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Addendum to A Catalog of Low Reynolds Number Airfoil Data for Wind Turbine Applications

A Subcontract Report

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PREFACE

This report was prepared by S. J. Miley of Texas A&M University, Department of Aerospace Engineering, Subcontract No. PFY 12781-W for Rockwell International Corporation's Wind Energy Research Center under their contract No. DE-AC04-76DP035333. As of October 1, 1984, the Wind Energy Research Center is under the operation of the Solar Energy Research Institute, which coordinated the publication of this report under Task No. 4807.20.

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TABLE OF CONTENTS

Page

1.0 Introduction..... 1

2.0 Airfoil Data..... 7

LIST OF FIGURES

	Page
Figure 1-1. Original Catalog Airfoil Data for AH 79-100A	5
Figure 1-2. Addendum Airfoil Data for AH 79-100A	5
AH 79-100A	8
AH 79-100B	10
AH 79-100C	12
CLARK Y	14
E 61	16
E 193	18
E 203	20
E 385	22
E 387	24
E 474	26
E 475	28
FX 60-100	30
FX 60-126	32
FX 61-140	34
FX 62-K-131	36
FX 63-137	38
FX M2	40
FX S 02-196	42
FX S 02/1-158	44
GO 417A	46
GO 535	48
GO 775	50
GO 801	52
K 2	56
NACA 0009	58
NACA 0012	62
NACA 2412	70
NACA 4409	74
SOKOLOV	80

LIST OF TABLES

Page

1-1. Index of Airfoil Data..... 3

SECTION 1.0

INTRODUCTION

The prediction of wind turbine performance requires airfoil data at Reynolds numbers lower than those used for aircraft operation. Even wind turbines with rotor diameters in excess of 100 feet rarely operate at Reynolds numbers greater than several million.

Until the publication of A Catalog of Low Reynolds Number Airfoil Data for Wind Turbine Applications* in 1982, available airfoil data for this purpose were widely scattered in a variety of publications not known to most wind turbine designers. The catalog was developed by this author at Texas A&M University under contract to Rockwell International, which operated the Rocky Flats Wind Systems Program for the U.S. Department of Energy. The resulting publication includes airfoil data up to a Reynolds number of 3,000,000. Airfoils covered in the catalog include the Eppler series; the Wortmann FX series; the Gottingen Go series; and the NACA four-digit, five-digit, and six-digit airfoils.

The data presented in the catalog were obtained in the following manner from the respective reports and papers. Data values were taken from the original graphical curves using a digitizing procedure. Each graph was placed on a digitizing board which was connected to a microcomputer. A data digitizing program code was formulated to operate the system. Four reference points were selected for each graph coordinate system to develop a coordinate transformation. This procedure helped compensate for any distortion that may have been introduced into the original graph as a result of reproduction. The digitized data were stored on floppy disk for additional processing. The tabulated values were obtained from the digitized values using a standard cubic spline interpolation procedure. As part of the processing, the drag coefficients were converted from dependency on lift coefficient to dependency on angle of attack to facilitate use of the tabulated values for SWECS performance analyses. The interpolation procedures used for the drag curves required considerable effort. The steep slopes at the ends of the drag curves caused numerical instabilities which resulted in large gyrations in the interpolated curve between the original data points. A coordinate transformation using the reciprocal of the log of the drag coefficient was ultimately found to work satisfactorily.

After the catalog was published, it was brought to the author's attention that the cubic spline fitting routine used in generating the curves from discrete data caused inaccuracies for some of the airfoils. This problem was primarily related to airfoils having a sharp drag rise at stall, such as those developed by Eppler and Wortmann. The curves for these airfoils exhibit excessive

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*Miley, S. J., February 1982, A Catalog of Low Reynolds Number Airfoil Data for Wind Turbine Applications, RFP-3387, Golden, CO: Rockwell International Corp.

smoothing of the drag data in this region due to the fitting routine employed. A point-to-point curve fitting routine was found to produce more accurate results. Differences in one of the affected airfoils can be seen by comparing Figures 1-1 and 1-2.

In the interest of achieving the greatest possible accuracy for performance prediction, it was decided to issue this addendum to the catalog correcting the drag data for the affected airfoils. A point-to-point curve fitting routine has been used throughout the addendum.

To ensure use of accurate data curves, it is recommended that Table 1-1 be reproduced and pasted over the Table of Contents page in the original catalog. The contents page will then automatically refer the user to the correct volume for each airfoil.

The airfoil data presented in the addendum include a graphical presentation of airfoil characteristics including lift coefficient, drag coefficient, pitching moment coefficient at the quarter-chord, and lift/drag ratio; and a tabulation of the coefficient values as a function of angle of attack (AOA) and Reynolds number. If more pages are required for the data, the page formats are repeated.

Table 1-1. Index of Airfoil Data

	Catalog Page	Addendum Page		Catalog Page	Addendum Page
AH 79-100A	A-4	8	GO 409	A-198	
AH 79-100B	A-8	10	GO 410	A-202	
AH 79-100C	A-12	12	GO 417A	A-206	46
CLARK Y	A-16	14	GO 436	A-210	
E 61	A-20	16	GO 508	A-214	
E 193	1-24	18	GO 535	A-218	48
E 203	1-28	20	GO 564	A-222	
E 385	A-32	22	GO 596	A-226	
E 387	A-36	24	GO 608	A-230	
E 474	A-40	26	GO 609	A-234	
E 475	A-44	28	GO 610	A-238	
FX 38-153	A-48		GO 622	A-242	
FX 60-100	A-52		GO 623	A-246	
FX 60-126	A-56	30	GO 624	A-250	
FX 60-126/1	A-62	32	GO 625	A-254	
FX 60-157	A-66		GO 652	A-260	
FX 60-177	A-70		GO 683	A-264	
FX 61-140	A-74	34	GO 708	A-268	
FX 61-147	A-80		GO 711	A-272	
FX 61-163	A-84		GO 735	A-276	
FX 61-168	A-88		GO 738	A-280	
FX 61-184	A-92		GO 741	A-284	
FX 62-K-131	A-96	36	GO 744	A-288	
FX 63-137	A-100	38	GO 746	A-292	
FX 63-143	A-106		GO 766	A-296	
FX 63-145	A-110		GO 767	A-300	
FX 63-147	A-114		GO 769	A-304	
FX 63-158	A-118		GO 775	A-308	50
FX 66-17A-175	A-122		GO 776	A-312	
FX 66-17AII-182	A-126		GO 795	A-316	
FX 66-S-161	A-130		GO 796	A-322	
FX 66-S-196	A-134		GO 797	A-326	
FX 66-S-196 V1	A-138		GO 801	A-330	52
FX 72-MS-150A	A-142		GO 803	A-338	
FX 72-MS-150B	A-146		GO 804	A-342	
FX L III-142	A-150		GU 25-5(11)8	A-346	
FX L V-152	A-154		K 2	A-350	56
FX M2	A-158	40	M-300	A-354	
FX S 02-196	A-162	42	NACA 0009	A-358	58
FX S 02/1-158	A-166	44	NACA 0012	A-366	62
FX S 03-182	A-179		NACA 0015	A-378	
GO 227	A-174		NACA 0018	A-384	
GO 242	A-128		NACA 2412	A-390	70
GO 243	A-182		NACA 2415	A-398	
GO 289	A-186		NACA 4409	A-402	74
GO 335	A-190		NACA 4412	A-410	
GO 342	A-194		NACA 4415	A-420	

Table 1-1. Index of Airfoil Data (Concluded)

	Catalog Page	Addendum Page		Catalog Page	Addendum Page
NACA 6412	A-434		NACA 64(1)-012	A-500	
NACA 6712	A-440		NACA 64(1)A212	A-508	
NACA 8318	A-446		NACA 64(1)-412	A-514	
NACA 2R(2) 12	A-452		NACA 64(1)-612	A-520	
NACA 23012	A-458		NACA 64(2)-415	A-526	
NACA 23012-33	A-472		NACA 64(3)-418	A-534	
NACA 23015	A-478		NACA 65(2)-415	A-540	
NACA 63(2)-415	A-484		NACA 66(2)-415	A-546	
NACA 63(3)-618	A-490		NACA LS(1)-0413 MOD	A-552	
NACA 64-409	A-494		NACA LS(1)-0417 MOD	A-556	
			SOKOLOV	A-562	80
			UI-1720	A-566	

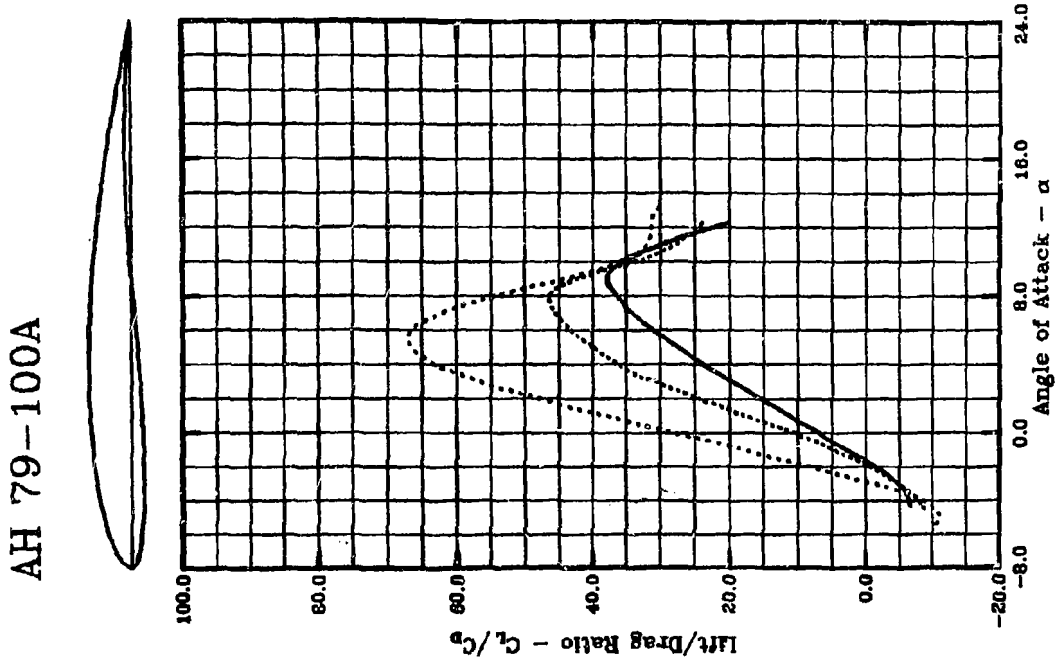


Figure 1-1. Original Catalog Airfoil Data for AH 79-100A

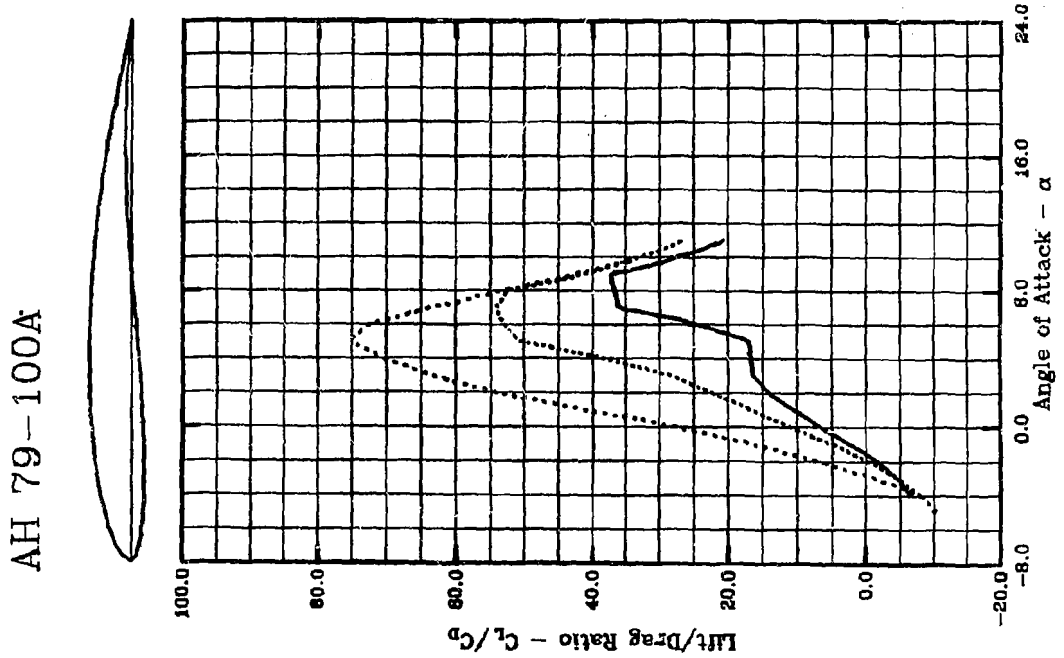


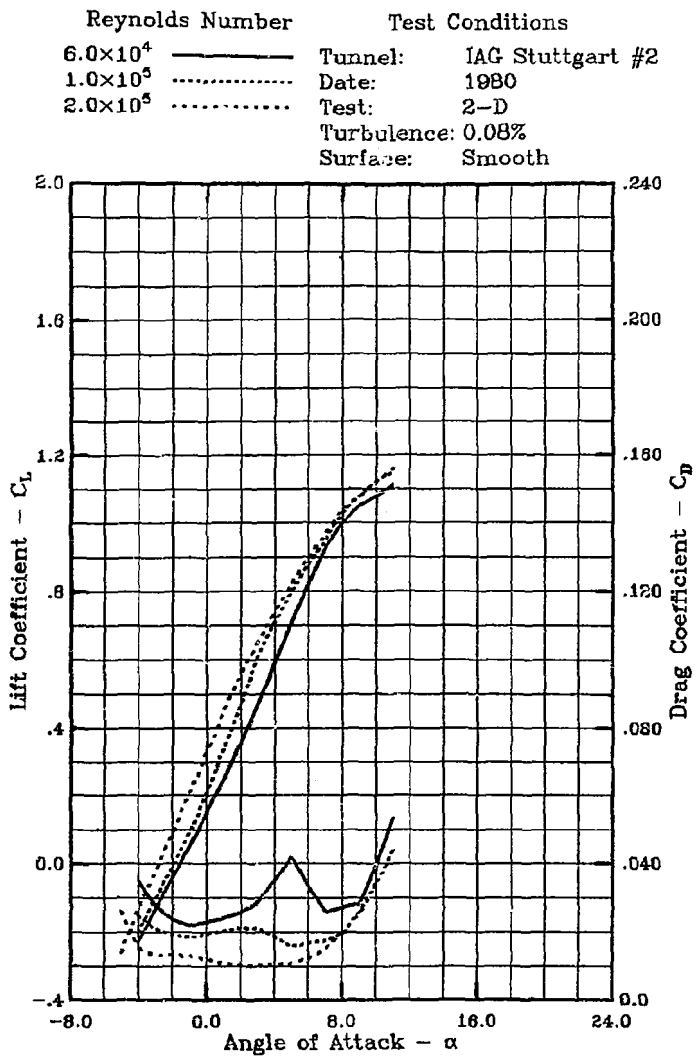
Figure 1-2. Addendum Airfoil Data for AH 79-100A

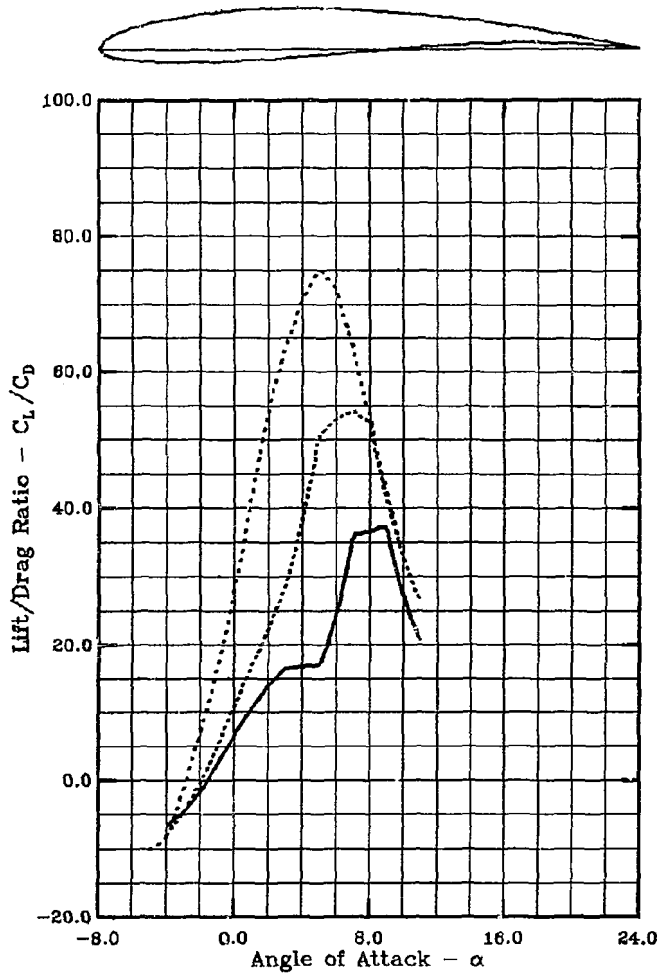
SERI

SECTION 2.0

AIRFOIL DATA

AH 79-100A

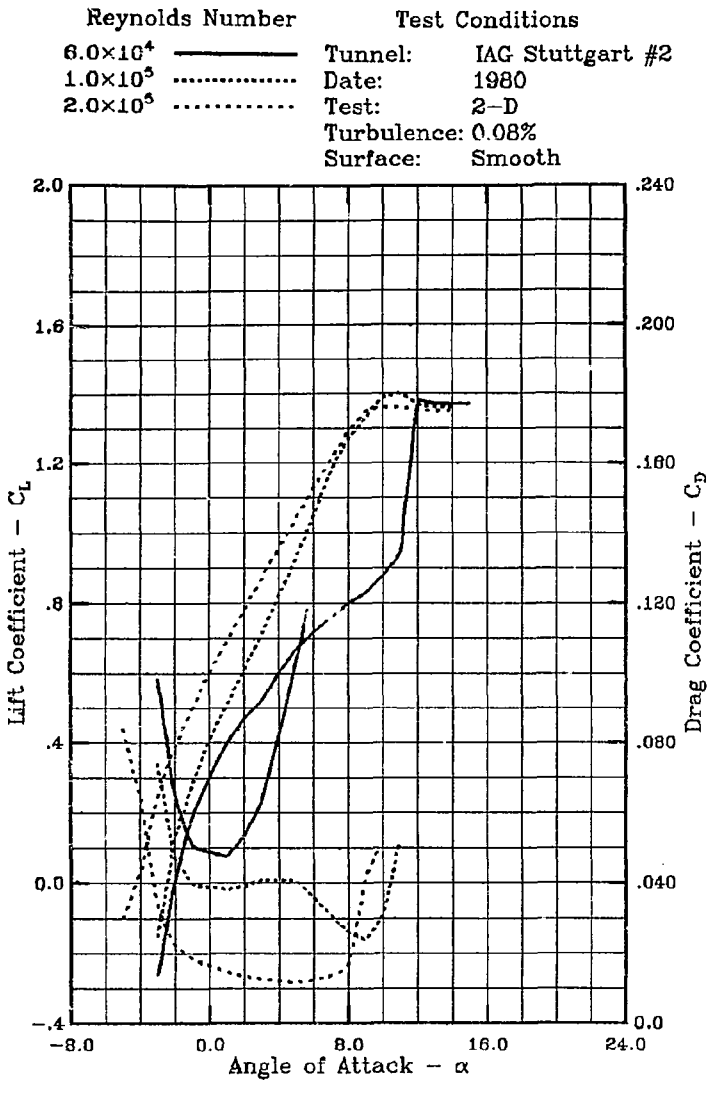

Reynolds Number
6.0×10^4
1.0×10^5
2.0×10^5
Test Conditions
Tunnel: IAG Stuttgart #2
Date: 1980
Test: 2-D
Turbulence: 0.08%
Surface: Smooth
Lift Coefficient – C_L
Drag Coefficient – C_D
Angle of Attack – α
2.0
1.6
1.2
.8
.4
0.0
-.4
.240
.200
.160
.120
.080
.040
0.0
-8.0
0.0
8.0
16.0
24.0

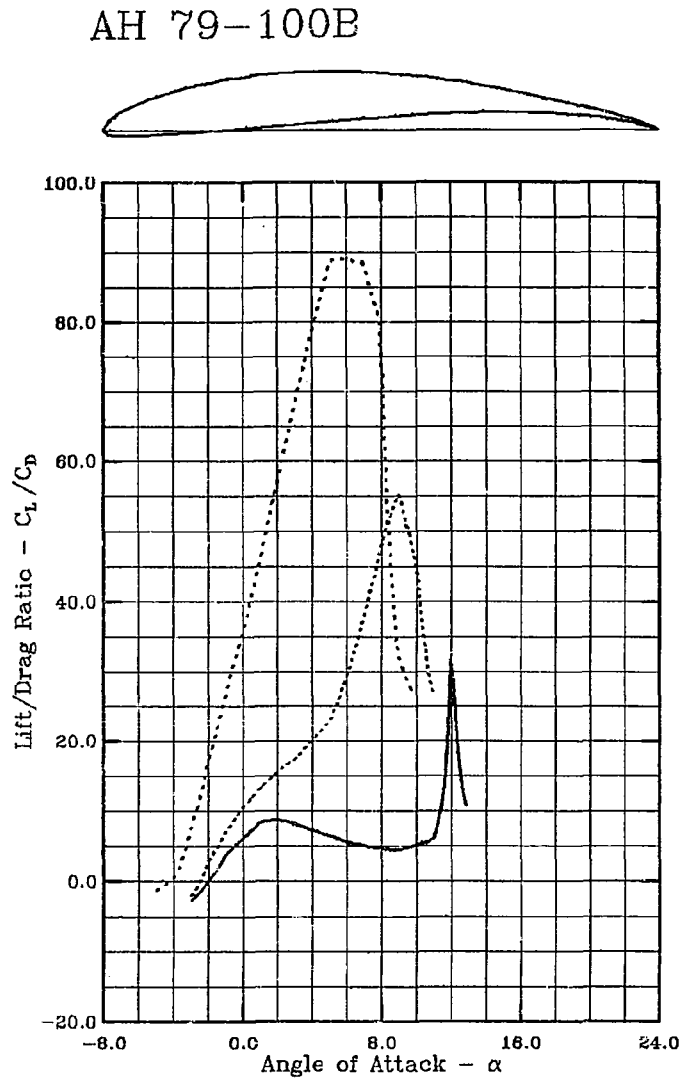

Lift/Drag Ratio – C_L/C_D
Angle of Attack – α
100.0
80.0
60.0
40.0
20.0
0.0
-20.0
-8.0
0.0
8.0
16.0
24.0

AH 79-100A

Tunnel: IAG Stuttgart #2 / Date: 1980 / Test: 2-D / Turbulence: 0.08% / Surface: Smooth

RN	6.0×10^4		1.0×10^5		2.0×10^5	
AOA	CL	CD	CL	CD	CL	CD
-5.0	-	-	-	-	-.26	.0259
-4.0	-.23	.0352	-.20	.0251	-.13	.0155
-3.0	-.13	.0275	-.10	.0211	-.02	.0132
-2.0	-.04	.0237	-.01	.0192	.09	.0133
-1.0	.05	.0221	.09	.0185	.21	.0129
.0	.15	.0230	.21	.0194	.33	.0119
1.0	.25	.0240	.34	.0204	.45	.0108
2.0	.36	.0258	.47	.0211	.56	.0103
3.0	.47	.0286	.61	.0214	.65	.0102
4.0	.59	.0352	.71	.0185	.74	.0105
5.0	.71	.0418	.80	.0158	.82	.0109
6.0	.82	.0336	.88	.0166	.90	.0124
7.0	.93	.0258	.95	.0175	.97	.0152
8.0	1.00	.0273	1.03	.0196	1.04	.0194
9.0	1.05	.0281	1.08	.0260	1.08	.0253
10.0	1.08	.0394	1.12	.0339	1.12	.0334
11.0	1.11	.0534	1.15	.0437	1.16	-

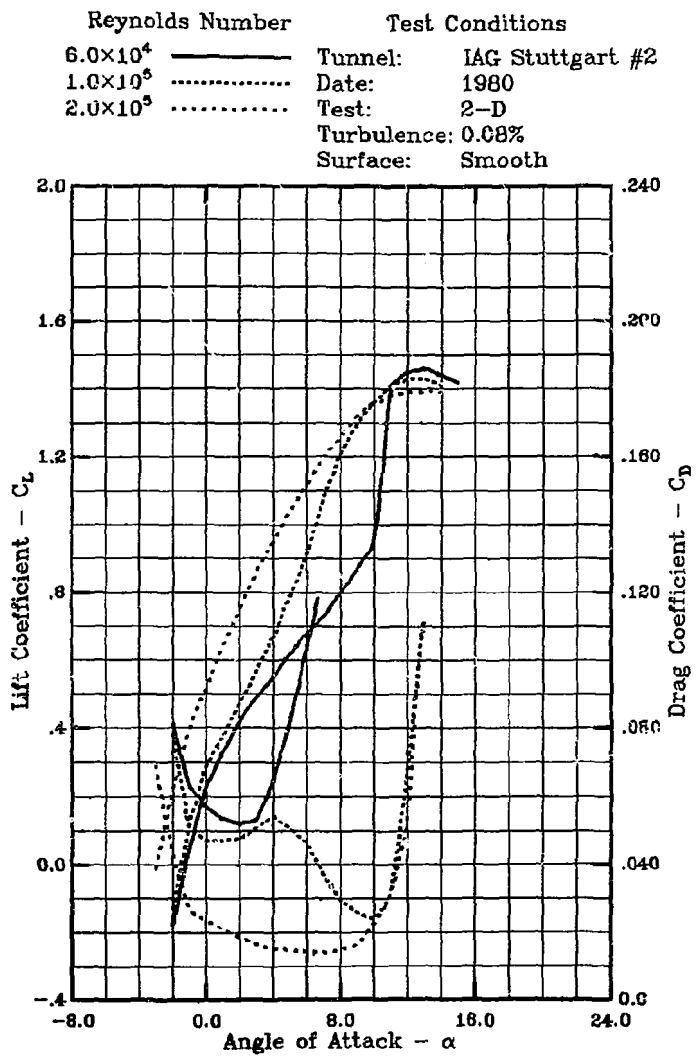

Reynolds Number
6.0×10⁴
1.0×10⁵
2.0×10⁵
Test Conditions
Tunnel: IAG Stuttgart #2
Date: 1980
Test: 2-D
Turbulence: 0.08%
Surface: Smooth
Lift Coefficient – C_L
Drag Coefficient – C_D
Angle of Attack – α
2.0
1.6
1.2
.8
.4
0.0
-.4
.240
.200
.160
.120
.080
.040
0.0
-8.0
0.0
8.0
16.0
24.0

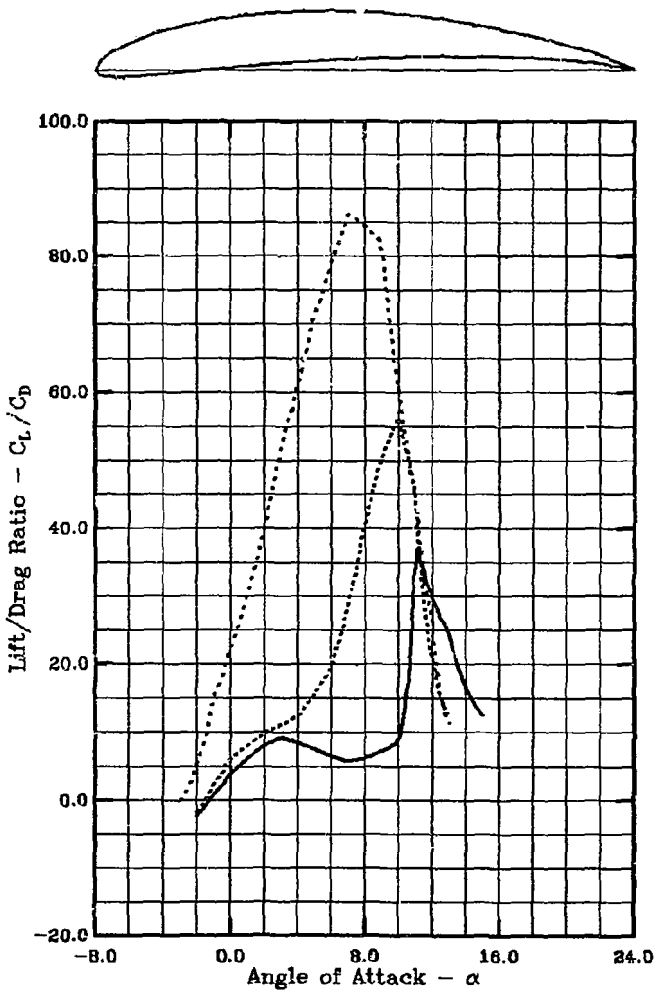

AH 79-100B
Lift/Drag Ratio – C_L/C_D
Angle of Attack – α
100.0
80.0
60.0
40.0
20.0
0.0
-20.0
-8.0
0.0
8.0
16.0
24.0

AH 79-100B

Tunnel: IAG Stuttgart #2 / Date: 1980 / Test: 2-D / Turbulence: 0.08% / Surface: Smooth

RN	6.0×10^4		1.0×10^5		2.0×10^5	
AOA	CL	CD	CL	CD	CL	CD
-5.0	-	-	-	-	-.10	.0839
-4.0	-	-	-	-	.03	.0647
-3.0	-.26	.0984	-.15	.0740	.25	.0325
-2.0	.01	.0643	.13	.0469	.39	.0223
-1.0	.19	.0504	.28	.0396	.50	.0186
.0	.30	.0488	.41	.0389	.60	.0166
1.0	.40	.0474	.51	.0383	.69	.0149
2.0	.47	.0533	.61	.0391	.78	.0136
3.0	.52	.0629	.71	.0409	.87	.0127
4.0	.60	.0823	.82	.0407	.96	.0122
5.0	.67	.1030	.93	.0406	1.04	.0117
6.0	.72	.1269	1.05	.0359	1.13	.0127
7.0	.76	.1511	1.18	.0308	1.21	.0137
8.0	.80	.1708	1.27	.0261	1.29	.0162
9.0	.83	.1866	1.33	.0238	1.35	.0421
10.0	.88	.1726	1.39	.0306	1.36	.0524
11.0	.94	.1579	1.40	.0532	1.36	-
12.0	1.38	.0353	1.37	-	1.35	-
13.0	1.37	.1460	1.36	-	1.35	-
14.0	1.37	-	1.36	-	1.35	-
15.0	1.37	-	-	-	-	-


Reynolds Number
6.0×10^4
1.0×10^5
2.0×10^5
Test Conditions
Tunnel: IAG Stuttgart #2
Date: 1980
Test: 2-D
Turbulence: 0.08%
Surface: Smooth
Lift Coefficient – C_L
Drag Coefficient – C_D
Angle of Attack – α
2.0
1.6
1.2
.8
.4
0.0
-.4
.240
.200
.160
.120
.080
.040
0.0
-8.0
0.0
8.0
16.0
24.0

