251 CD=0.02009	CL= 1.251 CD=0.02078	CL= 1.251 CD=0.02057
	CM=-0.1087	CM=-0.1087	CM=-0.1086

B.L.SUMMARY AIRFOIL S827 21% ALPHA0= 3.165 DEG.
*-WARNING WITH VARIABLE LIMIT ALPHA REL. CHORD LINE

ALPHA(DEG.)	R= 3500000 MU=3.0	R= 3500000 MU=1.3	R= 3500000 MU=9.0
-4.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3691 0.0093 0.0023	1.0099 0.0414 0.0056	0.9234 0.0410 0.0055
LOWER	0.5395 0.0046 0.0029	0.9664 0.1848 0.0061	1.0218 0.1913 0.0064*
TOTAL	CL=-0.097 CD=0.00523	CL=-0.062 CD=0.01162	CL=-0.059 CD=0.01190
	CM=-0.0782	CM=-0.0846	CM=-0.0849
-3.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3724 0.0124 0.0025	1.0099 0.0461 0.0060	0.9387 0.0457 0.0059
LOWER	0.5367 0.0000 0.0027	0.9664 0.1684 0.0056	1.0142 0.1735 0.0058
TOTAL	CL= 0.009 CD=0.00517	CL= 0.028 CD=0.01156	CL= 0.030 CD=0.01170
	CM=-0.0821	CM=-0.0861	CM=-0.0864
-2.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3758 0.0155 0.0026	1.0098 0.0509 0.0065	0.9545 0.0505 0.0064
LOWER	0.5336 0.0000 0.0026	0.9664 0.1503 0.0051	1.0011 0.1539 0.0052
TOTAL	CL= 0.116 CD=0.00521	CL= 0.119 CD=0.01158	CL= 0.120 CD=0.01162
	CM=-0.0863	CM=-0.0877	CM=-0.0879
-1.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3793 0.0189 0.0028	1.0099 0.0557 0.0070	0.9694 0.0554 0.0069
LOWER	0.5303 0.0000 0.0025	0.9664 0.1303 0.0047	0.9872 0.1323 0.0047
TOTAL	CL= 0.222 CD=0.00524	CL= 0.210 CD=0.01168	CL= 0.211 CD=0.01165
	CM=-0.0904	CM=-0.0893	CM=-0.0894
0.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3828 0.0227 0.0029	1.0099 0.0608 0.0076	0.9832 0.0605 0.0075
LOWER	0.5267 0.0000 0.0024	0.9664 0.1076 0.0043	0.9724 0.1083 0.0043
TOTAL	CL= 0.327 CD=0.00528	CL= 0.303 CD=0.01186	CL= 0.303 CD=0.01180
	CM=-0.0944	CM=-0.0909	CM=-0.0909
1.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3863 0.0261 0.0031	1.0099 0.0659 0.0082	0.9947 0.0657 0.0081
LOWER	0.5228 0.0000 0.0023	0.9664 0.0813 0.0039	0.9548 0.0803 0.0039
TOTAL	CL= 0.433 CD=0.00532	CL= 0.398 CD=0.01211	CL= 0.398 CD=0.01204
	CM=-0.0983	CM=-0.0925	CM=-0.0925
2.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3900 0.0296 0.0032	1.0099 0.0710 0.0089	1.0080 0.0710 0.0089
LOWER	0.5187 0.0000 0.0021*	0.9664 0.0495 0.0036	0.9365 0.0464 0.0035
TOTAL	CL= 0.538 CD=0.00537	CL= 0.495 CD=0.01244	CL= 0.495 CD=0.01240
	CM=-0.1021	CM=-0.0943	CM=-0.0943
3.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3941 0.0334 0.0034	1.0099 0.0763 0.0096	1.0190 0.0765 0.0096
LOWER	0.5142 0.0000 0.0020*	0.9664 0.0000 0.0033	0.9204 0.0000 0.0032
TOTAL	CL= 0.642 CD=0.00544	CL= 0.595 CD=0.01286	CL= 0.595 CD=0.01287
	CM=-0.1058	CM=-0.0960	CM=-0.0960
4.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3987 0.0375 0.0036	1.0099 0.0819 0.0103	1.0280 0.0823 0.0105
LOWER	0.5103 0.0000 0.0019*	0.9664 0.0000 0.0031	0.8949 0.0000 0.0030
TOTAL	CL= 0.745 CD=0.00553	CL= 0.695 CD=0.01344	CL= 0.694 CD=0.01355
	CM=-0.1093	CM=-0.0988	CM=-0.0988
5.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.4043 0.0418 0.0039	1.0099 0.0877 0.0112	1.0352 0.0884 0.0115
LOWER	0.5067 0.0000 0.0018*	0.9663 0.0000 0.0029	0.8722 0.0000 0.0029
TOTAL	CL= 0.848 CD=0.00566	CL= 0.793 CD=0.01409	CL= 0.793 CD=0.01434
	CM=-0.1126	CM=-0.1015	CM=-0.1013
6.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.4121 0.0467 0.0041	1.0099 0.0942 0.0121	1.0402 0.0953 0.0126
LOWER	0.5033 0.0000 0.0017*	0.9664 0.0000 0.0027	0.8498 0.0000 0.0027
TOTAL	CL= 0.950 CD=0.00584	CL= 0.891 CD=0.01480	CL= 0.889 CD=0.01525
	CM=-0.1156	CM=-0.1038	CM=-0.1036
7.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	1.0268 0.1019 0.0134	1.0268 0.1019 0.0134	1.0414 0.1028 0.0138
LOWER	0.4998 0.0000 0.0016*	0.9638 0.0000 0.0025	0.8153 0.0000 0.0025
TOTAL	CL= 0.985 CD=0.01503	CL= 0.985 CD=0.01596	CL= 0.984 CD=0.01626
	CM=-0.1058	CM=-0.1058	CM=-0.1056
8.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	1.0409 0.1108 0.0151*	1.0409 0.1108 0.0151*	1.0416 0.1109 0.0151*
LOWER	0.4963 0.0000 0.0015	0.9638 0.0000 0.0024	0.7767 0.0000 0.0023
TOTAL	CL= 1.078 CD=0.01664	CL= 1.078 CD=0.01747	CL= 1.077 CD=0.01741
	CM=-0.1073	CM=-0.1073	CM=-0.1073
9.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	1.0412 0.1197 0.0166*	1.0412 0.1197 0.0166*	1.0417 0.1198 0.0166*
LOWER	0.4925 0.0000 0.0014	0.9638 0.0000 0.0022	0.6411 0.0000 0.0019
TOTAL	CL= 1.169 CD=0.01803	CL= 1.169 CD=0.01878	CL= 1.169 CD=0.01856
	CM=-0.1087	CM=-0.1087	CM=-0.1087
10.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	1.0413 0.1299 0.0182*	1.0413 0.1299 0.0182*	1.0418 0.1301 0.0183*
LOWER	0.4884 0.0000 0.0013	0.9358 0.0000 0.0020	0.6366 0.0000 0.0018
TOTAL	CL= 1.257 CD=0.01959	CL= 1.257 CD=0.02026	CL= 1.257 CD=0.02008
	CM=-0.1096	CM=-0.1096	CM=-0.1096

