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Aerodynamic Characteristics of Seven Symmetrical Airfoil Sections Through 180-Degree Angle of Attack for Use in Aerodynamic Analysis of Vertical Axis Wind Turbines

Robert E. Sheldahl, Paul C. Klimas

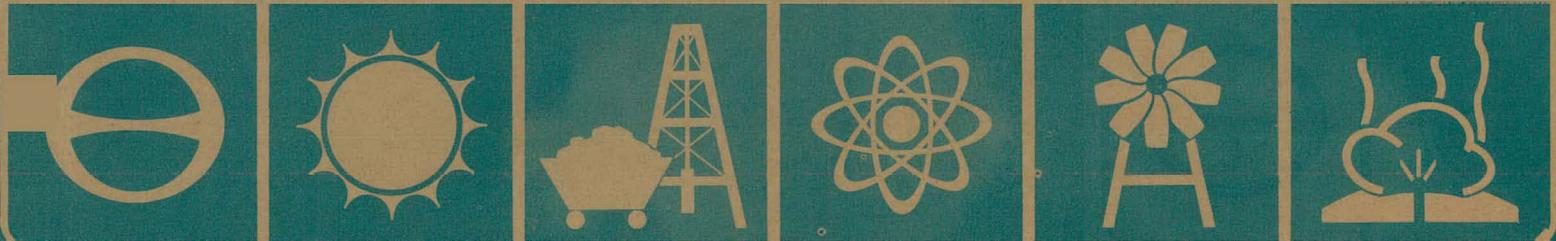
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Robert E. Sheldahl
Aerothermodynamics Division 5633
and
Paul C. Klimas
Advanced Energy Projects Division 4715
Sandia National Laboratories
Albuquerque, NM 87185

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ABSTRACT

When work began on the Darrieus vertical axis wind turbine (VAWT) program at Sandia National Laboratories, it was recognized that there was a paucity of symmetrical airfoil data needed to describe the aerodynamics of turbine blades. Curved-bladed Darrieus turbines operate at local Reynolds numbers (Re) and angles of attack (α) seldom encountered in aeronautical applications. This report describes (1) a wind tunnel test series conducted at moderate values of Re in which $0 \leq \alpha \leq 180^\circ$ force and moment data were obtained for four symmetrical blade candidate airfoil sections (NACA-0009, -0012, -0012H, and -0015), and (?) how an airfoil property synthesizer code can be used to extend the measured properties to arbitrary values of Re ($10^4 \leq Re \leq 10^7$) and to certain other section profiles (NACA-0018, -0021, -0025).

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B. F. Blackwell, Sandia National Laboratories Organization, 1537, was involved with the Sandia wind energy program when the experimental data for this report were obtained; his contributions to the program are gratefully acknowledged. The efforts of Professor M. H. Snyder and the personnel of the Walter H. Beech Memorial Low-Speed Wind Tunnel at Wichita State University, Wichita, Kansas, in obtaining the experimental airfoil section data and R. E. French, Sandia Organization, 5636, in producing the computed airfoil data are greatly appreciated.

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SYMBOLS

- A_s Turbine swept area
 c Airfoil chord length
 c_a Section axial force coefficient, axial force per unit span/ $q_\infty c$
 c_d Section drag coefficient, section drag per unit span/ $q_\infty c$
 c_l Section lift coefficient, section lift per unit span/ $q_\infty c$
 c_m Section moment coefficient, section moment at $c/4$ per unit span/ $q_\infty c^2$
 C_p Power coefficient, $\frac{Q\omega}{\frac{1}{2}\rho_\infty V_\infty^3 A_s}$
 Q Turbine Aerodynamic torque
 q_∞ Dynamic pressure, $\frac{1}{2}\rho_\infty V_\infty^2$
 R Rotor radius
 Re Reynolds numbers, $\frac{\rho_\infty U c}{\mu_\infty}$
 U Relative velocity
 V_∞ Free stream wind velocity
 X Tip speed ratio, $\frac{R\omega}{V_\infty}$
 α Angle of attack
 θ Angle of rotation about the turbine vertical axis
 μ_∞ Free stream viscosity
 ρ_∞ Free stream density
 ω Turbine angular velocity

Aerodynamic Characteristics of Seven Symmetrical Airfoil Sections Through 180-Degree Angle of Attack for Use in Aerodynamic Analysis of Vertical Axis Wind Turbines

Introduction

When analytical work began on the vertical axis wind turbine, it immediately became apparent that available data for symmetrical airfoil sections was limited. The section data requirements for application to vertical axis wind turbines are broader in scope than are those the aircraft industry usually concerns itself with. Figure 1 shows the range of angle of attack the airfoil at the equatorial plane of a Darrieus turbine is exposed to for various tip speed ratios. At low tip speed ratios, it is possible to be at an angle of attack approaching 180 deg. In operation, with a tip speed ratio in excess of 2.0, the angle of attack can exceed 25 deg. Portions of the airfoil closer to the axis of rotation will see even greater angles of attack. This figure shows only one-half of the revolution; the second half will be similar except the angles of attack will be negative. Thus the airfoil is subjected to a continually changing angle of attack cycling from positive to negative back to positive as it revolves about the vertical axis. This particular figure is for the 17-m turbine but results are similar for turbines of all sizes. The requirements here call for section data for angles of attack to 180 deg and data for both increasing and decreasing angle of attack showing airfoil hysteresis.

The turbine blade changes its angle of attack as it makes its orbit about the rotational axis. The local Reynolds number changes also. In Figure 2, the Reynolds number is shown as a function of the rotation angle for several tip speed ratios. Again, this is for the 17-m system at a fixed rotational speed of 46 rpm (4.82 rad/sec) and a blade chord of approximately 0.5 m. When the turbine operates with a tip speed ratio in excess of 2.0, the Reynolds number range is from 0.5×10^6 to 2×10^6 . Scaled down turbines will also have lower Reynolds numbers proportional to chord length. A Sandia 2-m wind tunnel model operated over a range of Reynolds numbers from 0.1×10^6

to 0.3×10^6 in a recent wind tunnel test. The requirements here call for section data over a wide Reynolds number range. Data for the low Reynolds numbers (less than 0.5×10^6) are needed to compare the solutions from computer models with the data from wind tunnel model tests.

These requirements are generally out of the range of most published airfoil section data. Examples of published data for symmetrical airfoil sections are presented in Refs 1 and 2. The NACA-0012 is one of the more popular symmetrical airfoils because of its favorable lift to drag ratio, so there are more data available for that airfoil.

Sandia National Laboratories contracted with Wichita State University to construct four different symmetrical airfoil sections and to test the models at angles of attack to 180 deg for three different Reynolds numbers. We selected the lowest Reynolds number obtainable that would still be within the operational range of its facility and balance system. The purpose of these tests was to obtain needed section data for the NACA-0009, -0012, and -0015 airfoils over the angle of attack range of interest at as low a Reynolds number as possible. Also, a nonstandard airfoil, a modified-0012 designated NACA-0012H, was tested.

Airfoil Section Models

Four symmetrical airfoil models were constructed of aluminum; a fifth model was constructed of wood to standard wind tunnel model tolerances by Wichita State University. All the aluminum models had 6-in. (15.24-cm) chords with a 3-ft (0.91-m) span. Three of these models (NACA-009, -0012, and -0015) had standard airfoil cross sections; geometries for these airfoils are found in Ref 3. The fourth model was a nonstandard airfoil. It was a modification of the

NACA-0012 provided by Raymond M. Hicks of NASA/Ames Research Center.⁴ The modification was designed with the aid of a computer program to increase the $c_{l_{max}}$ of a given airfoil by reducing the leading edge pressure spike associated with subsonic airfoils. The new airfoil has been designated NACA-0012H because its thickness to chord ratio was left unchanged at 12%. The geometry for this airfoil is presented in Table 1. The fifth airfoil model had a 15-in. chord (38.10-cm) with a 3-ft (0.91-m) span and also had an NACA-0012 cross section. This model was constructed to obtain airfoil data at higher Reynolds numbers and could not, because of its size, be tested at an angle of attack greater than 30 deg.

Test Facility

The airfoils were tested in the Walter H. Beech Memorial Wind Tunnel at Wichita State University.⁵ The Tunnel has a 7 x 10-ft (2.13 x 3.05 m) test section fitted with floor to ceiling two-dimensional inserts for testing two-dimensional airfoil sections. These inserts in the center of the test section act as flow splitters to form a separate test section 3 ft (0.91 m) wide by 7 ft (2.13 m) tall. Part of the total airflow in the wind tunnel passes through the 3 x 7 ft section and part passes by each side. The 3 x 7 ft section is separately instrumented with pitot-static probes for determining flow conditions within that section. A wake survey probe was installed in the wind tunnel on a separate series of tests to obtain the airfoil section drag at low angles of attack for all airfoil models.

Test Description

The airfoil models were attached to the end plates in the walls of the two-dimensional inserts. These end plates are the attachments to the angle-of-attack control mechanism and the facility balance system. The aluminum models were tested at nominal Reynolds numbers of 0.35×10^6 , 0.50×10^6 and 0.70×10^6 through angles of attack of 180 deg. The angle-of-attack control mechanism has an approximate range of 60 deg; this required that the model be reoriented on the end plates three times to complete the full range of angles of attack to 180 deg. This allowed for some overlap of data near 40, 90, and 130 deg. The 15-in. chord model was tested at Reynolds numbers of 0.86×10^6 , 1.36×10^6 and 1.76×10^6 through angles of attack of -20 to +30 deg.

Data for each airfoil were first obtained over the range of -24 to +32 deg (increasing α) and then from +32 deg to -24 deg (decreasing α) for the three Reynolds numbers. The 15-in. chord model was limited to a range of -20 to +30 deg. This was done to

obtain the hysteresis loop in the region of airfoil stall. All full range data were obtained with increasing angles of attack to 180 deg. Lift, drag, and moment data were obtained from the balance system. All the data were corrected for wake and solid blockage, buoyancy, upwash, and wind-turbulence factor.⁶ The turbulence factors used to correct the Reynolds numbers to 0.35×10^6 , 0.50×10^6 , and 0.70×10^6 were 1.38, 1.29, and 1.13, respectively. All of the tests reported here were performed on aerodynamically smooth airfoils. A separate test of the NACA-0015 airfoil with transition strips was conducted; the strips were of No. 80 carborundum grit glued to a strip approximately 0.1-in. (0.25-cm) wide located approximately at 17% of chord station. The results with the strips were similar to the results without them and thus were inconclusive and are not presented here.

Experimental Results

The section coefficient of lift data for the four 6-in. chord airfoils and the 15-in. airfoil are shown in Figures 3 through 7 for the angles of attack from -24 to +24 degrees at nominal Reynolds numbers of 0.35×10^6 and 0.70×10^6 for the 6-in. chord airfoils and 0.86×10^6 and 1.76×10^6 for the wooden 15-in. chord airfoil. Each airfoil cross section is sketched in the figures. These figures include data obtained for both increasing and decreasing angle of attack; they demonstrate the extent of the lift coefficient hysteresis for each airfoil. The lift coefficient for the NACA-0009 airfoil shown in Figure 3 reaches a maximum of approximately 0.8 near 10-deg angle of attack. There is not a significant drop in lift past stall nor is there any significant hysteresis. Data for the NACA-0012 are shown in Figure 4; we see that $c_{l_{max}}$ has increased to 1.0 for positive angles and to -1.08 for negative angles with a hysteresis loop most pronounced for negative angles. The lift coefficient data for the wooden NACA-0012 airfoil at Reynolds numbers of 0.86×10^6 and 1.76×10^6 are shown in Figure 5; here, the anticipated improved $c_{l_{max}}$ at the larger Reynolds numbers can be seen.

The NACA-0012H lift data are presented in Figure 6 and show dramatic improvement in lift characteristics over the NACA-0012 for similar Reynolds numbers. The maximum lift coefficient approaches ± 1.2 at the higher Reynolds number condition. Note the larger size of the hysteresis in the lift data near positive and negative stall angles. The dashed line in the figure shows the curvature of the standard NACA-0012 airfoil. The lift data for the NACA-0015 (Figure 7) are similar to the NACA-0012H. The maximum lift coefficient for the -0015 is slightly less than

that for the -0012H, but stall is less abrupt and occurs at a slightly greater angle of attack. Figure 8 is a composite of the data for the four 6-in. chord airfoils and shows lift data at a Reynolds number of 0.7×10^6 . Data shown are for increasing angle of attack for positive angles and decreasing angle of attack for negative angles; this shows the increased performance of the NACA-0012H and the favorable performance of the NACA-0015.

Figures 9 through 12 show the full range section lift coefficient data for the four small airfoils. All data were taken with the angle of attack increasing. The data for all the airfoils beyond 25-deg angle of attack are similar. At an angle of 40 to 45 deg, the lift coefficient for a -0009 airfoil is greater than 1.1; with increasing airfoil thickness, the lift coefficient decreases to 1.05 but, generally speaking, the effect of the Reynolds number (in the range of 0.35×10^6 to 0.70×10^6) and the airfoil geometry have little effect on the lift coefficient in the angle of attack range of 25 to 180 deg.

The section drag coefficients for the airfoils are shown in Figures 13 through 17 over the angle-of-attack range of -16 to +16 deg. The minimum drag coefficient near zero lift is approximately 0.006 for the NACA-0009. The data for the drag coefficients were obtained by the balance system and were corrected by data obtained in the angle-of-attack range of positive to negative stall by a wake survey method.⁴ This corrected the force data for drag on the end plates. The full range section drag coefficients for the four small airfoil sections are shown in Figures 18 through 21. These data are similar for all angles greater than 20 deg. At 90 deg, the drag coefficient of approximately 1.8 is near Hoerner's value of 1.98 for a two-dimensional flat plate.⁷

For completeness, the airfoil section moment coefficients for the tested airfoils are included here. Shown in Figures 22 through 26 are the section quarter chord moment coefficients of each airfoil for the angle-of-attack range from -24 to +24 deg for both increasing and decreasing angles of attack. The effect of hysteresis on the moment coefficients in the region of aerodynamic stall can be clearly seen. The moment coefficients are very near zero at small angles of attack (before airfoil stall) as is anticipated for a symmetrical airfoil. In Figures 27 through 30 are the full range section moment coefficients about the quarter chord for the four airfoils with 6-in. chords at nominal Reynolds numbers of 0.36×10^6 , 0.50×10^6 and 0.70×10^6 . There is a great deal of scatter in the data for angles of attack greater than 45 deg and less than 135 deg. The full range moment coefficients are very similar for all four airfoils.

The component of force that makes a vertical axis wind turbine work is the chordwise or axial force. It is desirable to increase the area under the positive portion of the curve for both positive and negative angles of attack and to minimize the negative axial force coefficients near zero angle of attack. Figures 31 through 33 show the full range axial force coefficients for the NACA-0012, -0012H, and -0015 airfoil sections. The important thing to note is the larger area under the curve before airfoil stall for the -0012H and -0015 when compared to the -0012. This should provide better performance from a wind turbine, using either one of these, than the NACA-0012 airfoil. Note that the axial force coefficient is obtained by

$$c_a = c_l \sin \alpha - c_d \cos \alpha .$$

Data obtained in this manner beyond 20 deg become very scattered because the results are obtained by taking small differences of larger numbers.

Reynolds Number Extrapolation

Section data at Reynolds numbers not tested, especially lower values, are needed to perform VAWT aerodynamic analyses with accuracy. The need also arises to consider blades whose airfoil sections are not included among the four profiles examined in the wind tunnel entry described above. These requirements may be met by combining section property predictions from one of the currently available section synthesizer computer codes and those properties measured. Tables 2 through 6 list c_l and c_d vs α information for $0 \leq \alpha \leq 180^\circ$ at Reynolds numbers between 10^4 and 10^7 obtained by such a combination. Pre- and early stall section information was calculated, using the computer code PROFILE.⁸ Late and post-stall section characteristics were taken from the measurements detailed above. Figures 34 and 35 compare calculated and measured zero lift drag coefficients and maximum lift coefficient, respectively, for the NACA 0015 airfoil. Agreement was considered close enough to justify the use of PROFILE predictions over the linear and early nonlinear portions of the c_l - α curve. For other values of α , it was seen that behavior was sufficiently independent of the Reynolds number to use the Wichita State University data at all values of Re for which section information was sought. The precise angle of attack where the tables switched from calculated to measured performance coefficients was determined by trial and error. The criterion used was that the VAWT performance

as calculated by the conservation of momentum-based model DARTER⁹ using the hybrid airfoil characteristics most closely matched that obtained in field tests of the Sandia 17-m height-to-diameter ($H/D = 1$), two-bladed turbine with blades of NACA 0015 section. The final comparison, using Table 3 (0015) information, is shown in Figure 36 for a turbine angular velocity of 50.6 rpm. The same crossover point was then used in creating Tables 2, 4, 5, and 6 (0012, 0018, 0021, and 0025) data combinations. Note that the tabulations for the 18%, 21%, and 25% thick sections relied upon Reynolds number independence at high values of α .

Since Tables 2 through 4 were written, a next-generation class of aerodynamic loads/performance models has come into use at Sandia National Laboratories. These are vortex/lifting line models and are described in Ref 10. Figures 36 and 37 compare predicted and measured performance for the Sandia 17-m and 5-m turbines ($H/D = 1$). These comparisons would appear to further validate the hybridizing scheme used.

Conclusions

The aerodynamic section data for four different symmetrical airfoil cross sections (NACA-0009, -0012, -0012H, and -0015) were obtained for angles of attack up to 180 deg at nominal Reynolds numbers of 0.36×10^6 , 0.50×10^6 and 0.70×10^6 . In addition, experimental section coefficients were obtained for the NACA-0012 airfoil with a larger chord length at Reynolds numbers up to 1.76×10^6 . The data were obtained for

use with vertical axis wind turbines performance prediction computer codes. We extended the data to a wider Reynolds number range (from 10^4 to 10^7) and expanded to additional symmetrical airfoils (NACA-0018, -0021, and -0025) by the use of an airfoil section characteristics synthesizer computer code. These airfoil characteristics as used by the vertical axis wind turbine performance prediction codes appear to be adequately predicting VAWT performance.

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Table 1. Coordinates for the Modified NACA-0012 (NACA-0012II) Airfoil

x/c	$\pm y/c$	x/c	$\pm y/c$
0.0	0.0	0.275	0.06048
0.005	0.01438	0.299	0.06002
0.010	0.02074	0.349	0.05951
0.020	0.02925	0.399	0.05808
0.030	0.03522	0.449	0.05588
0.040	0.03982	0.500	0.05294
0.050	0.04351	0.550	0.04952
0.060	0.04655	0.600	0.04563
0.080	0.05121	0.650	0.04133
0.100	0.05454	0.700	0.03664
0.125	0.05740	0.750	0.03160
0.150	0.05924	0.800	0.02623
0.175	0.06033	0.850	0.02053
0.200	0.06087	0.900	0.01448
0.225	0.06100	0.950	0.00807
0.250	0.06084	1.000	0.00126

Table 2. Lift and Drag Coefficients for the NACA-0012 Airfoil ($10^4 \leq Re \leq 10^7$)

Re	α	C_L	C_d
10000.0 NACA 0012 SECTION DATA, EPPLER MODEL, CL, CD, DEC78			
0	0.0000	0.0000	.0337
0	1.0000	.0830	.0338
0	2.0000	.1534	.0343
0	3.0000	.2009	.0351
0	4.0000	.2003	.0359
0	5.0000	.0328	.0351
0	6.0000	-.1413	.0460
0	7.0000	-.1142	.0580
0	8.0000	-.0703	.0720
0	9.0000	-.0215	.0860
0	10.0000	.0311	.1010
0	11.0000	.0848	.1170
0	12.0000	.1387	.1340
0	13.0000	.1928	.1520
0	14.0000	.2468	.1710
0	15.0000	.3008	.1900
0	16.0000	.3548	.2100
0	17.0000	.4079	.2310
0	18.0000	.4606	.2520
0	19.0000	.5121	.2740
0	20.0000	.5838	.2970
0	21.0000	.6161	.3200
0	22.0000	.6687	.3440
0	23.0000	.7216	.3690
0	24.0000	.7744	.3940
0	25.0000	.8276	.4200
0	26.0000	.8810	.4460
0	27.0000	.9345	.4730
0	30.0000	.9150	.5700
0	35.0000	1.0200	.7450
0	40.0000	1.0750	.9200
0	45.0000	1.0850	1.0750
0	50.0000	1.0400	1.2150
0	55.0000	.9650	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7650	1.5750
0	70.0000	.6500	1.6650
0	75.0000	.5150	1.7350
0	80.0000	.3700	1.7800
0	85.0000	.2200	1.8000
0	90.0000	.0700	1.8000
0	95.0000	-.0700	1.7800
0	100.0000	-.2200	1.7500
0	105.0000	-.3700	1.7000
0	110.0000	-.5100	1.6350
0	115.0000	-.6250	1.5550
0	120.0000	-.7350	1.4650

Table 2. (cont)

0	125.0000	-.8400	1.3500
0	130.0000	-.9100	1.2250
0	135.0000	-.9450	1.0850
0	140.0000	-.9450	.9250
0	145.0000	-.9100	.7550
0	150.0000	-.8500	.5750
0	155.0000	-.7400	.4200
0	160.0000	-.6600	.3200
0	165.0000	-.6750	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6900	.0550
1	180.0000	0.0000	.0250
0	20000.0	NACA 0012 SECTION DATA, EPPLER MODEL, CL, CD, DEC78	
0	0.0000	0.0000	.0245
0	1.0000	.1057	.0247
0	2.0000	.2072	.0251
0	3.0000	.3032	.0259
0	4.0000	.3929	.0270
0	5.0000	.4781	.0282
0	6.0000	-.0298	.0460
0	7.0000	-.1089	.0580
0	8.0000	-.0699	.0720
0	9.0000	-.0198	.0860
0	10.0000	.0320	.1010
0	11.0000	.0856	.1170
0	12.0000	.1894	.1340
0	13.0000	.1934	.1520
0	14.0000	.2474	.1710
0	15.0000	.3014	.1910
0	16.0000	.3554	.2100
0	17.0000	-.4089	.2300
0	18.0000	.4620	.2520
0	19.0000	.5147	.2740
0	20.0000	.5663	.2970
0	21.0000	.6184	.3200
0	22.0000	.6709	.3440
0	23.0000	.7238	.3690
0	24.0000	.7765	.3940
0	25.0000	.8297	.4200
0	26.0000	.8831	.4460
0	27.0000	.9365	.4730
0	30.0000	.9150	.5700
0	35.0000	1.0200	.7450
0	40.0000	1.0750	.9200
0	45.0000	1.0850	1.0750
0	50.0000	1.0400	1.2150
0	55.0000	.9650	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7650	1.5750
0	70.0000	.6500	1.6650

Table 2. (cont)

0	75.0000	.5150	1.7350
0	80.0000	.3700	1.7800
0	85.0000	.2200	1.8000
0	90.0000	.0700	1.8000
0	95.0000	-.0700	1.7800
0	100.0000	-.2200	1.7500
0	105.0000	-.3700	1.7000
0	110.0000	-.5100	1.6350
0	115.0000	-.6250	1.5550
0	120.0000	-.7350	1.4650
0	125.0000	-.8400	1.3500
0	130.0000	-.9100	1.2250
0	135.0000	-.9450	1.0850
0	140.0000	-.9450	.9250
0	145.0000	-.9100	.7550
0	150.0000	-.8500	.5750
0	155.0000	-.7400	.4200
0	160.0000	-.6600	.3200
0	165.0000	-.5750	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6900	.0550
1	180.0000	0.0000	.0250
400000.0 NACA 0012 SECTION DATA, EPPLER MODEL, CL, CD, DEC78			
0	0.0000	0.0000	.0175
0	1.0000	.1100	.0177
0	2.0000	.2200	.0181
0	3.0000	.3376	.0189
0	4.0000	.4464	.0199
0	5.0000	.5276	.0218
0	6.0000	.6115	.0232
0	7.0000	-.0212	.0580
0	8.0000	-.0615	.0720
0	9.0000	-.0160	.0860
0	10.0000	.0344	.1010
0	11.0000	.0869	.1170
0	12.0000	.1406	.1340
0	13.0000	.1945	.1520
0	14.0000	.2484	.1710
0	15.0000	.3024	.1900
0	16.0000	.3563	.2100
0	17.0000	.4107	.2310
0	18.0000	.4644	.2520
0	19.0000	.5178	.2740
0	20.0000	.5708	.2970
0	21.0000	.6232	.3200
0	22.0000	.6755	.3440
0	23.0000	.7283	.3690
0	24.0000	.7809	.3940
0	25.0000	.8340	.4200
0	26.0000	.8873	.4460

Table 2. (cont)

0	27.0000	.9407	.4730
0	30.0000	.9150	.5700
0	35.0000	1.0200	.7450
0	40.0000	1.0750	.9200
0	45.0000	1.0850	1.0750
0	50.0000	1.0400	1.2150
0	55.0000	.9650	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7650	1.5750
0	70.0000	.6500	1.6650
0	75.0000	.5150	1.7350
0	80.0000	.3700	1.7800
0	85.0000	.2200	1.8000
0	90.0000	.0700	1.8000
0	95.0000	-.0700	1.7800
0	100.0000	-.2200	1.7500
0	105.0000	-.3700	1.7000
0	110.0000	-.5100	1.6350
0	115.0000	-.6250	1.5550
0	120.0000	-.7350	1.4650
0	125.0000	-.8400	1.3500
0	130.0000	-.9100	1.2250
0	135.0000	-.9450	1.0850
0	140.0000	-.9450	.9250
0	145.0000	-.9100	.7550
0	150.0000	-.0500	.5750
0	155.0000	-.7400	.4200
0	160.0000	-.6600	.3200
0	165.0000	-.6750	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6900	.0550
1	180.0000	0.0000	.0250
80000.0 NACA 0012 SECTION DATA, EPPLER MODEL, CL, CD, DEC78			
0	0.0000	0.0000	.0133
0	1.0000	.1100	.0134
0	2.0000	.2200	.0138
0	3.0000	.3300	.0145
0	4.0000	.4400	.0155
0	5.0000	.5500	.0170
0	6.0000	.6384	.0189
0	7.0000	.7227	.0204
0	8.0000	.6930	.0222
0	9.0000	-.0010	.0600
0	10.0000	.0413	.0600
0	11.0000	.0911	.1170
0	12.0000	.1430	.1340
0	13.0000	.1966	.1520
0	14.0000	.2504	.1710
0	15.0000	.3043	.1900
0	16.0000	.3582	.2100

Table 2. (cont)

0	17.0000	.4139	.2310
0	18.0000	.4689	.2520
0	19.0000	.5232	.2740
0	20.0000	.5770	.2970
0	21.0000	.6305	.3200
0	22.0000	.6839	.3440
0	23.0000	.7373	.3690
0	24.0000	.7902	.3940
0	25.0000	.8432	.4200
0	26.0000	.8963	.4460
0	27.0000	.9496	.4730
0	30.0000	.9150	.5700
0	35.0000	1.0200	.7450
0	40.0000	1.0750	.9200
0	45.0000	1.0850	1.0750
0	50.0000	1.0400	1.2150
0	55.0000	.9650	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7650	1.5750
0	70.0000	.6500	1.6650
0	75.0000	.5150	1.7350
0	80.0000	.3700	1.7800
0	85.0000	.2200	1.8000
0	90.0000	.0700	1.8000
0	95.0000	-.0700	1.7800
0	100.0000	-.2200	1.7500
0	105.0000	-.3700	1.7000
0	110.0000	-.5100	1.6350
0	115.0000	-.6250	1.5550
0	120.0000	-.7350	1.4650
0	125.0000	-.8400	1.3500
0	130.0000	-.9100	1.2250
0	135.0000	-.9450	1.0850
0	140.0000	-.9450	.9250
0	145.0000	-.9100	.7550
0	150.0000	-.8500	.5750
0	155.0000	-.7400	.4200
0	160.0000	-.6600	.3200
0	165.0000	-.6750	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6900	.0550
1	180.0000	0.0000	.0250
160000.0	NACA 0012 SECTION DATA, EPPLER MODEL, CL, CD, DEC78		
0	0.0000	0.0000	.0103
0	1.0000	.1100	.0104
0	2.0000	.2200	.0108
0	3.0000	.3300	.0114
0	4.0000	.4400	.0124
0	5.0000	.5500	.0140
0	6.0000	.6600	.0152

Table 2. (cont)

0	7.0000	.7460	.0170
0	8.0000	.8274	.0185
0	9.0000	.8527	.0203
0	10.0000	.1325	.0188
0	11.0000	.1095	.0760
0	12.0000	.1533	.1340
0	13.0000	.2030	.1520
0	14.0000	.2546	.1710
0	15.0000	.3082	.1900
0	16.0000	.3620	.2100
0	17.0000	.4200	.2310
0	18.0000	.4768	.2520
0	19.0000	.5322	.2740
0	20.0000	.5870	.2970
0	21.0000	.6414	.3200
0	22.0000	.6956	.3440
0	23.0000	.7497	.3690
0	24.0000	.8034	.3940
0	25.0000	.8572	.4200
0	26.0000	.9109	.4460
0	27.0000	.9646	.4730
0	30.0000	.9150	.5700
0	35.0000	1.0200	.7450
0	40.0000	1.0750	.9200
0	45.0000	1.0850	1.0750
0	50.0000	1.0400	1.2150
0	55.0000	.9650	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7650	1.5750
0	70.0000	.6500	1.6650
0	75.0000	.5150	1.7350
0	80.0000	.3700	1.7800
0	85.0000	.2200	1.8000
0	90.0000	.0700	1.8000
0	95.0000	-.0700	1.7800
0	100.0000	-.2200	1.7500
0	105.0000	-.3700	1.7000
0	110.0000	-.5100	1.6350
0	115.0000	-.6250	1.5550
0	120.0000	-.7350	1.4650
0	125.0000	-.8400	1.3500
0	130.0000	-.9100	1.2250
0	135.0000	-.9450	1.0850
0	140.0000	-.9450	.9250
0	145.0000	-.9100	.7550
0	150.0000	-.8500	.5750
0	155.0000	-.7400	.4200
0	160.0000	-.6600	.3200
0	165.0000	-.6750	.2300
0	170.0000	-.8500	.1400

Table 2. (cont)

