Advanced Recovery Systems Wind Tunnel Test Report

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LIST OF TERMS AND SYMBOLS

Distance between the point at which Fu attaches to the parafoil and the a

point at which Ru passes through the PACS top plate, ft

Reference Area(s), sq-ft AREF b Span of parafoil, ft

С Chord of parafoil, ft Co. CD Drag coefficient CL, CL Lift coefficient

C_I, CMX Rolling moment coefficient

CLDi Control line load coefficient (i = 1 to 2)

CM, CMY Pitching moment coefficient Cn, CMZ Yawing moment coefficient

Cy, CY Side force coefficient

CTLi Control line deflection (i = 1 to 2), in.

C.P. Confluence point

C/4, Q.C. Quarter chord of parafoil

C.G. Center of gravity

CX Distance between Fu and Ru on the parafoil keel, ft

D Drag, lbf

Fu Leading edge exposed riser length, ft **FCLDi** Force in control line (i = 1 to 2), lbf FRISE

Force in riser (i = 1 to 20), lbf

FTETHI, TI Force in lateral tethers (i = 1 to 4), lbf

i, ia Parafoil rigging angle (angle between line perpendicular to the parafoil keel and

a line from the quarter chord to the confluence point), deg

k Keel length, ft

نا Riser line distance from bottom of parafoil to bottom of PACS bottom plate, ft Lof(i), F, R Riser line distance from top of PACS top plate to bottom of bottom plate, ft

L/D Lift to drag ratio

Lift, lbf

LREF Reference Length (c for longitudinal, b for lateral), ft

L.E. Leading edge riser line

L, LBAR Distance from PACS pivot point to weight centroid, in. LR Length of riser from parafoil to confluence point, ft

LA Total exposed riser line length, ft

LP Distance from top of PACS to plate to confluence point, ft

MRP Moment reference point

PACS Parafoil attitude control system

Dynamic pressure, psf

RISEI Riser load coeffocient (i = 1 to 20)

Ru Aft exposed riser length, ft

LIST OF TERMS AND SYMBOLS (CONTINUED)

s Planform area of parafoil, sq-ft

TETHi Lateral tether load coefficient (i = 1 to 4)

UVi Unit vector for each tether (i = 1 to 4)

Wpacs Weight of PACS without struts, lbs.

XCP, XCP Center of pressure location, in.

x/c Location of airfoil as a portion of chord, x direction

X, XBAR X-axis weight centroid of PACS, in.

XX Distance between Fu and Ru on the PACS top plate, ft
Xf Distance from PACS hinge to leading edge riser hole, ft
y/c Location on airfoil as a portion of chord, y direction

Z, ZBAR Z-axis weight centroid of PACS, in.

GREEK TERMS AND SYMBOLS

α, ALPHA Angle of attack of the parafoil (measured from keel of parafoil to freestream velocity vector), deg.
 αρ, ALPHAP Angle between the top plate of the PACS and the tunnel floor, deg.
 Angle between top plate and the line from the PACS pivot point to the PACS weight centroid deg.

 δρ, DELP Angle between the top and bottom plate of the PACS, deg.
 θ, THETA Angle between the leading edge/centerline riser and the top plate of the PACS in the spanwise direction, deg.

Angle between the leading edge/centerline riser and the top plate of the PACS

in the chordwise direction, deg.

φ, PHI

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FOREWORD

This document presents the results of wind tunnel testing performed under the Phase 2 option of contract NAS8-36631, Advanced Recovery Systems for Advanced Launch Vehicles. It satisfies the requirements for reporting wind tunnel data under the ARS contract.

			
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1.0 SUMMARY

Pioneer Aerospace Corporation (PAC) conducted parafoil wind tunnel testing in the NASA-AMES 80 X 120 test section of the National Full-scale Aerodynamic Complex, Moffett Field, California (Fig. 1.0-1). The investigation was conducted to determine the aerodynamic characteristics of two (2) scale ram air wings in support of air drop testing and full scale development of Advanced Recovery Systems For The Next Generation Space Transportation System.

Two models were tested during this investigation - The primary test article, a 1/9 Geometric scale model with wing area of 1200 square feet and secondary test article, a 1/36 geometric scale model with wing area of 300 square feet, both of which had an aspect ratio of 3.

The test results show that both models were statically stable about a model reference point at angles of attack from 2 to 10 degrees. The maximum lift-drag ratio varied between 2.9 and 2.4 for increasing wing loading.

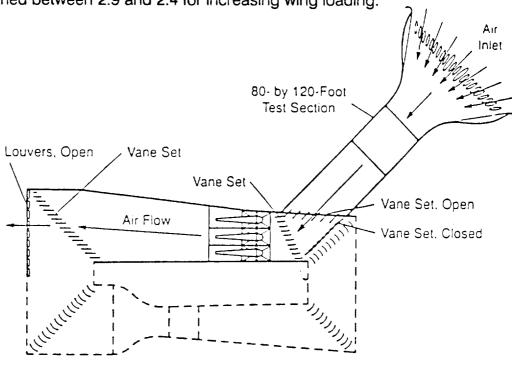


FIGURE 1.0-1, NATIONAL FULL-SCALE AERODYNAMIC COMPLEX

80- by 120-Foot Wind Tunnel Operation

2.0 INTRODUCTION

Pioneer Aerospace Corporation (PAC) was selected by NASA's MSFC to investigate promising concepts for recovering valued assets from the Next Generation Space Transportation System. Reuse of selected STS elements (such as core stages, upper stage propulsion/avionics modules, booster stages, booster P/A modules, and fuel-oxidizer tanks) is critical to a low cost space transportation system. Reuse inherently requires recovery, retrieval and refurbishment. Therefore, development of advanced recovery systems for high cost launch vehicle components, along with the ability to recover at selected sites, to refurbish rapidly, and reuse certain vehicle components is needed to provide an efficient operating system with minimal overall program cost. Through Phase 1 concept identification and preliminary trades analysis tasks, Pioneer identified "best candidate" recovery system concept for a list of prospective recoverable STS elements. ARS Phase 2 will demonstrate the Advanced Recovery Systems ability to precisely and controllably soft land an emulated P/AM which in full scale, would weigh approximately 60,000 pounds. This requires employment of a controllably maneuverable Ram Air Inflated Wing whose size and weight characteristics are well beyond today's state-of-the-art. An orderly program has been planned which includes analytical modeling, scale model tow testing, wind tunnel testing and air drop flight testing. The demonstration culminates in a flight test of a full-scale Ram Air Inflated (Parafoil) prototype system.

2.1 BACKGROUND

Prior to the selection of a Ram Air Inflated Wing for this program, various recovery methods were considered. Among those considered were a Ballistic (L/D=0) Parachute System and a Low Glide (L/D=1) Parachute System. For both the Ballistic and the Low Glide systems, a huge data base exists upon which to build, making either of these systems relatively low risk. Along with the low risk factors which these two systems share, the data also show that each system carries a large weight penalty and has very little or no capability to maneuver. Both systems are good, reliable decelerators but have almost no target acquisition capability.

The Ram Air Inflated Wing has many advantages over the more conventional Parachute system such as low weight, high maneuverability and the capability to flare for a soft, stable landing. However the vast majority of the data base for Ram Air Inflated Wings is for small (personnel size) systems. Going beyond the personnel sized canopies (175 to 340 ft²), some very limited research has been done on Ram Air Inflation Systems up to 3200 ft². The canopy size required for this test program must go far beyond any that have been previously studied. The full scale prototype (10,800 ft²) exceeds the size of 3,200 ft² by 338%.

Several wind tunnel investigations were conducted in the 1960's in the University of Notre Dame 2' X 2' test section by John D. Nicolaides⁴ and in the NASA Langley 30' X 60' (elliptic) test section by George M. Ware and James L. Hassell, Jr.⁵. These wind tunnel tests were conducted on models at relatively low wing loadings (1-2 PSF) and small size models up to 300 ft². Due to the lack of data for ARS size Parafoils a large scale wind tunnel test was conducted to establish a data base of large (1,200 ft²) Ram Air inflated wings.

2.2 TEST SITES AND DATES

This wind tunnel test program is sponsored by NASA-MSFC with Pioneer Aerospace Corporation being the prime contractor. Lockheed Missiles and Space Company is a sub-contractor whose primary wind tunnel related task is development of the wind tunnel interface, Parafoil Attitude Control System (PACS). The wind tunnel testing was conducted during the month of September 1988 in the 80' X 120' test section of the National Full-Scale Aerodynamics Complex (NFAC) at the National Aeronautics and Space Administration's (NASA) Ames Research Center (ARC), Moffett Field, California.

3.0 OBJECTIVES

The objective of the wind tunnel test was to obtain data in support of air drop flight testing and development of a full-scale Ram Air Inflated prototype Advanced Recovery System.

3.1 BASIC IN-PLANE LONGITUDINAL AERODYNAMICS

The first primary objective was to obtain basic in-plane longitudinal aerodynamics, ie., lift, drag and pitching moment data. These data were obtained over a range of angles of attack from approximately zero to stall (0 to 10 degrees). This range was selected to support the basic gliding flight and rigging requirements of the air drop test program.

3.2 FLARE DATA FOR TRAILING EDGE DEFLECTIONS

The second primary objective was to obtain data to support the flare maneuver. Lift, drag and pitching moment data was collected for various trailing edge deflections and angles of attack. Associated control line loads were also measured for all deflections.

3.3 CONTROL DATA

The last primary objective was to obtain data to support the sizing of the control mechanisms for the drop test. Control line loads as a function of displacement and incremental changes in longitudinal aerodynamics was acquired for various control methods. As a secondary objective associated lateral aerodynamic forces and moment were obtained for different control methods. Figure 3.3-1 shows the different control methods.

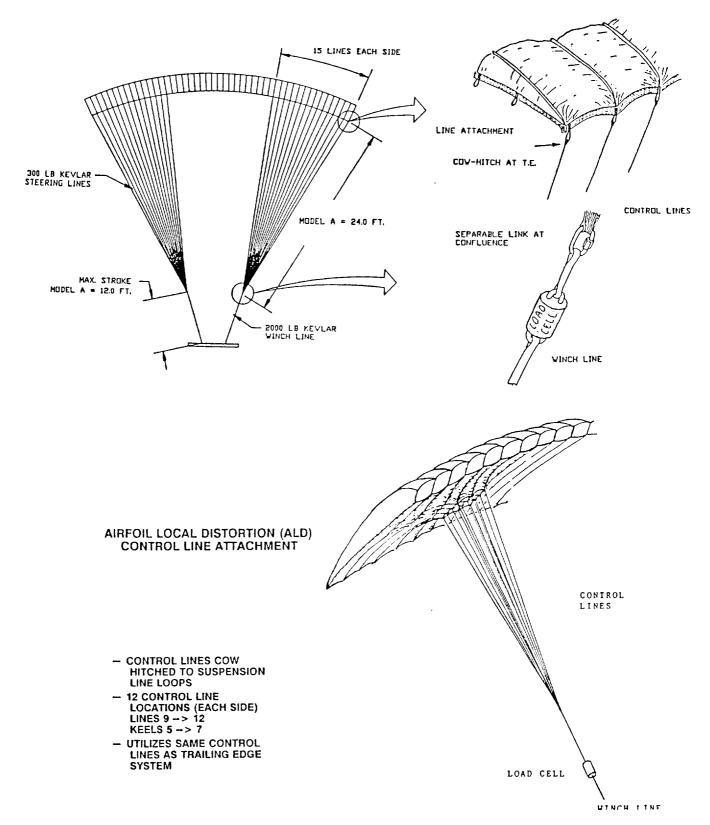


FIGURE 3.3-1, TRAILING EDGE STEERING, L/D MODULATION LINE ARRANGEMENT

3.4 LOAD DISTRIBUTION

The load distribution across the wing is needed for canopy and suspension line design of drop test and eventual full-scale models. The distribution of the load on the parafoil was measured by placing load cells in chordwise and spanwise locations in the suspension lines and data obtained for all configurations.

3.5 SCALE EFFECTS

A review of past programs indicates that there is often a scaling problem associated with flexible wings. Therefore the next objective of the test was to obtain data on scale effects to aid in scaling the data up to full scale. This was accomplished by testing a second model one half the linear scale of the primary model. Testing of the smaller model was limited to selected test conditions. Table 3.5-1 shows an overview of how and when each objective was met.

DATE	RUN #	Q	OBJECTIVE	COMMENTS
8 SEPT.	1	3	TRIM PARAFOIL	FIRST RUN
9 SEPT.	2 3	0 6	CALIBRATION LONGITUDINAL AERO	PACS/INSTRUMENTATION CALIBRATION
12 SEPT.	4	6	LONGITUDINAL AERO	
13 SEPT.	5	6/9	LONGITUDINAL AERO	FINAL TRIMMING OF PARAFOIL
14 SEPT.	6	6	FLARE DATA	
15 SEPT.	7	0	CALIBRATION	
19 SEPT.	8	3	PHOTOGRAPHS	
20 SEPT.	9 10	9 9	LONGITUDINAL & FLARE AERO FLARE DATA	
21 SEPT.	11 12	6 6/9	CONTROL INPUTS CONTROL/FLARE	TRAILING EDGE DEFLECTORS
22 SEPT.	13 14	6 9/12	CONTROL INPUTS CONTROL/LONGITUDINAL DATA	AIRFOIL LOCAL DISTORTION
23 SEPT.	15	6/9/12	PACS AERODYNAMICS	PARAFOIL REMOVED
27 SEPT.	16	3/6	TRIM PARAFOIL	SMALL PARAFOIL
28 SEPT.	17	6	LONGITUDINAL AERO SCALE DATA	

TABLE 3.5-1, WIND TUNNEL TEST OVERVIEW

4.0 TEST FACILITIES AND TECHNIQUES

4.1 TUNNEL DESCRIPTION

A review of past programs indicates that there is often a scaling problem associated with flexible (Parachute/Parafoil) configurations. Therefore, conducting a wind tunnel test with the largest possible scale model was the main goal. This goal was achieved by selecting the largest available wind tunnel for testing. The newly commissioned 80' X 120' test section of the National Full-Scale Aerodynamics Complex at NASA's Ames Research Center was chosen because it is the largest wind tunnel available. The new 80' X 120' leg is basically an open circuit tunnel with a closed throat test section (Figure 4.1-1). The 135,000 horse power fan drive system is enough to attain speeds at more then 115 MPH, more than enough to achieve the relatively high wing loadings required for this test program.

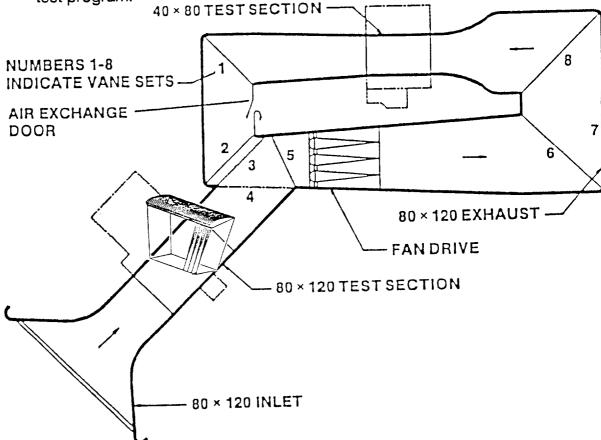


FIGURE 4.1-1, NATIONAL FULL-SCALE AERODYNAMIC COMPLEX

4.2 TEST STAND - PARAFOIL ATTITUDE CONTROL SYSTEM

The Parafoil Attitude Control System (PACS)(Figure 4.2-1) was developed to enable the parafoil to reach its natural trim point and still be able to change the parafoil angle of attack. The PACS includes two carriage struts which attach to the tunnel support/balance system. Each of these struts incorporates a free-floating pivot point which attaches to the top plate of the hinged plate substructure. This point is translated along the top plate by the Xcp actuator mechanism. The hinged plates are driven apart by the L/D actuator. The combination of the Xcp and L/D actuators results in setting the parafoil to the desired attitude. Each plate is divided into removable sections which contain the riser pattern for the parafoil being tested. The suspension lines pass through the top plate and continue through the bottom plate then are attached to the underside of the bottom plate. Two control winches are mounted on the underside of the bottom plate and are used for the various control deflections. Two linear potentiometers monitor the Xcp and L/D actuators. The control winches are monitored by rotary potentiometers while the angle between the leading edge/center suspension line and the top plate (ϕ and θ) is measured by a single joystick potentiometer. An inclinometer was used to measure the top plate angle (ap) with respect to the tunnel floor. A flow deflector was mounted on the tunnel floor just upstream of the PACS to minimize data uncertainty resulting from flow interaction with the PACS. A more detailed description of the PACS is contained in the "Preliminary" Analysis of Parafoil Attitude Control (PAC) Model", ARS-WP-09.6

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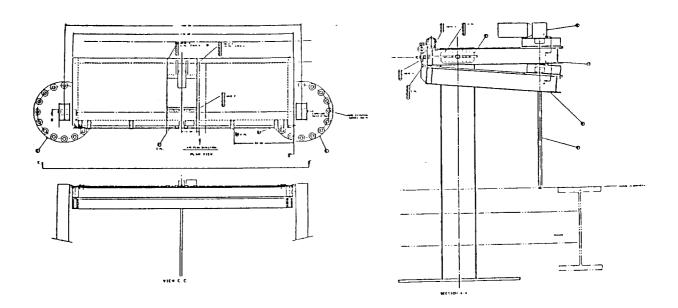


FIGURE 4.2-1, PARAFOIL ATTITUDE CONTROL SYSTEM (PACS)

4.3 TEST MODELS

In keeping with the main objective of this test program, testing the largest possible model, Pioneer designed the largest wing that could effectively be flown in the wind tunnel. The parafoil size was chosen to be as big as possible without interfering with the air flow near the tunnel walls.

The primary test article (Part #7901) was a 1/9 area scale model of the ARS prototype parafoil. The model had a chord of 20 ft and a span of 60 ft, thus having 1,200 ft² area. The parafoil consisted of 47 spanwise cells and was constructed with 1.1 oz/yd nylon. This wing had 960 suspension lines attached in 48 spanwise rows and 20 chordwise columns. Each suspension line was 300 lb Kevlar and each three spanwise groups were cascaded down to one attachment point on the PACS making a total of 320 PACS connecting locations. One of the objectives for this model was to collect data for various symmetrical and asymmetrical trailing edge/control deflections to support the flare and control maneuvers. The wing was equipped with 30 movable/removable control lines that were adjusted using the two winches located on the PACS.

Another of the objectives for this test program was to determine what the effects of size (scaling) are. A 1/36 area scale model (1/4 scale of the primary test article) (Part # 7900) was constructed and tested for this propose. The small model had a chord of 10 ft, a span of 30 ft and an area of 300 ft². This second parafoil was identical to the first parafoil in geometry, material and construction (48 cells, 1.1 oz/yd nylon/300 lb Kevlar and same airfoil section). This parafoil was not equipped with the various control methods. This model was exclusively used to evaluate the scaling effects on wings of this type.

