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PARAMETRIC TRANSONIC EVALUATION OF TYPE A VSTOL NACELLE DRAG.(U)
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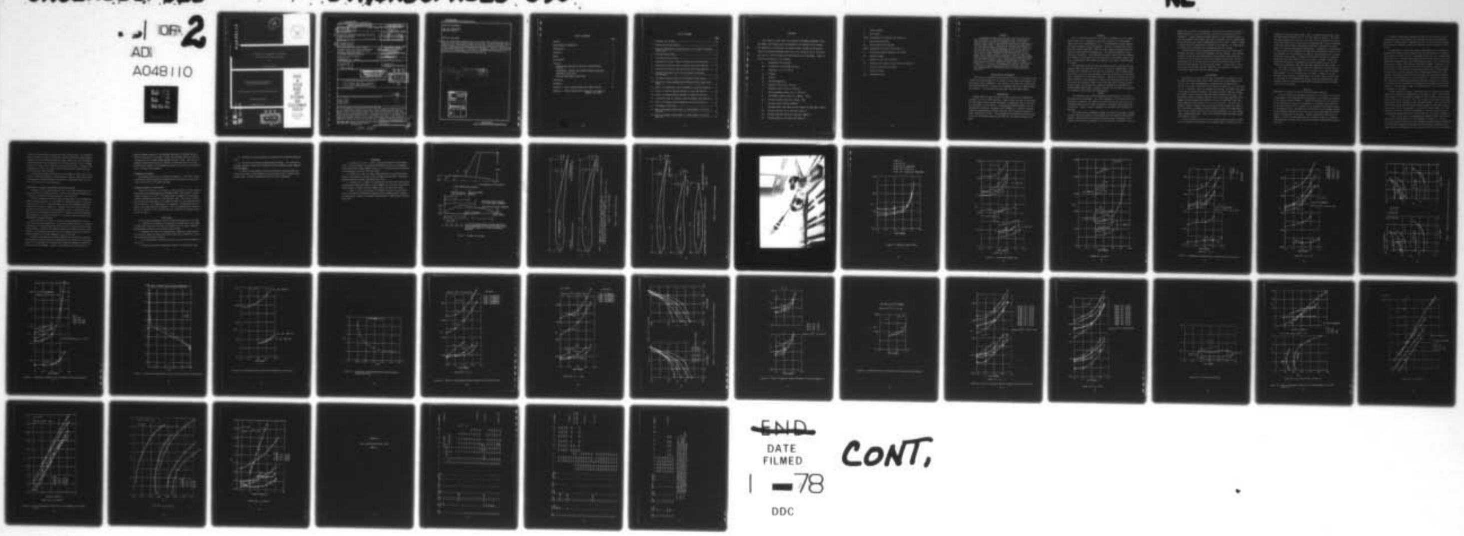

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PARAMETRIC TRANSONIC EVALUATION OF TYPE A VSTOL NACELLE DRAG

by

Jonah Ottensoser

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AVIATION AND SURFACE EFFECTS DEPARTMENT

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DAVID W. TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

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A parametric evaluation of the zero lift drag characteristics attributable to the large nacelles found on some Type A VSTOL candidate aircraft was conducted in the 7- by 10-foot transonic wind tunnel of the David W. Taylor Naval Ship Research and Development Center. Mounting the nacelles in proximity to the wings and fuselage yields levels of interference drag three to four times the isolated drag which results in the nacelle interference drag producing approximately 50 percent of the total aircraft drag. Movement of the nacelles away

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from the wings either longitudinally or vertically tends to reduce drag. Except for the nacelles mounted forward of the wing, the nacelles have an adverse effect on lift. The particular wide nose body used proved to be highly unstable longitudinally although adding nacelles above or behind the wings tended to reduce this instability. Five pairs of axisymmetric nacelles, four pairs of pylons, three longitudinal and two vertical positions were investigated on a 10-percent scale, low (supercritical) wing model.

TABLE OF CONTENTS

	Page
ABSTRACT	1
ADMINISTRATIVE INFORMATION	1
INTRODUCTION	1
APPARATUS	2
MODELS	2
TEST PROGRAM	3
ANALYSIS	4
COMPARISON OF NACELLES IN AND OUT OF WING/FUSELAGE VICINITY	4
LONGITUDINAL, VERTICAL AND SPANWISE NACELLE VARIATION	6
INCREMENTAL PYLON DRAG	7
STANDARD AERODYNAMIC COEFFICIENTS	7
CONCLUSIONS	7
REFERENCES	9
APPENDIX A - TYPE A VSTOL NACELLE DRAG TUNNEL RUN LOG	37
APPENDIX B - FINAL TABULATED DATA (available on request to DTNSRDC, Code 1660)	

LIST OF FIGURES

		Page
1	- Schematic of the Model	10
2	- Nacelle and Pylon Contours	11
3	- Typical Configuration Installed in the 7- by 10-Foot Transonic Wind Tunnel	13
4	- Reynolds Number Effect	14
5	- Incremental Nacelle Drag	15
6	- Comparison of Nacelle Drag on Shortest Pylon with Wing On	17
7	- Comparison of Nacelle Drag on Longest Pylon with Wing Off	19
8	- Comparison of Nacelle Drag on Shortest Pylon with Wing Off	20
9	- Theoretical Nacelle Outer Surface Pressure Coefficient Distribution	21
10	- Incremental Nacelle Drag with Intermediate Length Pylon	22
11	- Drag Ratio versus Nondimensional Minimum Nacelle Height above Wing	23
12	- Effect of Longitudinal Nacelle Movement on Drag with Wing On	24
13	- Effect of Vertical Nacelle Movement on Drag with Wing On	26
14	- Effect of Spanwise Nacelle Movement on Drag with Wing Off	27
15	- Incremental Drag for Spanwise Nacelle Movement with Wing Off	28
16	- Effect of Spanwise Nacelle Movement on Drag with Wing On	29
17	- Incremental Pylon Drag	31
18	- Basic Aerodynamic Coefficients at a Mach Number of 0.6 with Wing Off	32
19	- Basic Aerodynamic Coefficients at a Mach Number of 0.6 with Wing On	34

NOTATION

The results in this report are reduced to standard aerodynamic force and moment coefficients and are presented in the stability axis system. All moments are referenced to the balance center located at the quarter chord of the mean aerodynamic chord (27.40 in. (0.696 m) aft of the nose) and 2.25 in. (0.057 m) above the lower surface of the fuselage. Angles of attack are relative to the fuselage.

B	Designation for fuselage
BW	Designation for fuselage and wing
b	Wing span, 4.77 ft (1.45 m)
C_D	Drag/qs
C_L	Lift/qs
C_M	Pitching Moment/qsc
C_P	Pressure coefficient, $(P-P_o)/q$
c	Reference chord, 0.671 ft (0.205 m)
$\bar{c}$	Mean aerodynamic chord, 0.74 ft (0.226 m)
D	Incremental nacelle drag (e.g., $BWP_1N_1 - BWP_1$)
D_o	Isolated nacelle drag (e.g., $BP_4N_1 - BP_4$)
d	Maximum nacelle external diameter
h	Minimum height from nacelle outer surface to wing upper surface
LA	Nacelle position aft of wing (see Figure 1)
LF	Nacelle position forward of wing (see Figure 1)
LW	Nacelle position over wing (see Figure 1)

l	Nacelle length
M	Mach number
N1-N5	Designation for nacelles (see Figure 2)
P	Local static pressure
P_o	Free-stream static pressure
P1-P4	Designation for pylons (see Figure 2)
q	Free-stream dynamic pressure, psf (N/m^2)
Re	Reynolds number
S	Wing area 3.196 ft^2 (0.2969 m^2)
UW	Raised nacelle position above wing (see Figure 1)
x	Distance along nacelle length
α	Angle of attack
ΔC_D	Incremental drag

ABSTRACT

A parametric evaluation of the zero lift drag characteristics attributable to the large nacelles found on some Type A VSTOL candidate aircraft was conducted in the 7- by 10-foot transonic wind tunnel of the David W. Taylor Naval Ship Research and Development Center. Mounting the nacelles in proximity to the wings and fuselage yields levels of interference drag three to four times the isolated drag which results in the nacelle interference drag producing approximately 50 percent of the total aircraft drag. Movement of the nacelles away from the wings either longitudinally or vertically tends to reduce drag. Except for the nacelles mounted forward of the wing, the nacelles have an adverse effect on lift. The particular wide nose body used proved to be highly unstable longitudinally, although adding nacelles above or behind the wings tended to reduce this instability. Five pairs of axisymmetric nacelles, four pairs of pylons, and three longitudinal and two vertical positions were investigated on a 10-percent scale, low (supercritical) wing model.

ADMINISTRATIVE INFORMATION

This work was undertaken by the Aircraft Division of the Aviation and Surface Effects Department at the David W. Taylor Naval Ship Research and Development Center (DTNSRDC) at the request of the Naval Air Systems Command (NAVAIR PMA-269) in support of the NAVAIR 53013 Type A VSTOL evaluation program. The program was funded under Task Area W0590-SL006.

INTRODUCTION

NAVAIR 53013 has been involved for some time with the competitive evaluation of Type A VSTOL aircraft. Some of these aircraft are typified by large engine nacelles whose drag plays a significant role in the overall performance of the vehicle. Consequently, NAVAIR requested that an experimental program be performed in the DTNSRDC 7- by 10-foot transonic tunnel to parametrically evaluate the zero lift drag characteristics of these (unpowered) nacelles. The information thus generated would be used as part of the NAVAIR empirical data base for the VSTOL evaluation program.

APPARATUS

The 7- by 10-foot transonic wind tunnel at DTNSRDC is of the closed-circuit type that is capable of continuous operation in a Mach number range from 0.20 to approximately 1.15. A six-component internal balance was used to measure forces and moments. Because of balance load limits, two such balances were used: TSB-6 for most wing-off configurations and TSB-24 for most wing-on configurations. The external geometry of both balances is identical. Each balance was used in conjunction with Adapter 29, Adapter 26, and Sting 4 and then connected to the tunnel support system. A dangleometer was mounted internally to the model to measure angle of attack.

The starboard nacelle of each pair had four static pressure taps 90 degrees apart from each other and 4.5 in. aft of the leading edge. These pressures were recorded on four separate transducers, and although these data were not used in this evaluation, they are included in the tabulated data of Appendix B for potential interest. Separate transducers were also used to measure cavity pressure for axial force corrections and for the five total and one static probe in the drag rake used to measure nacelle internal drag. The balance and transducer signals were processed by a Beckman Model 4040C analog to digital converter and recorded and processed on a Hewlett-Packard Model 2100 minicomputer.

MODELS

The 10-percent Type A VSTOL fuselage was constructed of wood with a thin covering of fiberglass. All other components of this model were constructed of aluminum. The inboard 5-percent span of the wing was a conventional unswept airfoil shape followed by a 26-degree sweep supercritical airfoil. Figure 1 shows a schematic of the model with pertinent dimensions.

The nacelles were axisymmetric bodies of revolution mounted on pylons without relative incidence to the fuselage with N1 chosen as the baseline nacelle. Mass flow ratios through the nacelle based on high-lite (entrance) and exit areas averaged 0.53 for nacelles N1, N2 and N3, 0.65 for nacelle N4, and 0.42 for nacelle N5. The pylon was constant chord NACA 64A012 airfoil in cross section with variations in span length for P1 through P4. Figure 2 shows pertinent details of the nacelles and pylons. Contoured wooden filler blocks were used to smoothly fill in fuselage gaps as the nacelles were varied longitudinally and vertically. Figure 3 shows a typical wing-on configuration installed in the tunnel. No longitudinal or vertical tail surfaces were evaluated during this program.

Transition grit (#120 carborundum particles) was used on the wings, fuselage, nacelles, and pylons throughout the test program. The location and size of the grit were determined by the procedure outlined in Ref. 1. A 1/8-in. (0.32-cm) wide band of grit was placed 10 percent of the fuselage length aft of the nose and at a constant 10-percent chord on the upper and lower surfaces of the wing and pylons. A similar band of grit was placed on the inner and outer surfaces of the nacelles 10 percent of the nacelle length back from the leading edge.

TEST PROGRAM

The majority of the wing-off data, as indicated in Appendix A, were run under settling chamber vented (SCV) conditions at Mach numbers from 0.50 to 0.85. This corresponds to a dynamic pressure range of 300 (14,364) to 660 psf (31,600 N/m^2) and a Reynolds number per foot variation of 3 to 4.1 million. With the addition of the wing, the normal front gage of the balance became overloaded. The initial balance TSB-6 was changed for TSB-24, and the test was continued under evacuated conditions. The Mach number range for wing-on data was 0.30 to 0.65 which corresponds to a dynamic pressure range of 80 (4,070) to 310 psf (14,843 N/m^2) and a Reynolds number per foot variation of 1.3 to 2.3 million. The effect of a Reynolds number on drag for the two different tunnel conditions, however, did not present a problem in the data analysis because data compared between the two tunnel conditions was of the incremental type (e.g., $BWN_1P_1 - BWP_1$ compared with $BN_1P_1 - BP_1$) where Reynolds number variation should have almost no effect.

A wake rake with one static and five total probes was used to survey the exit plane of the nacelles at zero degrees angle of attack for measurement of nacelle internal drag. (Ref. 2 indicates that nacelle internal drag remains constant from -4 to 4 deg angle of attack.) The internal profile drag was so low (i.e., the ratio of total pressure in the nacelle exit plane to the free-stream total pressure was 1.0 over 95 percent of the exit plane) that no measureable difference between the internal drag of the various nacelles was discernible. Consequently, internal drag of these nacelles was assumed to be small and approximately equal for all the nacelles, and no correction for internal drag was applied to the data presented in this report. (Theoretical estimates indicate the internal drag coefficient per nacelle to be on the order of 0.0010. These estimates were obtained by considering the internal wetted area of the nacelles as an equivalent flat plate and then applying the data of Ref. 3.)

The angle of attack range, within the constraints of model fouling, was -4 to 9 deg. for Mach number 0.5 or less and -4 to 4 deg. for higher Mach numbers. For all configurations the angle of sideslip was zero. Fuselage cavity pressure was measured by two probes taped to either side of the sting at the fuselage exit plane. These two pressures were then averaged, and the average was appropriately applied to adjust the axial force to zero base drag.

ANALYSIS

COMPARISON OF NACELLES IN AND OUT OF WING/FUSELAGE VICINITY

The most significant information contained in this report is the tremendous amount of interference drag generated by the nacelles in proximity to the wing as shown in Figure 5. Moving the nacelles into the vicinity of the fuselage, as shown by a comparison of ΔC_D between the nacelles on P1 and the nacelles on P4 in Figure 5, also produces a substantial amount of interference drag. Movement into the vicinity of the fuselage approximately doubled the drag and this drag level is then approximately doubled again in the vicinity of the wing. Nacelle interference drag tends to double or triple the body-wing drag and, as shown in Figure 6, generates even more drag as a very early drag rise develops at Mach numbers greater than 0.50.

Incremental drag values presented in Figure 5 are obtained by subtracting the drag of the nacelle-off configuration from the appropriate nacelle-on configurations. Wing-off data used to obtain these increments are presented in Figures 7 and 8; the wing-on data are presented in Figure 6.

An examination of individual nacelle drag (Figure 5), as measured by mounting the nacelles on the longest pylon with the wings off, indicates that the basic nacelle (N1) has a reasonable drag level but a surprisingly early drag rise. Decreasing the high-lite radius by 25 percent (N5) substantially decreases drag, while shortening the nacelle (N4) or thickening the external countour (N2) increase drag about equally. Thinning the external contour (N3) relative to the basic nacelle (N1) produces the largest increase in drag but also produces the largest drag rise Mach number. The high drag level of N3 may be due to leading edge separation on this nacelle. The theoretical pressure coefficients for N3 are more negative than for the other nacelles, as shown in Figure 9. The data of Figure 9 were obtained by considering potential flow about nacelle cross sections in conjunction with the method of conformal transformations as described in Ref. 4. Interestingly enough, as discussed later, this trend reverses in proximity to the wing.