0	175.0000	- .6900	.0550
1	180.0000	0.0000	.0250
360000.0 NACA 0012 SECTION DATA, EPPLER MODEL, CL, CD, DEC78			
0	0.0000	0.0000	.0079
0	1.0000	.1100	.0080
0	2.0000	.2200	.0084
0	3.0000	.3300	.0089
0	4.0000	.4400	.0098
0	5.0000	.5500	.0113
0	6.0000	.6600	.0125
0	7.0000	.7700	.0135
0	8.0000	.8542	.0153
0	9.0000	.9352	.0167
0	10.0000	.9811	.0184
0	11.0000	.9132	.0204
0	12.0000	.4832	.0217
0	13.0000	.2759	.0222
0	14.0000	.2893	.1060
0	15.0000	.3305	.1900
0	15.0000	.3792	.2100
0	17.0000	.4455	.2310
0	18.0000	.5047	.2520
0	19.0000	.5591	.2740
0	20.0000	.6120	.2970
0	21.0000	.6643	.3200
0	22.0000	.7179	.3440
0	23.0000	.7715	.3690
0	24.0000	.8246	.3940
0	25.0000	.8780	.4200
0	26.0000	.9313	.4460
0	27.0000	.9846	.4730
0	30.0000	.9150	.5700
0	35.0000	1.0200	.7450
0	40.0000	1.0750	.9200
0	45.0000	1.0850	1.0750
0	50.0000	1.0400	1.2150
0	55.0000	.9650	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7650	1.5750
0	70.0000	.6500	1.6650
0	75.0000	.5150	1.7350
0	80.0000	.3700	1.7800
0	85.0000	.2200	1.8000
0	90.0000	.0700	1.8000
0	95.0000	-.0700	1.7800
0	100.0000	-.2200	1.7500
0	105.0000	-.3700	1.7000
0	110.0000	-.5100	1.6350
0	115.0000	-.6250	1.5550
0	120.0000	-.7350	1.4650

Table 2. (cont)

0	125.0000	-.8400	1.3500
0	130.0000	-.9100	1.2250
0	135.0000	-.9450	1.0850
0	140.0000	-.9450	.9250
0	145.0000	-.9100	.7550
0	150.0000	-.8500	.5750
0	155.0000	-.7400	.4200
0	160.0000	-.6600	.3200
0	165.0000	-.6750	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6900	.0550
1	180.0000	0.0000	.0250
700000.0 NACA 0012 SECTION DATA, EPPLER MODEL, CL, CD, DEC78			
0	0.0000	0.0000	.0067
0	1.0000	.1100	.0068
0	2.0000	.2200	.0070
0	3.0000	.3300	.0075
0	4.0000	.4400	.0083
0	5.0000	.5500	.0097
0	6.0000	.6600	.0108
0	7.0000	.7700	.0118
0	8.0000	.8800	.0128
0	9.0000	.9598	.0144
0	10.0000	1.0343	.0159
0	11.0000	1.0749	.0175
0	12.0000	1.0390	.0195
0	13.0000	.8737	.0216
0	14.0000	.6284	.0236
0	15.0000	.4907	.1170
0	16.0000	.4696	.2100
0	17.0000	.5175	.2300
0	18.0000	.5584	.2520
0	19.0000	.6032	.2740
0	20.0000	.6474	.2970
0	21.0000	.6949	.3200
0	22.0000	.7446	.3440
0	23.0000	.7948	.3690
0	24.0000	.8462	.3940
0	25.0000	.8984	.4200
0	26.0000	.9506	.4460
0	27.0000	1.0029	.4730
0	30.0000	.9150	.5700
0	35.0000	1.0200	.7450
0	40.0000	1.0750	.9200
0	45.0000	1.0850	1.0750
0	50.0000	1.0400	1.2150
0	55.0000	.9650	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7650	1.5750
0	70.0000	.6500	1.6650

Table 2. (cont)

0	75.0000	.5150	1.7350
0	80.0000	.3700	1.7800
0	85.0000	.2200	1.8000
0	90.0000	.0700	1.8000
0	95.0000	-.0700	1.7800
0	100.0000	-.2200	1.7500
0	105.0000	-.3700	1.7000
0	110.0000	-.5100	1.6350
0	115.0000	-.6250	1.5550
0	120.0000	-.7350	1.4650
0	125.0000	-.8400	1.3500
0	130.0000	-.9100	1.2250
0	135.0000	-.9450	1.0850
0	140.0000	-.9450	.9250
0	145.0000	-.9100	.7550
0	150.0000	-.8500	.5750
0	155.0000	-.7400	.4200
0	160.0000	-.6600	.3200
0	165.0000	-.6750	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6900	.0550
1	180.0000	0.0000	.0250
0	1000000.0	NACA 0012 SECTION DATA, EPPLER MODEL, C ₋ , CD, DEC78	
0	0.0000	0.0000	.0065
0	1.0000	.1100	.0066
0	2.0000	.2200	.0068
0	3.0000	.3300	.0071
0	4.0000	.4400	.0078
0	5.0000	.5500	.0091
0	6.0000	.6600	.0101
0	7.0000	.7700	.0110
0	8.0000	.8800	.0119
0	9.0000	.9661	.0134
0	10.0000	1.0512	.0147
0	11.0000	1.1097	.0162
0	12.0000	1.1212	.0180
0	13.0000	1.0487	.0200
0	14.0000	.8846	.0222
0	15.0000	.7108	.0245
0	16.0000	.6060	.1280
0	17.0000	.5906	.2310
0	18.0000	.6030	.2520
0	19.0000	.6334	.2740
0	20.0000	.6716	.2970
0	21.0000	.7162	.3200
0	22.0000	.7613	.3440
0	23.0000	.8097	.3690
0	24.0000	.8589	.3940
0	25.0000	.9093	.4200
0	26.0000	.9618	.4460

Table 2. (cont.)

0	27.0000	1.0144	.4730
0	30.0000	.9150	.5700
0	35.0000	1.0200	.7450
0	40.0000	1.0750	.9200
0	45.0000	1.0850	1.0750
0	50.0000	1.0400	1.2150
0	55.0000	.9650	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7650	1.5750
0	70.0000	.6500	1.6650
0	75.0000	.5150	1.7350
0	80.0000	.3700	1.7800
0	85.0000	.2200	1.8000
0	90.0000	.0700	1.8000
0	95.0000	-.0700	1.7800
0	100.0000	-.2200	1.7500
0	105.0000	-.3700	1.7000
0	110.0000	-.5100	1.6350
0	115.0000	-.6250	1.5550
0	120.0000	-.7350	1.4650
0	125.0000	-.8400	1.3500
0	130.0000	-.9100	1.2250
0	135.0000	-.9450	1.0850
0	140.0000	-.9450	.9250
0	145.0000	-.9100	.7550
0	150.0000	-.8500	.5750
0	155.0000	-.7400	.4200
0	160.0000	-.6600	.3200
0	165.0000	-.6750	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6900	.0550
1	180.0000	0.0000	.0250
0	2000000.0	NACA 0012 SECTION DATA, EPPLER MODEL, CL, CD, DEC78	
0	0.0000	0.0000	.0064
0	1.0000	.1100	.0064
0	2.0000	.2200	.0066
0	3.0000	.3300	.0069
0	4.0000	.4400	.0073
0	5.0000	.5500	.0081
0	6.0000	.6600	.0090
0	7.0000	.7700	.0097
0	8.0000	.8800	.0105
0	9.0000	.9900	.0113
0	10.0000	1.0727	.0128
0	11.0000	1.1539	.0140
0	12.0000	1.2072	.0155
0	13.0000	1.2169	.0172
0	14.0000	1.1614	.0191
0	15.0000	1.0478	.0213
0	16.0000	.9221	.0237

Table 2. (cont)

0	17.0000	.7826	.1380
0	18.0000	.7163	.2520
0	19.0000	.7091	.2740
0	20.0000	.7269	.2970
0	21.0000	.7595	.3200
0	22.0000	.7981	.3440
0	23.0000	.8429	.3690
0	24.0000	.8882	.3940
0	25.0000	.9352	.4200
0	26.0000	.9842	.4460
0	27.0000	1.0355	.4730
0	30.0000	.9150	.5700
0	35.0000	1.0200	.7450
0	40.0000	1.0750	.9200
0	45.0000	1.0850	1.0750
0	50.0000	1.0400	1.2150
0	55.0000	.9650	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7650	1.5750
0	70.0000	.6500	1.6650
0	75.0000	.5150	1.7350
0	80.0000	.3700	1.7800
0	85.0000	.2200	1.8000
0	90.0000	.0700	1.8000
0	95.0000	-.0700	1.7800
0	100.0000	-.2200	1.7500
0	105.0000	-.3700	1.7000
0	110.0000	-.5100	1.6350
0	115.0000	-.6250	1.5550
0	120.0000	-.7350	1.4650
0	125.0000	-.8400	1.3500
0	130.0000	-.9100	1.2250
0	135.0000	-.9450	1.0850
0	140.0000	-.9450	.9250
0	145.0000	-.9100	.7550
0	150.0000	-.8500	.5750
0	155.0000	-.7400	.4200
0	160.0000	-.6600	.3200
0	165.0000	-.6750	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6900	.0550
1	180.0000	0.0000	.0250
5000000.0	NACA 0012 SECTION DATA, EPPLER MODEL, CL, CD, DEC78		
0	0.0000	0.0000	.0064
0	1.0000	.1100	.0064
0	2.0000	.2200	.0066
0	3.0000	.3300	.0068
0	4.0000	.4400	.0072
0	5.0000	.5500	.0076
0	6.0000	.6600	.0081

Table 2. (cont)

0	7.0000	.7700	.0086
0	8.0000	.8800	.0092
0	9.0000	.9900	.0098
0	10.0000	1.1000	.0106
0	11.0000	1.1842	.0118
0	12.0000	1.2673	-.0130
0	13.0000	1.3242	.0143
0	14.0000	1.3423	.0159
0	15.0000	1.3093	.0177
0	16.0000	1.2195	.0198
0	17.0000	1.0365	.0229
0	18.0000	.9054	.1480
0	19.0000	.8412	.2740
0	20.0000	.8233	.2970
0	21.0000	.8327	.3200
0	22.0000	.8563	.3440
0	23.0000	.8903	.3690
0	24.0000	.9295	.3940
0	25.0000	.9718	.4200
0	26.0000	1.0193	.4460
0	27.0000	1.0680	.4730
0	30.0000	.9150	.5700
0	35.0000	1.0200	.7450
0	40.0000	1.0750	.9200
0	45.0000	1.0850	1.0750
0	50.0000	1.0400	1.2150
0	55.0000	.9650	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7650	1.5750
0	70.0000	.6500	1.6650
0	75.0000	.5150	1.7350
0	80.0000	.3700	1.7800
0	85.0000	.2200	1.8000
0	90.0000	.0700	1.8000
0	95.0000	-.0700	1.7800
0	100.0000	-.2200	1.7500
0	105.0000	-.3700	1.7000
0	110.0000	-.5100	1.6350
0	115.0000	-.6250	1.5550
0	120.0000	-.7350	1.4650
0	125.0000	-.8400	1.3500
0	130.0000	-.9100	1.2250
0	135.0000	-.9450	1.0850
0	140.0000	-.9450	.9250
0	145.0000	-.9100	.7550
0	150.0000	-.8500	.5750
0	155.0000	-.7400	.4200
0	160.0000	-.6600	.3200
0	165.0000	-.6750	.2300
0	170.0000	-.8500	.1400

Table 2. (cont)

0	175.0000	-.6900	.0550
1	180.0000	0.0000	.0250
10000000.0 NACA 0012 SECTION DATA, EPPLER MODEL, CL, CD, DEC78			
0	0.0000	0.0000	.0054
0	1.0000	.1100	.0064
0	2.0000	.2200	.0066
0	3.0000	.3300	.0068
0	4.0000	.4400	.0071
0	5.0000	.5500	.0074
0	6.0000	.6600	.0078
0	7.0000	.7700	.0082
0	8.0000	.8800	.0086
0	9.0000	.9900	.0091
0	10.0000	1.1000	.0097
0	11.0000	1.2100	.0104
0	12.0000	1.2906	.0116
0	13.0000	1.3687	.0127
0	14.0000	1.4171	.0141
0	15.0000	1.4214	.0157
0	16.0000	1.2941	.0182
0	17.0000	1.1200	.0210
0	18.0000	.9795	.0241
0	19.0000	.8983	.1610
0	20.0000	.8668	.2970
0	21.0000	.8665	.3200
0	22.0000	.8859	.3440
0	23.0000	.9151	.3690
0	24.0000	.9492	.3940
0	25.0000	.9927	.4200
0	26.0000	1.0371	.4450
0	27.0000	1.0833	.4730
0	30.0000	.9150	.5700
0	35.0000	1.0200	.7450
0	40.0000	1.0750	.9200
0	45.0000	1.0850	1.0750
0	50.0000	1.0400	1.2150
0	55.0000	.9650	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7650	1.5750
0	70.0000	.6500	1.6650
0	75.0000	.5150	1.7350
0	80.0000	.3700	1.7800
0	85.0000	.2200	1.8000
0	90.0000	.0700	1.8000
0	95.0000	-.0700	1.7800
0	100.0000	-.2200	1.7500
0	105.0000	-.3700	1.7000
0	110.0000	-.5100	1.6350
0	115.0000	-.6250	1.5550
0	120.0000	-.7350	1.4650

Table 2. (cont)

0	125.0000	- .8400	1.3500
0	130.0000	- .9100	1.2250
0	135.0000	- .9450	1.0850
0	140.0000	- .9450	.9250
0	145.0000	- .9100	.7550
0	150.0000	- .8500	.5750
0	155.0000	- .7400	.4200
0	160.0000	- .6600	.3200
0	165.0000	- .6750	.2300
0	170.0000	- .8500	.1400
0	175.0000	- .6900	.0550
2	180.0000	0.0000	.0250

Table 3. Lift and Drag Coefficients for the NACA-0015 Airfoil ($10^4 \leq Re \leq 10^7$)

Re	α	C_L	C_d
10000.0		NACA 0015 SECTION DATA, EPPLER MODEL, CL, CD, DEC 78	
0	0.0000	0.0000	.0360
0	1.0000	.0434	.0362
0	2.0000	.0715	.0366
0	3.0000	.0725	.0373
0	4.0000	.0581	.0383
0	5.0000	.0162	.0393
0	6.0000	-.0781	.0400
0	7.0000	-.1517	.0510
0	8.0000	-.1484	.0640
0	9.0000	-.1194	.0770
0	10.0000	-.0791	.0910
0	11.0000	-.0348	.1070
0	12.0000	.0138	.1230
0	13.0000	.0649	.1400
0	14.0000	.1172	.1580
0	15.0000	.1706	.1770
0	16.0000	.2242	.1960
0	17.0000	.2780	.2170
0	18.0000	.3319	.2380
0	19.0000	.3859	.2600
0	20.0000	.4399	.2820
0	21.0000	.4939	.3050
0	22.0000	.5479	.3290
0	23.0000	.6019	.3540
0	24.0000	.6559	.3790
0	25.0000	.7099	.4050
0	26.0000	.7639	.4320
0	27.0000	.8174	.4600
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650

Table 3. (cont)

0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200
0	160.0000	-.6350	.3200
0	165.0000	-.6800	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6600	.0550
1	180.0000	0.0000	.0250
20000.0 NACA 0015 SECTION DATA, EPPLER MODEL, CL, CD, DEC 78			
0	0.0000	0.0000	.0265
0	1.0000	.0891	.0267
0	2.0000	.1740	.0271
0	3.0000	.2452	.0279
0	4.0000	.3041	.0290
0	5.0000	.3359	.0303
0	6.0000	.3001	.0410
0	7.0000	.0570	.0510
0	8.0000	-.1104	.0640
0	9.0000	-.1050	.0770
0	10.0000	-.0728	.0910
0	11.0000	-.0300	.1070
0	12.0000	.0173	.1230
0	13.0000	.0678	.1400
0	14.0000	.1193	.1580
0	15.0000	.1721	.1770
0	16.0000	.2256	.1960
0	17.0000	.2792	.2170
0	18.0000	.3331	.2380
0	19.0000	.3869	.2600
0	20.0000	.4409	.2820
0	21.0000	.4949	.3050
0	22.0000	.5489	.3290
0	23.0000	.6029	.3540
0	24.0000	.6569	.3790
0	25.0000	.7109	.4050
0	26.0000	.7649	.4320
0	27.0000	.8191	.4600
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650

Table 3. (cont)

0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200
0	160.0000	-.6350	.3200
0	165.0000	-.6800	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6600	.0550
1	180.0000	0.0000	.0250
40000.0 NACA 0015 SECTION DATA, EPPLER MODEL, CL, CD, DEC 78			
0	0.0000	0.0000	.0196
0	1.0000	.1054	.0198
0	2.0000	.2099	.0202
0	3.0000	.3078	.0209
0	4.0000	.4017	.0219
0	5.0000	.4871	.0232
0	6.0000	.5551	.0249
0	7.0000	.5730	.0267
0	8.0000	.4663	.0520
0	9.0000	.0433	.0770
0	10.0000	-.0413	.0910
0	11.0000	-.0144	.1070
0	12.0000	.0261	.1230
0	13.0000	.0741	.1400
0	14.0000	.1244	.1580
0	15.0000	.1756	.1770
0	16.0000	.2280	.1960
0	17.0000	.2815	.2170
0	18.0000	.3351	.2380
0	19.0000	.3889	.2600
0	20.0000	.4427	.2820
0	21.0000	.4966	.3050
0	22.0000	.5506	.3290
0	23.0000	.6045	.3540
0	24.0000	.6585	.3790
0	25.0000	.7125	.4050
0	26.0000	.7666	.4320

Table 3. (cont)

0	27.0000	.8222	.4600
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200
0	160.0000	-.6350	.3200
0	165.0000	-.6800	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6600	.0550
1	180.0000	0.0000	.0250
0	80000.0	NACA 0015 SECTION DATA, EPPLER MODEL, CL, CD, DEC 78	
0	0.0000	0.0000	.0147
0	1.0000	.1100	.0148
0	2.0000	.2200	.0151
0	3.0000	.3300	.0156
0	4.0000	.4186	.0168
0	5.0000	.5180	.0181
0	6.0000	.6048	.0197
0	7.0000	.6760	.0214
0	8.0000	.7189	.0234
0	9.0000	.6969	.0255
0	10.0000	.5122	.0277
0	11.0000	.1642	.0760
0	12.0000	.0749	.1230
0	13.0000	.0967	.1400
0	14.0000	.1382	.1580
0	15.0000	.1861	.1770
0	16.0000	.2364	.1960

Table 3. (cont)

0	17.0000	.2873	.2170
0	18.0000	.3393	.2380
0	19.0000	.3927	.2600
0	20.0000	.4463	.2820
0	21.0000	.5001	.3050
0	22.0000	.5539	.3290
0	23.0000	.6078	.3540
0	24.0000	.6617	.3790
0	25.0000	.7156	.4050
0	26.0000	.7700	.4320
0	27.0000	.8277	.4600
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200
0	160.0000	-.6350	.3200
0	165.0000	-.6800	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6600	.0550
1	180.0000	0.0000	.0250
160000.0	NACA 0015 SECTION DATA, EPPLER MODEL, CL, CD, DEC 78		
0	0.0000	0.0000	.0116
0	1.0000	.1100	.0117
0	2.0000	.2200	.0120
0	3.0000	.3300	.0124
0	4.0000	.4400	.0132
0	5.0000	.5500	.0142
0	6.0000	.6299	.0160

Table 3. (cont)

0	7.0000	.7150	.0176
0	8.0000	.7851	.0193
0	9.0000	.8311	.0212
0	10.0000	.8322	.0233
0	11.0000	.7623	.0256
0	12.0000	.5936	.0281
0	13.0000	.3548	.0302
0	14.0000	.2371	.1040
0	15.0000	.2376	.1770
0	16.0000	.2665	.1970
0	17.0000	.3098	.2170
0	18.0000	.3567	.2380
0	19.0000	.4066	.2600
0	20.0000	.4575	.2820
0	21.0000	.5087	.3050
0	22.0000	.5611	.3290
0	23.0000	.6148	.3540
0	24.0000	.6685	.3790
0	25.0000	.7224	.4050
0	26.0000	.7771	.4320
0	27.0000	.8382	.4600
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200
0	160.0000	-.6350	.3200
0	165.0000	-.6800	.2300
0	170.0000	-.8500	.1400

Table 3. (cont)

0	175.0000	-.6600	.0550
1	180.0000	0.0000	.0250
360000.0 NACA 0015 SECTION DATA, EPPLER MODEL, CL, CD, DEC 78			
0	0.0000	0.0000	.0091
0	1.0000	.1100	.0092
0	2.0000	.2200	.0094
0	3.0000	.3300	.0098
0	4.0000	.4400	.0105
0	5.0000	.5500	.0114
0	6.0000	.6600	.0126
0	7.0000	.7390	.0143
0	8.0000	.8240	.0157
0	9.0000	.8946	.0173
0	10.0000	.9440	.0191
0	11.0000	.9572	.0211
0	12.0000	.9285	.0233
0	13.0000	.8562	.0257
0	14.0000	.7483	.0283
0	15.0000	.6350	.0312
0	16.0000	.5384	.0240
0	17.0000	.4851	.02170
0	18.0000	.4782	.02380
0	19.0000	.4908	.02600
0	20.0000	.5247	.02820
0	21.0000	.5616	.03050
0	22.0000	.6045	.03290
0	23.0000	.6528	.03540
0	24.0000	.7015	.03790
0	25.0000	.7511	.04050
0	26.0000	.8055	.04320
0	27.0000	.8788	.04600
0	30.0000	.8550	.05700
0	35.0000	.9800	.07450
0	40.0000	1.0350	.09200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650

Table 3. (cont)

0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200
0	160.0000	-.6350	.3200
0	165.0000	-.6800	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6600	.0550
1	180.0000	0.0000	.0250
700000.0 NACA 0015 SECTION DATA, EPPLER MODEL, CL, CD, DEC 78			
0	0.0000	0.0000	.0077
0	1.0000	.1100	.0078
0	2.0000	.2200	.0080
0	3.0000	.3300	.0083
0	4.0000	.4400	.0089
0	5.0000	.5500	.0098
0	6.0000	.6600	.0108
0	7.0000	.7483	.0122
0	8.0000	.8442	.0135
0	9.0000	.9260	.0149
0	10.0000	.9937	.0164
0	11.0000	1.0363	.0182
0	12.0000	1.0508	.0200
0	13.0000	1.0302	.0221
0	14.0000	.9801	.0244
0	15.0000	.9119	.0269
0	16.0000	.8401	.0297
0	17.0000	.7799	.1340
0	18.0000	.7305	.2380
0	19.0000	.7041	.2600
0	20.0000	.6990	.2820
0	21.0000	.7097	.3050
0	22.0000	.7298	.3290
0	23.0000	.7593	.3540
0	24.0000	.7961	.3790
0	25.0000	.8353	.4050
0	26.0000	.8838	.4320
0	27.0000	.9473	.4600
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650

Table 3. (cont)

0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200
0	160.0000	-.6350	.3200
0	165.0000	-.6800	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6600	.0550
1	180.0000	0.0000	.0250
1000000.0	NACA 0015 SECTION DATA, EPPLER MODEL, C _L , CD, DEC 78		
0	0.0000	0.0000	.0074
0	1.0000	.1100	.0075
0	2.0000	.2200	.0076
0	3.0000	.3300	.0079
0	4.0000	.4400	.0083
0	5.0000	.5500	.0091
0	6.0000	.6600	.0101
0	7.0000	.7700	.0111
0	8.0000	.8504	.0126
0	9.0000	.9387	.0138
0	10.0000	1.0141	.0152
0	11.0000	1.0686	.0168
0	12.0000	1.0971	.0186
0	13.0000	1.0957	.0205
0	14.0000	1.0656	.0225
0	15.0000	1.0145	.0249
0	16.0000	.9567	.0275
0	17.0000	.8996	.0303
0	18.0000	.8566	.1450
0	19.0000	.8226	.2600
0	20.0000	.8089	.2820
0	21.0000	.8063	.3050
0	22.0000	.8189	.3290
0	23.0000	.8408	.3540
0	24.0000	.8668	.3790
0	25.0000	.9023	.4050
0	26.0000	.9406	.4320

Table 3. (cont)

0	27.0000	.9912	.4600
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200
0	160.0000	-.6350	.3200
0	165.0000	-.6800	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6600	.0550
1	180.0000	0.0000	.0250
0	2000000.0	NACA 0015 SECTION DATA, EPPLER MODEL, CL, CD, DEC 78	
0	0.0000	0.0000	.0070
0	1.0000	.1100	.0071
0	2.0000	.2200	.0072
0	3.0000	.3300	.0075
0	4.0000	.4400	.0078
0	5.0000	.5500	.0083
0	6.0000	.6600	.0090
0	7.0000	.7700	.0098
0	8.0000	.8800	.0108
0	9.0000	.9574	.0121
0	10.0000	1.0433	.0133
0	11.0000	1.1138	.0146
0	12.0000	1.1667	.0161
0	13.0000	1.1948	.0177
0	14.0000	1.1962	.0195
0	15.0000	1.1744	.0215
0	16.0000	1.1356	.0237

Table 3. (cont)

0	17.0000	1.0921	.0261
0	18.0000	1.0510	.0288
0	19.0000	1.0173	.1550
0	20.0000	.9954	.2820
0	21.0000	.9837	.3050
0	22.0000	.9827	.3290
0	23.0000	.9910	.3540
0	24.0000	1.0078	.3790
0	25.0000	1.0317	.4050
0	26.0000	1.0591	.4320
0	27.0000	1.0810	.4600
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200
0	160.0000	-.6350	.3200
0	165.0000	-.6800	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.5600	.0550
1	180.0000	0.0000	.0250
5000000.0	NACA 0015 SECTION DATA, EPPLER MODEL, CL, CD, DEC 78		
0	0.0000	0.0000	.0068
0	1.0000	.1100	.0069
0	2.0000	.2200	.0070
0	3.0000	.3300	.0073
0	4.0000	.4400	.0075
0	5.0000	.5500	.0080
0	6.0000	.6600	.0084

Table 3. (cont)

0	7.0000	.7700	.0089
0	8.0000	.8800	.0095
0	9.0000	.9900	.0102
0	10.0000	1.0685	.0113
0	11.0000	1.1553	.0124
0	12.0000	1.2290	.0136
0	13.0000	1.2847	.0149
0	13.0000	1.2847	.0149
0	14.0000	1.3187	.0164
0	15.0000	1.3298	.0180
0	16.0000	1.3186	.0198
0	17.0000	1.2917	.0218
0	18.0000	1.2576	.0240
0	19.0000	1.2242	.0265
0	20.0000	1.1965	.0260
0	21.0000	1.1771	.03050
0	22.0000	1.1647	.03290
0	23.0000	1.1611	.03540
0	24.0000	1.1563	.03790
0	25.0000	1.1322	.04050
0	26.0000	1.1268	.04320
0	27.0000	1.1397	.04600
0	30.0000	.8550	.05700
0	35.0000	.9800	.07450
0	40.0000	1.0350	.09200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
U	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	-2.300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200
0	160.0000	-.6350	.3200
0	165.0000	-.6800	.2300

Table 3. (cont)

0	170.0000	-.8500	.1400
0	175.0000	-.6600	.0550
1	180.0000	0.0000	.0250
10000000.0	NACA 0015 SECTION DATA, EPPLER MODEL, CL, CD, DEC 78		
0	0.0000	0.0000	.0068
0	1.0000	.1100	.0068
0	2.0000	.2200	.0069
0	3.0000	.3300	.0071
0	4.0000	.4400	.0074
0	5.0000	.5500	.0077
0	6.0000	.6600	.0081
0	7.0000	.7700	.0086
0	8.0000	.8800	.0090
0	9.0000	.9900	.0096
0	10.0000	1.1000	.0103
0	11.0000	1.1749	.0114
0	12.0000	1.2591	.0123
0	13.0000	1.3300	.0134
0	14.0000	1.3825	.0147
0	15.0000	1.4136	.0161
0	16.0000	1.4233	.0176
0	17.0000	1.4136	.0194
0	18.0000	1.3897	.0213
0	19.0000	1.3608	.0234
0	20.0000	1.3325	.0257
0	21.0000	1.3077	.0270
0	22.0000	1.2767	.0290
0	23.0000	1.1981	.0354
0	24.0000	1.1538	.0379
0	25.0000	1.1380	.0405
0	26.0000	1.1374	.0432
0	27.0000	1.1519	.0460
0	30.0000	.8550	.0570
0	35.0000	.9800	.0745
0	40.0000	1.0350	.0920
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550

Table 3. (cont)

0	120.0000	- .6700	1.4650
0	125.0000	- .7600	1.3500
0	130.0000	- .8500	1.2250
0	135.0000	- .9300	1.0850
0	140.0000	- .9800	.9250
0	145.0000	- .9000	.7550
0	150.0000	- .7700	.5750
0	155.0000	- .6700	.4200
0	160.0000	- .6350	.3200
0	165.0000	- .6800	.2300
0	170.0000	- .8500	.1400
0	175.0000	- .6600	.0550
2	180.0000	0.0000	.0250

Table 4. Lift and Drag Coefficients for the NACA-0018 Airfoil ($10^4 \leq Re \leq 5 \times 10^6$)

Re	α	C_L	C_d
10000.0		NACA 0018 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79	
0	0.0000	0.0000	.0385
0	1.0000	-.0045	.0387
0	2.0000	-.0154	.0391
0	3.0000	-.0233	.0399
0	4.0000	-.0368	.0410
0	5.0000	-.0577	.0425
0	6.0000	-.0839	.0443
0	7.0000	-.1182	.0463
0	8.0000	-.1501	.0489
0	9.0000	-.1584	.0525
0	10.0000	-.1423	.0574
0	11.0000	-.1125	.0800
0	12.0000	-.0767	.1230
0	14.0000	.0085	.1580
0	16.0000	.1051	.1960
0	18.0000	.2070	.2380
0	20.0000	.3111	.2820
0	22.0000	.4172	.3290
0	25.0000	.5775	.4050
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200

Table 4. (cont)