B.L.SUMMARY AIRFOIL S827 21% ALPHA0= 3.165 DEG.
*-WARNING WITH VARIABLE LIMIT ALPHA REL. CHORD LINE

ALPHA(DEG.)	R= 4000000 MU=3.0			R= 4000000 MU=1.3			R= 4000000 MU=9.0		
-4.00	S TURB	S SEP	CD	S TURB	S SEP	CD	S TURB	S SEP	CD
UPPER	0.3714	0.0077	0.0023	1.0099	0.0398	0.0054	0.9312	0.0394	0.0054
LOWER	0.5414	0.0000	0.0028	0.9664	0.1794	0.0059	1.0219	0.1861	0.0063
TOTAL	CL=-0.097	CD=0.00508		CL=-0.062	CD=0.01137		CL=-0.060	CD=0.01167	
	CM=-0.0781			CM=-0.0845			CM=-0.0849		
-3.00	S TURB	S SEP	CD	S TURB	S SEP	CD	S TURB	S SEP	CD
UPPER	0.3748	0.0108	0.0024	1.0099	0.0444	0.0059	0.9453	0.0441	0.0058
LOWER	0.5386	0.0000	0.0027	0.9664	0.1627	0.0054	1.0155	0.1681	0.0057
TOTAL	CL= 0.010	CD=0.00507		CL= 0.028	CD=0.01132		CL= 0.029	CD=0.01147	
	CM=-0.0824			CM=-0.0861			CM=-0.0864		
-2.00	S TURB	S SEP	CD	S TURB	S SEP	CD	S TURB	S SEP	CD
UPPER	0.3783	0.0139	0.0025	1.0098	0.0491	0.0064	0.9608	0.0488	0.0063
LOWER	0.5356	0.0000	0.0026	0.9664	0.1444	0.0050	1.0031	0.1483	0.0051
TOTAL	CL= 0.117	CD=0.00510		CL= 0.119	CD=0.01134		CL= 0.120	CD=0.01139	
	CM=-0.0867			CM=-0.0877			CM=-0.0879		
-1.00	S TURB	S SEP	CD	S TURB	S SEP	CD	S TURB	S SEP	CD
UPPER	0.3817	0.0171	0.0027	1.0099	0.0539	0.0069	0.9746	0.0536	0.0068
LOWER	0.5324	0.0000	0.0024	0.9664	0.1241	0.0046	0.9898	0.1264	0.0046
TOTAL	CL= 0.223	CD=0.00512		CL= 0.211	CD=0.01144		CL= 0.211	CD=0.01143	
	CM=-0.0908			CM=-0.0893			CM=-0.0894		
0.00	S TURB	S SEP	CD	S TURB	S SEP	CD	S TURB	S SEP	CD
UPPER	0.3852	0.0208	0.0028	1.0099	0.0588	0.0074	0.9872	0.0586	0.0074
LOWER	0.5289	0.0000	0.0023	0.9664	0.1009	0.0042	0.9761	0.1018	0.0042
TOTAL	CL= 0.329	CD=0.00516		CL= 0.304	CD=0.01161		CL= 0.304	CD=0.01157	
	CM=-0.0948			CM=-0.0909			CM=-0.0910		
1.00	S TURB	S SEP	CD	S TURB	S SEP	CD	S TURB	S SEP	CD
UPPER	0.3887	0.0242	0.0030	1.0099	0.0639	0.0080	0.9995	0.0638	0.0080
LOWER	0.5252	0.0000	0.0022	0.9664	0.0739	0.0038	0.9604	0.0733	0.0038
TOTAL	CL= 0.435	CD=0.00519		CL= 0.399	CD=0.01186		CL= 0.399	CD=0.01182	
	CM=-0.0987			CM=-0.0926			CM=-0.0926		
2.00	S TURB	S SEP	CD	S TURB	S SEP	CD	S TURB	S SEP	CD
UPPER	0.3925	0.0277	0.0031	1.0099	0.0690	0.0087	1.0107	0.0690	0.0087
LOWER	0.5211	0.0000	0.0021	0.9664	0.0404	0.0035	0.9429	0.0377	0.0035
TOTAL	CL= 0.540	CD=0.00524		CL= 0.497	CD=0.01218		CL= 0.497	CD=0.01216	
	CM=-0.1026			CM=-0.0945			CM=-0.0944		
3.00	S TURB	S SEP	CD	S TURB	S SEP	CD	S TURB	S SEP	CD
UPPER	0.3966	0.0313	0.0033	1.0099	0.0742	0.0094	1.0206	0.0744	0.0094
LOWER	0.5166	0.0000	0.0020*	0.9664	0.0000	0.0032	0.9267	0.0000	0.0032
TOTAL	CL= 0.644	CD=0.00530		CL= 0.598	CD=0.01258		CL= 0.598	CD=0.01261	
	CM=-0.1063			CM=-0.0965			CM=-0.0964		
4.00	S TURB	S SEP	CD	S TURB	S SEP	CD	S TURB	S SEP	CD
UPPER	0.4014	0.0353	0.0035	1.0099	0.0796	0.0101	1.0296	0.0800	0.0103
LOWER	0.5123	0.0000	0.0019*	0.9664	0.0000	0.0030	0.9059	0.0000	0.0030
TOTAL	CL= 0.748	CD=0.00539		CL= 0.697	CD=0.01317		CL= 0.697	CD=0.01330	
	CM=-0.1099			CM=-0.0993			CM=-0.0993		
5.00	S TURB	S SEP	CD	S TURB	S SEP	CD	S TURB	S SEP	CD
UPPER	0.4075	0.0396	0.0038	1.0099	0.0853	0.0109	1.0362	0.0860	0.0112
LOWER	0.5086	0.0000	0.0018*	0.9663	0.0000	0.0029	0.8847	0.0000	0.0028
TOTAL	CL= 0.851	CD=0.00552		CL= 0.796	CD=0.01380		CL= 0.795	CD=0.01407	
	CM=-0.1132			CM=-0.1020			CM=-0.1019		
6.00	S TURB	S SEP	CD	S TURB	S SEP	CD	S TURB	S SEP	CD
UPPER	0.4168	0.0446	0.0040	1.0099	0.0915	0.0118	1.0408	0.0927	0.0123
LOWER	0.5050	0.0000	0.0017*	0.9664	0.0000	0.0027	0.8612	0.0000	0.0026
TOTAL	CL= 0.952	CD=0.00571		CL= 0.894	CD=0.01448		CL= 0.892	CD=0.01496	
	CM=-0.1162			CM=-0.1045			CM=-0.1042		
7.00	S TURB	S SEP	CD	S TURB	S SEP	CD	S TURB	S SEP	CD
UPPER	1.0268	0.0990	0.0131	1.0268	0.0990	0.0131	1.0415	0.0999	0.0135
LOWER	0.5016	0.0000	0.0016*	0.9638	0.0000	0.0025	0.8405	0.0000	0.0024
TOTAL	CL= 0.989	CD=0.01470		CL= 0.989	CD=0.01562		CL= 0.988	CD=0.01595	
	CM=-0.1064			CM=-0.1064			CM=-0.1062		
8.00	S TURB	S SEP	CD	S TURB	S SEP	CD	S TURB	S SEP	CD
UPPER	1.0409	0.1077	0.0148*	1.0409	0.1077	0.0148*	1.0416	0.1078	0.0148*
LOWER	0.4980	0.0000	0.0015	0.9638	0.0000	0.0023	0.8058	0.0000	0.0023
TOTAL	CL= 1.082	CD=0.01628		CL= 1.082	CD=0.01710		CL= 1.082	CD=0.01707	
	CM=-0.1080			CM=-0.1080			CM=-0.1080		
9.00	S TURB	S SEP	CD	S TURB	S SEP	CD	S TURB	S SEP	CD
UPPER	1.0412	0.1165	0.0162*	1.0412	0.1165	0.0162*	1.0417	0.1166	0.0163*
LOWER	0.4944	0.0000	0.0014	0.9638	0.0000	0.0021	0.7735	0.0000	0.0021
TOTAL	CL= 1.173	CD=0.01764		CL= 1.173	CD=0.01838		CL= 1.173	CD=0.01836	
	CM=-0.1094			CM=-0.1094			CM=-0.1094		
10.00	S TURB	S SEP	CD	S TURB	S SEP	CD	S TURB	S SEP	CD
UPPER	1.0413	0.1263	0.0178*	1.0413	0.1263	0.0178*	1.0418	0.1265	0.0179*
LOWER	0.4904	0.0000	0.0013	0.9358	0.0000	0.0020	0.6446	0.0000	0.0018
TOTAL	CL= 1.263	CD=0.01916		CL= 1.263	CD=0.01983		CL= 1.262	CD=0.01966	
	CM=-0.1105			CM=-0.1105			CM=-0.1104		