Further analysis of Figure 5 indicates that the relative drag levels change with the nacelles approaching the fuselage or wing. The governing factor appears to be the relative amount of nacelle surface area in proximity to the wing or fuselage. Thus, the shortest nacelle (N4) has a lower drag than N1 in the vicinity of the wing and fuselage. Also, the thinnest nacelle (N3), which had the highest isolated drag, has the lowest drag in the vicinity of the wing because it is furthest from the wing. The same drastic increase for nacelles in proximity to the wing occurs even with the nacelles mounted outboard of the fuselage (P3), as shown in Figure 10.

A curve of drag ratio to nondimensional minimum nacelle height above the wing at a Mach number of 0.5 is presented in Figure 11. The drag ratio is defined as the ratio of the incremental nacelle drag as installed on a body/wing configuration divided by the particular isolated nacelle drag. The curve is general for all nacelles except N3, which was excluded because of possible local separation in the isolated case. As mentioned above, the data in Figure 11 show that nacelle interference drag tends to increase as the nacelle approaches the wing. While the curve is general, caution should be used in applying it to other nacelles in that fuselage proximity or other local conditions could alter the data. It should also be pointed out that this curve is only valid below the sharp drag rise associated with these nacelles.

An attempt was made to develop a curve similar to Figure 11 for the effect of fuselage proximity on nacelle drag. However, this effect is not as pronounced as wing proximity; therefore in combination with local effects, no similar curve was developed.

LONGITUDINAL, VERTICAL, AND SPANWISE NACELLE VARIATION

Movement of the nacelle forward or aft of the wing substantially reduces the nacelle interference drag. Of the two movements, movement aft of the wing provides the greatest benefit; see Figure 12.

Vertical movement up and away from the wing reduces the interference drag, as shown in Figure 13. The effect of spanwise movement of the nacelles with wing off is shown in Figure 14, and the incremental drag for this effect is shown in Figure 15. Movement away from the fuselage decreases overall drag till pylon drag begins to play a significant role, at which point drag increases; see Figure 14. However, from an incremental drag viewpoint, as shown in Figure 15, the nacelle drag continuously decreases with spanwise movement.

Figure 16 shows the effect on drag of spanwise movement of the nacelle for wing-on configurations. For the N1 nacelle the drag is "lowest" in proximity to the fuselage and increases as the distance from the fuselage increases. However, the opposite variation in drag occurs for the N2 nacelle. Conflicting trends also occur for spanwise variation of the N1 nacelle forward of the wing compared to aft of the wing.

A possible explanation for these anomalies may be that the interference drag of the nacelle reaches a maximum with the nacelles in some proximity to the fuselage, but decreases with spanwise movement in either direction from this maximum. Thus the N1 nacelle on the P1 pylon has a smaller minimum distance to the fuselage (because of fuselage contour) than the N2 nacelle on the same P1 pylon and therefore may be on the decreasing part of the drag versus spanwise position curve. This theory is somewhat substantiated by data in Figure 13 which show that for the N1 nacelle moved closer to the fuselage by using the LA pylon in the LW position, the drag also decreases.

INCREMENTAL PYLON DRAG

Incremental pylon drag is presented in Figure 17. Not only is there a detrimental drag interference between nacelle and wing, but this same effect holds true for the pylon and wing.

STANDARD AERODYNAMIC COEFFICIENTS

Curves of C_L versus α, C_L versus C_D, and C_M versus α for some typical body/nacelle and body/wing/nacelle configurations, respectively, are presented in Figures 18 and 19. Of significance in Figure 18 is the longitudinal destabilizing effect of the wide nose body. This effect carries through even with the wings on, as shown in Figure 19; but nacelles mounted over and aft of the wing improve the stability, although they tend to make the pitching moment more negative. Also of significance in the figure is the penalty in lift incurred when the nacelles are mounted above or aft of the wing.

CONCLUSIONS

The following conclusions have been drawn from analysis of the data:

1. Nacelles in proximity to the wing and fuselage yield an incremental drag level three to four times the isolated nacelle drag, producing approximately 50 percent of the total aircraft drag.

2. Movement away from the fuselage/wing combination longitudinally or vertically tends to reduce interference drag, with movement aft of the wing yielding the greatest benefit.

3. The installation of nacelles results in drag rise Mach numbers as low as 0.5.

4. Pylons also produce a significant amount of interference drag.

5. In general, the installation of nacelles has an adverse effect on lift.

6. The wide nose body was longitudinally unstable. The addition of nacelles tended to reduce this instability while producing a more negative pitching moment.

7. There is some evidence from this evaluation indicating that nacelles very close to the fuselage (buried nacelles) tend to reduce interference drag. Further investigation of this area is warranted.

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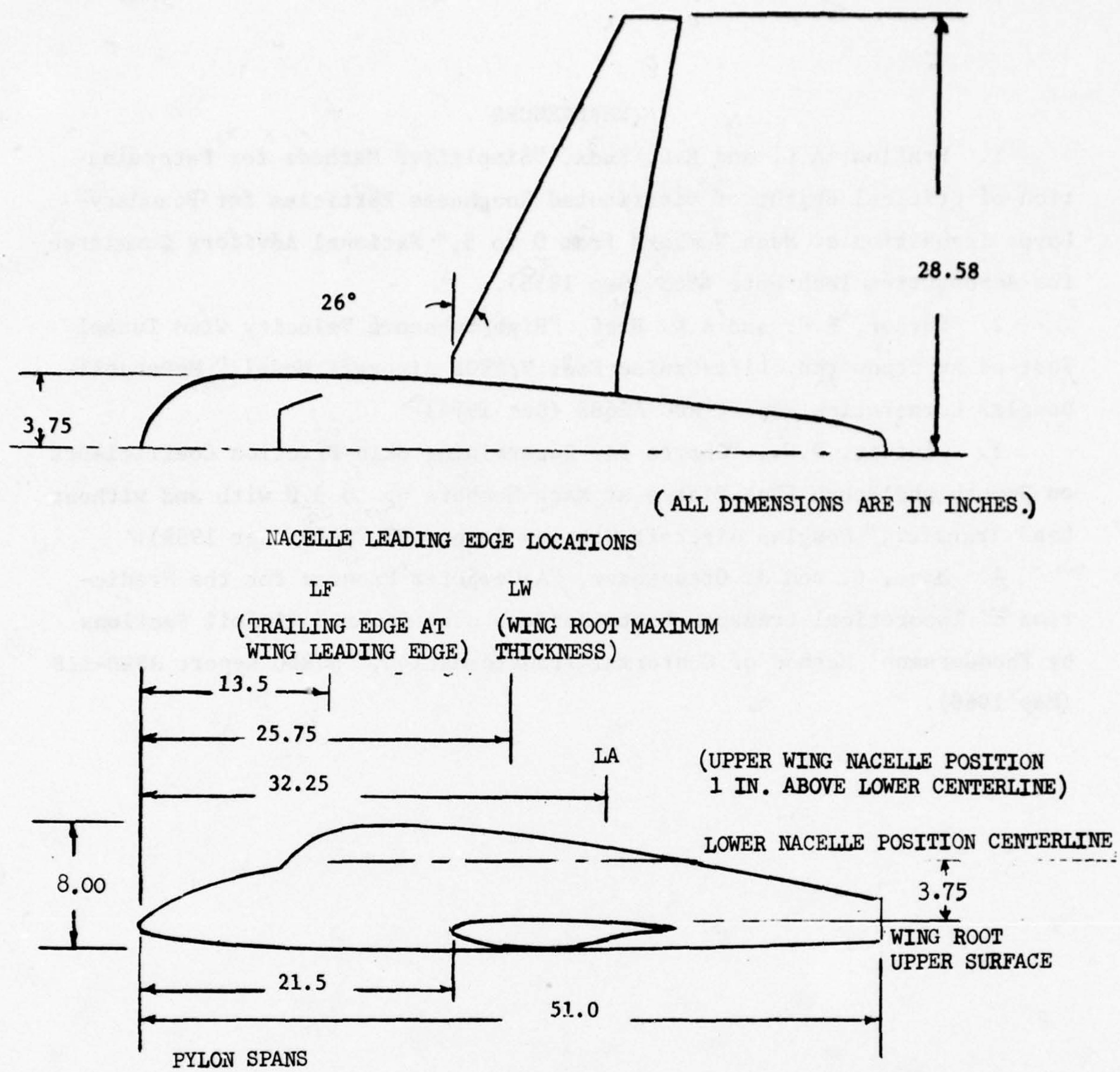
4. More, E. and J. Ottensoser, "A Computer Program for the Prediction of Theoretical Pressure Distributions over General Airfoil Sections by Theodorsens' Method of Conformal Transformation," NSRDC Report ASED-118 (May 1969).

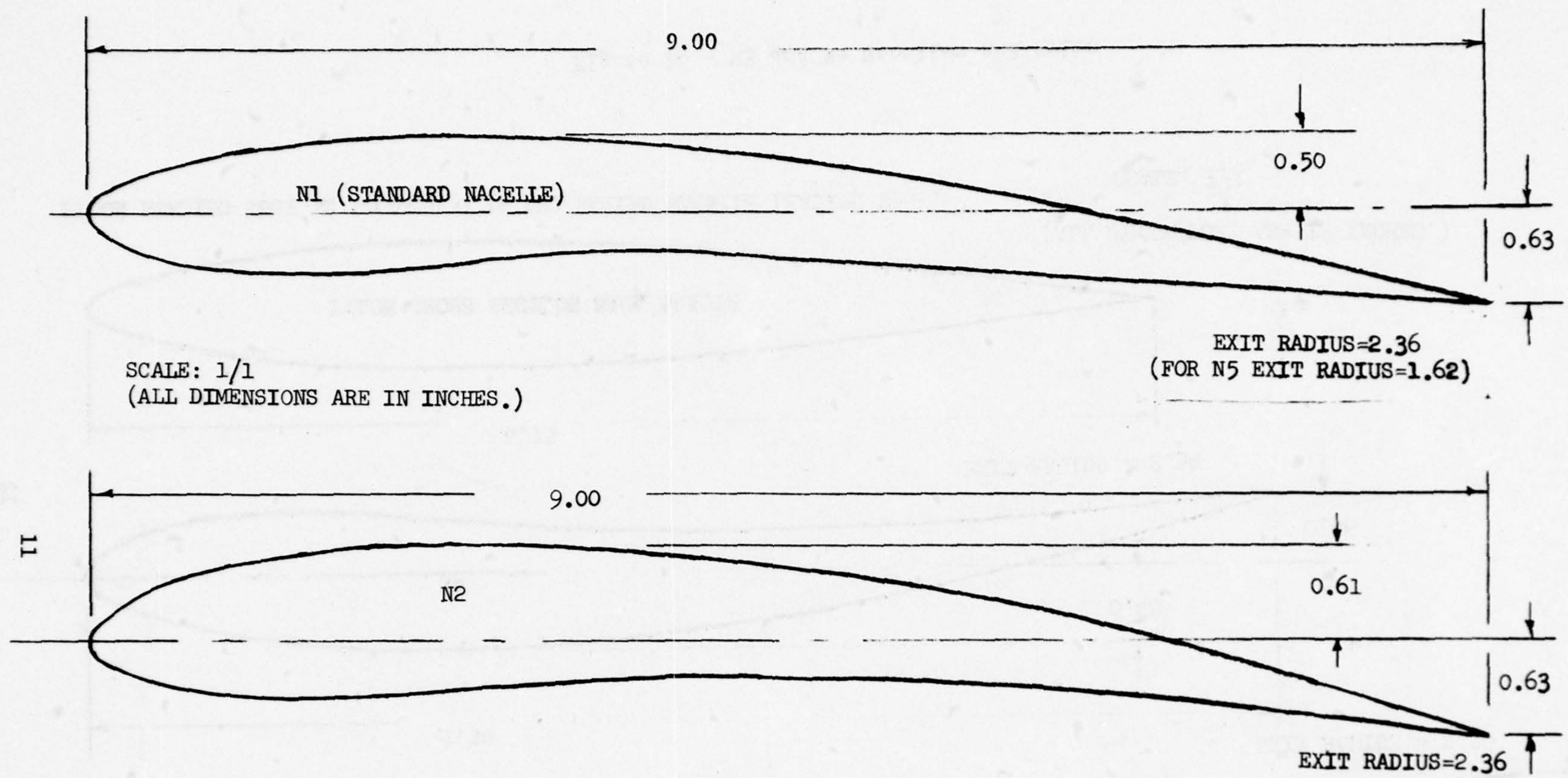


PYLON SPANS

	P1	P2	P3	P4
x	0.75	2.55	4.50	12.0

"x" IS THE SPANWISE DISTANCE MEASURED BETWEEN THE NACELLE LEADING EDGE AND THE LOCAL FUSELAGE CONTOUR AND IS HELD CONSTANT AT THE THREE LONGITUDINAL POSITIONS.

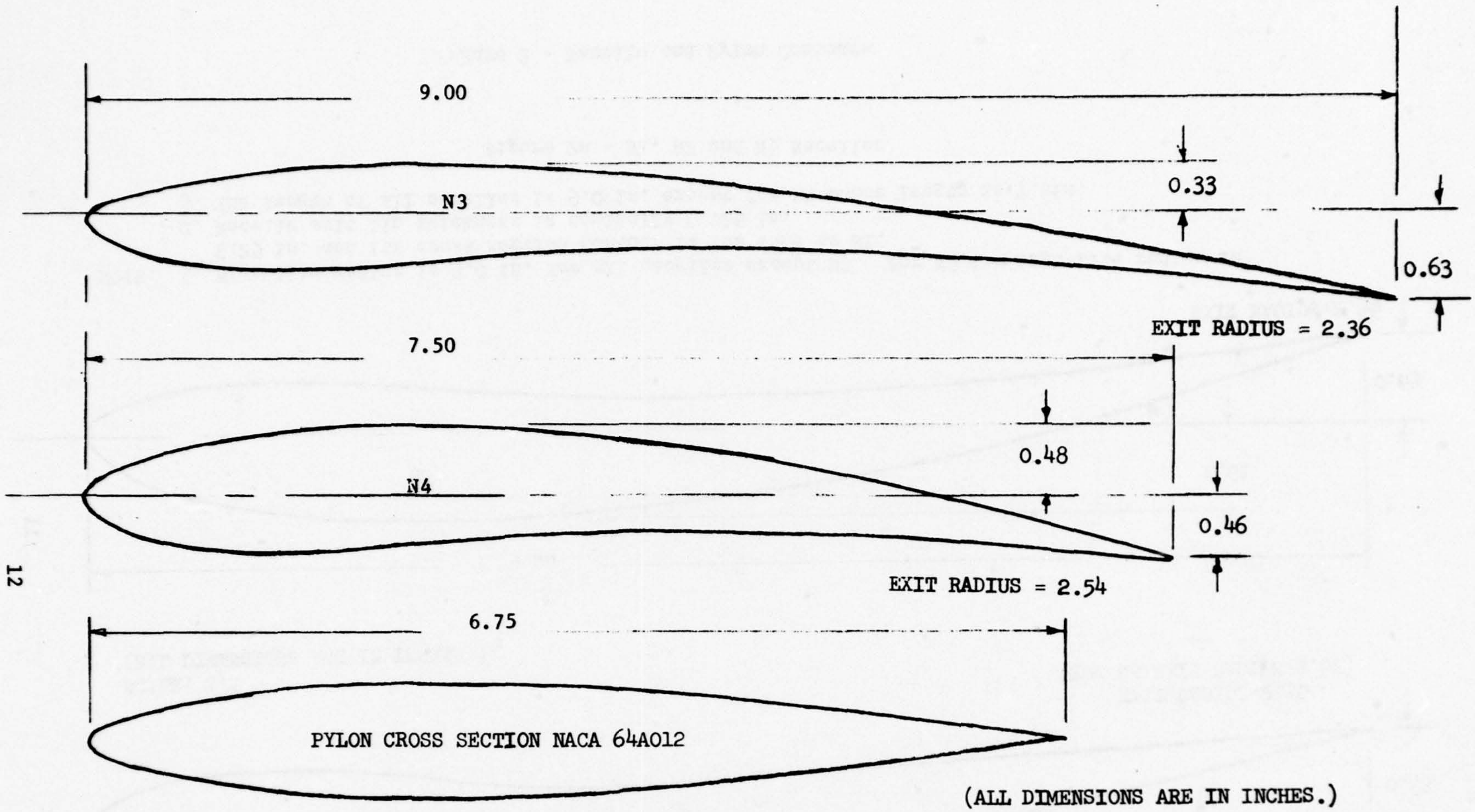
Figure 1 - Schematic of the Model



NOTE: 1. High-lite radius is 3.0 in. for all nacelles except N5. For N5 the high-lite radius is 2.25 in. and its cross section contour is the same as N1.
2. Nacelle exit lip thickness is nominally 0.025 in.
3. The length of all nacelles is 9.0 in. except for N4 whose length is 7.5in.