0	160.0000	- .6350	.3200
0	165.0000	- .6800	.2300
0	170.0000	- .8500	.1400
0	175.0000	- .6600	.0550
1	180.0000	0.0000	.0250
	20000.0	NACA 0018 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79	
0	0.0000	0.0000	.0286
0	1.0000	.0607	.0288
0	2.0000	.1135	.0292
0	3.0000	.1550	.0299
0	4.0000	.1788	.0310
0	5.0000	.1788	.0323
0	6.0000	.1582	.0339
0	7.0000	.1161	.0358
0	8.0000	.0214	.0376
0	9.0000	- .0682	.0396
0	10.0000	- .1003	.0630
0	12.0000	- .0602	.1230
0	14.0000	.0172	.1580
0	16.0000	.1114	.1960
0	18.0000	.2120	.2380
0	20.0000	.3151	.2820
0	22.0000	.4198	.3290
0	25.0000	.5798	.4050
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	- .0500	1.7800
0	100.0000	- .1850	1.7500
0	105.0000	- .3200	1.7000
0	110.0000	- .4500	1.6350
0	115.0000	- .5750	1.5550
0	120.0000	- .6700	1.4650
0	125.0000	- .7600	1.3500
0	130.0000	- .8500	1.2250
0	135.0000	- .9300	1.0850
0	140.0000	- .9800	.9250
0	145.0000	- .9000	.7550
0	150.0000	- .7700	.5750
0	155.0000	- .6700	.4200

Table 4. (cont)

0	160.0000	-.6350	.3200
0	165.0000	-.6800	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6600	.0550
1	180.0000	0.0000	.0250
	40000.0	NACA 0018 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79	
0	0.0000	0.0000	.0214
0	1.0000	.0936	.0215
0	2.0000	.1833	.0219
0	3.0000	.2688	.0225
0	4.0000	.3495	.0235
0	5.0000	.4117	.0247
0	6.0000	.4573	.0263
0	7.0000	.4758	.0282
0	8.0000	.4428	.0303
0	9.0000	.3544	.0327
0	10.0000	.2108	.0620
0	12.0000	.0139	.1230
0	14.0000	.0489	.1580
0	16.0000	.1287	.1960
0	18.0000	.2228	.2380
0	20.0000	.3236	.2820
0	22.0000	.4265	.3290
0	25.0000	.5840	.4050
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200

Table 4. (cont)

0	160.0000	-.6350	.3200
0	165.0000	-.6800	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6600	.0550
1	180.0000	0.0000	.0250
80000.0 NACA 0018 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79			
0	0.0000	0.0000	.0162
0	1.0000	.0889	.0163
0	2.0000	.1935	.0167
0	3.0000	.2924	.0172
0	4.0000	.3880	.0181
0	5.0000	.4753	.0192
0	6.0000	.5615	.0206
0	7.0000	.6224	.0223
0	8.0000	.6589	.0242
0	9.0000	.6606	.0264
0	10.0000	.6248	.0288
0	11.0000	.5531	.0315
0	12.0000	.4408	.0800
0	14.0000	.2256	.1580
0	16.0000	.2027	.1960
0	18.0000	.2603	.2380
0	20.0000	.3472	.2820
0	22.0000	.4430	.3290
0	25.0000	.5963	.4050
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750

Table 4. (cont)

0	155.0000	- .6700	.4200
0	160.0000	- .6350	.3200
0	165.0000	- .6800	.2300
0	170.0000	- .8500	.1400
0	175.0000	- .6600	.0550
1	180.0000	0.0000	.0250
160000.0 NACA 0018 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79			
0	0.0000	0.0000	.0128
0	1.0000	.1100	.0129
0	2.0000	.2200	.0131
0	3.0000	.3088	.0137
0	4.0000	.4114	.0144
0	5.0000	.5068	.0153
0	6.0000	.5960	.0166
0	7.0000	.6724	.0181
0	8.0000	.7373	.0198
0	9.0000	.7781	.0217
0	10.0000	.7949	.0238
0	11.0000	.7852	.0262
0	12.0000	.7488	.0288
0	13.0000	.6923	.0770
0	14.0000	.6237	.1580
0	15.0000	.4896	.1960
0	18.0000	.4202	.2380
0	20.0000	.4382	.2820
0	22.0000	.5026	.3290
0	25.0000	.6321	.4050
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	- .0500	1.7800
0	100.0000	- .1850	1.7500
0	105.0000	- .3200	1.7000
0	110.0000	- .4500	1.6350
0	115.0000	- .5750	1.5550
0	120.0000	- .6700	1.4650
0	125.0000	- .7600	1.3500
0	130.0000	- .8500	1.2250
0	135.0000	- .9300	1.0850
0	140.0000	- .9800	.9250

Table 4. (cont)

0	145.0000	- .9000	.7550
0	150.0000	- .7700	.5750
0	155.0000	- .6700	.4200
0	160.0000	- .6350	.3200
0	165.0000	- .6800	.2300
0	170.0000	- .8500	.1400
0	175.0000	- .6600	.0550
1	180.0000	0.0000	.0250
3600000.0 NACA 0018 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79			
0	0.0000	0.0000	.0101
0	1.0000	.1100	.0102
0	2.0000	.2200	.0104
0	3.0000	.3300	.0107
0	4.0000	.4400	.0112
0	5.0000	.5240	.0121
0	6.0000	.6228	.0132
0	7.0000	.7100	.0145
0	8.0000	.7879	.0159
0	9.0000	.8526	.0176
0	10.0000	.8983	.0194
0	11.0000	.9249	.0213
0	12.0000	.9279	.0235
0	13.0000	.9104	.0259
0	14.0000	.8803	.0940
0	16.0000	.8007	.1960
0	18.0000	.7319	.2380
0	20.0000	.6997	.2820
0	22.0000	.7050	.3290
0	25.0000	.7724	.4050
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	- .0500	1.7800
0	100.0000	- .1850	1.7500
0	105.0000	- .3200	1.7000
0	110.0000	- .4500	1.6350
0	115.0000	- .5750	1.5550
0	120.0000	- .6700	1.4650
0	125.0000	- .7600	1.3500
0	130.0000	- .8500	1.2250

Table 4. (cont)

0	135.0000	- .9300	1.0850
0	140.0000	- .9800	.9250
0	145.0000	- .9000	.7550
0	150.0000	- .7700	.5750
0	155.0000	- .6700	.4200
0	160.0000	- .6350	.3200
0	165.0000	- .6800	.2300
0	170.0000	- .8500	.1400
0	175.0000	- .6600	.0550
1	180.0000	0.0000	.0250
700000.0 NACA 0018 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79			
0	0.0000	0.0000	.0085
0	1.0000	.1100	.0087
0	2.0000	.2200	.0088
0	3.0000	.3300	.0091
0	4.0000	.4400	.0096
0	5.0000	.5500	.0102
0	6.0000	.6328	.0112
0	7.0000	.7291	.0123
0	8.0000	.8156	.0136
0	9.0000	.8904	.0150
0	10.0000	.9541	.0166
0	11.0000	.9973	.0183
0	12.0000	1.0245	.0202
0	13.0000	1.0289	.0223
0	14.0000	1.0175	.0245
0	15.0000	.9938	.0202
0	15.0000	.9648	.1960
0	18.0000	.9150	.2380
0	20.0000	.8877	.2820
0	22.0000	.8867	.3290
0	25.0000	.9326	.4050
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	- .0500	1.7800
0	100.0000	- .1850	1.7500
0	105.0000	- .3200	1.7000
0	110.0000	- .4500	1.6350
0	115.0000	- .5750	1.5550

Table 4. (cont)

0	120.0000	- .6700	1.4650
0	125.0000	- .7600	1.3500
0	130.0000	- .8500	1.2250
0	135.0000	- .9300	1.0850
0	140.0000	- .9800	.9250
0	145.0000	- .9000	.7550
0	150.0000	- .7700	.5750
0	155.0000	- .6700	.4200
0	160.0000	- .6350	.3200
0	165.0000	- .6800	.2300
0	170.0000	- .8500	.1400
0	175.0000	- .6600	.0550
1	180.0000	0.0000	.0250
1000000.0 NACA 0018 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79			
0	0.0000	0.0000	.0082
0	1.0000	.1100	.0082
0	2.0000	.2200	.0083
0	3.0000	.3300	.0086
0	4.0000	.4400	.0089
0	5.0000	.5500	.0095
0	6.0000	.6600	.0102
0	7.0000	.7362	.0115
0	8.0000	.8256	.0126
0	9.0000	.9067	.0139
0	10.0000	.9751	.0154
0	11.0000	1.0284	.0170
0	12.0000	1.0664	.0187
0	13.0000	1.0804	.0206
0	14.0000	1.0793	.0227
0	15.0000	1.0624	.0251
0	16.0000	1.0402	.0180
0	18.0000	.9959	.0280
0	20.0000	.9707	.02820
0	22.0000	.9696	.0290
0	25.0000	1.0107	.04050
0	30.0000	.8550	.05700
0	35.0000	.9800	.07450
0	40.0000	1.0350	.09200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500

Table 4. (cont)

0	105.0000	- .3200	1.7000
0	110.0000	- .4500	1.6350
0	115.0000	- .5750	1.5550
0	120.0000	- .6700	1.4650
0	125.0000	- .7600	1.3500
0	130.0000	- .8500	1.2250
0	135.0000	- .9300	1.0850
0	140.0000	- .9800	.9250
0	145.0000	- .9000	.7550
0	150.0000	- .7700	.5750
0	155.0000	- .6700	.4200
0	160.0000	- .6350	.3200
0	165.0000	- .6800	.2300
0	170.0000	- .8500	.1400
0	175.0000	- .6600	.0550
1	180.0000	0.0000	.0250
2000000.0 NACA 0018 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79			
0	0.0000	0.0000	.0077
0	1.0000	.1100	.0077
0	2.0000	.2200	.0078
0	3.0000	.3300	.0080
0	4.0000	.4400	.0084
0	5.0000	.5500	.0087
0	6.0000	.6600	.0093
0	7.0000	.7449	.0101
0	8.0000	.8439	.0111
0	9.0000	.9314	.0122
0	10.0000	1.0111	.0134
0	11.0000	1.0772	.0148
0	12.0000	1.1296	.0163
0	13.0000	1.1662	.0179
0	14.0000	1.1813	.0197
0	15.0000	1.1813	.0218
0	16.0000	1.1695	.0240
0	17.0000	1.1550	.1200
0	18.0000	1.1383	.2380
0	20.0000	1.1172	.2820
0	22.0000	1.1127	.3290
0	25.0000	1.1468	.4050
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800

Table 4. (cont)

0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200
0	160.0000	-.6350	.3200
0	165.0000	-.6800	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6600	.0550
1	180.0000	0.0000	.0250
5000000.0 NACA 0018 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79			
0	0.0000	0.0000	.0073
0	1.0000	.1100	.0073
0	2.0000	.2200	.0075
0	3.0000	.3300	.0077
0	4.0000	.4400	.0079
0	5.0000	.5500	.0083
0	6.0000	.6600	.0087
0	7.0000	.7700	.0093
0	8.0000	.8538	.0100
0	9.0000	.9525	.0108
0	10.0000	1.0404	.0117
0	11.0000	1.1211	.0128
0	12.0000	1.1884	.0140
0	13.0000	1.2430	.0153
0	14.0000	1.2808	.0168
0	15.0000	1.3004	.0185
0	16.0000	1.3067	.0203
0	17.0000	1.3038	.0223
0	18.0000	1.2960	.0244
0	19.0000	1.2853	.0260
0	20.0000	1.2768	.02820
0	22.0000	1.2714	.03290
0	25.0000	1.2925	.04050
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450

Table 4. (cont)

0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200
0	160.0000	-.5350	.3200
0	155.0000	-.6800	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6600	.0550
2	180.0000	0.0000	.0250

Table 5. Lift and Drag Coefficients for the NACA-0021 Airfoil ($10^4 \leq Re \leq 5 \times 10^6$)

Re	α	C_L	C_d
10000.0		NACA 0021 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79	
0	0.0000	0.0000	.0413
0	1.0000	-.0320	.0414
0	2.0000	-.0631	.0420
0	3.0000	-.0854	.0429
0	4.0000	-.0995	.0441
0	5.0000	-.1156	.0459
0	6.0000	-.1240	.0480
0	7.0000	-.1400	.0507
0	8.0000	-.1475	.0538
0	9.0000	-.1581	.0575
0	10.0000	-.1581	.0750
0	12.0000	-.1276	.1230
0	14.0000	-.0658	.1580
0	16.0000	.0123	.1960
0	18.0000	.1035	.2380
0	20.0000	.2006	.2820
0	22.0000	.3002	.3290
0	25.0000	.4539	.4050
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200
0	160.0000	-.6350	.3200

Table 5. (cont)

0	165.0000	-.6800	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6600	.0550
1	180.0000	0.0000	.0250
20000.0 NACA 0021 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79			
0	0.0000	0.0000	.0309
0	1.0000	.0243	.0310
0	2.0000	.0393	.0314
0	3.0000	.0472	.0321
0	4.0000	.0619	.0332
0	5.0000	.0505	.0345
0	6.0000	.0475	.0362
0	7.0000	.0266	.0382
0	8.0000	.0120	.0407
0	9.0000	-.0190	.0435
0	10.0000	-.0506	.0700
0	12.0000	-.0713	.1230
0	14.0000	-.0362	.1580
0	16.0000	.0331	.1960
0	18.0000	.1180	.2380
0	20.0000	.2124	.2820
0	22.0000	.3103	.3290
0	25.0000	.4618	.4050
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200
0	160.0000	-.6350	.3200

Table 5. (cont)

0	165.0000	- .6800	.2300
0	170.0000	- .8500	.1400
0	175.0000	- .6600	.0550
1	180.0000	0.0000	.0250
40000.0 NACA 0021 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79			
0	0.0000	0.0000	.0232
0	1.0000	.0752	.0233
0	2.0000	.1465	.0237
0	3.0000	.2103	.0243
0	4.0000	.2730	.0253
0	5.0000	.3086	.0264
0	6.0000	.3382	.0279
0	7.0000	.3427	.0297
0	8.0000	.3420	.0319
0	9.0000	.3162	.0343
0	10.0000	.2691	.0620
0	12.0000	.1660	.1230
0	14.0000	.0833	.1580
0	16.0000	.0981	.1960
0	18.0000	.1619	.2380
0	20.0000	.2414	.2820
0	22.0000	.3345	.3290
0	25.0000	.4802	.4050
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	- .0500	1.7800
0	100.0000	- .1850	1.7500
0	105.0000	- .3200	1.7000
0	110.0000	- .4500	1.6350
0	115.0000	- .5750	1.5550
0	120.0000	- .6700	1.4650
0	125.0000	- .7600	1.3500
0	130.0000	- .8500	1.2250
0	135.0000	- .9300	1.0850
0	140.0000	- .9800	.9250
0	145.0000	- .9000	.7550
0	150.0000	- .7700	.5750
0	155.0000	- .6700	.4200
0	160.0000	- .6350	.3200

Table 5. (cont)

0	165.0000	-.6800	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6600	.0550
1	180.0000	0.0000	.0250
80000.0 NACA 0021 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79			
0	0.0000	0.0000	.0177
0	1.0000	.0921	.0178
0	2.0000	.1839	.0181
0	3.0000	.2731	.0186
0	4.0000	.3564	.0194
0	5.0000	.4324	.0204
0	6.0000	.4953	.0217
0	7.0000	.5445	.0233
0	8.0000	.5751	.0252
0	9.0000	.5874	.0273
0	10.0000	.5780	.0297
0	11.0000	.5564	.0700
0	12.0000	.5228	.1230
0	14.0000	.4296	.1580
0	16.0000	.3499	.1960
0	18.0000	.3221	.2380
0	20.0000	.3475	.2820
0	22.0000	.4091	.3290
0	25.0000	.5297	.4050
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200

Table 5. (cont)

0	160.0000	- .6350	.3200
0	165.0000	- .6800	.2300
0	170.0000	- .8500	.1400
0	175.0000	- .6600	.0550
1	180.0000	0.0000	.0250
160000.0 NACA 0021 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79			
0	0.0000	0.0000	.0139
0	1.0000	.0842	.0140
0	2.0000	.1879	.0143
0	3.0000	.2861	.0148
0	4.0000	.3800	.0155
0	5.0000	.4687	.0163
0	6.0000	.5486	.0174
0	7.0000	.6209	.0187
0	8.0000	.6745	.0204
0	9.0000	.7148	.0222
0	10.0000	.7374	.0243
0	11.0000	.7443	.0266
0	12.0000	.7363	.0292
0	13.0000	.7255	.0860
0	14.0000	.6993	.1580
0	16.0000	.6487	.1960
0	18.0000	.6098	.2380
0	20.0000	.5920	.2820
0	22.0000	.5023	.3290
0	25.0000	.6664	.4050
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550

Table 5. (cont)

0	150.0000	- .7700	.5750
0	155.0000	- .6700	.4200
0	160.0000	- .6350	.3200
0	165.0000	- .6800	.2300
0	170.0000	- .8500	.1400
0	175.0000	- .6600	.0550
1	180.0000	0.0000	.0250
3600000.0 NACA 0021 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79			
0	0.0000	0.0000	.0111
0	1.0000	.1100	.0111
0	2.0000	.2200	.0113
0	3.0000	.3024	.0117
0	4.0000	.4044	.0122
0	5.0000	.4998	.0129
0	6.0000	.5891	.0138
0	7.0000	.6728	.0149
0	8.0000	.7434	.0163
0	9.0000	.8026	.0178
0	10.0000	.8500	.0195
0	11.0000	.8779	.0215
0	12.0000	.8938	.0237
0	13.0000	.8973	.0260
0	14.0000	.8937	.0286
0	15.0000	.8840	.1040
0	16.0000	.8717	.1960
0	18.0000	.8489	.2380
0	20.0000	.8397	.2820
0	22.0000	.8453	.3290
0	25.0000	.8866	.4050
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	- .0500	1.7800
0	100.0000	- .1850	1.7500
0	105.0000	- .3200	1.7000
0	110.0000	- .4500	1.6350
0	115.0000	- .5750	1.5550
0	120.0000	- .6700	1.4650
0	125.0000	- .7600	1.3500
0	130.0000	- .8500	1.2250

Table 5. (cont)

0	135.0000	- .9300	1.0850
0	140.0000	- .9800	.9250
0	145.0000	- .9000	.7550
0	150.0000	- .7700	.5750
0	155.0000	- .6700	.4200
0	160.0000	- .6350	.3200
0	165.0000	- .6800	.2300
0	170.0000	- .8500	.1400
0	175.0000	- .6600	.0550
1	180.0000	0.0000	.0250
	700000.0	NACA 0021 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79	
0	0.0000	0.0000	.0094
0	1.0000	-1100	.0094
0	2.0000	.2200	.0096
0	3.0000	.3300	.0098
0	4.0000	.4128	.0103
0	5.0000	.5146	.0109
0	6.0000	.5100	.0117
0	7.0000	.6988	.0126
0	8.0000	.7802	.0138
0	9.0000	.8498	.0152
0	10.0000	.9091	.0166
0	11.0000	.9543	.0184
0	12.0000	.9843	.0202
0	13.0000	1.0020	.0223
0	14.0000	1.0122	.0244
0	15.0000	1.0105	.0269
0	16.0000	1.0056	.0293
0	17.0000	.9973	.0250
0	18.0000	.9911	.0280
0	20.0000	.9858	.02820
0	22.0000	.9940	.0290
0	25.0000	1.0350	.04050
0	30.0000	.8550	.05700
0	35.0000	.9800	.07450
0	40.0000	1.0350	.09200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	- .0500	1.7800
0	100.0000	- .1850	1.7500
0	105.0000	- .3200	1.7000
0	110.0000	- .4500	1.6350

Table 5. (cont)

0	115.0000	- .5750	1.5550
0	120.0000	- .6700	1.4650
0	125.0000	- .7600	1.3500
0	130.0000	- .8500	1.2250
0	135.0000	- .9300	1.0850
0	140.0000	- .9800	.9250
0	145.0000	- .9000	.7550
0	150.0000	- .7700	.5750
0	155.0000	- .6700	.4200
0	160.0000	- .6350	.3200
0	165.0000	- .6800	.2300
0	170.0000	- .8500	.1400
0	175.0000	- .6600	.0550
1	180.0000	0.0000	.0250
1000000.0	NACA 0021 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79		
0	0.0000	0.0000	.0089
0	1.0000	.1100	.0089
0	2.0000	.2200	.0090
0	3.0000	.3300	.0092
0	4.0000	.4400	.0096
0	5.0000	.5192	.0101
0	6.0000	.6191	.0108
0	7.0000	.7102	.0117
0	8.0000	.7939	.0128
0	9.0000	.8694	.0140
0	10.0000	.9364	.0154
0	11.0000	.9862	.0170
0	12.0000	1.0257	.0187
0	13.0000	1.0492	.0206
0	14.0000	1.0657	.0226
0	15.0000	1.0709	.0248
0	16.0000	1.0690	.0273
0	17.0000	1.0641	.0300
0	18.0000	1.0588	.1350
0	20.0000	1.0554	.2820
0	22.0000	1.0644	.3290
0	25.0000	1.1018	.4050
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000

Table 5. (cont)

0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200
0	160.0000	-.6350	.3200
0	165.0000	-.6800	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6600	.0550
1	180.0000	0.0000	.0250
2000000.0	NACA 0021 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79		
0	0.0000	0.0000	.0082
0	1.0000	.1100	.0083
0	2.0000	.2200	.0084
0	3.0000	.3300	.0086
0	4.0000	.4400	.0089
0	5.0000	.5500	.0092
0	6.0000	.6268	.0098
0	7.0000	.7254	.0105
0	8.0000	.8143	.0114
0	9.0000	.8986	.0124
0	10.0000	.9739	.0135
0	11.0000	1.0398	.0148
0	12.0000	1.0906	.0162
0	13.0000	1.1305	.0179
0	14.0000	1.1580	.0196
0	15.0000	1.1747	.0215
0	16.0000	1.1823	.0236
0	17.0000	1.1824	.0260
0	18.0000	1.1814	.0285
0	19.0000	1.1797	.1450
0	20.0000	1.1812	.2820
0	22.0000	1.1893	.3290
0	25.0000	1.2230	.4050
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750

Table 5. (cont)

0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200
0	160.0000	-.6350	.3200
0	165.0000	-.6800	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6600	.0550
1	180.0000	0.0000	.0250
5000000.0 NACA 0021 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79			
0	0.0000	0.0000	.0078
0	1.0000	.1100	.0078
0	2.0000	.2200	.0079
0	3.0000	.3300	.0081
0	4.0000	.4400	.0083
0	5.0000	.5500	.0086
0	6.0000	.6600	.0091
0	7.0000	.7354	.0097
0	8.0000	.8334	.0104
0	9.0000	.9222	.0112
0	10.0000	1.0049	.0121
0	11.0000	1.0787	.0132
0	12.0000	1.1453	.0143
0	13.0000	1.1979	.0156
0	14.0000	1.2410	.0170
0	15.0000	1.2680	.0186
0	16.0000	1.2860	.0205
0	17.0000	1.2977	.0224
0	18.0000	1.3031	.0245
0	19.0000	1.3066	.0268
0	20.0000	1.3054	.0293
0	22.0000	1.3130	.3290
0	25.0000	1.3476	.4050
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200

Table 5. (cont)

0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200
0	160.0000	-.6350	.3200
0	165.0000	-.6800	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6600	.0550
2	180.0000	0.0000	.0250

Table 6. Lift and Drag Coefficients for the NACA-0025 Airfoil ($10^4 \leq Re \leq 5 \times 10^6$)

Re	α	C_L	C_d
10000.0	NACA 0025 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79		
0	0.0000	0.0000	.0455
0	1.0000	-.0434	.0457
0	2.0000	-.0807	.0463
0	3.0000	-.1151	.0474
0	4.0000	-.1403	.0488
0	5.0000	-.1585	.0508
0	6.0000	-.1723	.0532
0	7.0000	-.1799	.0562
0	8.0000	-.1797	.0597
0	9.0000	-.1776	.0638
0	10.0000	-.1747	.0686
0	11.0000	-.1647	.0820
0	12.0000	-.1512	.1230
0	14.0000	-.1134	.1580
0	16.0000	-.0604	.1960
0	18.0000	.0082	.2380
0	20.0000	.0883	.2820
0	22.0000	.1785	.3290
0	25.0000	.3205	.4050
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200

Table 6. (cont)

0	160.0000	-.6350	.3200
0	165.0000	-.6800	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6600	.0550
1	180.0000	0.0000	.0250
	20000.0	NACA 0025 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79	
0	0.0000	0.0000	.0341
0	1.0000	-.0223	.0342
0	2.0000	-.0376	.0346
0	3.0000	-.0509	.0354
0	4.0000	-.0550	.0365
0	5.0000	-.0589	.0379
0	6.0000	-.0650	.0397
0	7.0000	-.0690	.0419
0	8.0000	-.0683	.0445
0	9.0000	-.0653	.0476
0	10.0000	-.0635	.0511
0	11.0000	-.0607	.0810
0	12.0000	-.0572	.1230
0	14.0000	-.0377	.1580
0	16.0000	-.0027	.1960
0	18.0000	.0512	.2380
0	20.0000	.1213	.2820
0	22.0000	.2071	.3290
0	25.0000	.3435	.4050
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750

Table 6. (cont)

0	155.0000	- .6700	.4200
0	160.0000	- .6350	.3200
0	165.0000	- .6800	.2300
0	170.0000	- .8500	.1400
0	175.0000	- .6600	.0550
1	180.0000	0.0000	.0250
	40000.0	VACA 0025 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79	
0	0.0000	0.0000	.0258
0	1.0000	.0411	.0259
0	2.0000	.0821	.0263
0	3.0000	.1167	.0269
0	4.0000	.1479	.0278
0	5.0000	.1693	.0290
0	6.0000	.1778	.0304
0	7.0000	.1856	.0322
0	8.0000	.1929	.0343
0	9.0000	.1942	.0367
0	10.0000	.1915	.0396
0	11.0000	.1889	.0428
0	12.0000	.1813	.0850
0	14.0000	.1753	.1580
0	16.0000	.1669	.1960
0	18.0000	.1824	.2380
0	20.0000	.2183	.2820
0	22.0000	.2843	.3290
0	25.0000	.4026	.4050
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550

Table 6. (cont)

0	150.0000	- .7700	.5750
0	155.0000	- .6700	.4200
0	160.0000	- .6350	.3200
0	165.0000	- .6800	.2300
0	170.0000	- .8500	.1400
0	175.0000	- .6600	.0550
1	180.0000	0.0000	.0250
	80000.0	NACA 0025 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79	
0	0.0000	0.0000	.0197
0	1.0000	.0743	.0198
0	2.0000	.1487	.0201
0	3.0000	.2198	.0207
0	4.0000	.2832	.0214
0	5.0000	.3413	.0224
0	6.0000	.3866	.0236
0	7.0000	.4215	.0250
0	8.0000	.4503	.0268
0	9.0000	.4656	.0288
0	10.0000	.4749	.0311
0	11.0000	.4797	.0338
0	12.0000	.4783	.0368
0	13.0000	.4754	.0401
0	14.0000	.4713	.1010
0	16.0000	.4588	.1960
0	18.0000	.4522	.2380
0	20.0000	.4547	.2820
0	22.0000	.4826	.3290
0	25.0000	.5574	.4050
0	30.0000	.3550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850

Table 6. (cont)

0	140.0000	- .9800	.9250
0	145.0000	- .9000	.7550
0	150.0000	- .7700	.5750
0	155.0000	- .6700	.4200
0	160.0000	- .6350	.3200
0	165.0000	- .6800	.2300
0	170.0000	- .8500	.1400
0	175.0000	- .6600	.0550
1	180.0000	0.0000	.0250
160000.0	NACA 0025 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79		
0	0.0000	0.0000	.0155
0	1.0000	.0875	.0156
0	2.0000	.1745	.0158
0	3.0000	.2613	.0163
0	4.0000	.3400	.0169
0	5.0000	.4170	.0177
0	6.0000	.4831	.0187
0	7.0000	.5263	.0201
0	8.0000	.5916	.0213
0	9.0000	.6271	.0230
0	10.0000	.6539	.0250
0	11.0000	.6720	.0272
0	12.0000	.6811	.0296
0	13.0000	.6866	.0324
0	14.0000	.6886	.0355
0	15.0000	.6906	.0389
0	16.0000	.6921	.0426
0	17.0000	.6935	.0466
0	18.0000	.6945	.0510
0	19.0000	.7006	.0558
0	20.0000	.7069	.0610
0	21.0000	.7164	.0668
0	22.0000	.7289	.0730
0	23.0000	.7421	.0796
0	24.0000	.7605	.0870
0	25.0000	.7840	.0947
0	26.0000	.8047	.1029
0	27.0000	.8305	.1117
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.5300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000

Table 6. (cont)

0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200
0	160.0000	-.6350	.3200
0	165.0000	-.6800	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6600	.0550
1	180.0000	0.0000	.0250
360000.0 NACA 0025 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79			
0	0.0000	0.0000	.0121
0	1.0000	.0982	.0122
0	2.0000	.1721	.0125
0	3.0000	.2682	.0129
0	4.0000	.3608	.0135
0	5.0000	.4495	.0141
0	6.0000	.5295	.0149
0	7.0000	.6062	.0159
0	8.0000	.6701	.0170
0	9.0000	.7256	.0185
0	10.0000	.7713	.0200
0	11.0000	.8039	.0219
0	12.0000	.8295	.0239
0	13.0000	.8471	.0261
0	14.0000	.8565	.0286
0	15.0000	.8656	.0314
0	16.0000	.8742	.0343
0	17.0000	.8821	.0375
0	18.0000	.8890	.0411
0	19.0000	.8992	.0448
0	20.0000	.9114	.0489
0	21.0000	.9216	.0534
0	22.0000	.9381	.0582
0	23.0000	.9529	.0634
0	24.0000	.9727	.0690
0	25.0000	.9907	.0750
0	26.0000	1.0147	.0814
0	27.0000	1.0396	.0881
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450

Table 6. (cont)

0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200
0	160.0000	-.6350	.3200
0	165.0000	-.6800	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6600	.0550
1	180.0000	0.0000	.0250
700000.0	NACA 0025 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79		
0	0.0000	0.0000	.0104
0	1.0000	.0817	.0104
0	2.0000	.1851	.0105
0	3.0000	.2861	.0109
0	4.0000	.3811	.0113
0	5.0000	.4743	.0119
0	6.0000	.5627	.0126
0	7.0000	.6440	.0134
0	8.0000	.7194	.0144
0	9.0000	.7852	.0156
0	10.0000	.8405	.0170
0	11.0000	.8873	.0185
0	12.0000	.9230	.0202
0	13.0000	.9491	.0222
0	14.0000	.9685	.0244
0	15.0000	.9820	.0267
0	16.0000	.9944	.0292
0	17.0000	1.0052	.0319
0	18.0000	1.0157	.0349
0	19.0000	1.0276	.0381