AIRFOIL S828 16%				-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00
N	X	Y	NUE	CP-DISTR. FOR THE ABOVE ALPHA REL. CHORD LINE						
1	1.00000	0.00000	0.00	0.444	0.444	0.444	0.445	0.445	0.447	0.448
2	0.99595	0.00050	1.00	0.436	0.435	0.434	0.433	0.433	0.433	0.434
3	0.98420	0.00250	2.00	0.395	0.393	0.391	0.389	0.388	0.387	0.387
4	0.96579	0.00665	3.00	0.329	0.325	0.321	0.318	0.316	0.313	0.311
5	0.94187	0.01297	4.00	0.244	0.238	0.233	0.228	0.223	0.219	0.216
6	0.91342	0.02103	5.00	0.153	0.145	0.137	0.130	0.123	0.117	0.111
7	0.88101	0.03029	6.00	0.073	0.062	0.052	0.042	0.032	0.024	0.016
8	0.84507	0.04046	7.00	-0.001	-0.014	-0.028	-0.040	-0.053	-0.064	-0.075
9	0.80626	0.05131	8.00	-0.086	-0.104	-0.121	-0.137	-0.153	-0.168	-0.182
10	0.76532	0.06246	9.00	-0.184	-0.205	-0.227	-0.247	-0.267	-0.286	-0.305
11	0.72289	0.07334	10.00	-0.292	-0.319	-0.345	-0.371	-0.396	-0.420	-0.444
12	0.67954	0.08339	11.00	-0.409	-0.442	-0.475	-0.507	-0.538	-0.569	-0.599
13	0.63573	0.09180	12.00	-0.534	-0.575	-0.614	-0.653	-0.692	-0.730	-0.767
14	0.59134	0.09770	13.00	-0.579	-0.626	-0.671	-0.717	-0.761	-0.806	-0.850
15	0.54576	0.10103	14.00	-0.540	-0.590	-0.640	-0.690	-0.739	-0.788	-0.836
16	0.49904	0.10241	15.00	-0.500	-0.554	-0.609	-0.663	-0.717	-0.771	-0.824
17	0.45176	0.10219	16.00	-0.459	-0.518	-0.577	-0.636	-0.695	-0.754	-0.813
18	0.40444	0.10053	17.00	-0.417	-0.480	-0.544	-0.608	-0.673	-0.738	-0.803
19	0.35762	0.09756	18.00	-0.372	-0.441	-0.510	-0.581	-0.651	-0.723	-0.795
20	0.31183	0.09340	19.00	-0.325	-0.400	-0.475	-0.552	-0.630	-0.709	-0.788
21	0.26758	0.08817	20.00	-0.274	-0.355	-0.438	-0.522	-0.608	-0.695	-0.783
22	0.22536	0.08199	21.00	-0.218	-0.307	-0.397	-0.490	-0.584	-0.681	-0.780
23	0.18564	0.07497	22.00	-0.155	-0.251	-0.351	-0.453	-0.559	-0.667	-0.777
24	0.14886	0.06724	23.00	-0.082	-0.188	-0.297	-0.411	-0.529	-0.651	-0.776
25	0.11542	0.05894	24.00	0.006	-0.111	-0.233	-0.360	-0.493	-0.631	-0.775
26	0.08569	0.05019	25.00	0.112	-0.016	-0.152	-0.296	-0.448	-0.607	-0.773
27	0.05999	0.04116	26.00	0.246	0.106	-0.047	-0.210	-0.385	-0.570	-0.766
28	0.03860	0.03202	27.00	0.419	0.266	0.096	-0.091	-0.295	-0.515	-0.752
29	0.02173	0.02295	28.00	0.642	0.486	0.303	0.091	-0.147	-0.413	-0.705
30	0.00956	0.01419	29.00	0.898	0.772	0.596	0.371	0.098	-0.225	-0.596
31	0.00226	0.00609	30.00	0.952	1.000	0.946	0.791	0.533	0.174	-0.285
32	0.00038	0.00215	30.54	0.443	0.789	0.970	0.987	0.839	0.526	0.049
33	0.00003	0.00053	30.79	-0.208	0.405	0.803	0.987	0.955	0.707	0.245
34	0.00009	-0.00090	31.04	-1.464	-0.410	0.352	0.822	0.998	0.882	0.471
35	0.00069	-0.00224	31.29	-1.283	-0.440	0.210	0.667	0.930	0.998	0.872
36	0.00179	-0.00364	31.54	-1.163	-0.461	0.104	0.532	0.823	0.975	0.989
37	0.00481	-0.00633	32.00	-1.023	-0.486	-0.032	0.341	0.631	0.837	0.960
38	0.01546	-0.01240	33.00	-0.869	-0.516	-0.199	0.082	0.325	0.532	0.701
39	0.03146	-0.01840	34.00	-0.747	-0.492	-0.256	-0.040	0.157	0.333	0.489
40	0.05264	-0.02409	35.00	-0.642	-0.448	-0.264	-0.093	0.067	0.214	0.350
41	0.07880	-0.02943	36.00	-0.566	-0.411	-0.263	-0.122	0.011	0.136	0.253
42	0.10964	-0.03438	37.00	-0.506	-0.378	-0.255	-0.137	-0.024	0.083	0.185
43	0.14480	-0.03894	38.00	-0.462	-0.354	-0.250	-0.148	-0.051	0.043	0.133
44	0.18387	-0.04309	39.00	-0.428	-0.336	-0.245	-0.157	-0.072	0.011	0.091
45	0.22636	-0.04679	40.00	-0.403	-0.322	-0.243	-0.165	-0.090	-0.016	0.056
46	0.27176	-0.05002	41.00	-0.383	-0.312	-0.242	-0.173	-0.106	-0.040	0.025
47	0.31952	-0.05274	42.00	-0.369	-0.306	-0.244	-0.182	-0.121	-0.061	-0.002
48	0.36907	-0.05490	43.00	-0.359	-0.302	-0.246	-0.191	-0.136	-0.082	-0.028
49	0.41982	-0.05645	44.00	-0.351	-0.300	-0.250	-0.200	-0.150	-0.101	-0.052
50	0.47117	-0.05732	45.00	-0.345	-0.300	-0.255	-0.209	-0.164	-0.119	-0.074
51	0.52253	-0.05746	46.00	-0.342	-0.301	-0.260	-0.219	-0.178	-0.136	-0.095
52	0.57329	-0.05681	47.00	-0.339	-0.302	-0.265	-0.228	-0.191	-0.153	-0.116
53	0.62288	-0.05527	48.00	-0.338	-0.305	-0.272	-0.238	-0.204	-0.170	-0.136
54	0.67072	-0.05275	49.00	-0.338	-0.308	-0.278	-0.248	-0.217	-0.186	-0.155
55	0.71627	-0.04898	50.00	-0.331	-0.305	-0.278	-0.251	-0.224	-0.196	-0.167
56	0.75939	-0.04362	51.00	-0.278	-0.256	-0.234	-0.210	-0.187	-0.163	-0.138
57	0.80026	-0.03672	52.00	-0.179	-0.161	-0.142	-0.124	-0.104	-0.084	-0.064
58	0.83903	-0.02873	53.00	-0.048	-0.035	-0.020	-0.006	0.009	0.025	0.041
59	0.87561	-0.02049	54.00	0.088	0.098	0.109	0.119	0.131	0.143	0.155
60	0.90947	-0.01301	55.00	0.200	0.207	0.215	0.223	0.232	0.240	0.250
61	0.93959	-0.00705	56.00	0.289	0.294	0.299	0.305	0.311	0.318	0.325
62	0.96481	-0.00298	57.00	0.356	0.359	0.363	0.367	0.372	0.376	0.382
63	0.98395	-0.00080	58.00	0.403	0.405	0.408	0.410	0.414	0.417	0.421
64	0.99592	-0.00008	59.00	0.433	0.433	0.435	0.436	0.438	0.440	0.443
65	1.00000	0.00000	60.00	0.444	0.444	0.444	0.445	0.445	0.447	0.448