Both models are shown in Figure 4.3-1. A stress and design analysis is contained in "Advanced Recovery System Parachute/Parafoil Stress and Design Loads Analysis", ARS-WP-10 Rev. A.⁷

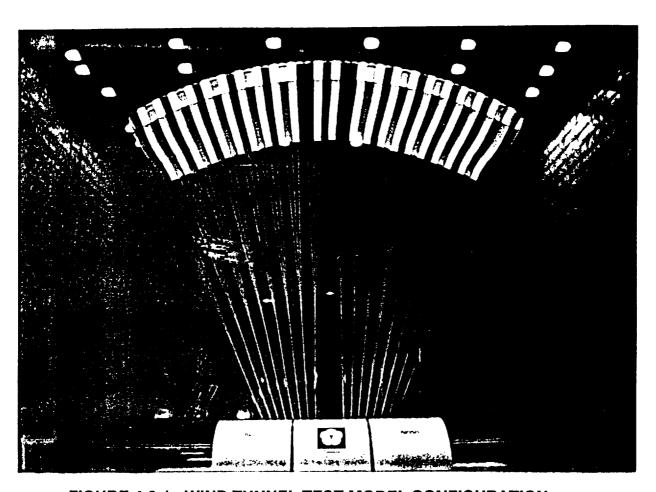


FIGURE 4.3-1, WIND TUNNEL TEST MODEL CONFIGURATION

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4.4 TEST TECHNIQUES

Figure 4.4-1 shows the 20' x 60' parafoil during testing. While testing both models were allowed to fly in the wind tunnel by use of a active tether system (Figure 4.4-2). Five ceiling and four side tethers were used to raise the parafoil for initial inflation and to hold the wing to measure lateral loads during asymmetrical control deflections. During most of the testing, once the parafoil reached a stable trim point, all tethered were released to allow the wing to fly unrestrained. A test procedure was adopted during testing that when the parafoil reached stall or any unstable condition the wind tunnel was shut down, the parafoil angle of attack decreased and ceiling tethers tightened. By using this procedure the wing would stabilize quickly and reduce the chance of any damage occurring to the wing.

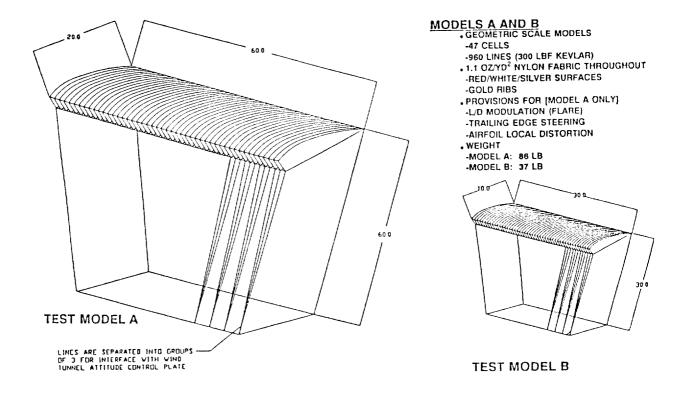


FIGURE 4.4-1, 20' x 60' PARAFOIL

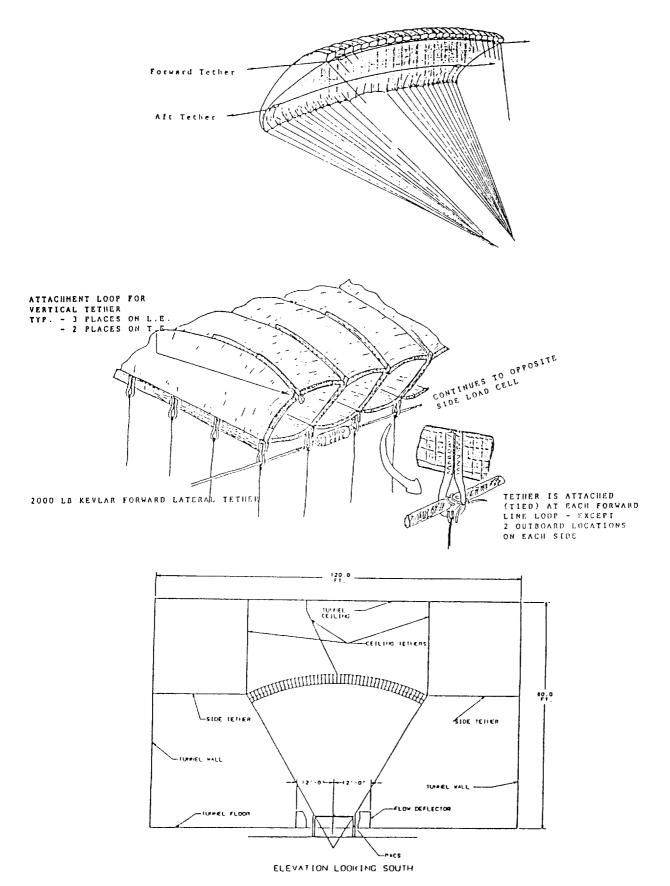


FIGURE 4.4-2, LATERAL TETHER LOCATIONS

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4.5 DATA ACQUISITION

The PACS served as the interface between the parafoil and the tunnel's balance/data acquisition system. Lift, drag and side forces were transmitted directly through the PACS to the balance and recorded on the systems computer. Rolling and yawing moments were also measured using the tunnel balance system. The PACS was designed to find the center of pressure of the parafoil by finding the point on the plate where the pitching moment was zero. Then using simple force transformations the pitching moment could be calculated.

Twenty load cells were placed in the suspension lines to give spanwise and chordwise load distribution across the wing. The load cells were connected directly to the tunnels data acquisition system. Four additional load cells were placed in the side tethers to measure side forces during the control deflections. Two load cells were also placed in the two (one each side) control lines to measure the force required for control line deflections.

All data was recorded for each data point on the tunnel's computer. The data was then corrected using the tunnels standard corrections and output on hard copies for further use.

Five video cameras were placed at various locations around the wind tunnel to observe and record the testing. One of the five cameras was located on the west wall, adjacent to the parafoil wing tip. This camera was used as an alternate method of measuring the angle of attack of the wing. The other four cameras were used for documentation purposes only.

4.6 PROBLEMS AND CORRECTIVE ACTION

Several problems occurred during testing. This section describes the problems and the corrective action utilized.

PROBLEM: PACS Xcp Retention Pin Failure - The pin used to hold the Xcp thrust bearing in place sheared during testing. The retention pin design was faulty in that it could not withstand the high shear loads during testing.

CORRECTIVE ACTION: The bearing journal was modified to accept a collar that would fit on both sides of the thrust bearing thus retaining the bearing under high loading conditions. Figure 4.6-1 shows the Xcp retention pin failure and modification used to correct the problem.

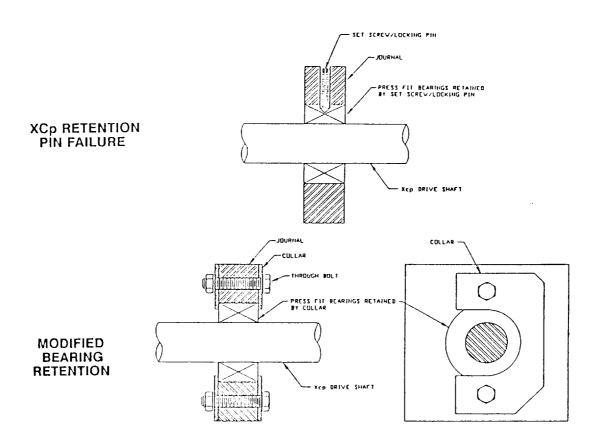


FIGURE 4.6-1, RETENTION PIN MODIFICATION

ORIGINAL PAGE IS OF POOR QUALITY PROBLEM: Parafoil/Tether Failure - The Parafoil was designed with nine tether attachment locations. The tethers were used to keep the wing from diverging too far once the wing reached an unstable trim point. During testing the tethers encountered loads that were higher than expected. The results were that the parafoil was damaged in the locations where the tethers were located.

CORRECTIVE ACTION: The parafoil was fixed and strengthened at the tether locations using Rip-Stop and Kevlar reinforcing materials. The materials were sewn in place using a sewing machine. All tether locations were reinforced and no more damage occurred during testing. Figure 4.6-2 shows the parafoil/tether damage and correction.

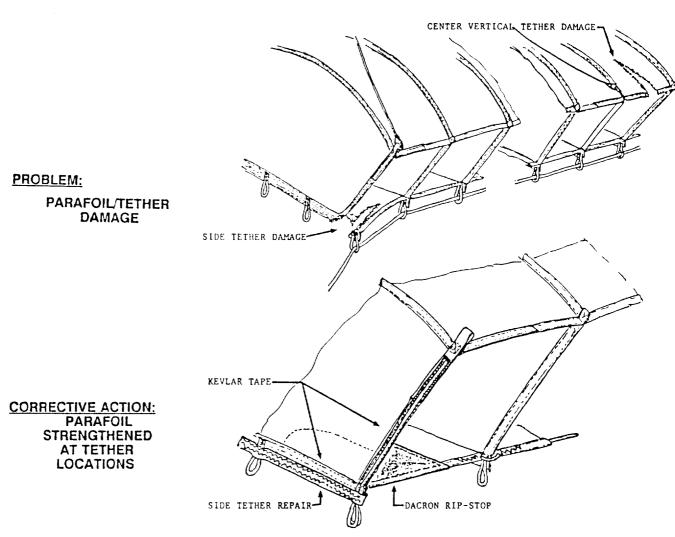


FIGURE 4.6-2, PARAFOIL/ TETHER DAMAGE AND CORRECTION

OF HUUR QUALITY

PROBLEM: Small Parafoil PACS Problem - The 10' x 30' parafoil could not generate enough lift to balance the PACS due to the short range of the PACS Xcp drive system.

CORRECTIVE ACTION: The front of the PACS was secured to the tunnel balance system to level the PACS. This allowed the small wing to be tested but the data could only be taken over a very small range due to the PACS not being able to move.

PROBLEM: Q Effects on Parafoil Angle of Attack - It was observed during testing that the angle of attack not only is a function of the rigging geometry but also is a function of the dynamic pressure (Q). Therefore, there was not an easy way to measure the angle of attack during testing. CORRECTIVE ACTION: The angle of attack was derived as a function of rigging geometry and dynamic pressure for data reduction and analysis purposes. The angle of attack was also measured and compared using video and still photographic techniques.

5.0 ANALYSIS OF RESULTS

The information in this section describes how the data was reduced after testing was completed.

5.1 ANGLE OF ATTACK SUMMARY

One of the basic differences between testing fabric wings and rigid structures is finding the wings angle of attack. With a rigid wing the angles can be measured directly by mounting sensors directly on the wing. Previous to this test it was thought that any instrumentation mounted in the wing would significantly change the shape of the wing, thus invalidating the test results. For this reason a inclinometer was not incorporated in the wing.

The angle of attack was derived as a function of the physical constants of the PACS and parafoil and of the variables measured during testing. The physical constants were the PACS plate hole geometry, parafoil suspension line geometry and parafoil chord length. The measured variables included; dynamic pressure (Q), angle between PACS top and bottom plates (δp), angle measured between front center suspension line and top plate (ϕj) and angle of the top plate relative to horizontal (αp).

A data base was compiled that consisted of geometric variables and aerodynamic coefficients measured during testing and was used in conjunction with a computer program to calculate the angle of attack for each data point. Figure 5.1-1 shows the angle of attack as a function of δp and dynamic pressure.

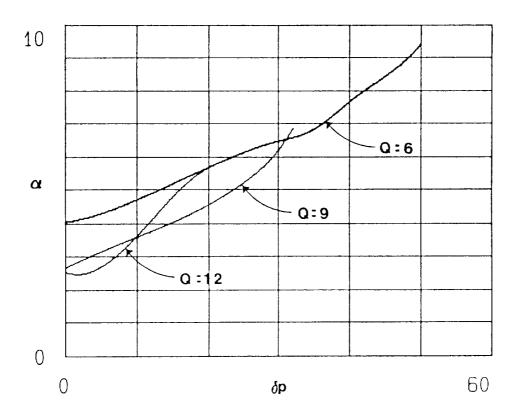


FIGURE 5.1-1, ANGLE OF ATTACK AS FUNCTION OF δ p AND DYNAMIC PRESSURE

The angle of attack was also measured using 70mm black and white and video photography. The method used was to place the cameras in the tunnel wall adjacent to where the wing would be flying. The wing tip was then photographed when each data point was taken. After testing was completed a grid was placed in the tunnel, in the same plane as the parafoil wing tip was flying, and photographed using the same two camera locations. The two films were superimposed and the angle of attack then directly measured (Figure 5.1-2).

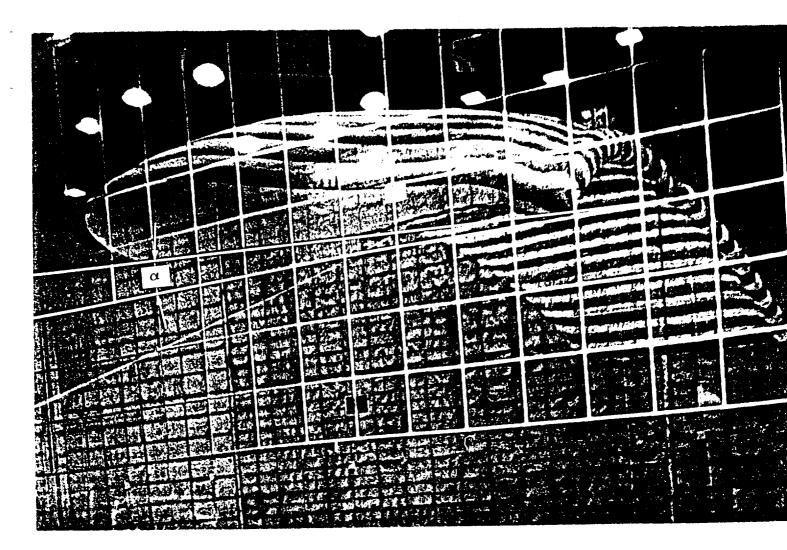
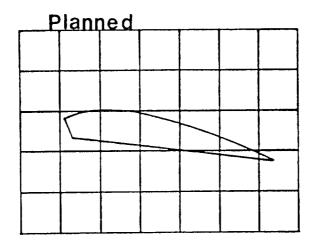


FIGURE 5.1-2, DIRECT MEASUREMENT OF ANGLE OF ATTACK

There were two problems with this method. The first problem was that the cameras had to be located in existing view ports that were located slightly aft and above the wing. The second problem encountered was that the wing distorted at high dynamic pressures. The distorted wing profile made it difficult to find the actual chord line of the parafoil therefore a average chordline was assumed.

Figure 5.1-3 shows planned versus actual angle measuring techniques. All of the measured values agree with calculated values to within 10%.



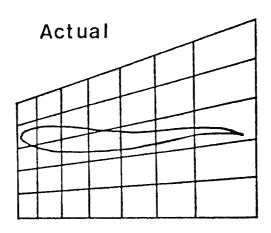


FIGURE 5.1-3, ANGLE OF ATTACK MEASURING TECHNIQUES
PLANNED VS. ACTUAL

5.1.1 Angle of Attack Calculation

Figure 5.1-4 depicts the geometry used in determining parafoil angle of attack. Values for L₁, length of forward suspension line, and L₄, length of fourth suspension line, are constants to this configuration. The values for Cx, XX and Xf are also constant and are shown in the figure. The values of φ , δp , and αp , R, Ru, F, Fu, a, q_1 and q_2 vary for each set of test conditions.

To determine parafoil angle of attack the following set of equations are used:

$$\alpha = \alpha p - \phi + (180 - \theta 1 - \theta 2)$$

where:

$$\theta_1 = \cos^{-1} ((Fu^2 + a^2 - XX^2)/(2 Fu a))$$

 $\theta_2 = \cos^{-1} ((Cx^2 + a^2 - Ru^2)/(2 Cx a))$

$$a = (Fu^2 + XX^2 - 2 Fu XX \cos \phi)^{1/2}$$

To determine Fu and Ru the following is used:

$$Fu = L_1 - F$$

$$Ru = L_4 - R$$

Where:

$$L_1 = L_R(1) - L_p(1) + L_{DP}(1)$$

 $L_4 = L_R(4) - L_p(4) + L_{DP}(4)$

Where LR is the line length from the parafoil to the confluence point, LP the length from the confluence point to the top plate and LDP the length from the bottom plate to the top plate. From analysis conducted in Section 5.3:

$$L_R(1) = 59.405 \text{ ft}$$
 $L_R(4) = 60.268 \text{ ft}$ $L_p(1) = 11.880 \text{ ft}$ $L_p(4) = 12.020 \text{ ft}$

To determine LDP:

LDP =
$$(.3403 + 2(.3942 + x)^2 - 2(.3942 + x)(.3403 + (.3942 + x)^2)^{1/2} \cos(5 + \tan^{-1}(.5833/(.3942 + x))))^{1/2} + .0833$$

Where X is the longitudinal distance of the PACS hole location for the specific line. For line 1, $X=0.0\,\mathrm{ft}$; for line 4, $X=0.5869\,\mathrm{ft}$. Therefore,

$$L_{DP}(1) = 0.701 \text{ ft}$$
 $L_{DP}(4) = 0.752 \text{ ft}$

and the following are the resulting line lengths:

$$L_1 = 48.2 \, \text{ft}$$
 $L_4 = 49.0 \, \text{ft}$

The quantities L and R are functions of δp , the plate separation angle:

$$F(\delta p) = (.3403 + 2(.3942)^{2} - 2(.3942)(.3403 + (.3942)^{2})^{1/2}$$

$$\cos ((\delta p + 5) + \tan^{-1}(.5833/.3942)))^{1/2} + .0833$$

$$R(\delta p) = (.3403 + 2(0.9838)^2 - 2(0.9838)(.3403 + (0.9838)^2)^{1/2} \cos((\delta p + 5) + \tan^{-1}(.5838/0.938)))^{1/2} + .0833$$

Table 5.1-5 shows the quantities R, Ru, F, Fu as a function of δp.