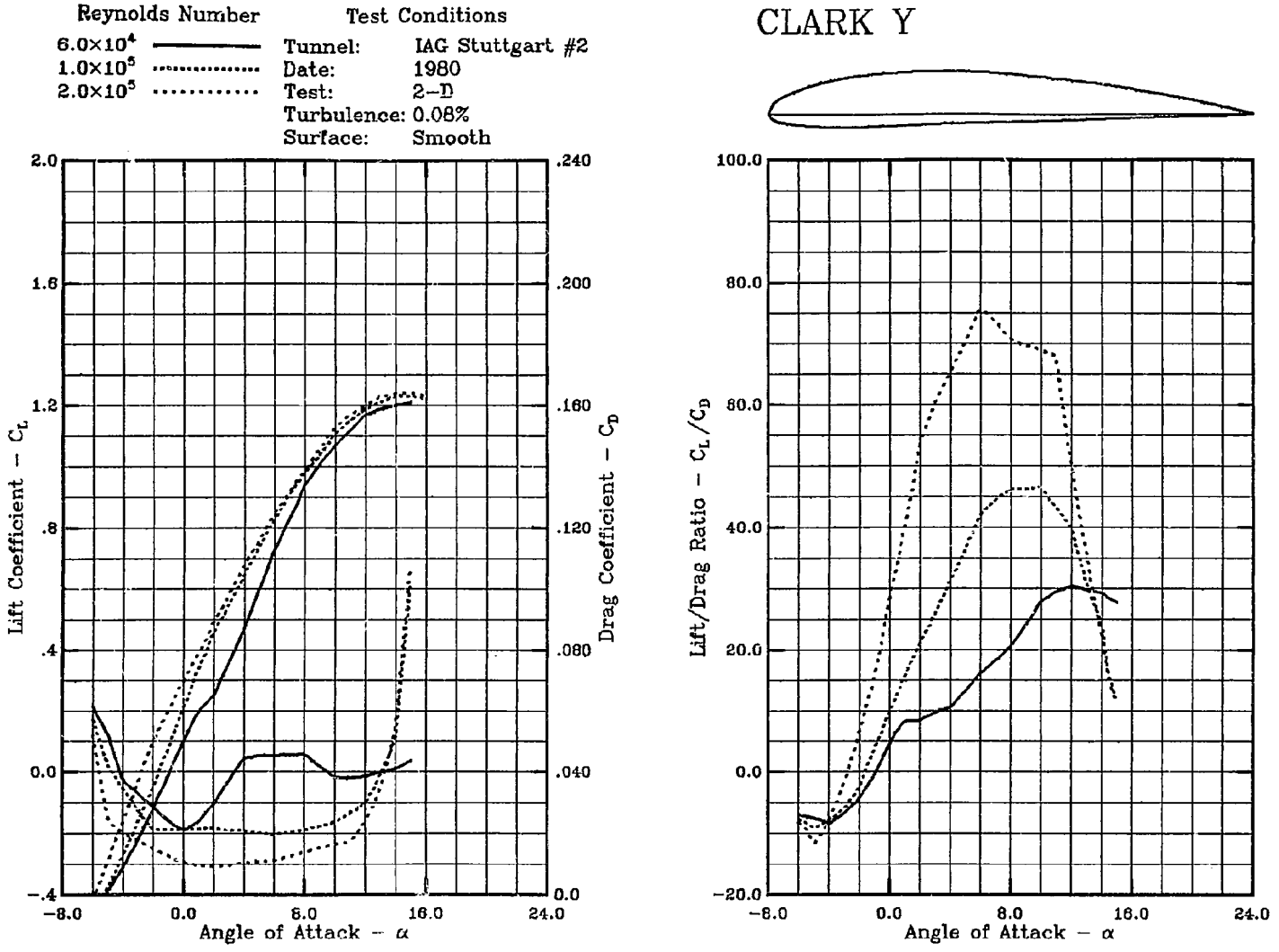

AH 79-100C
Lift/Drag Ratio – C_L/C_D
Angle of Attack – α
100.0
80.0
60.0
40.0
20.0
0.0
-20.0
-8.0
0.0
8.0
16.0
24.0

AH 79-100C

Tunnel: IAG Stuttgart #2 / Date: 1980 / Test: 2-D / Turbulence: 0.08% / Surface: Smooth

RN	6.0×10^4		1.0×10^5		2.0×10^5	
AOA	CL	CD	CL	CD	CL	CD
-3.0	-	-	-	-	-.01	.0693
-2.0	-.18	.0813	-.13	.0782	.22	.0424
-1.0	.05	.0629	.12	.0506	.40	.0264
.0	.23	.0568	.29	.0471	.52	.0237
1.0	.33	.0535	.38	.0474	.64	.0211
2.0	.42	.0522	.47	.0477	.75	.0187
3.0	.49	.0529	.57	.0509	.86	.0165
4.0	.55	.0647	.67	.0543	.95	.0155
5.0	.62	.0819	.79	.0507	1.04	.0146
6.0	.68	.1040	.91	.0462	1.12	.0142
7.0	.73	.1252	1.08	.0373	1.20	.0139
8.0	.80	.1296	1.21	.0294	1.26	.0149
9.0	.87	.1196	1.30	.0256	1.32	.0161
10.0	.94	.1096	1.36	.0241	1.36	.0223
11.0	1.41	.0372	1.41	.0306	1.38	.0308
12.0	1.45	.0483	1.43	.0673	1.39	.0524
13.0	1.46	.0594	1.43	.1172	1.39	.1240
14.0	1.44	.0866	1.41	-	1.39	-
15.0	1.42	.1138	-	-	-	-

CLARK Y

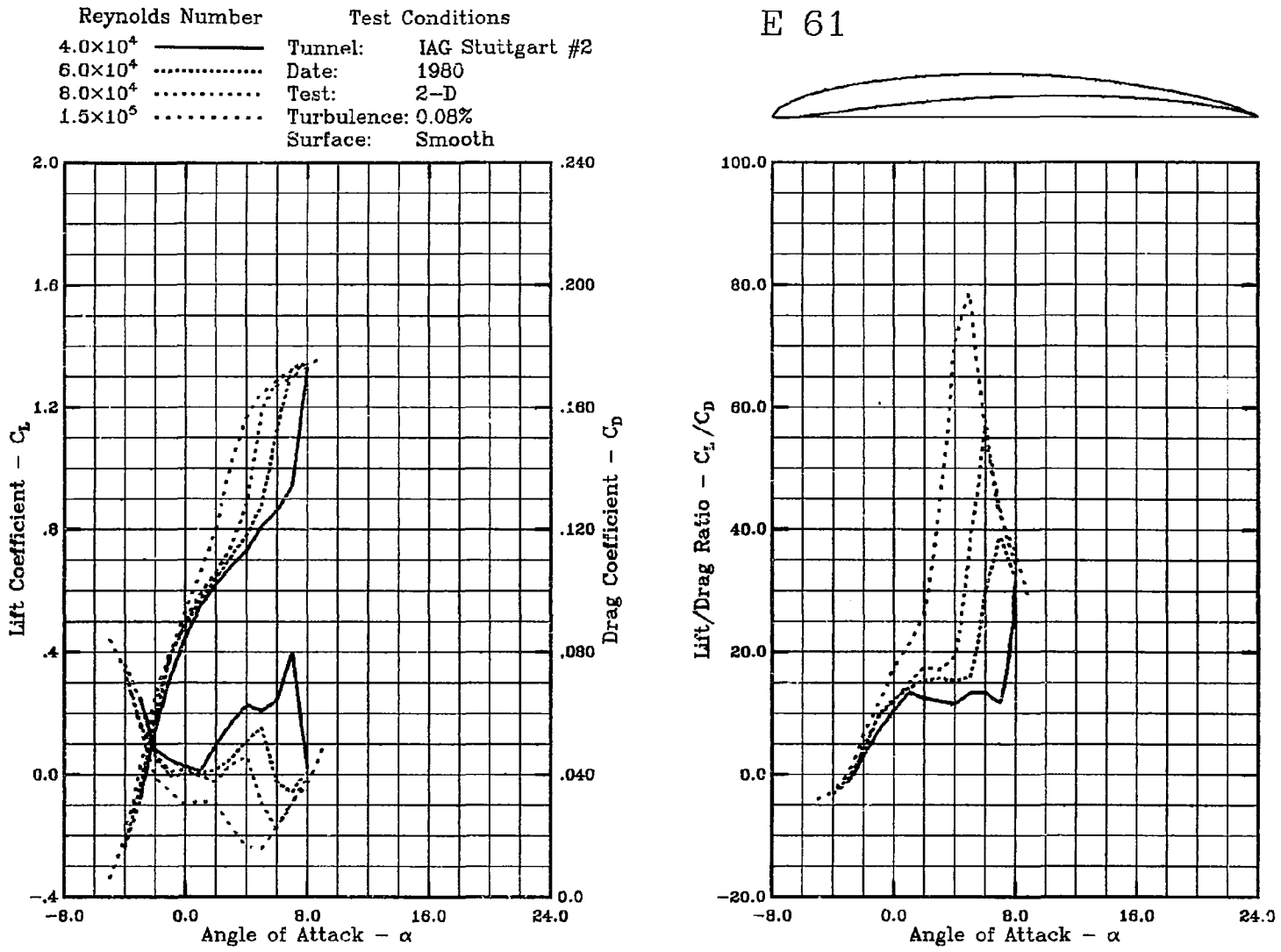

Reynolds Number
6.0×10^4
1.0×10^5
2.0×10^5
Test Conditions
Tunnel: IAG Stuttgart #2
Date: 1980
Test: 2-D
Turbulence: 0.08%
Surface: Smooth
Lift Coefficient – C_L
Drag Coefficient – C_D
Angle of Attack – α
Lift/Drag Ratio – C_L/C_D
Angle of Attack – α

CLARK Y

Tunnel: IAG Stuttgart #2 / Date: 1980 / Test: 2-D / Turbulence: 0.08% / Surface: Smooth

RN	6.0×10^4		1.0×10^5		2.0×10^5	
AOA	CL	CD	CL	CD	CL	CD
-6.0	-.43	.0614	-.44	.0573	-.42	.0520
-5.0	-.39	.0523	-.38	.0420	-.29	.0243
-4.0	-.31	.0371	-.27	.0347	-.16	.0202
-3.0	-.22	.0329	-.16	.0274	-.03	.0176
-2.0	-.12	.0285	-.05	.0213	.10	.0150
-1.0	-.01	.0242	.08	.0213	.20	.0126
.0	.10	.0210	.21	.0214	.30	.0103
1.0	.20	.0239	.34	.0216	.39	.0097
2.0	.25	.0297	.46	.0217	.49	.0091
3.0	.36	.0371	.55	.0212	.58	.0096
4.0	.47	.0445	.65	.0208	.68	.0104
5.0	.60	.0452	.74	.0202	.76	.0108
6.0	.73	.0453	.83	.0197	.85	.0112
7.0	.83	.0455	.91	.0204	.92	.0125
8.0	.94	.0457	.98	.0212	.99	.0140
9.0	1.01	.0419	1.04	.0225	1.06	.0152
10.0	1.07	.0382	1.11	.0239	1.13	.0164
11.0	1.12	.0379	1.15	.0266	1.17	.0172
12.0	1.17	.0385	1.19	.0298	1.20	.0238
13.0	1.19	.0400	1.21	.0391	1.23	.0342
14.0	1.20	.0411	1.23	.0507	1.24	.0547
15.0	1.21	.0437	1.23	.1062	1.24	.1125
16.0	-	-	1.22	-	1.23	-

E 61

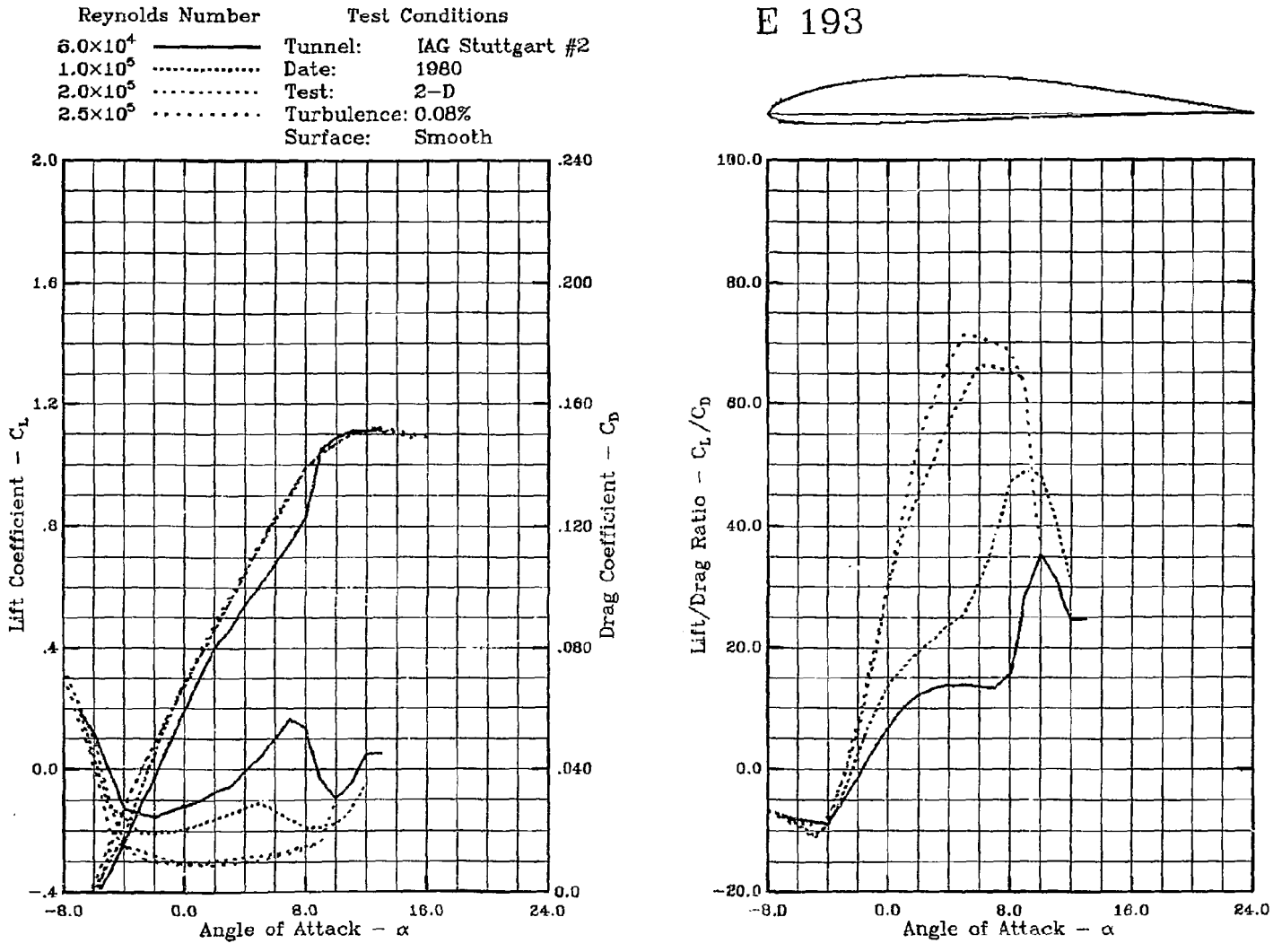

Reynolds Number
4.0×10⁴
6.0×10⁴
8.0×10⁴
1.5×10⁵
Test Conditions
Tunnel: IAG Stuttgart #2
Date: 1980
Test: 2-D
Turbulence: 0.08%
Surface: Smooth
Lift Coefficient – C_L
Drag Coefficient – C_D
Lift/Drag Ratio – C_L/C_D
Angle of Attack – α
2.0
1.6
1.2
.8
.4
0.0
-.4
.240
.200
.160
.120
.080
.040
0.0
100.0
80.0
60.0
40.0
20.0
0.0
-20.0
-8.0
0.0
8.0
16.0
24.0

E 61

Tunnel: IAG Stuttgart #2 / Date: 1980 / Test: 2-D / Turbulence: 0.08% / Surface: Smooth

RN	4.0×10^4		6.0×10^4		8.0×10^4		1.5×10^5	
AOA	CL	CD	CL	CD	CL	CD	CL	CD
-5.0	-	-	-	-	-	-	-.34	.0840
-4.0	-	-	-.23	.0740	-.24	.0761	-.21	.0742
-3.0	-.08	.0652	-.04	.0568	-.08	.0644	.02	.0558
-2.0	.15	.0482	.18	.0458	.22	.0466	.26	.0390
-1.0	.32	.0447	.39	.0396	.39	.0410	.40	.0342
.0	.45	.0425	.49	.0400	.50	.0416	.53	.0302
1.0	.55	.0411	.57	.0403	.59	.0394	.66	.0312
2.0	.62	.0497	.64	.0416	.66	.0376	.80	.0305
3.0	.68	.0567	.71	.0452	.74	.0432	1.02	.0229
4.0	.73	.0628	.78	.0509	.88	.0460	1.17	.0165
5.0	.81	.0608	.88	.0553	1.19	.0307	1.25	.0158
6.0	.86	.0643	1.13	.0374	1.29	.0222	1.27	.0224
7.0	.94	.0802	1.33	.0340	1.32	.0308	1.30	.0310
8.0	1.33	.0421	1.34	.0416	1.34	.0389	1.33	.0364
9.0	-	-	-	-	-	-	1.37	.0484

E 193


Reynolds Number
6.0×10^4
1.0×10^5
2.0×10^5
2.5×10^5
Test Conditions
Tunnel: IAG Stuttgart #2
Date: 1980
Test: 2-D
Turbulence: 0.08%
Surface: Smooth
Lift Coefficient – C_L
Drag Coefficient – C_D
Angle of Attack – α
Lift/Drag Ratio – C_L/C_D
Angle of Attack – α

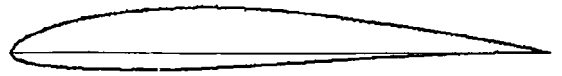
E 193

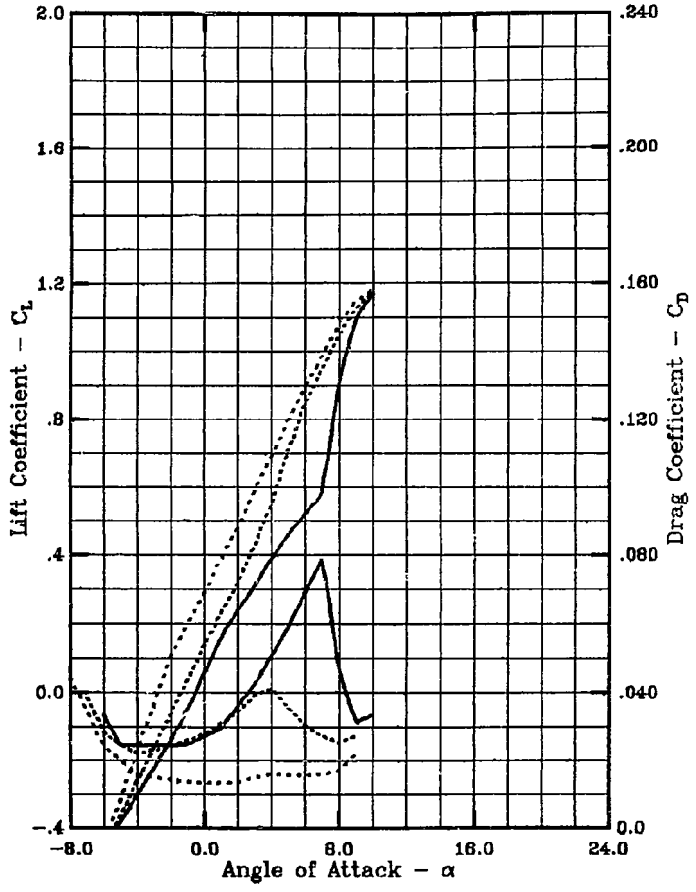
Tunnel: IAG Stuttgart #2 / Date: 1980 / Test: 2-D / Turbulence: 0.08% / Surface: Smooth

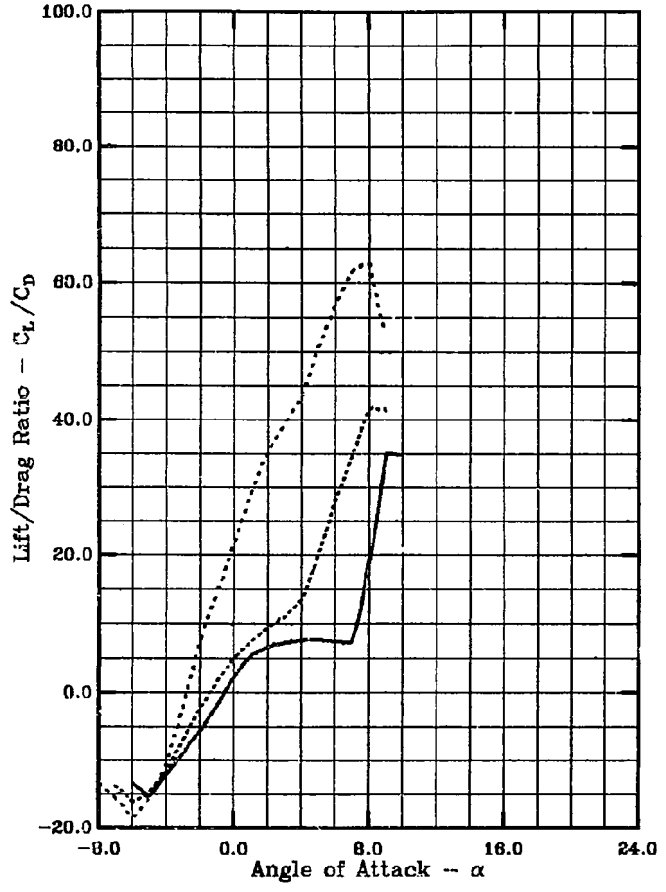
RN	6.0×10^4		1.0×10^5		2.0×10^5		2.5×10^5	
AOA	CL	CD	CL	CD	CL	CD	CL	CD
-8.0	-	-	-	-	-.50	.0735	-.49	.0707
-7.0	-.46	.0594	-.45	.0599	-.46	.0615	-.45	.0560
-6.0	-.42	.0518	-.39	.0440	-.43	.0495	-.38	.0412
-5.0	-.34	.0398	-.30	.0276	-.27	.0302	-.24	.0207
-4.0	-.24	.0272	-.22	.0246	-.12	.0153	-.13	.0154
-3.0	-.13	.0255	-.08	.0192	-.02	.0137	-.01	.0112
-2.0	-.03	.0245	.05	.0193	.08	.0121	.08	.0102
-1.0	.08	.0262	.17	.0195	.18	.0104	.18	.0095 *
.0	.19	.0279	.28	.0204	.27	.0089	.28	.0092
1.0	.30	.0297	.37	.0221	.37	.0095	.38	.0090
2.0	.40	.0328	.46	.0238	.46	.0102	.48	.0089
3.0	.46	.0344	.55	.0256	.55	.0108	.57	.0094
4.0	.54	.0392	.65	.0273	.65	.0114	.66	.0099
5.0	.61	.0441	.74	.0290	.74	.0120	.75	.0105
6.0	.68	.0500	.82	.0264	.83	.0125	.83	.0117
7.0	.75	.0565	.90	.0237	.91	.0138	.91	.0130
8.0	.83	.0532	.99	.0210	.99	.0152	.99	.0144
9.0	1.05	.0364	1.04	.0213	1.03	.0161	1.04	.0165
10.0	1.09	.0307	1.07	.0222	1.07	-	1.09	.0295
11.0	1.11	.0354	1.10	.0267	1.10	-	1.11	-
12.0	1.11	.0451	1.11	.0359	1.11	-	1.11	-
13.0	1.12	.0453	1.11	-	1.11	-	1.12	-
14.0	-	-	1.11	-	1.10	-	1.11	-
15.0	-	-	-	-	1.09	-	1.10	-
16.0	-	-	-	-	-	-	1.09	-

E 203

Reynolds Number	Test Conditions	
6.0×10^4 ———	Tunnel:	IAG Stuttgart #2
8.0×10^4 ·····	Date:	1980
1.5×10^5 ·····	Test:	2–D
	Turbulence:	0.08%
	Surface:	Smooth





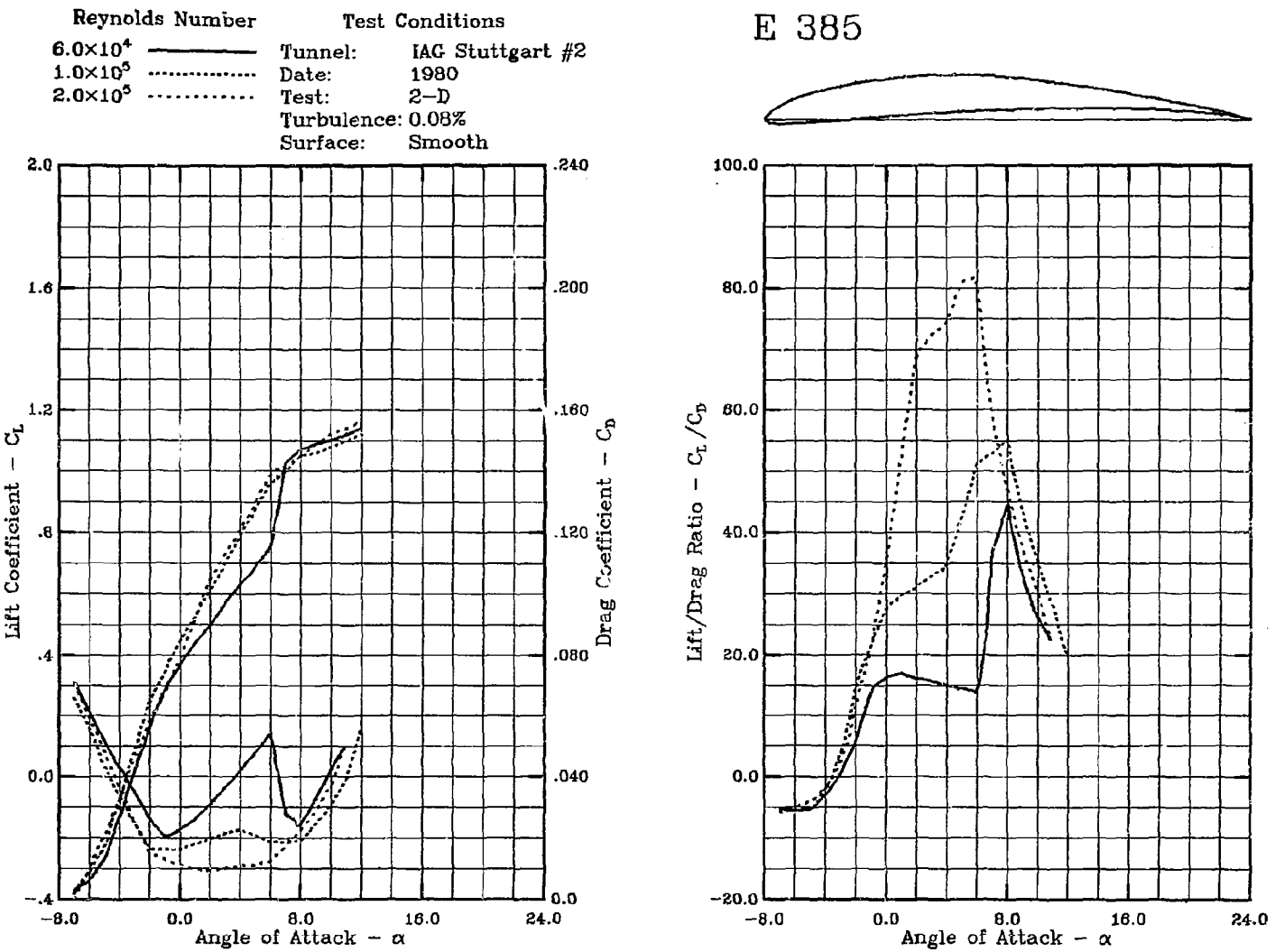


E 203

Tunnel: IAG Stuttgart #2 / Date: 1980 / Test: 2-D / Turbulence: 0.08% / Surface: Smooth

RN	6.0×10^4		8.0×10^4		1.5×10^5	
AOA	CL	CD	CL	CD	CL	CD
-8.0	-	-	-	-	-.60	.0446
-7.0	-	-	-.53	.0385	-.53	.0340
-6.0	-.45	.0335	-.46	.0284	-.45	.0241
-5.0	-.38	.0245	-.36	.0245	-.31	.0199
-4.0	-.30	.0245	-.26	.0219	-.17	.0160
-3.0	-.22	.0245	-.16	.0229	-.03	.0151
-2.0	-.14	.0245	-.06	.0241	.11	.0143
-1.0	-.05	.0248	.04	.0260	.20	.0138
.0	.06	.0272	.14	.0281	.29	.0134
1.0	.16	.0296	.23	.0310	.39	.0134
2.0	.24	.0361	.32	.0342	.48	.0136
3.0	.31	.0425	.43	.0394	.59	.0150
4.0	.39	.0508	.55	.0412	.69	.0160
5.0	.46	.0592	.71	.0355	.80	.0158
6.0	.52	.0691	.85	.0304	.90	.0158
7.0	.58	.0791	.95	.0274	.99	.0160
8.0	.91	.0470	1.05	.0251	1.08	.0171
9.0	1.10	.0313	1.13	.0273	1.15	.0219
10.0	1.17	.0336	1.17	-	1.18	-

E 385


Reynolds Number
6.0×10^4
1.0×10^5
2.0×10^5
Test Conditions
Tunnel: IAG Stuttgart #2
Date: 1980
Test: 2-D
Turbulence: 0.08%
Surface: Smooth
Lift Coefficient – C_L
Drag Coefficient – C_D
Angle of Attack – α
Lift/Drag Ratio – C_L/C_D
Angle of Attack – α

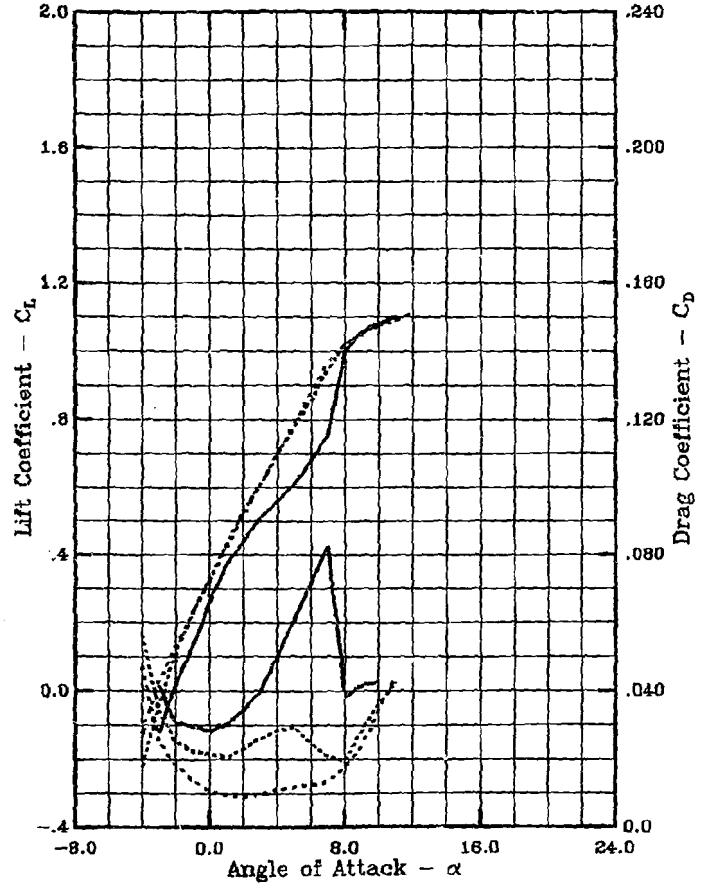
E 385

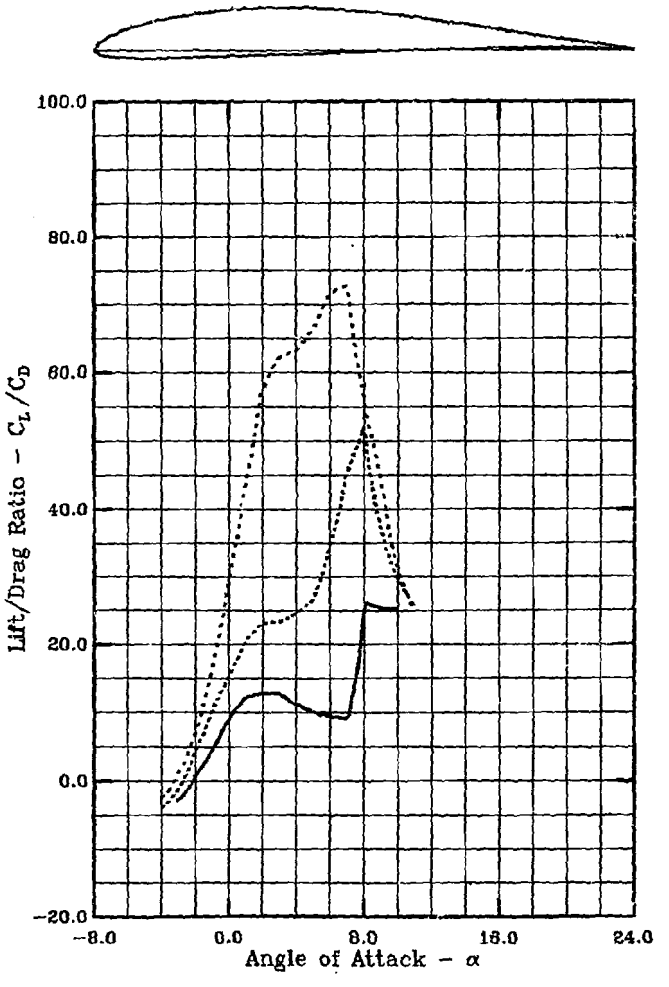
Tunnel: IAG Stuttgart #2 / Date: 1980 / Test: 2-D / Turbulence: 0.08% / Surface: Smooth