ALPHA0= 2.03 DEGREES CM0=-0.0432 ETA= 1.122

AIRFOIL S828 16%				4.00	5.00	6.00	7.00	8.00	9.00	10.00
N	X	Y	NUE	CP-DISTR. FOR THE ABOVE ALPHA REL. CHORD LINE						
1	1.00000	0.00000	0.00	0.450	0.452	0.455	0.458	0.461	0.464	0.468
2	0.99595	0.00050	1.00	0.435	0.436	0.437	0.439	0.442	0.444	0.447
3	0.98420	0.00250	2.00	0.386	0.387	0.387	0.388	0.389	0.391	0.393
4	0.96579	0.00665	3.00	0.310	0.309	0.308	0.308	0.308	0.309	0.310
5	0.94187	0.01297	4.00	0.213	0.210	0.208	0.206	0.205	0.204	0.204
6	0.91342	0.02103	5.00	0.106	0.101	0.097	0.094	0.091	0.088	0.086
7	0.88101	0.03029	6.00	0.008	0.001	-0.006	-0.012	-0.017	-0.021	-0.026
8	0.84507	0.04046	7.00	-0.086	-0.096	-0.105	-0.113	-0.121	-0.129	-0.135
9	0.80626	0.05131	8.00	-0.196	-0.209	-0.222	-0.234	-0.245	-0.255	-0.265
10	0.76532	0.06246	9.00	-0.323	-0.341	-0.357	-0.373	-0.388	-0.403	-0.416
11	0.72289	0.07334	10.00	-0.467	-0.490	-0.511	-0.532	-0.552	-0.572	-0.590
12	0.67954	0.08339	11.00	-0.628	-0.656	-0.684	-0.711	-0.737	-0.762	-0.787
13	0.63573	0.09180	12.00	-0.804	-0.840	-0.875	-0.910	-0.943	-0.976	-1.007
14	0.59134	0.09770	13.00	-0.893	-0.935	-0.977	-1.018	-1.058	-1.098	-1.136
15	0.54576	0.10103	14.00	-0.884	-0.932	-0.979	-1.025	-1.070	-1.115	-1.159
16	0.49904	0.10241	15.00	-0.877	-0.930	-0.982	-1.034	-1.086	-1.136	-1.186
17	0.45176	0.10219	16.00	-0.872	-0.931	-0.989	-1.047	-1.104	-1.162	-1.218
18	0.40444	0.10053	17.00	-0.868	-0.933	-0.998	-1.063	-1.128	-1.192	-1.256
19	0.35762	0.09756	18.00	-0.867	-0.939	-1.012	-1.085	-1.157	-1.230	-1.302
20	0.31183	0.09340	19.00	-0.868	-0.949	-1.030	-1.112	-1.194	-1.276	-1.358
21	0.26758	0.08817	20.00	-0.872	-0.963	-1.054	-1.146	-1.239	-1.332	-1.426
22	0.22536	0.08199	21.00	-0.880	-0.981	-1.085	-1.189	-1.295	-1.401	-1.509
23	0.18564	0.07497	22.00	-0.890	-1.005	-1.123	-1.242	-1.364	-1.487	-1.611
24	0.14886	0.06724	23.00	-0.905	-1.037	-1.172	-1.310	-1.451	-1.594	-1.740
25	0.11542	0.05894	24.00	-0.923	-1.076	-1.233	-1.395	-1.561	-1.731	-1.904
26	0.08569	0.05019	25.00	-0.946	-1.126	-1.313	-1.506	-1.705	-1.911	-2.121
27	0.05999	0.04116	26.00	-0.973	-1.189	-1.416	-1.652	-1.897	-2.152	-2.415
28	0.03860	0.03202	27.00	-1.005	-1.273	-1.557	-1.856	-2.170	-2.498	-2.839
29	0.02173	0.02295	28.00	-1.023	-1.368	-1.738	-2.133	-2.552	-2.996	-3.463
30	0.00956	0.01419	29.00	-1.015	-1.482	-1.995	-2.554	-3.160	-3.809	-4.503
31	0.00226	0.00609	30.00	-0.846	-1.506	-2.264	-3.121	-4.075	-5.125	-6.269
32	0.00038	0.00215	30.54	-0.591	-1.395	-2.360	-3.486	-4.772	-6.215	-7.814
33	0.00003	0.00053	30.79	-0.432	-1.322	-2.425	-3.739	-5.263	-6.995	-8.932
34	0.00009	-0.00090	31.04	-0.232	-1.227	-2.513	-4.088	-5.950	-8.097	-10.527
35	0.00069	-0.00224	31.29	0.551	0.037	-0.671	-1.571	-2.662	-3.944	-5.413
36	0.00179	-0.00364	31.54	0.865	0.602	0.202	-0.335	-1.010	-1.820	-2.765
37	0.00481	-0.00633	32.00	1.000	0.956	0.828	0.617	0.323	-0.054	-0.513
38	0.01546	-0.01240	33.00	0.832	0.926	0.982	1.000	0.980	0.922	0.826
39	0.03146	-0.01840	34.00	0.625	0.740	0.834	0.907	0.959	0.990	1.000
40	0.05264	-0.02409	35.00	0.472	0.583	0.680	0.765	0.837	0.896	0.942
41	0.07880	-0.02943	36.00	0.362	0.463	0.556	0.640	0.715	0.782	0.840
42	0.10964	-0.03438	37.00	0.282	0.373	0.458	0.537	0.610	0.677	0.738
43	0.14480	-0.03894	38.00	0.219	0.301	0.379	0.452	0.522	0.587	0.647
44	0.18387	-0.04309	39.00	0.168	0.243	0.314	0.382	0.447	0.508	0.567
45	0.22636	-0.04679	40.00	0.126	0.193	0.258	0.321	0.382	0.440	0.496
46	0.27176	-0.05002	41.00	0.089	0.150	0.210	0.269	0.325	0.380	0.432
47	0.31952	-0.05274	42.00	0.055	0.112	0.167	0.221	0.274	0.325	0.375
48	0.36907	-0.05490	43.00	0.025	0.077	0.128	0.178	0.228	0.276	0.323
49	0.41982	-0.05645	44.00	-0.003	0.045	0.092	0.139	0.185	0.230	0.274
50	0.47117	-0.05732	45.00	-0.029	0.015	0.059	0.102	0.145	0.187	0.229
51	0.52253	-0.05746	46.00	-0.054	-0.013	0.027	0.068	0.108	0.147	0.187
52	0.57329	-0.05681	47.00	-0.078	-0.040	-0.003	0.035	0.072	0.109	0.146
53	0.62288	-0.05527	48.00	-0.101	-0.066	-0.031	0.003	0.038	0.073	0.108
54	0.67072	-0.05275	49.00	-0.123	-0.091	-0.059	-0.027	0.005	0.038	0.070
55	0.71627	-0.04898	50.00	-0.139	-0.110	-0.080	-0.051	-0.021	0.009	0.039
56	0.75939	-0.04362	51.00	-0.113	-0.087	-0.062	-0.035	-0.009	0.018	0.045
57	0.80026	-0.03672	52.00	-0.043	-0.022	0.000	0.022	0.044	0.067	0.090
58	0.83903	-0.02873	53.00	0.058	0.075	0.092	0.110	0.128	0.146	0.165
59	0.87561	-0.02049	54.00	0.168	0.181	0.195	0.208	0.223	0.237	0.252
60	0.90947	-0.01301	55.00	0.260	0.270	0.280	0.291	0.302	0.314	0.326
61	0.93959	-0.00705	56.00	0.332	0.340	0.348	0.357	0.365	0.375	0.384
62	0.96481	-0.00298	57.00	0.387	0.393	0.399	0.406	0.413	0.420	0.428
63	0.98395	-0.00080	58.00	0.425	0.429	0.434	0.439	0.445	0.450	0.456
64	0.99592	-0.00008	59.00	0.446	0.449	0.453	0.457	0.461	0.465	0.470
65	1.00000	0.00000	60.00	0.450	0.452	0.455	0.458	0.461	0.464	0.468

ALPHA0= 2.03 DEGREES CM0=-0.0432 ETA= 1.122

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B.L.SUMMARY AIRFOIL S828  16%  ALPHA0=  2.027 DEG.
 *-WARNING WITH VARIABLE LIMIT  ALPHA REL. CHORD LINE