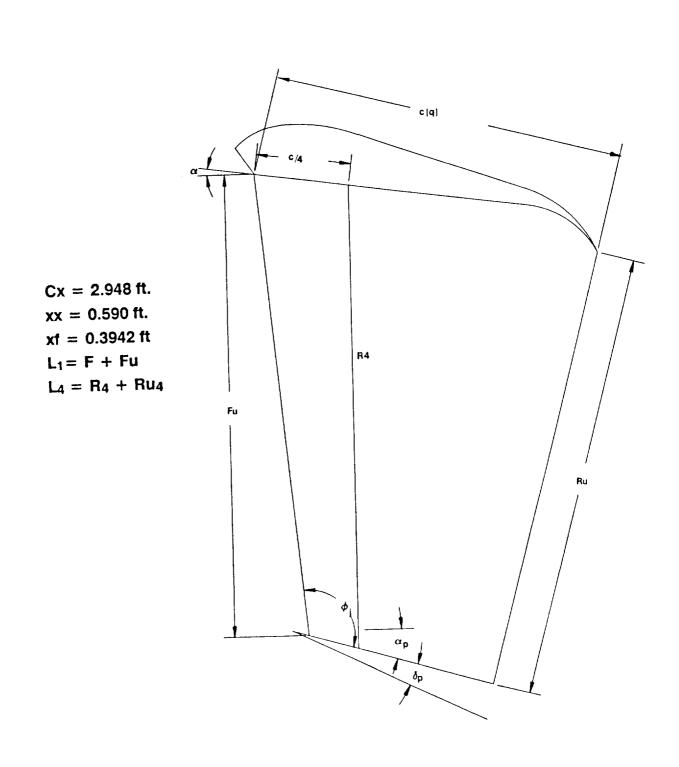


FIGURE 5.1-4, ANGLE OF ATTACK GEOMETRY

δρ	R	RU	F	FU
0.0000 5.0000	0.7524 0.8376	48.4476	0.7010	47.9990
10.0000	0.9219	48.3624 48.2781	0.7351 0.7688	47.9649 47.9312
20.0000	1.0050	48.1950	0.8019	47.8981
	1.0866	48.1134	0.8341	47.8659
25.0000	1.1666	48.0334	0.8655	47.8345
30.0000	1.2446	47.9554	0.8959	47.8041
35.0000	1.3206	47.8794	0.9251	47.7749
40.0000	1.3944	47.8056	0.9531	47.7469
45.0000	1.4657	47.7343	0.9797	47.7203
50.0000	1.5345	47.6655	1.0050	47.6950
55.0000	1.6006	47.5994	1.0288	47.6712
60.0000	1.6639	47.5361	1.0511	47.6489
65.0000	1.7242	47.4758	1.0717	47.6283
70.0000	1.7815	47.4185	1.0907	47.6093
75.0000	1.8355	47.364 5	1.1080	47.5920
80.0000	1.8863	47.3137	1.1236	47.5764
85.0000	1.9337	47.2663	1.1373	47.5627

TABLE 5.1-5, LINE LENGTH FUNCTIONS

5.1.3 Angle of Attack Results

Table 5.1-6 shows the resulting parafoil angles of attack for wind tunnel runs 1-17, along with values discussed in Section 5.1.2.

R P	ALPHAP	DELTAP	FU	RU	xx	A	сх	THETA1	THETA2	ALPHA	PHI
** .						47 75	2.95	0.70	92.29	4.99	84.33
1 3	2.31	29.75		47.98	0.59	47.75	2.95	0.70	90.43	6.39	79.94
1 4	-2.54	45.02		47.73	Ø.59	47.62 47.88	2.95	0.69	99.04	4.09	78.56
3 3	2.38	1.10	47.99	48.43	Ø.59	47.79	2.95	0.70	94.61	5.98	81.91
3 4	3.18	20.00	47.87	48.11	Ø.59	47.72	2.95	0.70	92.81	7.40	81.48
3 5	2.39	29.98	47.80	47.96	Ø.59	47.73	2.95	0.70	92.59	8.49	82.57
3 5 4 3	2.35	30.02	47.80	47.98	Ø.59 Ø.59	47.70	2.95	0.70	91.77	6.85	82.05
4 4	1.37	35.05	47.77	47,88	Ø.59	47.68	2.95	0.70	91.10	7.69	80.98
4 5	0.45	40.04	47.75	47.81 47.73	0.59	47.63	2.95	0.70	90.26	8.44	80.80
4 8	0.20	45.03	47.72	47.67	0.59	47.59	2.95	0.70	89.62	9.42	79.76
4 7	-0.50	50.03	47.69	47.87	Ø.59	47.58	2.95	0.70	89.89	8.59	78.40
5 3	-2.43	50.00	47.89 47.99	48.43	0.59	47.87	2.95	0.69	99.11	2.35	78.17
5 4	0.32	1.16	47.92	48.24	0.59	47.78	2.95	Ø.89	97.23	3.29	76.34
5 5	-2.48	12.30	47.80	47.95	0.59	47.71	2.95	0.70	93.Ø1	4.61	80.43
8 3		30.05	47.80	47.95	0.59	47.87	2.95	0.89	93.71	4.52	76.89
8 4		30.03 29.93	47.80	47.96	0.59	47.68	2.95	0.89	93.95	4.23	75.78
8 5		29.93	47.81	47.96	0.59	47.66	2.95	Ø.69	94.06	4.54	75.28
8 6		29.81	47.81	47.98	0.59	47.65	2.95	0.68	94.16	4.85	74.80
8 7		29.78	47.81	47.96	0.59	47.84	2.95	0.68	94.52	8.29	72.97
6 8		1.10	47.99	48.43	0.59	47.87	2.95	0.89	99.13	2.79	78.12
9 3			47.87	48.12	0.59	47.75	2.95	0.69	95.41	4.53	78.17
9 4		25.01	47.83	48.03	0.59	47.72	2.95	0.69	94.31	5.22	78.62 79.04
			47.80	47.95	Ø.59	47.70	2.95	0.89	93.29	8.23	79.37
			47.79	47,93	Ø.59	47.69	2.95	0.70	92.90	6.80	80.01
9 7			47.83	48.03	0.59	47.74	2.95	0.70	94.04	5.53 4.84	78.14
-	9 -3.53		47.83	48.03	Ø.59	47.70	2.95	Ø.89	94.80	4.58	74.09
9 16			47.84	48.04	0.59	47.88	2.95	0.88	95.23	4.57	73.89
9 1			47.84	48.04	0.59	47.88	2.95	0.68	95.30	4.88	73.35
9 1			47.84	48.04	Ø.59	47.87	2.95	Ø.68	95.43 95.8 5	5.39	72.52
9 1			47.84	48.05	0.59	47.67	2.95	0.68	94.92	5.04	80.44
	3 1.09		47.87	48.11	Ø.59	47.77	2.95	0.70	95.52	4.16	77.39
	4 -2.24		47.87	48.11	0.59	47.74	2.95	Ø.69 Ø.68	96.23	3.75	73.91
	5 -5.43		47.87	48.12	0.59	47.71	2.95	0.88	98.29	3.71	73.74
	8 -5.58	19.69	47.87	48.12	Ø.59	47.71	2.95 2.95	Ø.88	96.36	3.80	73.47
	7 -5.89	19.58	47.87	48.12	0.59	47.70	2.95	Ø.68	98.58	4.48	72.52
	8 -5.78	3 19.51	47.87	48.12	0.59	47.70 47.78	2.95	0.70	94.82	4.27	81.Ø8
11	3 Ø.8			48.12	Ø.59	47.75	2.95	0.70	93.81	5.82	81.31
11	4 1.4			48.04	Ø.59 Ø.59		2.95	0.88	95.99	12.88	67.90
11	5 -2.5			48.00	Ø.59		2.95		92.78	5.59	81.85
11	6 Ø.9			47.98	Ø.59		2.95		92.98	5.44	80.91
11	7 0.0			47.98 47.96	0.59		2.95		92.93	5.78	81.11
11	8 0.5			47.98	ø.59		2.95		93.71	5.19	77.27
11	9 -3.1			47.98	0.59		2.95	0.70		5.58	
	10 0.2			47.96	Ø.59		2.95	Ø.89		4.87	
	11 -4.8				0.59		2.95	Ø.78		5.34	
	12 Ø.1				0.59		2.95			4.93	
	13 -5.4 14 Ø.2				0.59		2.95			5.43	
	-	·			0.59		2.95			5.28	
12	3 1.4 4 -Ø.3				0.59		2.98	0.78		4.98	
12 12	5 0.3				0.59		2.95			5.13 4.84	
12	6 -3.7	_		47.95		47.68	2.95			5.24	
12	7 0.2			47.95						4.46	
12	8 -5.2	_	2 47.88	47.95						5.2	
12	9 Ø.			47.95				-		_	
12				47.95							
12	-		3 47.8					_			_
12			3 47.8								
12	_		Ø 47.8	7 48.11	0.5	9 47.78	4.3				
_											

TABLE 5.1-6, ANGLE OF ATTACK RESULTS

R F	PALPHA	P DELTA	P FU	RU	xx	A	сх	THET	AI THETA	2 41.0	
12 14	8.87	19.93	47.87	40.11					TE INCIA	2 ALPI	HA PHI
12 15							2.95	0.7		4.2	7 81.12
12 16	-2.57				Ø.59		2.95	0.7		4.38	
12 17					0.59		2.95 2.95	0.6			77.45
12 18				48.11	0.59		2.95	Ø.76			
12 19 12 20					0.59		2.95	0.76			
12 21		19.37 19.30			0.59		2.95	Ø.68	96.89		
12 22		20.29			Ø.59		2.95	0.70	94.82		
12 23		20.32	47.86		Ø.59 Ø.59		2.95	0.88			
12 24		19.21	47.87	48.13	Ø.59	47.78 47.71	2.95 2.95	0.70		4.79	
12 25		19.35	47.87	48.12	0.59	47.79	2.95	Ø.88		3.41	
12 28		20.41	47.86	48.11	0.59	47.71	2.95	Ø.68		4.51	
12 27 12 28		1.07	47.99	48.43	0.59	47.84	2.95	Ø.88		3.48 2.02	
12 29		1.07	47.99	48.43	Ø.59	47.83	2.95		100.10	1.77	
12 30		0.89	47.99 47.99	48.43 48.43	0.59	47.82	2.95	0.87	100.30	1.28	
12 31	-5.62	0.84	47.99	48.43	Ø.59 Ø.59	47.82	2.95	0.87	100.27	0.98	
12 32	-3.32	0.95	47.99	48.43	Ø.59	47.82 47.84	2.95		100.25	0.70	
12 33	-3.32	Ø.98	47.99	48.43	0.59	47.84	2.95 2.95	Ø.68 Ø.68		1.80	
12 34 12 35	-3.89	0.98	47.99	48.43	Ø.59	47.83	2.95		99.91 100.07	1.78	74.33
12 35	-3.32 -3.89	Ø.95	47.99	48.43	0.59	47.84	2.95	Ø.68		1.83 1.81	73.53
12 37	-3.32	Ø.95 Ø.95	47.99 47.99	48.43	Ø.59	47.83	2.95		100.08	1.88	74.26 73.49
12 38	-5.44	Ø.93	47.99	48.43 48.43	0.59	47.84	2.95	0.88	99.92	1.78	74.30
12 39	-3.55	0.93	47.99	48.43	Ø.59 Ø.59	47.82	2.95		100.32	1.28	72.28
12 40	-5.33	0.94	47.99	48.43	0.59	47.84 47.81	2.95 2.95	0.68	99.95	1.63	74.19
12 41	-3.15	0.95	47.99	48.43	0.59	47.84	2.95	Ø.68	100.38	1.55	72.09
12 42 12 43	-5.44	0.77	47.99	48.43	0.59	47.82	2.95		99.92 100.33	1.98	74.29
12 44	-3.72 -5.44	0.79	47.99	48.43	Ø.59	47.84	2.95	0.68	99.98	1.13	72.43 74.25
12 45	-3.43	1.88	47.99 47.99	48.43	0.59	47.81	2.95	0.87	100.37	1.53	71.99
12 46	-5,44	0.48	48.00	48.43 48.44	Ø.59 Ø.59	47.83	2.95	0.68	99.95	1.90	74.04
12 47	-3.37	0.53	48.00	48.44	Ø.59	47.82 47.84	2.95	0.87	100.42	1.17	72.30
12 48	-5.44	1.18	47.99	48.43	Ø.59	47.81	2.95 2.95	0.68	100.03	1.75	74.17
12 49	-4.87	1.06	47.99	48.43	0.59	47.82	2.95	Ø.07	100.31 100.25	1.48	72.10
12 5Ø 13 3	-3.55	1.07	47.99	48.43	0.59	47.83	2.95	Ø.88	99.98	1.69 1.91	72.51
13 4	1.61 1.61	29.99 29.99	47.80	47.98	Ø.59	47.73	2.95	0.70	92.69	8.14	73.88 82.08
13 5	1.61	30.00	47.8Ø 47.8Ø	47.98 47.98	Ø.59	47.73	2.95	0.70	92.69	6.11	82.11
13 6	1.61	29.99	47.80	47.98	Ø.59 Ø.59	47.73 47.73	2.95	Ø.78	92.88	6.08	82.15
13 7	1.50	29.99	47.80	47.98	Ø.59	47.72	2.95 2.95	0.70	92.71	6.22	81.97
13 8	1.44	29.99	47.80	47.98	0.59	47.72	2.95	0.70 0.70	92.75 92.81	8.28	81.79
13 9 13 10	1.44	29.99	47.80	47.98	0.59	47.72	2.95	0.70	92.89	8.43 8.74	81.50
13 11	1.04 0.28	30.00 29.98	47.80	47.98	0.59	47.71	2.95	0.70	93.03	8.92	81.11 80.39
13 12	2.19	29.99	47.8Ø 47.8Ø	47.98	Ø.59	47.89	2.95	0.89	93.38	7.59	78.81
13 13	2.30	30.00	47.80	47.98 47.98	Ø.59 Ø.59	47.88	2.95	Ø.89	93.95	11.83	75.73
13 14	2.59	30.00	47.80	47.98	0.59	47.73 47.74	2.95	0.70	92.55	6.27	82.78
13 15	2.59	29.98	47.80		Ø.59	47.73	2.95	0.70	92.51	8.40	82.98
13 16		29.98	47.80	47.98	Ø.59	47.73	2.95 2.95	0.70 0.70	92.55 92.57	8.52	82.82
13 17 13 18	2.24	30.00	47.80	47.98	ð.59	47.73	2.95	9.78	92.58	6.83 6.31	82.69
13 19	2.Ø1 1.61	30.00	47.80	47.98	Ø.59	47.73	2.95	Ø.7Ø	92.69	6.54	82.85 82.08
13 20	1.61	30.00 29.98	47.8Ø 47.8Ø	47.98 47.98	Ø.59	47.72	2.95	0.70	92.77	6.45	81.69
13 21	Ø.52	29.98	47.80	47.96	Ø.59 Ø.59	47.72 47.71	2.95	8.78	92.87	6.82	81.22
13 22	-8.28	29.99	47.80	47.98		47.78	2.95 2.95	Ø.7Ø	93.Ø8	6.62	80.12
13 23			47.80	47.98		47.68	2.95	Ø.7Ø Ø.69	93.25	6.50	79.28
13 24				47.96	0.59	47.74	2.95	Ø.7Ø	93.63 92.48	7.77 6.47	77.35
14 3 14 4	Ø.18 Ø.18	1.11		48.43		47.87	2.95	0.89	99.16		83.17 77.93
• •	~.10	1.11	47.99	48.43	Ø.59	47.87	2.95	0.89	99.19	2.48	77.82
											-

TABLE 5.1-6, ANGLE OF ATTACK RESULTS (CONTINUED)

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14 39 1.15 9.93 47.93 48.20 0.30 0.00 0.00 0.00 0.00 0.00 0.00	1.	4 39	1.15										79.55
14 40 1.10 15.09 47.90 48.19 0.50 17.70 2.05 4.89 05.91 5.87 75.40	1	4 40	1.10		_						-		75.48
14 41 -2.28 19.91 47.87 48.11 6.59 47.72 2.95 6.89 95.91 5.87 75.41	1	4 41	-2.28	19.91	47.87	48.11	0.59	41.12	2.95	B.09	90.31	0.01	, , , , ,

TABLE 5.1-6, ANGLE OF ATTACK RESULTS (CONTINUED)

5.2 PACS WEIGHT TARE

The Parafoil Attitude Control System (PACS) was originally conceived to enable a parafoil to be tested through a range of rigging angles and to allow the parafoil to find its natural trim point. This concept consisted of a set of hinged plates to effect the change in rigging angle and a moveable pivot point (Xcp drive system) to allow the parafoil to fly at its natural trim angle without distorting the suspension system. The original design concept included an active counterweight system which would balance the PACS in both the X- and Z-axes thus keeping the center of gravity of the PACS at the pivot point no matter what the angle between the plates of the Xcp setting. This balanced system would reduce the effect of the PACS on the test article to only the dynamic moment of inertia of the system.

Due to time and budget constraints, the active counterweight system was replaced by a static counterweight. This static counterweight essentially only balanced the PACS in the X-axis at one angle between the plates and one Xcp setting. Because of this imbalance in the PACS, the test article was required to overcome the moment imposed about the pivot point by the weight of the PACS. This meant that the Xcp setting had to be increased to allow the parafoil normal force to overcome the increase in moment. During testing it was found that the travel of the Xcp drive system was insufficient to overcome this moment; thus the Xcp of the PACS could not be matched to the natural trim condition of the test article.

As a result of the imbalance of the PACS and the limited Xcp travel the data were compromised in two ways: (1) since the PACS could not match the natural trim condition of the test article, the parafoil suspension lines were slightly distorting the parafoil; and (2) the data included the moment created by the shift in the center of gravity (c.g.) of the PACS. The distortion of the parafoil was found to be minimal and could be considered within the accuracy of the rigging of the parafoil; however, the moment created by the PACS c.g. was found to be significant and required development of a methodology to modify the data to eliminate

the effect of the PACS c.g. shift. This section documents the methodology which was developed to calculate the weight tare of the PACS.

5.2.1 Weight Tare Methodology

Since the weight of the PACS with no tunnel flow always acts in the vertical plane in line with the pivot point, it is possible to determine the weight centroid of the PACS at a given angle between the plates. This is done by setting the PACS at the positive and negative Xcp limits and measuring the angle of the top plate with respect to horizontal at each of the Xcp settings. Given this information for a range of angles between the plates (δp) a set of calibration curves for the weight centroid can be developed as a function of δp . Figure 5.2-1 below defines the nomenclature necessary to develop the equations to calculate the weight centroid.

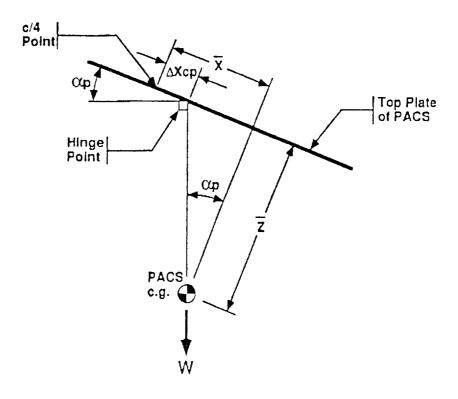


FIGURE 5.2-1, WEIGHT TARE NOMENCLATURE

The angle of the top plate (αp) is defined by the following equation.

$$\alpha p = tan^{-1}((x-\Delta X cp)/z)$$

For two ΔX cp locations the equation above can be transformed to the two equations below.

z tan
$$\alpha p_1 = x - \Delta X c p_1$$

z tan $\alpha p_2 = x - \Delta X c p_2$

Subtracting these equations and solving for the Z-axis centroid location yields the following equation.

$$z = (\Delta X cp_2 - \Delta X cp_1)/(\tan \alpha p_1 - \tan \alpha p_2)$$

Substituting the above equation into the original equation yields the following equation for the X-axis centroid location.

$$x = ((\Delta X cp_2 - \Delta X cp_1)/(\tan \alpha p_1 - \tan \alpha p_2)) \tan \alpha p_1 + \Delta X cp_1$$

This weight tare calibration was performed post-test at discrete values for the angle between the PACS plate ($\delta_p = 1^o$, 5^o , 10^o ,..., 50^o , 55^o , 59^o). These data were used to develop the weight tare calibration.

5.2.2 Inclinometer Calibration

When the weight tare calibration was performed it was discovered that the angle of the top plate exceeded the calibration range of the inclinometer used to measure the angle. A calibration of the inclinometer was performed to extend the calibrated range of the inclinometer. It was originally felt that this calibration might be questionable and outside the linear range of the inclinometer; however when the measured data were compared to the original calibration as shown below, the data showed a very good correlation.