Figure 2a - N1, N2 and N5 Nacelles

Figure 2 - Nacelle and Pylon Contours



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PYLON LEADING EDGE IS LOCATED 0.75 IN. BEHIND NACELLE LEADING EDGE.

SCALE: 1/1

Figure 2b - N3 and N4 Nacelles and Pylon

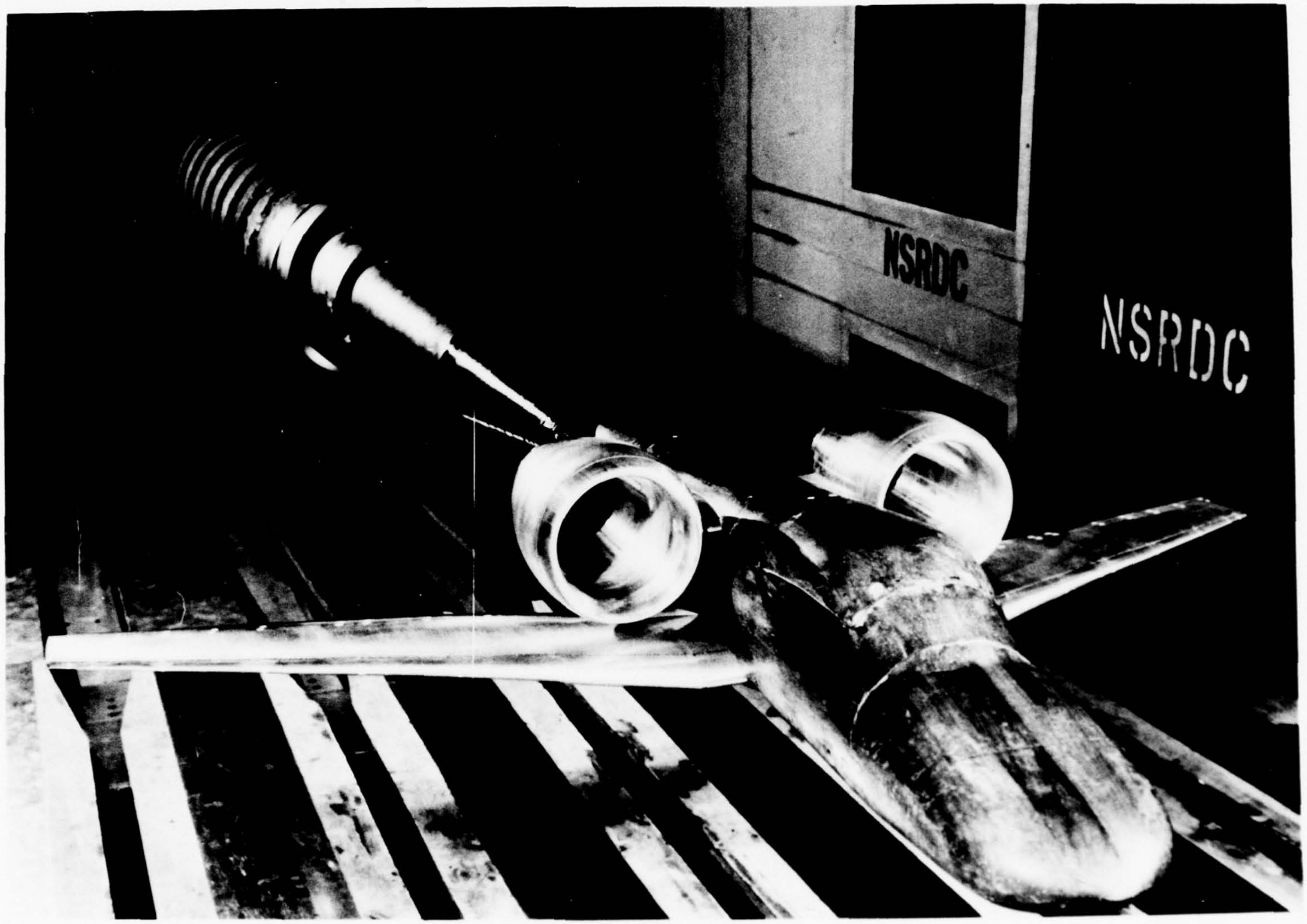


Figure 3 - Typical Configuration Installed in the 7- by 10- Foot Transonic Wind Tunnel