RN	6.0×10^4		1.0×10^5		2.0×10^5	
AOA	CL	CD	CL	CD	CL	CD
-7.0	-.37	.0710	-.38	.0661	-.40	.0707
-6.0	-.34	.0614	-.31	.0558	-.30	.0594
-5.0	-.27	.0511	-.23	.0430	-.19	.0478
-4.0	-.13	.0429	-.07	.0336	-.07	.0364
-3.0	.02	.0346	.09	.0246	.06	.0250
-2.0	.16	.0263	.25	.0164	.18	.0150
-1.0	.29	.0201	.35	.0162	.28	.0130
.0	.37	.0227	.45	.0162	.39	.0110
1.0	.44	.0259	.53	.0179	.52	.0098
2.0	.50	.0311	.61	.0197	.65	.0094
3.0	.57	.0363	.70	.0213	.73	.0101
4.0	.63	.0420	.79	.0228	.81	.0109
5.0	.69	.0478	.88	.0206	.90	.0111
6.0	.75	.0542	.96	.0187	.99	.0121
7.0	1.03	.0279	1.00	.0189	1.02	.0172
8.0	1.07	.0239	1.05	.0190	1.05	.0223
9.0	1.09	.0330	1.06	.0244	1.09	.0291
10.0	1.10	.0420	1.08	.0306	1.12	.0368
11.0	1.12	.0508	1.10	.0391	1.14	.0519
12.0	1.14	-	1.12	.0559	1.16	-

E 387

Reynolds Number	Test Conditions	
6.0×10^4 ———	Tunnel:	IAG Stuttgart #2
1.0×10^5 ·····	Date:	1980
2.0×10^5 ·····	Test:	2-D
	Turbulence:	0.08%
	Surface:	Smooth

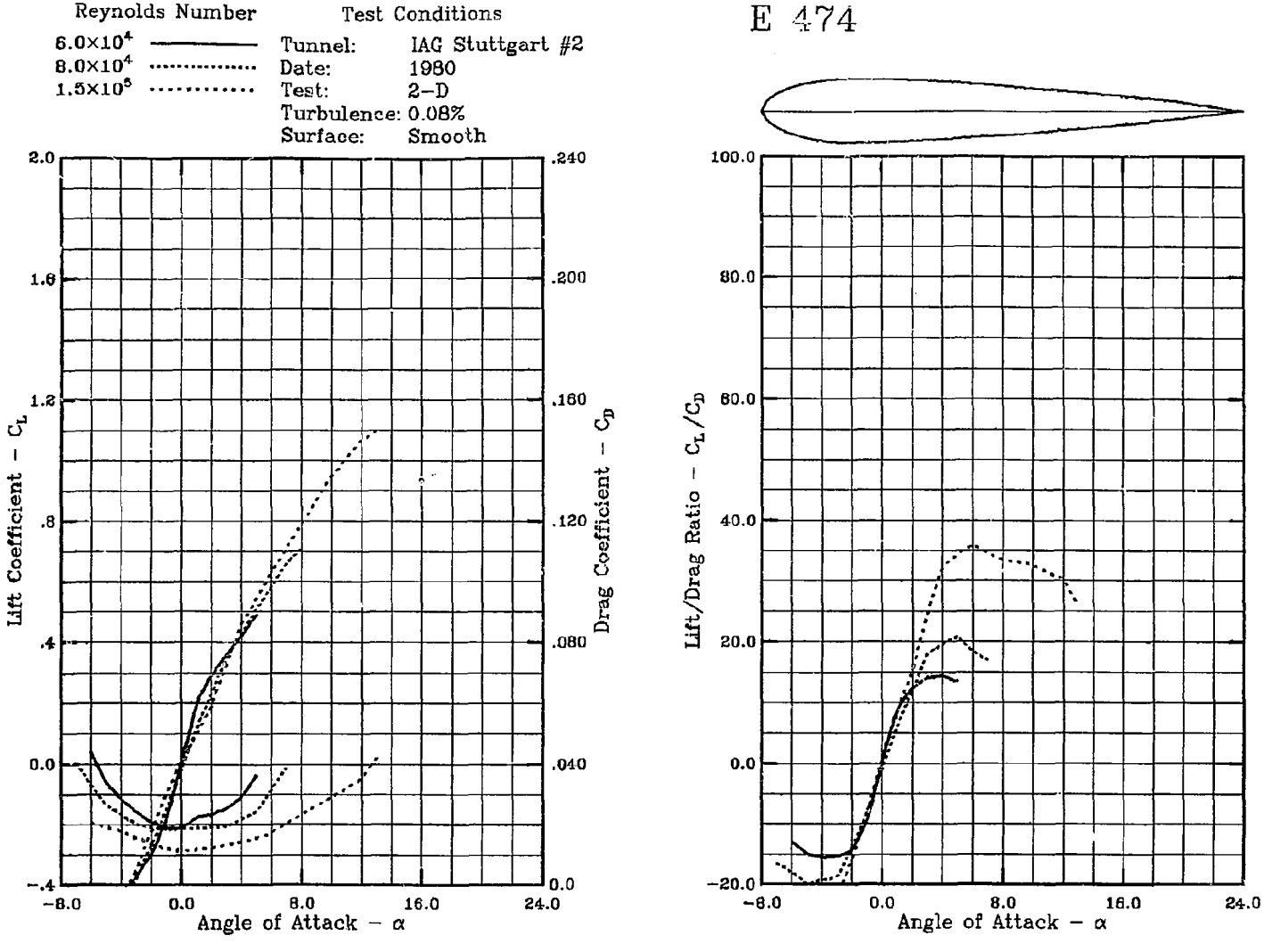




E 387

Tunnel: IAG Stuttgart #2 / Date: 1980 / Test: 2-D / Turbulence: 0.08% / Surface: Smooth

RN	6.0×10^4		1.0×10^5		2.0×10^5	
AOA	CL	CD	CL	CD	CL	CD
-4.0	-	-	-.22	.0562	-.12	.0469
-3.0	-.12	.0416	-.04	.0343	.03	.0254
-2.0	.02	.0307	.11	.0253	.13	.0182
-1.0	.13	.0297	.23	.0224	.23	.0140
.0	.26	.0283	.33	.0216	.32	.0108
1.0	.37	.0303	.43	.0208	.42	.0096
2.0	.44	.0344	.53	.0230	.52	.0090
3.0	.51	.0399	.61	.0261	.61	.0098
4.0	.56	.0501	.70	.0285	.70	.0111
5.0	.61	.0607	.78	.0294	.79	.0119
6.0	.68	.0718	.86	.0249	.88	.0123
7.0	.76	.0832	.95	.0208	.97	.0133
8.0	1.00	.0383	1.02	.0196	1.02	.0181
9.0	1.06	.0417	1.06	.0286	1.05	.0236
10.0	1.08	.0428	1.08	.0364	1.08	.0347
11.0	1.10	-	1.09	.0425	1.09	.0443
12.0	-	-	-	-	1.11	-


Reynolds Number
6.0×10^4
8.0×10^4
1.5×10^5
Test Conditions
Tunnel: IAG Stuttgart #2
Date: 1980
Test: 2-D
Turbulence: 0.08%
Surface: Smooth
Lift Coefficient - C_L
Drag Coefficient - C_D
Angle of Attack - α
2.0
1.6
1.2
.8
.4
0.0
-.4
.240
.200
.160
.120
.080
.040
0.0
-8.0
0.0
8.0
16.0
24.0
E 474
Lift/Drag Ratio - C_L/C_D
100.0
80.0
60.0
40.0
20.0
0.0
-20.0
Angle of Attack - α

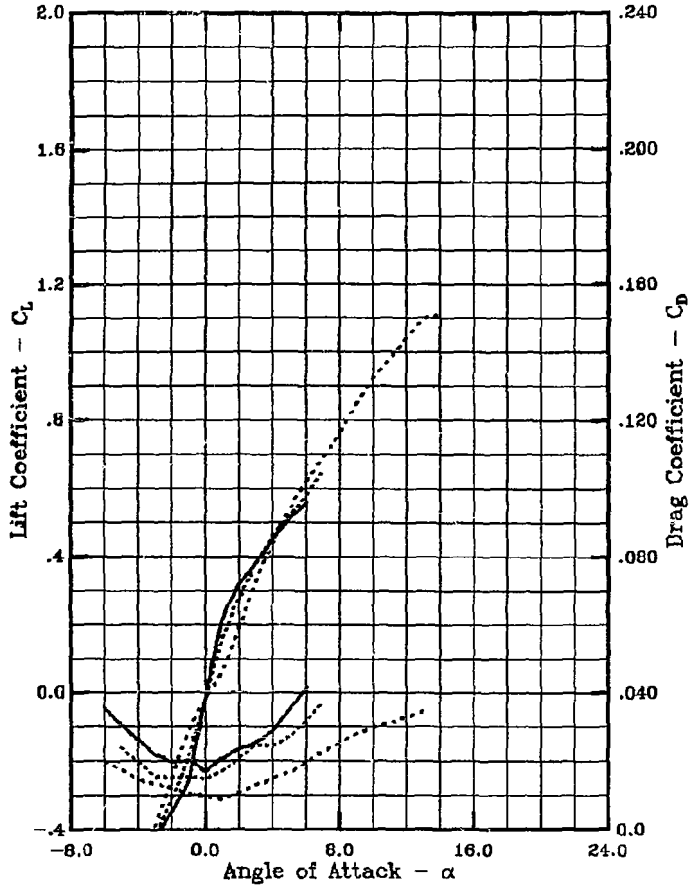
E 474

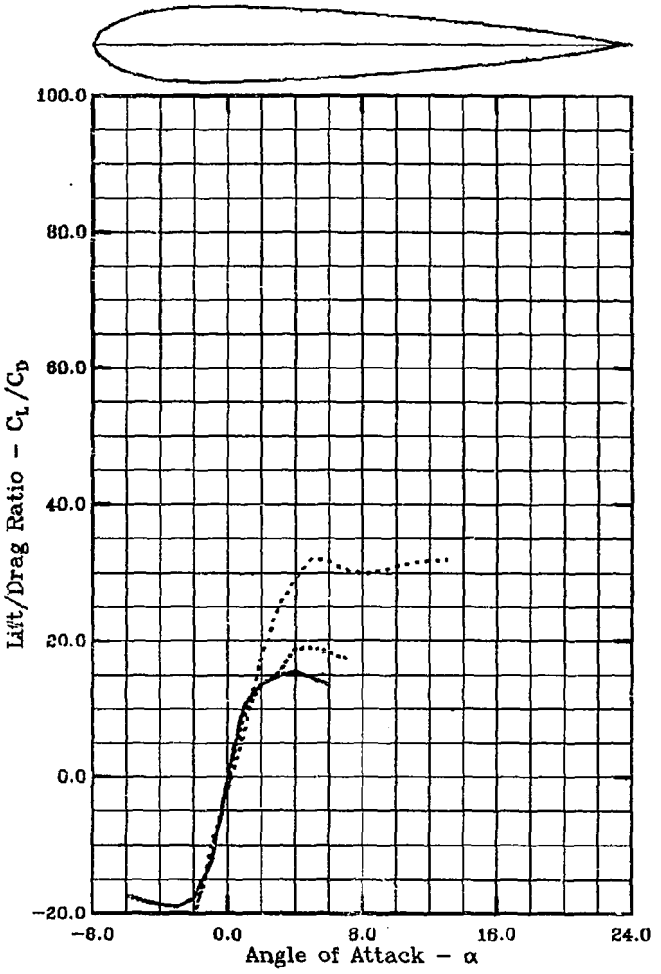
Tunnel: IAG Stuttgart #2 / Date: 1980 / Test: 2-D / Turbulence: 0.08% / Surface: Smooth

RN	6.0×10^4		8.0×10^4		1.5×10^5	
AOA	CL	CD	CL	CD	CL	CD
-7.0	-	-	-.67	.0404	-	-
-6.0	-.57	.0439	-.60	.0332	-.63	.0206
-5.0	-.51	.0341	-.53	.0265	-.55	.0193
-4.0	-.44	.0284	-.45	.0233	-.47	.0179
-3.0	-.37	.0242	-.38	.0201	-.35	.0158
-2.0	-.30	.0209	-.27	.0193	-.22	.0138
-1.0	-.18	.0191	-.15	.0186	-.10	.0123
.0	.00	.0187	-.02	.0187	.01	.0113
1.0	.20	.0225	.12	.0189	.10	.0119
2.0	.29	.0234	.23	.0192	.19	.0126
3.0	.36	.0255	.35	.0195	.33	.0134
4.0	.42	.0290	.43	.0219	.46	.0143
5.0	.49	.0363	.51	.0245	.54	.0157
6.0	-	-	.58	.0315	.63	.0175
7.0	-	-	.66	.0389	.71	.0205
8.0	-	-	.71	-	.79	.0236
9.0	-	-	-	-	.87	.0263
10.0	-	-	-	-	.95	.0291
11.0	-	-	-	-	1.01	.0322
12.0	-	-	-	-	1.07	.0353
13.0	-	-	-	-	1.10	.0421

E 475

Reynolds Number	Test Conditions	
6.0×10^4 ———	Tunnel:	IAG Stuttgart #2
3.0×10^4 ·····	Date:	1980
1.5×10^4 ·····	Test:	2–D
	Turbulence:	0.08%
	Surface:	Smooth





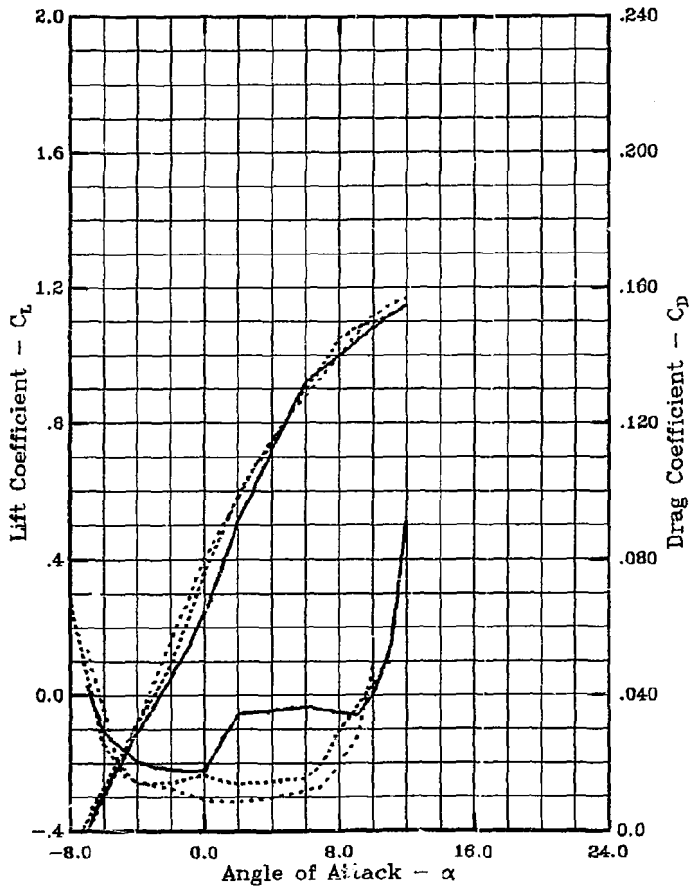
E 475

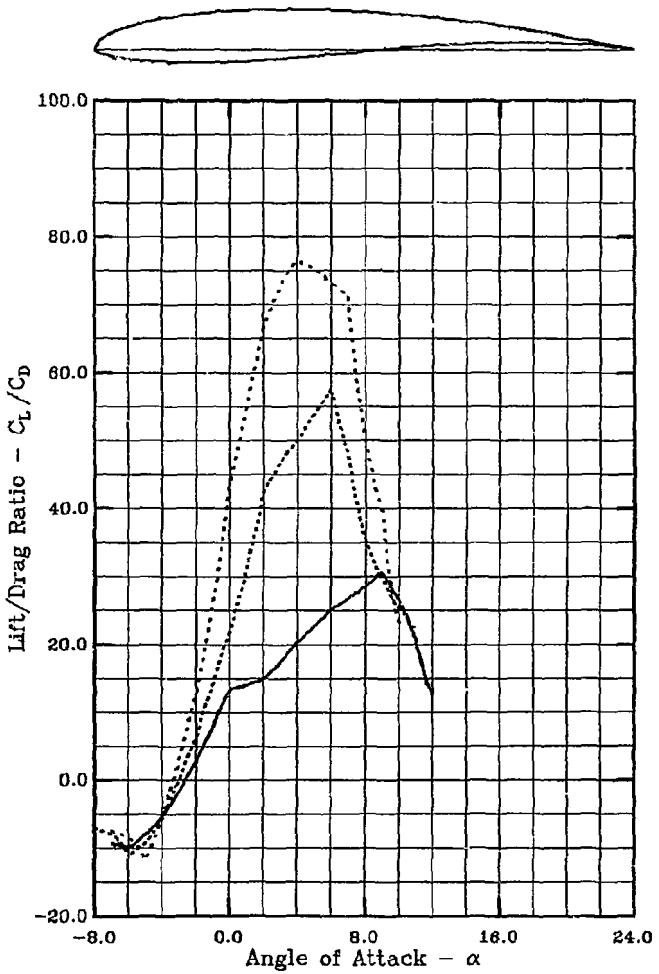
Tunnel: IAG Stuttgart #2 / Date: 1980 / Test: 2-D / Turbulence: 0.08% / Surface: Smooth

RN	6.0×10^4		8.0×10^4		1.5×10^5	
AOA	CL	CD	CL	CD	CL	CD
-6.0	-.62	.0357	-	-	-.67	.0201
-5.0	-.55	.0303	-.56	.0241	-.59	.0174
-4.0	-.49	.0263	-.49	.0198	-.52	.0148
-3.0	-.42	.0221	-.42	.0155	-.39	.0132
-2.0	-.35	.0197	-.31	.0153	-.25	.0119
-1.0	-.26	.0203	-.19	.0154	-.11	.0106
.0	-.01	.0171	-.02	.0150	-.02	.0097
1.0	.22	.0208	.16	.0172	.06	.0090
2.0	.32	.0235	.28	.0209	.19	.0108
3.0	.38	.0255	.38	.0248	.33	.0132
4.0	.45	.0288	.46	.0244	.44	.0151
5.0	.51	.0348	.52	.0273	.54	.0168
6.0	.56	.0416	.58	.0315	.62	.0196
7.0	-	-	.65	.0371	.69	.0226
8.0	-	-	-	-	.76	.0254
9.0	-	-	-	-	.85	.0281
10.0	-	-	-	-	.92	.0298
11.0	-	-	-	-	.98	.0312
12.0	-	-	-	-	1.04	.0328
13.0	-	-	-	-	1.10	.0345
14.0	-	-	-	-	1.11	-

FX 60-100

Reynolds Number	Test Conditions	
6.0×10^4 ———	Tunnel:	IAG Stuttgart #2
1.0×10^5 ·····	Date:	1980
2.0×10^5 ·····	Test:	2-D
	Turbulence:	0.08%
	Surface:	Smooth



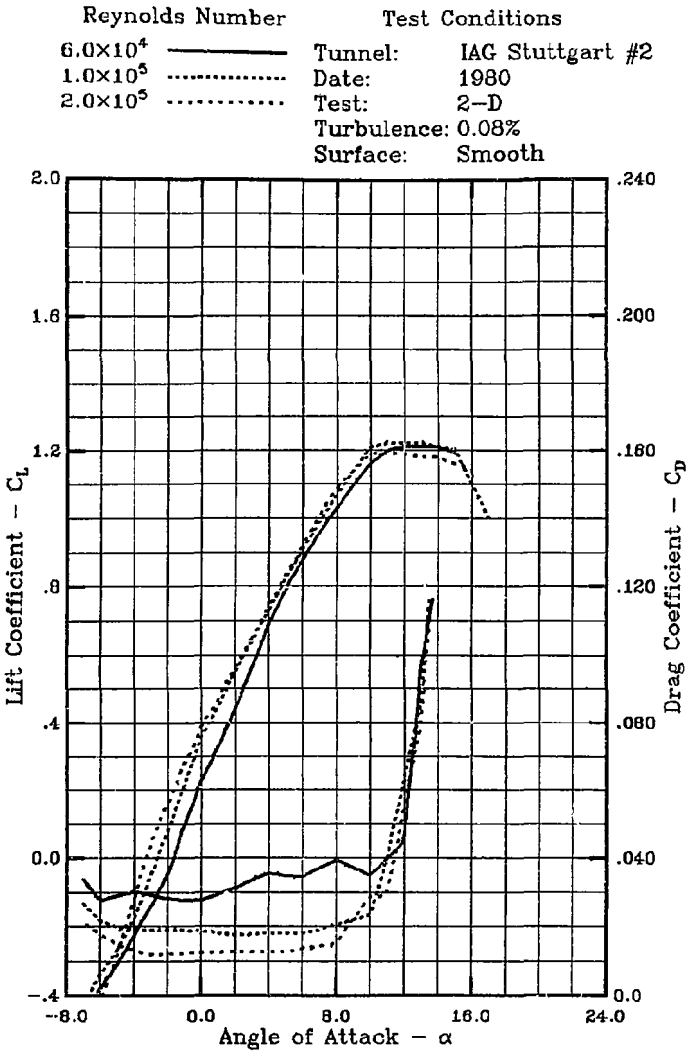


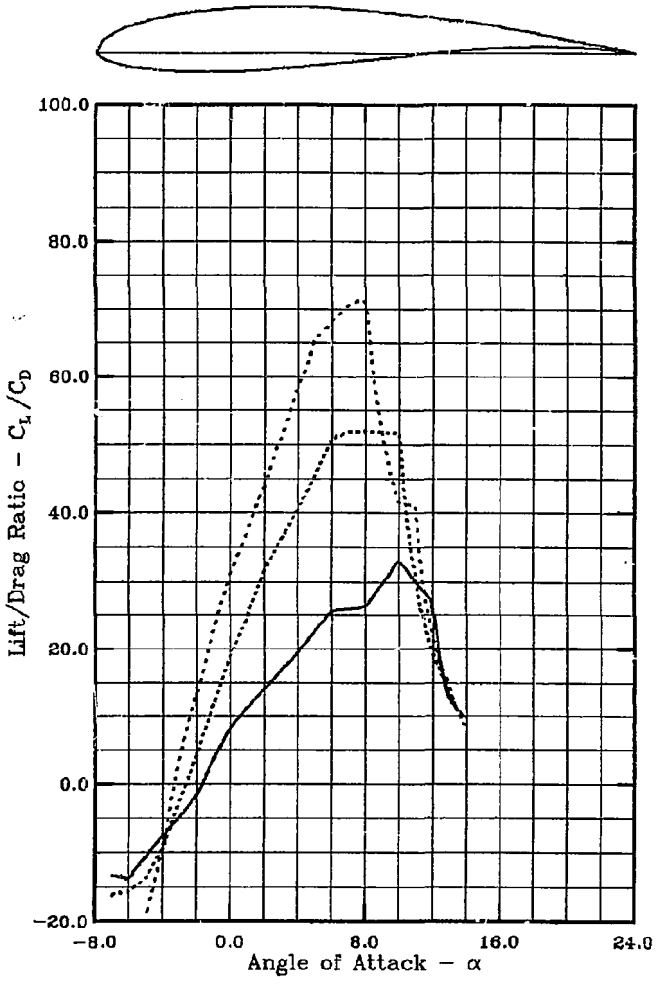
FX 60-100

Tunnel: IAG Stuttgart #2 / Date: 1980 / Test: 2-D / Turbulence: 0.08% / Surface: Smooth

RN	6.0×10^4		1.0×10^5		2.0×10^5	
AOA	CL	CD	CL	CD	CL	CD
-8.0	-	-	-.47	.0672	-.50	-
-7.0	-.40	.0427	-.37	.0458	-.40	.0536
-6.0	-.29	.0292	-.27	.0249	-.30	.0353
-5.0	-.20	.0247	-.18	.0193	-.20	.0170
-4.0	-.11	.0203	-.08	.0140	-.08	.0145
-3.0	-.03	.0191	.00	.0141	.04	.0135
-2.0	.05	.0181	.09	.0143	.16	.0125
-1.0	.14	.0177	.22	.0155	.28	.0108
.0	.24	.0178	.36	.0164	.40	.0091
1.0	.37	.0262	.47	.0152	.49	.0089
2.0	.51	.0345	.59	.0139	.58	.0087
3.0	.61	.0350	.67	.0143	.67	.0092
4.0	.72	.0355	.74	.0148	.75	.0098
5.0	.82	.0361	.82	.0152	.82	.0109
6.0	.92	.0366	.90	.0156	.88	.0120
7.0	.96	.0359	.97	.0202	.94	.0132
8.0	1.00	.0349	1.05	.0296	1.00	.0200
9.0	1.04	.0339	1.08	.0363	1.06	.0268
10.0	1.08	.0403	1.10	.0433	1.12	.0483
11.0	1.12	.0530	1.12	.0503	1.15	-
12.0	1.15	.0910	-	-	1.17	-

FX 60-126

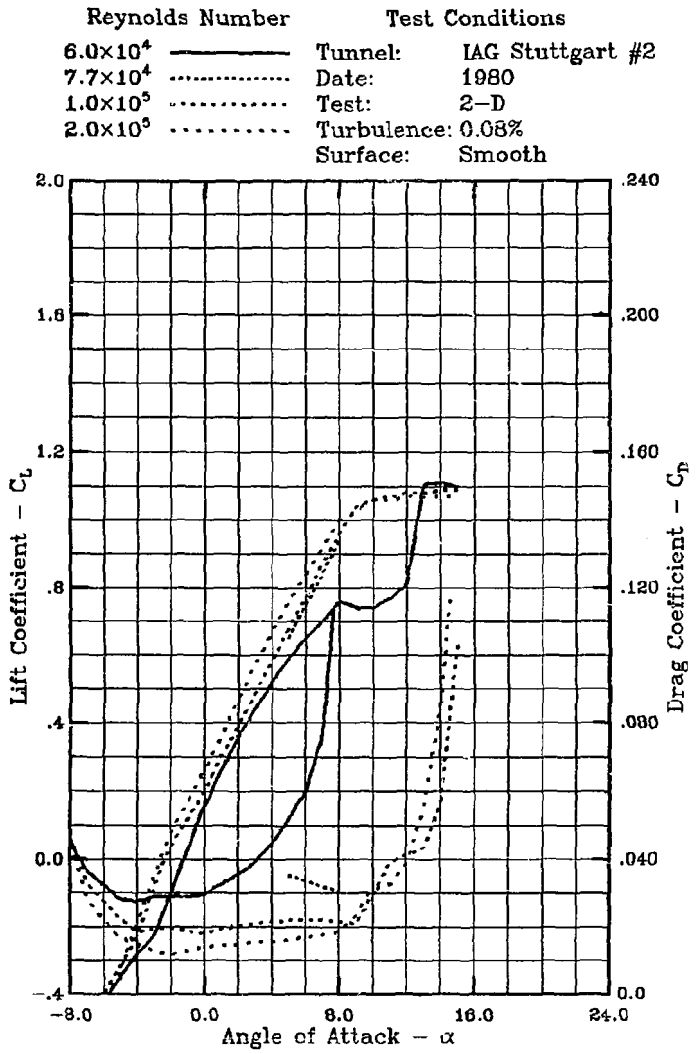

Reynolds Number
6.0×10^4
1.0×10^5
2.0×10^5
Test Conditions
Tunnel: IAG Stuttgart #2
Date: 1980
Test: 2-D
Turbulence: 0.08%
Surface: Smooth
Lift Coefficient – C_L
Drag Coefficient – C_D
Angle of Attack – α
2.0
1.6
1.2
.8
.4
0.0
-.4
.240
.200
.160
.120
.080
.040
0.0
-8.0
0.0
8.0
16.0
24.0


Lift/Drag Ratio – C_L/C_D
Angle of Attack – α
100.0
80.0
60.0
40.0
20.0
0.0
-20.0
-8.0
0.0
8.0
16.0
24.0

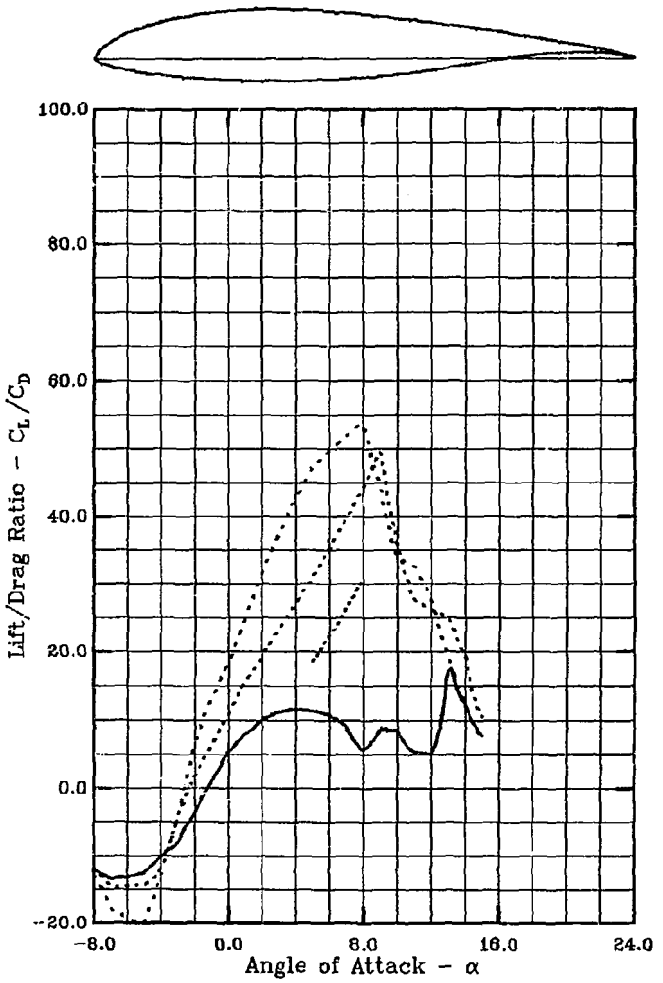
FX 60-126

Tunnel: IAG Stuttgart #2 / Date: 1980 / Test: 2-D / Turbulence: 0.08% / Surface: Smooth

RN	6.0×10^4		1.0×10^5		2.0×10^5	
AOA	CL	CD	CL	CD	CL	CD
-8.0	-	-	-.52	-	-.57	-
-7.0	-.45	.0338	-.43	.0267	-.49	.0215
-6.0	-.38	.0276	-.34	.0218	-.42	.0176
-5.0	-.31	.0291	-.27	.0197	-.29	.0148
-4.0	-.23	.0302	-.18	.0190	-.12	.0133
-3.0	-.14	.0292	-.05	.0190	.05	.0119
-2.0	-.05	.0282	.08	.0189	.16	.0121
-1.0	.10	.0277	.22	.0189	.28	.0123
.0	.23	.0278	.36	.0188	.39	.0125
1.0	.33	.0295	.45	.0181	.47	.0126
2.0	.44	.0313	.55	.0174	.56	.0127
3.0	.56	.0335	.64	.0177	.65	.0127
4.0	.69	.0354	.73	.0180	.74	.0127
5.0	.79	.0348	.82	.0180	.83	.0127
6.0	.88	.0344	.91	.0179	.92	.0135
7.0	.96	.0371	.99	.0191	1.01	.0143
8.0	1.03	.0393	1.07	.0206	1.09	.0152
9.0	1.10	.0371	1.14	.0220	1.14	.0223
10.0	1.16	.0349	1.21	.0234	1.19	.0287
11.0	1.20	.0398	1.22	.0401	1.19	.0290
12.0	1.21	.0448	1.22	.0633	1.19	.0550
13.0	1.21	.0959	1.22	.0866	1.18	.0810
14.0	1.21	.1260	1.21	.1455	1.18	.1395
15.0	1.19	-	1.20	-	1.16	-
16.0	-	-	1.10	-	1.14	-
17.0	-	-	1.00	-	-	-