ALPHA(DEG.) R= 2000000 MU=3.0      R= 2000000 MU=1.3      R= 2000000 MU=9.0
-3.00    S TURB  S SEP   CD      S TURB  S SEP   CD      S TURB  S SEP   CD
   UPPER 0.3669 0.0064 0.0024*  1.0030 0.0409 0.0055  0.8920 0.0399 0.0053
   LOWER 0.2724 0.0203 0.0020   0.9568 0.0446 0.0058  1.0071 0.0453 0.0061
   TOTAL CL=-0.100 CD=0.00441   CL=-0.105 CD=0.01128  CL=-0.104 CD=0.01142
         CM=-0.0405             CM=-0.0391             CM=-0.0393
-2.00    S TURB  S SEP   CD      S TURB  S SEP   CD      S TURB  S SEP   CD
   UPPER 0.3699 0.0105 0.0025*  1.0030 0.0464 0.0059  0.9116 0.0456 0.0058
   LOWER 0.2634 0.0125 0.0019   0.9568 0.0392 0.0054  0.9906 0.0395 0.0055
   TOTAL CL= 0.003 CD=0.00439   CL=-0.006 CD=0.01129  CL=-0.005 CD=0.01128
         CM=-0.0425             CM=-0.0406             CM=-0.0407
-1.00    S TURB  S SEP   CD      S TURB  S SEP   CD      S TURB  S SEP   CD
   UPPER 0.3733 0.0145 0.0027*  1.0029 0.0522 0.0064  0.9309 0.0514 0.0063
   LOWER 0.2562 0.0043 0.0017   0.9568 0.0337 0.0050  0.9759 0.0339 0.0050
   TOTAL CL= 0.105 CD=0.00440   CL= 0.093 CD=0.01138  CL= 0.094 CD=0.01129
         CM=-0.0445             CM=-0.0421             CM=-0.0422
 0.00    S TURB  S SEP   CD      S TURB  S SEP   CD      S TURB  S SEP   CD
   UPPER 0.3771 0.0193 0.0028*  1.0030 0.0581 0.0070  0.9492 0.0574 0.0068
   LOWER 0.2501 0.0000 0.0016*  0.9568 0.0280 0.0046  0.9597 0.0281 0.0046
   TOTAL CL= 0.209 CD=0.00444   CL= 0.192 CD=0.01155  CL= 0.193 CD=0.01141
         CM=-0.0470             CM=-0.0436             CM=-0.0437
 1.00    S TURB  S SEP   CD      S TURB  S SEP   CD      S TURB  S SEP   CD
   UPPER 0.3811 0.0237 0.0030*  1.0030 0.0642 0.0075  0.9670 0.0637 0.0074
   LOWER 0.2447 0.0000 0.0015*  0.9568 0.0221 0.0042  0.9396 0.0220 0.0042
   TOTAL CL= 0.315 CD=0.00453   CL= 0.291 CD=0.01179  CL= 0.292 CD=0.01163
         CM=-0.0499             CM=-0.0451             CM=-0.0451
 2.00    S TURB  S SEP   CD      S TURB  S SEP   CD      S TURB  S SEP   CD
   UPPER 0.3853 0.0283 0.0032   1.0030 0.0704 0.0082  0.9822 0.0700 0.0081
   LOWER 0.2399 0.0000 0.0015*  0.9568 0.0158 0.0039  0.9200 0.0156 0.0039
   TOTAL CL= 0.420 CD=0.00464   CL= 0.390 CD=0.01210  CL= 0.390 CD=0.01195
         CM=-0.0526             CM=-0.0465             CM=-0.0466
 3.00    S TURB  S SEP   CD      S TURB  S SEP   CD      S TURB  S SEP   CD
   UPPER 0.3898 0.0331 0.0034   1.0030 0.0767 0.0089  0.9972 0.0766 0.0088
   LOWER 0.2357 0.0000 0.0014*  0.9568 0.0091 0.0036  0.8988 0.0087 0.0035
   TOTAL CL= 0.524 CD=0.00477   CL= 0.488 CD=0.01250  CL= 0.488 CD=0.01239
         CM=-0.0553             CM=-0.0480             CM=-0.0480
 4.00    S TURB  S SEP   CD      S TURB  S SEP   CD      S TURB  S SEP   CD
   UPPER 0.3947 0.0384 0.0036   1.0030 0.0834 0.0096  1.0105 0.0836 0.0097
   LOWER 0.2317 0.0000 0.0013*  0.9568 0.0000 0.0033  0.8766 0.0000 0.0033
   TOTAL CL= 0.627 CD=0.00492   CL= 0.586 CD=0.01297  CL= 0.586 CD=0.01294
         CM=-0.0577             CM=-0.0492             CM=-0.0492
 5.00    S TURB  S SEP   CD      S TURB  S SEP   CD      S TURB  S SEP   CD
   UPPER 0.4005 0.0441 0.0038   1.0030 0.0906 0.0104  1.0191 0.0911 0.0106
   LOWER 0.2280 0.0000 0.0013*  0.9568 0.0000 0.0031  0.8536 0.0000 0.0030
   TOTAL CL= 0.730 CD=0.00510   CL= 0.684 CD=0.01351  CL= 0.684 CD=0.01360
         CM=-0.0600             CM=-0.0509             CM=-0.0508
 6.00    S TURB  S SEP   CD      S TURB  S SEP   CD      S TURB  S SEP   CD
   UPPER 0.4078 0.0504 0.0041   1.0030 0.0984 0.0113  1.0260 0.0995 0.0117
   LOWER 0.2243 0.0000 0.0012*  0.9568 0.0000 0.0029  0.8310 0.0000 0.0028
   TOTAL CL= 0.831 CD=0.00533   CL= 0.781 CD=0.01423  CL= 0.780 CD=0.01449
         CM=-0.0621             CM=-0.0524             CM=-0.0522
 7.00    S TURB  S SEP   CD      S TURB  S SEP   CD      S TURB  S SEP   CD
   UPPER 1.0127 0.1075 0.0125*  1.0127 0.1075 0.0125*  1.0310 0.1087 0.0129
   LOWER 0.2207 0.0000 0.0011*  0.9568 0.0000 0.0027   0.8021 0.0000 0.0026
   TOTAL CL= 0.876 CD=0.01364   CL= 0.876 CD=0.01523  CL= 0.875 CD=0.01552
         CM=-0.0535             CM=-0.0535             CM=-0.0533
 8.00    S TURB  S SEP   CD      S TURB  S SEP   CD      S TURB  S SEP   CD
   UPPER 1.0253 0.1180 0.0140*  1.0253 0.1180 0.0140*  1.0333 0.1189 0.0143*
   LOWER 0.2171 0.0000 0.0011*  0.9568 0.0000 0.0026   0.7812 0.0000 0.0025
   TOTAL CL= 0.968 CD=0.01509   CL= 0.968 CD=0.01656  CL= 0.967 CD=0.01672
         CM=-0.0542             CM=-0.0542             CM=-0.0541
 9.00    S TURB  S SEP   CD      S TURB  S SEP   CD      S TURB  S SEP   CD
   UPPER 1.0331 0.1300 0.0157*  1.0331 0.1300 0.0157*  1.0335 0.1301 0.0158*
   LOWER 0.2135 0.0000 0.0010*  0.9541 0.0000 0.0024   0.7468 0.0000 0.0023
   TOTAL CL= 1.057 CD=0.01677   CL= 1.057 CD=0.01813  CL= 1.057 CD=0.01804
         CM=-0.0546             CM=-0.0546             CM=-0.0546
10.00    S TURB  S SEP   CD      S TURB  S SEP   CD      S TURB  S SEP   CD
   UPPER 1.0333 0.1433 0.0174*  1.0333 0.1433 0.0174*  1.0336 0.1434 0.0174*
   LOWER 0.2097 0.0000 0.0010*  0.9541 0.0000 0.0022   0.7232 0.0000 0.0021
   TOTAL CL= 1.143 CD=0.01838   CL= 1.143 CD=0.01964  CL= 1.143 CD=0.01956
         CM=-0.0546             CM=-0.0546             CM=-0.0546
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B.L.SUMMARY AIRFOIL S828  16%  ALPHA0=  2.027 DEG.
 *-WARNING WITH VARIABLE LIMIT  ALPHA REL. CHORD LINE