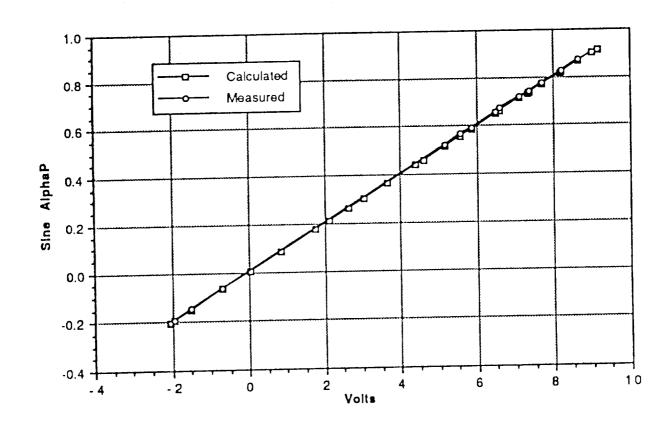


FIGURE 5.2-2, INCLINOMETER CALIBRATION

5.2.3 Weight Tare Calibration

Table 5.2-3 and Figure 5.2-4 were developed using the equations developed in the weight tare methodology section, the data obtained in the weight tare calibration, and the original inclinometer calibration. Due to the small plate angle changes with changes in Xcp at $\delta_p = 1^o$ and 5^o , the trigonometric tangent function accuracy cause these data to be questionable, therefore they were removed from the data base.

Point #	Lpot	DelP	Хср	Output	Calc Sine	Calc	Zbar	Xbar
	(İn)	(deg)	(ln)	(volts)		AlphaP		
1			-2.500	2.118	0.2118	12.2259		
2	0.027	1	-2.505	7.373	0.7375	47.5194	-19.8377	-24.1688
3	0.027	1	3.932	8.167	0.8169	54.7799		
5	0.211	5	-2.501	9.142	0.9145	66.1330	5.4176	9.7435
4	0.211	5	3.933	7.312	0.7314	47.0042	4.6507	8.0103
28	0.211	5	3.938	6.586	0.6588	41.2061		
6	0.507	10	-2.501	9.025	0.9028	64.5261	4.5154	6.9768
27	0.507	10	3.938	5.582	0.5583	33.9400		
7	0.871	15	-2.501	8.655	0.8658	59.9701	5.3189	6.7004
26	0.871	15	3.939	4.607	0.4608	27.4374		
В	1.296	20	-2.501	8.200	0.8202	55.1092	6.1812	6.3626
25	1.296	20	3.939	3.650	0.3650	21.4098	i l	
9	1.775	25	-2.501	7.683	0.7685	50.2212	6.9533	5.8509
24	1.775	25	3.940	2.650	0.2650	15.3664		
10	2.301	30	-2.501	7.100	0.7102	45.2507	7.7676	5.3349
23	2.301	30	3.940	1.768	0.1767	10.1805		
11	2.866	35	-2.501	6.486	0.6488	40.4486	8.3721	4.6365
22	2.866	3.5	3.940	0.830	0.0829	4.7557		
12	3.463	40	-2.501	5.845	0.5846	35.7773	8.9790	3.9695
21	3.463	40	3.941	0.033	0.0032	0.1817	1	
13	4.085	4.5	-2.501	5.151	0.5152	31.0111	9.6171	3.2801
20	4.085	4.5	3.941	-0.684	-0.0686	-3.9314		
14	4.727	50	-2.501	4.397	0.4398	26.0892	10.0489	2.4195
19	4.727	50	3.941	-1.495	-0.1497	-8.6095		
15	5.378	5.5	-2.501	3.659	0.3659	21.4652	10.9141	1.7905
18	5.378	5.5	3.941	-1.931	-0.1933	-11.1465		
16	5.905	59	-2.501	3.030	0.3030	17.6383	12.2237	1.3856
17	5.905	5 9	3.937	-2.041	-0.2043	-11.7899		

TABLE 5.2-3, PACS CENTER OF GRAVITY CALCULATIONS

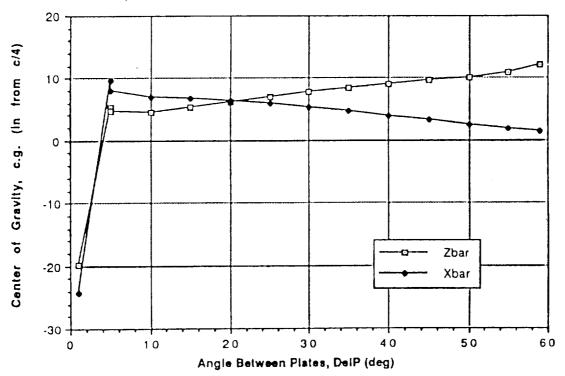


FIGURE 5.2-4, PACS CENTER OF GRAVITY LOCATION

5.2.4 Induced Moment

As mentioned earlier when the test article is "flying" it must overcome the moment induced by the offset in the PACS center of gravity. Figure 5.2-5 below depicts the nomenclature which defines this phenomenon.

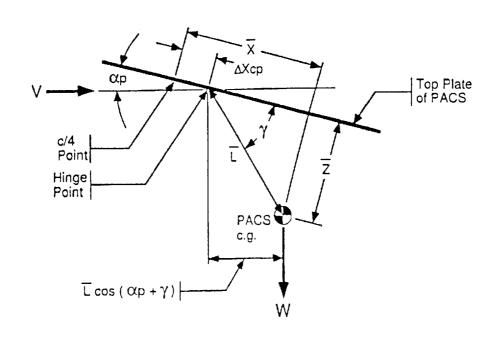


FIGURE 5.2-5, INDUCED MOMENT NOMENCLATURE

The distance from the pivot point to the PACS c.g. is given by the following equation.

$$L = ((x - \Delta X cp)^2 + (z)^2)^{1/2}$$

The angle between the top plate of the PACS, the pivot point, and the PACS c.g. is determined by the following equation.

$$\gamma = \tan^{-1}(z/(x-\Delta X cp))$$

The induced moment is therefore determined by the following equation.

$$\Delta MPACS(c.g.) = WPACSL \sin(\alpha_D + \gamma)$$

This methodology was applied to all the data and the induced moment, due to the offset in the PACS c.g., was removed from the data.

5.3 SUSPENSION LINE LIFT AND DRAG STUDY

A study was conducted to determine the percentage of vehicle lift and drag due to the suspension lines. Originally a value of 15% was quoted for the line drag value, which is normal for an average parafoil setup. However, due to the number of lines found in the ARS Parafoil (960) a new study was conducted. To conduct this study the configuration and data were taken from the 20×60 ft parafoil tested at NASA Ames Research Center in August 1988.

5.3.1 Parafoil Configuration

The parafoil configuration, shown in Figure 5.3-1, is the 20 x 60 ft, 1/3 scale model. In estimating the line lift and drag, since the parafoil is laterally symmetrical, half the model was analyzed. (The final values were then doubled.) The test case chosen was at $\alpha = 0.0$, L/D = 2.90. Figure 5.3-2 shows the longitudinal line geometry at the test case.

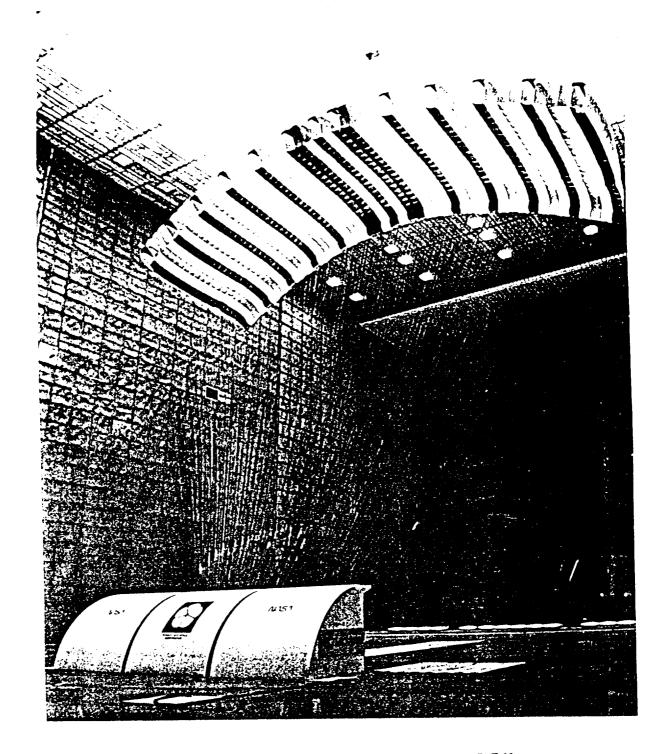


FIGURE 5.3-1, 20 FT X 60 FT PARAFOIL 1/3 SCALE MODEL

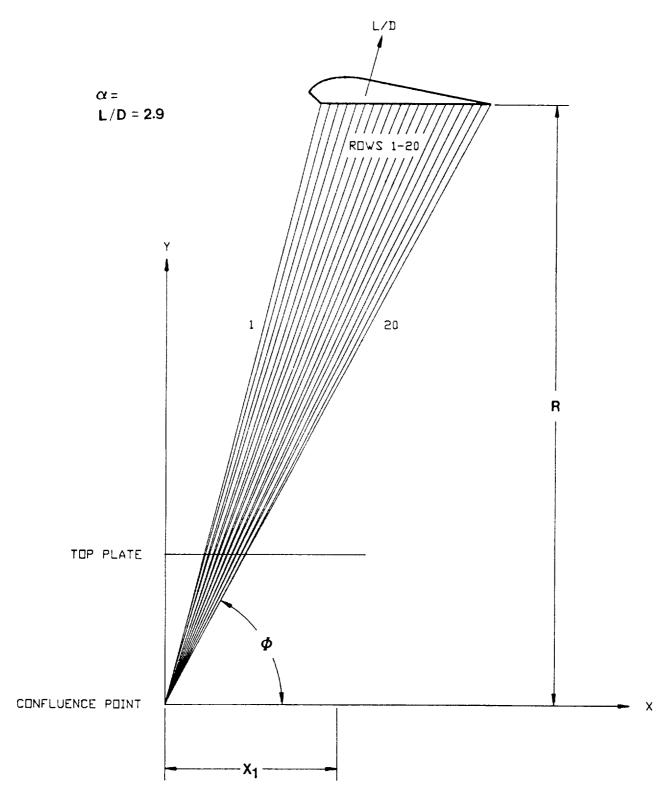


FIGURE 5.3-2, LONGITUDINAL LINE GEOMETRY

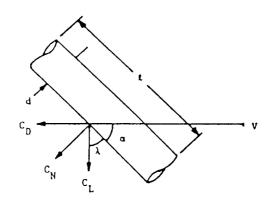
5.3.2 Drag Coefficient Estimate

As a means of comparison to the wind tunnel test case, which lists aero coefficients, a C_D for the suspension lines had to be determined. In <u>Fluid Dynamic Drag</u> (Hoerner, 1965) the Cross Flow Principle is used, which determines coefficients for flow around wires and cables. Figure 5.3-3 depicts the nomenclature for the Cross Flow Principle. To determine C_D the following equations are used:

where CD1 is the Drag Coefficient based on each line's reference area, CD2 the Drag Coefficient based on the total line reference area (105.87 $\rm ft^2$), CD3 the Drag Coefficient based on the parafoil reference area (1200 $\rm ft^2$) and ϕ is the angle of attack. Table 5.3-7 lists the values calculated for the angle ϕ , and Table 5.3-8 the values for A_{ref}1.

In the equations above the line diameter, D, was assumed to be 4.458×10^{-3} ft, or the average diameter of the lines under load. In determining the length, L, only the line length exposed to the flow was used. The following equation was used to obtain this length.

where LR is the length from the parafoil to the confluence point, LP the length from confluence point to the top plate, and LA the exposed length (see Figure 5.3-4). Tables 5.3-9 to 5.3-11 give values calculated for the line lengths, LA.



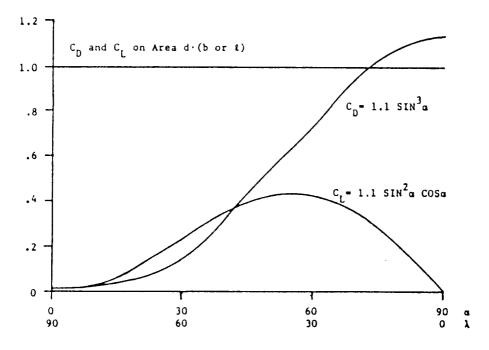


FIGURE 5.3-3, CROSS FLOW PRINCIPLE

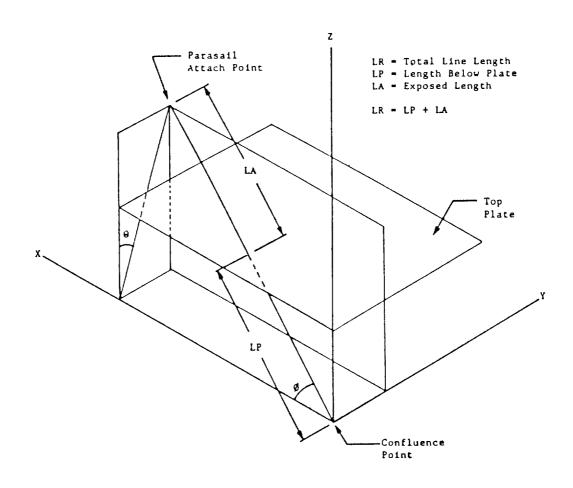


FIGURE 5.3-4, LINE LENGTH NOMENCLATURE

5.3.3 Drag Coefficient Results

Drag coefficients were calculated using equations derived in Section 5.3.2. The results for C_{D1} , C_{D2} and C_{D3} can be found in Tables 5.3-6, 5.3-7 and 5.3-8 respectively. The total C_{D} 's for the lines were found to be the following:

 $C_{D2T} = 1.73709$ (based on $A_{ref}2$) $C_{D3T} = 0.15326$ (based on $A_{ref}3$)

5.3.4 Lift Coefficient Estimate

A C_L for the suspension lines also had to be determined for comparison purposes. The same Cross Flow principle found in Fluid Dynamic Drag (Hoerner 1965)² is used. Figure 5.3-3 depicts the nomenclature for the Cross Flow Principle, and Figure 5.3-5 depicts the geometry for determining C_L. The following set of equations are used in calculating C_L:

 $C_{L1} = 1.10 \sin^2(\phi) * \cos(\phi) * \cos(\theta)$ Aref = Aref1 $C_{L2} = C_{L1} * Aref1/Aref2$ Aref = Aref2 $C_{L3} = C_{L2} * Aref2/Aref3$ Aref = Aref3

where C_{L1} is the Lift Coefficient based on each line's reference area, C_{L2} with Lift Coefficient based on the total line reference area (105.87 ft²), C_{L3} the Lift Coefficient based on the parafoil reference area (1200 ft²), ϕ is the angle of attack, and θ is the rotation angle in the YZ plane. Table 5.3-1 lists the values calculated for the angle ϕ , Table 5.3-9 the values for angle θ , and Table 5.3-3 the values for $A_{ref}1$.

In the equations above the line diameter, D, was assumed to be 4.458×10^{-3} ft, or the average diameter of the lines under load. In determining the length, L, only exposed the line length discussed in Section 5.3.2 was used.

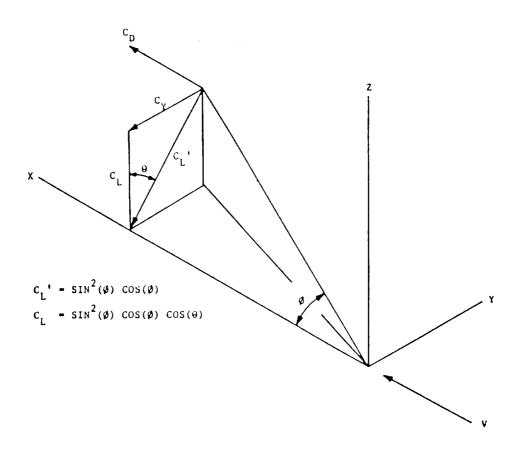


FIGURE 5.3-5, LIFT COEFFICIENT GEOMETRY

5.3.5 Lift Coefficient Results

Lift coefficients were calculated using equations developed in section 5.3.4. The results for C_{L1} , C_{L2} and C_{L3} can be found in Tables 5.3-10, 5.3-11 and 5.3-12 respectively.

The total CL's for the lines were found to be the following:

CL2T = -0.66988 (based on Aref2)

CL3T = -0.05910 (based on Aref3)

NOTE: The negative sign reflects that the line lift acts in the opposite direction of parafoil lift.

5.3.6 Comparison to Test Data

To determine the percentage of drag due to the lines a test point from the wind tunnel was selected having a similar set of parafoil attitude conditions. Shown in Figure 5.3-6 is the selected point with an $\alpha p = 0.2$ and an L/D of 2.93. As the figure shows:

$$C_D = 0.315895$$

and for the lines:

$$C_{D3T} = 0.15236$$

Therefore:

$$C_D$$
 Lines = 48.5% of total drag

In determining the percentage of lift due to the lines, the same test condition shown in Figure 5.3-6 was used. As the figure shows:

$$C_L = 0.927782$$

and for the lines:

$$C_{L3T} = -0.05910$$

Therefore:

C_L Lines = 6.4% of total Lift (negative sense)

N N	•	POINT	•	ACQU	ACQUIRED (9/12/88 AT 17:33: 1	AT 17	. 33:		TE PRINTED	DATE PRINTED 18/13/88		TIME PRINTED 15:32:63	5:32:63	COM		CONF 1.0 VEK 3	•
TUNNE	STUMMEL CONDITIONS	TIONS	6 6 1 1	; ; ;	! ! !		! ! !	1	! !	PACS		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		CONTRO	LINE	S	CONTROL LINES CONTROL, C	;
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ď	6.0463	6								THETA	96.36			CTL2	6.682	~		
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•	27.2 7		32.8	::	47.9	16	23.8	9	11.6	M	4.6 7	4.9	11	7.9 15	о. М	01		•
~	34.3	_	6.8 12	12	43.6 16	16	16.9	28	6.1	•	6.7 8	1.1	12	7.1 16	2.6	36		•
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רולוו	67	6732. PITCHU	ITCH	!	-813.	LIFTC		6732.	PITCHC	-813.	٦/١	2.937	17 CL	6.927782	١ –	¥	CMY -6.866681	
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SIDED	7	-156. ROLLU	TOLLU		-617.	SIDEC	ı	-166.	ROLLC	-617.			5	-8.821591	. !	×	CWX -0.861187	_

FIGURE 5.3-6, WIND TUNNEL TEST CASE

Chordwise Riser Line No.