Table 6. (cont)

0	20.0000	1.0403	.0415
0	21.0000	1.0521	.0453
0	22.0000	1.0678	.0493
0	23.0000	1.0831	.0536
0	24.0000	1.1035	.0583
0	25.0000	1.1223	.0632
0	26.0000	1.1458	.0685
0	27.0000	1.1704	.0741
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200
0	160.0000	-.6350	.3200
0	165.0000	-.6800	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6600	.0550
1	180.0000	0.0000	.0250
10000000.0		NACA 0025 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79	
0	0.0000	0.0000	.0097
0	1.0000	.1100	.0098
0	2.0000	.1890	.0098
0	3.0000	.2917	.0101
0	4.0000	.3900	.0105
0	5.0000	.4844	.0110
0	6.0000	.5757	.0116
0	7.0000	.6622	.0124
0	8.0000	.7387	.0133
0	9.0000	.8117	.0144

Table 6. (cont)

0	10.0000	.8710	.0157
0	11.0000	.9228	.0171
0	12.0000	.9656	.0187
0	13.0000	.9960	.0205
0	14.0000	1.0192	.0225
0	15.0000	1.0382	.0246
0	16.0000	1.0522	.0269
0	17.0000	1.0654	.0294
0	18.0000	1.0774	.0322
0	19.0000	1.0896	.0351
0	20.0000	1.1031	.0382
0	21.0000	1.1151	.0417
0	22.0000	1.1294	.0454
0	23.0000	1.1476	.0493
0	24.0000	1.1645	.0535
0	25.0000	1.1856	.0581
0	26.0000	1.2071	.0629
0	27.0000	1.2317	.0680
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200
0	160.0000	-.6350	.3200
0	165.0000	-.6800	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6600	.0550
1	180.0000	0.0000	.0250
	2000000.0	NACA 0025 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79	

Table 6. (cont)

0	0.0000	0.0000	.0090
0	1.0000	.1100	.0090
0	2.0000	.2200	.0091
0	3.0000	.2978	.0093
0	4.0000	.4000	.0096
0	5.0000	.4977	.0100
0	6.0000	.5913	.0106
0	7.0000	.6810	.0112
0	8.0000	.7664	.0120
0	9.0000	.8415	.0129
0	10.0000	.9135	.0140
0	11.0000	.9723	.0151
0	12.0000	1.0245	.0165
0	12.0000	1.0245	.0165
0	13.0000	1.0672	.0180
0	14.0000	1.0989	.0197
0	15.0000	1.1258	.0215
0	16.0000	1.1488	.0235
0	17.0000	1.1654	.0257
0	18.0000	1.1806	.0280
0	19.0000	1.1953	.0305
0	20.0000	1.2094	.0332
0	21.0000	1.2220	.0362
0	22.0000	1.2354	.0394
0	23.0000	1.2537	.0428
0	24.0000	1.2683	.0465
0	25.0000	1.2890	.0504
0	26.0000	1.3087	.0545
0	27.0000	1.3347	.0589
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800
0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250

Table 6. (cont)

0	135.0000	- .9300	1.0850
0	140.0000	- .9800	.9250
0	145.0000	- .9000	.7550
0	150.0000	- .7700	.5750
0	155.0000	- .6700	.4200
0	160.0000	- .6350	.3200
0	165.0000	- .6800	.2300
0	170.0000	- .8500	.1400
0	175.0000	- .6600	.0550
1	180.0000	0.0000	.0250
5000000.0 NACA 0025 SECTION DATA, EPPLER MODEL, CL, CD, JAN 79			
0	0.0000	0.0000	.0084
0	1.0000	.1100	.0084
0	2.0000	.2200	.0085
0	3.0000	.3300	.0087
0	4.0000	.4078	.0089
0	5.0000	.5097	.0092
0	6.0000	.6076	.0097
0	7.0000	.6997	.0103
0	8.0000	.7886	.0110
0	9.0000	.8730	.0117
0	10.0000	.9472	.0126
0	11.0000	1.0177	.0137
0	12.0000	1.0750	.0148
0	13.0000	1.1270	.0161
0	14.0000	1.1717	.0175
0	15.0000	1.2065	.0190
0	16.0000	1.2358	.0207
0	17.0000	1.2617	.0225
0	18.0000	1.2790	.0245
0	19.0000	1.2952	.0267
0	20.0000	1.3121	.0290
0	21.0000	1.3257	.0316
0	22.0000	1.3378	.0344
0	23.0000	1.3558	.0374
0	24.0000	1.3735	.0404
0	25.0000	1.3960	.0436
0	26.0000	1.4187	.0470
0	27.0000	1.4395	.0509
0	30.0000	.8550	.5700
0	35.0000	.9800	.7450
0	40.0000	1.0350	.9200
0	45.0000	1.0500	1.0750
0	50.0000	1.0200	1.2150
0	55.0000	.9550	1.3450
0	60.0000	.8750	1.4700
0	65.0000	.7600	1.5750
0	70.0000	.6300	1.6650
0	75.0000	.5000	1.7350
0	80.0000	.3650	1.7800

Table 6. (cont)

0	85.0000	.2300	1.8000
0	90.0000	.0900	1.8000
0	95.0000	-.0500	1.7800
0	100.0000	-.1850	1.7500
0	105.0000	-.3200	1.7000
0	110.0000	-.4500	1.6350
0	115.0000	-.5750	1.5550
0	120.0000	-.6700	1.4650
0	125.0000	-.7600	1.3500
0	130.0000	-.8500	1.2250
0	135.0000	-.9300	1.0850
0	140.0000	-.9800	.9250
0	145.0000	-.9000	.7550
0	150.0000	-.7700	.5750
0	155.0000	-.6700	.4200
0	160.0000	-.6350	.3200
0	165.0000	-.6800	.2300
0	170.0000	-.8500	.1400
0	175.0000	-.6600	.0550
2	180.0000	0.0000	.0250

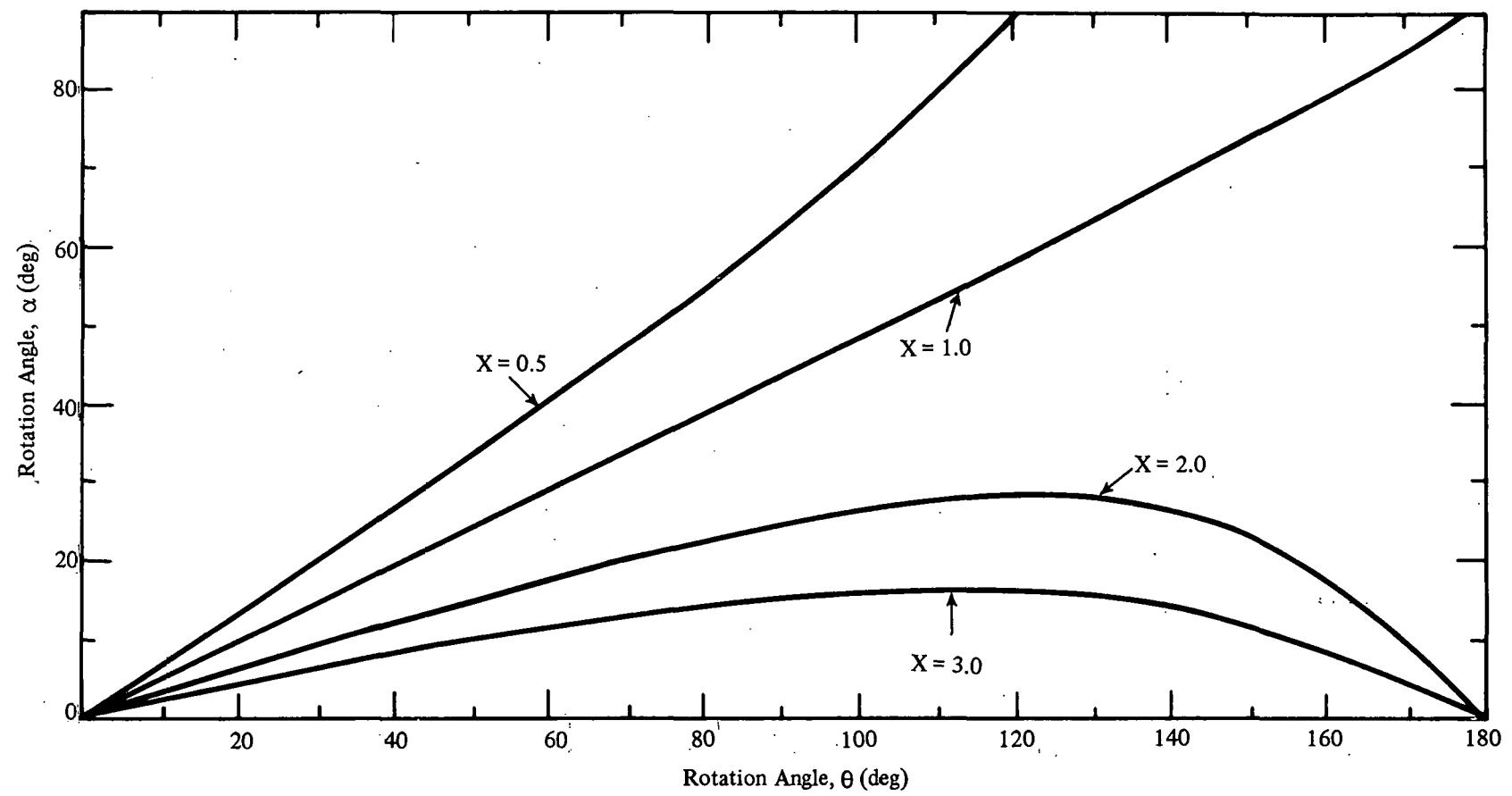


Figure 1. Equatorial Plane Angle of Attack Variation for the 17-Metre Turbine at a Rotational Speed of 46 rpm (4.82 rad/s)

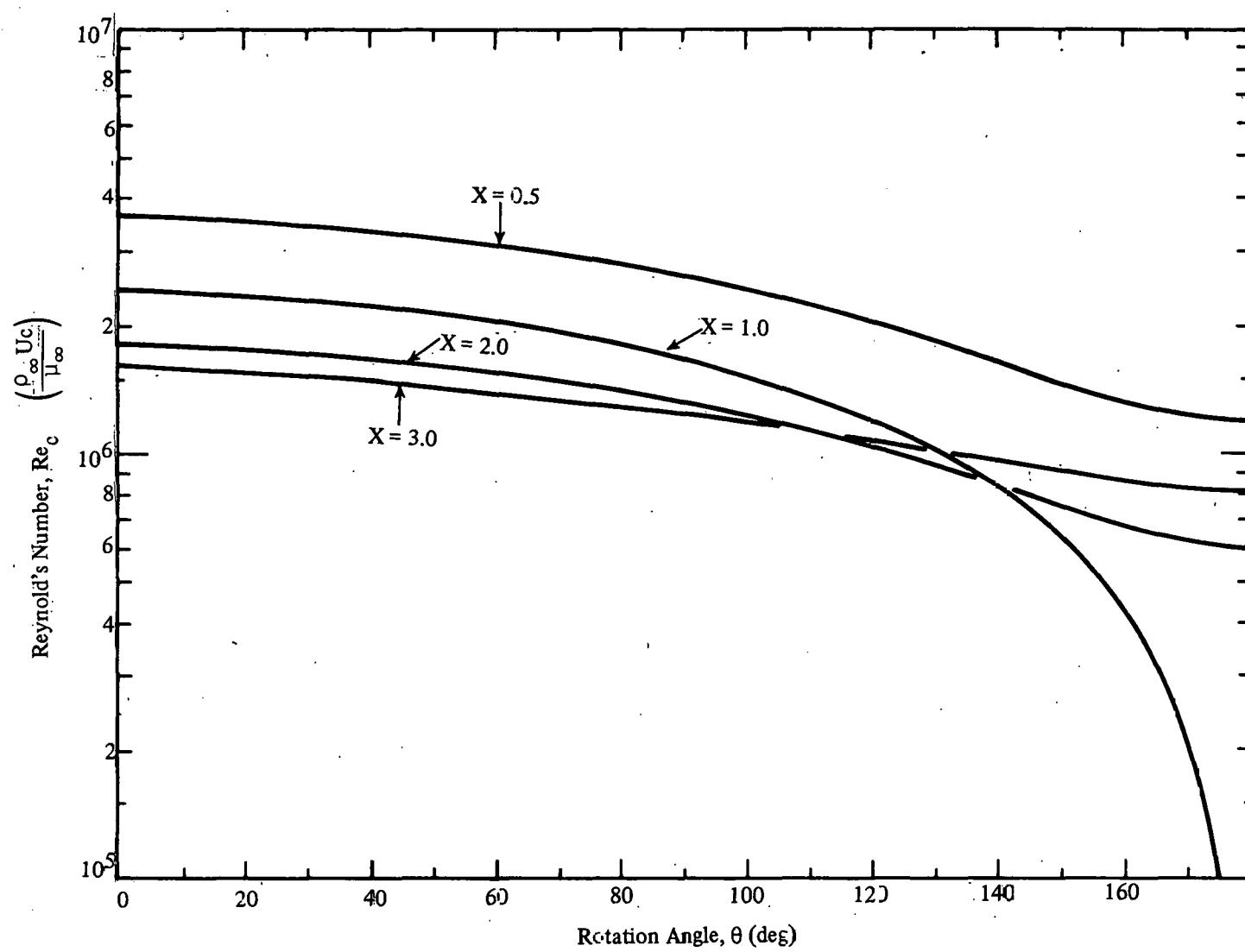


Figure 2. Variation of the Chord Reynolds Number at the Equatorial Plane of the 17-Metre Turbine at a Rotational Speed of 46 rpm (4.82 rad/s)

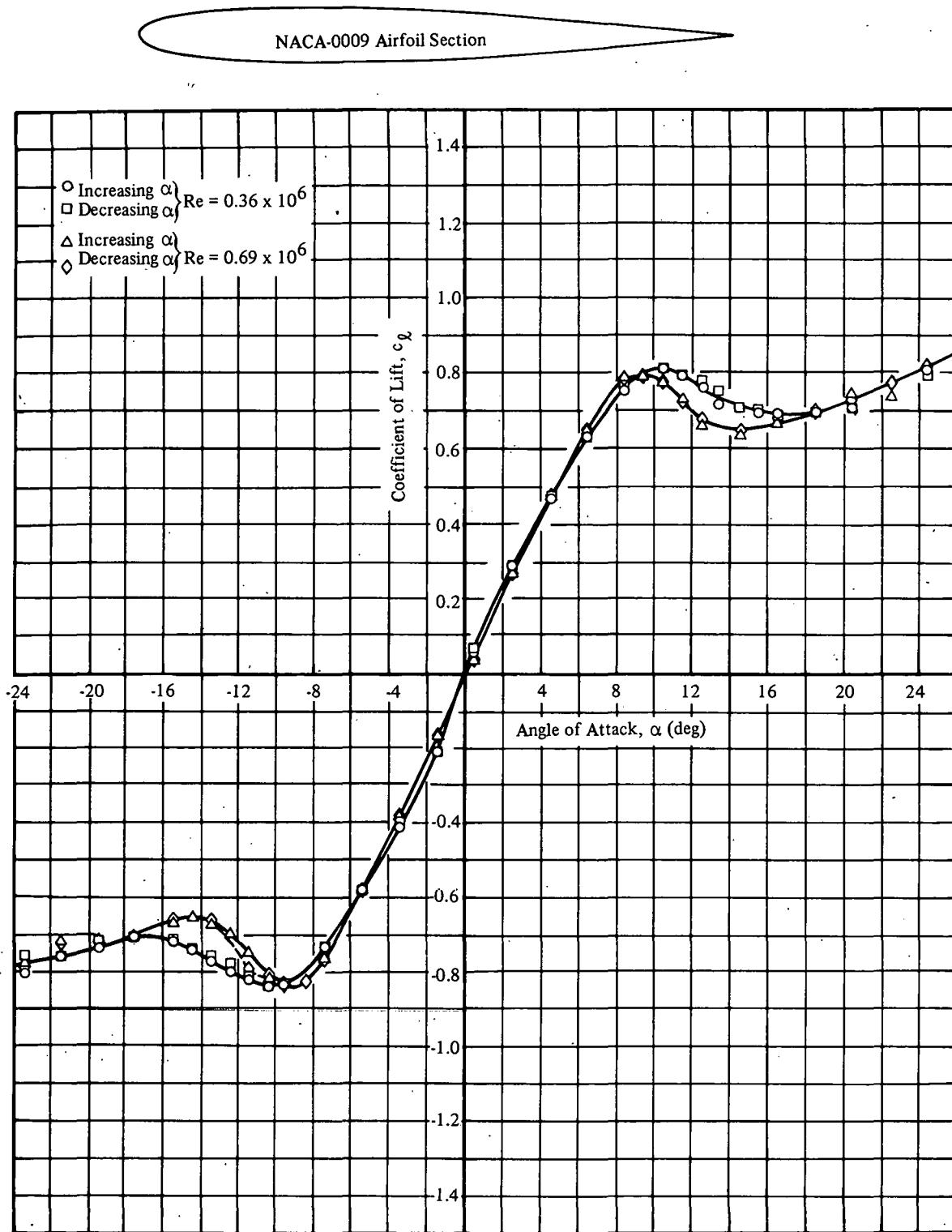


Figure 3. Section Lift Coefficients for the NACA-0009 Airfoil at Reynolds Numbers of 0.36×10^6 and 0.69×10^6

NACA-0012 Airfoil Section

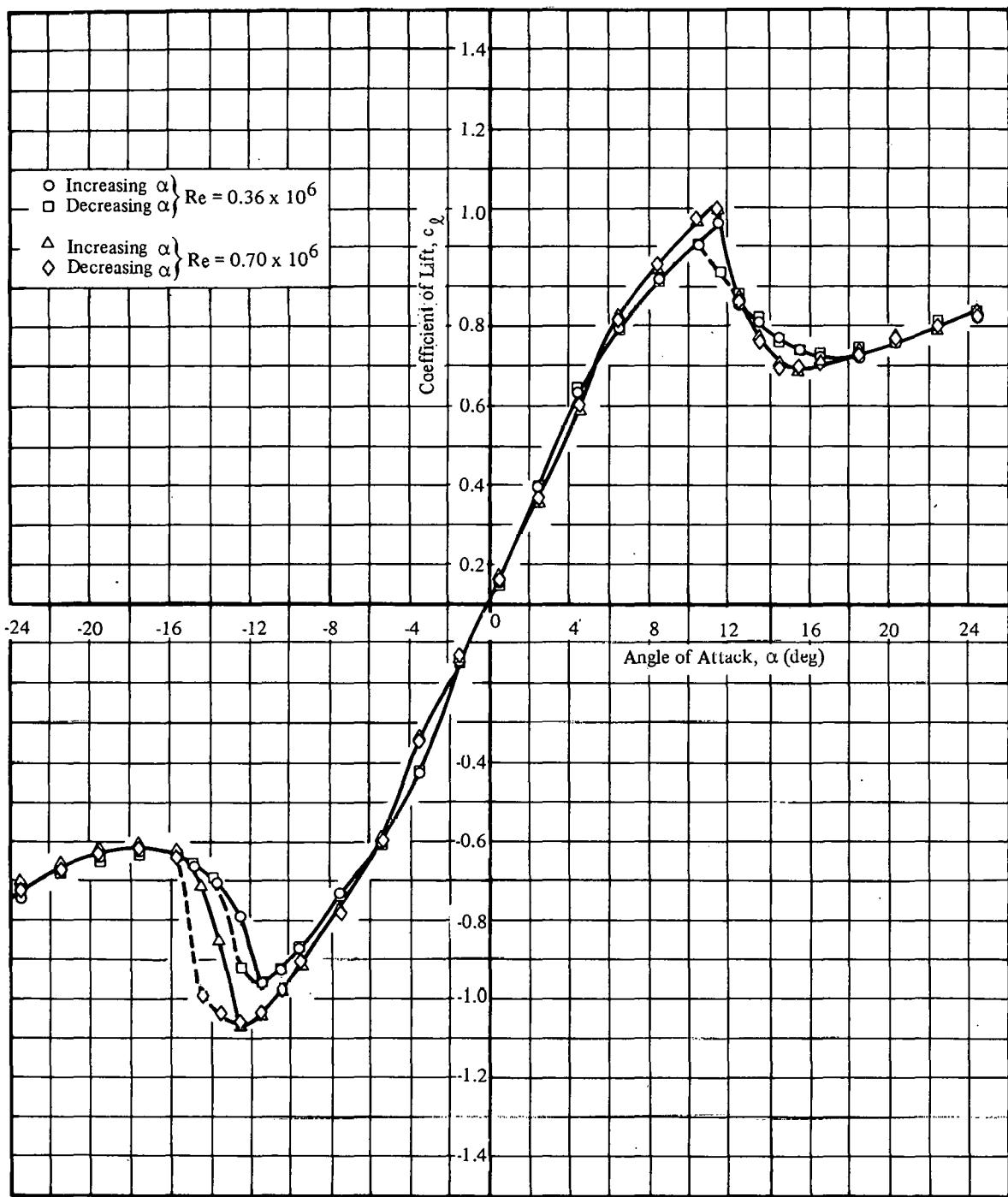


Figure 4. Section Lift Coefficients for the NACA-0012 Airfoil at Reynolds Numbers of 0.36×10^6 and 0.70×10^6

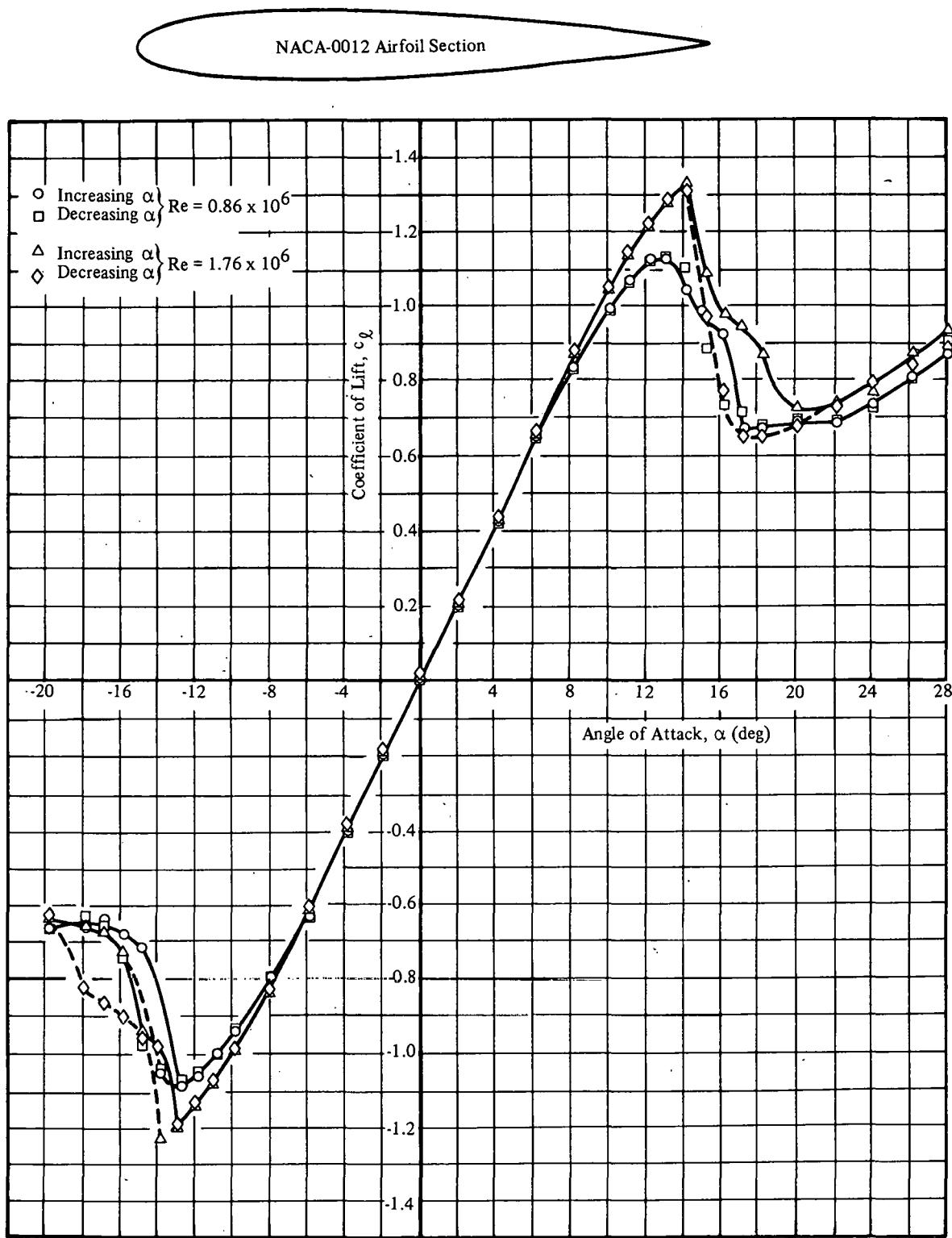


Figure 5. Section Lift Coefficients for the NACA-0012 Airfoil at Reynolds Numbers of 0.86×10^6 and 1.76×10^6

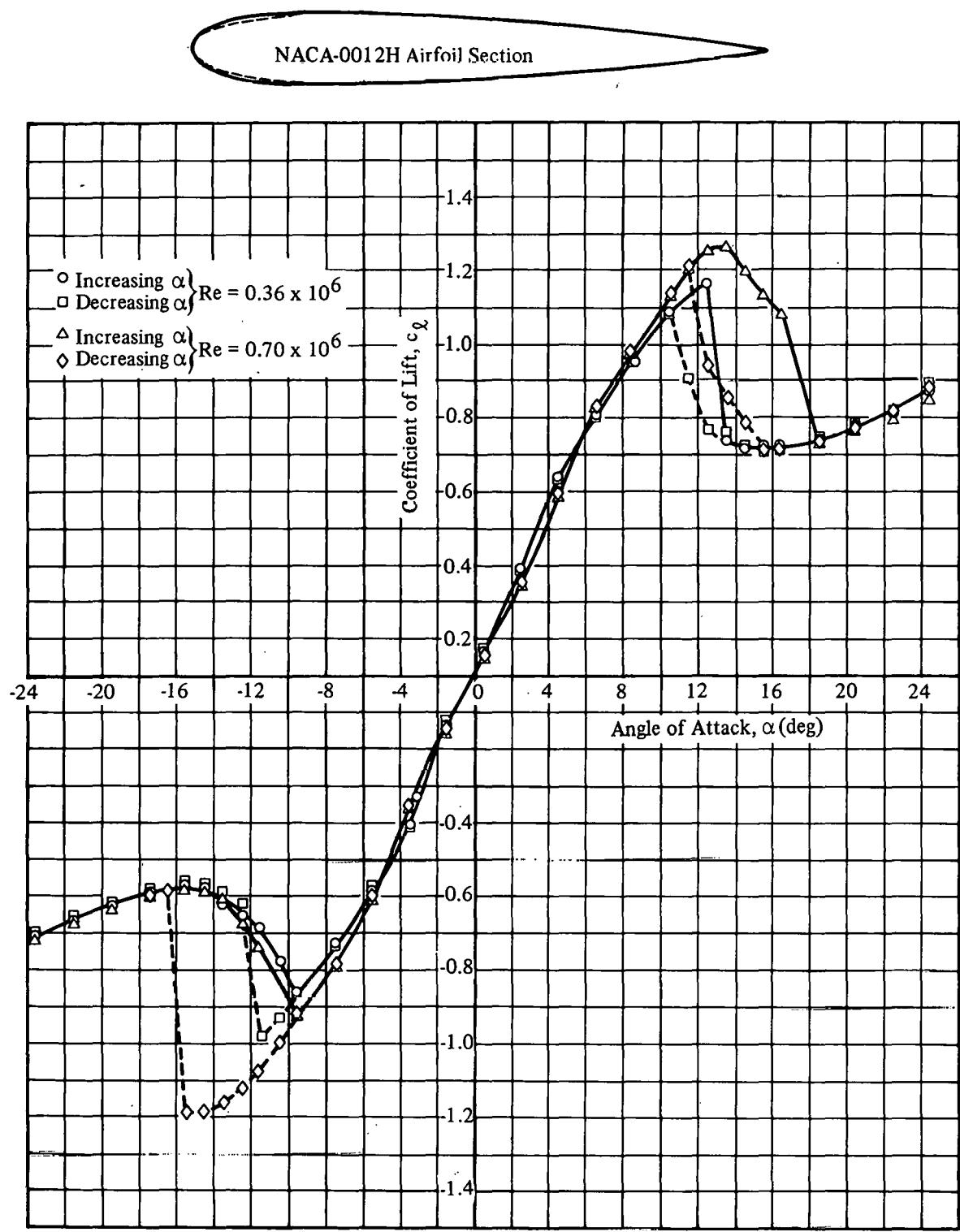


Figure 6. Section Lift Coefficients for the NACA-0012H Airfoil at Reynolds Numbers of 0.36×10^6 and 0.70×10^6