ALPHA(DEG.) R= 2500000 MU=3.0      R= 2500000 MU=1.3      R= 2500000 MU=9.0
-3.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.3699 0.0002 0.0023*  1.0030 0.0378 0.0053  0.9080 0.0370 0.0052
   LOWER 0.2786 0.0078 0.0019   0.9568 0.0406 0.0056  1.0082 0.0413 0.0059
   TOTAL CL=-0.103 CD=0.00416   CL=-0.106 CD=0.01088  CL=-0.105 CD=0.01106
         CM=-0.0397             CM=-0.0390             CM=-0.0392
-2.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.3731 0.0065 0.0024*  1.0030 0.0434 0.0057  0.9262 0.0427 0.0056
   LOWER 0.2686 0.0002 0.0017   0.9568 0.0351 0.0052  0.9937 0.0355 0.0053
   TOTAL CL=-0.001 CD=0.00414   CL=-0.006 CD=0.01090  CL=-0.005 CD=0.01094
         CM=-0.0416             CM=-0.0406             CM=-0.0407
-1.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.3769 0.0106 0.0025*  1.0029 0.0490 0.0062  0.9433 0.0484 0.0061
   LOWER 0.2609 0.0000 0.0016   0.9568 0.0296 0.0048  0.9806 0.0298 0.0049
   TOTAL CL= 0.106 CD=0.00414   CL= 0.094 CD=0.01098  CL= 0.094 CD=0.01094
         CM=-0.0447             CM=-0.0421             CM=-0.0422
 0.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.3808 0.0145 0.0027   1.0030 0.0547 0.0067  0.9601 0.0542 0.0066
   LOWER 0.2545 0.0000 0.0015   0.9568 0.0238 0.0044  0.9664 0.0239 0.0045
   TOTAL CL= 0.213 CD=0.00422   CL= 0.193 CD=0.01114  CL= 0.194 CD=0.01106
         CM=-0.0478             CM=-0.0437             CM=-0.0438
 1.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.3849 0.0192 0.0028   1.0030 0.0607 0.0073  0.9749 0.0603 0.0072
   LOWER 0.2489 0.0000 0.0015   0.9568 0.0178 0.0041  0.9494 0.0177 0.0041
   TOTAL CL= 0.318 CD=0.00431   CL= 0.292 CD=0.01138  CL= 0.293 CD=0.01127
         CM=-0.0507             CM=-0.0452             CM=-0.0453
 2.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.3890 0.0235 0.0030   1.0030 0.0667 0.0079  0.9885 0.0665 0.0078
   LOWER 0.2438 0.0000 0.0014*  0.9568 0.0114 0.0038  0.9309 0.0112 0.0037
   TOTAL CL= 0.424 CD=0.00441   CL= 0.392 CD=0.01168  CL= 0.392 CD=0.01158
         CM=-0.0535             CM=-0.0468             CM=-0.0468
 3.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.3936 0.0280 0.0032   1.0030 0.0729 0.0086  1.0022 0.0729 0.0086
   LOWER 0.2393 0.0000 0.0013*  0.9568 0.0040 0.0035  0.9123 0.0036 0.0034
   TOTAL CL= 0.529 CD=0.00452   CL= 0.490 CD=0.01206  CL= 0.490 CD=0.01200
         CM=-0.0563             CM=-0.0483             CM=-0.0482
 4.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.3987 0.0329 0.0034   1.0030 0.0793 0.0093  1.0135 0.0796 0.0094
   LOWER 0.2352 0.0000 0.0013*  0.9568 0.0000 0.0032  0.8918 0.0000 0.0031
   TOTAL CL= 0.633 CD=0.00466   CL= 0.590 CD=0.01249  CL= 0.589 CD=0.01250
         CM=-0.0589             CM=-0.0499             CM=-0.0499
 5.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.4049 0.0383 0.0036   1.0030 0.0862 0.0101  1.0216 0.0867 0.0103
   LOWER 0.2313 0.0000 0.0012*  0.9568 0.0000 0.0030  0.8729 0.0000 0.0029
   TOTAL CL= 0.735 CD=0.00483   CL= 0.689 CD=0.01307  CL= 0.688 CD=0.01320
         CM=-0.0613             CM=-0.0517             CM=-0.0516
 6.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.4131 0.0441 0.0039   1.0030 0.0936 0.0109  1.0272 0.0947 0.0113
   LOWER 0.2276 0.0000 0.0011   0.9568 0.0000 0.0028  0.8489 0.0000 0.0028
   TOTAL CL= 0.837 CD=0.00504   CL= 0.786 CD=0.01375  CL= 0.785 CD=0.01404
         CM=-0.0635             CM=-0.0533             CM=-0.0531
 7.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 1.0127 0.1023 0.0120   1.0127 0.1023 0.0120  1.0320 0.1036 0.0125
   LOWER 0.2240 0.0000 0.0011   0.9568 0.0000 0.0027  0.8254 0.0000 0.0026
   TOTAL CL= 0.882 CD=0.01312   CL= 0.882 CD=0.01469  CL= 0.880 CD=0.01504
         CM=-0.0545             CM=-0.0545             CM=-0.0542
 8.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 1.0253 0.1125 0.0135*  1.0253 0.1125 0.0135*  1.0334 0.1134 0.0138
   LOWER 0.2204 0.0000 0.0010   0.9568 0.0000 0.0025  0.8031 0.0000 0.0024
   TOTAL CL= 0.974 CD=0.01451   CL= 0.974 CD=0.01597  CL= 0.973 CD=0.01616
         CM=-0.0553             CM=-0.0553             CM=-0.0551
 9.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 1.0331 0.1241 0.0152*  1.0331 0.1241 0.0152*  1.0336 0.1242 0.0152*
   LOWER 0.2168 0.0000 0.0010   0.9541 0.0000 0.0023  0.7751 0.0000 0.0022
   TOTAL CL= 1.064 CD=0.01615   CL= 1.064 CD=0.01750  CL= 1.064 CD=0.01744
         CM=-0.0557             CM=-0.0557             CM=-0.0557
10.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 1.0333 0.1369 0.0168*  1.0333 0.1369 0.0168*  1.0337 0.1370 0.0168*
   LOWER 0.2131 0.0000 0.0009   0.9541 0.0000 0.0022  0.7551 0.0000 0.0021
   TOTAL CL= 1.151 CD=0.01770   CL= 1.151 CD=0.01895  CL= 1.151 CD=0.01890
         CM=-0.0558             CM=-0.0558             CM=-0.0558
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B.L.SUMMARY AIRFOIL S828  16%  ALPHA0=  2.027 DEG.
 *-WARNING WITH VARIABLE LIMIT  ALPHA REL. CHORD LINE

ALPHA(DEG.) R= 3000000 MU=3.0      R= 3000000 MU=1.3      R= 3000000 MU=9.0
-3.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.3726 0.0000 0.0022*  1.0030 0.0353 0.0051  0.9198 0.0347 0.0050
   LOWER 0.2847 0.0006 0.0018   0.9568 0.0372 0.0054  1.0090 0.0380 0.0057
   TOTAL CL=-0.107 CD=0.00398   CL=-0.106 CD=0.01056  CL=-0.106 CD=0.01077
         CM=-0.0388             CM=-0.0389             CM=-0.0391
-2.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.3762 0.0025 0.0023*  1.0030 0.0409 0.0056  0.9360 0.0403 0.0055
   LOWER 0.2735 0.0000 0.0016   0.9568 0.0317 0.0050  0.9964 0.0322 0.0052
   TOTAL CL= 0.001 CD=0.00396   CL=-0.006 CD=0.01058  CL=-0.006 CD=0.01065
         CM=-0.0422             CM=-0.0405             CM=-0.0406
-1.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.3801 0.0076 0.0024   1.0029 0.0463 0.0060  0.9519 0.0459 0.0059
   LOWER 0.2652 0.0000 0.0016   0.9568 0.0261 0.0046  0.9843 0.0264 0.0047
   TOTAL CL= 0.108 CD=0.00401   CL= 0.094 CD=0.01067  CL= 0.094 CD=0.01066
         CM=-0.0452             CM=-0.0421             CM=-0.0422
 0.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.3840 0.0115 0.0026   1.0030 0.0519 0.0065  0.9674 0.0516 0.0064
   LOWER 0.2585 0.0000 0.0015   0.9568 0.0202 0.0043  0.9716 0.0203 0.0043
   TOTAL CL= 0.215 CD=0.00407   CL= 0.194 CD=0.01082  CL= 0.194 CD=0.01078
         CM=-0.0483             CM=-0.0438             CM=-0.0438
 1.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.3881 0.0159 0.0027   1.0030 0.0578 0.0071  0.9808 0.0575 0.0070
   LOWER 0.2526 0.0000 0.0014   0.9568 0.0141 0.0040  0.9562 0.0141 0.0040
   TOTAL CL= 0.321 CD=0.00415   CL= 0.294 CD=0.01105  CL= 0.294 CD=0.01098
         CM=-0.0512             CM=-0.0454             CM=-0.0454
 2.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.3923 0.0202 0.0029   1.0030 0.0638 0.0077  0.9934 0.0636 0.0076
   LOWER 0.2474 0.0000 0.0013   0.9568 0.0076 0.0037  0.9387 0.0074 0.0036
   TOTAL CL= 0.427 CD=0.00423   CL= 0.393 CD=0.01134  CL= 0.393 CD=0.01128
         CM=-0.0542             CM=-0.0470             CM=-0.0470
 3.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.3970 0.0245 0.0031   1.0030 0.0698 0.0083  1.0057 0.0699 0.0083
   LOWER 0.2426 0.0000 0.0013   0.9568 0.0000 0.0034  0.9222 0.0000 0.0034
   TOTAL CL= 0.532 CD=0.00434   CL= 0.492 CD=0.01170  CL= 0.492 CD=0.01167
         CM=-0.0570             CM=-0.0485             CM=-0.0485
 4.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.4023 0.0291 0.0033   1.0030 0.0761 0.0090  1.0155 0.0764 0.0091
   LOWER 0.2383 0.0000 0.0012   0.9568 0.0000 0.0031  0.9039 0.0000 0.0031
   TOTAL CL= 0.636 CD=0.00447   CL= 0.593 CD=0.01213  CL= 0.592 CD=0.01218
         CM=-0.0597             CM=-0.0505             CM=-0.0505
 5.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.4089 0.0343 0.0035   1.0030 0.0827 0.0098  1.0233 0.0833 0.0100
   LOWER 0.2343 0.0000 0.0011   0.9568 0.0000 0.0030  0.8847 0.0000 0.0029
   TOTAL CL= 0.739 CD=0.00463   CL= 0.692 CD=0.01272  CL= 0.691 CD=0.01288
         CM=-0.0621             CM=-0.0524             CM=-0.0522
 6.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 0.4186 0.0401 0.0038   1.0030 0.0897 0.0106  1.0283 0.0909 0.0110
   LOWER 0.2305 0.0000 0.0011   0.9568 0.0000 0.0028  0.8638 0.0000 0.0027
   TOTAL CL= 0.841 CD=0.00485   CL= 0.790 CD=0.01336  CL= 0.789 CD=0.01368
         CM=-0.0644             CM=-0.0540             CM=-0.0538
 7.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 1.0127 0.0981 0.0117   1.0127 0.0981 0.0117  1.0325 0.0995 0.0121
   LOWER 0.2269 0.0000 0.0010   0.9568 0.0000 0.0026  0.8419 0.0000 0.0025
   TOTAL CL= 0.886 CD=0.01271   CL= 0.886 CD=0.01427  CL= 0.885 CD=0.01464
         CM=-0.0553             CM=-0.0553             CM=-0.0550
 8.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 1.0253 0.1080 0.0131*  1.0253 0.1080 0.0131*  1.0335 0.1089 0.0134
   LOWER 0.2232 0.0000 0.0010   0.9568 0.0000 0.0024  0.8206 0.0000 0.0024
   TOTAL CL= 0.979 CD=0.01406   CL= 0.979 CD=0.01551  CL= 0.978 CD=0.01573
         CM=-0.0562             CM=-0.0562             CM=-0.0560
 9.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 1.0331 0.1194 0.0147*  1.0331 0.1194 0.0147*  1.0336 0.1195 0.0148*
   LOWER 0.2196 0.0000 0.0009   0.9541 0.0000 0.0023  0.7985 0.0000 0.0022
   TOTAL CL= 1.070 CD=0.01566   CL= 1.070 CD=0.01700  CL= 1.070 CD=0.01696
         CM=-0.0566             CM=-0.0566             CM=-0.0566
10.00     S TURB  S SEP   CD     S TURB  S SEP   CD     S TURB  S SEP   CD
   UPPER 1.0333 0.1317 0.0163*  1.0333 0.1317 0.0163*  1.0337 0.1319 0.0163*
   LOWER 0.2159 0.0000 0.0009   0.9541 0.0000 0.0021  0.7749 0.0000 0.0021
   TOTAL CL= 1.158 CD=0.01717   CL= 1.158 CD=0.01840  CL= 1.158 CD=0.01837
         CM=-0.0568             CM=-0.0568             CM=-0.0568
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B.L.SUMMARY AIRFOIL S828 16% ALPHA0= 2.027 DEG.
*-WARNING WITH VARIABLE LIMIT ALPHA REL. CHORD LINE