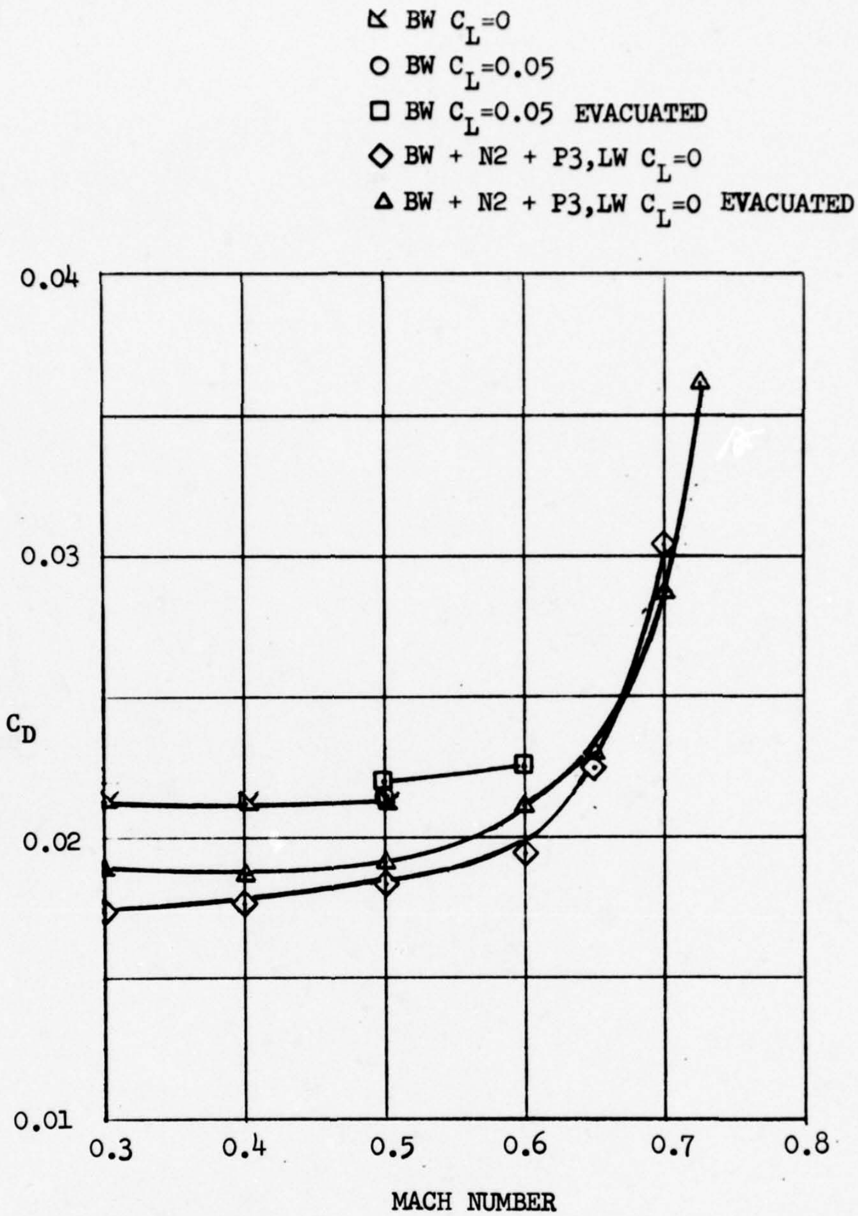


Figure 4 - Reynolds Number Effect

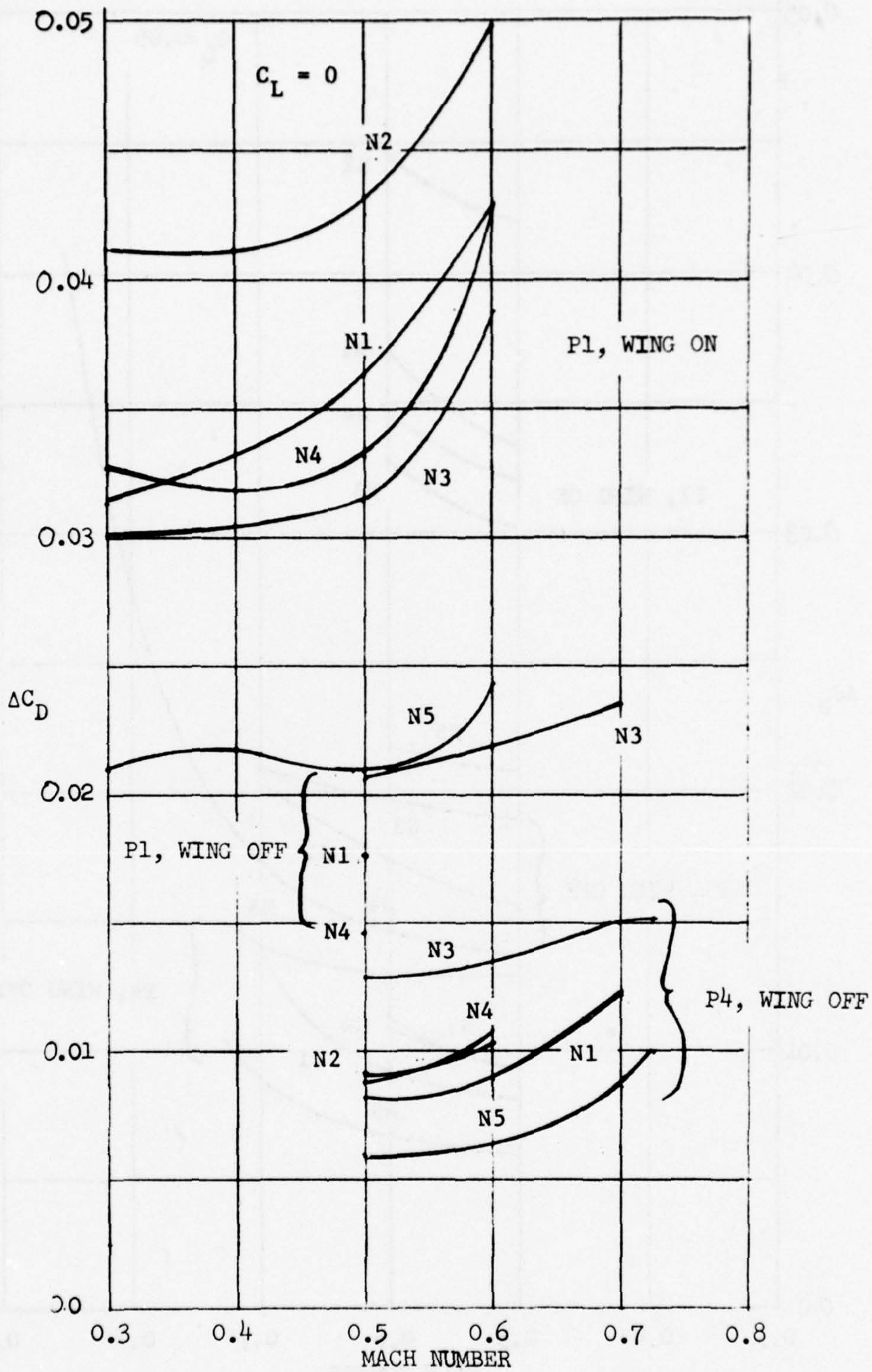


Figure 5a - C_L=0

Figure 5 - Incremental Nacelle Drag

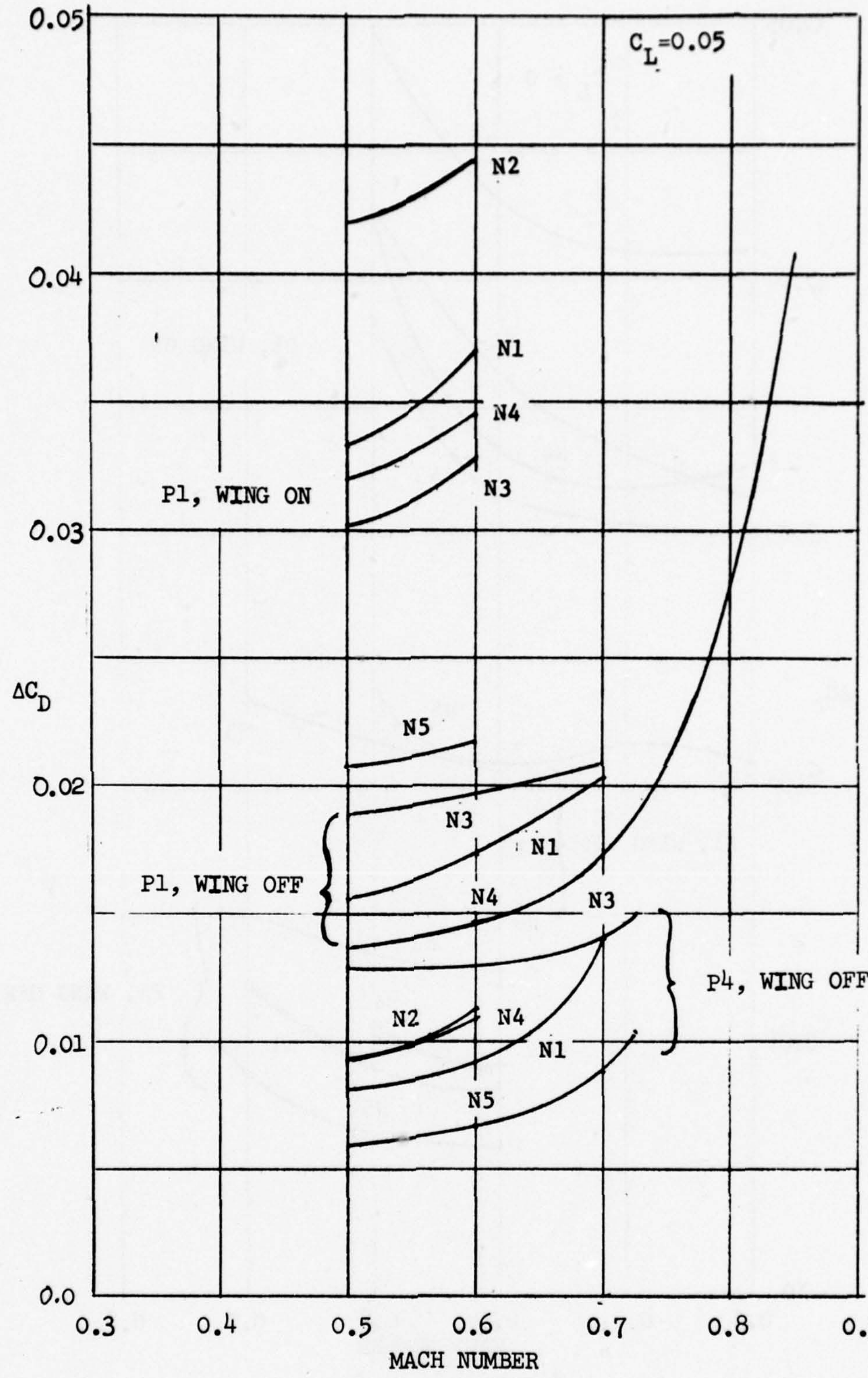


Figure 5b - C_L=0.05

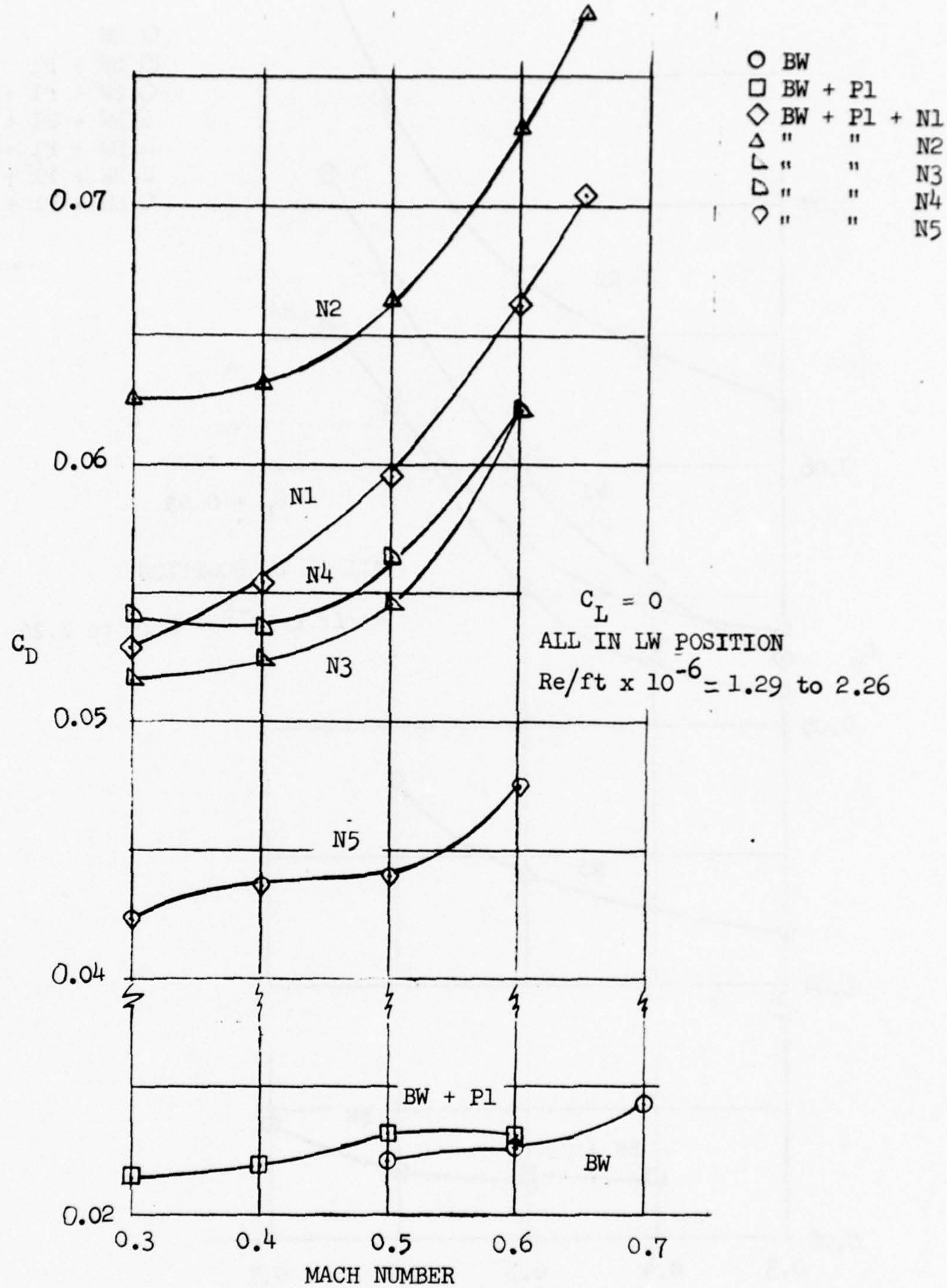


Figure 6a - $C_L = 0$

Figure 6 - Comparison of Nacelle Drag on Shortest Pylon with Wing On

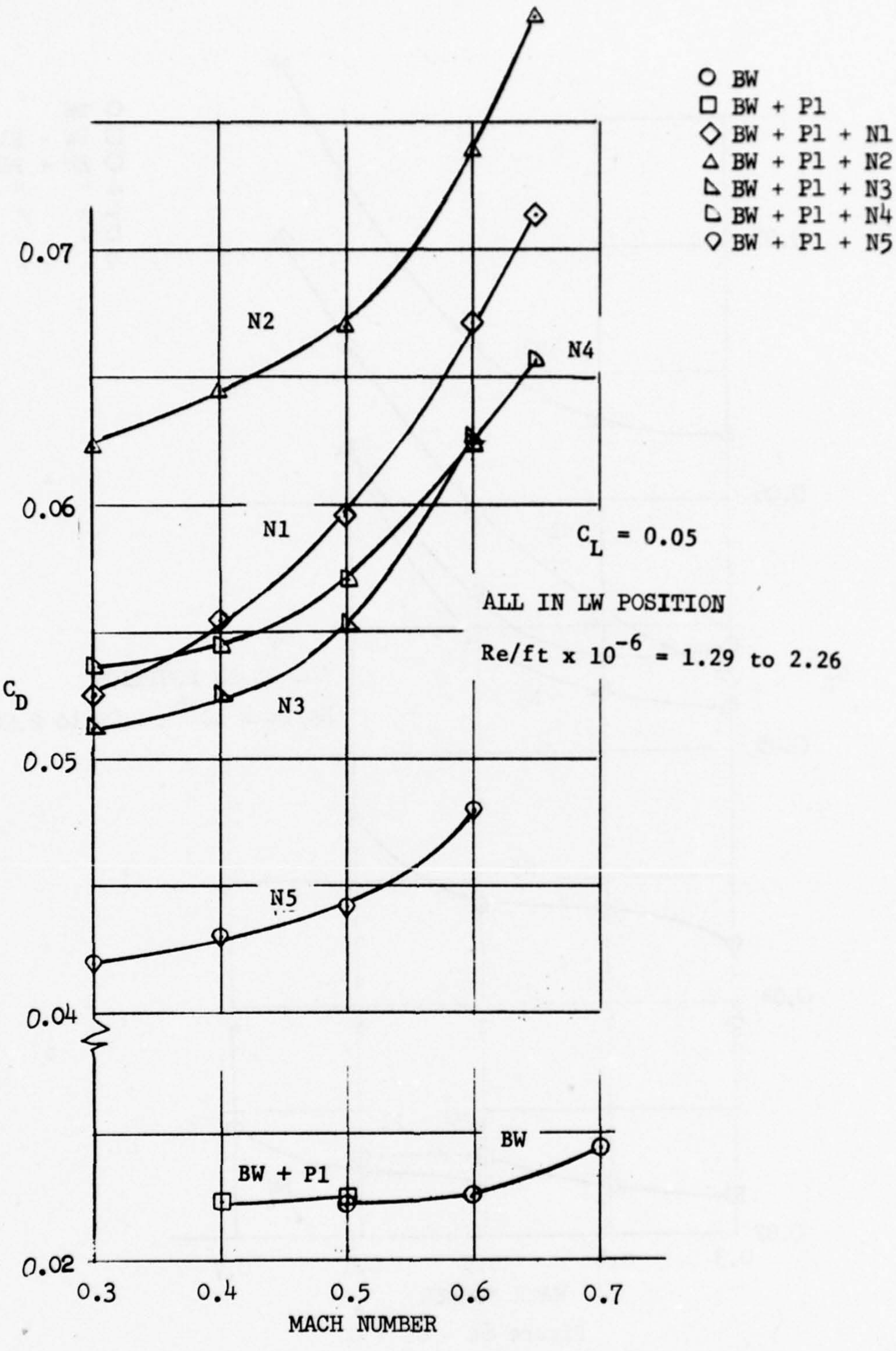


Figure 6b - C_L = 0.05

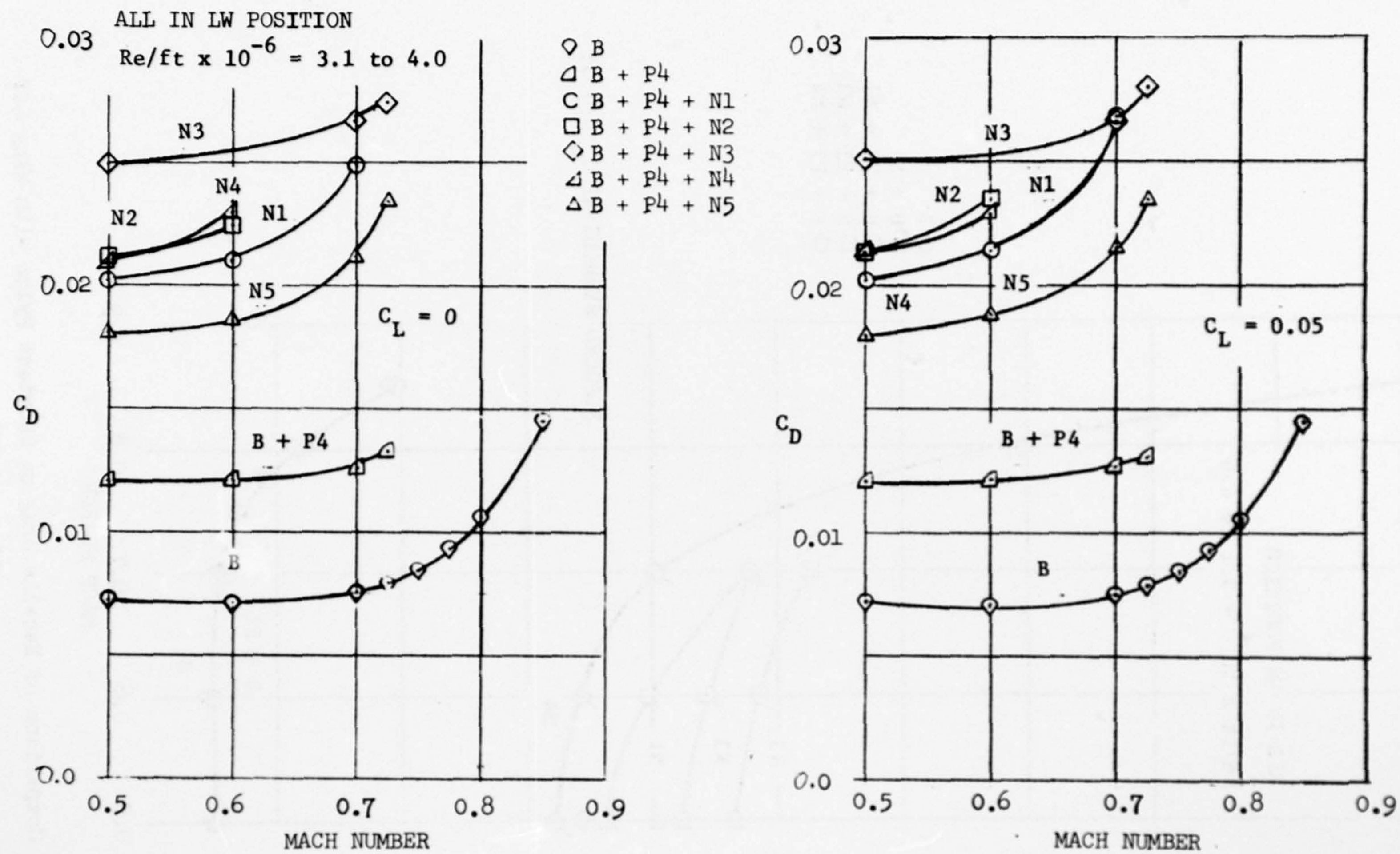