NACA-0015 Airfoil Section

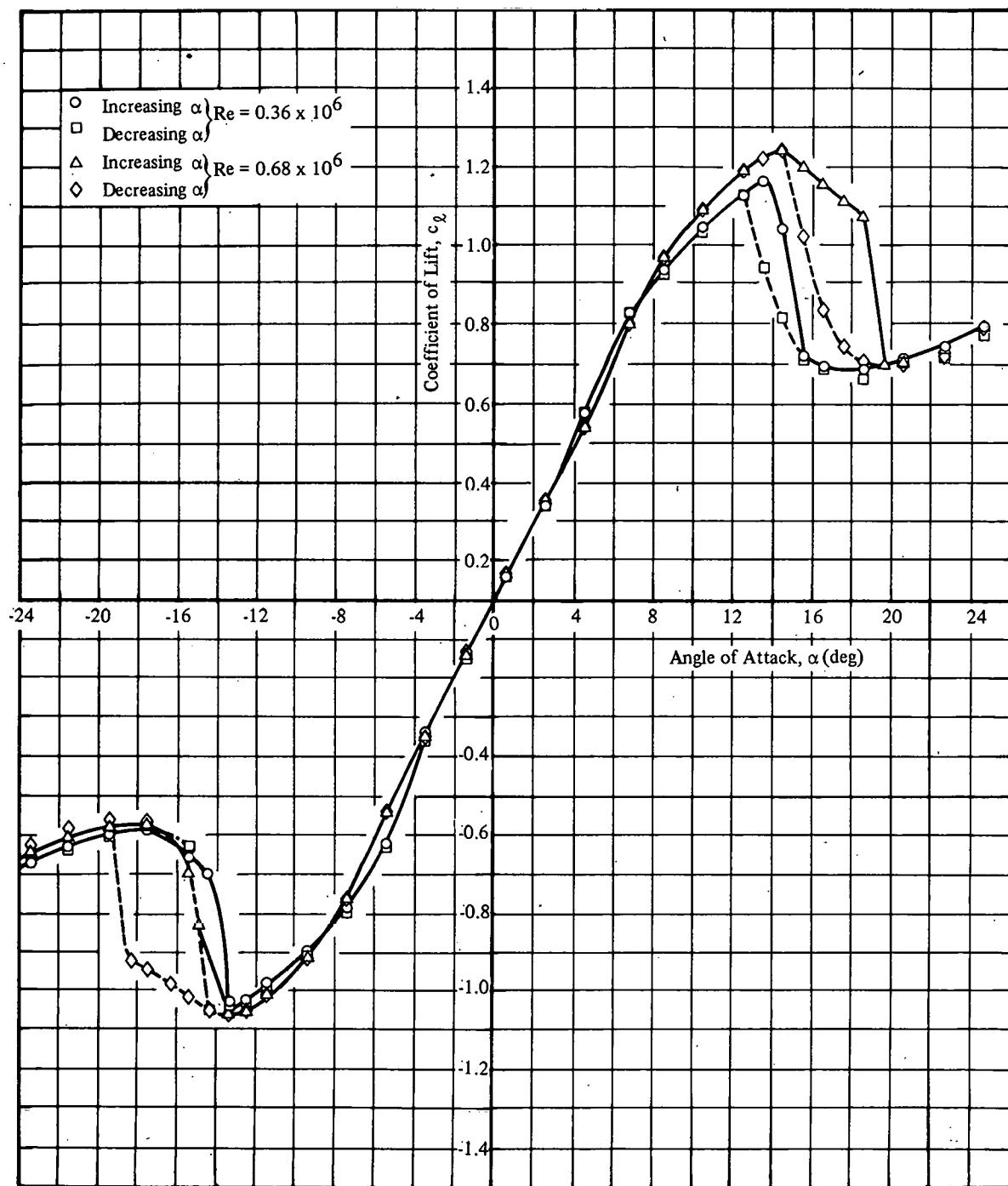


Figure 7. Section Lift Coefficients for the NACA-0015 Airfoil at Reynolds Numbers of 0.36×10^6 and 0.68×10^6

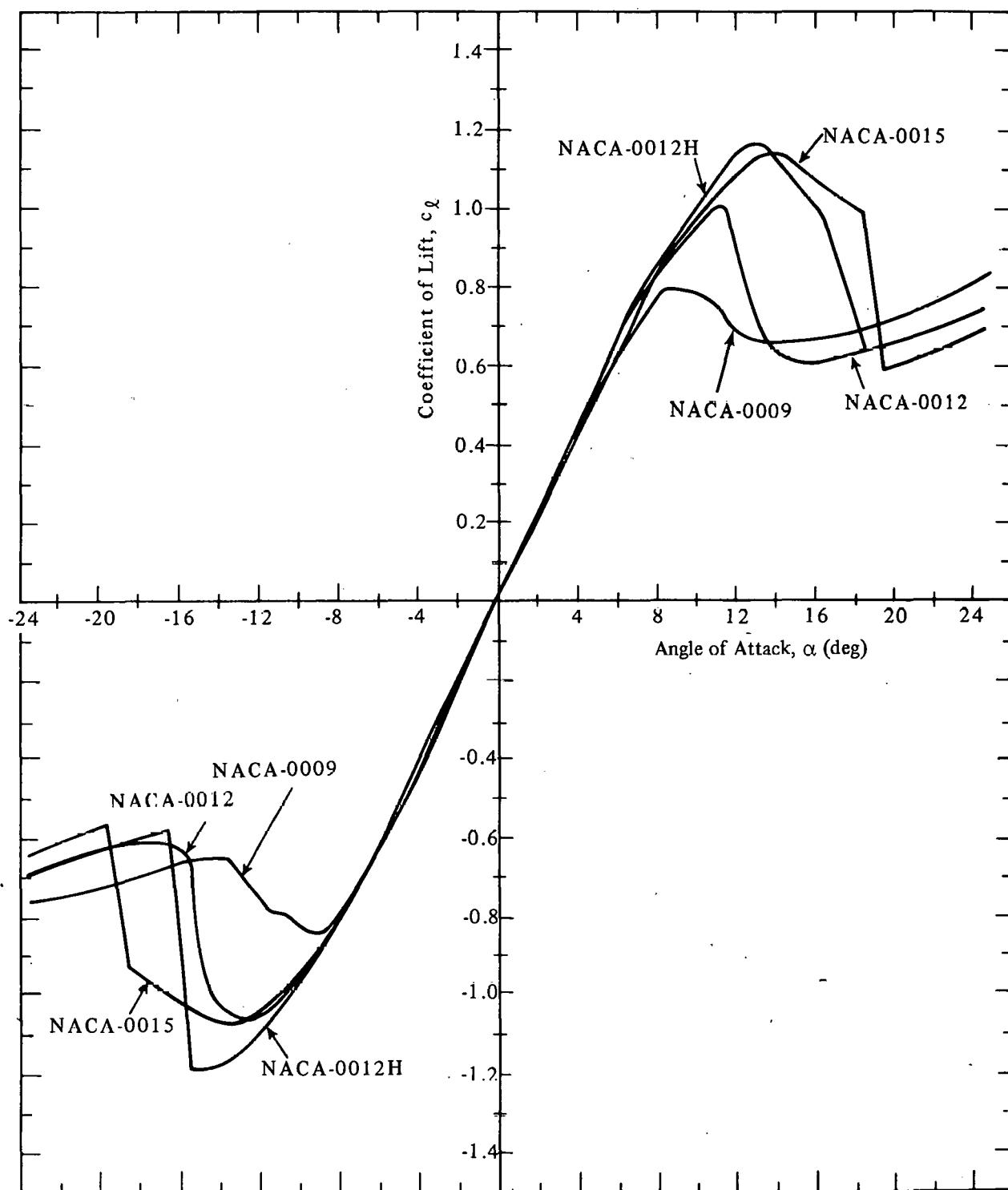


Figure 8. Section Lift Coefficients for Four Airfoil Sections at an Approximate Reynolds Number of 0.70×10^6

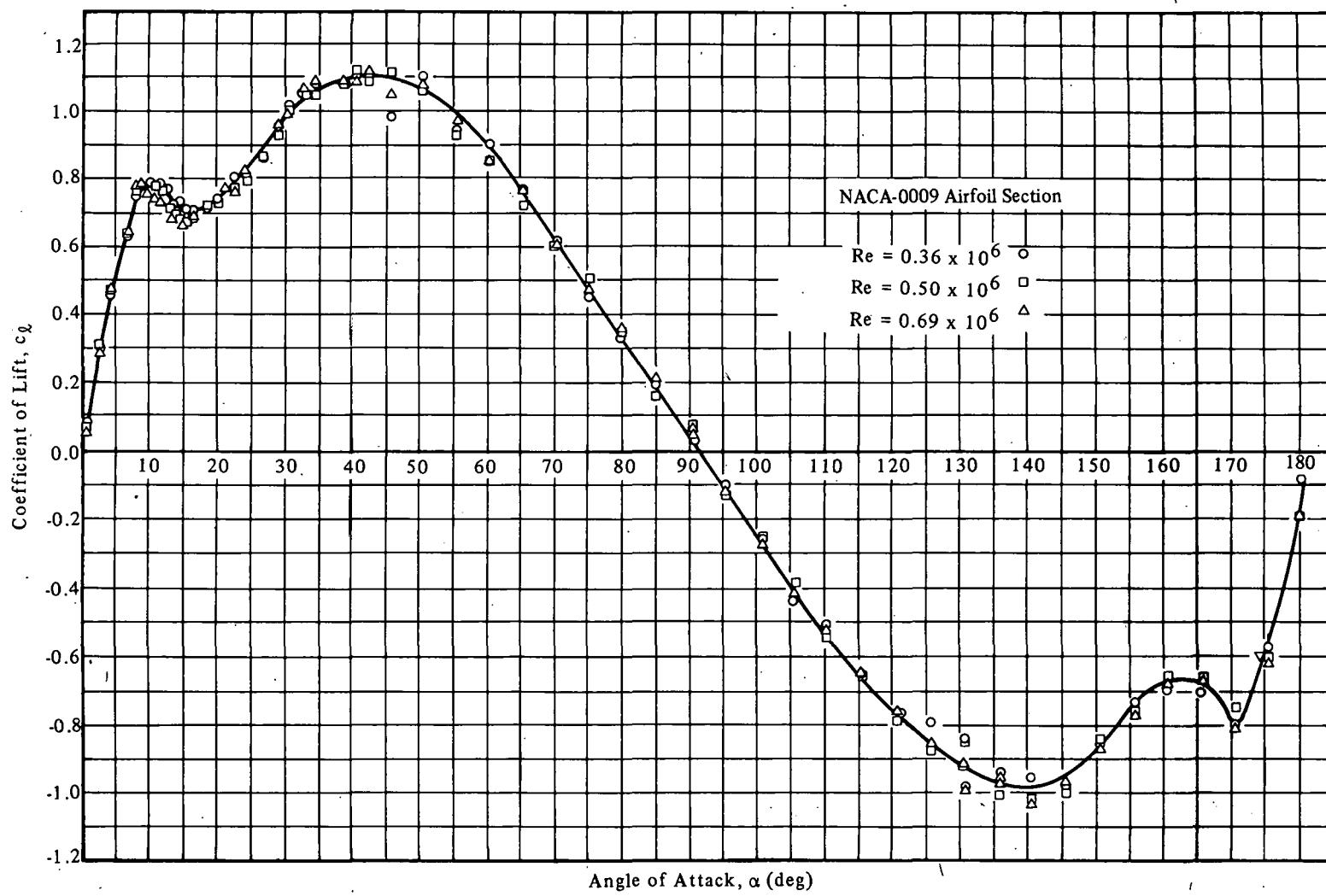


Figure 9. Full Range Section Lift Coefficients for the NACA-0009 Airfoil at Reynolds Numbers of 0.36×10^6 , 0.50×10^6 , and 0.69×10^6

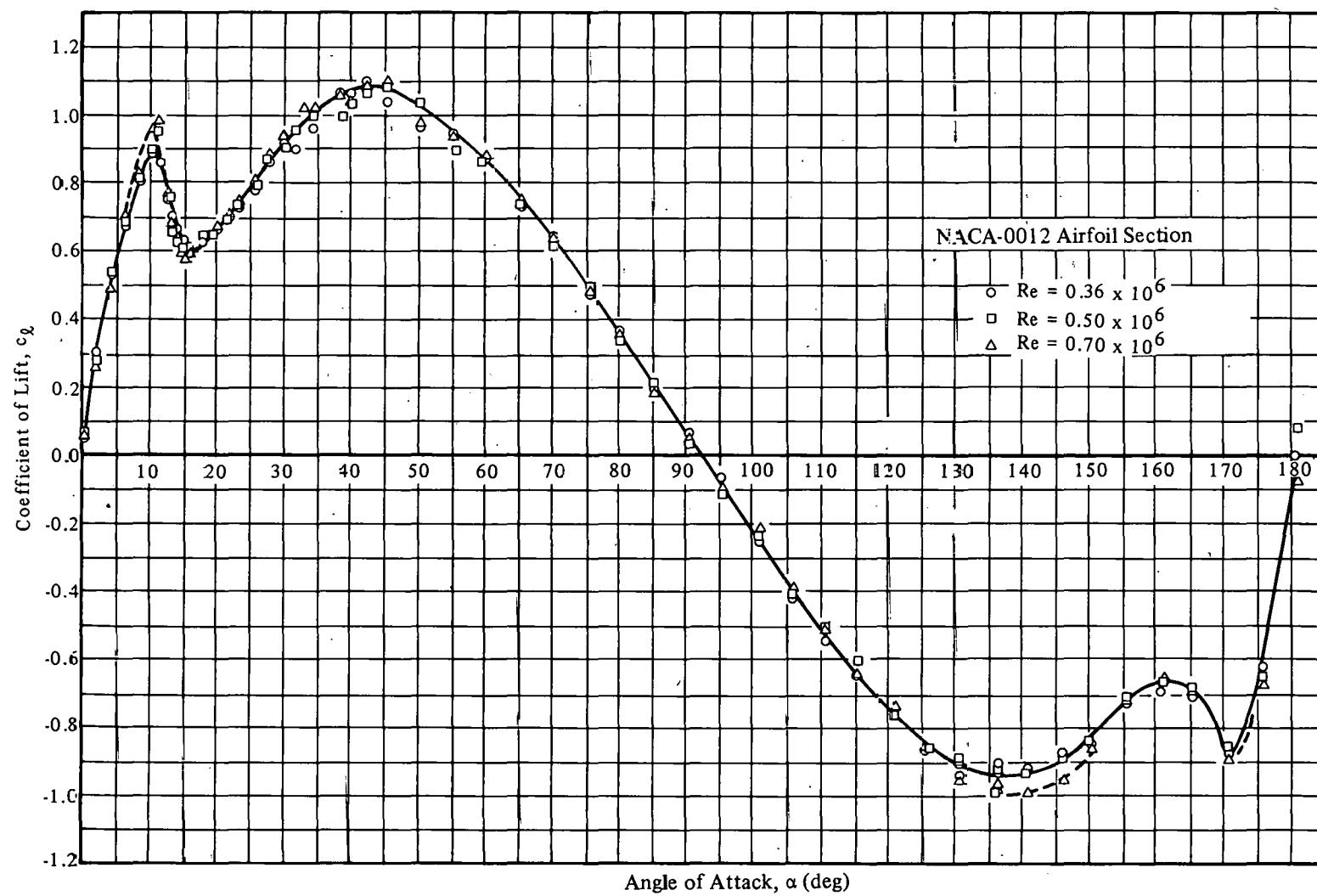


Figure 10. Full Range Section Lift Coefficients for the NACA-0012 Airfoil at Reynolds Numbers of 0.36×10^6 , 0.50×10^6 , and 0.70×10^6

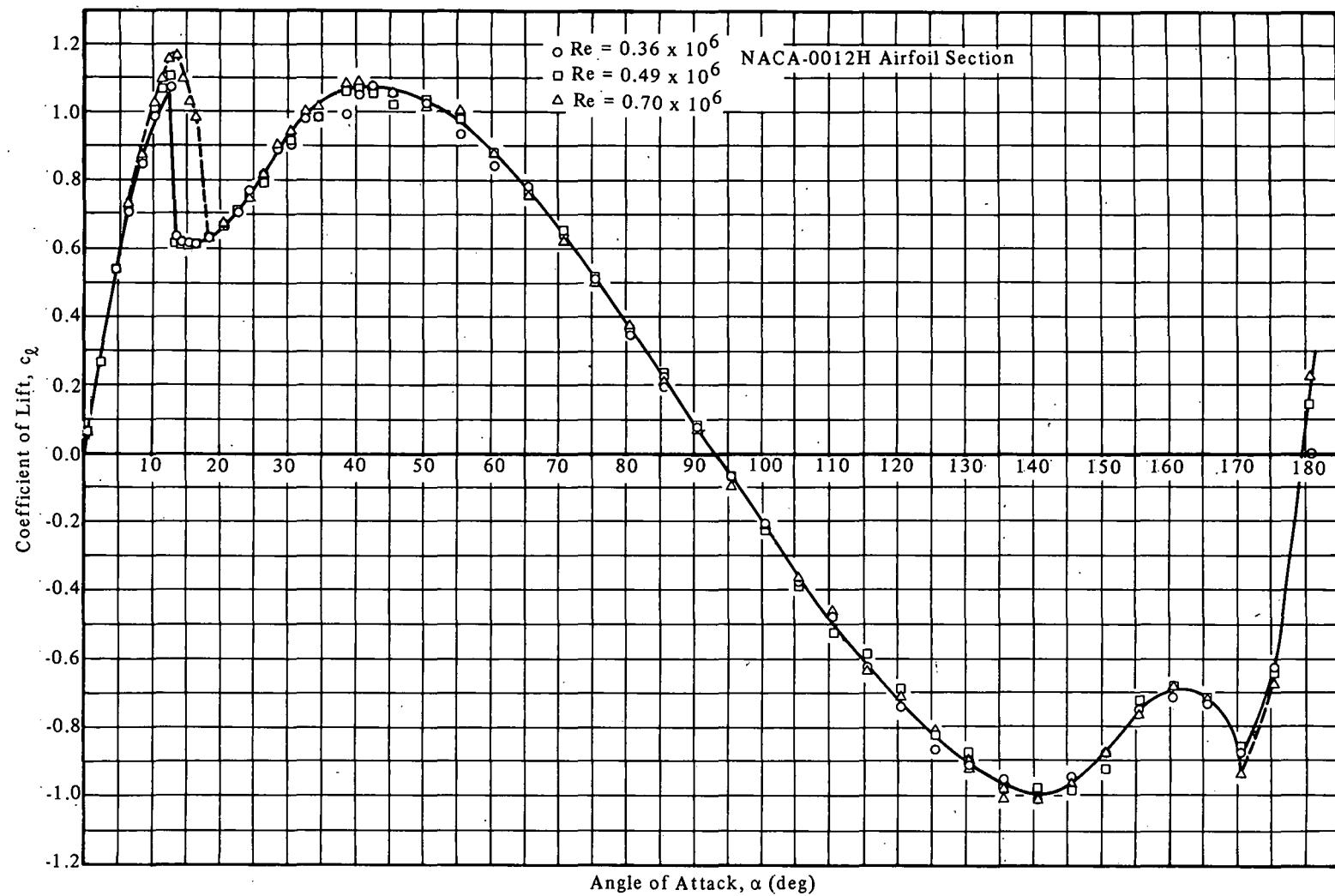


Figure 11. Full Range Section Lift Coefficients for the NACA-0012H Airfoil at Reynolds Numbers of 0.36×10^6 , 0.49×10^6 , and 0.70×10^6

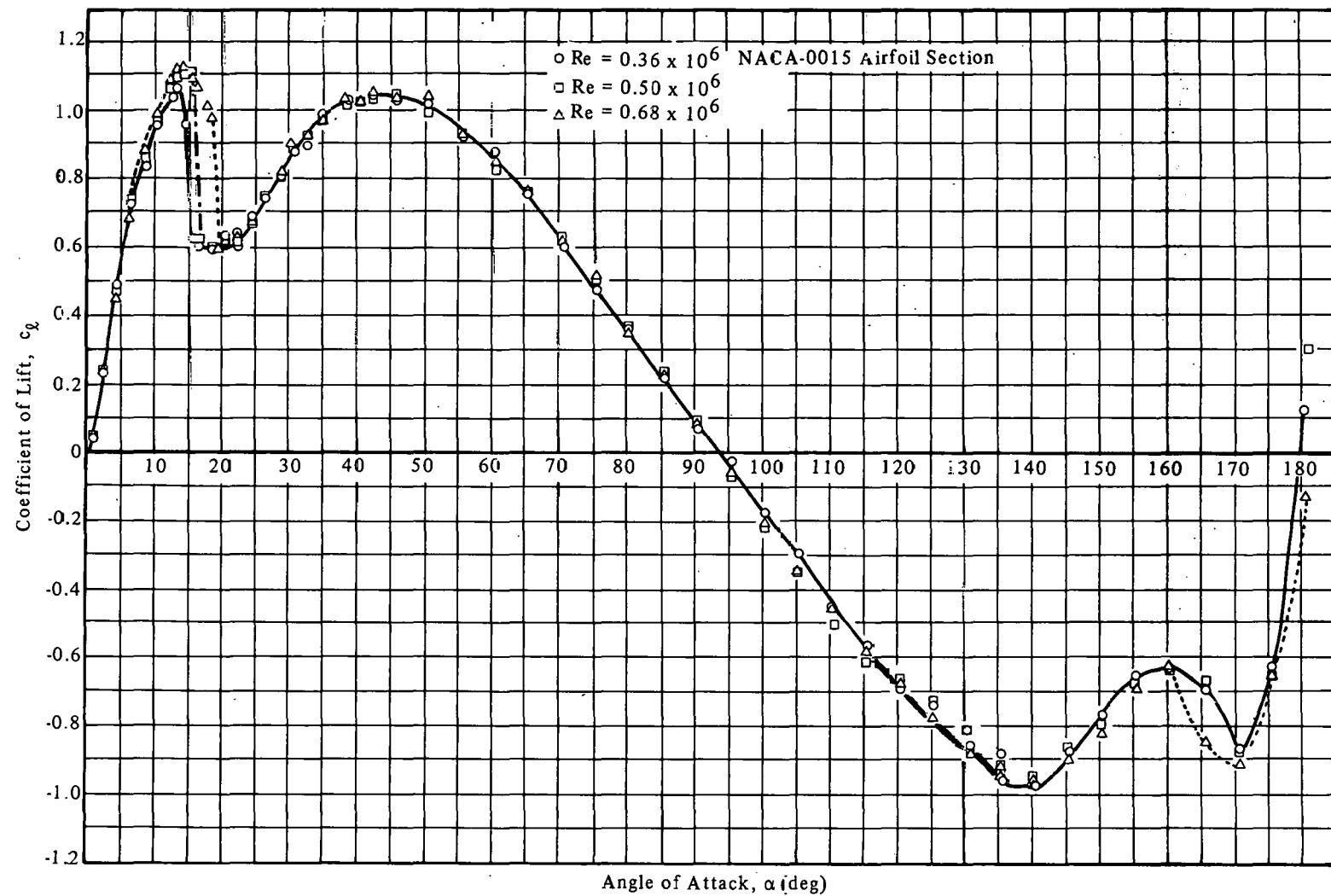


Figure 12. Full Range Section Lift Coefficients for the NACA-0015 Airfoil at Reynolds Numbers of 0.36×10^6 , 0.50×10^6 , and 0.68×10^6

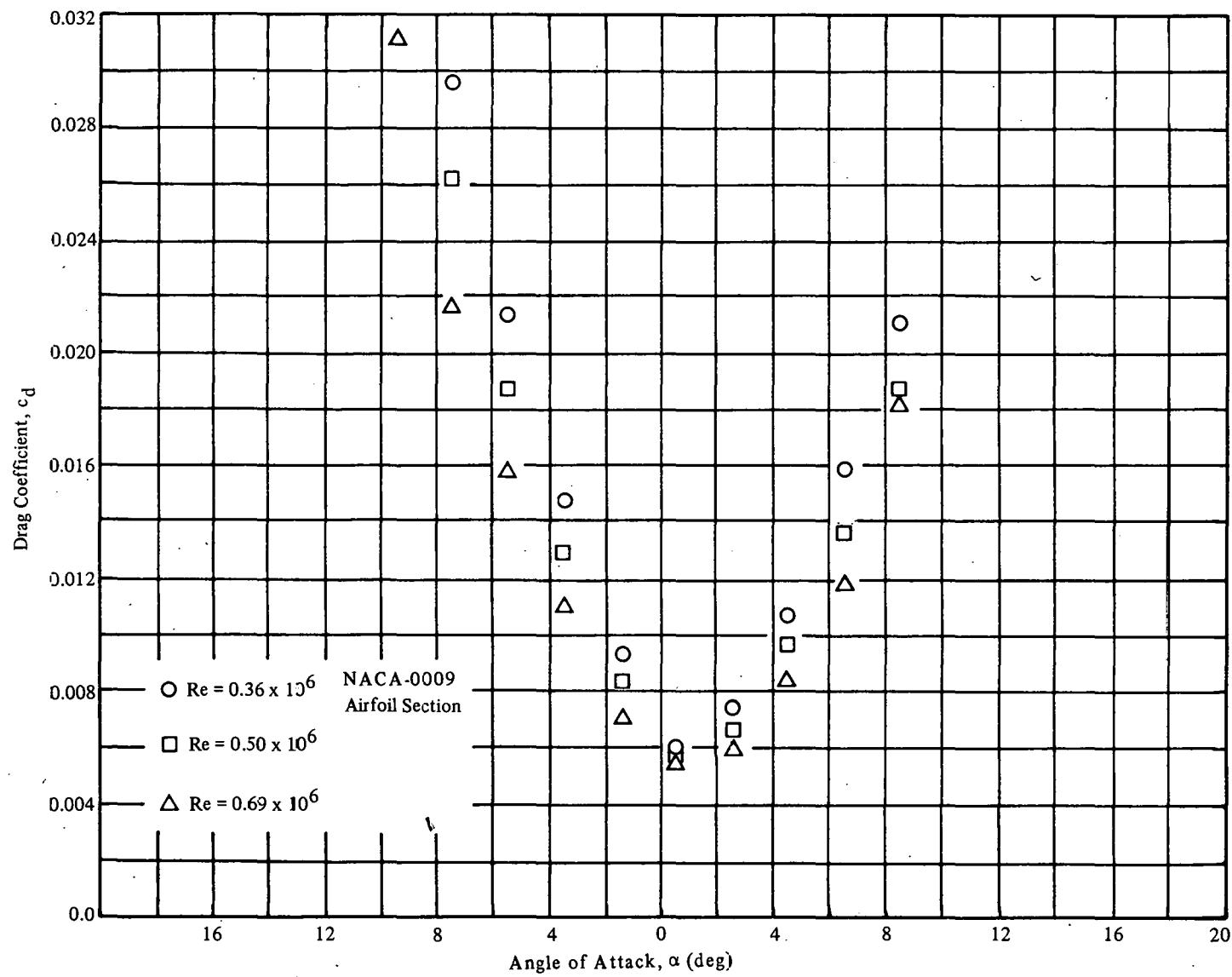


Figure 13. Section Drag Coefficients for the NACA-0009 Airfoil at Small Angles of Attack and Reynolds Numbers of 0.36×10^6 , 0.50×10^6 , and 0.69×10^6 .