ALPHA(DEG.)	R= 3500000 MU=3.0	R= 3500000 MU=1.3	R= 3500000 MU=9.0
-3.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3753 0.0000 0.0021	1.0030 0.0332 0.0050	0.9291 0.0327 0.0049
LOWER	0.2912 0.0000 0.0017	0.9568 0.0344 0.0053	1.0099 0.0351 0.0056
TOTAL	CL=-0.107 CD=0.00384	CL=-0.107 CD=0.01029	CL=-0.106 CD=0.01053
	CM=-0.0387	CM=-0.0388	CM=-0.0390
-2.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3791 0.0000 0.0022	1.0030 0.0387 0.0054	0.9433 0.0382 0.0053
LOWER	0.2780 0.0000 0.0016	0.9568 0.0288 0.0049	0.9987 0.0293 0.0051
TOTAL	CL= 0.003 CD=0.00385	CL=-0.006 CD=0.01032	CL=-0.006 CD=0.01042
	CM=-0.0425	CM=-0.0405	CM=-0.0406
-1.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3829 0.0051 0.0024	1.0029 0.0441 0.0059	0.9587 0.0437 0.0058
LOWER	0.2692 0.0000 0.0015	0.9568 0.0231 0.0045	0.9873 0.0234 0.0046
TOTAL	CL= 0.110 CD=0.00389	CL= 0.094 CD=0.01041	CL= 0.094 CD=0.01043
	CM=-0.0456	CM=-0.0421	CM=-0.0422
0.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3868 0.0092 0.0025	1.0030 0.0497 0.0064	0.9729 0.0493 0.0063
LOWER	0.2621 0.0000 0.0015	0.9568 0.0172 0.0042	0.9754 0.0173 0.0042
TOTAL	CL= 0.216 CD=0.00394	CL= 0.194 CD=0.01056	CL= 0.195 CD=0.01054
	CM=-0.0487	CM=-0.0438	CM=-0.0439
1.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3909 0.0135 0.0026	1.0030 0.0554 0.0069	0.9848 0.0551 0.0068
LOWER	0.2560 0.0000 0.0014	0.9568 0.0110 0.0039	0.9611 0.0110 0.0039
TOTAL	CL= 0.323 CD=0.00402	CL= 0.294 CD=0.01078	CL= 0.295 CD=0.01073
	CM=-0.0517	CM=-0.0455	CM=-0.0455
2.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3952 0.0176 0.0028	1.0030 0.0613 0.0075	0.9973 0.0612 0.0075
LOWER	0.2506 0.0000 0.0013	0.9568 0.0040 0.0036	0.9453 0.0039 0.0036
TOTAL	CL= 0.429 CD=0.00410	CL= 0.394 CD=0.01107	CL= 0.394 CD=0.01103
	CM=-0.0547	CM=-0.0471	CM=-0.0471
3.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.4000 0.0219 0.0030	1.0030 0.0672 0.0081	1.0083 0.0673 0.0081
LOWER	0.2456 0.0000 0.0012	0.9568 0.0000 0.0033	0.9293 0.0000 0.0033
TOTAL	CL= 0.534 CD=0.00420	CL= 0.495 CD=0.01140	CL= 0.494 CD=0.01140
	CM=-0.0575	CM=-0.0490	CM=-0.0489
4.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.4056 0.0264 0.0031	1.0030 0.0734 0.0088	1.0166 0.0737 0.0089
LOWER	0.2411 0.0000 0.0012	0.9568 0.0000 0.0031	0.9124 0.0000 0.0030
TOTAL	CL= 0.639 CD=0.00432	CL= 0.595 CD=0.01186	CL= 0.595 CD=0.01193
	CM=-0.0603	CM=-0.0510	CM=-0.0509
5.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.4128 0.0314 0.0034	1.0030 0.0798 0.0095	1.0245 0.0805 0.0097
LOWER	0.2370 0.0000 0.0011	0.9568 0.0000 0.0029	0.8945 0.0000 0.0029
TOTAL	CL= 0.742 CD=0.00448	CL= 0.695 CD=0.01242	CL= 0.694 CD=0.01260
	CM=-0.0628	CM=-0.0529	CM=-0.0528
6.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.7884 0.0757 0.0077	1.0030 0.0866 0.0103	1.0292 0.0878 0.0107
LOWER	0.2331 0.0000 0.0011	0.9568 0.0000 0.0027	0.8754 0.0000 0.0027
TOTAL	CL= 0.805 CD=0.00875	CL= 0.793 CD=0.01304	CL= 0.792 CD=0.01338
	CM=-0.0567	CM=-0.0546	CM=-0.0544
7.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	1.0127 0.0947 0.0114	1.0127 0.0947 0.0114	1.0331 0.0961 0.0118
LOWER	0.2294 0.0000 0.0010	0.9568 0.0000 0.0026	0.8552 0.0000 0.0025
TOTAL	CL= 0.890 CD=0.01237	CL= 0.890 CD=0.01392	CL= 0.888 CD=0.01432
	CM=-0.0560	CM=-0.0560	CM=-0.0557
8.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	1.0253 0.1043 0.0127*	1.0253 0.1043 0.0127*	1.0335 0.1052 0.0130
LOWER	0.2258 0.0000 0.0010	0.9568 0.0000 0.0024	0.8357 0.0000 0.0023
TOTAL	CL= 0.984 CD=0.01370	CL= 0.984 CD=0.01513	CL= 0.983 CD=0.01536
	CM=-0.0569	CM=-0.0569	CM=-0.0567
9.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	1.0331 0.1155 0.0144*	1.0331 0.1155 0.0144*	1.0337 0.1156 0.0144*
LOWER	0.2221 0.0000 0.0009	0.9541 0.0000 0.0022	0.8139 0.0000 0.0022
TOTAL	CL= 1.075 CD=0.01526	CL= 1.075 CD=0.01658	CL= 1.074 CD=0.01656
	CM=-0.0574	CM=-0.0574	CM=-0.0574
10.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	1.0333 0.1274 0.0159*	1.0333 0.1274 0.0159*	1.0338 0.1276 0.0159*
LOWER	0.2185 0.0000 0.0009	0.9541 0.0000 0.0021	0.7928 0.0000 0.0020
TOTAL	CL= 1.163 CD=0.01673	CL= 1.163 CD=0.01795	CL= 1.163 CD=0.01793
	CM=-0.0577	CM=-0.0577	CM=-0.0576