Figure 7 - Comparison of Nacelle Drag on Longest Pylon with Wing Off

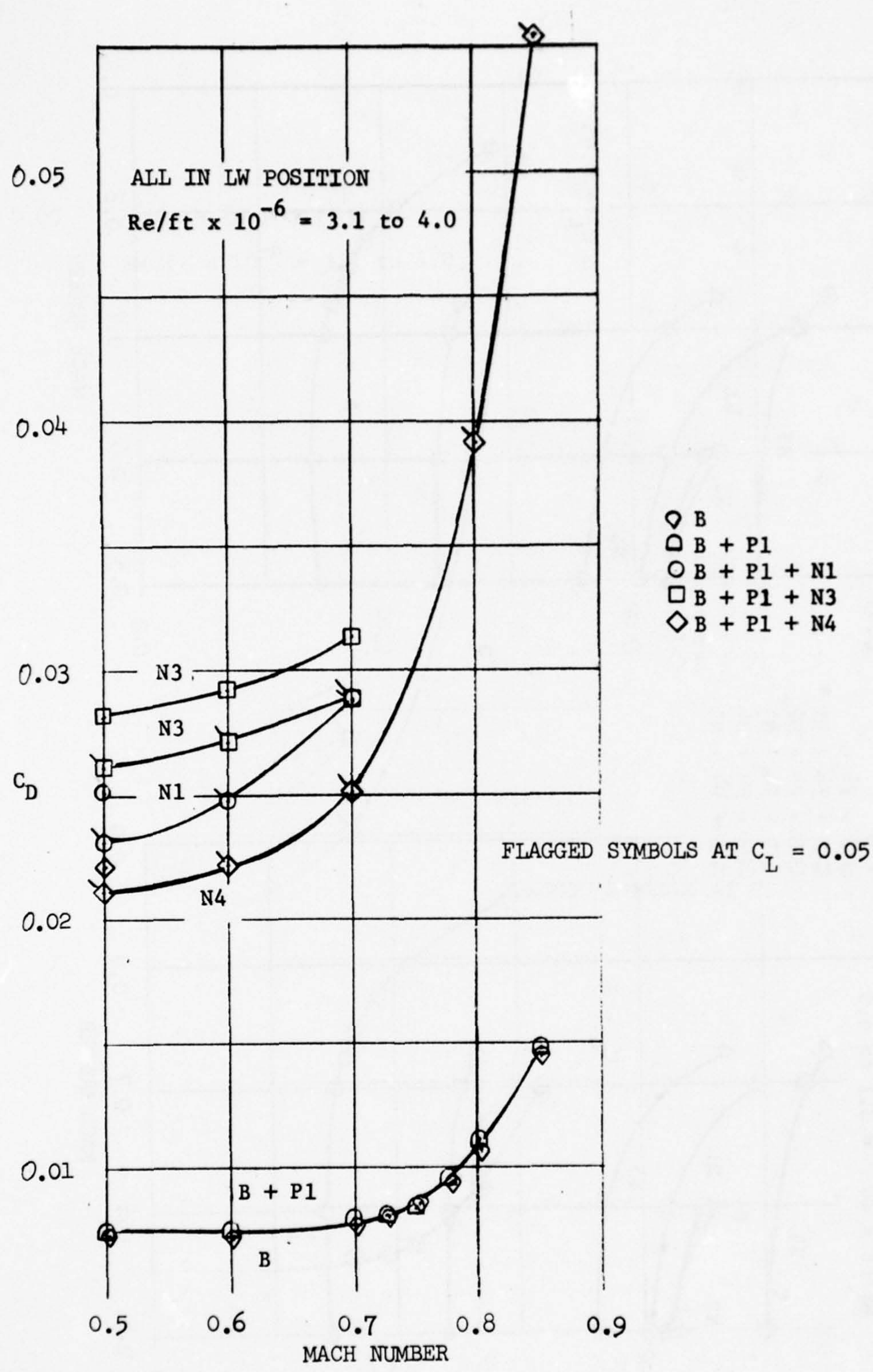


Figure 8 - Comparison of Nacelle Drag on Shortest Pylon with Wing Off

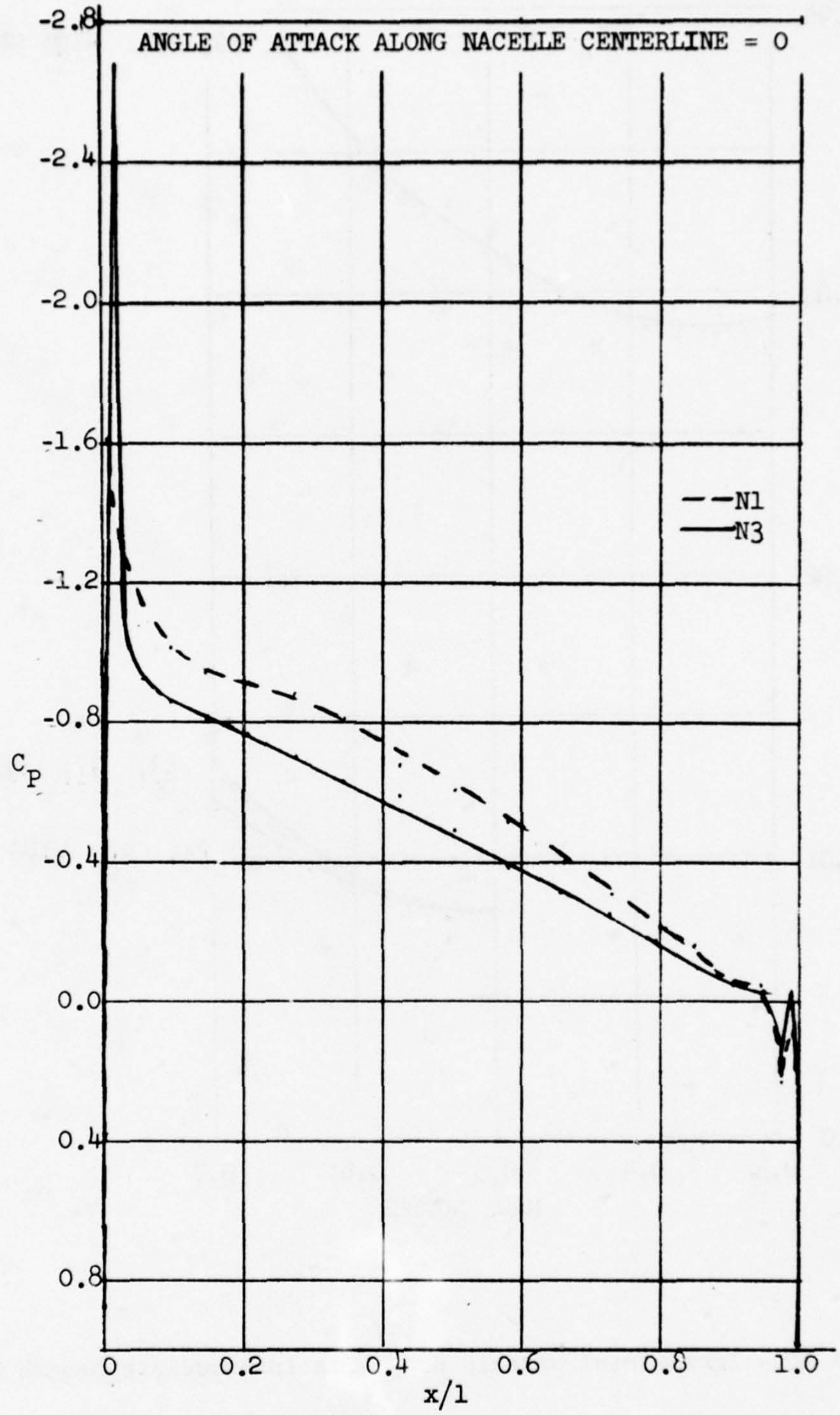


Figure 9 - Theoretical Nacelle Outer Surface Pressure Coefficent Distribution

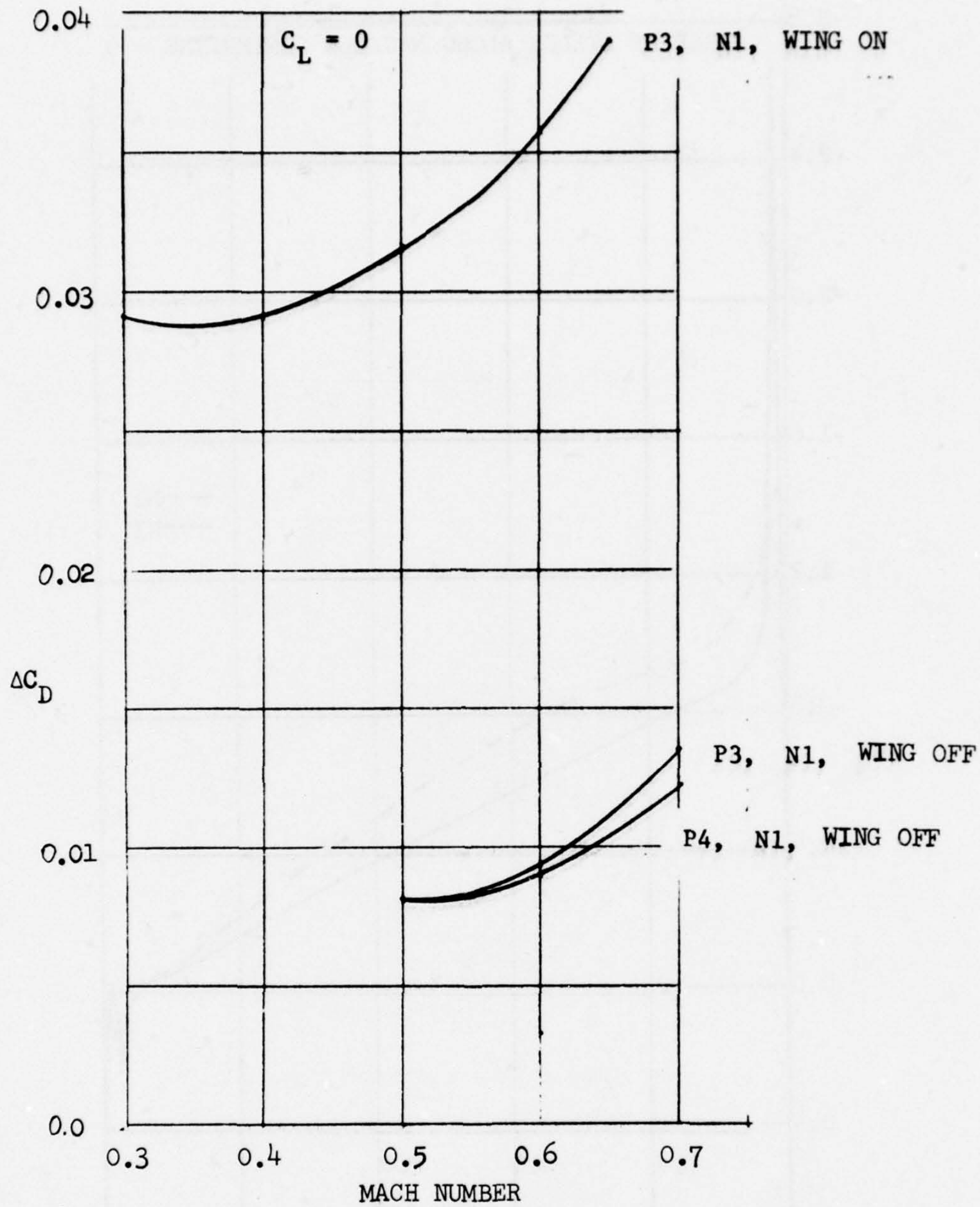


Figure 10 - Incremental Nacelle Drag with Intermediate Length Pylon

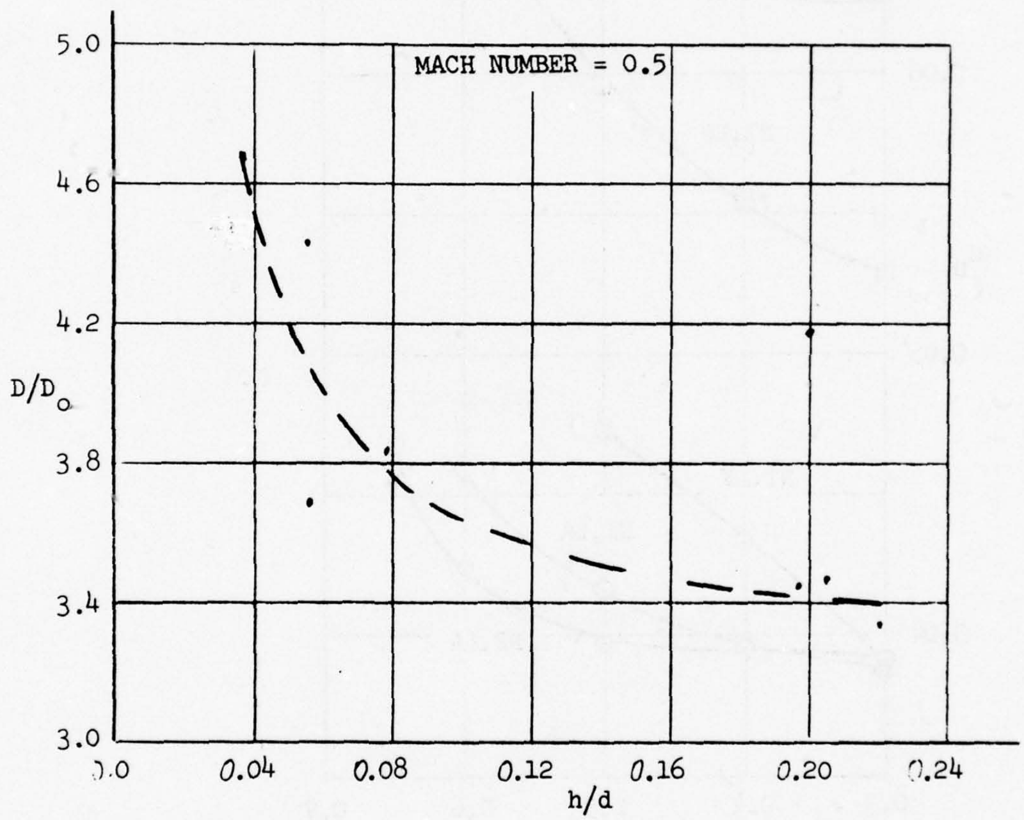