Reynolds Number
6.0×10⁴
7.7×10⁴
1.0×10⁵
2.0×10⁵
Test Conditions
Tunnel: IAG Stuttgart #2
Date: 1980
Test: 2–D
Turbulence: 0.08%
Surface: Smooth
Lift Coefficient – C_L
Drag Coefficient – C_D
Angle of Attack – α
2.0
1.6
1.2
.8
.4
0.0
–.4
.240
.200
.160
.120
.080
.040
0.0
–8.0
0.0
8.0
16.0
24.0

FX 61–140

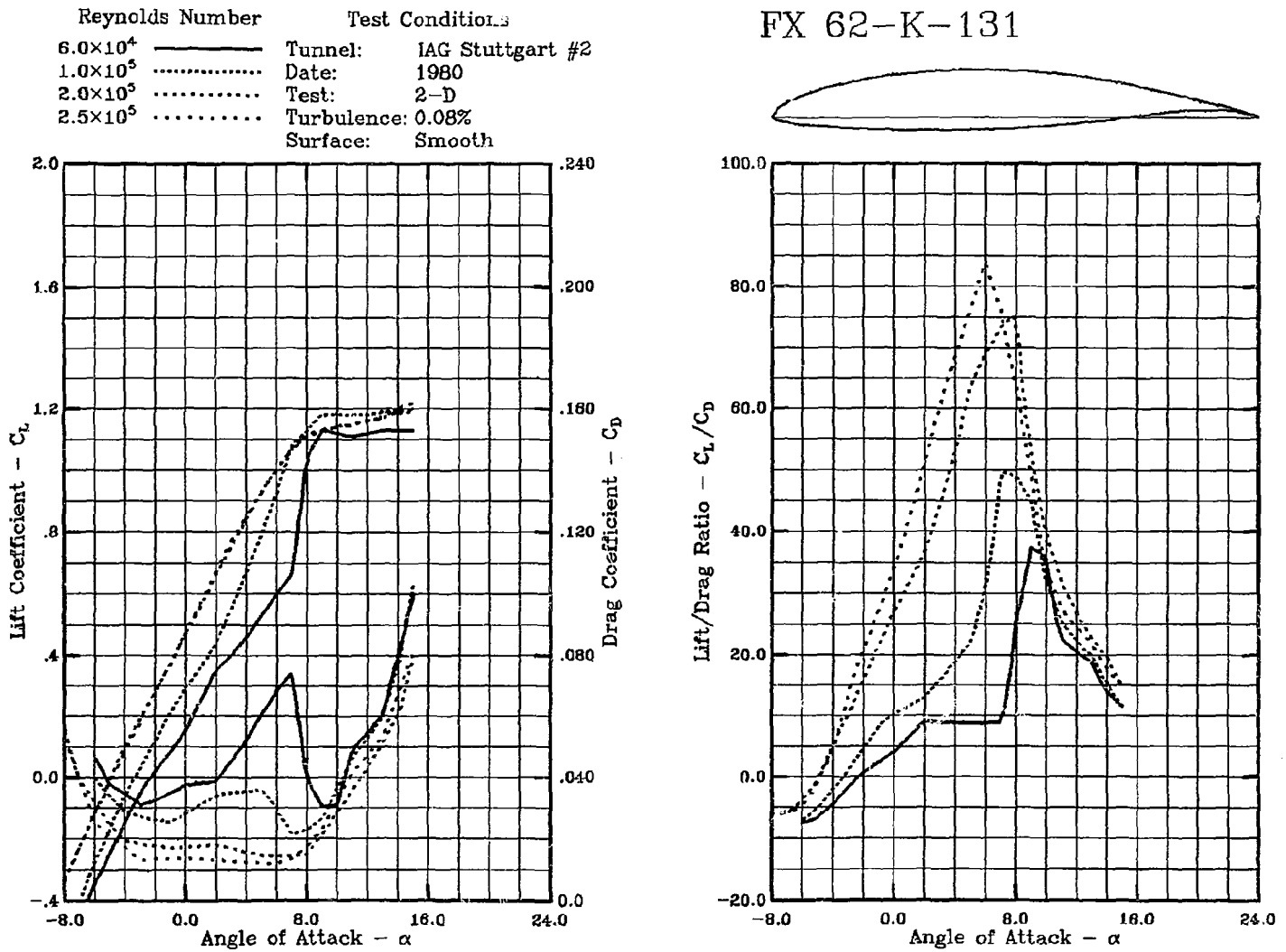

Lift/Drag Ratio – C_L/C_D
Angle of Attack – α
100.0
80.0
60.0
40.0
20.0
0.0
–20.0
–8.0
0.0
8.0
16.0
24.0

FX 61-140

Tunnel: IAG Stuttgart #2 / Date: 1980 / Test: 2-D / Turbulence: 0.08% / Surface: Smooth

RN	6.0×10^4		7.7×10^4		1.0×10^5		2.0×10^5	
AOA	CL	CD	CL	CD	CL	CD	CL	CD
-8.0	-.54	.0450	-	-	-.54	.0460	-.57	.0443
-7.0	-.49	.0365	-	-	-.48	.0328	-.51	.0283
-6.0	-.42	.0323	-	-	-.40	.0276	-.43	.0221
-5.0	-.35	.0281	-	-	-.32	.0223	-.33	.0165
-4.0	-.28	.0275	-	-	-.23	.0184	-.19	.0148
-3.0	-.23	.0289	-	-	-.08	.0194	-.05	.0130
-2.0	-.10	.0289	-	-	.04	.0198	.08	.0117
-1.0	.03	.0289	-	-	.12	.0189	.17	.0129
.0	.16	.0297	-	-	.20	.0181	.26	.0141
1.0	.26	.0327	-	-	.30	.0192	.36	.0145
2.0	.36	.0357	-	-	.39	.0203	.47	.0149
3.0	.44	.0390	-	-	.49	.0209	.57	.0153
4.0	.52	.0446	-	-	.58	.0215	.67	.0157
5.0	.59	.0518	.65	.0351	.68	.0220	.76	.0161
6.0	.65	.0599	.75	.0336	.77	.0219	.84	.0169
7.0	.70	.0757	.84	.0320	.87	.0219	.92	.0177
8.0	.76	.1347	.94	.0304	.96	.0217	1.00	.0185
9.0	.74	.0846	-	-	1.04	.0208	1.03	.0233
10.0	.74	.0865	-	-	1.06	.0295	1.06	.0314
11.0	.77	.1439	-	-	1.07	.0390	1.06	.0323
12.0	.81	.1594	-	-	1.08	.0413	1.07	.0384
13.0	1.11	.0576	-	-	1.08	.0430	1.07	.0548
14.0	1.11	.0909	-	-	1.09	.0556	1.07	.0840
15.0	1.10	.1415	-	-	1.09	.1033	1.07	.1440

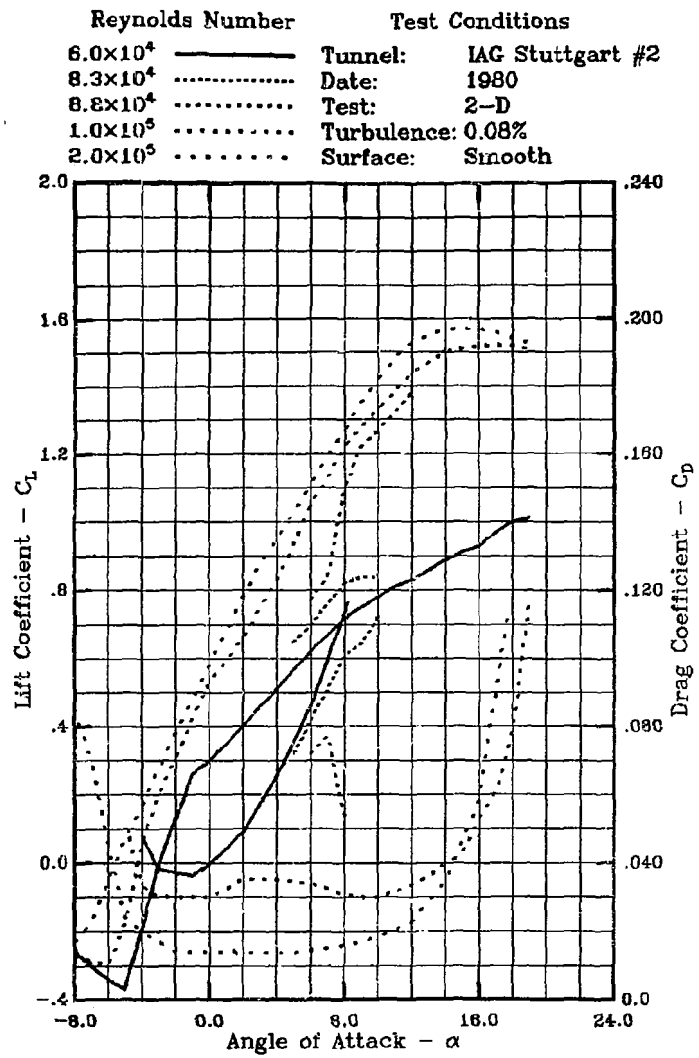
FX 62-K-131

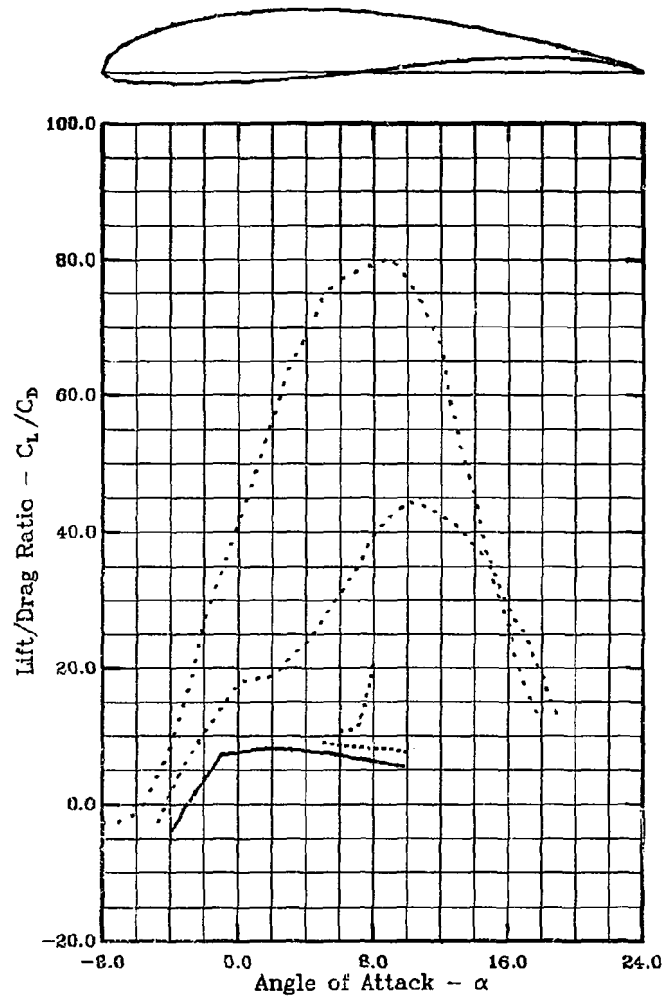

Reynolds Number
6.0×10^4
1.0×10^5
2.0×10^5
2.5×10^5
Test Conditions
Tunnel: IAG Stuttgart #2
Date: 1980
Test: 2-D
Turbulence: 0.08%
Surface: Smooth
Lift Coefficient – C_L
Drag Coefficient – C_D
Lift/Drag Ratio – C_L/C_D
Angle of Attack – α
2.0
1.6
1.2
.8
.4
0.0
-.4
.240
.200
.160
.120
.080
.040
0.0
100.0
80.0
60.0
40.0
20.0
0.0
-20.0
-8.0
0.0
8.0
16.0
24.0

FX 62-K-131

Tunnel: IAG Stuttgart #2 / Date: 1980 / Test: 2-D / Turbulence: 0.08% / Surface: Smooth

RN	6.0×10^4		1.0×10^5		2.0×10^5		2.5×10^5	
AOA	CL	CD	CL	CD	CL	CD	CL	CD
-8.0	-.43	-	-.47	-	-.33	.0549	-.34	.0561
-7.0	-.45	-	-.40	-	-.23	.0392	-.23	.0396
-6.0	-.35	.0470	-.28	.0401	-.12	.0321	-.12	.0256
-5.0	-.25	.0380	-.17	.0339	-.01	.0251	-.02	.0213
-4.0	-.15	.0345	-.06	.0286	.10	.0191	.08	.0172
-3.0	-.05	.0310	.03	.0275	.19	.0184	.18	.0132
-2.0	.02	.0325	.12	.0263	.28	.0177	.28	.0134
-1.0	.08	.0349	.21	.0254	.37	.0170	.37	.0136
.0	.15	.0374	.29	.0283	.47	.0173	.47	.0138
1.0	.25	.0381	.36	.0312	.56	.0177	.57	.0135
2.0	.35	.0386	.44	.0340	.66	.0180	.67	.0131
3.0	.40	.0450	.55	.0348	.75	.0169	.77	.0127
4.0	.46	.0523	.67	.0354	.84	.0158	.85	.0124
5.0	.53	.0603	.79	.0359	.93	.0146	.93	.0122
6.0	.60	.0683	.93	.0297	1.00	.0145	1.00	.0119
7.0	.66	.0742	1.08	.0217	1.07	.0146	1.06	.0139
8.0	1.04	.0399	1.13	.0231	1.11	.0147	1.12	.0174
9.0	1.13	.0302	1.18	.0263	1.13	.0214	1.13	.0228
10.0	1.12	.0311	1.18	.0363	1.14	.0286	1.14	.0334
11.0	1.11	.0490	1.18	.0464	1.15	.0359	1.15	.0414
12.0	1.12	.0547	1.18	.0531	1.16	.0431	1.16	.0474
13.0	1.13	.0604	1.19	.0599	1.17	.0516	1.17	.0535
14.0	1.13	.0801	1.19	.0773	1.19	.0601	1.20	.0673
15.0	1.13	.0997	1.19	.1032	1.20	.0797	1.22	.0818


Reynolds Number
6.0×10⁴
8.3×10⁴
8.8×10⁴
1.0×10⁵
2.0×10⁵
Test Conditions
Tunnel: IAG Stuttgart #2
Date: 1980
Test: 2-D
Turbulence: 0.08%
Surface: Smooth
Lift Coefficient – C_L
Drag Coefficient – C_D
Angle of Attack – α
2.0
1.6
1.2
.8
.4
0.0
-.4
.240
.200
.160
.120
.080
.040
0.0
-8.0
0.0
8.0
16.0
24.0

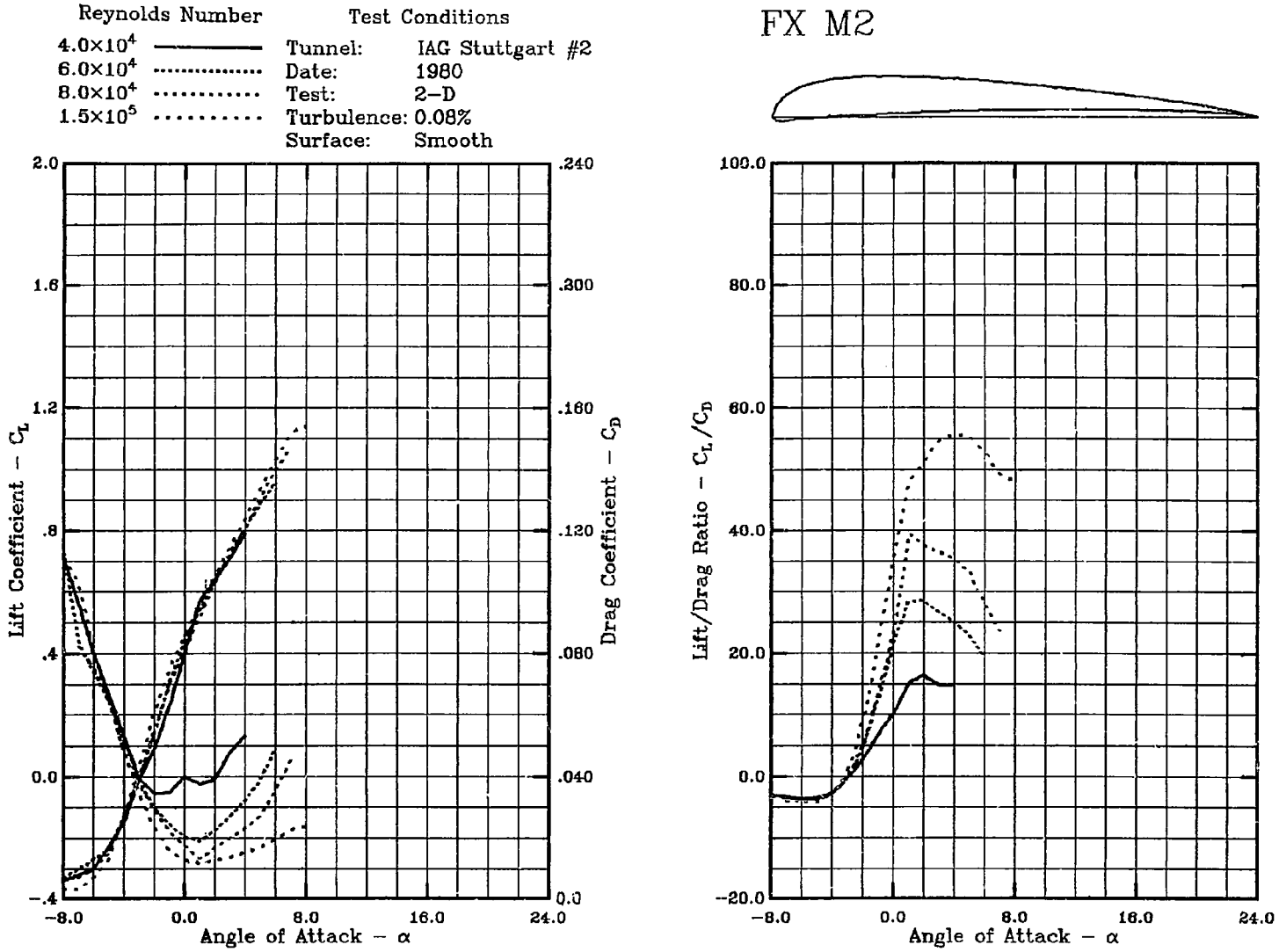

FX 63-137
Lift/Drag Ratio – C_L/C_D
Angle of Attack – α
100.0
80.0
60.0
40.0
20.0
0.0
-20.0
-8.0
0.0
8.0
16.0
24.0

FX 63-137

Tunnel: IAG Stuttgart #2 / Date: 1980 / Test: 2-D / Turbulence: 0.08% / Surface: Smooth

RN	6.0×10^4		8.3×10^4		8.8×10^4		1.0×10^5		2.0×10^5	
AOA	CL	CD	CL	CD	CL	CD	CL	CD	CL	CD
-8.0	-.26	-	-	-	-	-	-.27	-	-.23	.0855
-7.0	-.30	-	-	-	-	-	-.29	-	-.17	.0699
-6.0	-.34	-	-	-	-	-	-.30	-	-.05	.0450
-5.0	-.37	-	-	-	-	-	-.18	.0516	.07	.0234
-4.0	-.19	.0478	-	-	-	-	.06	.0332	.17	.0202
-3.0	.00	.0382	-	-	-	-	.20	.0300	.28	.0170
-2.0	.13	.0371	-	-	-	-	.31	.0300	.38	.0139
-1.0	.26	.0362	-	-	-	-	.42	.0300	.48	.0140
.0	.30	.0395	-	-	-	-	.53	.0300	.58	.0141
1.0	.35	.0443	-	-	-	-	.60	.0325	.68	.0140
2.0	.40	.0490	-	-	-	-	.66	.0353	.78	.0138
3.0	.46	.0573	-	-	-	-	.75	.0353	.88	.0137
4.0	.51	.0656	-	-	-	-	.83	.0350	.95	.0138
5.0	.57	.0757	.65	.0720	-	-	.94	.0345	1.03	.0138
6.0	.62	.0860	.70	.0816	.77	.0719	1.05	.0339	1.11	.0144
7.0	.67	.0999	.76	.0912	.84	.0772	1.13	.0325	1.19	.0152
8.0	.72	.1137	.82	.1009	1.10	.0530	1.22	.0307	1.27	.0160
9.0	.75	.1273	.84	.1042	1.22	-	1.28	.0302	1.35	.0168
10.0	.78	.1430	.84	.1125	1.27	-	1.33	.0299	1.42	.0184
11.0	.81	-	-	-	1.32	-	1.38	.0315	1.48	.0203
12.0	.83	-	-	-	1.38	-	1.44	.0339	1.53	.0228
13.0	.86	-	-	-	-	-	1.47	.0360	1.55	.0286
14.0	.89	-	-	-	-	-	1.50	.0396	1.57	.0344
15.0	.91	-	-	-	-	-	1.51	.0425	1.57	.0462
16.0	.93	-	-	-	-	-	1.52	.0529	1.57	.0587
17.0	.97	-	-	-	-	-	1.52	.0606	1.56	.0910
18.0	1.00	-	-	-	-	-	1.52	.0783	1.54	.1232
19.0	1.01	-	-	-	-	-	1.51	.1182	1.53	-

FX M2


Reynolds Number
4.0×10^4
6.0×10^4
8.0×10^4
1.5×10^5
Test Conditions
Tunnel: IAG Stuttgart #2
Date: 1980
Test: 2-D
Turbulence: 0.08%
Surface: Smooth
Lift Coefficient – C_L
Drag Coefficient – C_D
Angle of Attack – α
Lift/Drag Ratio – C_L/C_D
Angle of Attack – α

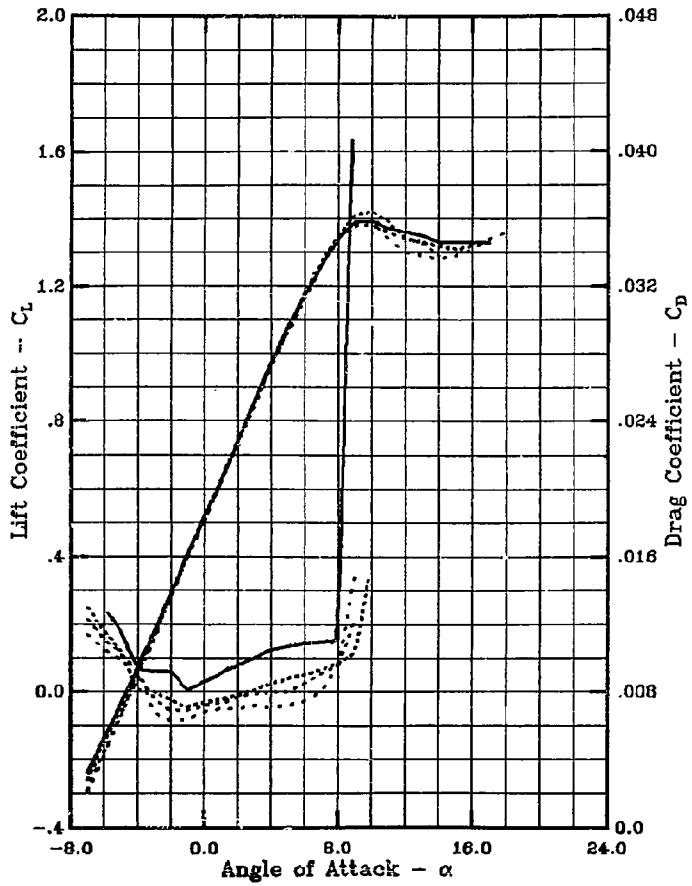
FX M2

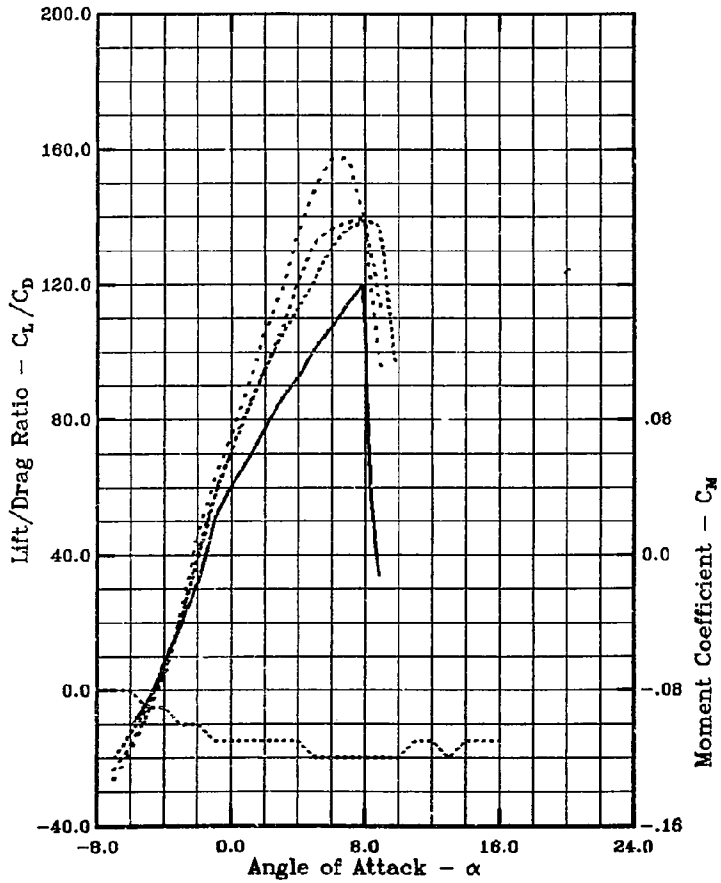
Tunnel: IAG Stuttgart #2 / Date: 1980 / Test: 2-D / Turbulence: 0.08% / Surface: Smooth

RN	4.0×10^4		6.0×10^4		8.0×10^4		1.5×10^5	
AOA	CL	CD	CL	CD	CL	CD	CL	CD
-8.0	-.34	.1110	-.33	.1129	-	-	-.37	.1114
-7.0	-.32	.0959	-.30	.0835	-.33	.0822	-.37	.1027
-6.0	-.30	.0801	-.27	.0741	-.30	.0753	-.33	.0806
-5.0	-.23	.0668	-.24	.0648	-.25	.0664	-.27	.0647
-4.0	-.15	.0532	-.14	.0518	-.13	.0475	-.13	.0484
-3.0	-.01	.0394	-.01	.0386	.00	.0374	.03	.0346
-2.0	.09	.0345	.14	.0298	.15	.0295	.21	.0234
-1.0	.23	.0347	.31	.0245	.30	.0221	.35	.0159
.0	.40	.0400	.44	.0204	.41	.0175	.46	.0129
1.0	.57	.0376	.54	.0190	.52	.0131	.56	.0117
2.0	.64	.0390	.64	.0225	.63	.0168	.65	.0127
3.0	.71	.0478	.72	.0270	.73	.0200	.75	.0137
4.0	.79	.0533	.81	.0323	.81	.0229	.84	.0151
5.0	-	-	.89	.0387	.91	.0273	.94	.0170
6.0	-	-	.96	.0493	1.00	.0354	1.03	.0195
7.0	-	-	-	-	1.07	.0452	1.12	.0228
8.0	-	-	-	-	-	-	1.14	.0237

FX S 02-196

Reynolds Number	Test Conditions	
1.0×10^6 ———	Tunnel:	IAG Stuttgart #1
1.5×10^6 ·····	Date:	1962 – 1972
2.0×10^6 ·····	Test:	2-D
3.0×10^6 ·····	Turbulence:	0.02%
	Surface:	Smooth



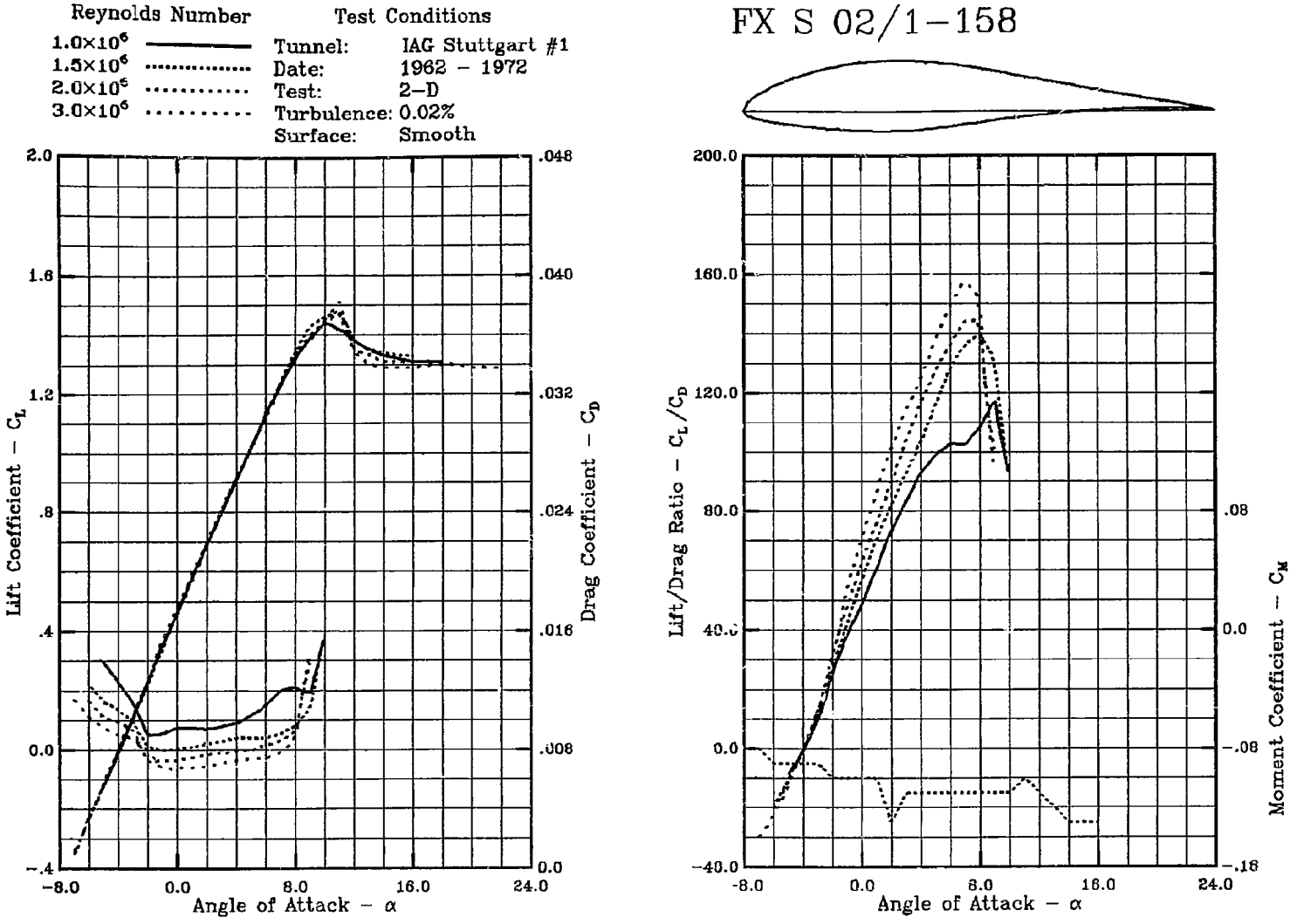


FX S 02-196

Tunnel: IAG Stuttgart #1 / Date: 1962-1972 / Test: 2-D / Turbulence: 0.02% / Surface: Smooth