		1	2	3	4	Б	6	7	8	9	16
	_	70 00501	75.34832	74.43865	73.53695	72.64356	71.75879	76.88293	76.61626	69.15982	68.31144
	1	76.26561 76.26561	75.34832	74.43865	73.53695	72.64356	71.75879	76.88293	78.61626	69.15962	68.31144
	2	78.26561	75.34832	74.43865	73.53695	72.64358	71.76879	78.88293	78.61526	69.15962	68.31144
	4	76.26561	75.34832	74.43865	73.53695	72.84358	71.75879	70.88293	76.61626	69.15902	68.31744
•	5	76.26561	75.34832	74.43865	73.53695	72.84358	71.75879	70.88293	76.61626	69.15962	68.31144
No	8	76.26561	75.34832	74.43865	73.53695	72.84358	71.75879	78.88293	76.61626	69.15962	68.31144 68.31144
	7	76.26561	75.34832	74.43865	73.53695	72.64356	71.76879	76.88293	70.61626	69.15962 69.15962	68.31144
Line	8	76.26581	75.34832	74.43865	73.53695	72.64356	71.75879 71.75879	76.88293 76.88293	70.01626 70.01626	69.15962	08.31144
-7	9	76.26561	75.34832	74.43865	73.53696	72.64356 72.64356	71.75879	76.88293	76.01626	69.15962	68.31144
-	1.	76.26561	75.34832	74.43865 74.43865	73.53695 73.53695	72.84356	71.75879	78.88293	78.81626	69.15962	68.31144
Sa .	11	76.26561	75.34832	74.43865	73.53695	72.64356	71.75879	78.88293	76.51626	69.15962	68.31144
ser	12	76.25561	75.34832 75.34832	74.43865	73.63696	72.64356	71.75879	76.88293	76.61626	69.15982	68.31144
. .	13	76.26561 76.26581	75.34832	74.43866	73.53695	72.64356	71.75879	76.88293	70.01626	69.15962	68.31144
α	14 15	76.26561	75.34832	74.43865	73.53695	72.84358	71.75879	76.88293	70.01626	69.15902	68.31144
as	18	76.26561	75.34832	74.43865	73.53695	72.84358	71.75879	76.88293	76.61626	89.15982	68.31144
se	17	76.26561	75.34832	74.43865	73.53695	72.64356	71.75879	70.88293	78.61626	69.16962	68.31144
	18	76.26581	75.34832	74.43865	73.53695	72.64356	71.75879	70.88293	76.01626	69.15962	68.31144
panwi	19	78.26561	75.34832	74.43865	73.53695	72.64356	71.75879	70.88293	78.81626	69.15962	68.31144
80	26	76.26561	75.34832	74.43865	73.53695	72.64358	71.75879	76.88293	76.81826	69.15902	68.31144 68.31144
SI	21	76.26561	75.34832	74.43865	73.53695	72.84358	71.75879	76.88293	78.61626	69.15962 69.15962	68.31144
	22	76.26561	75.34832	74.43865	73.63695	72.84358	71.75879	76.88293 76.88293	70.01626 70.01626	69.15962	68.31144
	23	76.26581	75.34832	74.43865	73.53695	72.84358	71.75879 71.75879	76.88293	76.61626	69.15962	68.31144
	24	78.26561	75.34832	74.43865	73.53695	72.64356	11.75075	10.00253	70.01020	00.10001	••••
		11	12	13	14	15	16	17	18	19	26
	1	67.47371	66.54652	65.82852	86.02137	64.22467	63.43852	62.66302	61.89822	61.14416	80.45689
	2	67.47371	66.54662	65.82852	65.02137	64.22467	63.43852	62.66362	61.89822	61.14416	60.46689
	ā	67.47371	66.64662	65.82852	65.02137	64.22467	63.43852	62.66362	61.89822	61.14416	60.4 66 89 60.4 66 89
	4	67.47371	66.64662	65.82852	66.02137	64.22467	63.43862	62.66362	61.89822 61.89822	61.14416	66.46689
	5	67.47371	66.84682	65.82852	65.62137	64.22467	63.43852 63.43852	62.663 <i>8</i> 2 62.663 <i>8</i> 2	61.89822	61.14416	68.46689
ċ	8	67.47371	66.84662	65.82852	66.62137	64.22467 64.22467	63.43852	62.66302	61.89822	61.14416	66.46689
No	7	67.47371	66.64682	65.82862	65.62137	64.22467	63.43862	62.66362	61.89822	61.14415	66.46689
a)	•	67.47371	66.64662	85.82852 85.82852	65.62137 65.62137	64,22467	63.43852	62.66362	61.89822	61.14416	68.4 66 89
Line	9	67.47371 67.47371	65.646 6 2 65.646 6 2	65.82862	65.82137	64.22467	63.43852	62.66362	61.89822	61.14416	58.4 66 89
=======================================	15	67.47371	66.84652	65.82852	65.62137	64.22467	63.43852	62.66302	61.89822	61.14416	58.40009
	12	67.47371	66.64662	65.82852	65.62137	64.22467	63.43852	62.863#2	61.89822	61,14416	66.4669
ser	13	67.47371	66.64662	65.82852	65.02137	64.22467	63.43852		61.89822	61.14416	60.4 66 89
86	14	67.47371		65.82852	85.62137	64.22467	63.43852		61.89822	61.14416	66.4 66 89
χ Ή	15	67.47371		65.82852	65.02137	64.22467	63.43852		61.89822	61.14416	60.4 06 89 80.4 06 89
	16	67.47371			65.82137	64.22467	63.43852		61.89822	61.14416	60.4 66 89
ë	17	67.47371			65.62137	64.22467	63.43852		61.89822	61.14416 61.14416	66.4 668 9
	18	67.47371			65.62137	64.22467	63.43852 63.43852		61.89822 61.89822	61.14416	66.46689
panvis	19	67.47371			85.02137	64.22467 64.22467	63.43852		61.89822	61.14416	68.46689
an	2.	67.47371			65.02137 65.02137	64.22467	63.43852		61.89822	61.14416	68.46689
å	21	67.47371			-	64.22467	63.43852		61.89822	61.14416	60.46689
S	22	67.47371				64.22467	63.43852		61.89822	61.14416	68.4 66 89
	23	67.47371 67.47371					63.43852		61.89822	61.14416	66.466891
	24	01.413/1	. 00.07002								

TABLE 5.3-7, PHI (LONGITUDINAL LINE ANGLE), deg

		1	2	3	4	Б	6	7	8	9	10
	1	8.21179	Ø.21262	6.21366	6.21444	6 01543					
	2	6.21179	6.21262	6.21366	6.21444	6.21543 6.21543	6.21648	6.21757	6.21872	6.21991	8.22116
	3	6.21179	6.21262	6.21356	0.21444	Ø.21543	6.21648	6.21757	6.21872	0.21991	0.22116
	4	6.21167	8.21256	0.21339	6.21432	6.21532	6.21648	6.21757	6.21872	6.21991	0.22116
	5	6.21167	6.21256	6.21339	6.21432	6.21532 6.21532	0.21636	6.21745	6.21866	6.21979	0.22184
No	8	6.21167	6.21256	6.21339	6.21432	6.21532	0.21636 0.21636	6 .21746	5.21866	6.21979	0.22104
	7	6.21134	6.21217	0.21366	6.21406	6.21499	Ø.21683	6 .21745	6.21860	6.21979	8.22184
ne	8	6.21134	8.21217	6.21366	6.21486	8.21499	6.21663	6.21712	6.21827	8.21946	8.22676
.5	9	8.21134	6.21217	8.21366	6.21466	8.21499	6.21603	Ø.21712	6.21827	8.21946	8.22878
Li	16	8.21888	6.21163	8.21251	0.21346	0.21444	6.21548	0.21712 6.21657	6.21827	8.21946	6.22676
	11	0.21080	6.21163	6.21251	0.21345	0.21444	6.21548	6.21657	6.21771	8.21891	6.22615
er	12	0.21586	6.21163	6.21251	6.21345	6.21444	0.21548	6.21657	6.21771	8.21891	0.22016
S	13	8.21864	8.21686	5.21174	6.21268	6.21366	Ø.21476	Ø.21579	6.21771 6.21693	6.21891	0.22015
Ri	14	0.21664	6.21686	6.21174	6.21268	6.21366	8.21478	6.21579	0.21693	6.21812	Ø.21936
14	15	6.21964	6.21686	6.21174	6.21268	8.21366	6.21478	6.21579	6.21693	6.21812	0.21936
a	16	6.25963	6.25985	6.21673	6.21166	6.21265	6.21368	6.21476	6.21596	0.21812	0.21936
9	17	6.2 596 3	6.26985	6.21673	Ø.21166	6.21265	6.21368	6.21476	6.21596	6.21768	0.21832
3	18	6.28963	6.26986	6.21673	6.21166	6.21265	6.21368	6.21476	5.21596	0.21708	0.21832
<u> </u>	19	6.25776	6.26858	6.26946	6.21838	6.21136	6.21239	6.21347	6.21466	Ø.217Ø8	0.21832
Spanwi	2.	8.28776	6.26858	6.25946	6.21638	6.21136	0.21239	6.21347	0.21466	0.21578	0.21701
S	21	5.25776	6.288 58	8.28946	6.21638	6.21136	6.21239	0.21347	0.21466	Ø.21578	0.21701
	22	6.26626	6.26762	6.26789	0.20881	6.26978	6.21881	6.21188	6.21361	0.21578	6.21761
	23	8.26625	6.26762	6.26789	6.26881	5.28978	6.21881	Ø.21188	6.21361	6.21418	0.21546
	24	6.26628	8.28782	6.26789	6.26881	8.28978	8.21681	5.21188	6.21361	6.21418 6.21418	0.21546
									0.21301	D.21410	8.21546
		11	12	13	14	15	16	17	18	19	28
	1	0.22245	6.22379	6 .22518	6.22661	6.22869	6.22961	6.23118	6.23279	6.23443	Ø.23612
	2	6.22245	8.22379	6.22518	6.22661	6.22869	6.22961	6.23118	6.23279	8.23443	Ø.23612
	3	0.22245	6.22379	6.22518	6.22661	6.22889	6.22961	6.23118	6.23279	Ø.23443	Ø.23612
No	4	0.22233	6.22367	6.22586	6.22649	0.22797	5.22949	6.23165	Ø.23266	0.23431	0.23666
Z	5	Ø.22233	6.22367	Ø.225Ø6	6.22649	6.22797	6.22949	0.23185	6.23286	0.23431	0.23666
a)	5	6.22233	6.22367	6.22566	0.22649	6.22797	6.22949	6.23165	6.23266	6.23431	6.23666
ne	7	6.22199	6.22333	5.22472	6.22615	6.22762	6.22914	6.23671	6.23231	6.23396	0.23564
Ξ.	8	6.22199	0.22333	6.22472	6.22615	8.22762	6.22914	6.23671	6.23231	6.23396	6.23564
	9	6.22199	0.22333	6.22472	6.22615	6.22762	0.22914	5.23571	5.23231	5.23396	8.23584
L.	16	6.22144	6.22277	0.22415	Ø.22558	0.22705	6.22857	6.23613	6.23173	6.23337	0.23566
se	11	6.22144	6.22277	6.22415	6.22558	0.22765	Ø.22857	6.23613	0.23173	6.23337	Ø.23586
	12	6.22144	6.22277	6.22415	6.22558	0.22705	8 .22857	6.23613	6.23173	0.23337	0.23566
\simeq	13	6.22664	6.22197	6.22335	6.22478	6.22624	5 .22776	6.22931	6.23691	6.23254	Ø.23422
မ	14	Ø.22864	6.22197	6.22335	6.22478	6.22624	6.22776	6.22931	6.23691	6.23254	Ø.23422
t q	15	6.22864	6.22197	6.22335	6.22478	6.22624	6.22776	6.22931	6.23691	6.23254	0.23422
panwi	16 17	5.21965	6.22693	6.22236	6.22372	6.22510	6.22669	6.22823	6.22982	6.23146	Ø.23313
ć		6.21966	8.22693	6.22236	6.22372	6.22518	5.22669	6.22823	6.22982	Ø.23145	Ø.23313
ğ	18	8.21968 5.21928	6.22693	6.22236	5.22372	6.22518	8.22669	6.22823	6.22982	6.23145	Ø.23313
Sp	19 2 6	5.2182B	6.21968	6.22597	6.22238	6.22384	6.22534	5 .22588	6.22925	6.23668	6.23174
•		5.21828 5.21828	6.21966	6.22697	6.22238	6.22384	0.22534	Ø.22688	8.22926	6.23668	6.23174
	21 22	6.21828	6.21966	6.22697	6.22238	6.22384	6.22534	6.22688	8.22926	6.23668	6.23174
	23	8.21667 6.21667	8.21798	0.21934	6.22574	6.22219	0.22368	●.22521	6.22678	8.22846	0.23066
	24	6.21667 6.21667	6.21798 4.21798	6.21934	6.22674	6.22219	.22368	●.22521	6.22678	8.22846	6.23665
	47	J. 4100/	0.21798	8.21934	8.22874	6.22219	6 .22368	●.22521	●.2267B	6.22846	6.23665

TABLE 5.3-8, AREF1 (LINE REFERENCE AREA), ft²

OF POOR QUALITY

		1	2	3	4	5	6	7	8	9	16
		59.38813	59.82969	69.88526	66.15828	60.44212	60.74252	61.05725	61.38611	61.72886	62.08527
	1 2	69.38813	59.82969	59.88526	60.15628	66.44212	60.74252	61.65725	61.38611	61.72886	62.08527
	3	59.38813	59.62969	59.88520	60.15628	60.44212	60.74252	61.85725	61.38611	61.72886	82.88527
	4	59.38813	59.62969	59.88525	60.15828	88.44212	68.74252	61.05725	61.38611	61.72886	62.08527 62.08527
ċ	6	59.38813	59.62969	59.8852Ø	60.15828	66.44212	80.74252	61.85725	61.38611	61.72886 61.72886	82.88527
No	6	59,38813	59.62969	59.88526	66.15628	60.44212	80.74252 80.74252	61.05725 61.05725	61.38611	61.72886	62.68527
n)	7	59.38813	59.62969	59.88525	66.15628	60.44212 60.44212	60.74252	61.86725	61.38611	61.72886	62.88527
ne	8	69.38813	59.82969	59.88526 59.88526	60.15828 60.15828	68.44212	60.74252	61.65725	61.38611	61.72886	62.68527
Li	9	59.38813	59.629 6 9 59.629 6 9	59.88526	66.15628	60.44212	60.74252	61.65725	61.38611	61.72886	82.08527
	18	59.38813 59.38813	59.82969	59.88526	66.15628	80.44212	88.74252	61.85725	61.38611	61.72886	62.88527
er	11 12	59.38813	59.62969	59.88526	66.15628	60.44212	60.74252	61.65725	61.38611	61.72886	62.88527
S	13	59.38813	59.62969	69.88626	68.15828	60.44212	80.74252	61.65725	61.38611	61.72886	62.88627
Ri	14	59.38813	59.82969	59.88525	65.15628	60.44212	60.74252	61.05725	61.38611	61.72886	62.88527
	15	59.38813	59.82969	59.88526	65.15628	66.44212	66.74252	61.65725	61.38611	61.72886	62.08527 62.08527
se	15	59.38813	59.62969	59.8852 5	60.15628	66.44212	66.74252	61.65725	61.38611	61.72886 61.72886	62.88527
•==	17	59.38813	59.629 69	59.8852 6	66.15628	86.44212	60.74252	61.65725 61.65725	61.38611	61.72886	62.68527
₹	18	59.38813	59.62969	59.88526	66.15828	66.44212	66.74252 66.74252	61.85725	61.38611	61.72886	62.88527
panwi	19	59.38813	59.62969	59.88525	66.15628 66.15628	66.44212 66.44212	66.74252	61.65725	61.38611	61.72886	62.68527
Sp	26	59.38813	59.62969	59.88526 59.88526	60.15628	68.44212	60.74252	61.65725	61.38611	61.72886	62.88527
01	21	59.38813	59.62969 59.62969	59.88520	68.15628	66.44212	66.74252	61.65725	61.38611	61.72886	62.68627
	22 23	59.38813 59.38813	59.62969	59.88626	60.15628	66.44212	66.74252	61.65725	61.38611	61.72886	62.58527
	24	59.38813	59.62969	59.88526	68.15628	68.44212	68.74252	61.65725	61.38611	61.72886	62.88527
		00.00015	•••••								
		11	12	13	14	15	16	17	18	19	25
	1	62.46511	62.83815	63.23414	63.64284	64.66461	64.49748	64.94277	65.39987	65.86847	66.34831
	2	62.45511	82.83815	83.23414	63.64284	64.86481	64.49740	64.94277	65.39987	65.86847	66.34831
	3	62.45511	62.83815	63.23414	63.64284	64.86461	64.49746	64.94277	66.39987	65.86847	66.34831
	4	62.45511	62.83815	63.23414	63.64284	64.66461	64.49746	84.94277	65.39987	65.86847	66.34831 66.34831
å	5	62.45511	62.83815	63.23414	63.64284	64.66401	84.49746	64.94277 64.94277	65.39987 65.39987	65.86847 65.86847	66.34831
N _O	6	62.45511	62.83815	83.23414	63.64284	64.66461	64,49746 64,49746	84.94277	65.39987	65.86847	66.34831
വ	7	62.45511	62.83815	63.23414	63.64284	64.66461 64.66461	64.49746	64.94277	65.39987	65.86847	66.34831
Line	8	62.45511	62.83815	83.23414 83.23414	63.64284	64.86481	64.49748	64.94277	65.39987	65.86847	66.34831
Ξ	9	62.45511	62.83815 62.83815	63.23414	63.64284	64.86481	64.49746	64.94277	65.39987	65.86847	66.34831
	1 5 11	62.45511 62.45511	62.83815	63.23414	63.64284	64.56461	64.49746	64.94277	65.39987	65.86847	66.34831
er	12	82.45511	62.83815	63.23414	63.64284	64.66461	64.49746	64.94277	65.39987	66.86847	66.34831
W	13	62.45511	62.83815	63.23414	63.64284	64.66461	64.49746	64.94277	65.39987	65.86847	66.34831
Ri	14	62.45511	62.83815	63.23414	63.64284	64.66461	64.49748	64.94277	65.39987	65.86847	66.34831 66.34831
	15	62.45511	62.83815	63.23414	63.64284	64.56461	64.49746	64.94277	65.39987 65.39987	65.86847 65.86847	66.34831
e e	16	62.45511	62.83815	63.23414	63.64284	64.86461	64.49748	64.94277 64.94277	65.39987	65.86847	66.34831
· <u>=</u>	17	62.45511	62.83815	63.23414	63.64284	64.66461 64.66461	64.49746 84.49746	64.94277	65.39987	65.86847	66.34831
ź	18	82.46511	62.83815	63.23414	63.64284 63.64284	64.66461	64.49746	64.94277	65.39987	66.86847	66.34831
Spanwise	19	62.45511	62.83815 62.83815	63.23414 63.23414	63.64284	64.66461	64.49746	64.94277	65.39987	65.86847	66.34831
Sp	25	82.45511 82.45511	62.83815	63.23414	63.64284	64.86481	64.49746	64.94277	65.39987	65.86847	66.34831
	21 22	62.45511	62.83815	63.23414	63.64284	64.86461	64.49746	64.94277	65.39987	65.86847	66.34831
	23	62.45511	62.83815	63.23414	63.64284	64.86461	64.49748	64.94277	65.39987	66.86847	66.34831
	24	62.45511		63.23414	63.64284	64.66461	84.49746	64.94277	65.39987	65.86847	66.34831