Figure 11 - Drag Ratio versus Nondimensional Minimum Nacelle Height above Wing

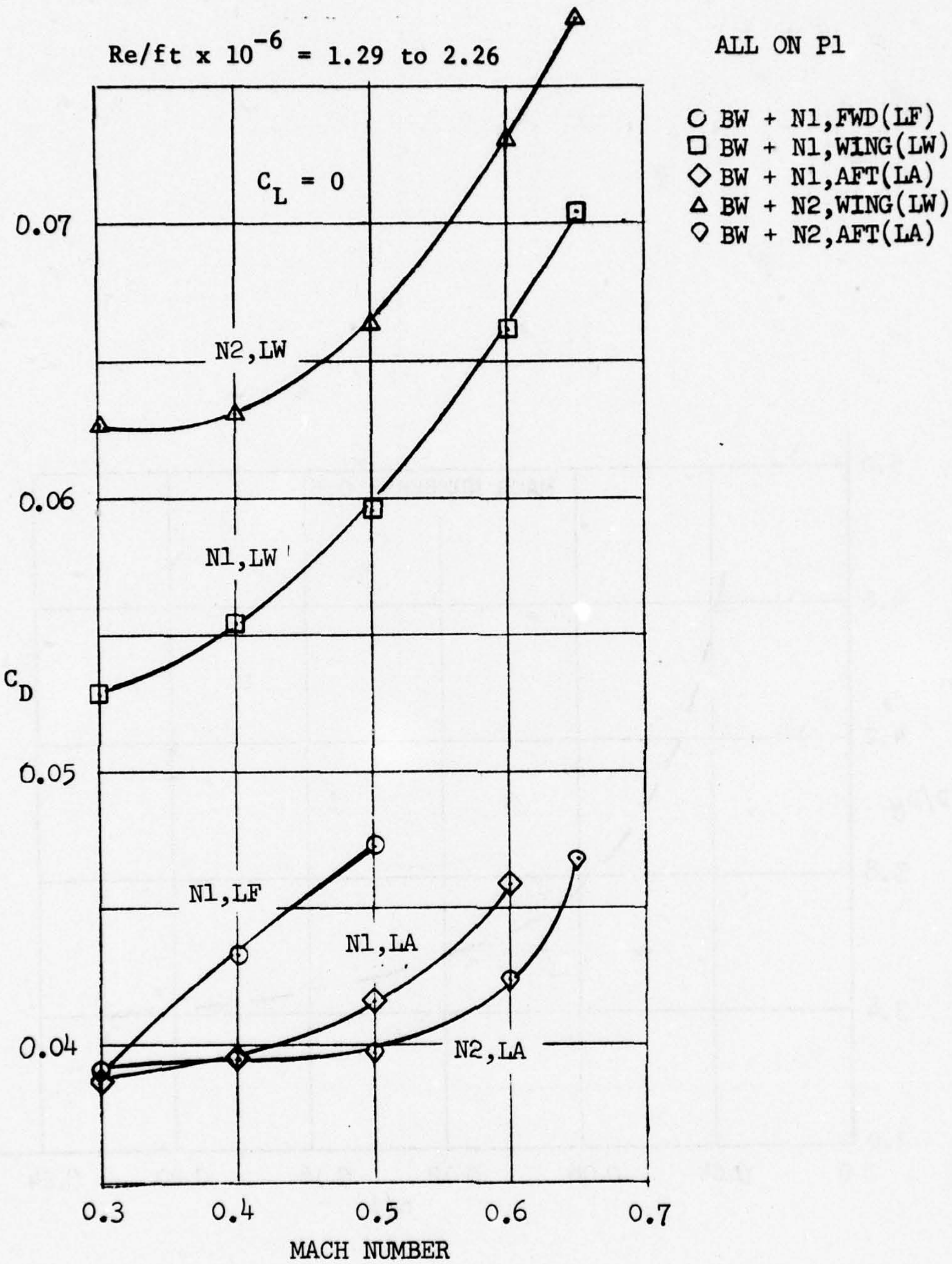


Figure 12a - C_L = 0

Figure 12 - Effect of Longitudinal Nacelle Movement on Drag with Wing On

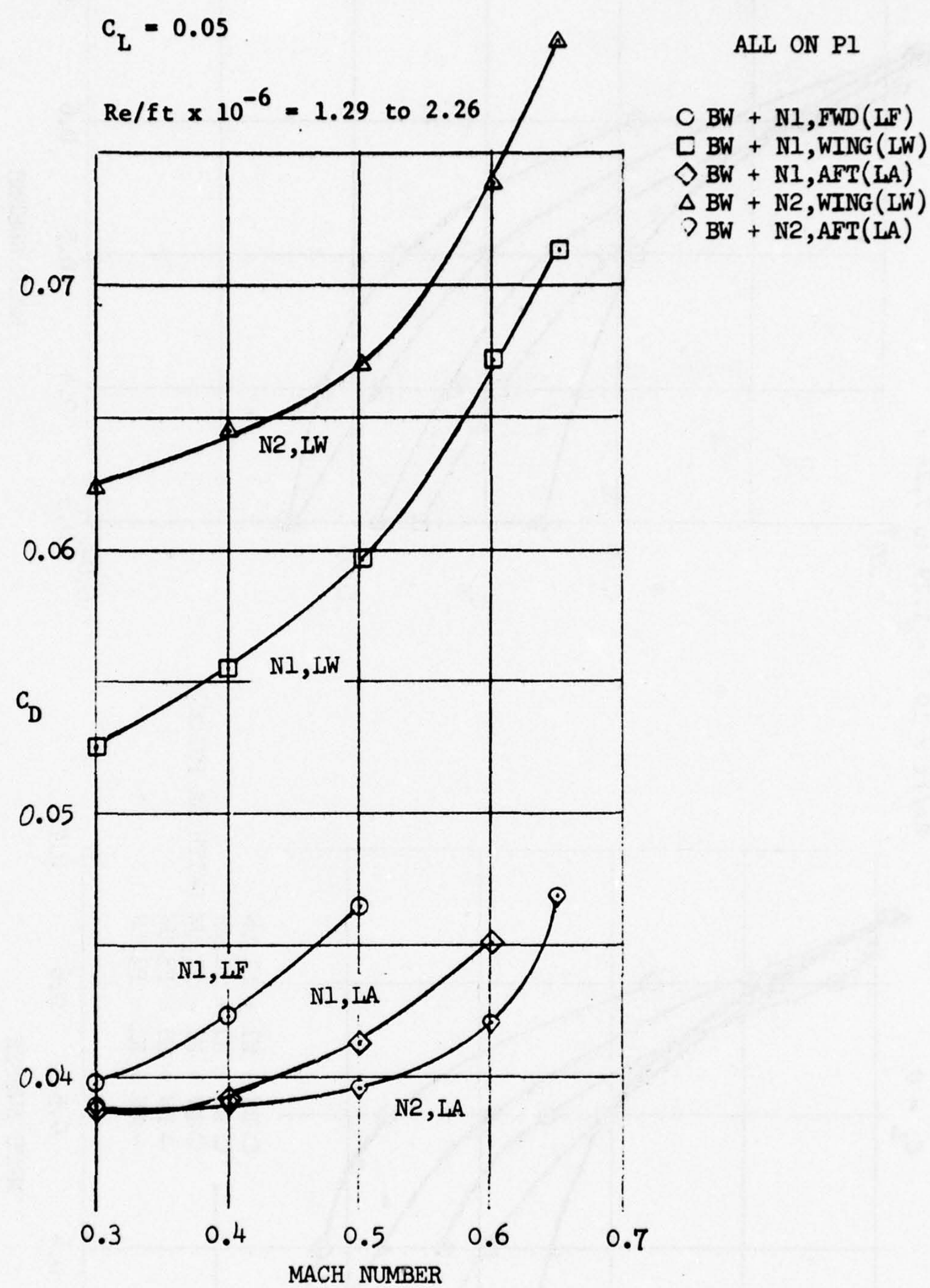


Figure 12b - C_L = 0.05

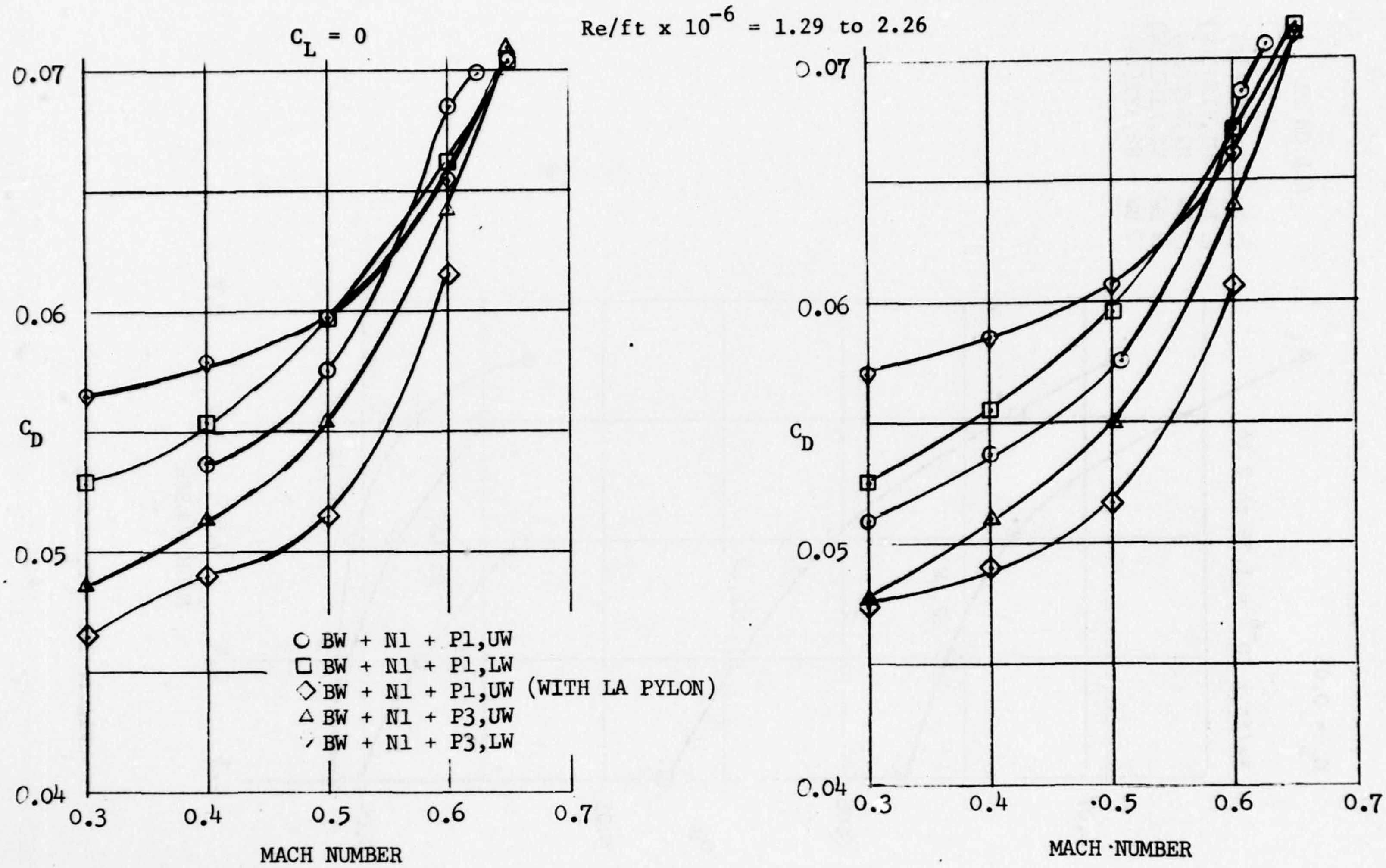


Figure 13 - Effect of Vertical Nacelle Movement on Drag with Wing On

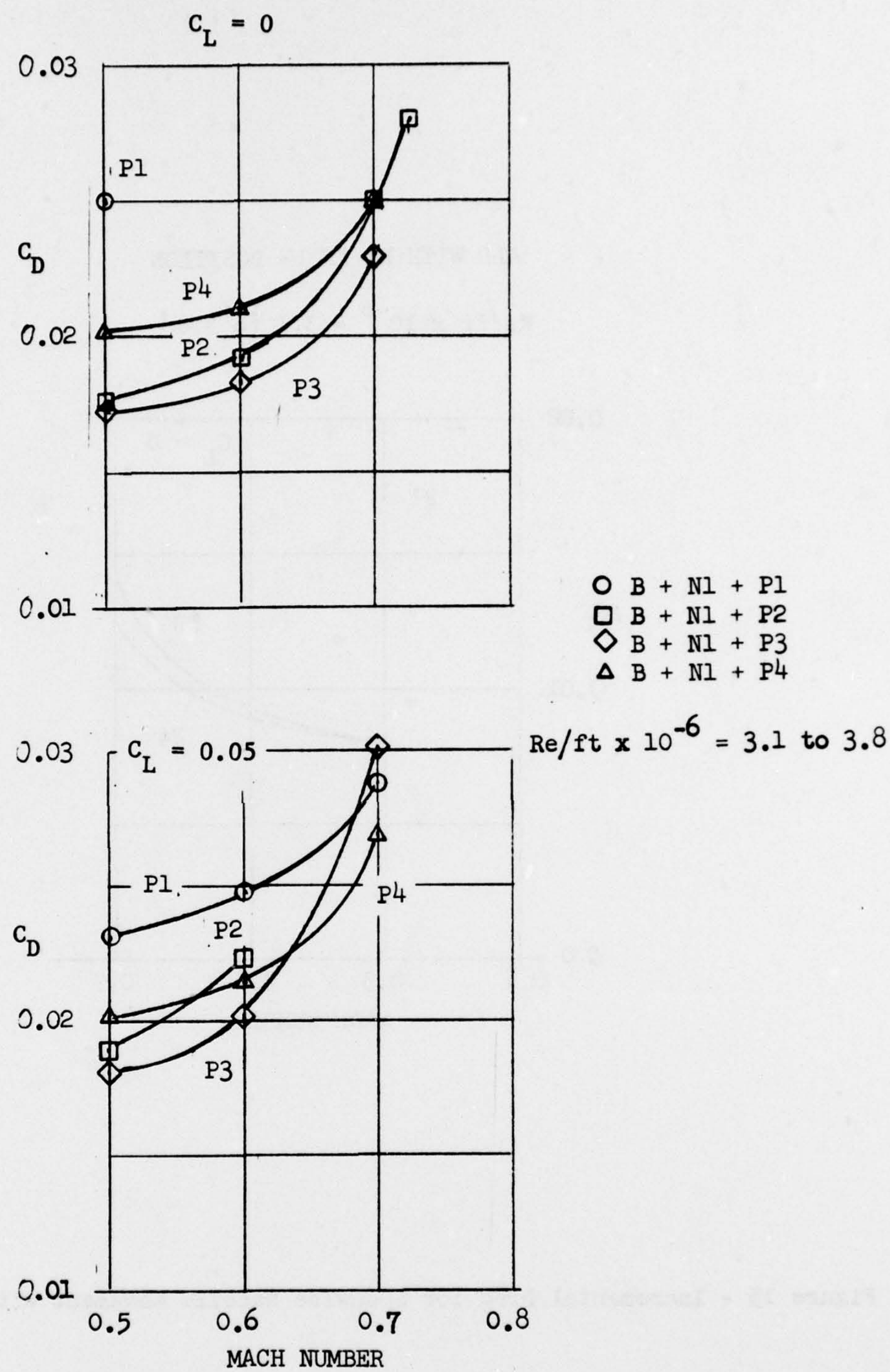


Figure 14 - Effect of Spanwise Nacelle Movement on Drag with Wing Off