RN	1.0×10^6		1.5×10^6			2.0×10^6		3.0×10^6	
AOA	CL	CD	CL	CD	CM	CL	CD	CL	CD
-7.0	-.24	-	-.26	.0130	-.08	-.29	.0123	-.30	.0114
-6.0	-.14	.0130	-.15	.0116	-.08	-.18	.0111	-.19	.0105
-5.0	-.04	.0116	-.05	.0104	-.09	-.07	.0103	-.07	.0099
-4.0	.07	.0093	.06	.0081	-.09	.04	.0090	.05	.0096
-3.0	.18	.0092	.17	.0080	-.10	.16	.0076	.16	.0068
-2.0	.29	.0092	.29	.0075	-.10	.28	.0069	.29	.0063
-1.0	.41	.0081	.41	.0071	-.11	.40	.0069	.40	.0064
.0	.52	.0086	.52	.0074	-.11	.51	.0072	.51	.0068
1.0	.62	.0091	.63	.0076	-.11	.62	.0074	.63	.0070
2.0	.74	.0096	.74	.0078	-.11	.73	.0077	.74	.0070
3.0	.86	.0100	.85	.0081	-.11	.84	.0079	.85	.0072
4.0	.97	.0105	.96	.0085	-.11	.97	.0080	.96	.0071
5.0	1.08	.0107	1.07	.0088	-.12	1.06	.0080	1.07	.0072
6.0	1.17	.0109	1.18	.0090	-.12	1.16	.0085	1.18	.0075
7.0	1.26	.0110	1.27	.0093	-.12	1.26	.0091	1.26	.0080
8.0	1.34	.0111	1.35	.0097	-.12	1.34	.0096	1.34	.0096
9.0	1.39	.0463	1.41	.0103	-.12	1.38	.0123	1.39	.0149
10.0	1.39	-	1.42	.0158	-.12	1.38	-	1.39	-
11.0	1.37	-	1.39	-	-.11	1.36	-	1.34	-
12.0	1.36	-	1.34	-	-.11	1.34	-	1.30	-
13.0	1.35	-	1.33	-	-.12	1.33	-	1.29	-
14.0	1.33	-	1.32	-	-.11	1.29	-	1.28	-
15.0	1.33	-	1.31	-	-.11	-	-	1.29	-
16.0	1.33	-	1.32	-	-.11	-	-	1.31	-
17.0	1.33	-	-	-	-.11	-	-	1.34	-
18.0	-	-	-	-	-.11	-	-	1.36	-

FX S 02/1-158


Reynolds Number
1.0×10^6
1.5×10^6
2.0×10^6
3.0×10^6
Test Conditions
Tunnel: IAG Stuttgart #1
Date: 1962 - 1972
Test: 2-D
Turbulence: 0.02%
Surface: Smooth
Lift Coefficient - C_L
Drag Coefficient - C_D
Angle of Attack - α
Lift/Drag Ratio - C_L/C_D
Moment Coefficient - C_M

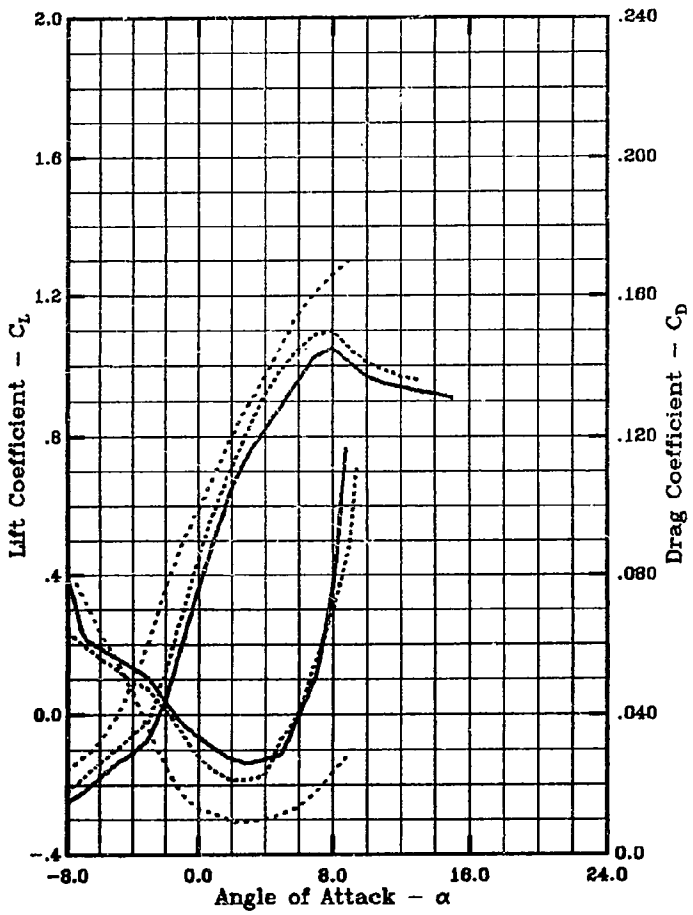
FX S 02/1-158

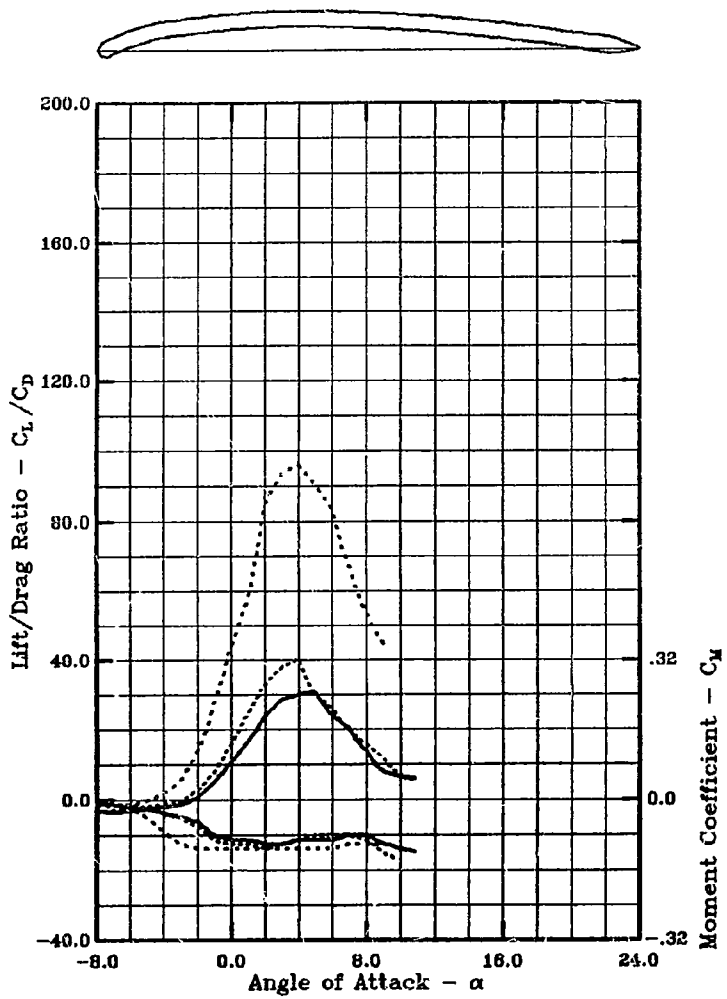
Tunnel: IAG Stuttgart #1 / Date: 1962-1972 / Test: 2-D / Turbulence: 0.02% / Surface: Smooth

RN	1.0×10^6		1.5×10^6			2.0×10^6		3.0×10^6	
AOA	CL	CD	CL	CD	CM	CL	CD	CL	CD
-7.0	-	-	-.35	-	-.08	-	-	-.34	.0114
-6.0	-	-	-.23	.0124	-.09	-.23	.0113	-.23	.0102
-5.0	-.12	.0139	-.12	.0113	-.09	-.11	.0102	-.12	.0095
-4.0	-.01	.0126	.00	.0107	-.09	.00	.0099	.00	.0090
-3.0	.11	.0112	.11	.0099	-.09	.12	.0094	.11	.0088
-2.0	.23	.0090	.22	.0082	-.10	.23	.0072	.23	.0080
-1.0	.35	.0091	.34	.0080	-.10	.35	.0073	.37	.0067
.0	.46	.0095	.46	.0081	-.10	.46	.0073	.48	.0068
1.0	.58	.0095	.58	.0082	-.10	.57	.0075	.59	.0068
2.0	.69	.0094	.69	.0084	-.10	.69	.0077	.70	.0069
3.0	.80	.0096	.80	.0086	-.11	.81	.0078	.81	.0071
4.0	.91	.0098	.91	.0088	-.11	.92	.0079	.91	.0073
5.0	1.02	.0103	1.02	.0088	-.11	1.02	.0080	1.02	.0074
6.0	1.13	.0110	1.13	.0088	-.11	1.13	.0083	1.12	.0075
7.0	1.23	.0120	1.24	.0091	-.11	1.24	.0086	1.23	.0078
8.0	1.32	.0122	1.34	.0096	-.11	1.33	.0092	1.33	.0087
9.0	1.39	.0118	1.43	.0108	-.11	1.40	.0140	1.38	.0147
10.0	1.44	.0156	1.46	.0160	-.11	1.45	-	1.45	-
11.0	1.42	-	1.48	-	-.10	1.47	-	1.51	-
12.0	1.38	-	1.38	-	-.11	1.35	-	1.34	-
13.0	1.35	-	1.35	-	-.12	1.33	-	1.30	-
14.0	1.33	-	1.34	-	-.13	1.31	-	1.29	-
15.0	1.32	-	1.33	-	-.13	1.31	-	1.29	-
16.0	1.31	-	1.33	-	-.13	1.31	-	1.29	-
17.0	1.31	-	-	-	-.13	-	-	1.30	-
18.0	1.31	-	-	-	-.13	-	-	1.30	-
19.0	-	-	-	-	-.13	-	-	1.30	-
2 .0	-	-	-	-	-.13	-	-	1.29	-
21.0	-	-	-	-	-	-	-	1.29	-
22.0	-	-	-	-	-	-	-	1.29	-

GO 417A

Reynolds Number		Test Conditions	
4.2×10^4	———	Tunnel:	Cologne 0.7m
1.7×10^5	·····	Date:	1918
4.2×10^5	·····	Test:	3–D
		Turbulence:	0.9%
		Surface:	Smooth





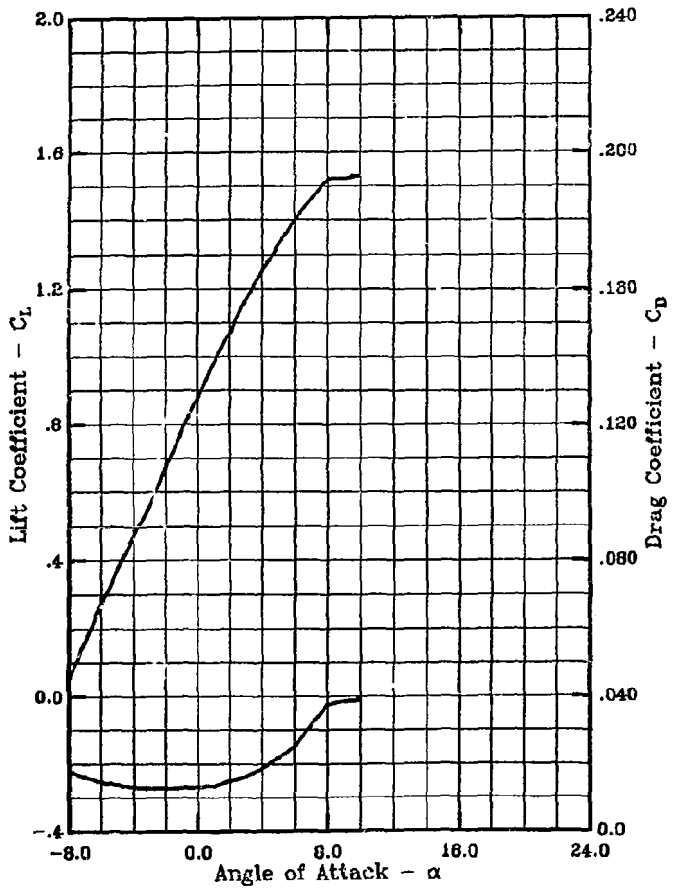
GO 417A

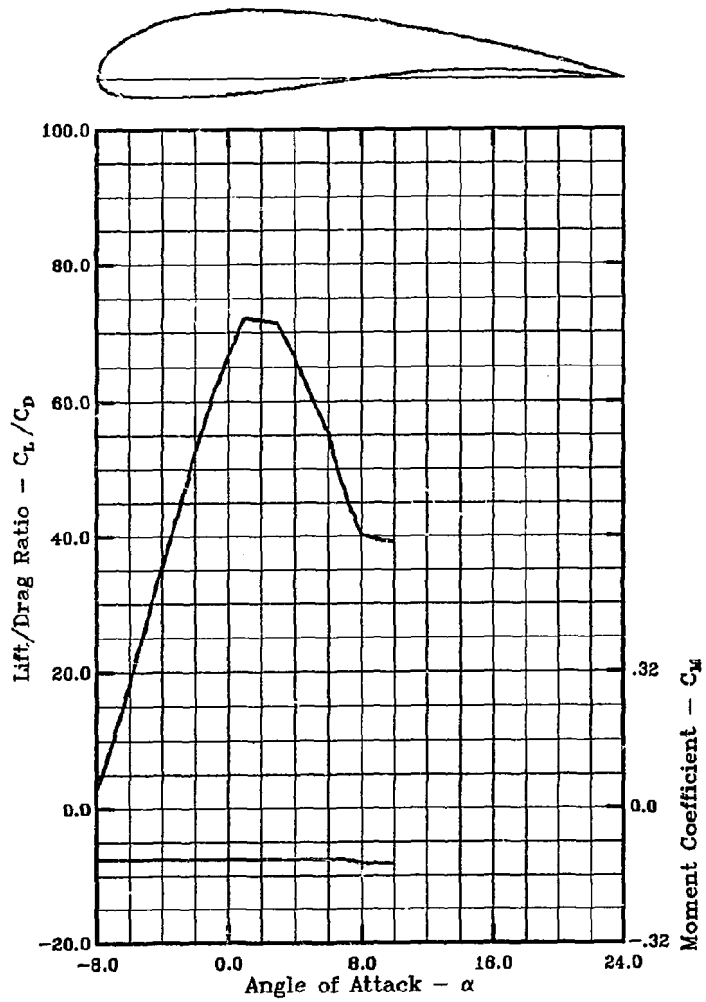
Tunnel: Cologne .7m / Date: 1918 / Test: 3-D / Turbulence: .9% / Surface: Smooth

RN	4.2×10^4			1.7×10^5			4.2×10^5		
AOA	CL	CD	CM	CL	CD	CM	CL	CD	CM
-8.0	-.25	.0797	-.01	-.22	.0636	.00	-.16	.0829	.00
-7.0	-.22	.0617	-.01	-.18	.0597	-.01	-.12	.0733	-.01
-6.0	-.18	.0589	-.02	-.14	.0562	-.01	-.08	.0636	-.02
-5.0	-.14	.0560	-.02	-.10	.0527	-.02	-.01	.0555	-.04
-4.0	-.11	.0532	-.03	-.06	.0492	-.03	.09	.0467	-.07
-3.0	-.07	.0503	-.04	-.02	.0473	-.04	.21	.0354	-.10
-2.0	.04	.0438	-.05	.12	.0414	-.06	.36	.0255	-.11
-1.0	.20	.0373	-.08	.28	.0349	-.09	.49	.0175	-.11
.0	.36	.0337	-.09	.45	.0280	-.10	.59	.0133	-.11
1.0	.51	.0304	-.09	.59	.0238	-.10	.69	.0119	-.11
2.0	.65	.0273	-.10	.71	.0214	-.11	.80	.0094	-.11
3.0	.75	.0261	-.10	.82	.0216	-.10	.89	.0095	-.11
4.0	.82	.0274	-.09	.92	.0228	-.09	.97	.0101	-.11
5.0	.89	.0287	-.09	.99	.0331	-.08	1.06	.0117	-.11
6.0	.96	.0399	-.09	1.05	.0403	-.08	1.15	.0137	-.11
7.0	1.03	.0509	-.08	1.09	.0553	-.08	1.21	.0180	-.10
8.0	1.05	.0757	-.08	1.10	.0697	-.09	1.26	.0235	-.10
9.0	1.01	.1276	-.10	1.05	.0887	-.12	1.30	.0290	-.10
10.0	.97	.1458	-.11	1.01	.1427	-.14	-	-	-
11.0	.95	.1633	-.12	.99	-	-	-	-	-
12.0	.94	-	-	.97	-	-	-	-	-
13.0	.93	-	-	.96	-	-	-	-	-
14.0	.92	-	-	-	-	-	-	-	-
15.0	.91	-	-	-	-	-	-	-	-

GO 535

Reynolds Number	Test Conditions	
4.2×10^5 ———	Tunnel:	AVA 2.25m
	Date:	1919–1935
	Test:	3–D
	Turbulence:	0.2%
	Surface:	Smooth





GO 535

Tunnel: AVA 2.25m / Date: 1919-1935 / Test: 3-D / Turbulence: .2% / Surface: Smooth

RN 4.2×10^5

AOA	CL	CD	CM
-8.0	.05	.0179	-.12
-7.0	.16	.0160	-.12
-6.0	.27	.0147	-.12
-5.0	.37	.0137	-.12
-4.0	.47	.0132	-.12
-3.0	.56	.0128	-.12
-2.0	.67	.0128	-.12
-1.0	.78	.0129	-.12
.0	.88	.0132	-.12
1.0	.98	.0136	-.12
2.0	1.07	.0149	-.12
3.0	1.17	.0164	-.12
4.0	1.25	.0188	-.12
5.0	1.33	.0219	-.12
6.0	1.40	.0252	-.12
7.0	1.46	.0314	-.12
8.0	1.52	.0377	-.13
9.0	1.52	.0385	-.13
10.0	1.53	.0390	-.13

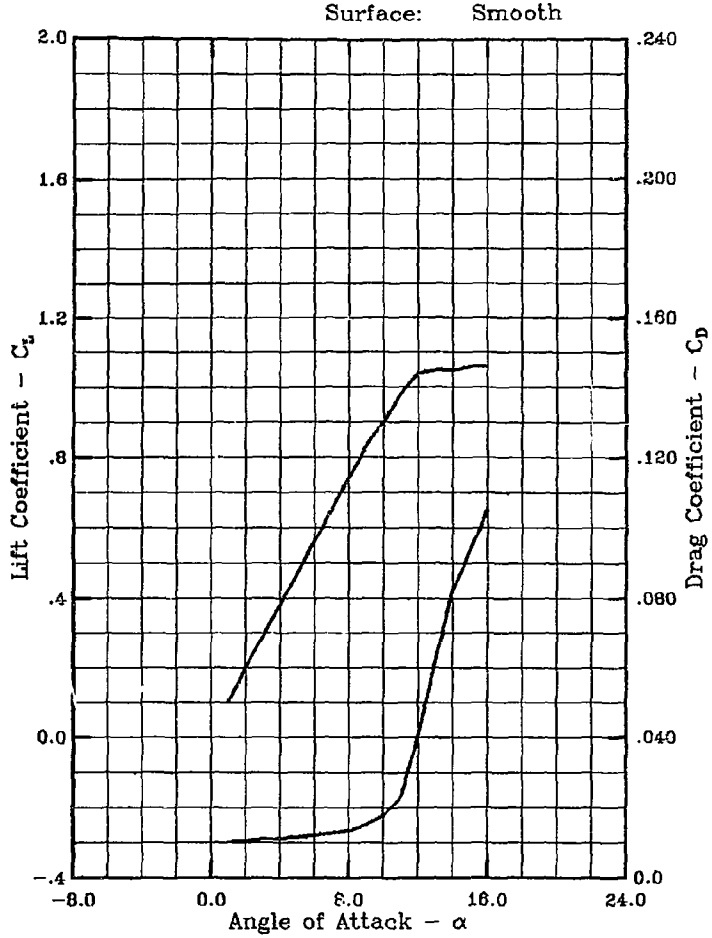
Reynolds Number

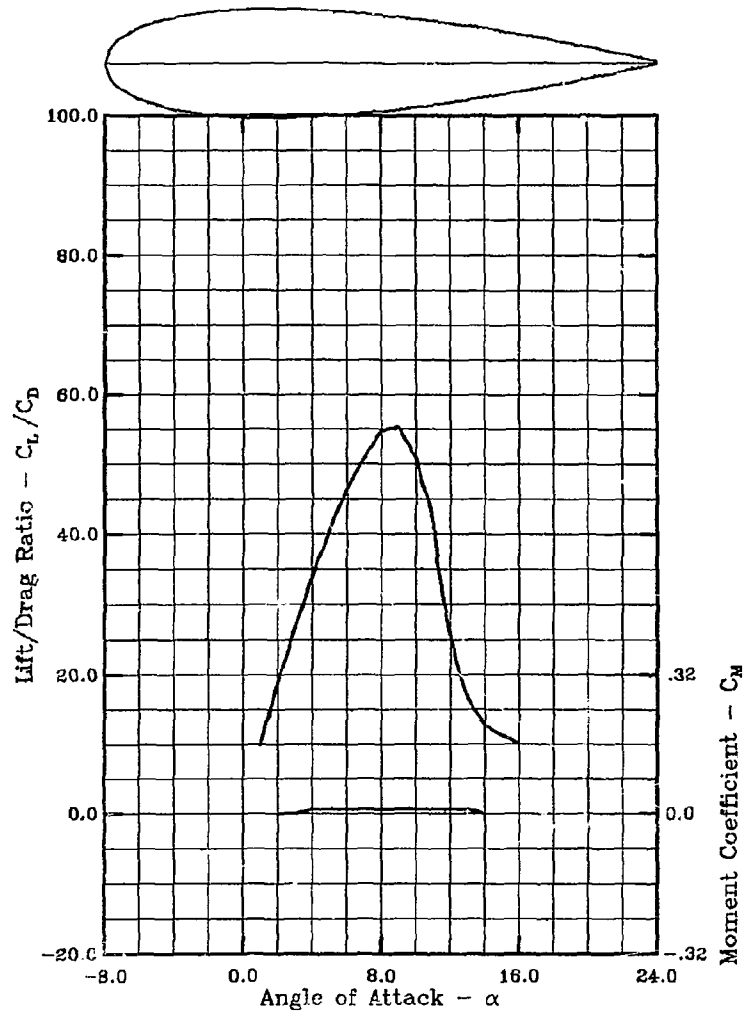
1.0×10^6 ———

Test Conditions

Tunnel: AVA 4m x 5.4m
Date: 1936–1945
Test: 3–D
Turbulence: 0.3%
Surface: Smooth

GO 775





GO 775

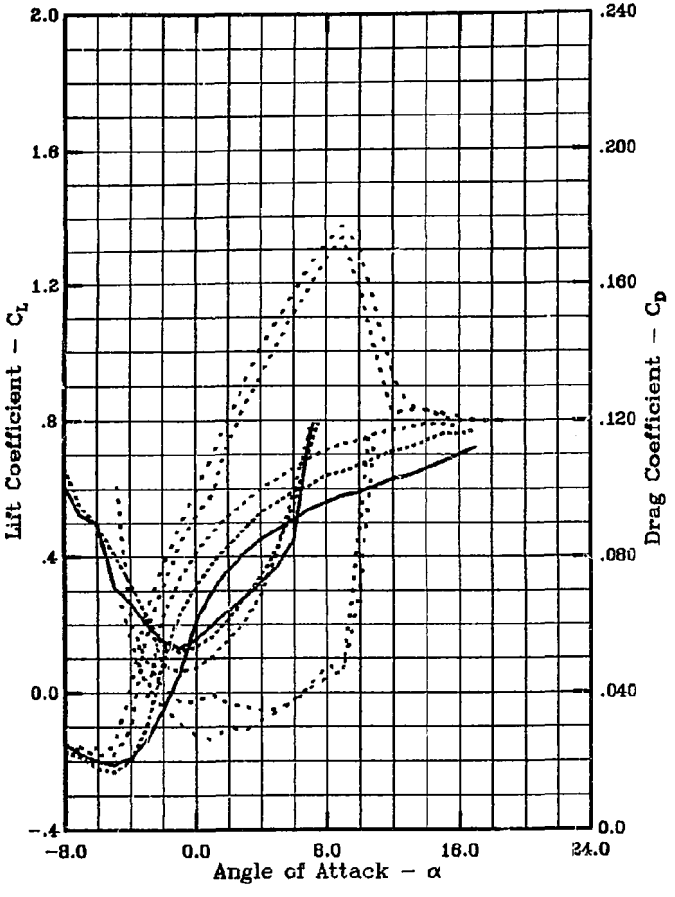
Tunnel: AVA 4m x 5.4m / Date: 1936-1945 / Test: 3-D / Turbulence: .3% / Surface: Smooth

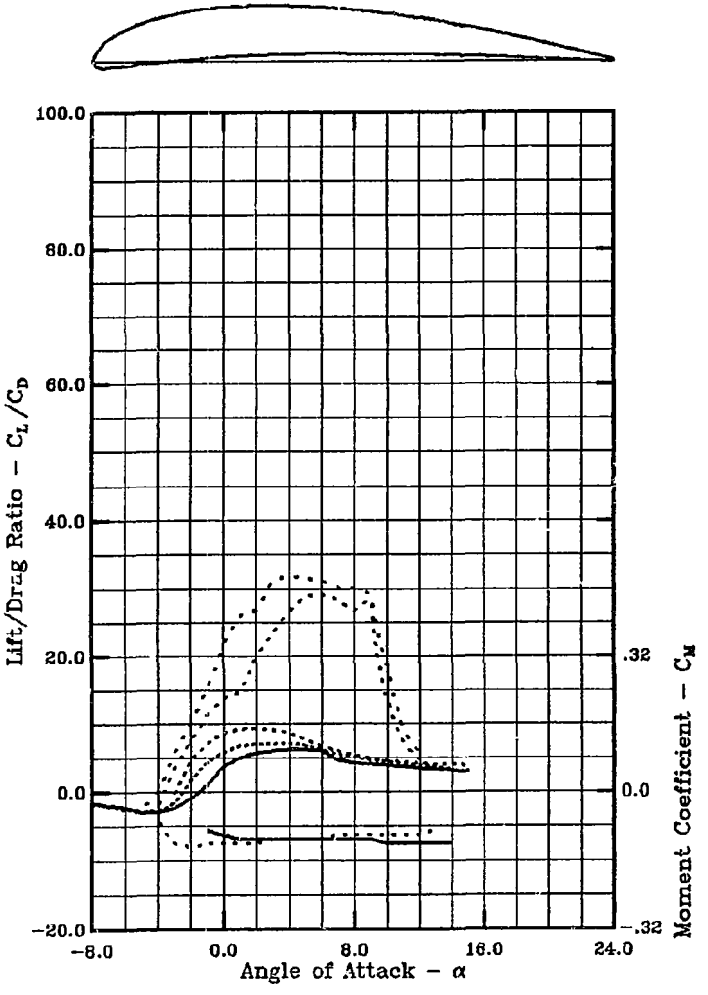
RN 1.0×10^6

AOA	CL	CD	CM
1.0	.10	.0103	-
2.0	.20	.0106	.00
3.0	.29	.0109	.00
4.0	.38	.0112	.01
5.0	.47	.0116	.01
6.0	.56	.0121	.01
7.0	.65	.0128	.01
8.0	.74	.0135	.01
9.0	.83	.0150	.01
10.0	.90	.0176	.01
11.0	.98	.0229	.01
12.0	1.04	.0400	.01
13.0	1.05	.0620	.01
14.0	1.05	.0824	.00
15.0	1.06	.0933	-
16.0	1.06	.1050	-

GO 801

Reynolds Number		Test Conditions	
2.1×10^4	————	Tunnel:	Gottingen 0.7m x 1m
4.2×10^4	·····	Date:	1956–1958
6.3×10^4	·····	Test:	3–D
7.5×10^4	·····	Turbulence:	0.3%
8.4×10^4	- - - - - - -	Surface:	Smooth





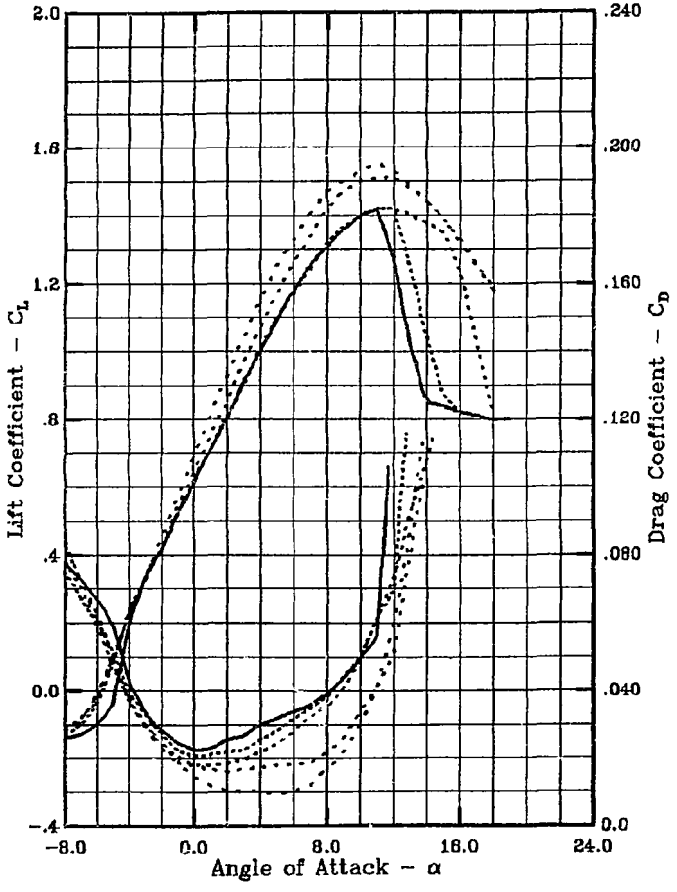
GO 801

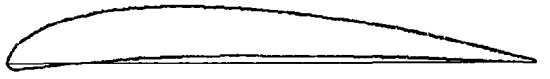
Tunnel: Gottingen .7m x 1m / Date: 1956-1958 / Test: 3-D / Turbulence: .3% / Surface: Smooth