TABLE 5.3-9, LR (LENGTH TO CONFLUENCE POINT), ft

		1	2	3	4	6	6	7	8	9	16
	1	11.88699	11.93558	11.99317	12.85366	12.11767	12.18329	12.25233	10 20452		
	2	11.88699	11.93558	11.99317	12.85366	12.11767	12.18329	12.25233	12.32469	12.39865	12.47570
	3	11.88099	11.93558	11.99317	12.85366	12.11767	12.18329	12.25233	12.32469	12.39855	12.47576
	4	11.96715	11.96182	12.81945	12.68664	12.14352	12.26982	12.27896	12.35085	12.39855	12.47576
N _o	5	11.90715	11.96182	12.61945	12.08004	12.14352	12.20982	12.27896	12.35085	12.42541 12.42541	12.50266
Z	6	11.96715	11.96182	12.61946	12.08004	12.14352	12.20982	12.27896	12.35085	12.42541	12.5 0 266 12.5 0 266
ne	7	11.98618	12.03563	12.69285	12.15365	12.21734	12.28392	12.35336	12.42547	12.50038	12.57792
2	8	11.98618	12.83583	12.69285	12.15385	12.21734	12.28392	12.36336	12.42547	12.50038	12.57792
Ľi	9	11.98018	12.03503	12.69285	12.15365	12.21734	12.28392	12.35330	12.42547	12.50038	12.57792
	15	12.16148	12.15666	12.21478	12.27591	12.33999	12.40706	12.47683	12.54945	12.62487	12.70296
63	11	12.10148	12.15886	12.21478	12.27591	12.33999	12.46766	12.47683	12.54945	12.62487	12.78296
se	12	12.10148	12.15866	12.21478	12.27591	12.33999	12.4 6 766	12.47683	12.54945	12.62487	12.70296
Ri	13 14	12.27345 12.27345	12.32898	12.38761	12.44925	12.51387	12.58147	12.65192	12.72522	12.80136	12.88021
14	15	12.27346	12.32898	12.38761	12.44925	12.51387	12.58147	12.85192	12.72522	12.80136	12.88621
a)	16	12.49949	12.55557	12.38761	12.44925	12.51387	12.58147	12.65192	12.72522	12.80136	12.88821
1.6	17	12.49949	12.55557	12.61478 12.61478	12.67707 12.67707	12.74242	12.81086	12.88209	12.95629	13.03334	13.11320
panwi	18	12.49949	12.55557	12.61478	12.67787	12.74242	12.8188	12.88269	12.95829	13.63334	13.11326
ä	19	12.78432	12.84169	12.96164	12.96418	12.74242 13.83642	12.81080	12.88209	12.95629	13.03334	13.11326
ď	25	12.78432	12.84169	12.96184	12.96418	13.83842	13.89976	13.17209	13.24742	13.32569	13.46678
S	21	12.78432	12.84189	12.96104	12.96418	13.83842	13.59976	13.17269	13.24742	13.32569	13.40678
	22	13.13417	13.19178	13.25266	13.31683	13.38421	13.45472	13.17269 13.52837	13.24742	13.32569	13.46678
	23	13.13417	13.19178	13.25266	13.31683	13.38421	13.46472	13.52837	13.60505 13.60505	13.68477	13.76746
	24	13.13417	13.19178	13.25266	13.31683	13.38421	13.46472	13.52837	13.60505	13.68477	13.76746
								10.0203,	13.00000	13.68477	13.76746
		11	12	13	14	15	16	17	18	19	26
	1	12.55542	12.63773	12.72250	12.80972	12.89946	12.99138	13.68572	13.18226	13.28186	13.38197
	2	12.55542	12.63773	12.72256	12.86972	12.89946	12.99138	13.68572	13.18226	13.28106	13.38197
	3	12.55542	12.63773	12.72250	12.80972	12.89945	12.99138	13.68572	13.18226	13.28106	13.38197
· ·	4	12.68263	12.86495	12.74985	12.83725	12.92786	13.61918	13.11366	13.21841	13.36931	13.41843
No	5	12.58253	12.66495	12.74985	12.83725	12.92766	13.61918	13.11366	13.21841	13.36931	13.41843
a)	6 7	12.58253	12.66495	12.74985	12.83725	12.92706	13.61918	13.11366	13.21641	13.30931	13.41043
Line	8	12.65813 12.65813	12.74688	12.82619	12.91399	13.66416	13.69676	13.19164	13.28886	13.38823	13.48984
· -	9	12.65813	12.74 6 88 12.74 6 88	12.82619	12.91399	13.66416	13.69676	13.19164	13.28885	13.38823	13.48984
	19	12.78371	12.88766	12.82619 12.95366	12.91399	13.56416	13.89676	13.19164	13.28885	13.38823	13.48984
ser	11	12.78371	12.86766	12.95366	13.64141 13.64141	13.13228	13.22559	13.32121	13.41914	13.51937	13.62175
9	12	12.78371	12.86766	12.95366	13.64141	13.13228 13.13228	13.22559	13.32121	13.41914	13.51937	13.62175
	13	12.96175	13.64594	13.13277	13.22216	13.31393	13.22559	13.32121	13.41914	13.51937	13.62175
α	14	12.96175	13.64594	13.13277	13.22216	13.31393	13.4Ø824 13.4Ø824	13.50496	13.66396	13.70523	13.86876
a	15	12.96175	13.64594	13.13277	13.22216	13.31393	13.46824	13.56496	13.66396	13.70523	13.86876
(2)	16	13.19586	13.28111	13.36966	13.45961	13.55271	13.54834	13.50496	13.66396	13.70523	13.86876
Spanwi	17	13.19586	13.28111	13.36966	13.45961	13.55271	13.54834	13.74637 13.74637	13.84679	13.94955	14.65459
Ē	18	13.19586	13.28111	13.36966	13.45961	13.55271	13.64834	13.74637	13.84679 13.84679	13.94955	14.85459
D.B	19	13.4 96 74	13.57742	13.66687	13.75897	13.85364	13.95691	14.55564	13.98661	13.94965 14.25745	14.85459
<u></u>	26	13.49674	13.57742	13.66687	13.75897	13.85364	13.95891	14.85864	13.98661	14.25745	14.36442 14.36442
	21	13.49674	13.57742	13.56687	13.75897	13.85364	13.95691	14.65664	13.98661	14.25745	
	22	13.85361	13.94145	14.63269	14.12663	14.22336	14.32256	14.42445	14.52887	14.63575	14.36442 14.745 6 1
	23	13.85361	13.94145	14.63269	14.12663	14.22336	14.32256	14.42445	14.52887	14.63576	14.74501
	24	13.85381	13.94146	14.83269	14.12663	14.22336	14.32258	14.42445	14.52887	14.63578	14.74501

TABLE 5.3-10, LP (LENGTH OF CONFLUENCE POINT TO TOP PLATE), ft

		1	2	3	4	5	6	7	8	9	16
		•	•					48.86492	49.66261	49.33030	49.60957
	1	47.50714	47.69351	47.89253	48.16262	48.32505	48.55923 48.55923	48.86492	49.56281	49.33836	49.68957
	2	47.50714	47.69351	47.89263	48.16262	48.32505	48.55923	48.86492	49.66261	49.33838	49.66957
	3	47.50714	47.89351	47.89263	48.10262	48.32505 48.29859	48.53269	48.77829	49.03526	49.30345	49.58261
	4	47.48098	47.66726	47.86575	48.67624	48.29859	48.53269	48.77829	49.03526	49.30345	49.58261
•	5	47.48098	47.66726	47.86575 47.86575	48.67624 48.67624	48.29859	48.53269	48.77829	49.03526	49.30345	49.58261
N _o	6	47.48698	47.68728	47.79235	48.00262	48.22478	48.45859	48.78396	48.96663	49.22848	49.50735
	7	47.46795	47.594 6 6 47.594 6 6	47.79235	48.86262	48.22478	48.45859	48.70396	48.96063	49.22848	49.50735
ne	8	47.40795 47.40795	47.59466	47.79235	48.56262	48.22478	48.45859	48.76396	48.96663	49.22848	49.50735
	9	47.28865	47.47248	47.67842	47.88636	48.10213	48.33551	48.58643	48.83665	49.10398	49.38231
Li	1 5 11	47.28665	47.47248	47.87842	47.88636	48.10213	48.33651	48.58043	48.83665	49.10398	49.38231
5 4	12	47.28665	47.47248	47.67642	47.88636	48.10213	48.33551	48.58643	48.83665	49.10398	49.38231 49.26566
ser	13	47.11468	47.36616	47.49759	47.76763	47.92825	48.16106	48.40633	48.66088	48.92750	49.28586
1.8	14	47.11468	47.36616	47.49759	47.76763	47.92825	48.16165	48.40533	48.66Ø88 48.66Ø88	48.92750 48.92750	49.28506
œ	15	47.11468	47.35615	47.49759	47.70703	47.92825	48.16105	48.46533	48.42982	48.69552	48.97268
a)	16	46.88864	47.87352	47.27842	47,47925	47.69976	47.93172	48.17516 48.17516	48,42982	48.69552	48.97258
se	17	46.88864	47.87352	47.27842	47.47920	47.69978	47.93172	48.17516	48.42982	48.69552	48.97258
panwi	18	46.88864	47.57352	47.27642	47.47926	47.89978	47.93172 47.64276	47.88517	48.13869	48.40317	48.87849
Ž	19	46.60381	46.78866	46.98416	47,19269	47.41176 47.41176	47.84278	47.88517	48.13869	48.40317	48.67849
(g)	25	46.66381	46.78866	46.98416	47.19269	47.41178	47.64276	47.88517	48.13869	48.46317	48.57849
Sp	21	46.60381	46.78866	48.98416	47.19269	47.86791	47.28786	47.52888	47,78166	48.64468	48.31781
٠.	22	46.25396	46.43736	46.63254	46.83945 46.83945	47.85791	47.28786	47.52888	47.78166	48.54458	48.31781
	23	46.25396	46.43736	46.63254	46.83945	47.85791	47.28786	47.52888	47.78166	48.64468	48.31781
	24	46.25396	46.43736	46.63254	40.03540	41.50.01					
		11	12	13	14	16	16	17	18	19	20
		49.89976	58.25642	58.51164	50.83312	51.16461	51.50602	51.85705	52.21761	52.58741	52.96634
	1 2	49.89976	58.28642	58.51164	50.83312	51.16461	51.50602	51.85706	52.21761	52.58741	52.96634 52.96634
	3	49.89978	58.28642	58.51164	50.83312	51.16461	51.50602	51.85705	52.21761	52.58741	52.93788
:	4	49.87259	58.17326	56.48429	50.80559	51.13695	51.47822	51.82911	52.18947	52.55916 52.55916	52.93788
S	Š	49.87259	58.17328	58.48429	58.86559	51.13695	51.47822	51.82911	52.18947 52.18947	52.55916	52.93788
	6	49.87259	56.17325	58.48429	58.86559	51.13696	51.47822	51.82911 51.75113	52.11183	52.48624	52.85847
ne	7	49.79698	58.69727	58,46795	56.72885	51.85984	51.46663 51.46663	51.75113	52.11103	52.48824	52.85847
Ë	8	49.79698	50.09727	56.46795	50.72885	51. 6 5984 51. 6 5984	51.46663	51.75113	52.11163	52.48624	52.85847
-	9	49,79698	58.69727	58.46795	58.72886	58.93173	51.27181	51.62158	51.98674	52.34916	52.72556
L	18	49.67141	49.97169	58.28114	55.66143	58.93173	51.27181	51.82158	51.98074	52.34916	52.72656
ser	11	49.67141	49.97169	56.28114	50.66143 50.66143	58.93173	51.27181	51.62156	51.98074	52.34916	52.72656
	12	49.87141	49.97159	58.28114 58.18137	50.42074	50.75008	51.88916		51.79598	52.16324	52.53955
Œ	13	49.49336	49.79221	56.15137	56.42574	50.75008	51.68916		51.79598	52.16324	52.53955
a)	14	49.49338	49.79221 49.79221	58.18137		50.75008	51.68916	51.43787	51.79598	52.16324	62.53965
ŭ	15	49,49336	49.55784			50.51130	50.84966	51.19648	51.55308	51.91892	52.29372
.2	18 17	49.25931 49.25931	49.55784	49.86588			58.84966		51.55388	51.91892	52.29372 50.29372
Ξ	18	49.25931	49.55764	49.86508		50.51130	58.84966	51.19640	51.55308	51.91892	52.29372 51.98389
Spanwise	. 19	48.98438	49.26673	49.58727	49.88387		56.54648		51.41326	51.61162	
Š	20	48.96438	49.28673	49.56727	49.88387		50.54648		51.41326	51.61162	61.98389
	21	48.96438	49.28673		49.88387		58.54648		51.41326 FA 97181	51.61162 51.23276	61.66336
	22	48.56211	48.89676				55.17484		50.87161 50.87161	51.23276	51.66336
	23	48.66211	48.89676				58.17484				· · · · · · · · · · · · · · · · · · ·
	24	48.88211	48.89676	49.26146	49.51621	49.84671	58.17484	58.51832	DW . 0 / 10 1	51.152/0	

TABLE 5.3-11, LA (EXPOSED LENGTH), ft

CHICLARL PAGE IS OF FUOR QUALITY

Chordwise Riser Line No.

		1	2	3	4	6	6	7	8	9	10
	1	1.56831	8.99614	6.98341	6.97618	6.95648	6.94236	6.92786	6.91363	6.89796	0.88253
	2	1.66831	Ø.99614	6.98341	6.97618	6.95648	0.94236	6.92786	6.91363	6.89796	Ø.88253
	3	1.00831	8.99614	0.98341	6.97618	0.95648	0.94236	6.92786	6.91363	6.89796	Ø.88263
•	4	1.66831	8.99614	6.98341	6.97018	0.95648	6.94236	6.92786	6.91363	6.89796	Ø.88263
No	5	1.00831	8.99614	6.98341	6.97618	8.95648	0.94236	6.92786	6.91363	6.89796	0.88253
Z	6	1.66831	8.99614	6.98341	6.97018	8.95648	0.94236	5.92785	6.91363	6.89796	Ø.88253
o	7	1.00831	8.99614	6.98341	6.97618	0.95848	6.94236	6.92786	6.91363	0.89790	0.88253
Line	8	1.86831	B.99514	6.98341	8.97018	8.95648	8.94236	6.92786	6.91363	6.89796	₫.88253
ij	9	1.86831	8.99614	6.98341	6.97018	6.95848	6.94236	6.92786	6.91363	6.89796	0.88253
	18	1.66831	8.99614	6.98341	0.97018	0.95648	6.94236	6.92786	6.91303	6.89796	0.88253
er	11	1.86831	8.99614	6.98341	6.97018	0.95648	6.94236	5.92786	6.91363	6.89796	8.88253
86	12	1.00831	8.99614	6.98341	6.97018	8.95848	0.94236	8.92786	6.91363	6.89796	Ø.88253
•••	13	1.66831	8.99614	5.98341	6.97018	Ø.95648	6.94238	6.92786	6.91363	Ø.8979 Ø	Ø.88253
œ	14	1.00831	8.99614	6.98341	6.97618	6.95848	6.94236	5.92786	6.91363	6.89796	Ø.88253
Ð	15	1.66831	8.99614	6.98341	6.97018	6.95548	6.94236	6.92786	6.91363	6.89796	Ø.88253
9	16	1.66831	6.99614	6.98341	6.97018	6.95648	6.94236	6.92786	8.91383	6.89796	0.882 53
 3	17	1.00831	6.99614	6.98341	6.97618	6.95648	6.94235	6.92786	6.91363	Ø.8979Ø	Ø.88253
ā	18	1.66831	6.99614	6.98341	6.97618	6.95648	0.94236	6.92786	6.91363	6.89796	Ø.88253
panw	19	1.66831	6.99614	6.98341	6.97618	5.95648	0.94235	5.92785	6.91363	6.89796	Ø.88253
S	26	1.00831	6.99614	6.98341	6.97618	9.95648	6.94236	5.92786	8.91383	6.89796	0.88253
	21	1.66831	6.99614	6.98341	6.97618	5.95648	6.94236	6.92786	6.91363	6.89796	Ø.88253
	22	1.66831	6.99614	6.98341	6.97018	6.95848	6.94236	6.92786	6.91363	Ø.8979Ø	Ø.88253
	23	1.66831	8.99614	0.98341	6.97618	0.95648	0.94236	6.92786	6.91363	Ø.89796	6 .88253
	24	1.66831	8.99614	6.98341	6.97618	8.95648	6.94236	6.92786	6.91363	6.89796	0.88253
		11	12	13	14	15	16	17	18	19	26
	1	8.86694	6.85119	Ø.8363Ø	6.81931	Ø.8Ø325	6.78717	6.77169	6.75503	6.73963	6.72311
	2	6.86694	8.85119	6.83536	6.81931	6.86325	6.78717	6.77189	6.75503	6.73963	0.72311
•	3	6.86694	6.85119	6.83536	8.81931	8.86325	Ø.78717	6.77189	6.75503	6.73963	0.72311
No	4	6.86694	6.85119	6.83536	6.81931	0.86325	6.78717	6.77169	6.75583	6.73963	0.72311
	5	6.86694	8.85119	6.83536	5.81931	6.86325	6.78717	6.77189	8.75583	6.73963	0.72311
ne	6	6.86694	6.85119	Ø.8353 6	6.81931	6.86325	6.78717	6.77169	6.76563	8.73963	6.72311
in	7	6.88894	6.85119	6.83536	6.81931	6.86325	Ø.78717	6.77189	6.75563	6.73963	0.72311
ii.	8	6.86694	6.85119	0.83536	6.81931	0.86325	6.78717	6.77189	6.75563	8.73963	0.72311
1.	9	6.86694	8.85119	Ø.8353Ø	Ø.81931	6.86325	0.78717	8.77189	6.75563	6.73963	6.72311
ser	18	6.86694	8.85119	6.83536	5.81931	6.86325	Ø.78717	6.77189	6.75503	6.7396 3	Ø.72311
	11	6.86694	6.85119	Ø.8353 6	6.81931	Ø.8 6 325	6.78717	6.77189	6.75503	6.73963	6.72311
⊼ i	12	6.86694	8.85119	Ø.8353 Ø	6.81931	6.86325	Ø.78717	6.77169	6.75563	6.73963	6.72311
j i-4	13	6.86694	8.85119	6.83536	8 .81931	6.86325	5 .78717	6.77169	6.75503	0.73963	0.72311
ð	14	9.86694	8.85119	6 .8353 6	6.81931	6.86325	Ø.78717	6.77169	6.75563	6 .73963	0.72311
	15	5.86694	6.85119	6.83536	6.81931	6.86325	Ø.78717	6.77169	6.75563	6 .739 6 3	8.72311
3	16	8.88694	6.85119	6.83536	6.81931	Ø.8Ø325	0.78717	6.77109	8.75503	6.73963	Ø.72311
E C	17	6.86694	6.85119	6.83536	6.81931	Ø.8 6 325	Ø.78717	6.77169	6.75503	6.73963	6.72311
panwise	18	5.86694	6.85119	6.83536	6.81931	6.86325	6.78717	6.77169	6.75563	6.73963	6.72311
S	19	6.86694	6.85119	6.83536	6.81931	6.86325	6.78717	6.77109	6.75563	6.73963	0.72311
	26	8.86694	6.85119	6.83536	6.81931	Ø.86325	6.78717	0.77169	6.75563	0.73963	0.72311
	21	6.86694	8.85119	6.83536	6.81931	6.86325	6.78717	8.77169	6.75563	0.73963	6.72311
	22 23	5.86694	6.85119 6.85119	6.83536	6.81931	6.88325	6.78717	6.77169	0.75503	6.73963	6.72311
	ッす	5 .86694									
	24	9.86694	0.85119	0.8353 <i>0</i> 0.8353 <i>0</i>	6.81931 6.81931	6.8 6 325 6.86 325	6.78717 6.78717	6.771 89 6.771 89	0.75503 0.75503	0.73963 0.73963	6.72311 6.72311

TABLE 5.3-12, CDI (DRAG COEFFICIENT BASED ON INDIVIDUAL REF AREA)

Chordwise Riser Line No.