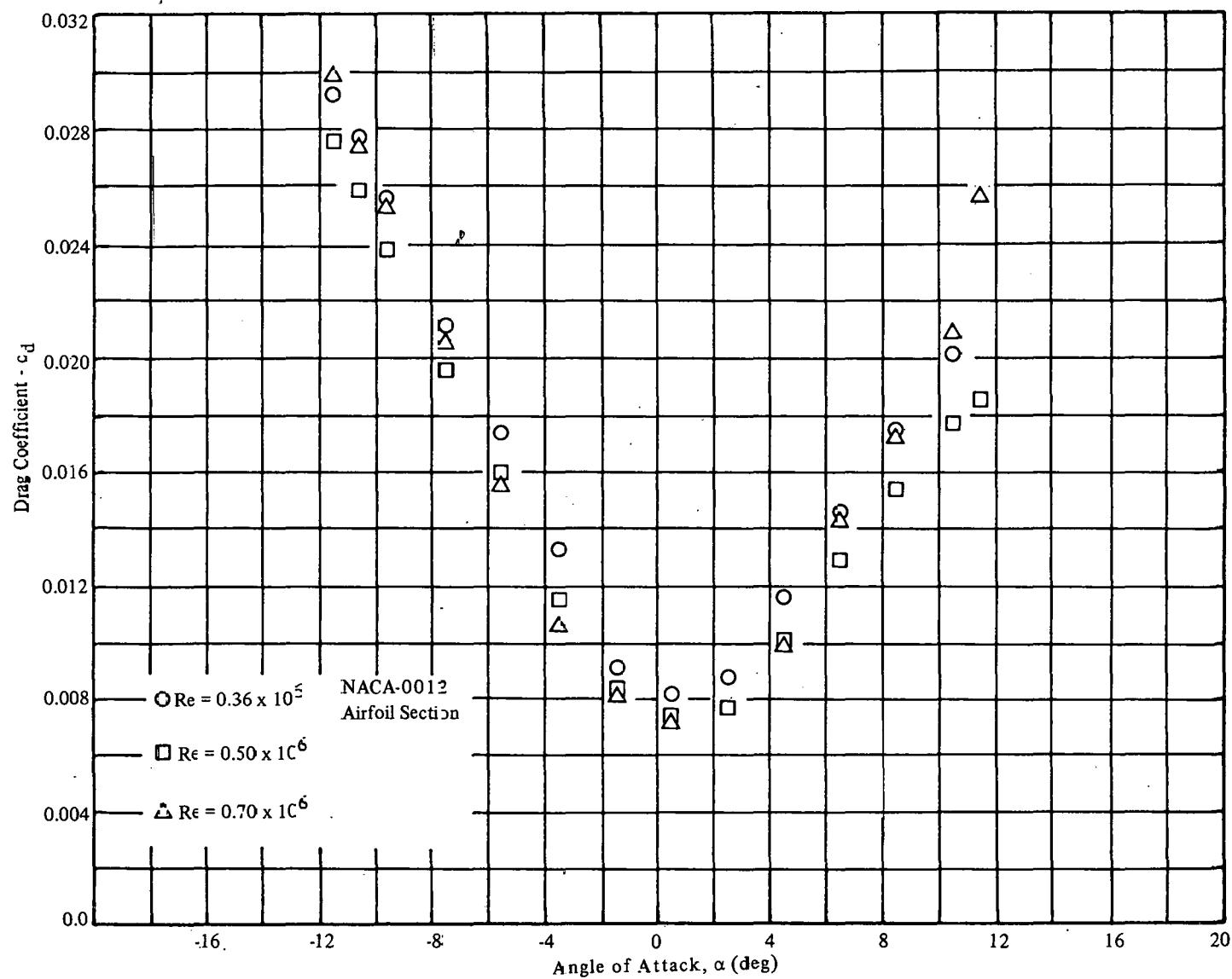


Figure 14. Section Drag Coefficients for the NACA-0012 Airfoil at Small Angles of Attack and Reynolds Numbers of 0.36×10^6 , 0.50×10^6 , and 0.70×10^6

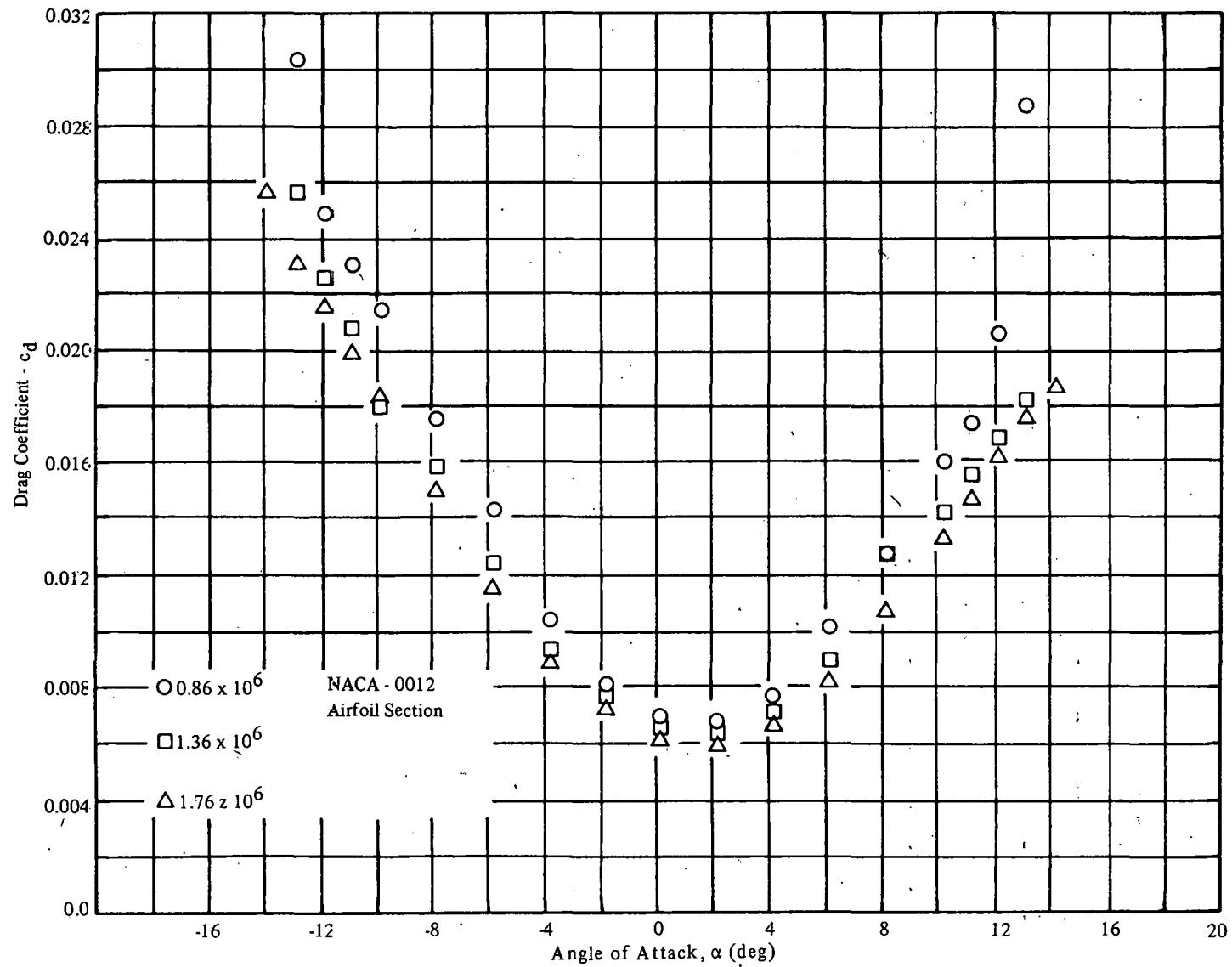


Figure 15. Section Drag Coefficients for the NACA-0012 Airfoil at Small Angles of Attack and Reynolds Numbers of 0.86×10^6 , 1.36×10^6 , and 1.76×10^6

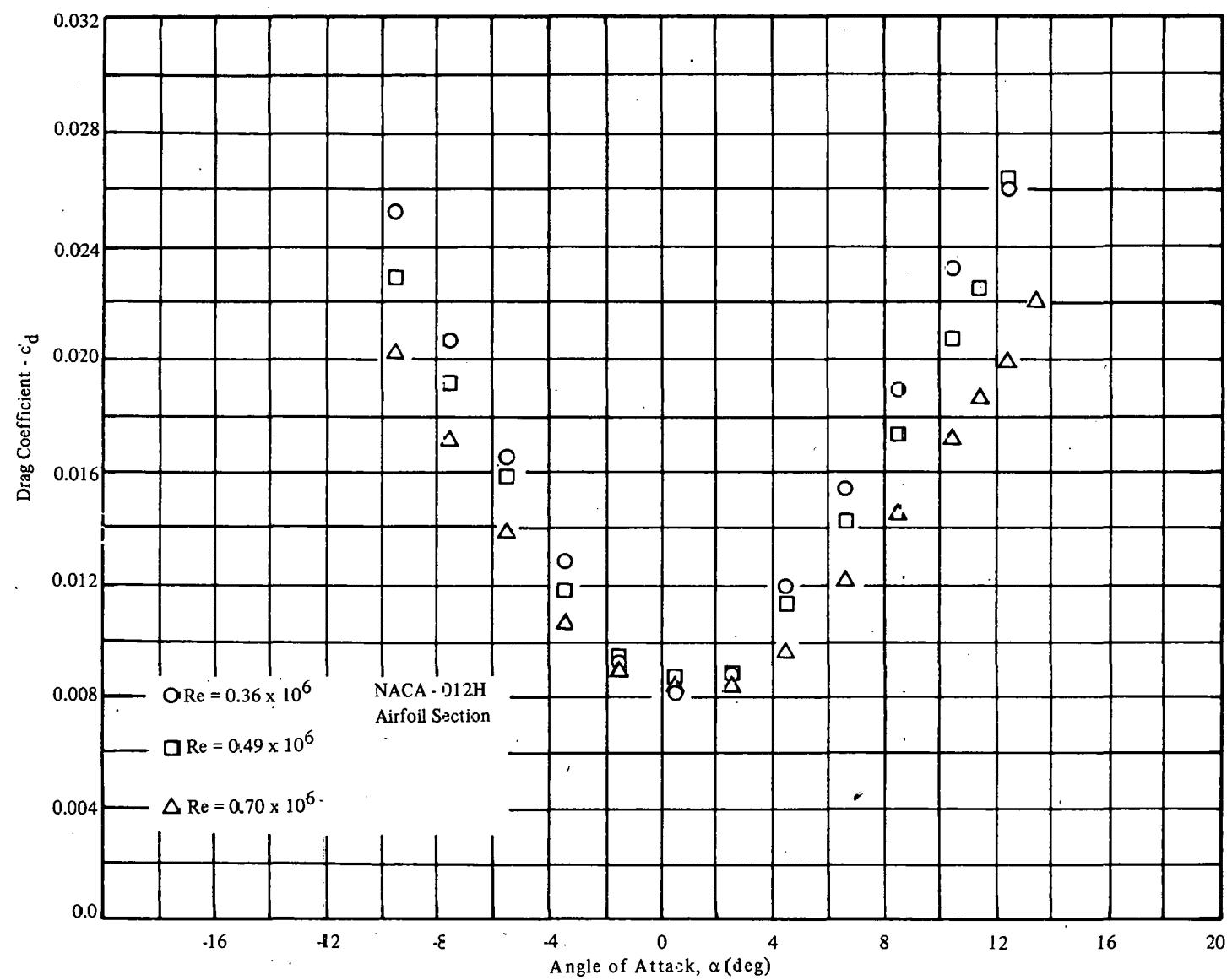


Figure 16. Section Drag Coefficients for the NACA-0012H Airfoil at Small Angles of Attack and Reynolds Numbers of 0.36×10^6 , 0.49×10^6 , and 0.70×10^6 .

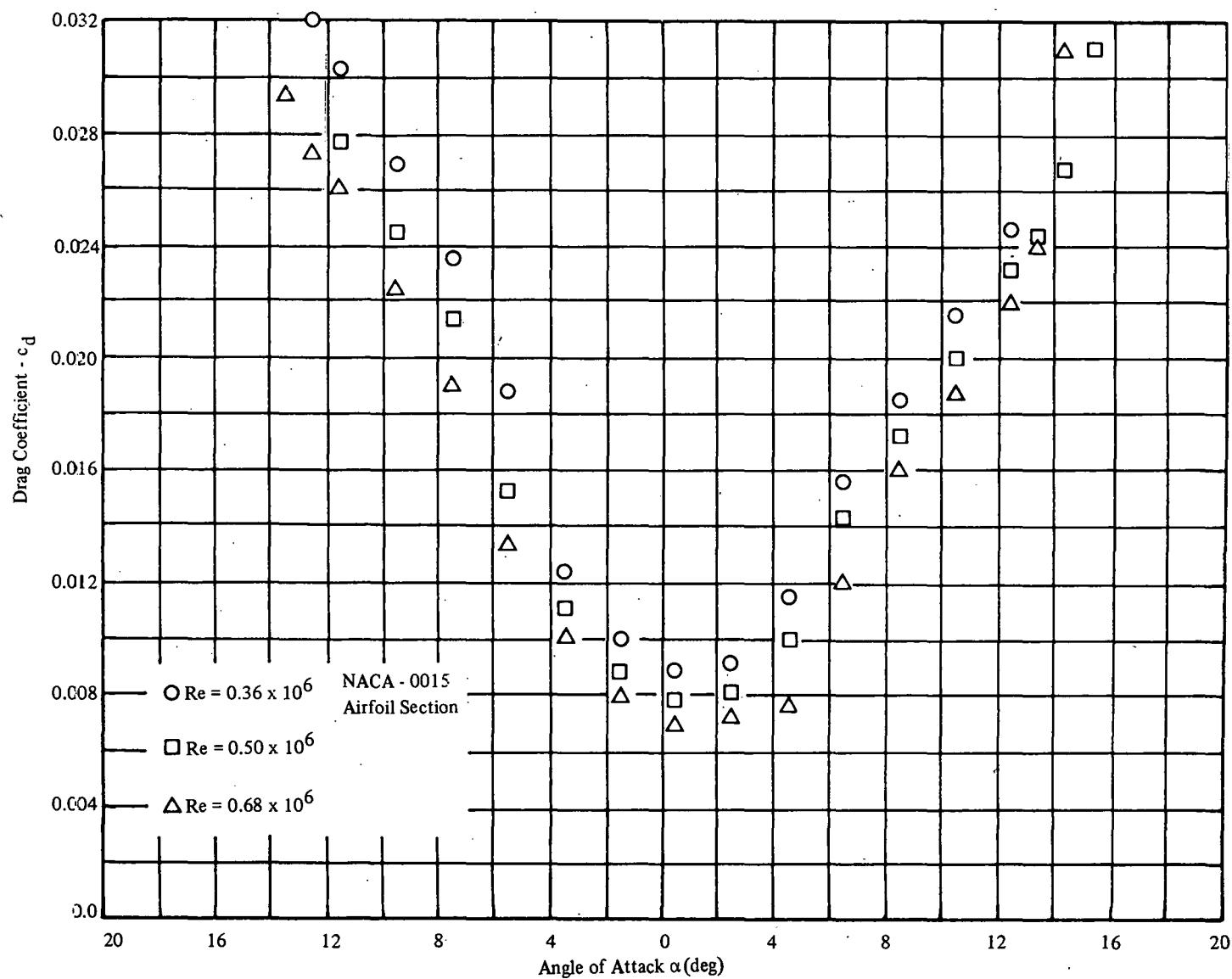


Figure 17, Section Drag Coefficients for the NACA-0015 Airfoil at Small Angles of Attack and Reynolds Numbers of 0.36×10^6 , 0.50×10^6 , and 0.68×10^6

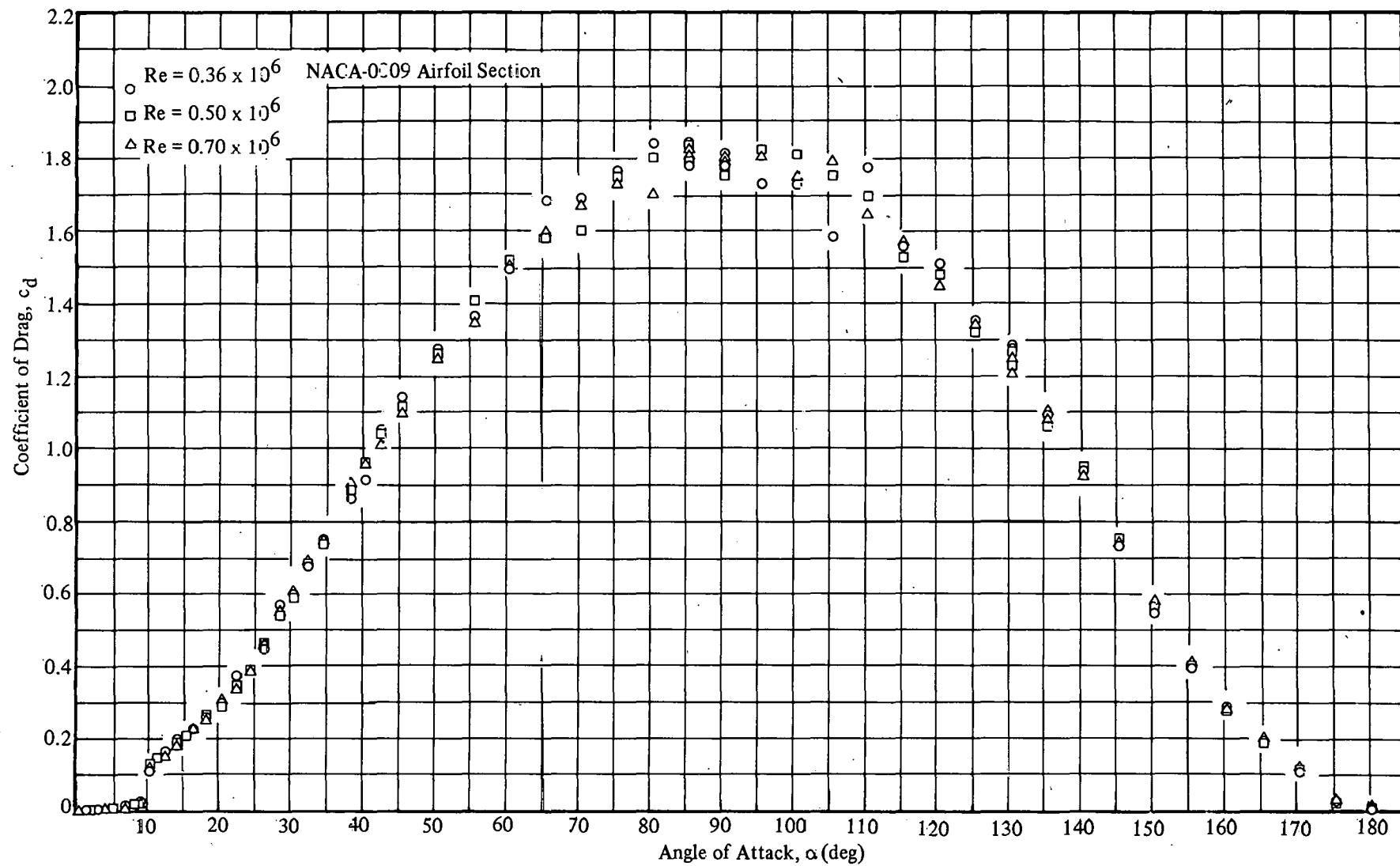


Figure 18. Full Range Section Drag Coefficients for the NACA-0009 Airfoil at Reynolds Numbers of 0.36×10^6 , 0.50×10^6 , and 0.69×10^6

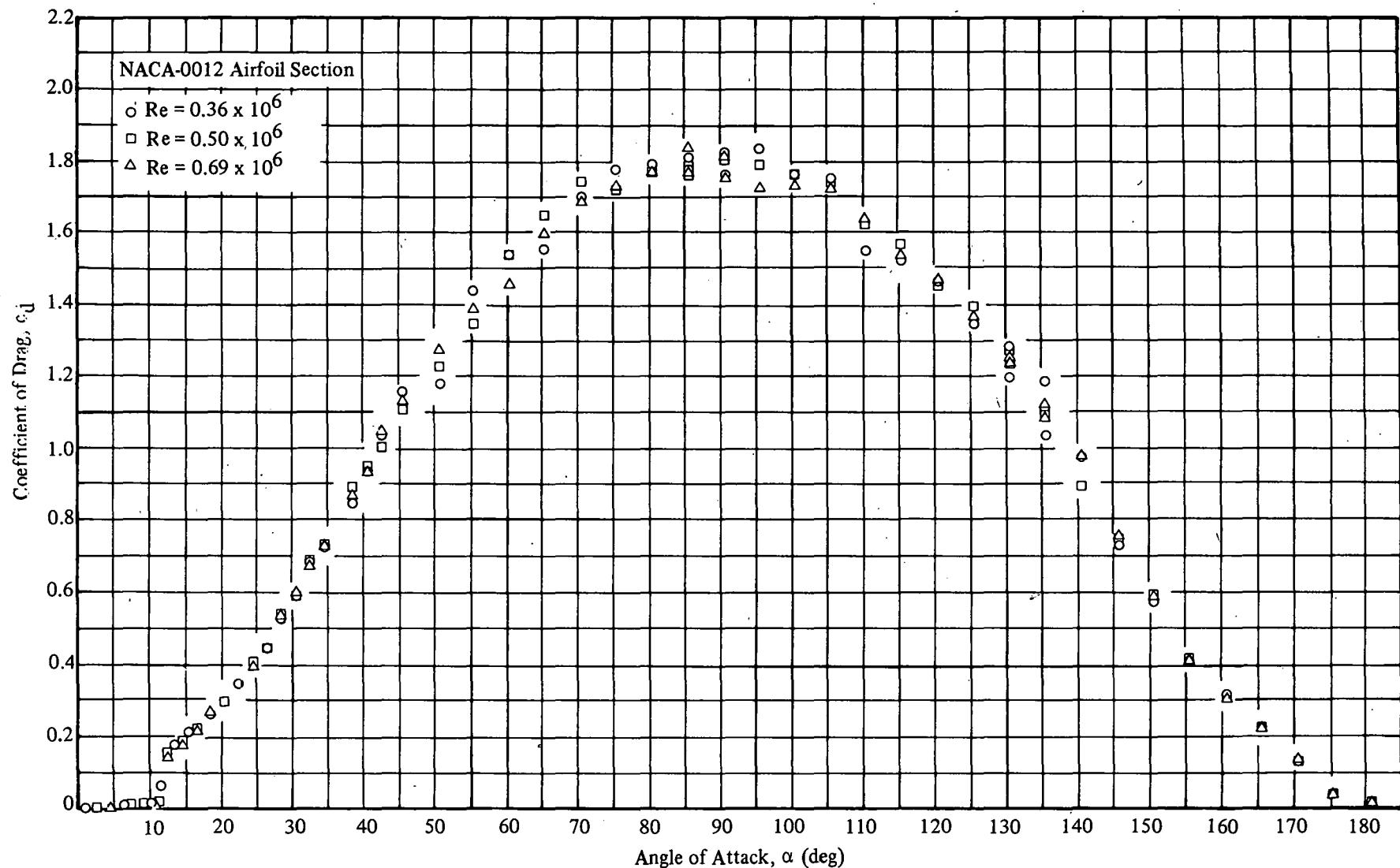


Figure 19. Full Range Section Drag Coefficients for the NACA-0012 Airfoil at Reynolds Numbers of 0.36×10^6 , 0.50×10^6 , and 0.70×10^6

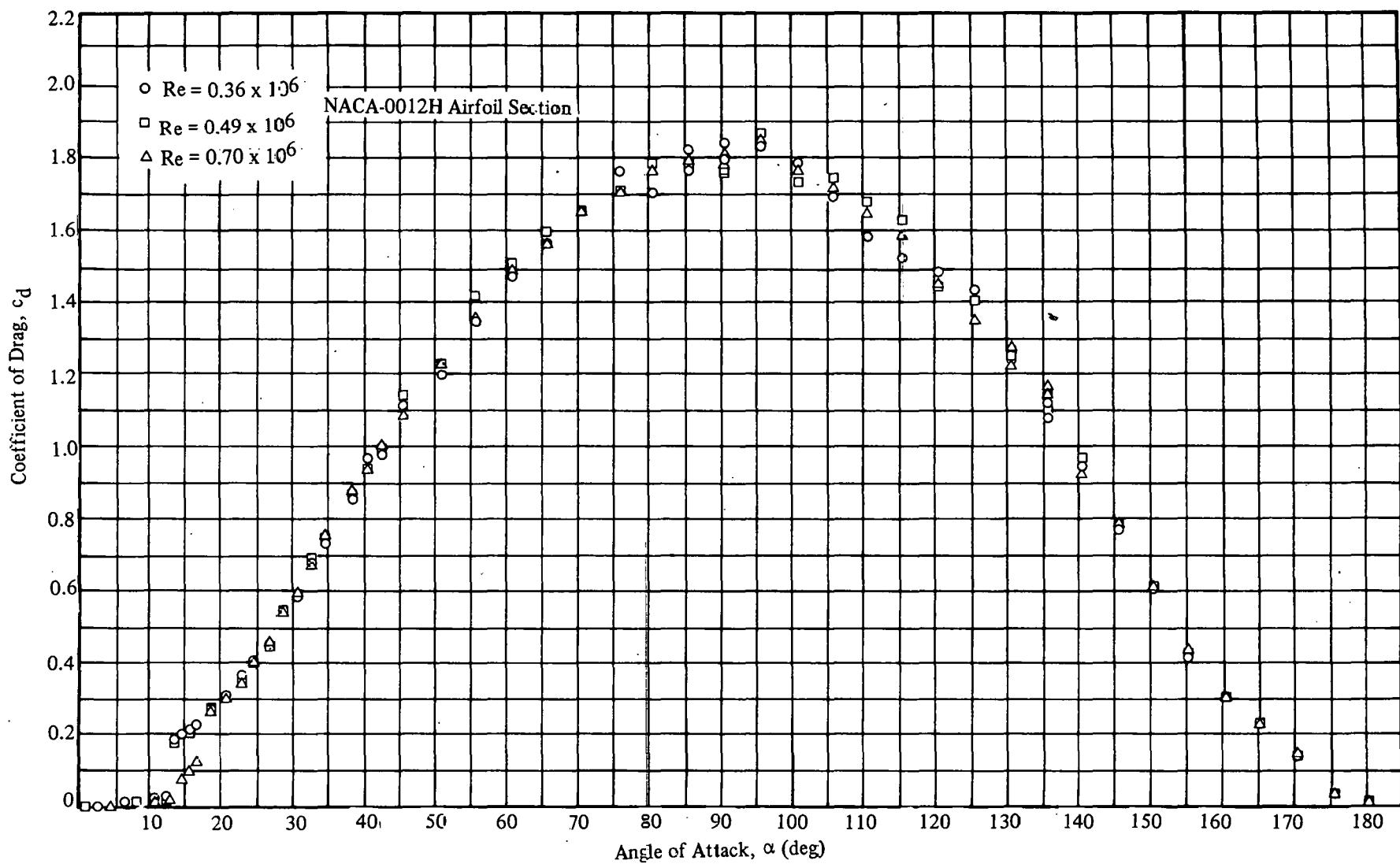


Figure 20. Full Range Section Drag Coefficients for the NACA-0012H Airfoil at Reynolds Numbers of 0.36×10^6 , 0.49×10^6 , and 0.70×10^6

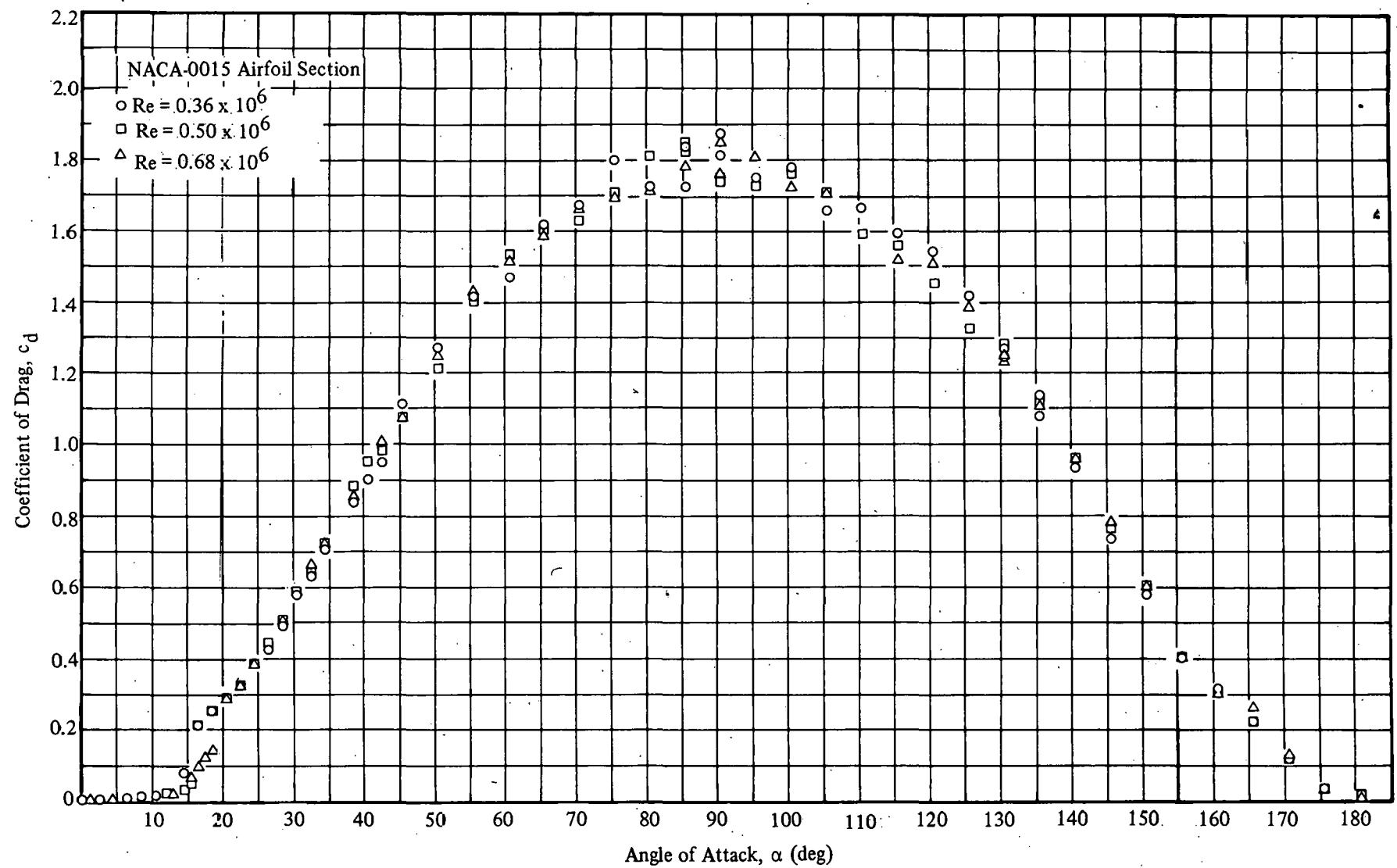


Figure 21. Full Range Section Drag Coefficients for the NACA-0015 Airfoil at Reynolds Numbers of 0.36×10^6 , 0.50×10^6 , and 0.68×10^6

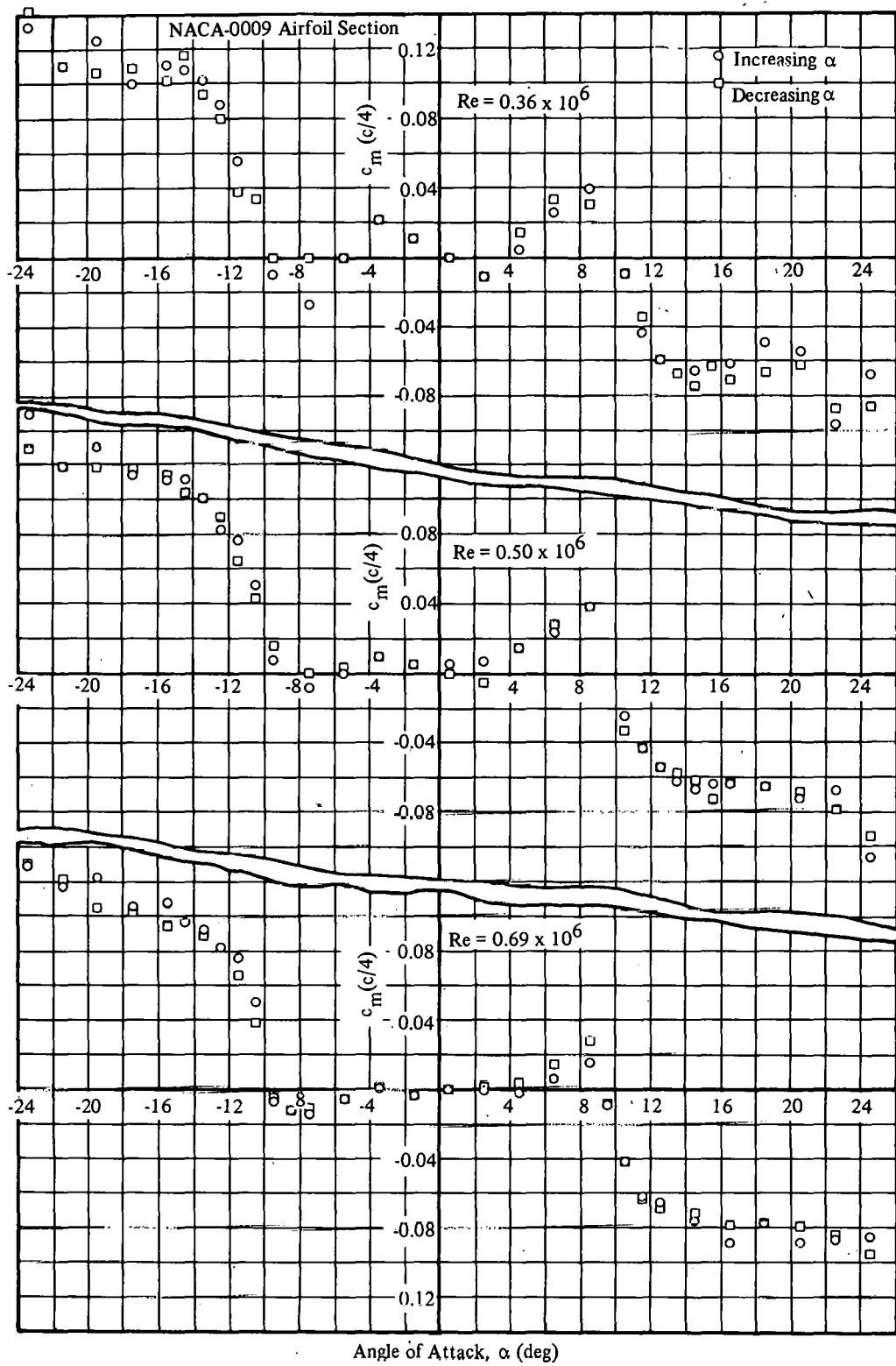


Figure 22. NACA-0009 Airfoil Section Moment Coefficients About the Quarter Chord for Reynolds Numbers of 0.36×10^6 , 0.50×10^6 , and 0.69×10^6 .