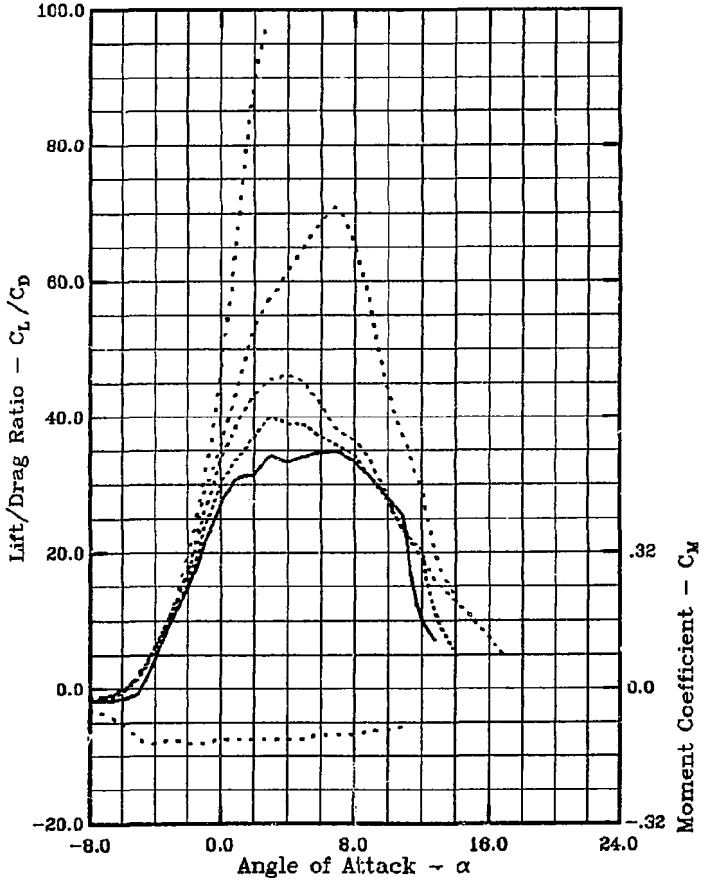
RN	2.1×10^4			4.2×10^4		6.3×10^4		7.5×10^4			8.4×10^4	
AOA	CL	CD	CM	CL	CD	CL	CD	CL	CD	CM	CL	CD
-8.0	-.15	.1010	-	-.17	.1062	-	-	-.15	-	-	-.15	-
-7.0	-.18	.0923	-	-.19	.0950	-	-	-.17	-	-	-.16	-
-6.0	-.20	.0899	-	-.22	.0895	-	-	-.18	-	-	-.16	-
-5.0	-.21	.0711	-	-.23	.0810	-	-	-.18	.1130	-	-.16	.0748
-4.0	-.19	.0663	-	-.20	.0722	-	-	-.11	.0615	-.07	.01	.0554
-3.0	-.14	.0599	-	-.10	.0624	-.01	.0615	.18	.0486	-.12	.25	.0422
-2.0	-.05	.0549	-	.09	.0537	.23	.0482	.31	.0415	-.13	.37	.0357
-1.0	.05	.0530	-.09	.23	.0521	.33	.0463	.43	.0374	-.12	.48	.0312
.0	.21	.0556	-.10	.31	.0534	.41	.0474	.52	.0376	-.12	.59	.0276
1.0	.30	.0600	-.11	.38	.0566	.47	.0507	.58	.0394	-.12	.69	.0264
2.0	.36	.0639	-.11	.43	.0616	.52	.0554	.73	.0368	-.12	.80	.0299
3.0	.41	.0680	-.11	.48	.0680	.56	.0610	.84	.0358	-.11	.91	.0290
4.0	.45	.0724	-.11	.53	.0742	.60	.0691	.93	.0349	-.11	1.01	.0318
5.0	.48	.0773	-.11	.56	.0824	.63	.0813	1.02	.0352	-.11	1.09	.0345
6.0	.51	.0846	-.11	.59	.0948	.66	.0989	1.11	.0381	-.11	1.17	.0374
7.0	.54	.1154	-.11	.61	.1117	.69	.1167	1.19	.0420	-.10	1.25	.0414
8.0	.56	.1308	-.11	.64	.1262	.71	.1315	1.27	.0476	-.10	1.32	.0438
9.0	.58	.1421	-.11	.65	.1388	.73	.1482	1.34	.0468	-.10	1.37	.0467
10.0	.59	.1515	-.12	.67	.1513	.74	.1618	1.19	.0876	-.10	1.31	.0697
11.0	.61	.1641	-.12	.69	.1668	.76	.1732	.99	.1352	-.10	1.12	.1183
12.0	.63	.1806	-.12	.71	.1842	.77	.1849	.82	.1788	-.10	.93	.1670
13.0	.64	.1954	-.12	.72	.2015	.78	.1959	.83	-	-.09	.84	-
14.0	.66	.2079	-.12	.74	.2217	.79	.1992	.83	-	-	.83	-
15.0	.68	.2314		.76	-	.79	.2012	.81	-	-	.82	-
16.0	.70	-		.76	-	.78	-	.80	-	-	.81	-
17.0	.72	-		.77	-	-	-	.80	-	-	.80	-
18.0	-	-		-	-	-	-	.80	-	-	.80	-
19.0	-	-		-	-	-	-	.80	-	-	.80	-

GO 801

Reynolds Number		Test Conditions	
1.1×10^5	———	Tunnel:	Gottingen 0.7m x 1m
1.3×10^5	·····	Date:	1956–1958
1.7×10^5	·····	Test:	3–D
2.8×10^5	·····	Turbulence:	0.3%
4.2×10^5	·····	Surface:	Smooth



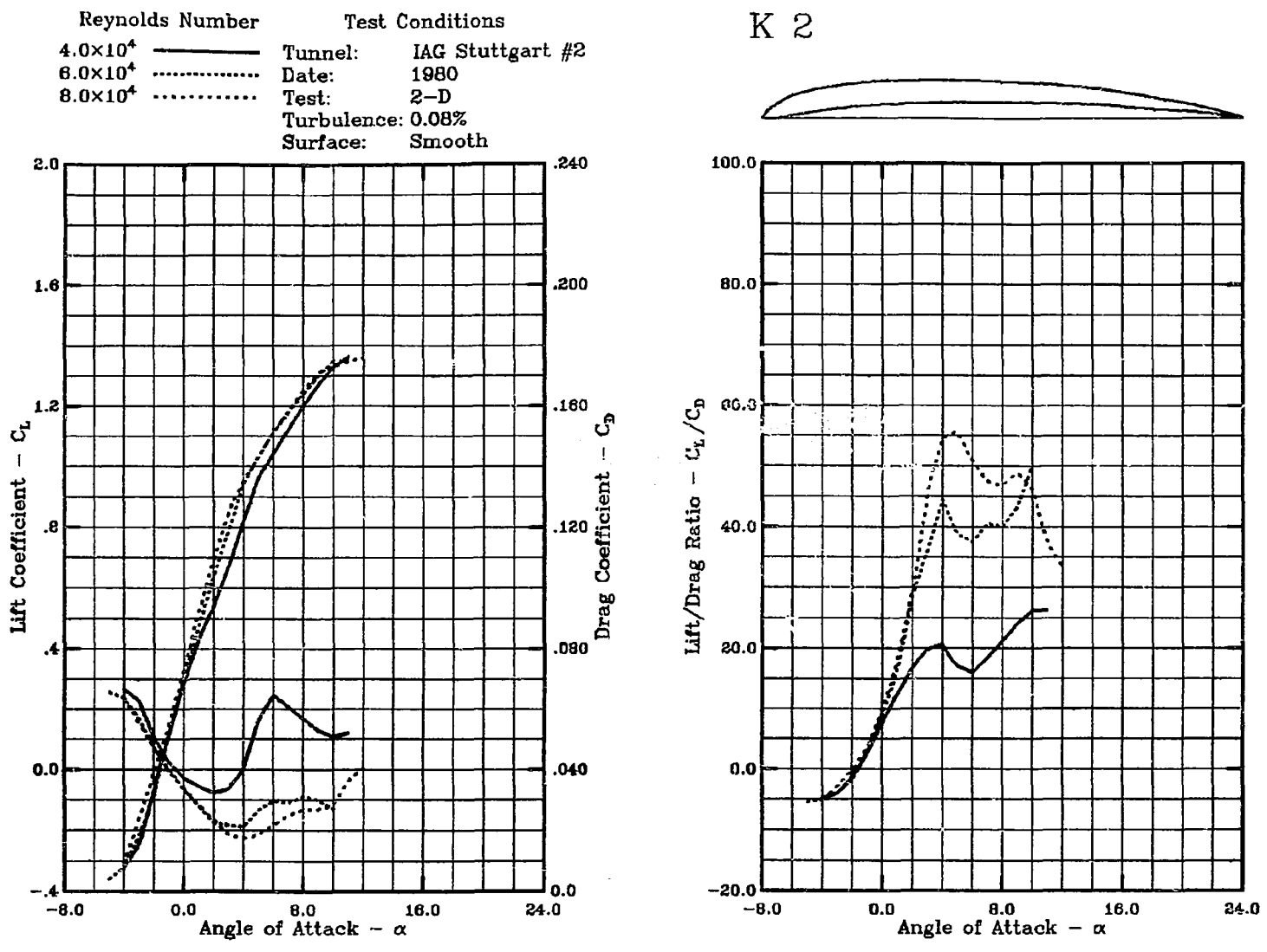




GO 801

Tunnel: Gottingen .7m x 1m / Date: 1956-1958 / Test: 3-D / Turbulence: .3% / Surface: Smooth

RN	1.1×10^5		1.3×10^5		1.7×10^5		2.8×10^5			4.2×10^5	
AOA	CL	CD	CL	CD	CL	CD	CL	CD	CM	CL	CD
-8.0	-.14	.0780	-.13	.0755	-.11	.0786	-.12	.0842	-.05	-.12	.0828
-7.0	-.13	.0726	-.10	.0668	-.08	.0702	-.08	.0719	-.06	-.09	.0724
-6.0	-.10	.0668	-.04	.0603	-.02	.0590	-.03	.0631	-.08	-.01	.0610
-5.0	-.04	.0595	.08	.0516	.10	.0476	.09	.0494	-.12	.10	.0474
-4.0	.20	.0428	.24	.0397	.23	.0379	.23	.0371	-.13	.23	.0370
-3.0	.34	.0333	.33	.0330	.33	.0298	.33	.0298	-.12	.33	.0293
-2.0	.42	.0284	.42	.0273	.42	.0245	.42	.0246	-.13	.45	.0227
-1.0	.52	.0245	.52	.0222	.52	.0203	.54	.0189	-.13	.57	.0187
.0	.61	.0225	.62	.0206	.62	.0185	.64	.0180	-.12	.69	.0148
1.0	.71	.0228	.71	.0210	.71	.0181	.75	.0169	-.12	.81	.0119
2.0	.80	.0255	.81	.0219	.80	.0185	.85	.0159	-.12	.93	.0103
3.0	.91	.0265	.90	.0224	.90	.0197	.97	.0168	-.12	1.04	.0103
4.0	1.00	.0301	1.00	.0256	1.01	.0218	1.07	.0174	-.12	1.15	.0101
5.0	1.09	.0319	1.09	.0280	1.10	.0243	1.17	.0179	-.12	1.25	.0095
6.0	1.18	.0340	1.18	.0318	1.17	.0279	1.26	.0183	-.11	1.33	.0100
7.0	1.25	.0358	1.25	.0351	1.24	.0326	1.34	.0188	-.11	1.41	.0122
8.0	1.31	.0392	1.32	.0383	1.31	.0358	1.42	.0216	-.11	1.47	.0170
9.0	1.36	.0438	1.37	.0442	1.36	.0405	1.47	.0260	-.10	1.50	.0218
10.0	1.40	.0498	1.40	.0502	1.40	.0496	1.50	.0340	-.10	1.53	.0301
11.0	1.42	.0562	1.42	.0617	1.42	.0619	1.51	.0413	-.09	1.55	.0412
12.0	1.27	.1263	1.42	.0700	1.42	.0735	1.51	.0511	-	1.53	.0598
13.0	1.02	.1572	1.25	.1280	1.40	.0918	1.48	.0809	-	1.49	.0872
14.0	.85	-	1.04	.1893	1.38	.1073	1.44	.1070	-	1.44	.1221
15.0	.84	-	.87	-	1.35	.1280	1.39	-	-	1.39	.1482
16.0	.82	-	.82	-	1.24	.1628	1.33	-	-	1.32	.1832
17.0	.81	-	.81	-	1.03	.2225	1.26	-	-	1.25	.2220
18.0	.80	-	.80	-	.82	-	1.19	-	-	1.18	-
19.0	.80	-	.80	-	-	-	-	-	-	-	-

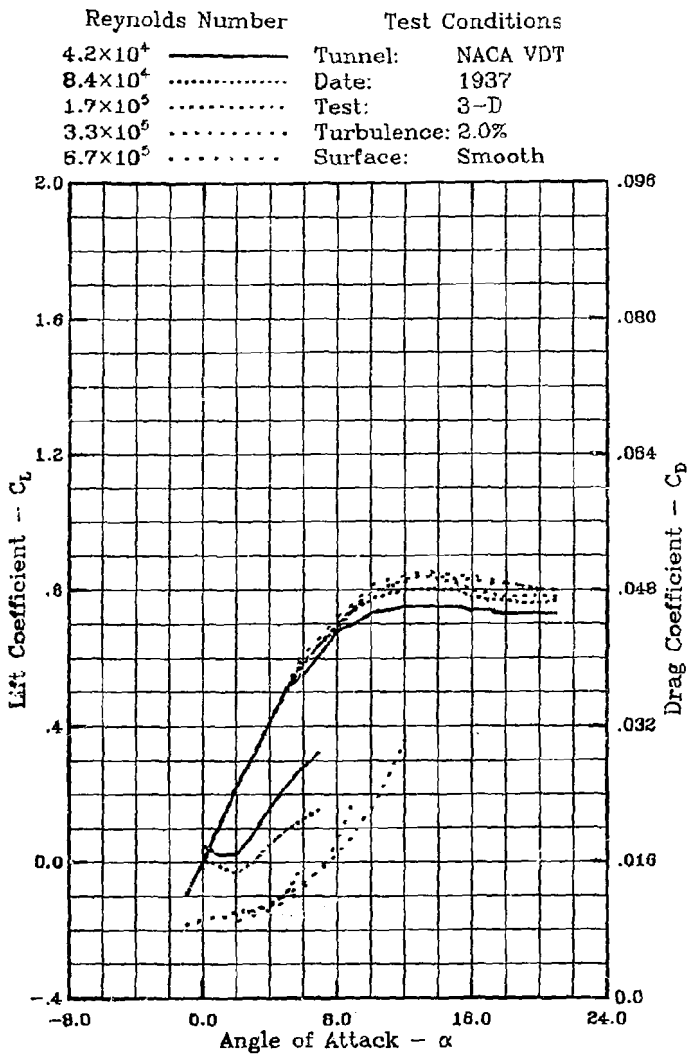

Reynolds Number
4.0×10⁴
6.0×10⁴
8.0×10⁴
Test Conditions
Tunnel: IAG Stuttgart #2
Date: 1980
Test: 2-D
Turbulence: 0.08%
Surface: Smooth
K 2
Lift Coefficient – C_L
Drag Coefficient – C_D
Angle of Attack – α
Lift/Drag Ratio – C_L/C_D
Angle of Attack – α

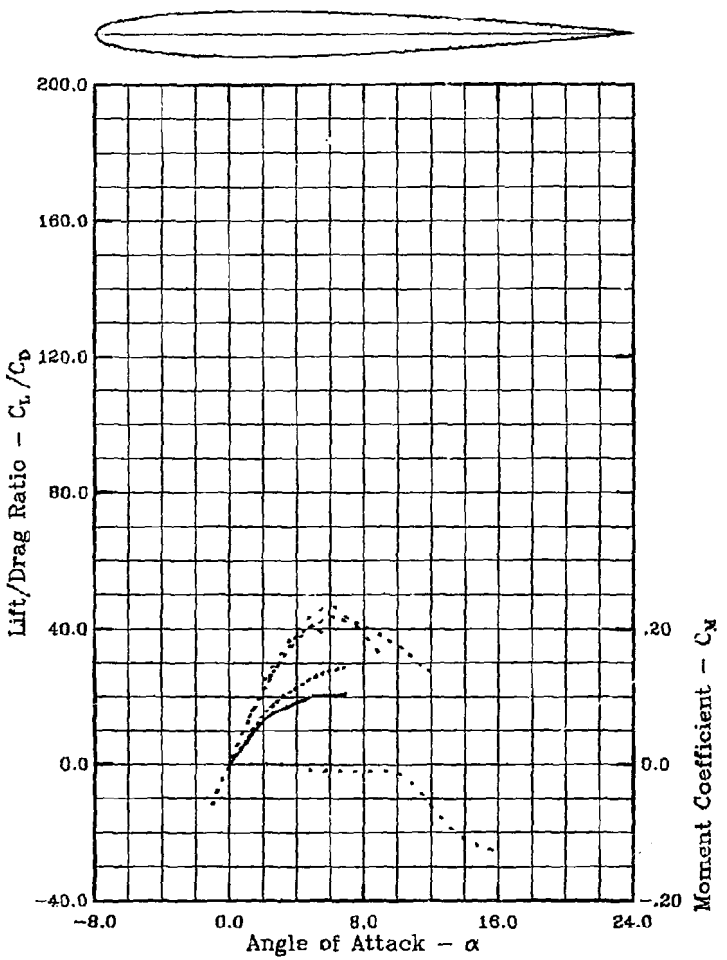
K 2

Tunnel: IAG Stuttgart #2 / Date: 1980 / Test: 2-D / Turbulence: 0.08% / Surface: Smooth

RN	4.0×10^4		6.0×10^4		8.0×10^4	
AOA	CL	CD	CL	CD	CL	CD
-5.0	-	-	-.36	.0656	-	-
-4.0	-.32	.0667	-.32	.0637	-.31	.0639
-3.0	-.25	.0628	-.22	.0568	-.16	.0554
-2.0	-.07	.0507	-.08	.0474	-.01	.0475
-1.0	.11	.0425	.11	.0404	.14	.0396
.0	.29	.0374	.30	.0335	.33	.0339
1.0	.43	.0343	.47	.0279	.52	.0284
2.0	.54	.0322	.64	.0224	.69	.0233
3.0	.67	.0337	.79	.0218	.85	.0185
4.0	.82	.0397	.94	.0211	.95	.0174
5.0	.96	.0561	1.03	.0266	1.03	.0185
6.0	1.04	.0647	1.11	.0296	1.11	.0218
7.0	1.12	.0608	1.18	.0291	1.18	.0248
8.0	1.20	.0568	1.24	.0310	1.25	.0267
9.0	1.27	.0529	1.30	.0300	1.31	.0268
10.0	1.33	.0507	1.35	.0270	1.33	.0285
11.0	1.36	.0519	-	-	1.35	.0361
12.0	-	-	-	-	1.36	.0406

NACA 0009


Reynolds Number
4.2×10⁴
8.4×10⁴
1.7×10⁵
3.3×10⁵
6.7×10⁵
Test Conditions
Tunnel: NACA VDT
Date: 1937
Test: 3-D
Turbulence: 2.0%
Surface: Smooth
Lift Coefficient – C_L
Drag Coefficient – C_D
Angle of Attack – α
2.0
1.6
1.2
.8
.4
0.0
-.4
.096
.080
.064
.048
.032
.016
0.0
-8.0
0.0
8.0
16.0
24.0


Lift/Drag Ratio – C_L/C_D
Moment Coefficient – C_M
Angle of Attack – α
200.0
160.0
120.0
80.0
40.0
0.0
-40.0
.20
0.0
-.20
-8.0
0.0
8.0
16.0
24.0

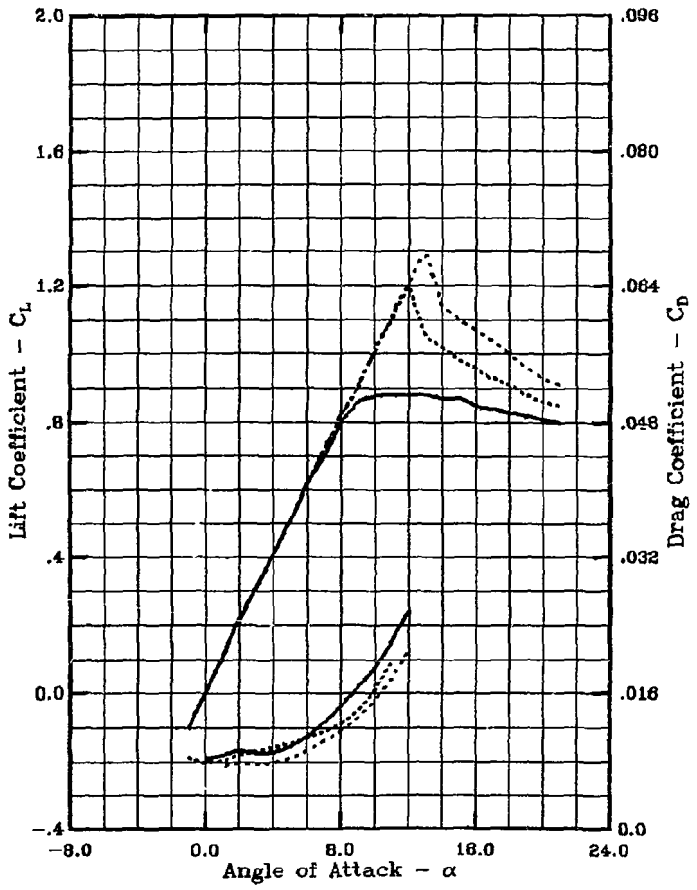
NACA 0009

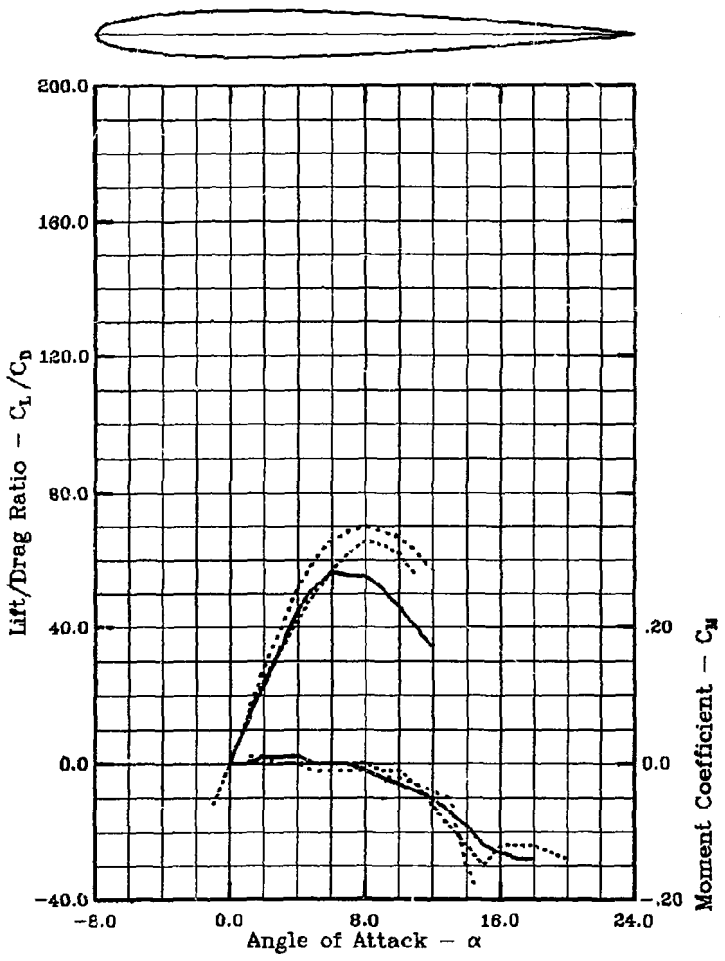
Tunnel: NACA VDT / Date: 1937 / Test: 3-D / Turbulence: 2.0% / Surface: Smooth

RN	4.2×10^4		8.4×10^4		1.7×10^5		3.3×10^5		6.7×10^5		
AOA	CL	CD	CL	CD	CL	CD	CL	CD	CL	CD	CM
-1.0	-.10	-	-.10	-	-.10	-	-.10	.0086	-.10	-	-
.0	.00	.0179	.00	.0162	.00	-	.00	.0092	.00	-	-
1.0	.11	.0169	.11	.0156	.11	.0093	.11	.0095	.11	-	.00
2.0	.22	.0169	.22	.0147	.22	.0102	.22	.0098	.22	.0091	.00
3.0	.31	.0192	.31	.0160	.31	.0103	.31	.0103	.31	.0097	.00
4.0	.41	.0224	.41	.0181	.41	.0108	.41	.0111	.41	.0104	.00
5.0	.51	.0251	.51	.0198	.51	.0124	.50	.0122	.51	.0115	-.01
6.0	.55	.0272	.59	.0212	.58	.0157	.59	.0135	.61	.0129	-.01
7.0	.61	.0290	.64	.0222	.64	-	.64	.0151	.66	.0151	-.01
8.0	.68	-	.69	-	.70	-	.70	.0170	.72	.0184	-.01
9.0	.70	-	.74	-	.75	-	.74	.0194	.76	.0235	-.01
10.0	.73	-	.77	-	.79	-	.79	.0223	.81	-	-.01
11.0	.74	-	.79	-	.81	-	.81	.0258	.83	-	-.03
12.0	.75	-	.80	-	.83	-	.82	.0304	.84	-	-.06
13.0	.75	-	.80	-	.84	-	.84	-	.85	-	-.09
14.0	.75	-	.80	-	.83	-	.84	-	.85	-	-.11
15.0	.75	-	.80	-	.82	-	.83	-	.84	-	-.12
16.0	.74	-	.78	-	.80	-	.83	-	.84	-	-.13
17.0	.74	-	.77	-	.79	-	.82	-	.83	-	-
18.0	.73	-	.77	-	.78	-	.82	-	.82	-	-
19.0	.73	-	.76	-	.78	-	.81	-	.81	-	-
20.0	.73	-	.76	-	.78	-	.80	-	.80	-	-
21.0	.73	-	.77	-	.78	-	.80	-	.80	-	-

NACA 0009

Reynolds Number	Test Conditions	
1.3×10^6 ———	Tunnel:	NACA VDT
2.3×10^6 ·····	Date:	1937
3.1×10^6 ·····	Test:	3-D
	Turbulence:	2.0%
	Surface:	Smooth





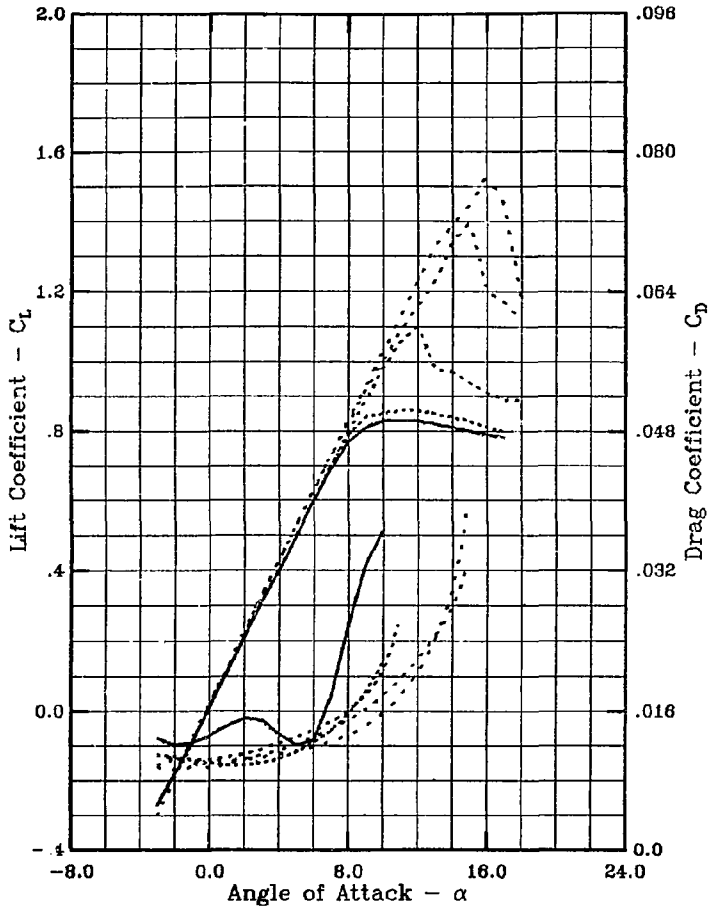
NACA 0009

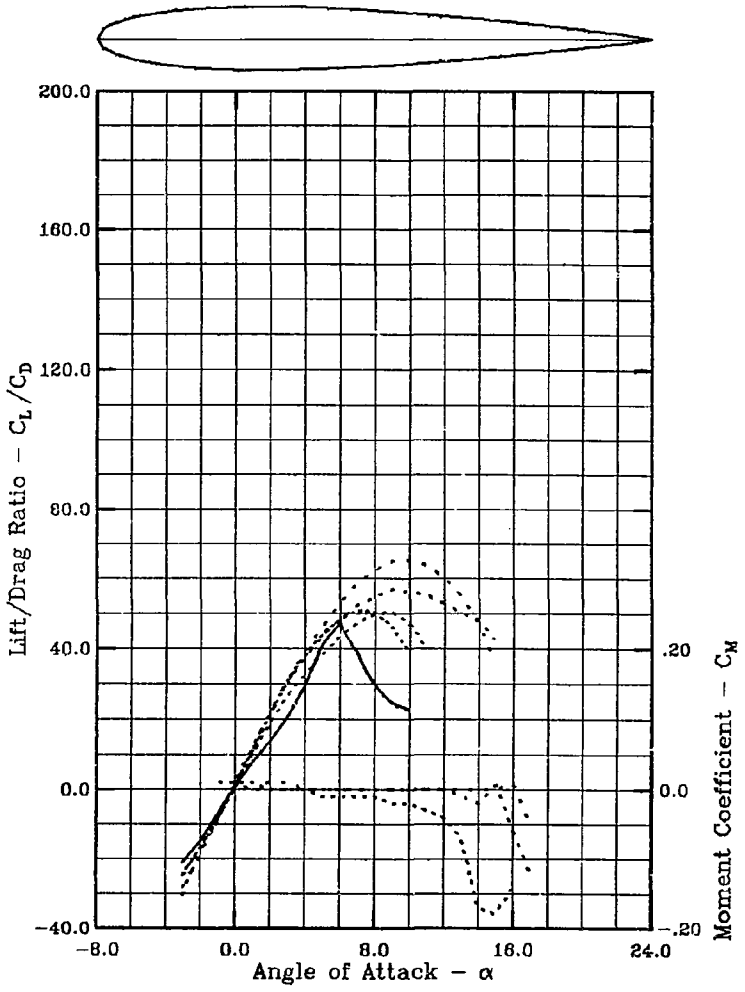
Tunnel: NACA VDT / Date: 1937 / Test: 3-D / Turbulence: 2.0% / Surface: Smooth

RN	1.3×10^6			2.3×10^6			3.1×10^6		
AOA	CL	CD	CM	CL	CD	CM	CL	CD	CM
-1.0	-.10	-	-	-.10	.0085	-	-.10	-	-
.0	.00	.0084	.00	.00	.0079	.00	.00	-	-
1.0	.11	.0088	.00	.11	.0082	.00	.11	.0076	.01
2.0	.22	.0094	.01	.22	.0089	.00	.22	.0078	.01
3.0	.31	.0091	.01	.31	.0093	.00	.31	.0078	.00
4.0	.41	.0091	.01	.41	.0097	.00	.41	.0079	.00
5.0	.51	.0098	.00	.51	.0102	.00	.51	.0085	-.01
6.0	.62	.0110	.00	.62	.0109	.00	.62	.0094	-.01
7.0	.70	.0126	.00	.72	.0116	.00	.72	.0105	-.01
8.0	.80	.0145	-.01	.82	.0125	.00	.82	.0117	-.01
9.0	.86	.0166	-.02	.90	.0139	-.01	.90	.0131	-.02
10.0	.88	.0191	-.03	1.01	.0163	-.01	1.01	.0151	-.02
11.0	.88	.0221	-.04	1.10	.0199	-.03	1.11	.0177	-.03
12.0	.88	.0258	-.05	1.20	-	-.06	1.21	.0213	-.04
13.0	.88	-	-.07	1.05	-	-.09	1.30	-	-.05
14.0	.87	-	-.09	1.02	-	-.12	1.14	-	-.15
15.0	.87	-	-.12	.98	-	-.15	1.10	-	-.21
16.0	.85	-	-.13	.96	-	-.12	1.07	-	-.24
17.0	.84	-	-.14	.93	-	-.12	1.04	-	-.23
18.0	.83	-	-.14	.91	-	-.12	1.00	-	-.20
19.0	.82	-	-	.88	-	-.13	.96	-	-.15
20.0	.81	-	-	.86	-	-.14	.93	-	-
21.0	.80	-	-	.85	-	-	.91	-	-

NACA 0012

Reynolds Number		Test Conditions	
1.7×10^5	———	Tunnel:	NACA VDT
3.3×10^5	·····-·····	Date:	1937
6.6×10^5	·····	Test:	3-D
1.3×10^6	·····	Turbulence:	2.0%
2.4×10^6	·····	Surface:	Smooth