		1	2	3	4	6	6	7	8	9	16
	1	6.86262	6.66256	6.66198	6.66197	8.00195	6.66193	6.86191	6.66189	0.60187	0.00184
	2	6.66262	6.66266	6.56198	6.66197	6.66195	6.66193	Ø. 80 191	6.66189	6.60187	6.00184
	3	6.66282	6.66266	6.56198	6.60197	6.00195	0.00193	0.00191	6.66189	0.00187	0.06184
	4	6.00202	6.86286	6.86198	8.86196	6.00195	6.60193	6.66191	6.66189	0 . 60 186	6.66184
å	Ď	6.60282	6.66266	6.66198	0.00196	0.00195	0.00193	6.66191	0.00189	0.00186	0.66184
No	8	6.86282	6.66256	6.66198	6.66196	6.00195	0.00193	0.00191	6.00189	0 . 00 186	0.00184
au	7	6.86281	6.86256	6.66198	0.00198	6.00194	0.66192	0.00190	0 .00188	0.00186	0.66184
ĭ	8	6.60261	6.66266	6.66198	0.00196	6.60194	0.00192	0.00190	6 .06188	0.00 186	0.66184
-⊶	9	6.86261	6.66266	6.66198	8.86196	6.96194	8.66192	0.00196	Ø.ØØ188	0. <i>9</i> 0186	6.66184
7	18	6.00291	6.66199	6.56197	5.56196	6.00194	0. <i>0</i> 0192	6.86196	6.00188	Ø. 00 186	0.00184
ы	11	0.00201	0.06199	6.06197	6.56196	0.00194	6.00192	6.66196	6.50188	0.60186	0.86184
e)	12	6.86261	6.86199	6.86197	6.66196	6.66194	0.00192	6.86196	6.66188	0.00186	8.56184
S	13	6.56256	6.66198	6.86197	6.66195	0.00193	0.00191	Ø.86189	6.60187	Ø. 98 185	6.06183
œ	14	6.66266	6.66198	6.66197	6.66195	6.66193	0.00191	6.66189	6.60187	6 . 60 185	0.00183
41	15	6.86286	6.66198	6.66197	6.66195	6.66193	6.66191	0.06189	6.60187	0.00185	0.66183
.	16	6.66199	6.86197	6.66196	6.66194	6.66192	6.66196	6.66188	0.00 186	0.00184	0.00182
.,=	17	6.66199	6.66197	6.56196	6.86194	6.66192	0.00190	6.06188	6.66186	0.00184	6.66182
3	18	6.56199	6.66197	6.66196	6.80194	6.66192	0.60196	0.06188	8.66 186	0.00 184	6.66182
9	19	6.66198	6.66196	6.66195	6.66193	6.66191	6.66189	Ø. 66 187	Ø. 60 185	Ø.86183	6.00181
panwi	26	6.86198	6.66196	6.66195	6.66193	0.00191	6.56189	6.66187	6.66185	0.00183	0.00181
S	21	6.66198	6.66196	6.66195	6.66193	6.66191	6.66189	Ø.ØØ187	0.60 185	0.80183	0.66181
	22	6.66196	0.06195	6.66193	6.66191	6.66196	6.56188	0.00186	6.66184	0.66182	6.66186
	23	0.06196	0.06195	6.66193	0.66191	6.66196	Ø.Ø6188	0.00186	6.66184	8.60182	0.66186
	24	6.66196	6.66195	6.56193	6.66191	6.66196	0.50 188	8.86186	6.66184	6.66182	6.66186
		11	12	13	14	15 6.66173	16 0.00171	17 0.00158	18 0.00166	19 0.00164	25 0.56161
	1	6.66182	6.50186	6.66178	6.66175		6.80171	6.80168	6.66166	6.88164	6.66161
	2	6.66182	8.86186	6.66178	6.66175	6.66173 6.66173	6.86171	6.00168	0.00166	6.88164	0.06161
No	3	6.66182	6.66186	5.66178	6.06 175 6.66 175	6.60173	6.66171	6.50168	6.60166	6.00164	8.66161
Z	4	0.66182	9.56186	6.66178	6.86175	6.80173	6.66171	6.66168	6.00166	6.66164	0.00161
a	5	6.60182	6.00186	6.66178	6.66175	6.50173	6.86171	0.00168	6.56166	6.66164	0.00161
ne	6	6.66182	6.86186	6.66178	6.86175	6.66173	6.86176	0.00168	6.56166	6.66163	6.66161
-11	7	6.56182	6.66186	6.86177 6.86177	8.86175	8.86173	8.66176	0.00168	0.86166	6.66163	6.66161
	8	6.66182	6.66186	8.86177	8.86175	5.66173	8.66176	0.00168	6.66166	6.06163	6.66161
iser	9	6.06182	6.66186	6.86177	8.88175	6.66172	8.86176	6.66168	6.60165	6.56153	6.80161
ĽĎ.	10	6.86181	6.86179 6.86179	6.66177	6.66175	6.66172	6.86176	0.00168	8.66165	0.00163	6.56161
٠,=	11	6.56181		8.66177	8.66175	6.60172	0.56175	6.66168	6.66165	6.66163	6.86161
α	12	6.66181	6.86179	6.66176	0.00174	6.60172	0.00169	6.00167	6.60166	0.00162	0.00166
61	13	6.66181	6.86178	5.55178	0.00174	6.66172	0.80169	6.86167	6.00185	8.86162	0.06186
9	14	6.66181	6.66178	6.66176	8.86174	6.66172	6.60169	6.60167	6.00165	8.66162	6.66166
٠.	15	6.66181	6.86178	6.66175	6.66173	6.00171	6.56169	8.80166	6.60164	0.00162	8.66159
panwise	16	6.66186	5.56178	6.66175	0.00173	6.86171	6.66169	6.80166	0.66164	8.66162	6.66159
ā	17	6.66186	6.66178		6.66173	6.96171	8.66169	6.80166	6.56164	6.00152	0.66159
Sp	18	6.66186	6.86178	6.66175 6.66174	6.66172	5.86178	8.66168	6.66165	6.60163	0.00161	6.66158
01	19	6.66179	6.86177	6.66174	6.66172	6.66176	6.66168	6.66165	0.00163	6.56161	0.66158
	26	6.66179	6.60177	6.66174	6.66172	6.66176	6.66168	6.66165	6.06163	0.00161	6.56158
	21	6.56179	6.66177	6.66173	6.66171	6.80169	6.50166	6.66164	6.66162	6.66159	0.56157
	22	6.66177	6.86175	6.66173	6.86171	6.86169	6.66166	5.86164	8.66162	8.66159	8.66157
	23	6.06177	6.66 175	6.86173	6.56171	6.96169	6.66166	5.50164	9.00162	8.86159	8.66157
	24	6.86177	6.06175	g. De 1/3	4.55111	2.50150	2.22.230	3.0020	2.22.24		

TABLE 5.3-13, CD2 (DRAG COEFFICIENT BASED ON TOTAL LINE REF AREA)

		1	2	3	4	Б	6	7	8	9	10
	1	6.56618	6.66618	6.56617	6.00617	6.86617	6.66617	6.66617	6.66617	5.60616	6.90016
	2	6.56618	5.66618	6.66617	6.66617	6.66617	6.66617	6.66617	6.66617	6.00016	6.00016
	3	6.86618	6.60618	6.60617	8.88817	8.88817	6.66617	6.88617	6.66617	6.666 16	6.50616
	4	0.60018	5.56618	6.00617	8.86617	8.66617	6.66617	6.66617	8.666 17	0.000 16	0.00016
:	5	6.66618	6.66618	0.060 17	6 . 000 17	6.88817	8. 866 17	6.6 66 17	8.86617	0.00016	0.00016
9 N	6	8.8 60 18	6.86618	5.66617	0.800 17	0.00017	0.006 17	6.66617	6.60017	0.00016	0.00016
	7	5 . 566 18	6.00018	6.66617	Ø. 900 17	6.6 00 17	0.00017	6.66617	6.888 17	8.000 16	0.00016
ne	8	6. <i>666</i> 18	0.0 00 18	0.866 17	6.86017	0.000 17	6 . 606 17	0.56617	6.800 17	0.00016	6.00016
-=	9	6.00018	6.66618	6. 506 17	6.6 66 17	8. 800 17	6.806 17	5.006 17	8.000 17	6.00016	6. 866 16
\vdash	16	6.86618	6.66618	6.800 17	8.00017	0. 806 17	0. 00 017	6.60617	6.888 17	6.80616	8.8 00 16
ы	11	6.88618	0. <i>000</i> 18	6.866 17	6.66017	₿. ₿₿₿ 17	8.868 17	6.66617	8.888 17	6 .88816	6. 866 16
Ð	12	Ø.86618	6.66618	6.86617	6.666 17	0. 000 17	8.88817	0.00017	6.00017	8 . 800 16	6.00016
16	13	0.000 18	6.06618	6.86617	6.66617	6.600 17	0.066 17	6.66617	6.500 17	0.000 16	5. <i>606</i> 16
£.	14	6.866 18	6.000 18	6.86617	6.66617	6.8 66 17	8 . 066 17	6.00617	6.00017	6.00016	8. <i>006</i> 16
-	15	6.860 18	0.00018	6.56617	8.666 17	0. 000 17	0.00017	6.66617	6.000 17	Ø. 800 16	6.866 16
e.	16	0.66618	6. 606 17	8.00017	8.66617	6 . 90 017	0.00017	0.666 17	6.00018	0.00016	6.00016
j 6	17	6. <i>666</i> 18	6.66017	6.00617	8.860 17	Ø.8 00 17	0.00017	6.66617	6.66616	6.00016	8.966 16
3	18	8.888 18	6.56617	0.566 17	6.00017	6.00017	0.66617	6.66617	0.000 16	0. 660 16	6.00016
Ę	19	8.86617	0.55017	6.86617	6.666 17	6 . 606 17	6.00017	6.666 17	6.00016	Ø. 000 16	8.00016
panw	26	0.86617	8.66617	6.56617	6.86017	0.66617	0.66617	0.60617	6. <i>6</i> 6616	6.00016	6.00016
S	21	8 . 866 17	6.00617	6.66617	8.860 17	6 .00017	6. 666 17	0.866 17	0.00016	6.800 16	6.00016
	22	8 . 800 17	8.86817	6.56617	Ø. 686 17	0.00017	0.66617	6.00016	8.00016	0.00016	6.00018
	23	6. 600 17	6.60617	6.86617	6.66617	8.00617	0.66617	6.66618	0.00016	6.80016	6.88616
	24	6.6 00 17	6.00617	0.66617	6.56617	6.60617	6.66617	0.800 15	6.80616	6.88616	6.66616
		11	12	13	14	15	16	17	18	19	25
	1		12 6.66615	13 6.00016	14 0.60615	15 6.80015	16 6.66615	17 6.66615	18 6.86615	19 6.86614	25 6.50614
	1 2	5.866 15			_					-	
	1 2 3	5.50515 5.50515	6.00016	6.06016	0.66615	6.00015	Ø. 866 15	6.00016	6.86615	6.86614	0.00014
	2	5.50515 5.50515 5.50515	6.88616 6.88616	6.66016 6.66016	0.00015 0.00015	6.86615 6.86615	6.66615 6.66615	6.60015 6.60015	6.86615 6.86615	0.88614 6.68614	6.66614 6.66614
·	2	5.50515 5.50515	6.00016 6.00016 6.00016	6.00016 6.00016 6.00016	8.66615 8.66615 8.66615	6.86615 6.86615 6.86615	6.66615 6.66615 6.66615	8.00016 8.00016 8.00015	6.86615 6.86615 6.86615	6.56614 6.56614 6.66614	6.60614 6.60614 6.60614
No.	2 3 4	5.50615 5.50616 5.50616 5.50616	6,00016 6,00016 6,00016 6,00016	6.86616 6.86616 6.86616	8.88615 8.86615 8.86615 6.86615	6.80015 6.80015 6.80015 6.80015	6.66615 6.66615 6.66615 6.66615	6.00016 6.00016 6.00016 6.00015	6.86615 6.86615 6.86615 6.86615	6.56614 6.56614 6.66614 6.66614	5.50614 6.50614 6.50614 5.50614
Z	2 3 4 5	\$.80615 \$.80615 6.80615 8.66616 8.60615	6,90616 6,90616 6,90616 6,96616 6,96616	6.56616 6.56616 6.56616 6.56616	6.00015 6.00015 6.00015 6.00015	6.00015 6.00015 6.00015 6.00015 6.00015	6.66615 6.66615 6.66615 6.66615	6.00016 6.00015 6.00015 6.00015 6.00015	6.00015 6.00015 6.00015 6.00015 6.00015	6.90014 6.50014 6.00014 6.00014	6.50614 6.50614 6.50614 5.50614
ne No.	2 3 4 5	5.00015 5.00016 6.00016 6.00016 6.00016	6.99616 6.99616 6.99616 6.99616 6.99616 5.99618	6.00016 6.00016 6.00016 6.00016 6.00016 6.00016	0.00015 0.00015 0.00015 0.00015 0.00015	6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.00015 6.00015 6.00015 6.00015 6.00015	6.50015 6.50015 6.50015 6.50015 6.50015 6.50015	6.90015 6.90015 6.90015 6.90015 6.90015 6.90015	6.96614 6.96614 6.96614 6.96614 6.96614	6.56614 6.56614 6.56614 6.56614 6.56614
ine N	2 3 4 5 6 7	5.50615 5.00016 6.00016 6.50016 6.50015 6.50015	6,00016 6,00016 6,00016 6,00016 6,00016 6,00016 6,00016	6.00016 6.00016 6.00016 6.00016 6.00016 6.00016	6.60615 6.60615 6.60615 6.60615 6.50615 9.50615	6.80015 6.80015 6.80015 6.80015 6.80015 6.80015 6.80015	6.60615 6.60615 6.96615 6.66615 6.66615 6.66615	6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.90015 6.90015 6.90015 6.90015 6.90015 6.90015	6.96014 6.96014 6.96014 6.96614 6.96614 6.96614	6.56614 6.56614 6.56614 6.56614 6.56614 6.56614
ne N	2 3 4 5 6 7	5.00615 5.00616 6.00616 6.00616 6.00616 6.00616 6.00616	6,96616 6,96616 6,96616 6,96616 6,96616 6,96616 6,96616	6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616	6.86615 6.86615 6.86615 6.86615 6.86615 6.86615 6.86615	6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.80615 6.80615 6.90615 6.80615 6.80615 6.80615 6.80615	8.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.00615 6.00615 6.00015 6.00015 6.00015 6.00015 6.00015	6.86614 6.96614 6.96614 6.96614 6.96614 6.96614 6.96614	8.90614 6.90614 6.90614 6.90614 6.90614 6.90614 6.90614
r Line N	2 3 4 5 6 7 8	5.00015 5.00016 5.00015 6.00016 5.00016 5.00016 5.00016 6.00016 6.00016	6,96616 6,96616 6,96616 6,96616 6,96616 6,96616 6,96616 6,96616	6.90016 6.90016 6.90016 6.90016 6.90016 6.90016 6.90016 6.90016	6.66615 6.66615 6.66615 6.66615 6.66615 6.66615 6.66615 6.66615	6.80615 6.80615 6.80615 6.80615 6.80615 6.80615 6.80615 6.80615	6.60615 6.60615 6.90615 6.60615 6.60615 6.60615 6.60615 6.60615	8.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.00615 6.00615 6.00015 6.00015 6.00615 6.00615 6.00615 6.00615	6.86614 6.96614 6.96614 6.96614 6.96614 6.96614 6.96614 6.96614	8.90614 6.90614 6.90614 6.90614 6.90614 6.90614 6.90614 6.90614
er Line N	2 3 4 5 6 7 8 9	5.00015 5.00015 6.00015 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016	6,96616 6,96616 6,96616 6,96616 6,96616 6,96616 6,96616 6,96616 6,96616	6.90016 6.90016 6.90016 6.90016 6.90016 6.90016 6.90016 6.90016 6.90016	8.86615 8.86615 8.86615 6.86615 6.86615 8.86615 6.86615 6.86615 6.86615	6.80015 6.90015 6.90015 6.90015 6.90015 6.90015 6.90015 6.90015	6.60615 6.60615 6.90615 6.90615 6.60615 6.90615 6.90615 6.90615 6.90615	8.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.86615 6.90615 6.90615 6.90615 6.60616 6.60615 6.60615 6.60615 6.60615	6.86014 6.96014 6.96014 6.96014 6.86614 6.86614 6.86614 6.86614 6.86614	8.90614 6.90614 6.90614 6.90614 6.90614 6.90614 6.90614 6.90614
ser Line N	2 3 4 5 6 7 8 9	6.00616 6.00016 6.00616 6.00616 6.00616 6.00616 6.00616 6.00616 6.00616 6.00616	6.90616 6.90616 6.90616 6.90616 6.90616 6.90616 6.90616 6.90616 6.90616 6.90616	6.00016 8.00016 8.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016	6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615	6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615	6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615	6.90014 6.50014 6.90614 6.90614 6.90614 6.90614 6.90614 6.90614 6.90614	6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014
er Line N	2 3 4 5 6 7 8 9 18 11	5.50515 5.50015 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616	6.00616 6.00616 6.00616 6.00616 6.00616 6.00616 6.00616 6.00616 6.00616 6.00616 6.00616	6.20016 5.20016 5.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016	8.80615 8.80615 8.80615 6.80615 8.80615 8.80615 6.80615 6.80615 6.80615 6.80615	6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615	6.00016 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.00615 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014	6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014
Riser Line N	2 3 4 5 6 7 8 9 10 11 12 13	6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016	6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016	6.20016 5.20016 5.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016	8.80615 8.90615 8.80615 6.80615 8.90915 8.80015 6.90815 6.80815 6.80815 6.80815 6.80815	6.86615 6.86615 6.86615 6.86615 6.86615 6.86615 6.86615 6.86615 6.86615 6.86615 6.86615	6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615	6.00016 6.00016 6.00015 6.00015 6.00015 6.00015 6.00015 6.00016 6.00016 6.00016	6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615	6.80014 6.50014 6.60614 6.60614 6.60614 6.60614 6.60614 6.60614 6.60614 6.60614 6.60614 6.60614	6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014
se Riser Line N	2 3 4 5 8 7 8 9 18 11 12 13 14	5.00016 5.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016	6.96616 6.96616 6.96616 6.96616 6.96616 6.96616 6.96616 6.96616 6.96616 6.96616 6.96616 6.96616	6.20016 5.20016 5.20016 6.50016 6.50016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016	6.80615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615	6.80615 6.80615 6.80615 6.80615 6.80615 6.80615 6.80615 6.80615 6.80615 6.80615 6.80615 6.80615	6.80615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615	8.00015 8.00015 8.00015 8.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615	6.80014 6.50014 6.00014 6.00014 6.00014 6.00014 6.50014 6.50014 6.50014 6.50014 6.50014 6.50014	6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014
se Riser Line N	2 3 4 5 6 7 8 9 10 11 12 13 14 15	5.00016 5.00016 5.00016 5.00016 5.00016 5.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016	6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016	6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016	6.80615 6.96615 6.96615 6.96615 6.96615 6.96615 6.96615 6.96615 6.96615 6.96615 6.96615 6.96615	6.80615 6.80615 6.80615 6.80615 6.80615 6.86615 6.86615 6.86615 6.80615 6.80615 6.80615 6.80615 6.80615	6.80615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615	8.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615	6.80014 6.80014 6.90014 6.90614 6.90614 6.90614 6.60014 6.60014 6.60014 6.90014 6.90014 6.90014 6.90014	6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014
se Riser Line N	2 3 4 5 6 7 8 9 10 11 12 13 14 15 16	5.50515 5.00016 5.00016 5.50516 5.50516 5.50516 6.50516 6.50516 6.50516 6.50516 6.50516 6.50516 6.50516 6.50516	6.99616 6.99616 6.99616 6.99616 6.99616 6.99616 6.99616 6.99616 6.99616 6.99616 6.99616 6.99616 6.99616	6.00016 8.00016 8.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016	6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615	6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615	6.00016 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014	6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014
se Riser Line N	2 3 4 5 6 7 8 9 18 11 12 13 14 15 16 17	5.50616 5.00016 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616	6.00616 6.00616 6.00616 6.00616 6.00616 6.00616 6.00616 6.00616 6.00616 6.00616 6.00616 6.00616 6.00616 6.00616 6.00616	6.00016 8.00016 9.00016 9.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016	6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.80015 6.80015 6.80015 6.80015 6.80015 6.80015 6.80015 6.80015 6.80015 6.80015 6.80015 6.80015 6.80015 6.80015	6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615 6.60615	6.00016 6.00016 6.00015 6.00015 6.00015 6.00015 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016	6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.80014 6.50014 6.60614 6.60614 6.60614 6.60614 6.60614 6.60614 6.60614 6.60614 6.60614 6.60614 6.60614 6.60614 6.60614 6.60614 6.60614 6.60614	6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014
panwise Riser Line N	2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	5.50616 5.50616 5.50616 5.50616 5.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616	6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016	6.20016 5.20016 5.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016	6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.80015 6.80015 6.80015 6.80015 6.80015 6.80015 6.80015 6.80015 6.80015 6.80015 6.80015 6.80015 6.80015 6.80015 6.80015	6.80615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615 6.90615	8.00015 8.00015 8.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00614 6.00614	6.80014 6.50014 6.60014 6.60014 6.60014 6.60014 6.60014 6.60014 6.60014 6.60014 6.60014 6.60014 6.60014 6.60014 6.60014 6.60014 6.60014 6.60014 6.60014	6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014
se Riser Line N	2 3 4 5 6 7 8 9 18 11 12 13 14 15 16 17 18 19	5.50515 5.00015 5.00015 5.50515 5.50015 5.50016 6.50016 6.50016 6.50016 6.50016 6.50016 6.50016 6.50016 6.50016 6.50016 6.50016 6.50016 6.50016 6.50016	6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016	6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016 6.20016	6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615	6.90014 6.50014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014	6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014
panwise Riser Line N	2 3 4 5 6 7 8 9 18 11 12 13 14 15 16 17 18 19 28	5.50516 5.00016 6.00016 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616 6.50616	6.90616 6.90616 6.90616 6.90616 6.90616 6.90616 6.90616 6.90616 6.90616 6.90616 6.90616 6.90616 6.90616 6.90616 6.90616 6.90616	6.00016 8.00016 9.00016 9.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00015 6.00015 6.00015 6.00015	6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615	6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.00016 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014	6.90014 6.50014 6.90614 6.90614 6.90614 6.90614 6.90614 6.50614 6.50614 6.50614 6.90614 6.90614 6.90614 6.90614 6.90614 6.90614 6.90614 6.90614 6.90614 6.90614 6.90614	6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014
panwise Riser Line N	2 3 4 5 6 7 8 9 18 11 12 13 14 15 16 17 18 19 28 21	5.50515 5.00016 5.00016 5.50516 5.50516 5.50516 6.50516 6.50516 6.50516 6.50516 6.50516 6.50516 6.50516 6.50516 6.50516 6.50516 6.50516 6.50516 6.50516	6.99616 6.99616	6.00016 8.00016 8.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016 6.00016	6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615	6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015 6.00015	6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615 6.00615	6.90014 6.50014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014 6.90014	6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014 6.00014