B.L.SUMMARY AIRFOIL S828 16% ALPHA0= 2.027 DEG.
*-WARNING WITH VARIABLE LIMIT ALPHA REL. CHORD LINE

ALPHA(DEG.)	R= 4000000 MU=3.0	R= 4000000 MU=1.3	R= 4000000 MU=9.0
-3.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3778 0.0000 0.0021	1.0030 0.0314 0.0049	0.9359 0.0309 0.0048
LOWER	0.3007 0.0000 0.0017	0.9568 0.0318 0.0052	1.0104 0.0326 0.0055
TOTAL	CL=-0.107 CD=0.00379	CL=-0.107 CD=0.01007	CL=-0.106 CD=0.01032
	CM=-0.0387	CM=-0.0387	CM=-0.0389
-2.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3816 0.0000 0.0022	1.0030 0.0368 0.0053	0.9502 0.0364 0.0052
LOWER	0.2826 0.0000 0.0016	0.9568 0.0262 0.0048	1.0003 0.0267 0.0050
TOTAL	CL= 0.003 CD=0.00376	CL=-0.006 CD=0.01010	CL=-0.006 CD=0.01022
	CM=-0.0425	CM=-0.0404	CM=-0.0405
-1.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3855 0.0023 0.0023	1.0029 0.0422 0.0058	0.9638 0.0419 0.0057
LOWER	0.2729 0.0000 0.0015	0.9568 0.0205 0.0044	0.9896 0.0207 0.0045
TOTAL	CL= 0.111 CD=0.00380	CL= 0.094 CD=0.01019	CL= 0.095 CD=0.01023
	CM=-0.0460	CM=-0.0421	CM=-0.0422
0.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3894 0.0072 0.0024	1.0030 0.0477 0.0062	0.9773 0.0474 0.0062
LOWER	0.2654 0.0000 0.0014	0.9568 0.0145 0.0041	0.9775 0.0147 0.0042
TOTAL	CL= 0.218 CD=0.00384	CL= 0.195 CD=0.01034	CL= 0.195 CD=0.01033
	CM=-0.0490	CM=-0.0439	CM=-0.0439
1.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3935 0.0115 0.0026	1.0030 0.0532 0.0068	0.9882 0.0531 0.0067
LOWER	0.2592 0.0000 0.0013	0.9568 0.0082 0.0038	0.9647 0.0083 0.0038
TOTAL	CL= 0.324 CD=0.00391	CL= 0.295 CD=0.01055	CL= 0.295 CD=0.01052
	CM=-0.0520	CM=-0.0456	CM=-0.0456
2.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.3978 0.0155 0.0027	1.0030 0.0591 0.0073	1.0005 0.0590 0.0073
LOWER	0.2536 0.0000 0.0013	0.9568 0.0003 0.0035	0.9509 0.0002 0.0035
TOTAL	CL= 0.430 CD=0.00399	CL= 0.395 CD=0.01084	CL= 0.395 CD=0.01082
	CM=-0.0551	CM=-0.0472	CM=-0.0472
3.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.4028 0.0198 0.0029	1.0030 0.0650 0.0079	1.0105 0.0651 0.0080
LOWER	0.2485 0.0000 0.0012	0.9568 0.0000 0.0032	0.9349 0.0000 0.0032
TOTAL	CL= 0.536 CD=0.00409	CL= 0.497 CD=0.01115	CL= 0.496 CD=0.01116
	CM=-0.0580	CM=-0.0494	CM=-0.0493
4.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.4087 0.0242 0.0031	1.0030 0.0710 0.0086	1.0176 0.0714 0.0087
LOWER	0.2438 0.0000 0.0011	0.9568 0.0000 0.0030	0.9196 0.0000 0.0030
TOTAL	CL= 0.641 CD=0.00421	CL= 0.597 CD=0.01163	CL= 0.597 CD=0.01171
	CM=-0.0607	CM=-0.0514	CM=-0.0514
5.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.4167 0.0292 0.0033	1.0030 0.0773 0.0093	1.0255 0.0780 0.0095
LOWER	0.2395 0.0000 0.0011	0.9568 0.0000 0.0029	0.9026 0.0000 0.0028
TOTAL	CL= 0.744 CD=0.00437	CL= 0.697 CD=0.01217	CL= 0.697 CD=0.01237
	CM=-0.0633	CM=-0.0534	CM=-0.0532
6.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	0.8637 0.0775 0.0083	1.0030 0.0839 0.0101	1.0300 0.0852 0.0105
LOWER	0.2355 0.0000 0.0010	0.9568 0.0000 0.0027	0.8843 0.0000 0.0026
TOTAL	CL= 0.803 CD=0.00937	CL= 0.796 CD=0.01277	CL= 0.795 CD=0.01313
	CM=-0.0564	CM=-0.0551	CM=-0.0549
7.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	1.0127 0.0917 0.0111	1.0127 0.0917 0.0111	1.0332 0.0931 0.0116
LOWER	0.2317 0.0000 0.0010	0.9568 0.0000 0.0025	0.8654 0.0000 0.0025
TOTAL	CL= 0.893 CD=0.01209	CL= 0.893 CD=0.01363	CL= 0.892 CD=0.01404
	CM=-0.0565	CM=-0.0565	CM=-0.0563
8.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	1.0253 0.1011 0.0125*	1.0253 0.1011 0.0125*	1.0336 0.1021 0.0128
LOWER	0.2280 0.0000 0.0009	0.9568 0.0000 0.0024	0.8465 0.0000 0.0023
TOTAL	CL= 0.987 CD=0.01339	CL= 0.987 CD=0.01481	CL= 0.986 CD=0.01506
	CM=-0.0575	CM=-0.0575	CM=-0.0573
9.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	1.0331 0.1121 0.0140*	1.0331 0.1121 0.0140*	1.0337 0.1122 0.0141*
LOWER	0.2244 0.0000 0.0009	0.9541 0.0000 0.0022	0.8265 0.0000 0.0021
TOTAL	CL= 1.079 CD=0.01493	CL= 1.079 CD=0.01624	CL= 1.078 CD=0.01623
	CM=-0.0581	CM=-0.0581	CM=-0.0581
10.00	S TURB S SEP CD	S TURB S SEP CD	S TURB S SEP CD
UPPER	1.0333 0.1237 0.0155*	1.0333 0.1237 0.0155*	1.0338 0.1239 0.0156*
LOWER	0.2208 0.0000 0.0008	0.9541 0.0000 0.0020	0.8058 0.0000 0.0020
TOTAL	CL= 1.168 CD=0.01636	CL= 1.168 CD=0.01756	CL= 1.168 CD=0.01756
	CM=-0.0584	CM=-0.0584	CM=-0.0584

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14. ABSTRACT *(Maximum 200 Words)*

A family of thick, natural-laminar-flow airfoils, the S827 and S828, for 40- to 50-meter, stall -regulated, horizontal-axis wind turbines has been designed and analyzed theoretically. The two primary objectives of restrained maximum lift, insensitive to roughness, and low profile drag have been achieved. The constraints on the pitching moments and the airfoil thicknesses have been satisfied. The airfoils should exhibit docile stalls.

15. SUBJECT TERMS
airfoils; wind turbine; airfoil design; Pennsylvania State University; wind energy

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