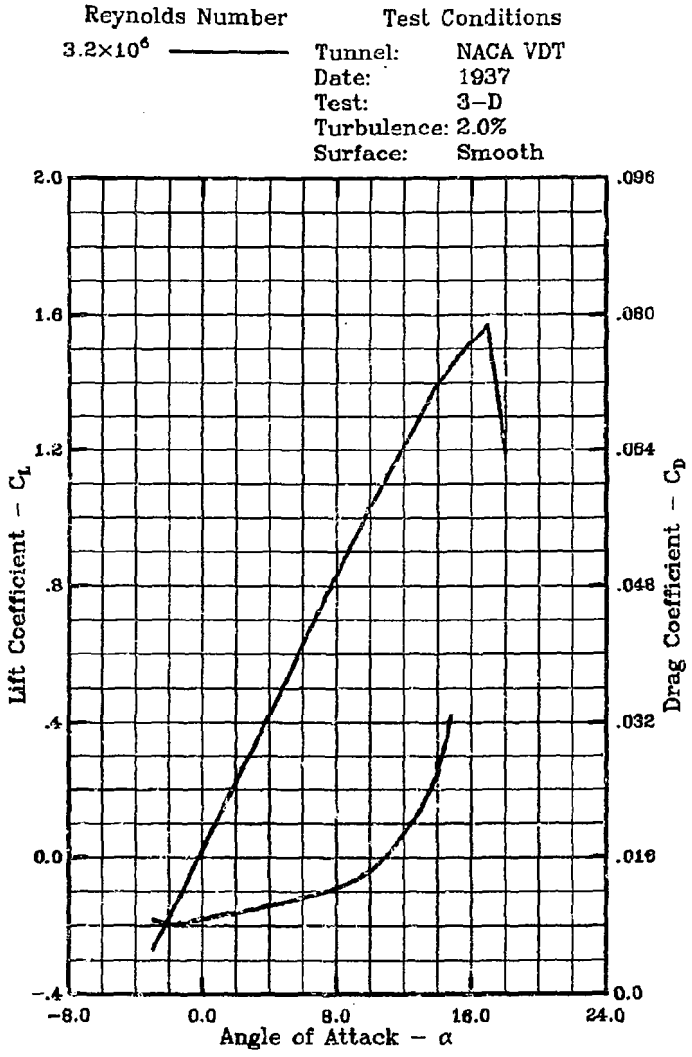


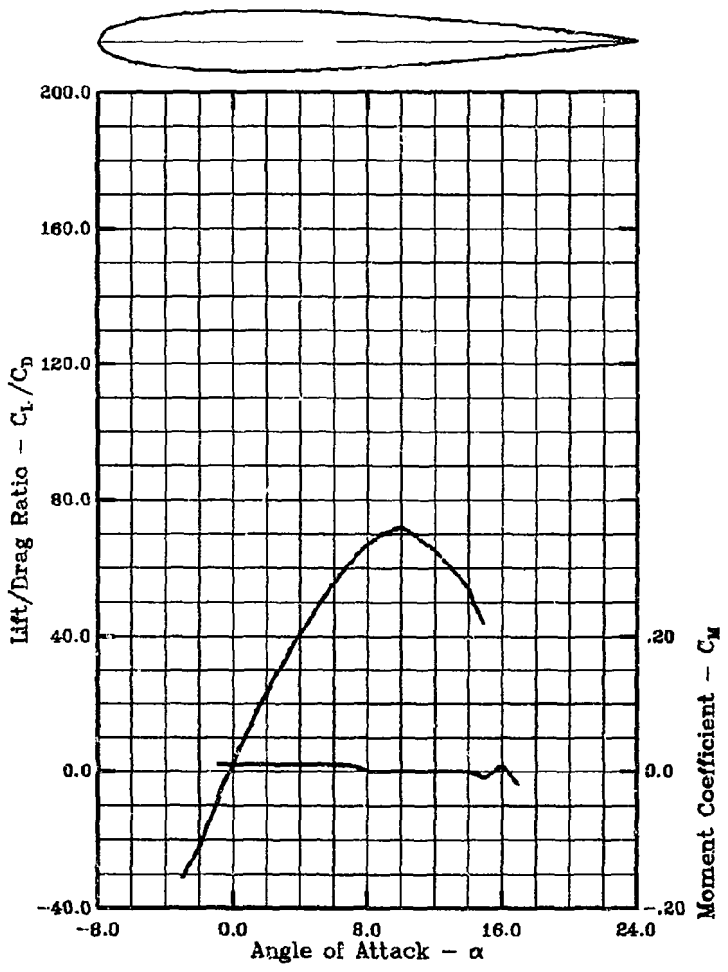
NACA 0012

Tunnel: NACA VDT / Date: 1937 / Test: 3-D / Turbulence: 2.0% / Surface: Smooth

RN	1.7×10^5		3.3×10^5		6.6×10^5			1.3×10^6			2.4×10^6		
AOA	CL	CD	CL	CD	CL	CD	CM	CL	CD	CM	CL	CD	CM
-3.0	-.27	.0129	-.27	.0109	-.27	.0110	-	-.30	.0098	-	-.27	.0096	-
-2.0	-.18	.0121	-.18	.0108	-.18	.0106	-	-.19	.0105	-	-.18	.0092	-
-1.0	-.09	.0124	-.09	.0104	-.09	.0104	.01	-.09	.0101	.01	-.08	.0096	.01
.0	.01	.0132	.01	.0100	.01	.0104	.01	.02	.0095	.01	.02	.0102	.01
1.0	.11	.0143	.11	.0098	.11	.0107	.01	.12	.0099	.00	.12	.0103	.01
2.0	.21	.0152	.21	.0098	.21	.0111	.00	.22	.0105	.00	.23	.0104	.01
3.0	.31	.0150	.31	.0100	.31	.0116	.00	.33	.0109	.00	.33	.0107	.01
4.0	.40	.0134	.40	.0105	.40	.0123	.00	.43	.0115	.00	.43	.0110	.00
5.0	.50	.0121	.50	.0113	.50	.0130	-.01	.53	.0122	.00	.53	.0114	.00
6.0	.60	.0127	.60	.0124	.60	.0138	-.01	.63	.0130	.00	.63	.0119	.00
7.0	.69	.0177	.70	.0138	.70	.0148	-.01	.73	.0139	.00	.73	.0125	.00
8.0	.77	.0258	.79	.0157	.80	.0160	-.01	.82	.0150	.00	.83	.0133	.00
9.0	.81	.0328	.84	.0182	.89	.0177	-.02	.92	.0162	.00	.93	.0143	.00
10.0	.83	.0365	.85	.0216	.98	.0206	-.02	1.00	.0178	.00	1.03	.0158	.00
11.0	.83	-	.86	-	1.06	.0266	-.03	1.09	.0197	.00	1.13	.0177	.00
12.0	.83	-	.86	-	1.10	-	-.04	1.16	.0220	.00	1.23	.0204	.00
13.0	.82	-	.85	-	.98	-	-.07	1.23	.0245	-.01	1.33	.0241	.00
14.0	.81	-	.84	-	.97	-	-.17	1.34	.0277	-.02	1.39	.0295	.00
15.0	.80	-	.83	-	.94	-	-.18	1.40	.0333	.01	1.45	.0403	.00
16.0	.79	-	.81	-	.91	-	-.14	1.20	-	-.06	1.53	-	.01
17.0	.78	-	.80	-	.89	-	-	1.17	-	-.12	1.45	-	-.05
18.0	78	-	78	-	.89	-	-	1.12	-	-	1.17	-	-

NACA 0012


Reynolds Number
3.2×10^6
Test Conditions
Tunnel: NACA VDT
Date: 1937
Test: 3-D
Turbulence: 2.0%
Surface: Smooth
Lift Coefficient – C_L
Drag Coefficient – C_D
Angle of Attack – α
2.0
1.6
1.2
.8
.4
0.0
-.4
.096
.080
.064
.048
.032
.016
0.0
-8.0
0.0
8.0
16.0
24.0


Lift/Drag Ratio – C_L/C_D
Moment Coefficient – C_M
Angle of Attack – α
200.0
160.0
120.0
80.0
40.0
0.0
-40.0
.20
0.0
-.20
-8.0
0.0
8.0
16.0
24.0

NACA 0012

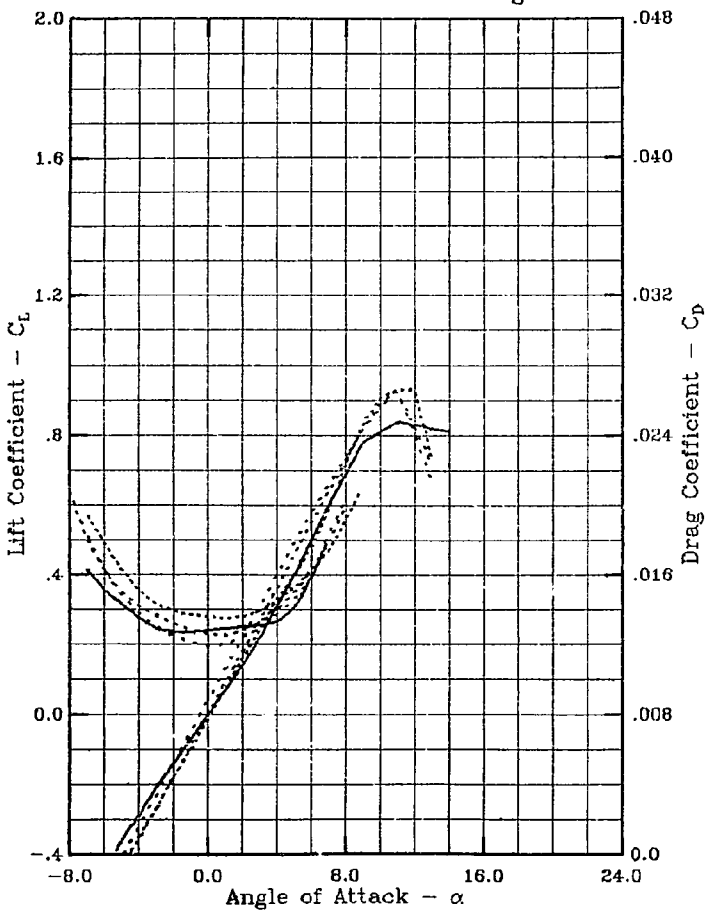
Tunnel: NACA VDT / Date: 1937 / Test: 3-D / Turbulence: 2.0% / Surface: Smooth

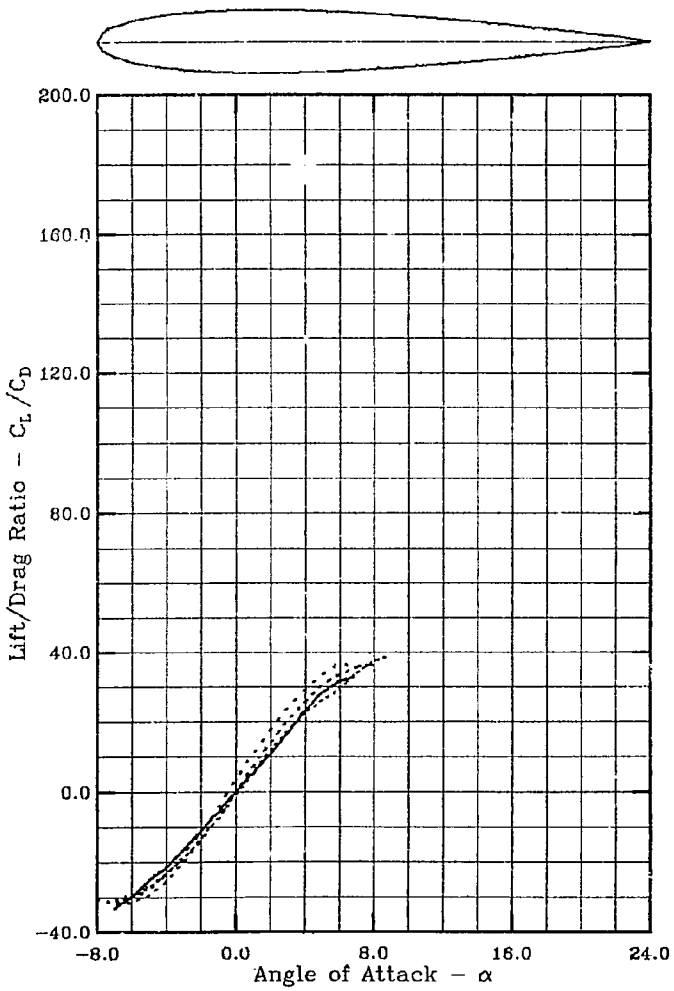
RN 3.2×10^6

AOA	CL	CD	CM
-3.0	-.27	.0087	-
-2.0	-.18	.0082	-
-1.0	-.08	.0083	.01
.0	.02	.0088	.01
1.0	.12	.0092	.01
2.0	.22	.0095	.01
3.0	.32	.0099	.01
4.0	.42	.0103	.01
5.0	.52	.0108	.01
6.0	.63	.0113	.01
7.0	.73	.0118	.01
8.0	.83	.0124	.00
9.0	.93	.0132	.00
10.0	1.03	.0143	.00
11.0	1.12	.0162	.00
12.0	1.21	.0186	.00
13.0	1.30	.0216	.00
14.0	1.40	.0257	.00
15.0	1.46	.0342	-.01
16.0	1.52	-	.01
17.0	1.57	-	-.02
18.0	1.19	-	-

NACA 0012

Reynolds Number		Test Conditions	
7.0×10^5	———	Tunnel:	NACA LTT
1.0×10^6	·····	Date:	1945
1.5×10^6	·····	Test:	2-D
2.0×10^6	·····	Turbulence:	0.03%
		Surface:	Rough





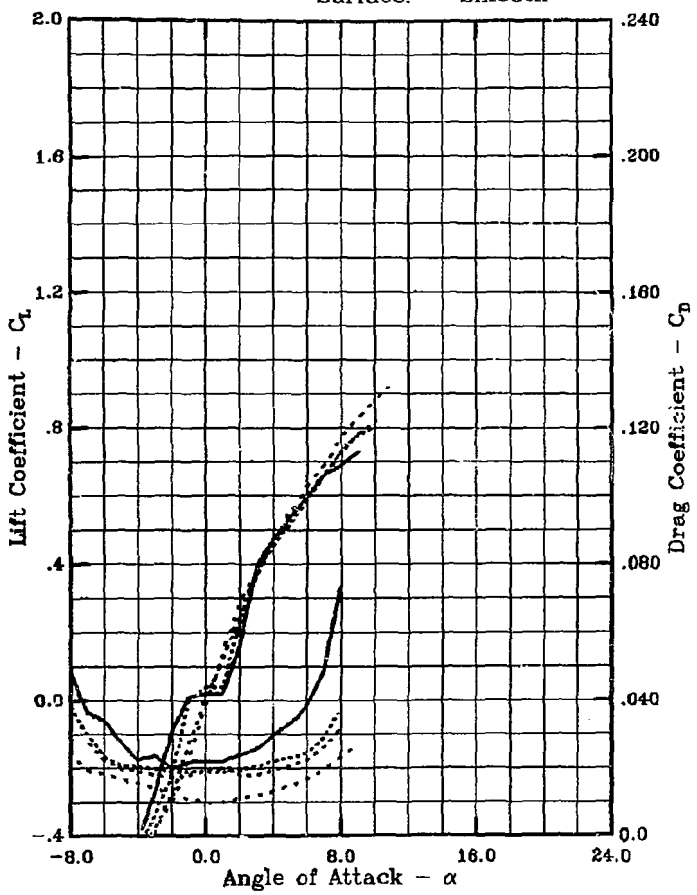
NACA 0012

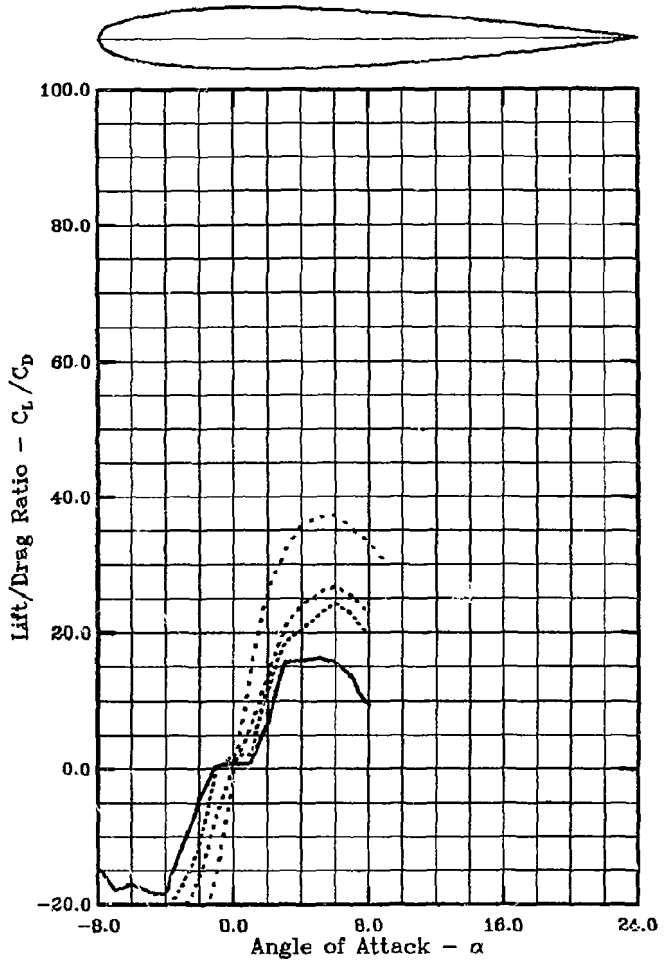
Tunnel: NACA LTT / Date: 1945 / Test: 2-D / Turbulence: 0.03% / Surface: Rough

RN	7.0×10^5		1.0×10^6		1.5×10^6		2.0×10^6	
AOA	CL	CD	CL	CD	CL	CD	CL	CD
-8.0	-	-	-.63	-	-.63	.0208	-.62	-
-7.0	-.54	.0163	-.60	.0195	-.57	.0180	-.56	.0183
-6.0	-.45	.0151	-.53	.0178	-.51	.0162	-.49	.0163
-5.0	-.36	.0143	-.44	.0163	-.44	.0150	-.41	.0148
-4.0	-.29	.0135	-.35	.0151	-.36	.0142	-.32	.0138
-3.0	-.21	.0129	-.27	.0143	-.27	.0136	-.23	.0130
-2.0	-.14	.0127	-.18	.0139	-.18	.0132	-.14	.0125
-1.0	-.07	.0127	-.10	.0137	-.09	.0128	-.05	.0121
.0	.00	.0128	-.01	.0136	.00	.0126	.04	.0119
1.0	.07	.0129	.07	.0135	.09	.0125	.13	.0120
2.0	.14	.0130	.16	.0136	.18	.0128	.22	.0124
3.0	.22	.0131	.24	.0139	.27	.0133	.31	.0129
4.0	.31	.0133	.33	.0145	.36	.0140	.40	.0137
5.0	.40	.0141	.40	.0153	.46	.0150	.49	.0146
6.0	.50	.0158	.48	.0163	.55	.0163	.58	.0158
7.0	.60	.0181	.59	.0174	.64	.0179	.66	.0184
8.0	.69	-	.72	.0192	.73	.0200	.74	.0204
9.0	.78	-	.83	.0211	.82	-	.82	-
10.0	.81	-	.91	-	.89	-	.88	-
11.0	.84	-	.93	-	.93	-	.93	-
12.0	.83	-	.93	-	.82	-	.80	-
13.0	.82	-	.73	-	.72	-	.67	-
14.0	.81	-	-	-	-	-	-	-

NACA 0012

Reynolds Number	Test Conditions	
4.0×10^4 ————	Tunnel:	IAG Stuttgart #2
6.0×10^4 ·····	Date:	1980
8.0×10^4 ·····	Test:	2-D
1.5×10^5 ·····	Turbulence:	0.08%
	Surface:	Smooth



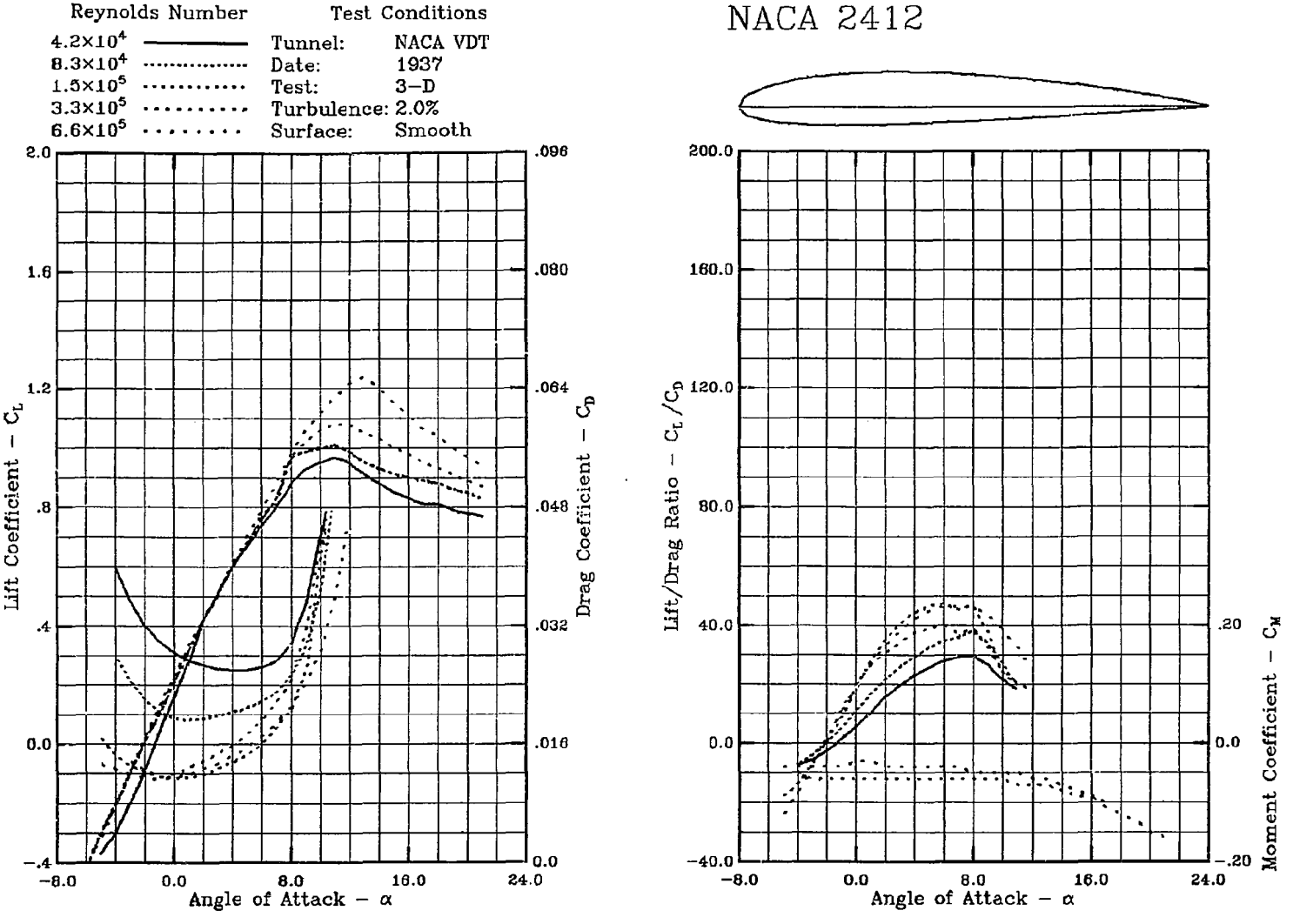


NACA 0012

Tunnel: IAG Stuttgart #2 / Date: 1980 / Test: 2-D / Turbulence: 0.08% / Surface: Smooth

RN	4.0×10^4		6.0×10^4		8.0×10^4		1.5×10^5	
AOA	CL	CD	CL	CD	CL	CD	CL	CD
-8.0	-.71	.0486	-.74	.0383	-.76	-	-.78	.0249
-7.0	-.65	.0363	-.67	.0300	-.68	.0277	-.71	.0195
-6.0	-.58	.0341	-.59	.0234	-.59	.0225	-.62	.0183
-5.0	-.50	.0275	-.51	.0207	-.52	.0199	-.54	.0172
-4.0	-.42	.0226	-.44	.0206	-.44	.0192	-.47	.0157
-3.0	-.27	.0239	-.34	.0198	-.38	.0182	-.39	.0142
-2.0	-.09	.0199	-.22	.0190	-.28	.0171	-.30	.0124
-1.0	.01	.0218	.00	.0189	-.13	.0181	-.17	.0108
.0	.02	.0221	.04	.0189	.01	.0192	-.01	.0098
1.0	.02	.0221	.04	.0189	.12	.0200	.14	.0099
2.0	.16	.0239	.23	.0195	.25	.0181	.29	.0111
3.0	.40	.0257	.38	.0205	.37	.0180	.38	.0120
4.0	.47	.0295	.45	.0220	.46	.0192	.47	.0131
5.0	.54	.0332	.52	.0232	.54	.0209	.55	.0149
6.0	.60	.0382	.59	.0243	.60	.0224	.63	.0169
7.0	.66	.0489	.66	.0291	.66	.0261	.69	.0196
8.0	.69	.0739	.73	.0373	.73	.0318	.77	.0231
9.0	.73	-	.78	-	.78	-	.83	.0273
10.0	-	-	.80	-	.82	-	.88	-
11.0	-	-	-	-	-	-	.93	-

NACA 2412


Reynolds Number
4.2×10^4
8.3×10^4
1.5×10^5
3.3×10^5
6.6×10^5
Test Conditions
Tunnel: NACA VDT
Date: 1937
Test: 3-D
Turbulence: 2.0%
Surface: Smooth
Lift Coefficient – C_L
Drag Coefficient – C_D
Angle of Attack – α
Lift/Drag Ratio – C_L/C_D
Moment Coefficient – C_M
Angle of Attack – α

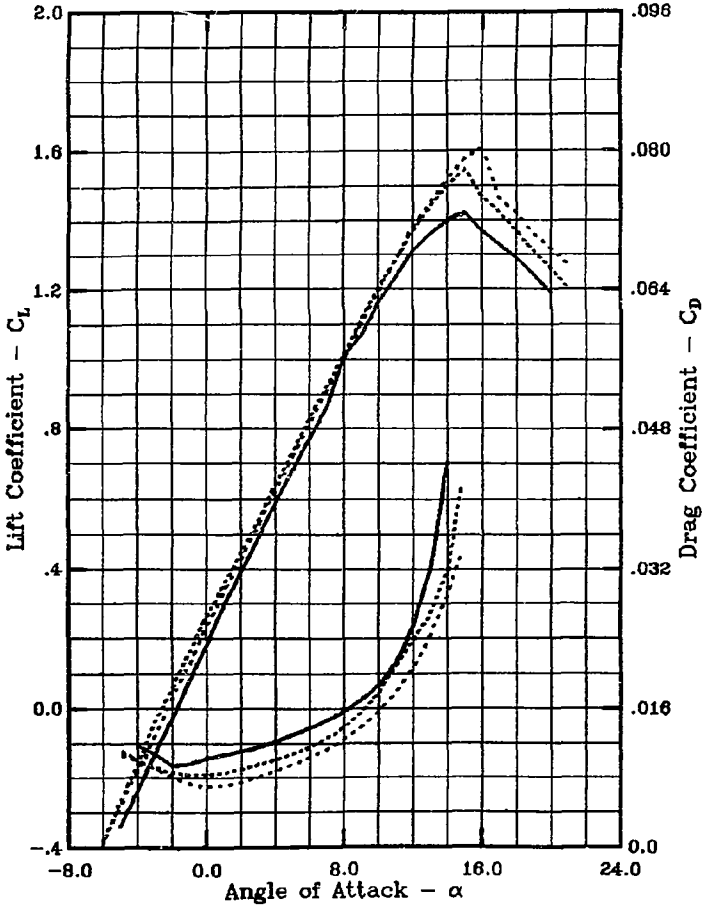
NACA 2412

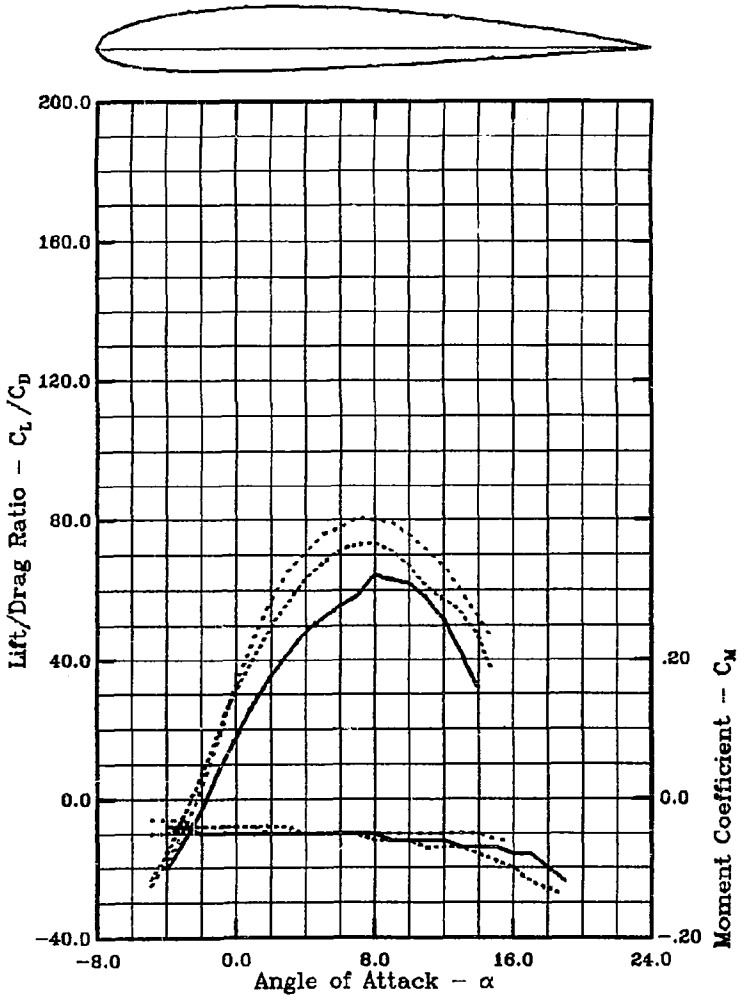
Tunnel: NACA VDT / Date: 1937 / Test: 3-D / Turbulence: 2.0% / Surface: Smooth

RN	4.2×10^4		8.3×10^4		1.5×10^5		3.3×10^5			6.6×10^5		
AOA	CL	CD	CL	CD	CL	CD	CL	CD	CM	CL	CD	CM
-6.0	-	-	-.42	-	-.42	-	-	-	-	-.42	-	-
-5.0	-.37	-	-.30	-	-.30	.0168	-.31	-	-	-.32	.0132	-.04
-4.0	-.30	.0399	-.20	.0280	-.20	.0145	-.20	-	-.05	-.21	.0126	-.04
-3.0	-.20	.0355	-.10	.0246	-.10	.0131	-.09	.0137	-.06	-.10	.0119	-.04
-2.0	-.09	.0321	.01	.0220	.01	.0122	.02	.0125	-.06	.01	.0114	-.04
-1.0	.04	.0299	.10	.0204	.10	.0116	.13	.0115	-.06	.12	.0113	-.04
.0	.16	.0284	.21	.0195	.21	.0114	.23	.0119	-.06	.22	.0115	-.03
1.0	.28	.0274	.32	.0193	.32	.0115	.34	.0128	-.06	.32	.0119	-.03
2.0	.42	.0267	.42	.0195	.42	.0119	.42	.0137	-.06	.42	.0126	-.04
3.0	.51	.0262	.51	.0198	.51	.0126	.50	.0147	-.06	.51	.0134	-.04
4.0	.60	.0260	.60	.0203	.60	.0135	.60	.0158	-.06	.61	.0144	-.04
5.0	.67	.0260	.68	.0209	.68	.0145	.67	.0173	-.06	.70	.0156	-.04
6.0	.74	.0264	.76	.0218	.76	.0160	.78	.0193	-.06	.79	.0170	-.04
7.0	.80	.0273	.83	.0231	.83	.0182	.81	.0217	-.06	.88	.0189	-.04
8.0	.88	.0297	.97	.0253	.97	.0208	.97	.0247	-.06	.98	.0211	-.05
9.0	.93	.0349	.99	.0292	.99	.0258	1.02	.0316	-.06	1.06	.0242	-.05
10.0	.95	.0441	1.00	.0367	1.00	.0414	1.06	.0428	-.06	1.12	.0287	-.05
11.0	.97	.0540	1.01	.0514	1.01	.0521	1.08	.0534	-.07	1.17	.0360	-.05
12.0	.95	-	.99	-	.99	-	1.08	.0601	-.07	1.22	.0476	-.06
13.0	.91	-	.95	-	.95	-	1.05	-	-.07	1.24	-	-.06
14.0	.88	-	.93	-	.93	-	1.03	-	-.08	1.20	-	-.07
15.0	.85	-	.91	-	.91	-	1.00	-	-.09	1.15	-	-.08
16.0	.83	-	.90	-	.90	-	.98	-	-.09	1.11	-	-.09
17.0	.81	-	.89	-	.89	-	.95	-	-.10	1.06	-	-.11
18.0	.81	-	.88	-	.88	-	.93	-	-	1.04	-	-.12
19.0	.79	-	.86	-	.86	-	.91	-	-	1.00	-	-.13
20.0	.78	-	.85	-	.85	-	.89	-	-	.97	-	-.15
21.0	.77	-	.83	-	83	-	.87	-	-	.94	-	-.16