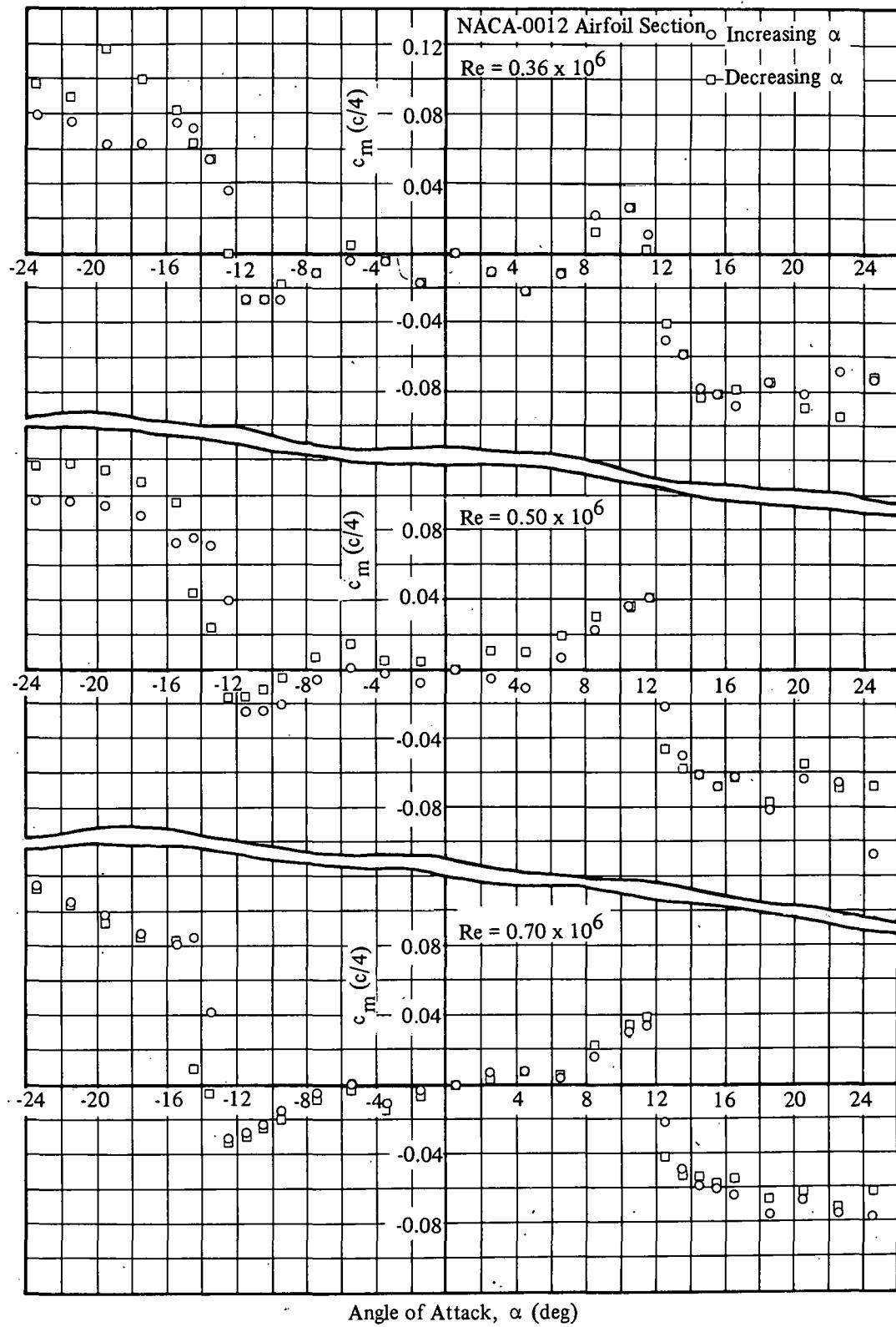


Figure 23. NACA-0012 Airfoil Section Moment Coefficients About the Quarter Chord for Reynolds Numbers of 0.36×10^6 , 0.50×10^6 , and 0.70×10^6

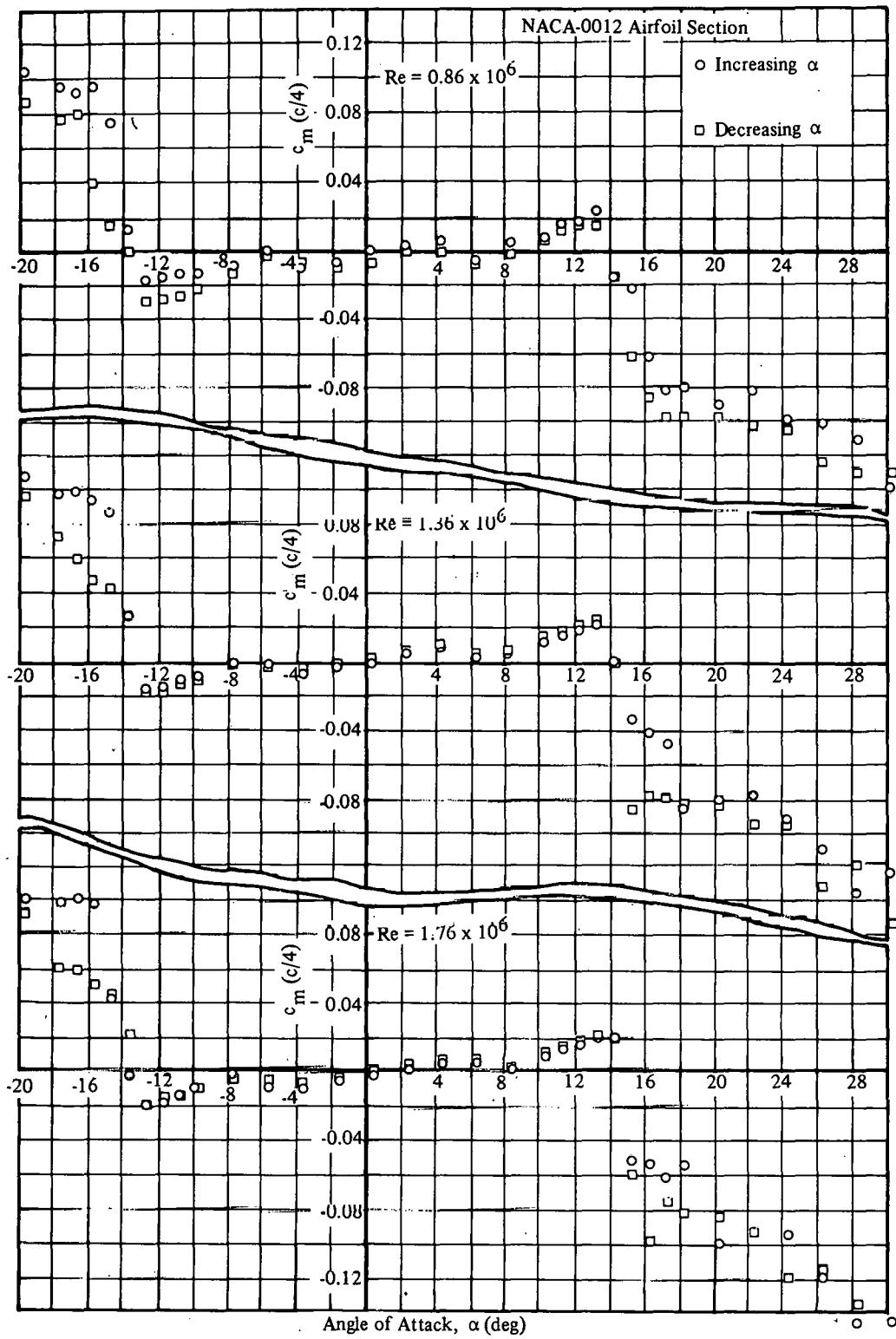


Figure 24. NACA-0012 Airfoil Section Moment Coefficients About the Quarter Chord for Reynolds Numbers of 0.86×10^6 , 1.36×10^6 , and 1.76×10^6

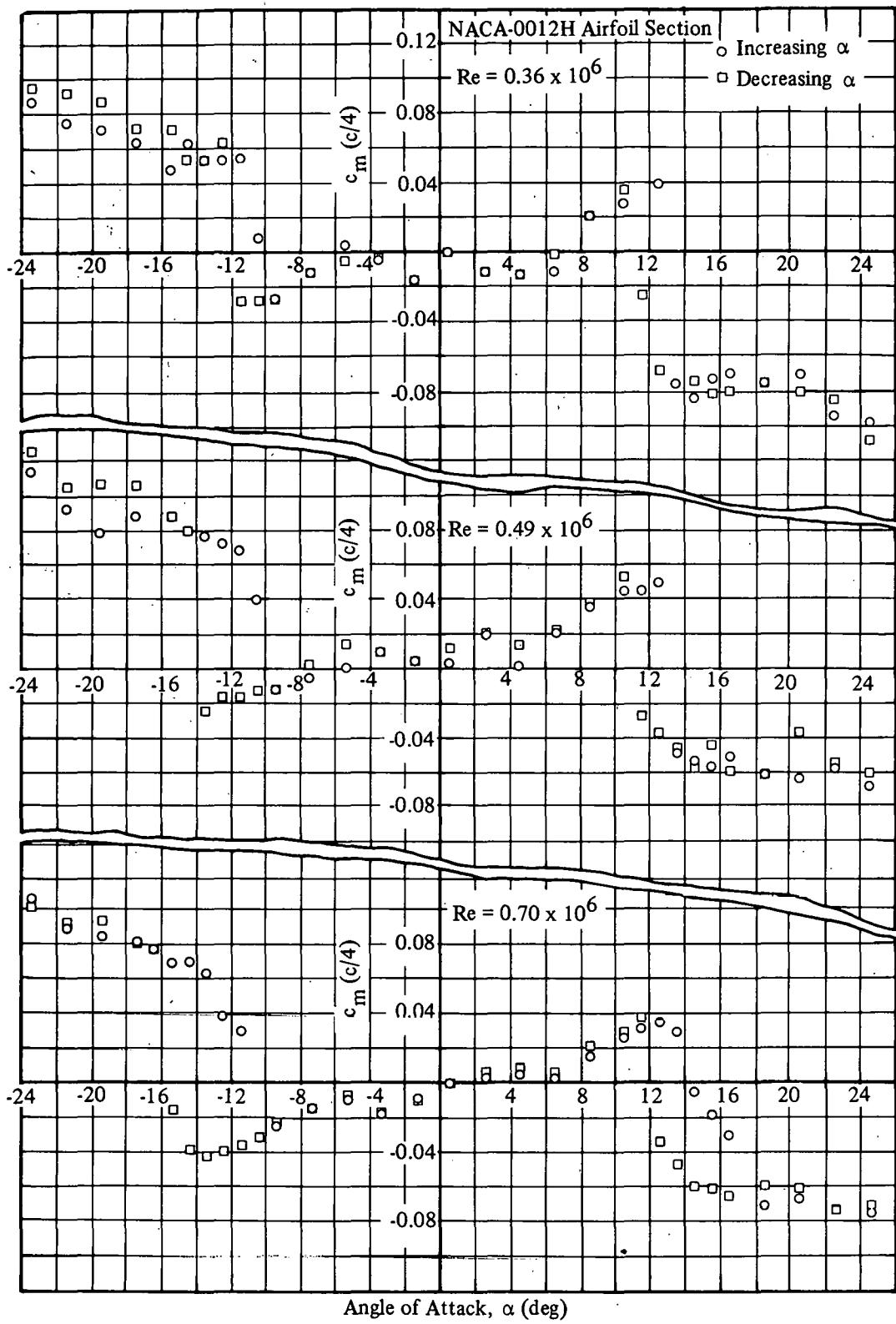


Figure 25. NACA-0012H Airfoil Section Moment Coefficients About the Quarter Chord for Reynolds Numbers of 0.36×10^6 , 0.49×10^6 , and 0.70×10^6

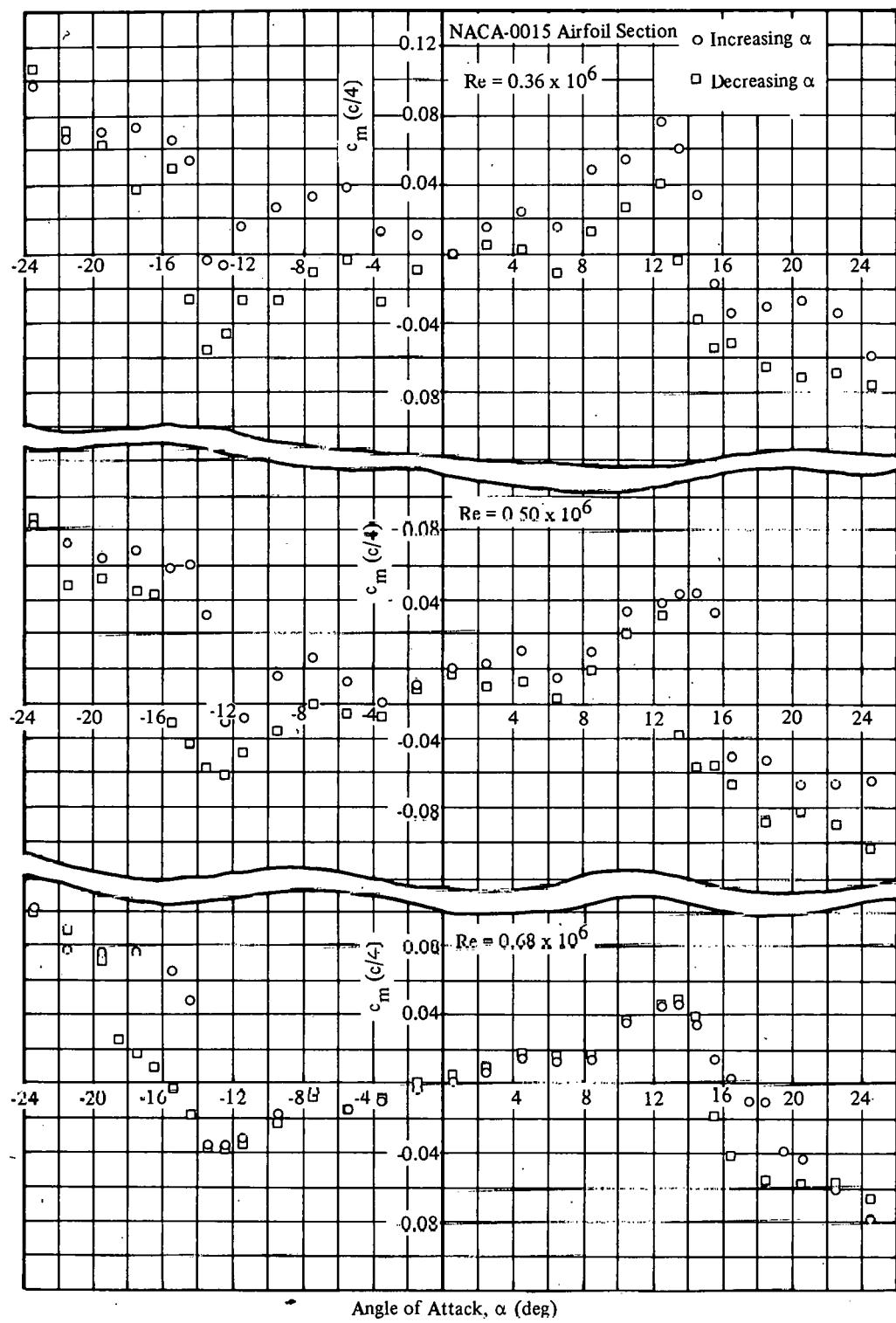


Figure 26. NACA-0015 Airfoil Section Moment Coefficients About the Quarter Chord for Reynolds Numbers of 0.36×10^6 , 0.50×10^6 , and 0.68×10^6 .

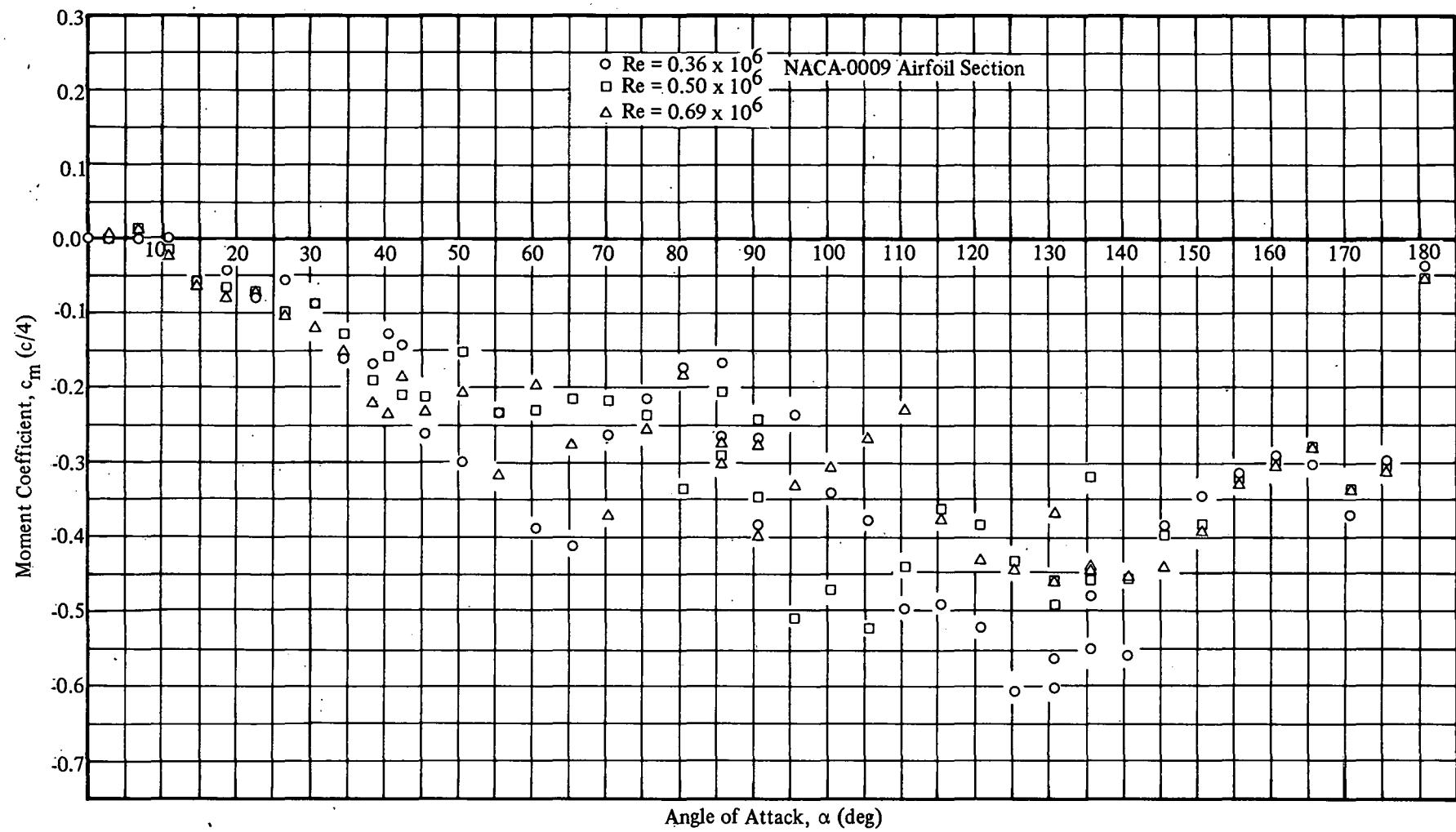


Figure 27. Full Range Section Moment Coefficients About the Quarter Chord for the NACA-0009 Airfoil at Reynolds Numbers of 0.36×10^6 , 0.50×10^6 , and 0.69×10^6

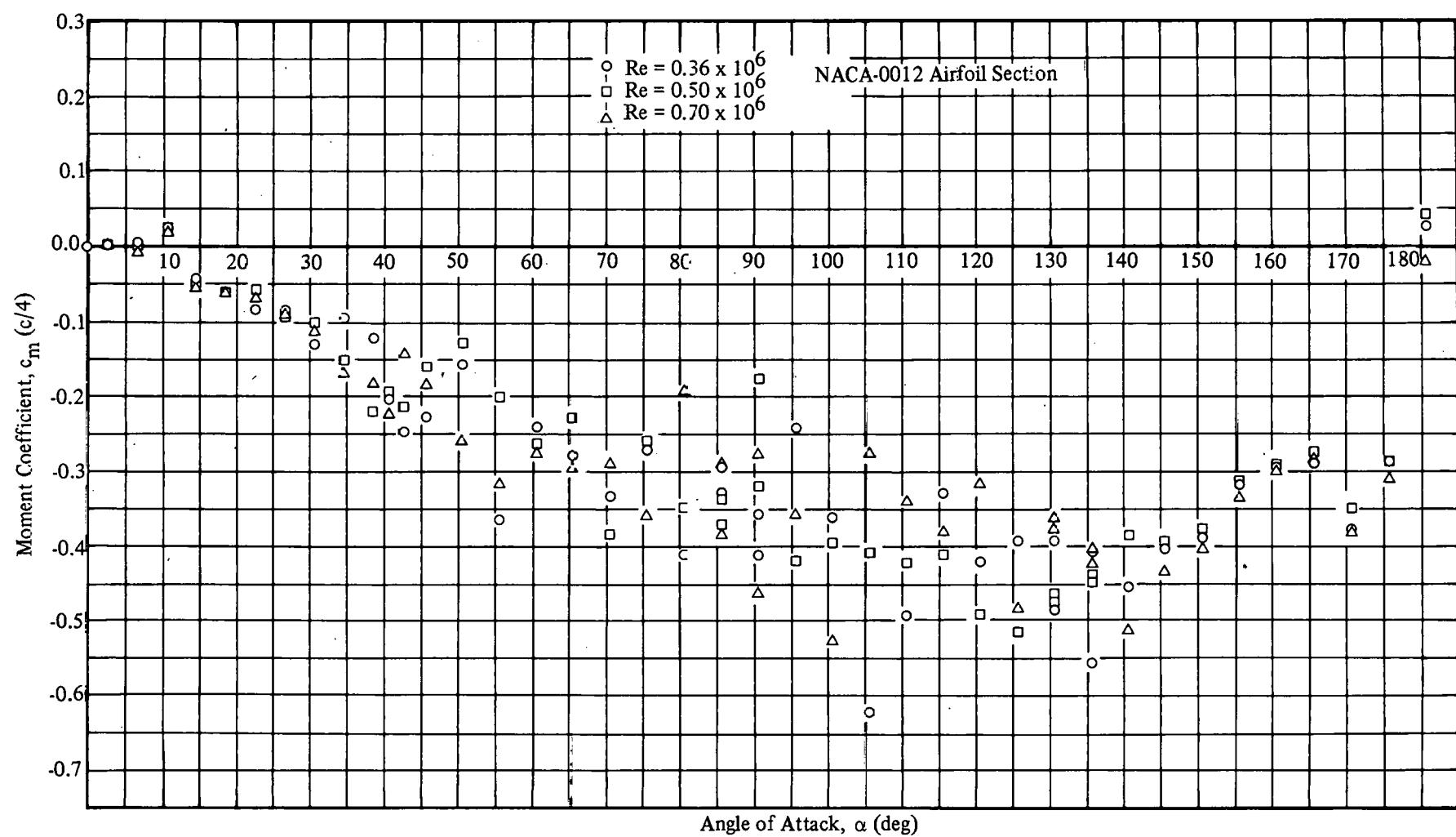


Figure 28. Full Range Section Moment Coefficients About the Quarter Chord for the NACA-0012 Airfoil at Reynolds Numbers of 0.36×10^6 , 0.50×10^6 , and 0.70×10^6

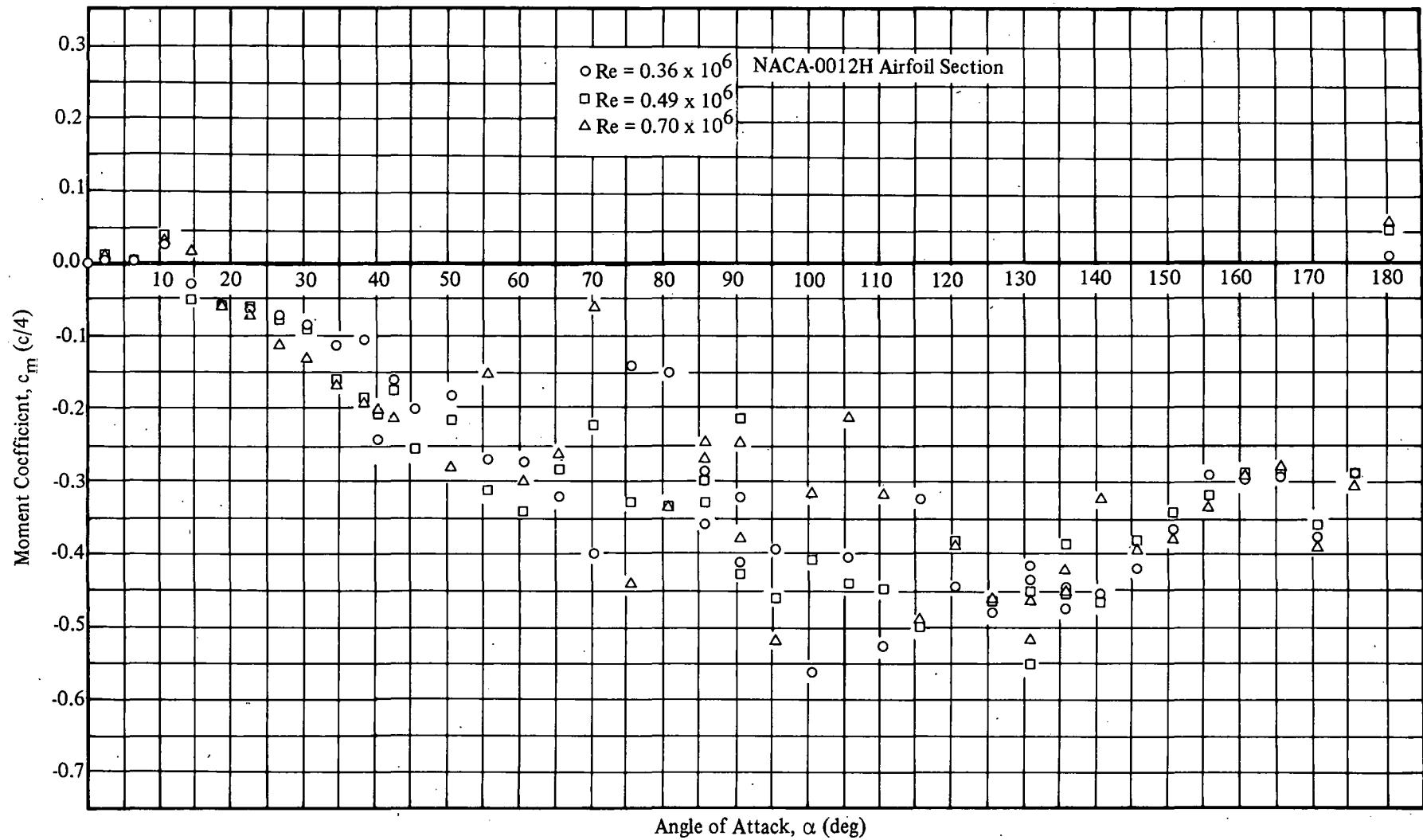


Figure 29. Full Range Section Moment Coefficients About the Quarter Chord for the NACA-0012H Airfoil at Reynolds Numbers of 0.36×10^6 , 0.49×10^6 , and 0.70×10^6