ALL WITH N1 IN LW POSITION

Re/ft x 10^{-6} = 3.1 to 3.8

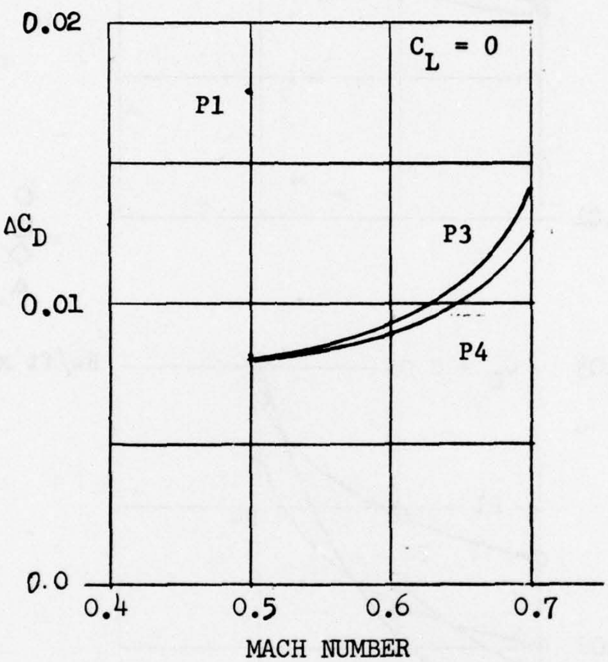


Figure 15 - Incremental Drag for Spanwise Nacelle Movement with Wing Off

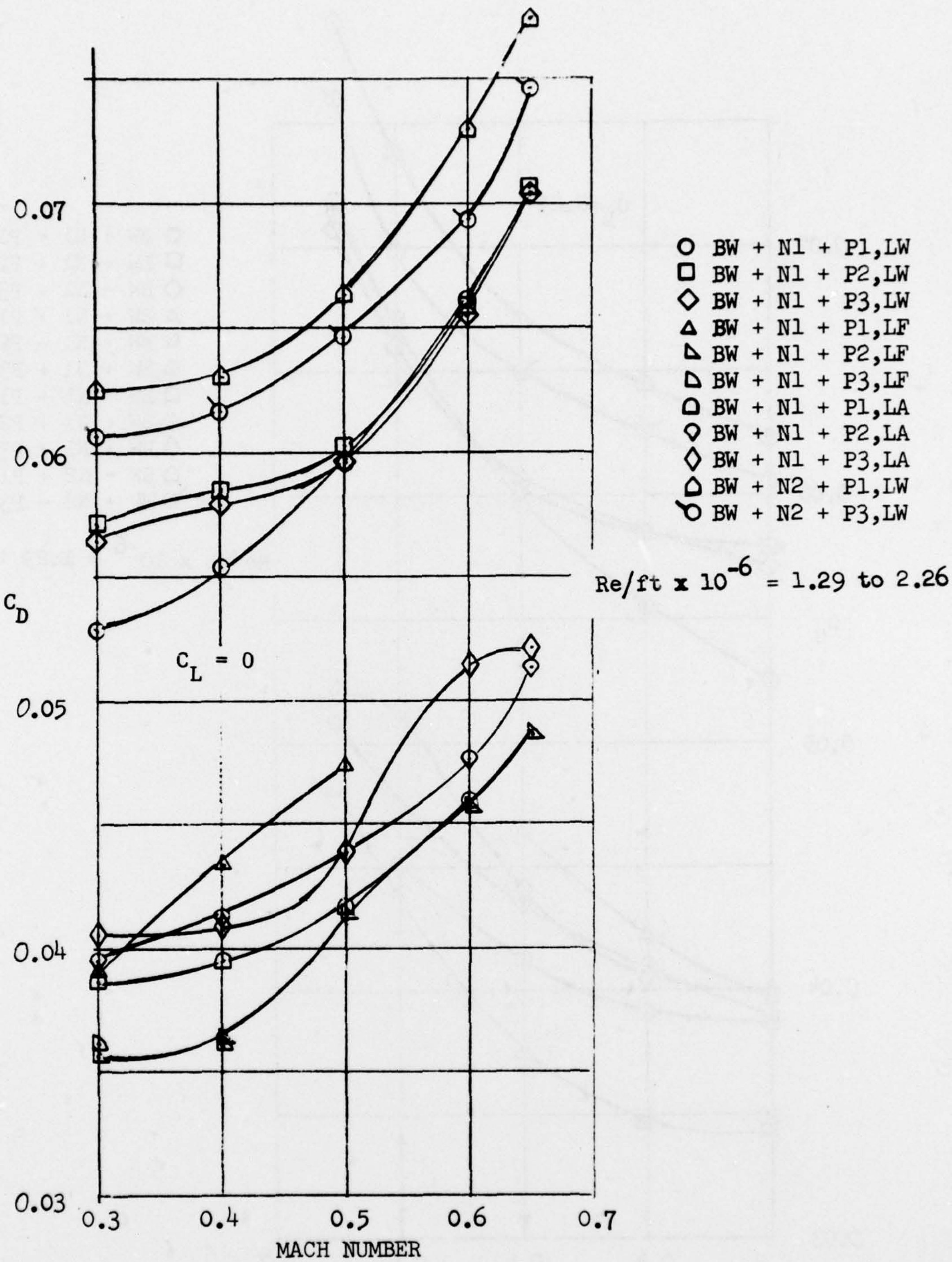


Figure 16a - $C_L = 0$

Figure 16 - Effect of Spanwise Nacelle Movement on Drag with Wing On

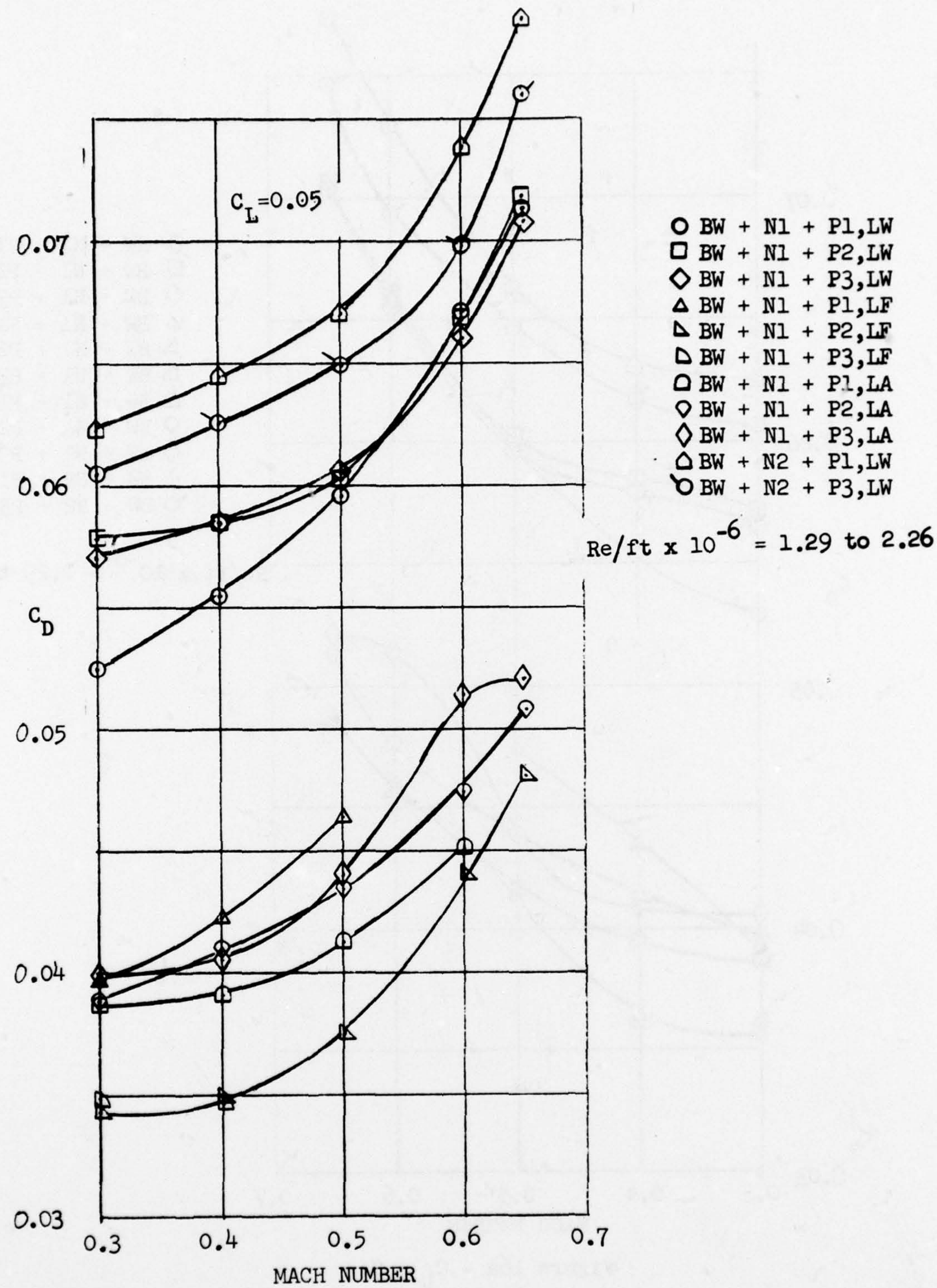


Figure 16b - C_L = 0.05

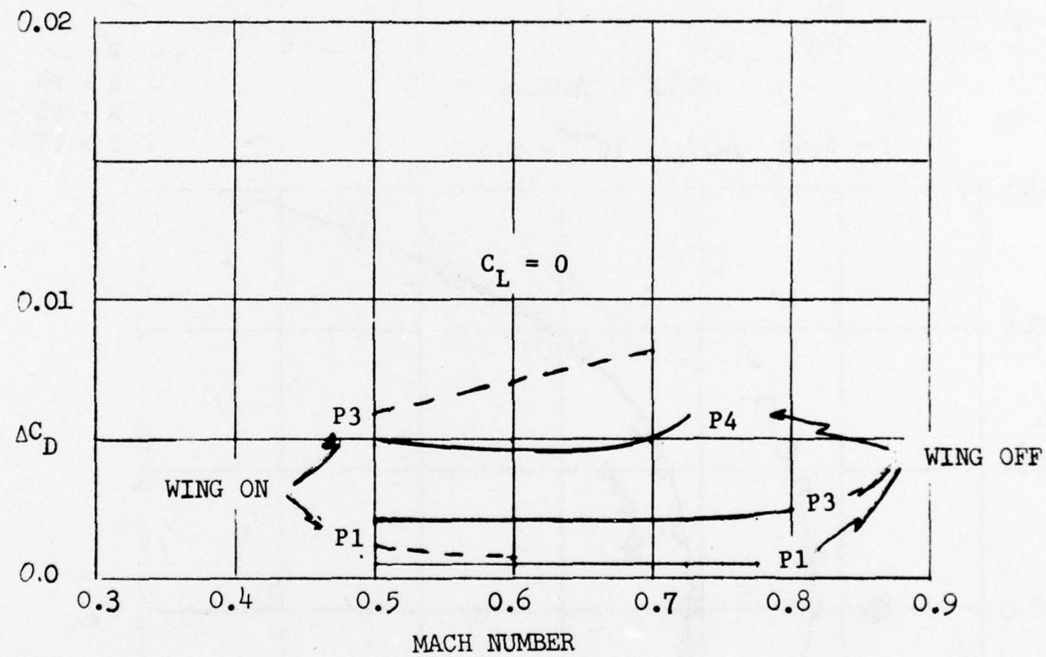
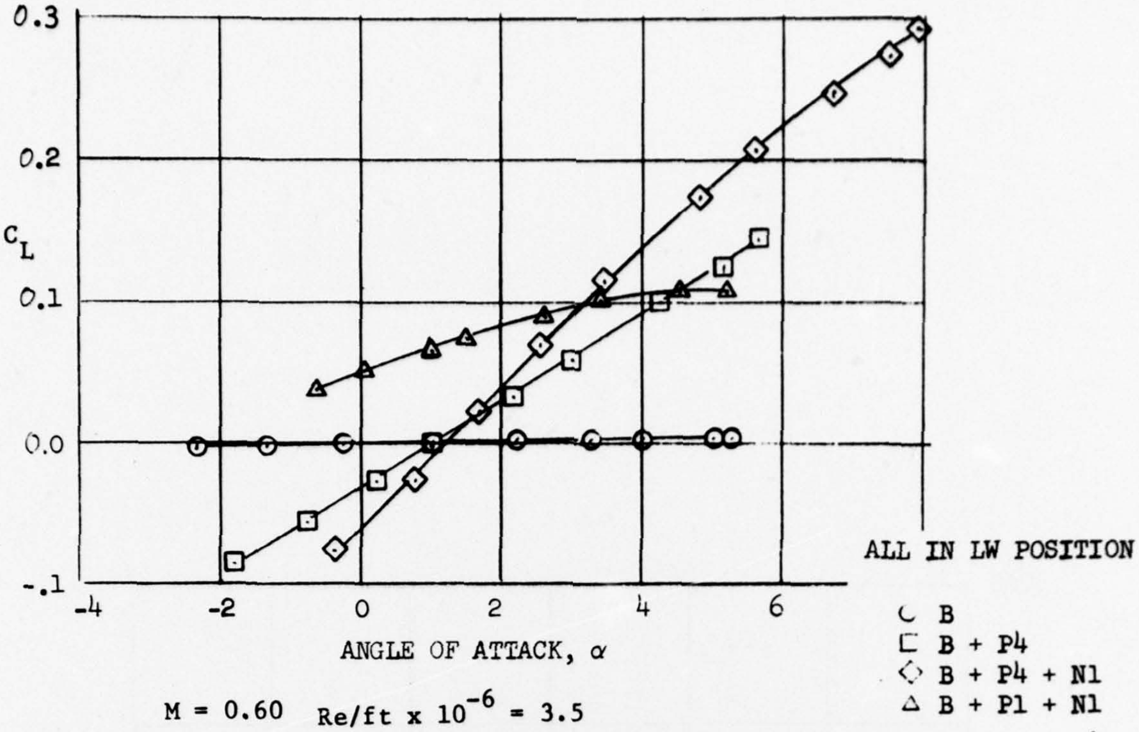