NACA 2412

Reynolds Number	Test Conditions	
1.3×10^6 ———	Tunnel:	NACA VDT
2.3×10^6 ·····	Date:	1937
3.1×10^6 ·····	Test:	3–D
	Turbulence:	2.0%
	Surface:	Smooth



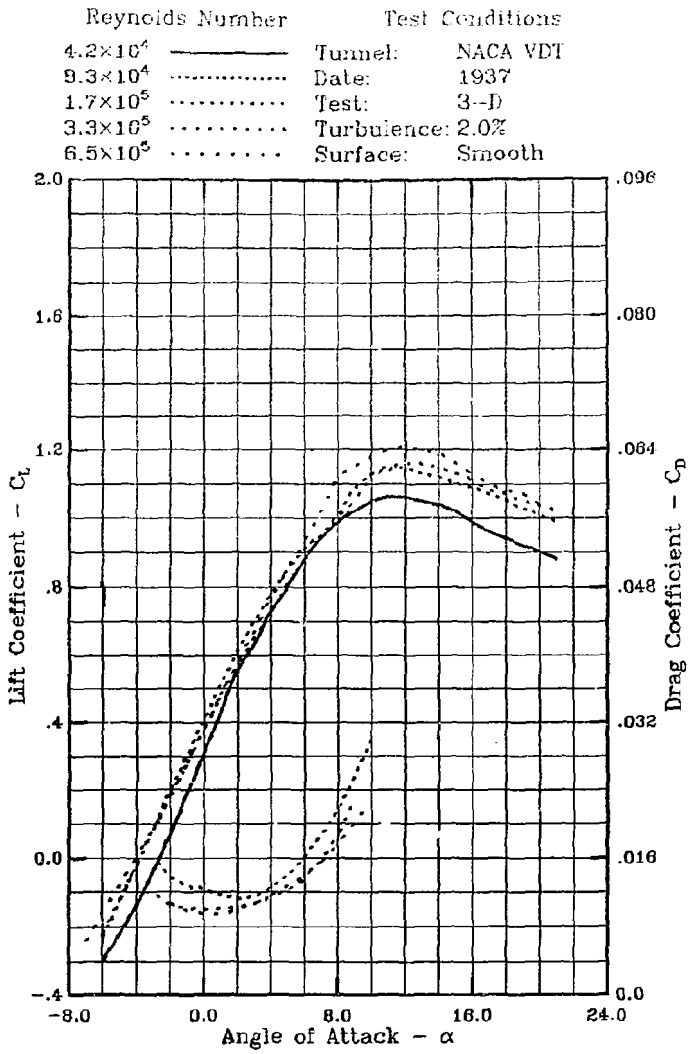


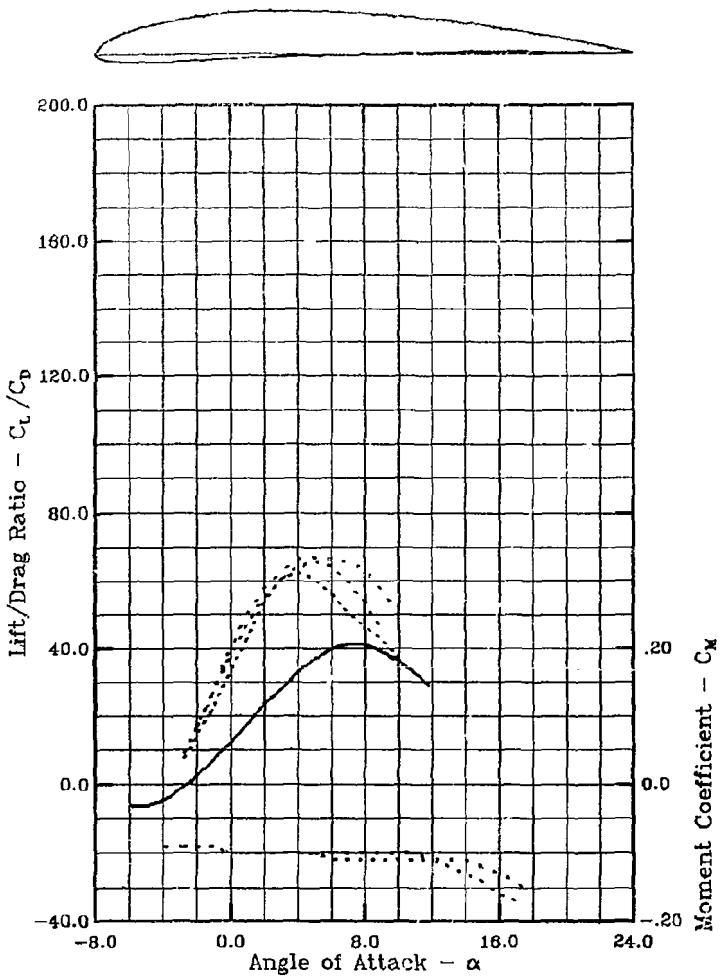
NACA 2412

Tunnel: NACA VDT / Date: 1937 / Test: 3-D / Turbulence: 2.0% / Surface: Smooth

RN	1.3×10^6			2.3×10^6			3.1×10^6		
AOA	CL	CD	CM	CL	CD	CM	CL	CD	CM
-6.0	-	-	-	-.39	-	-	-.38	-	-
-5.0	-.34	-	-	-.27	.0112	-.05	-.28	.0108	-.03
-4.0	-.24	.0118	-.04	-.16	.0100	-.05	-.18	.0100	-.03
-3.0	-.13	.0108	-.04	-.04	.0091	-.04	-.08	.0090	-.03
-2.0	-.03	.0094	-.05	.06	.0086	-.04	.03	.0080	-.04
-1.0	.08	.0096	-.05	.16	.0083	-.04	.13	.0073	-.04
.0	.18	.0103	-.05	.26	.0083	-.04	.23	.0070	-.04
1.0	.29	.0107	-.05	.35	.0086	-.04	.33	.0071	-.04
2.0	.39	.0111	-.05	.45	.0090	-.04	.43	.0075	-.05
3.0	.49	.0116	-.05	.54	.0095	-.04	.53	.0081	-.05
4.0	.59	.0122	-.05	.64	.0101	-.05	.62	.0088	-.05
5.0	.68	.0130	-.05	.73	.0108	-.05	.72	.0095	-.05
6.0	.77	.0138	-.05	.83	.0116	-.05	.81	.0104	-.05
7.0	.86	.0147	-.05	.92	.0126	-.05	.91	.0113	-.05
8.0	1.01	.0157	-.05	1.02	.0139	-.06	1.00	.0125	-.05
9.0	1.07	.0170	-.06	1.11	.0156	-.06	1.10	.0139	-.05
10.0	1.16	.0187	-.06	1.20	.0179	-.06	1.19	.0157	-.05
11.0	1.23	.0212	-.06	1.28	.0209	-.07	1.28	.0179	-.05
12.0	1.31	.0252	-.06	1.37	.0238	-.07	1.38	.0206	-.05
13.0	1.36	.0321	-.07	1.44	.0266	-.07	1.45	.0242	-.05
14.0	1.40	.0442	-.07	1.50	.0320	-.08	1.52	.0290	-.05
15.0	1.42	-	-.07	1.55	.0442	-.09	1.58	.0355	-.06
16.0	1.37	-	-.08	1.47	-	-.10	1.61	-	-.06
17.0	1.33	-	-.08	1.42	-	-.12	1.46	-	-
18.0	1.29	-	-.10	1.37	-	-.13	1.42	-	-
19.0	1.24	-	-.12	1.31	-	-.14	1.36	-	-
20.0	1.19	-	-	1.26	-	-	1.32	-	-
21.0	-	-	-	1.20	-	-	1.27	-	-

NACA 4409


Reynolds Number
4.2×10⁴
9.3×10⁴
1.7×10⁵
3.3×10⁵
6.5×10⁵
Test Conditions
Tunnel: NACA VDT
Date: 1937
Test: 3-D
Turbulence: 2.0%
Surface: Smooth
Lift Coefficient – C_L
Drag Coefficient – C_D
Angle of Attack – α
2.0
1.6
1.2
.8
.4
0.0
-.4
.096
.080
.064
.048
.032
.016
0.0
-8.0
0.0
8.0
16.0
24.0


Lift/Drag Ratio – C_L/C_D
Moment Coefficient – C_M
Angle of Attack – α
200.0
160.0
120.0
80.0
40.0
0.0
-40.0
.20
0.0
-.20
-8.0
0.0
8.0
16.0
24.0

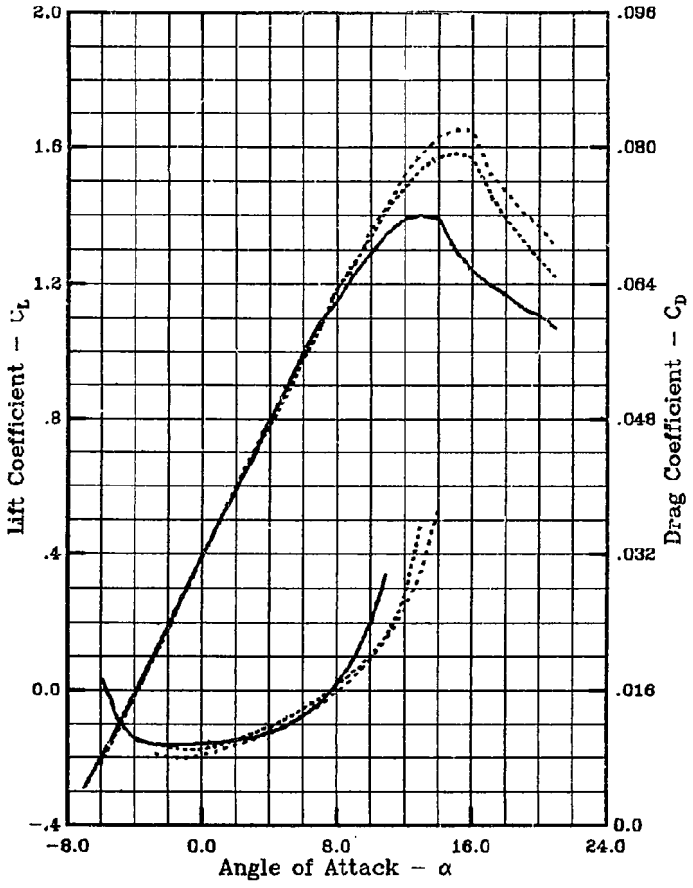
NACA 4409

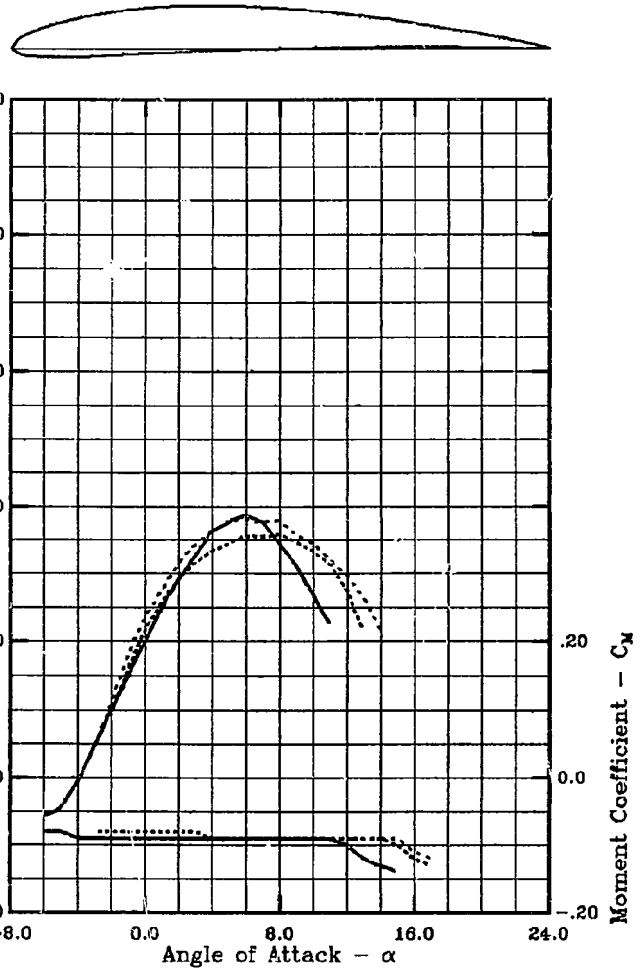
Tunnel: NACA VDT / Date: 1937 / Test: 3-D / Turbulence: 2.0% / Surface: Smooth

RN	4.2×10^4		8.3×10^4		1.7×10^5		3.3×10^5			6.5×10^5		
AOA	CL	CD	CL	CD	CL	CD	CL	CD	CM	CL	CD	CM
-7.0	-	-	-	-	-	-	-	-	-	-.24	-	-
-6.0	-.30	.0486	-.22	-	-.23	-	-.22	-	-	-.16	-	-
-5.0	-.22	.0350	-.14	-	-.13	-	-.12	-	-	-.08	-	-
-4.0	-.14	.0289	-.02	-	-.02	-	-.02	-	-	.00	-	-.09
-3.0	-.04	.0275	.10	.0227	.09	.0160	.08	.0119	-.09	.09	-	-.09
-2.0	.07	.0271	.20	.0219	.20	.0138	.18	.0105	-.09	.18	.0107	-.09
-1.0	.19	.0261	.30	.0219	.30	.0128	.28	.0101	-.09	.28	.0099	-.09
.0	.31	.0251	.41	.0196	.41	.0123	.38	.0100	-.10	.38	.0095	-.10
1.0	.43	.0243	.51	.0157	.51	.0117	.48	.0101	-.10	.48	.0095	-.10
2.0	.56	.0235	.60	.0128	.61	.0113	.57	.0103	-.10	.58	.0100	-.10
3.0	.63	.0227	.69	.0116	.70	.0115	.65	.0107	-.10	.67	.0107	-.10
4.0	.73	.0221	.79	.0118	.78	.0125	.73	.0114	-.10	.77	.0116	-.10
5.0	.80	.0218	.85	.0133	.85	.0140	.81	.0123	-.10	.85	.0127	-.10
6.0	.88	.0220	.90	.0158	.91	.0162	.88	.0137	-.11	.93	.0140	-.10
7.0	.94	.0227	.95	.0195	.95	.0187	.94	.0157	-.11	1.02	.0156	-.10
8.0	.99	.0241	1.01	.0247	1.01	.0217	1.00	.0186	-.11	1.12	.0176	-.10
9.0	1.02	.0261	1.08	.0327	1.09	.0255	1.05	.0230	-.11	1.15	.0201	-.10
10.0	1.05	.0288	1.11	-	1.13	.0302	1.13	-	-.11	1.18	.0232	-.10
11.0	1.06	.0325	1.13	-	1.14	-	1.15	-	-.11	1.20	-	-.10
12.0	1.06	.0374	1.13	-	1.15	-	1.16	-	-.11	1.21	-	-.11
13.0	1.05	-	1.13	-	1.13	-	1.16	-	-.12	1.20	-	-.11
14.0	1.04	-	1.12	-	1.12	-	1.15	-	-.13	1.19	-	-.11
15.0	1.02	-	1.10	-	1.10	-	1.13	-	-.14	1.16	-	-.12
16.0	.99	-	1.08	-	1.09	-	1.11	-	-.16	1.13	-	-.13
17.0	.96	-	1.05	-	1.07	-	1.08	-	-.17	1.10	-	-.14
18.0	.94	-	1.02	-	1.05	-	1.07	-	-	1.08	-	-.16
19.0	.92	-	1.00	-	1.03	-	1.05	-	-	1.07	-	-
20.0	.90	-	98	-	1.01	-	1.04	-	-	1.04	-	-
21.0	.88	-	.97	-	.99	-	1.02	-	-	1.02	-	-

NACA 4409

Reynolds Number		Test Conditions	
2.7×10^5	———	Tunnel:	NACA VDT
2.3×10^6	·····	Date:	1937
3.1×10^6	·····	Test:	3-D
		Turbulence:	2.0%
		Surface:	Smooth



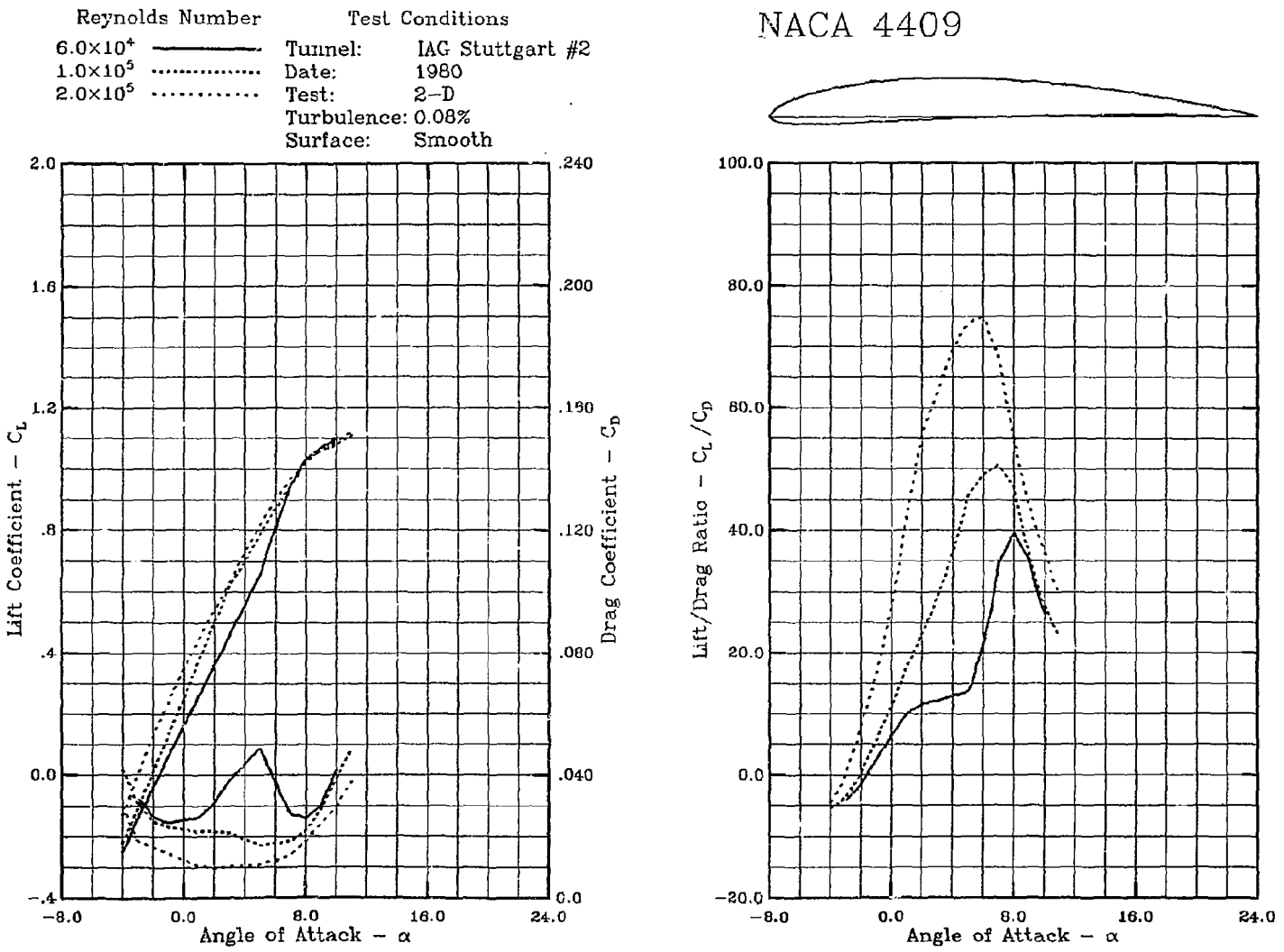


NACA 4409

Tunnel: NACA VDT / Date: 1937 / Test: 3-D / Turbulence: 2.0% / Surface: Smooth

RN	2.7×10^5			2.3×10^6			3.1×10^6		
AOA	CL	CD	CM	CL	CD	CM	CL	CD	CM
-7.0	-.29	-	-	-	-	-	-	-	-
-6.0	-.20	.0179	-.08	-.22	-	-	-.21	-	-
-5.0	-.11	.0125	-.08	-.12	-	-	-.11	-	-
-4.0	-.01	.0103	-.09	-.02	-	-	-.02	-	-
-3.0	.09	.0096	-.09	.08	-	-.08	.08	.0086	-.09
-2.0	.19	.0095	-.09	.18	.0093	-.08	.18	.0081	-.09
-1.0	.29	.0096	-.09	.29	.0090	-.08	.29	.0080	-.09
.0	.39	.0097	-.09	.39	.0090	-.08	.39	.0083	-.09
1.0	.49	.0098	-.09	.49	.0095	-.08	.49	.0089	-.09
2.0	.59	.0101	-.09	.59	.0101	-.08	.60	.0095	-.09
3.0	.68	.0104	-.09	.69	.0109	-.08	.70	.0102	-.09
4.0	.80	.0110	-.09	.78	.0117	-.09	.80	.0110	-.09
5.0	.89	.0118	-.09	.87	.0126	-.09	.90	.0119	-.09
6.0	1.00	.0129	-.09	.98	.0138	-.09	.99	.0130	-.09
7.0	1.09	.0145	-.09	1.07	.0151	-.09	1.07	.0142	-.09
8.0	1.15	.0167	-.09	1.19	.0166	-.09	1.19	.0157	-.09
9.0	1.23	.0197	-.09	1.26	.0182	-.09	1.25	.0175	-.09
10.0	1.29	.0240	-.09	1.34	.0201	-.09	1.36	.0197	-.09
11.0	1.35	.0301	-.09	1.42	.0226	-.09	1.43	.0223	-.09
12.0	1.39	-	-.10	1.48	.0268	-.09	1.52	.0255	-.09
13.0	1.40	-	-.12	1.54	.0360	-.09	1.58	.0299	-.09
14.0	1.39	-	-.13	1.57	-	-.09	1.63	.0375	-.09
15.0	1.30	-	-.14	1.58	-	-.10	1.65	-	-.09
16.0	1.24	-	-	1.57	-	-.12	1.65	-	-.11
17.0	1.20	-	-	1.47	-	-.13	1.53	-	-.12
18.0	1.17	-	-	1.39	-	-	1.47	-	-
19.0	1.13	-	-	1.33	-	-	1.41	-	-
20.0	1.11	-	-	1.27	-	-	1.37	-	-
21.0	1.07	-	-	1.22	-	-	1.30	-	-

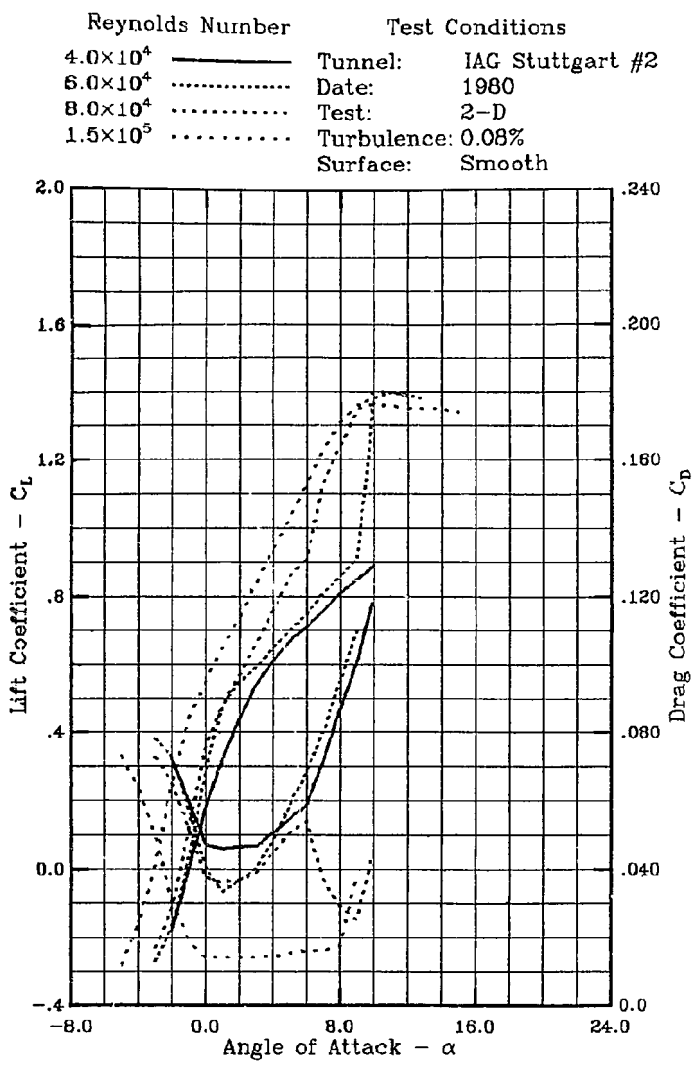
NACA 4409


Reynolds Number
6.0×10⁴
1.0×10⁵
2.0×10⁵
Test Conditions
Tunnel: IAG Stuttgart #2
Date: 1980
Test: 2-D
Turbulence: 0.08%
Surface: Smooth
Lift Coefficient – C_L
Drag Coefficient – C_D
Lift/Drag Ratio – C_L/C_D
Angle of Attack – α
2.0
1.6
1.2
.8
.4
0.0
-.4
.240
.200
.160
.120
.080
.040
0.0
100.0
80.0
60.0
40.0
20.0
0.0
-20.0
-8.0
0.0
8.0
16.0
24.0

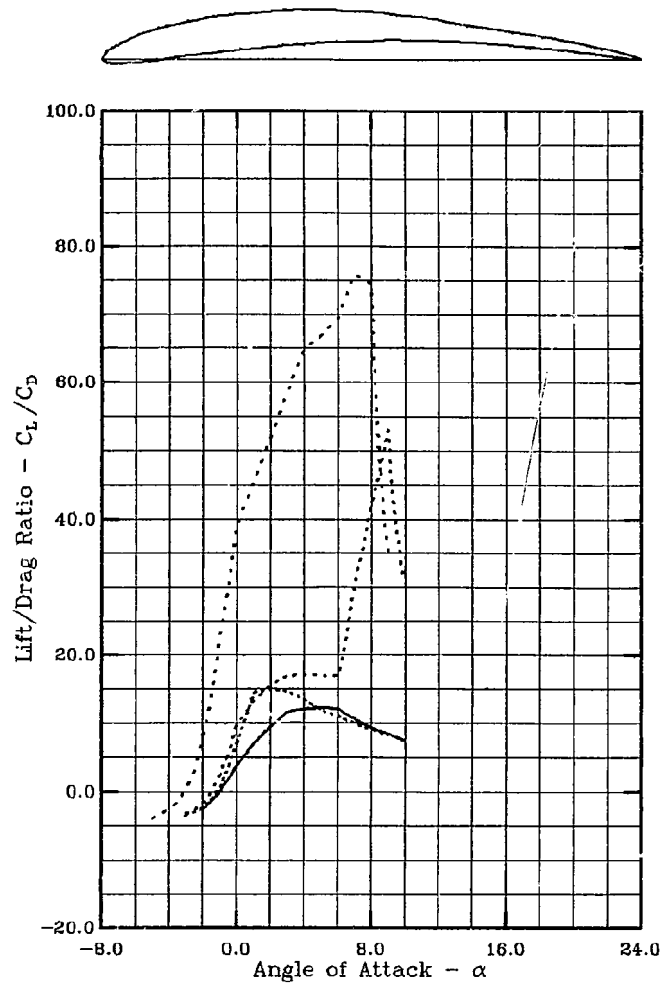
NACA 4409

Tunnel: IAG Stuttgart #2 / Date: 1980 / Test: 2-D / Turbulence: 0.08% / Surface: Smooth

RN	6.0×10^4		1.0×10^5		2.0×10^5	
AOA	CL	CD	CL	CD	CL	CD
-4.0	-.25	-	-.22	.0417	-.13	.0301
-3.0	-.14	.0327	-.11	.0305	.00	.0184
-2.0	-.04	.0265	.01	.0251	.13	.0166
-1.0	.06	.0244	.13	.0229	.24	.0146
.0	.16	.0254	.25	.0223	.35	.0126
1.0	.26	.0263	.38	.0217	.45	.0105
2.0	.36	.0310	.50	.0216	.54	.0097
3.0	.46	.0382	.62	.0213	.63	.0101
4.0	.56	.0435	.70	.0192	.73	.0105
5.0	.66	.0490	.79	.0173	.82	.0111
6.0	.81	.0375	.87	.0177	.90	.0120
7.0	.95	.0274	.95	.0188	.97	.0141
8.0	1.03	.0259	1.02	.0216	1.02	.0184
9.0	1.07	.0304	1.06	.0294	1.06	.0242
10.0	1.10	.0415	1.08	.0392	1.09	.0298
11.0	-	-	1.11	.0483	1.12	.0380


Reynolds Number
4.0×10^4
6.0×10^4
8.0×10^4
1.5×10^5
Test Conditions
Tunnel: IAG Stuttgart #2
Date: 1980
Test: 2-D
Turbulence: 0.08%
Surface: Smooth
Lift Coefficient - C_L
Drag Coefficient - C_D
Angle of Attack - α
2.0
1.6
1.2
.8
.4
0.0
-.4
.240
.200
.160
.120
.080
.040
0.0
-8.0
0.0
8.0
16.0
24.0

SOKOLOV


Lift/Drag Ratio - C_L/C_D
Angle of Attack - α
100.0
80.0
60.0
40.0
20.0
0.0
-20.0
-8.0
0.0
8.0
16.0
24.0

SOKOLOV

Tunnel: IAG Stuttgart #2 / Date: 1980 / Test: 2-D / Turbulence: 0.08% / Surface: Smooth

RN	4.0×10^4		6.0×10^4		8.0×10^4		1.5×10^5	
AOA	CL	CD	CL	CD	CL	CD	CL	CD
-5.0	-	-	-	-	-	-	-.28	.0730
-4.0	-	-	-	-	-	-	-.16	.0638
-3.0	-	-	-.27	.0781	-.23	.0726	.01	.0497
-2.0	-.18	.0719	-.17	.0729	-.12	.0653	.25	.0309
-1.0	.00	.0597	.03	.0575	.12	.0514	.44	.0191
.0	.18	.0471	.29	.0406	.36	.0376	.55	.0141
1.0	.32	.0460	.48	.0334	.48	.0362	.65	.0143
2.0	.44	.0466	.55	.0367	.57	.0368	.74	.0143
3.0	.54	.0467	.59	.0404	.66	.0391	.84	.0143
4.0	.61	.0506	.65	.0484	.76	.0447	.94	.0145
5.0	.67	.0547	.70	.0586	.86	.0508	1.03	.0154
6.0	.71	.0586	.75	.0683	.91	.0541	1.13	.0163
7.0	.76	.0718	.81	.0802	1.14	.0369	1.23	.0162
8.0	.81	.0868	.86	.0952	1.24	.0294	1.31	.0176
9.0	.85	.1010	.91	.1102	1.34	.0252	1.36	.0386
10.0	.89	.1205	1.38	-	1.40	.0463	1.36	-
11.0	-	-	1.40	-	1.40	-	1.36	-
12.0	-	-	1.39	-	1.39	-	1.35	-
13.0	-	-	1.38	-	-	-	1.35	-
14.0	-	-	-	-	-	-	1.35	-
15.0	-	-	-	-	-	-	1.34	-