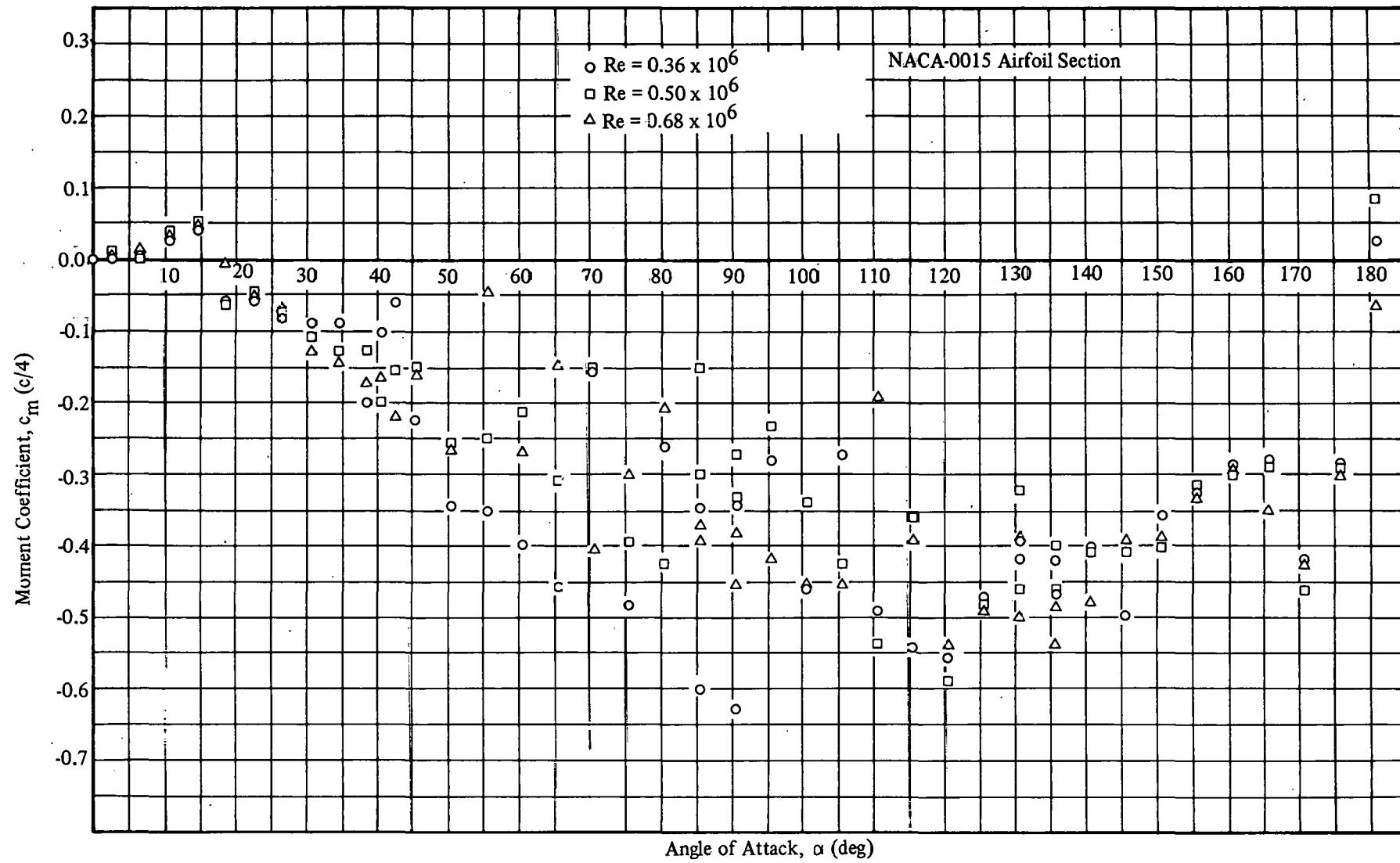


Figure 30. Full Range Sector. Moment Coefficients About the Quarter Chord for a NACA-0015 Airfoil at Reynolds Numbers of 0.36×10^6 , 0.50×10^6 , and 0.68×10^6

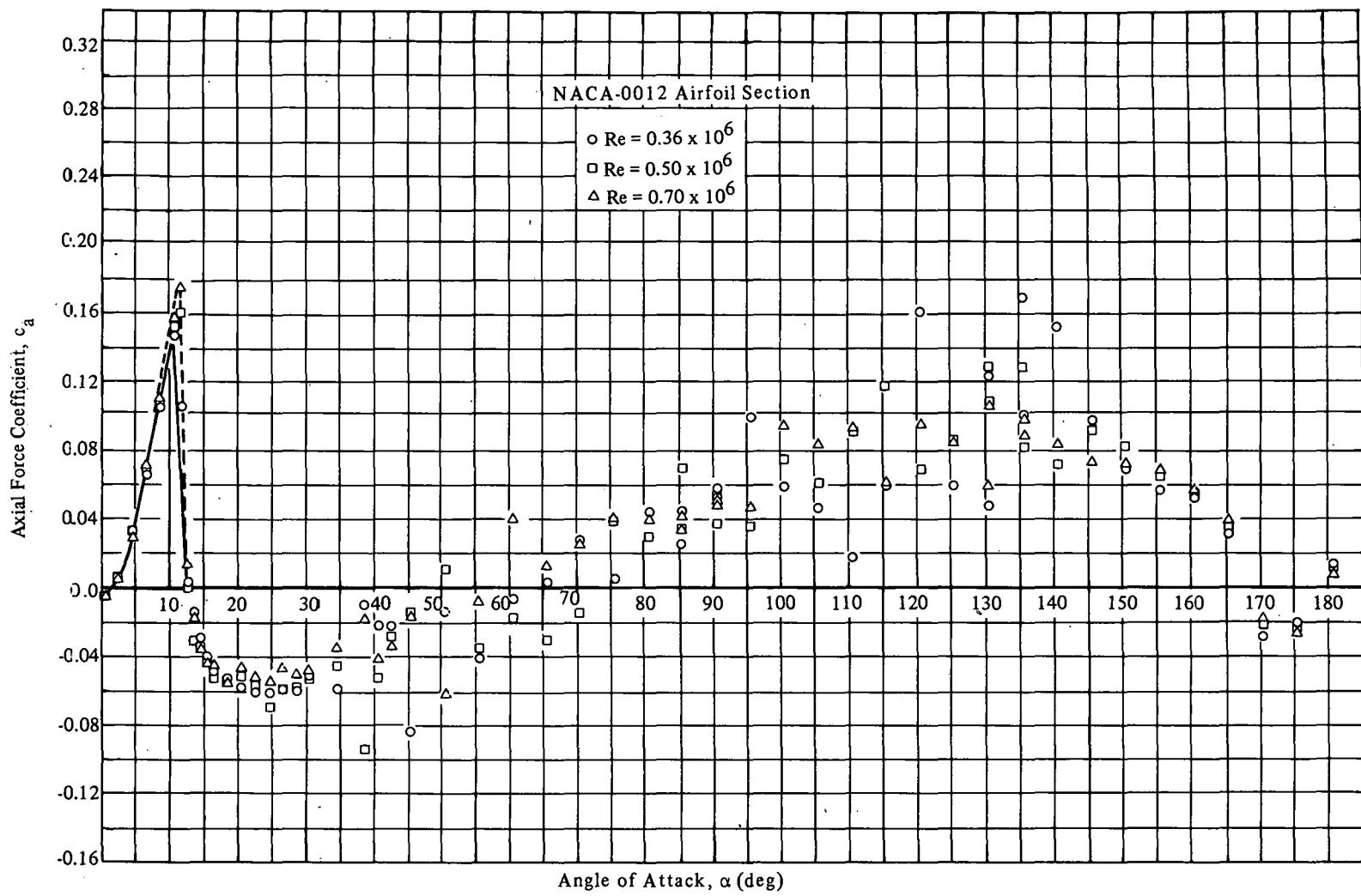


Figure 31. Full Range Section Axial Force Coefficients for the NACA-0012 Airfoil at Reynolds Numbers of 0.36×10^6 , 0.50×10^6 , and 0.70×10^6

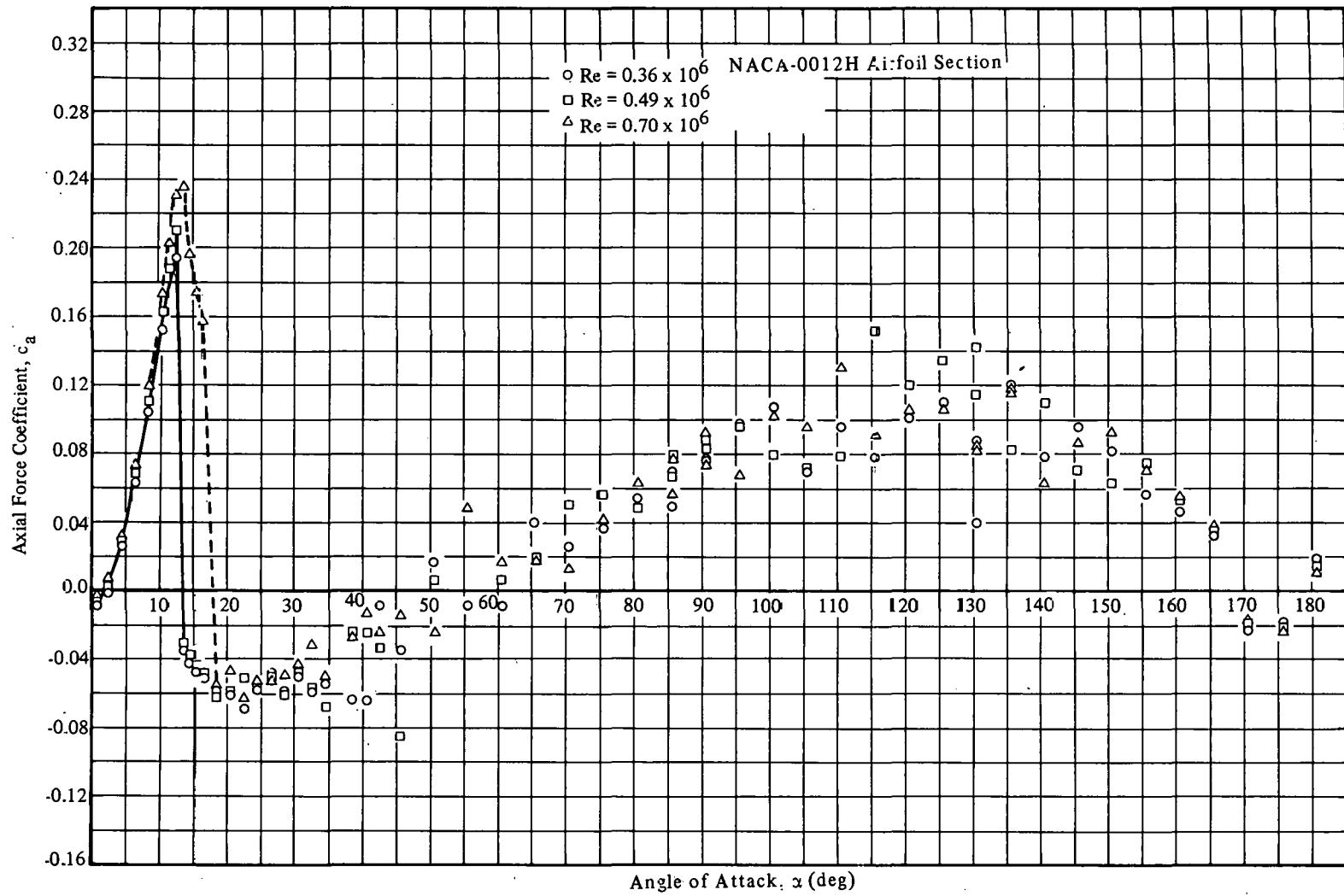


Figure 32. Full Range Section Axial Force Coefficients for the NACA-0012H Airfoil at Reynolds Numbers of 0.36×10^6 , 0.49×10^6 , and 0.70×10^6

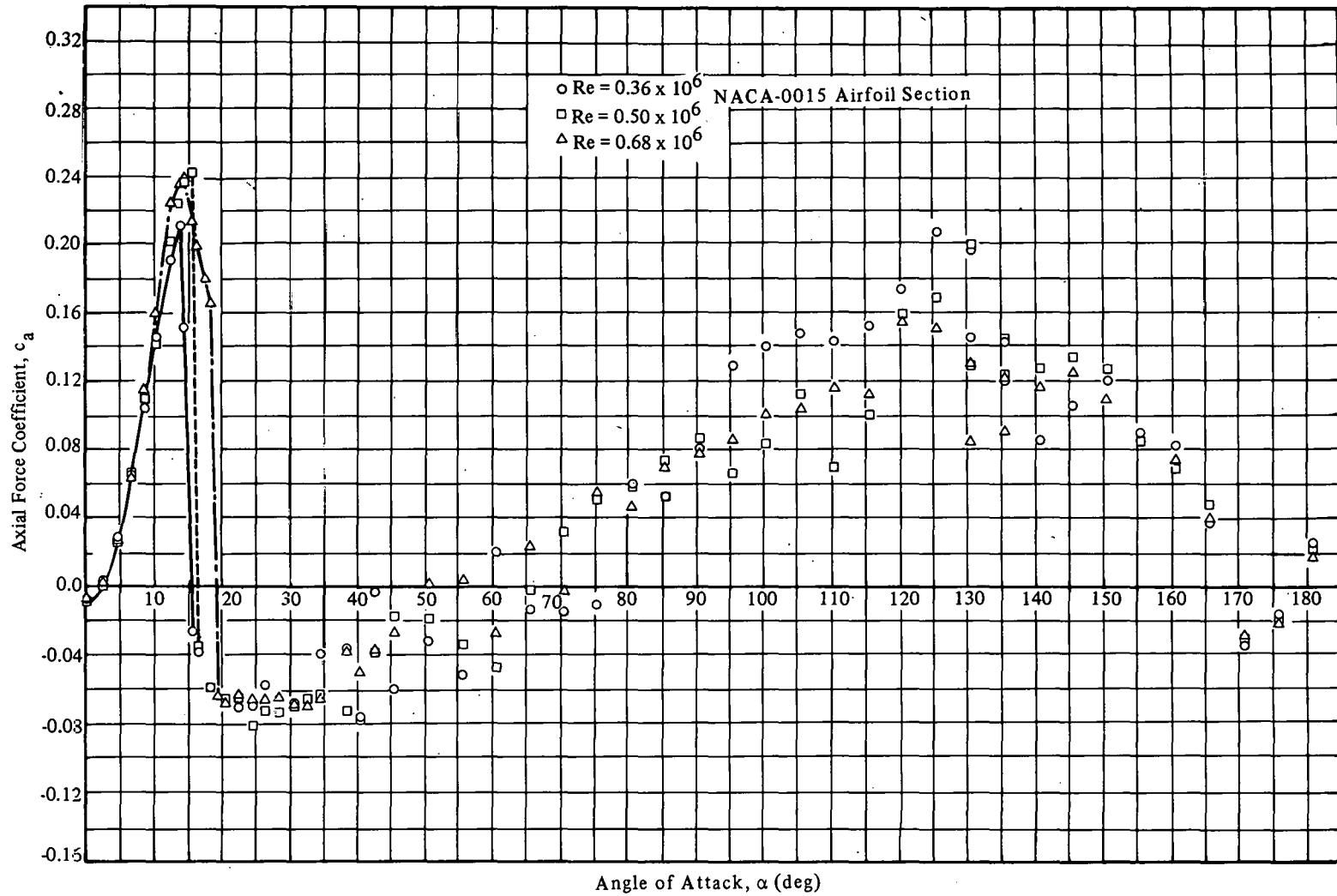


Figure 33. Full Range Section Axial Force Coefficients for the NACA-0015 Airfoil at Reynolds Numbers of 0.36×10^6 , 0.50×10^6 , and 0.68×10^6

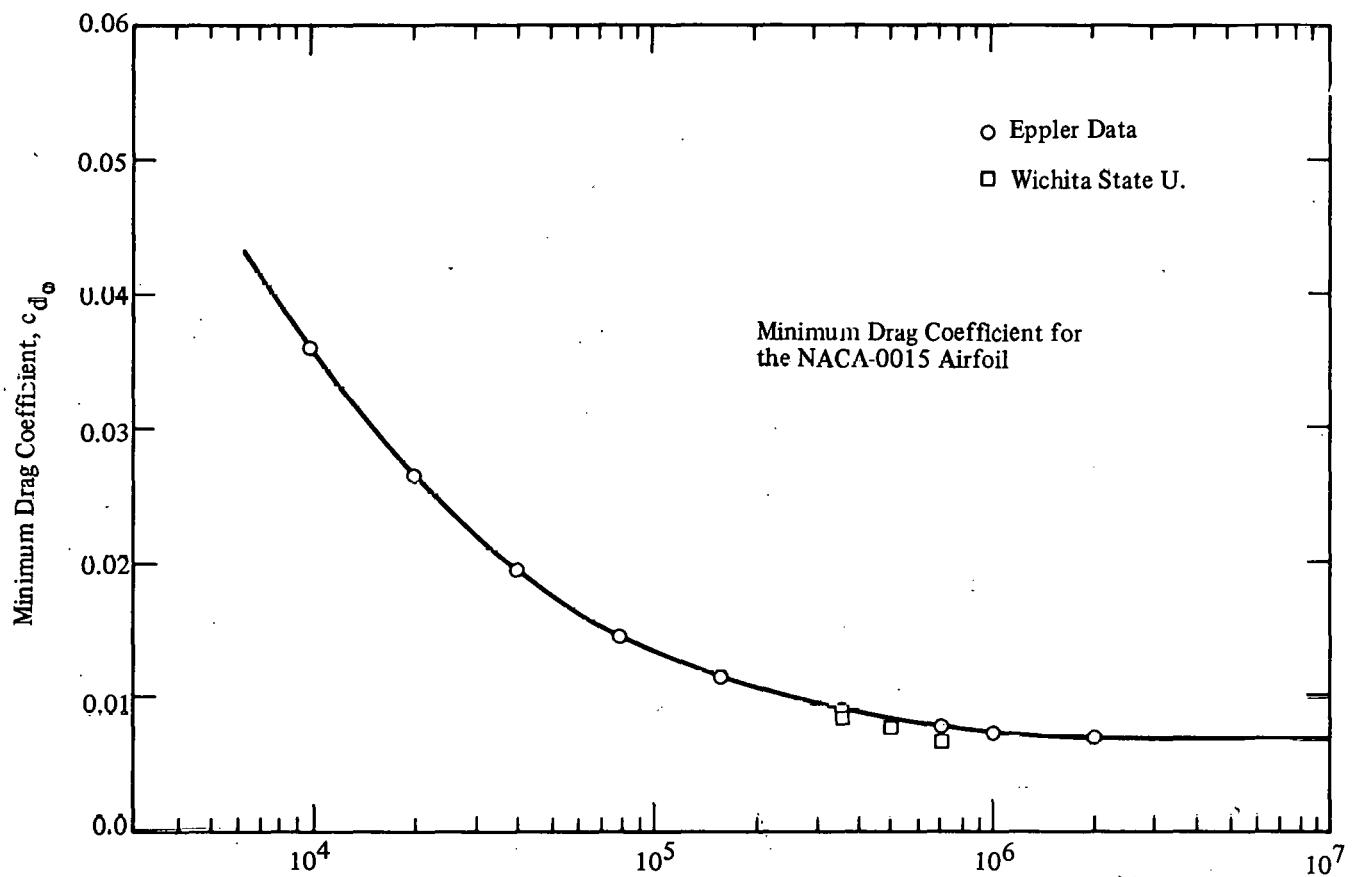


Figure 34. Predicted and Measured Values of Minimum Section Drag Coefficients, c_{d_0} , as a Function of Reynolds Number, Re

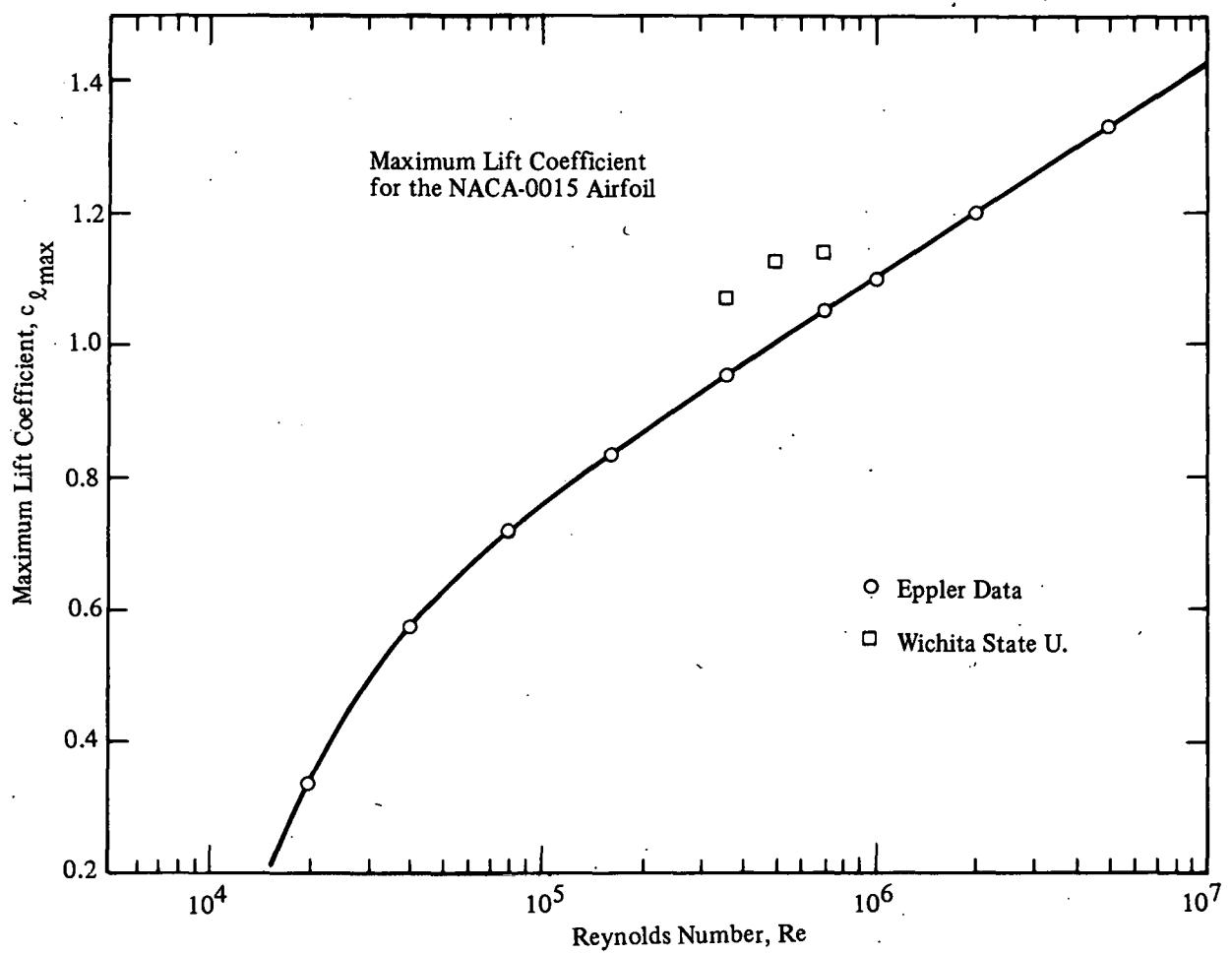


Figure 35. Predicted and Measured Values of Section Maximum Lift Coefficients, $c_{l_{\max}}$, as a Function of Reynolds Number, Re .

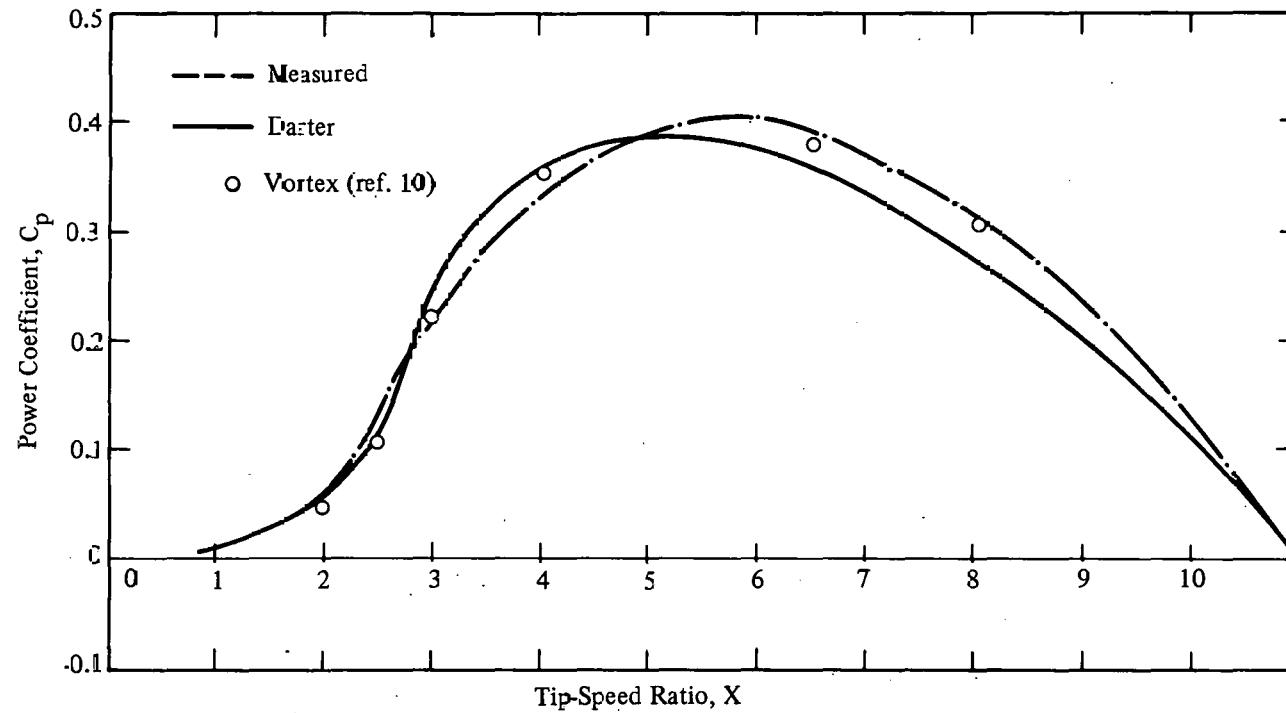


Figure 36. Power Coefficient as a Function of Tip-Speed Ratio for the Sandia 17-m Diameter Darrieus Turbine with a Height to Diameter Ratio of 1.0, Two NACA-0015 0.61-m Chord Blades at a Rotational Speed of 50.6 rpm

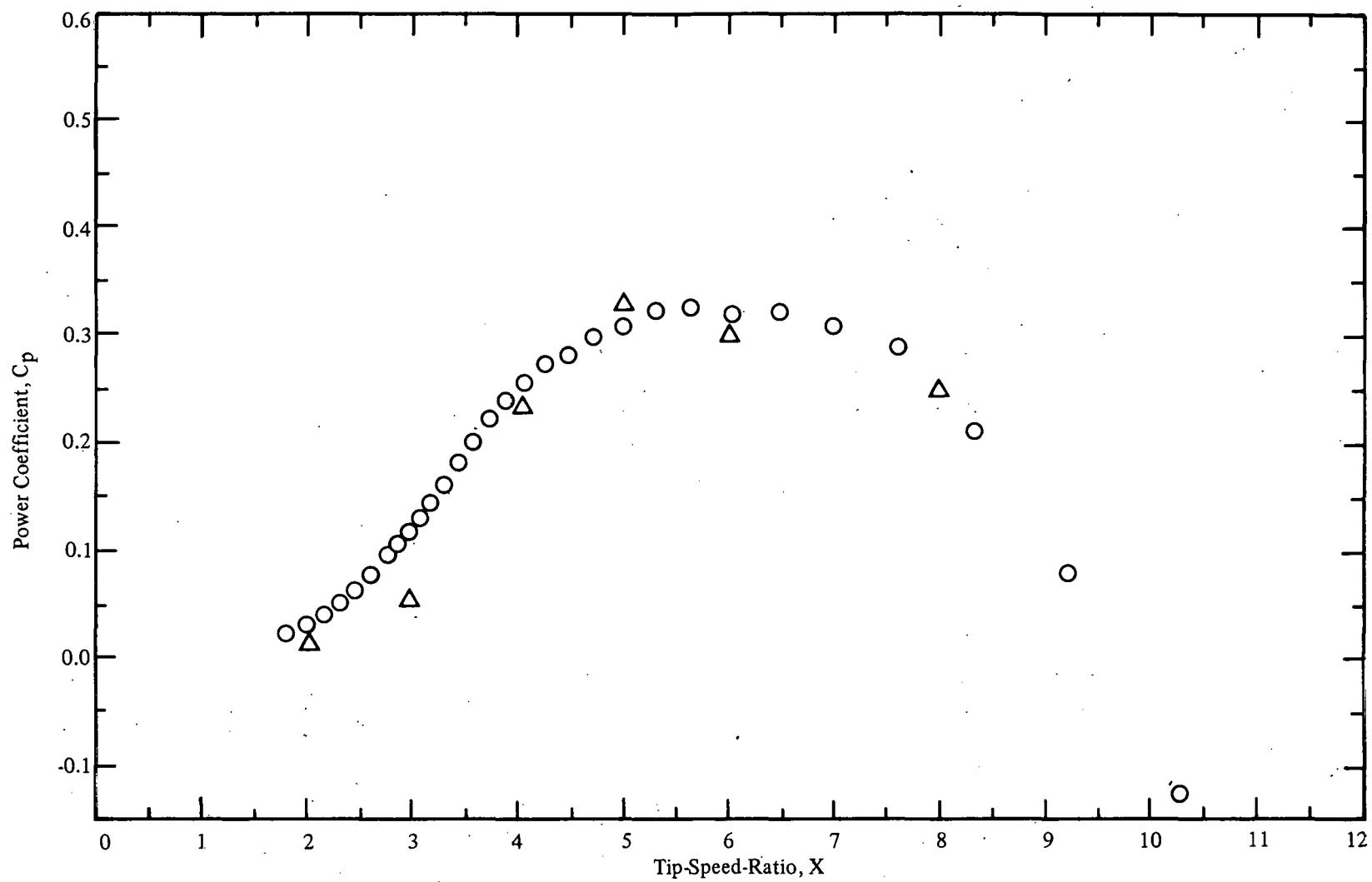


Figure 37. Power Coefficient as a Function of Tip-speed Ratio for the Sandia 5-m Diameter Darrieus Turbine with a Height to Diameter Ratio of 1.0, Two NACA-0015 0.15-m Chord Blades at a Rotational Speed of 162.5 rpm

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Iles de la Madeleine, Quebec

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Solar Energy Research Institute

1617 Cole Blvd.

Golden, CO 80401

Attn: I. E. Vas

National Aerospace Laboratory

Anthony Fokkerweg 2

Amsterdam 1017

THE NETHERLANDS

Attn: O. de Vries

West Virginia University

Department of Aero Engineering

1062 Kountz Avenue

Morgantown, WV 26505

Attn: R. Walters

Bonneville Power Administration

P.O. Box 3621

Portland, OR 97225

Attn: E. J. Warchol

Energy and Power Systems

ERA Ltd.

Cleeve Rd.

Leatherhead

Surrey KT22 7SA

ENGLAND

Attn: D. F. Warne, Manager

G. R. Watson, Project Manager

The Energy Center

Pennine House

4 Osborne Terrace

Newcastle upon Tyne NE2 1NE

UNITED KINGDOM

Watson Bowman Associates, Inc.

1290 Niagara St.

Buffalo, NY 14213

Attn: R. J. Watson

Tulane University

Department of Mechanical Engineering

New Orleans, LA 70018

Attn: R. G. Watts

Solar Energy Research Institute (3)

1617 Cole Blvd.

Golden, CO 80401

Attn: P. Weis

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Wind Program Manager
Wisconsin Division of State Energy
8th Floor
101 South Webster Street
Madison, WI 53702

Central Solar Energy Research
Corporation
1200 Sixth Street
328 Executive Plaza
Detroit, MI 48226
Attn: R. E. Wong
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