Figure 17 - Incremental Pylon Drag



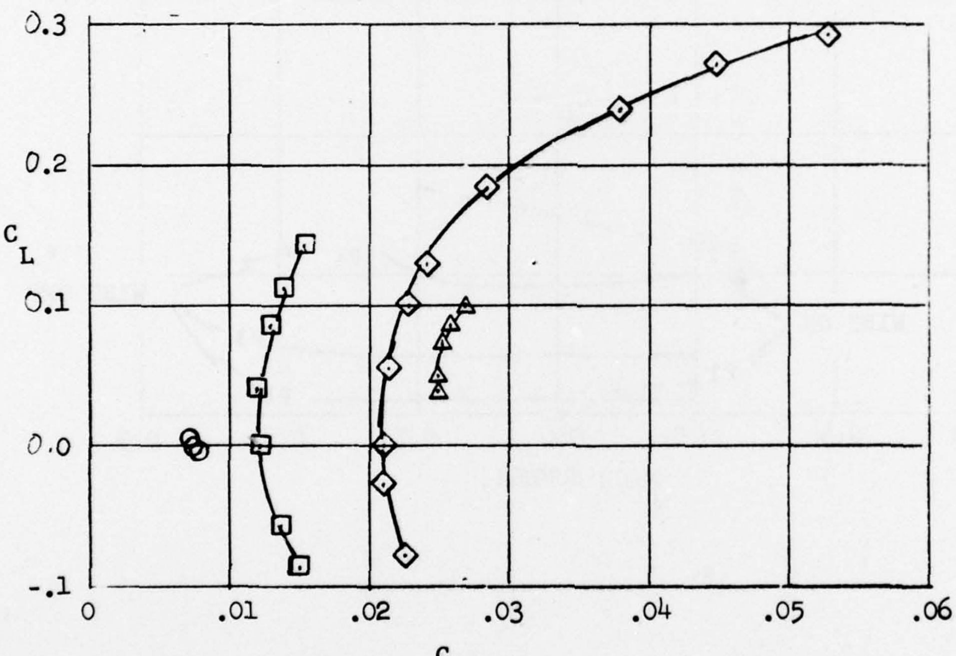


Figure 18a - C_L versus α and C_L versus C_D

Figure 18 - Basic Aerodynamic Coefficents at a Mach Number of 0.6 with Wing Off

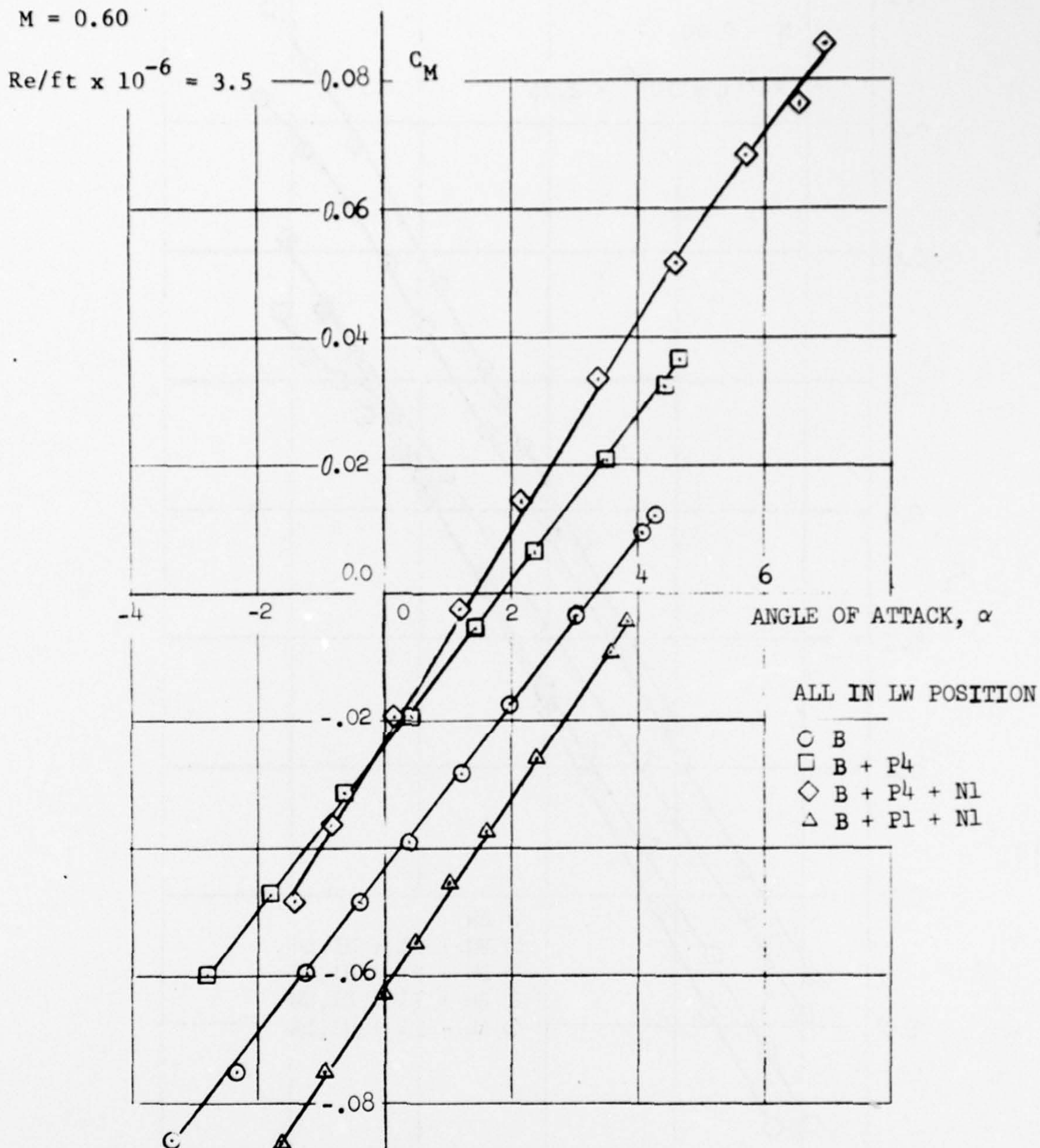


Figure 18b - C_M versus α

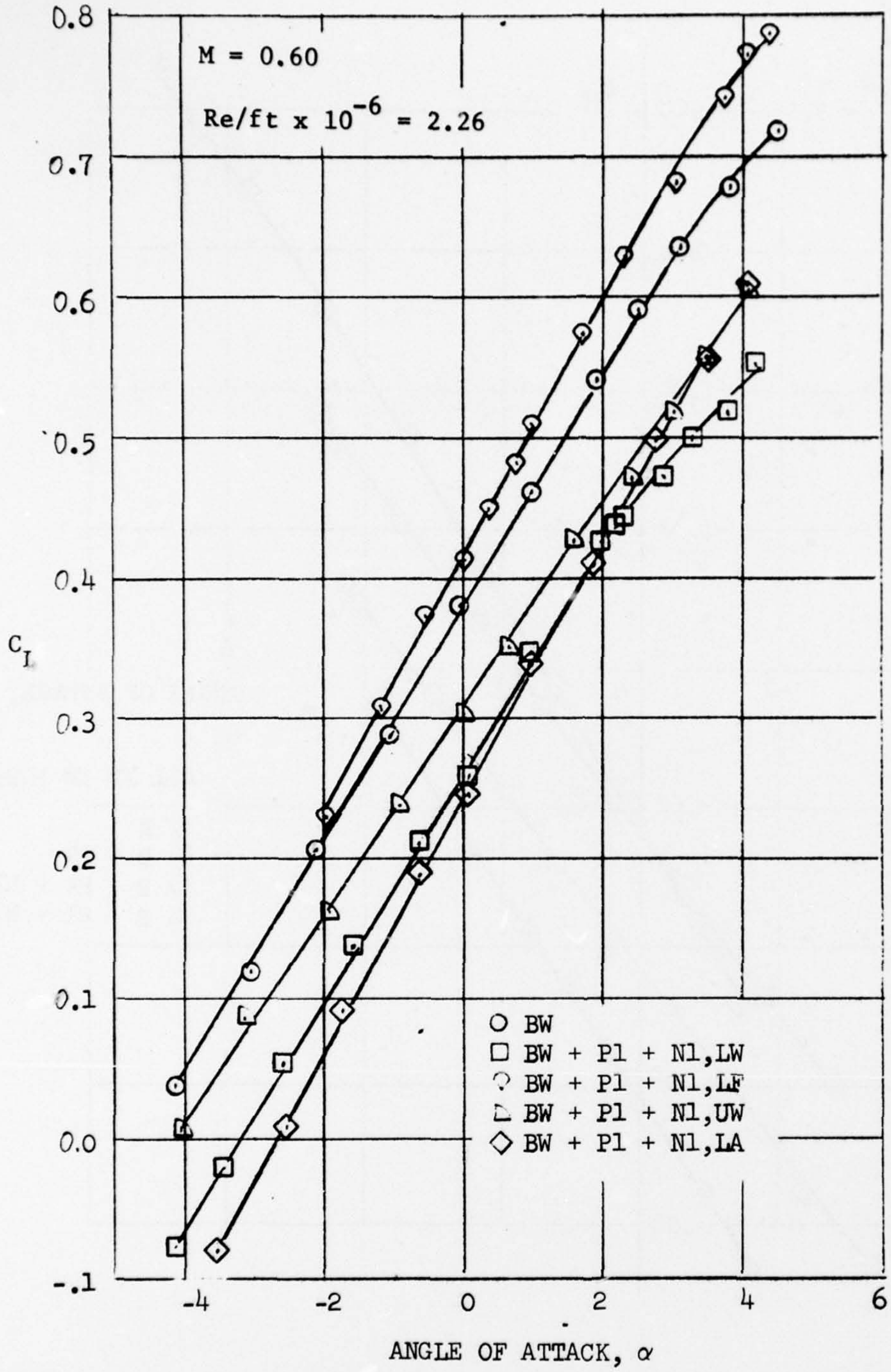


Figure 19a - C_L versus α

Figure 19 - Basic Aerodynamic Coefficents at a Mach Number of 0.6 with Wing On

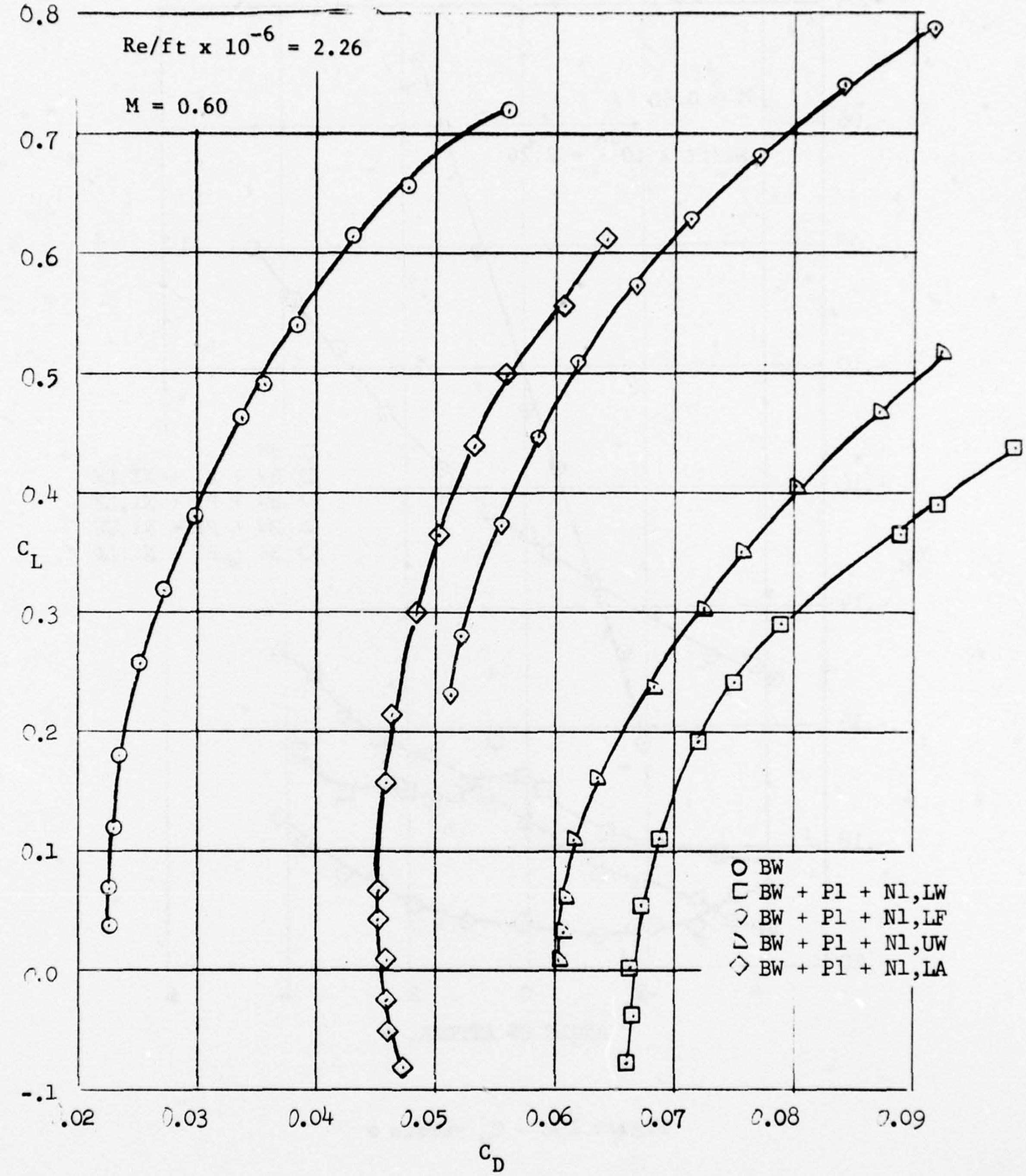


Figure 19b - C_L versus C_D

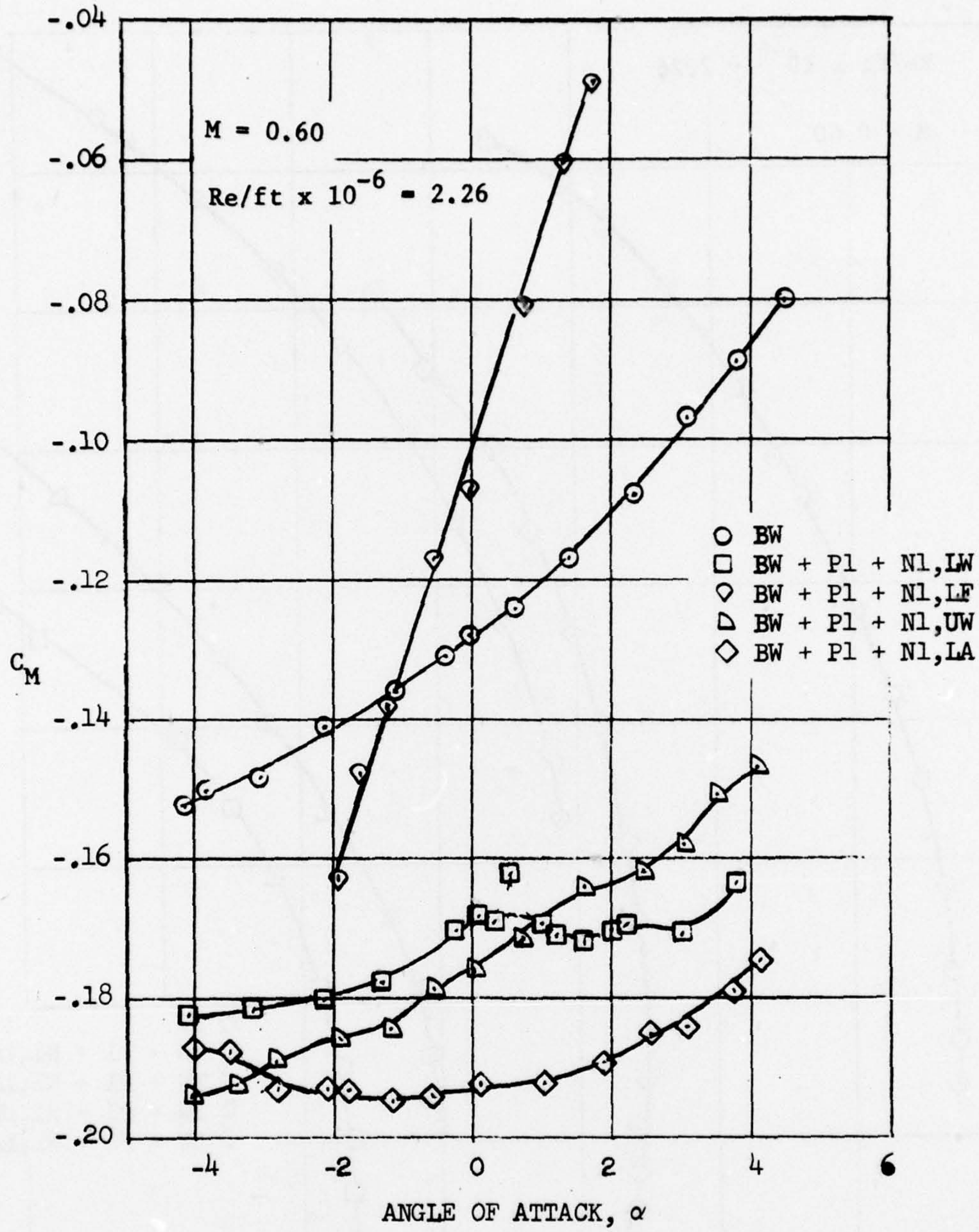


Figure 19c - C_M versus α

APPENDIX A

TYPE A V/STOL NACELLE DRAG TUNNEL

RUN LOG

CONF NO.	WING On/Off	PYLON POS.	PYLON SPAN	NACELLE #	CALIBRUN Tot	Stat	.3	.4	.5	.6	.65	.7	.725	.75	.775	.8	.825	.85	COMMENTS
1	Off	L W	4	1	-	-			2	3		4		NACELLE SHAKE					See Note 1
2	"	L W	4	2	-	-			6	7	NACELLE SHAKE								
3	"	L W	4	3	-	-			9/11	10		12	13	NACELLE SHAKE					
4	"	L W	4	5	-	-			15	16		17	18						
5	"	L W	4	4	-	-			20	21									
6	"	L W	4	0	-	-			23	24		25	26						
7	"	BODY ALONE			-	-			28	29		35	34	33	32	31		30	
8	"	L W	1	0	-	-			37	38		44	43	42	41	40		39	
9	"	L W	1	3	-	-			46	47		52	51	50	49	48			
10	"	L W	1	4	-	-			54	55		61	60	59	58	57		56	
11	"	L W	1	1	-	-			63	64		65	66	67	68	69			
12	"	L W	2	1	-	-			71	72		73	74	75	76	77	78		
13	"	U W	1	1	-	-			80	81		82	83	84	85	86	87		
14	"	U W	1	1	-	-			89	90		91	92	93	94	95	96		See Note 3
15	"	L A	1	1	-	-			98	99		100	101	102	103	104	105		
16	"	L F	1	1	-	-			107	108		- MODEL SHAKE							
17	ON	BODY WING			-	-			110	BALANCE OVERLOAD NF									See Note 2
18	OFF	L W	3	1	-	-			113	114		115	116	117	118	119			
18	OFF	L W	3	1	1	-			121	122		123	124	125	126	127	128		
18	OFF	L W	1	4	-	2			129	130		131	132	133	134	135	136		
19	OFF	L W	1	4	-	3			139	140		141	142	143	144	145	146		
19	"	L W	1	4	4	-			147	148		149	150	151 155	152	153	154		Rerun of 151
20	"	L W	1	5	5	-			157	158		159	160	161	162	163	164		

CONF NO.	WING On/Off OFF	PYLON POS.	PYLON SPAN	NACELLE #	CALIBRUN Tot	CALIBRUN Stat	.3	.4	.5	.6	.65	.7	.725	.75	.775	.8	.825	.85	COMMENTS
20	OFF	L W	1	5	-	6			165	166		167	168	169	170	171	172		
21	OFF	BODY ALONE		-	-	-			174	175		176	177	178	179	180	181		
22	"	L W	1	1	-	-			184	185		186	187	188	189	190	191		
23	"	L W	3	0	-	-			193	194		195	196	197	198	199	200		
24	ON	BODY WING		-	-	-			202	203									See Note 2
24	"	L W			-	-			211	210		209	208	207	206	205	204		
25	"	L W	1	1	-	-			217	216	214	215	213						Run 213 M=.67
26	"	U W	1	1	-	-	224	223	222	221	219	220							Run 220 M=.625
27	"	L W	1	-	-	-	235	234	233	232		231	230	229	228	227	226		
28	"	L A	1	1	-	-	241	240	239	238	237								
29	"	U W	1	1	-	-	247	246	245	244	243								See Note 3
30	"	L W	1	2	-	-	253	252	251	250	249								
31	"	L W	1	3	-	-	259	258	257	256	255								
32	"	L F	1	1	-	-	265	264	263	262	261								
24	"	BODY WING		-	-	-	266	267	268										See Note 2
33	"	L F	2	1	-	-	274	273	272	271	270								
34	"	L F	3	1	-	-	280	279	278	277	276								
35	"	L W	1	4	-	-	286	285	284	283	282								
36	"	L A	3	1	-	-	292	291	290	289	288								
37	"	L W	1	5	-	-	298	297	296	295	294								
38	"	L A	2	1	-	-	304	303	302	301	300								
39	"	L W	3	2	-	-	310	309	308	307	306								
40	"	L W	3	1	-	-	316	315	314	313	312								
41	"	U W	3	1	-	-	322	321	320	319	318								

CONF NO.	WING On/Off	PYLON POS.	PYLON SPAN	NACELLE #	CALIBRUN Tot	Stat	.3	.4	.5	.6	.65	.7	.725	.75	.77.	.8	.825	.85	COMMENTS
42	ON	L W	2	1	-	-	328	327	326	325	324								
43	"	L W	1	1	-	-	334	333	332	331	330								
44	"	L A	1	2	-	-	340	339	338	337	336								
45	"	L W	3	-	-	-	346	345	344	343	342								
46	OFF	L W	1	1	-	-	357	356	355	354	353	352	351	350	349	348			See Note 1
47	OFF	L W	3	2	-	-	368	367	366	365	364	363	362	361	360	359			
48	"	L W	3	2	-	-	369	370	371	372	373								

Note 1: All wing-off configurations were run at SCV conditions, except for Runs 348 through 368 which were run evacuated to 1400 psf.

Note 2: All wing-on configurations were run evacuated to 1400 psf, except for Runs 110,202,203,266,267 and 268 which were run at SCV conditions.

Note 3: These configurations were run with the LA pylon instead of the LW pylon which brought the nacelles 0.46 in. closer to the fuselage.

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A parametric evaluation of the zero lift drag characteristics attributable to the large nacelles found on some Type A VSTOL candidate aircraft was conducted in the 7- by 10-foot transonic wind tunnel of the David W. Taylor Naval Ship Research and Development Center. Mounting the nacelles in proximity to the wings and fuselage yields levels of interference drag three to four times the isolated drag which results in the nacelle interference drag producing approximately 50 percent of the total aircraft drag. Movement of the nacelles away

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