TABLE 5.3-14, CD3 (DRAG COEFFICIENT BASED ON PARAFOIL REF AREA)

OFFICENAL PAGE IS OF POOR QUALITY

		1	2	3	4	6	8	7	8	9	16
				4 07544	-6.97566	-6.97586	-6.97586	-8.97586	-6.97566	-6.97566	-0.97500
	1	-6.97566	-0.97566	-6.97586 6.22586	0.22506	Ø.22586	6.22566	6.22566	6.22566	Ø.22500	6.22500
	2	6.22586	6.22566	1.42566	1.42500	1.42566	1.42500	1.42566	1.42500	1.42500	1.42500
	3	1.42586	1.425 <i>66</i> 2.625 <i>66</i>	2.62586	2.82500	2.62566	2.62500	2.62566	2.82500	2.82500	2.62500
No	4	2.62566	3.82500	3.82500	3.82500	3.82586	3.82566	3.82586	3.82500	3.82500	3.82500
Z	5	3.825 66 5.625 66	5.825 66	5.02500	5.62566	5.82588	5.02500	5.82588	6.02500	5.62500	5.02500
Ð	8 7	6.22586	6.22566	6.22566	6.22500	6.22586	6.22566	6.22566	6.22506	6.22500	6.22500
ne	8	7.425 56	7.42586	7.42566	7.42500	7.42566	7.425 66	7.42566	7.425 00	7.42500	7.425 00 8.625 00
Li	9	8.82586	8.62586	8.82500	8.625 <i>66</i>	8.62500	8.62566	8.625 <i>06</i>	8.82500	8.62500	9.82566
	10	9.82586	9.82566	9.82566	9.82500	9.825 60	9.82566	9.82566	9.82566	9.82506	11.82586
er	11	11.62586	11.62566	11.82566	11.02500	11.02500	11.82588	11.62566	11.62500	11. 6 25 66 12.225 66	12.22566
8	12	12.22566	12.22586	12.22566	12.225 <i>6</i> 6	12.22500	12.22566	12.22566	12.22566	13.42500	13.42566
:=	13	13.42566	13.42566	13.42566	13.42500	13.42500	13.42506	13.42566	13.425 <i>06</i> 14.625 <i>66</i>	14.62500	14.82566
æ	14	14.62566	14.62566	14.62566	14.62500	14.82500	14.62566	14.82566	15.82566	15.82500	16.82586
e	15	15.82566	15.82566	15.82566	15.82500	16.82500	15.825	15.82566	17.52500	17.02500	17.82586
.9	16	17.82566	17.52555	17.62566	17.02500	17.02566	17.62566	17.62566	18.22566	18.22500	18.225
3	17	18.22566	18.22586	18.22506	18.225 <i>86</i>	18.22566	18.22566	18.225 <i>66</i> 19.425 <i>66</i>	19.42586	19.42566	19.42586
Ξ	18	19,42506	19.42566	19.42566	19.42506	19.42566	19.42566	26.62566	28.82586	28.62586	20.62566
panwise	19	26.52566	26.62566	26.62566	25.52556	25.62586	20.62566 21.82566	21.82566	21.82566	21.82506	21.82566
S	25	21.825 <i>6</i> 6	21.825 66	21.82566	21.82500	21.825 66 23. 6 25 66	23.82586	23.82566	23.82500	23.62566	23.82586
	21	23.62566	23.82566	23.62566	23.82586	24.22588	24.22586	24.22566	24.22566	24.22566	24.22566
	22	24.225 86	24.22586	24.22586	24.22500	25.42566	25.42586	25.42586	25 . 42566	25.42588	25.425 66
	23	25.42566	25.42566	25.42566	25.425 <i>66</i> 26.625 <i>66</i>	25.52586	26.62566	26.62566	26.62500	26.62566	26.625
	24	26.62566	26.82566	26.62566	20.02000	20.02000	20.02000				
		11	12	13	14	15	16	17	18	19	28
			4 07584	-6.97586	-6.97586	-8,97566	-6.97566	-0.97586	-8.975 66	-Ø.975 <i>00</i>	-0.97586
	1	-6.97500	-0.97586 5.22586	6,22586	6,22500	8.22586	6.22588	6.22566	6.22500	6.22566	0.22566
	2	8.22586	1.42566	1.42586	1.42500	1.42500	1.42586	1.42566	1.42500	1.42588	1.42566
:	3	1.42588	2.62566	2.62566	2.62586	2.62566	2.52566	2.625 66	2.62500	2.82500	2.625
No	5	2.625 66 3.825 86	3.82566	3.82566	3.82500	3.82500	3.82566	3.825 <i>66</i>	3.82500	3.82500	3.82586
	5	5.82586	5.82566	5.82586	5.62566	5.82586	5.62566	5.825 86	5.82586	5.82586	5.825 66 6.225 86
Line	7	6.22566	6.22566	6.22586	6.22586	6.22566	6.22566	6.22556	6.22566	6.22566	7.425 66
٠	á	7.42566	7.42586	7.42586	7.42500	7.42506	7.42566	7.42566	7.42566	7.42566	8.825 86
_	9	8.62566	8.52566	8.62566	8.62566	8.62566	8.62566	8.825 56	8.62566	8.625 <i>66</i> 9.825 <i>66</i>	9.82566
er	15	9.82566	9.82566	9.82586	9.82500	9.82566	9.82566	9.82588	9.82566	11.82588	11.82586
ย	11	11.62566	11.62566	11.82588	11.82588	11.62566	11.82586	11.82586	11.82508	12.22506	12.22586
15	12	12.22566	12.22566	12.22586	12.225 00	12.22566	12.22566	12.22566	12.225 <i>66</i> 13.425 <i>66</i>	13.42586	13.42586
~	13	13.42586	13.42566	13.42566	13.425 66	13.42566	13.42566		14.62500	14.62586	14.62500
a	14	14.62506	14.62566	14.62586	14.62586	14.62566	14.62566		15.82566	15.82566	15.82580
rn.	15	15.82566	15.82566	15.825 86	15.82566	15.82500	15.82556		17.02500	17.82586	17.62566
panwi	16	17.82566		17.82566	17.62566	17.52506	17.82566 18.22566		18.22500	18.22566	18.22566
ž	17	18.22566		18.22566	18.22566	18.22566	19.42566		19.42586	19.42500	19.42566
ā	18	19.42586		19.42566		19.42506 28.62506	28.62588		28.62566	25.62566	28.62566
S		28.62588		28.62500			21.82566		21.82500	21.82566	21.82566
	29	21.82566		21.82500					23.62566	23.82586	23.62566
	21	23.62586							24.22566	24.22586	24.225 88
	22	24.22596		24.22566		_			25.42586	25.42586	25.425 86
	23	25.425								26.82586	28.62586
	24	26.625	26.82500	26.825 86	49.040						

TABLE 5.3-15, THETA (FRONTAL ANGLE YZ PLANE), deg

		1	2	3	4	5	6	7	8	9	16
	1	-6.24641	-6.26848	-6.27382	-6.28666	-6.29896	-6.31854	-6.32168	-6.33197	-6.34177	-6.35696
	2	-6.24644	-6.26643	-6.27386	-6.28676	-0.29894	-0.31068	-8.32161	-0.33262	-6.34181	-6.35699
•	3	-6.24637	-6.26635	-6.27377	-6 .28661	-0.29885	-0.31049	-0.32151	-6.33192	-6.34171	-8.35689
No	4	-6.24618	-6.26016	-6.27357	-6.28646	-0.29863	-6.31626	-6.32127	-0.33167	-6.34146	-0.35663
	5	-6.24589	-6.25985	-6.27325	-6.28666	-0.29828	-6.38989	-6.32689	-0.33128	-8.34186	-0.35622
ne	6 7	-6.24549	-0.25943	-6.27281	-6.28580	-6.29786	-0.30939	-6.32637	-0.33075	-0.34668	-0.34965
er Li	8	-8.24499 -8.24438	-6.25896 -6.25825	-6.27224 -6.27158	-0.28501 -0.28430	-0.29718	-0.36875	-6.31971	-0.33066	-6.33986	-6.34893
	9	-6.24365	-6.25749	-6.27576	-6.28346	-0.29644 -0.29556	-0.30798 -0.30707	-8.31891 -3.31797	-8.32924	-0.33895	-0.34805
	15	-6.24283	-6.25662	-6.26984	-6.28250	-6.29458	-6.30663	-6.31689	-0.32827 -0.32715	-0.33795 -0.33680	-0.34763
	11	-6.24189	-6.25583	-6.25886	-6.28141	-6.29343	-0.30485	-6.31567	-6.32589	-6.33551	-0.34685 -0.34462
is	12	-6.24886	-6.25453	-6.26766	-8.28626	-6.29217	-0.30354	-6.31432	-6.32449	-0.33467	-6.34364
24	13	-6.23971	-0.25332	-6.26638	-6.27887	-0.29078	-0.36216	-Ø.31282	-6.32295	-0.33248	-6.34141
o)	14	-6.23846	-6.252 96	-6.26499	-6.27741	-6.28926	-8.36652	-6.31119	-0.32126	-0.33074	-6.33962
CO.	15	-6.23718	-6,25658	-6.26348	-6.27583	-6 .28761	-6.29881	-6.36942	-6.31944	-6.32886	-6.33769
panwi	16	-6.23584	-8.24962	-6.26186	-0 .27414	-Ø.28584	-0.29697	-0.30752	-6.31747	-0.32684	-8.33562
3	17	-6.23468	-0.24737	-6.26612	-6.27232	-6.28395	-0.29500	-0.30548	-0 .31537	-0.32467	-0.33339
<u> </u>	18	-6.23241	-0.24581	- 6 .25827	-6.27638	- 6 .28193	-0.29296	-0.30330	-0.31312	-6.32236	-0.33162
Sp	19	-6.23866	-6.24374	-6.25631	-6.25832	-6.2797B	-6.29668	-6.36106	-0.31074	-0.31991	-0.32850
0.	28	-6.22878	-6.24177	-6.25423	-8.26615	-6.27752	-6.28832	-6 .29856	-6.36822	-6.31732	-0.32584
	21	-6.22681	-6.23969	-6.25264	-0.26386	-0.27513	-6.28584	-6.29599	-0.30557	-6.31459	-0.32303
	22	-6.22474	-6.23758	-6.24974	-0.26145	-6.27262	-6.28323	-6.29329	-0.30278	-6.31172	-0.32569
	23	-6.22257	-6.23521	-6.24734	-6.25893	-0.26999	-6.28056	-6.29646	-0.29987	-6.30871	-8.31786
	24	-6.22631	-6.23282	-6.24482	-6.25630	-6.26724	-6.27765	-6 .28751	-0.29681	-0.30557	-Ø.31378
		11	12	13	14	16	16	17	18	19	26
	1	11 -6.35961	12 -0.36748	13 -6.37484	14 -6.38162	15 -6.38783	16 -0.39347		18 -6.46312		
	1 2							17 -6.39856 -6.39861		19 -6.46716 -6.46722	26 -6.41671 -6.41677
		-6.35961	-Ø.36748	-6.37484	-6.38162	-6.38783	-0.39347	-6.39856	-6.40312	-6.40716	-8.41671
	2 3 4	-6.35951 -6.35956 -6.35946 -6.35919	-0.36748 -0.36753 -0.36742 -0.36714	-6.37484 -6.37489 -6.37478 -6.37458	-6.38162 -6.38167 -6.38156 -6.38128	-6.38783 -6.38788	-0.39347 -0.39352	-6.39856 -6.39861	-6.46312 -6.46318	-6.48716 -6.48722	-6.41671 -6.41677
No.	2 3 4 5	-0.35961 -0.35966 -0.35946 -6.35919 -0.35877	-0.36748 -6.36753 -6.36742 -6.36714 -6.36671	-6.37484 -6.37489 -6.37478 -6.37456 -6.37466	-6.38162 -6.38167 -6.38156 -6.38128 -6.38683	-6.38783 -6.38788 -6.38776 -6.38747 -6.38762	-0.39347 -0.39352 -0.39346 -0.39311 -0.39255	-6.39858 -6.39851 -6.39849 -6.39826 -6.39773	-6.40312 -6.40318 -6.40305	-6.46716 -6.46722 -6.46716	-6.41671 -6.41677 -6.41664
. No.	2 3 4 5 6	-0.35951 -0.35956 -0.35946 -0.35919 -0.35877 -0.35818	-0.36748 -0.36753 -0.36742 -0.36714 -6.36671 -6.36612	-6.37484 -6.37489 -6.37478 -6.37456 -6.37466	-6.38162 -6.38167 -6.38156 -6.38128 -6.38683 -6.38621	-6.38783 -6.38788 -6.38776 -6.38747 -6.38762 -6.38639	-0.39347 -0.39352 -0.39346 -0.39311 -0.39265 -0.39261	-6.39856 -6.39861 -6.39849 -6.39826 -6.39773 -6.39769	-0.40312 -0.40318 -0.40305 -0.40276 -0.40228 -0.40163	-8.48716 -6.48722 -5.48716 -6.48686 -6.48632 -5.48566	-6.41671 -6.41677 -6.41664 -6.41634
	2 3 4 5 6 7	-0.35951 -0.35956 -0.35946 -0.35919 -0.35877 -0.35818 -0.35746	-0.36748 -0.36753 -0.36742 -0.36714 -6.36671 -6.36612 -0.36536	-6.37484 -6.37489 -6.37478 -6.37456 -6.37466 -6.37346	-6.38162 -6.38167 -6.38156 -6.38128 -6.38683 -6.38621 -6.37943	-6.38783 -6.38788 -6.38776 -6.38747 -6.38762 -6.38639 -6.38659	-0.39347 -0.39362 -0.39340 -0.39311 -0.39265 -0.39201 -0.39120	-6.39856 -6.39861 -6.39849 -6.39826 -6.39773 -6.39769 -6.39627	-0.40312 -0.40318 -0.40305 -0.40276 -0.40228 -0.40163 -0.40086	-8.48716 -6.48722 -5.48716 -6.4688 -6.46832 -5.46566 -6.46482	-6.41671 -6.41677 -6.41664 -6.41634 -6.46985 -6.46919 -6.46835
ine	2 3 4 5 6 7	-0.35951 -0.35956 -0.35946 -0.35949 -0.35818 -0.35745 -0.35855	-0.36748 -0.36753 -0.36742 -0.36714 -6.36671 -0.36636 -0.36636	-6.37484 -6.37489 -6.37478 -6.37466 -6.37466 -6.37346 -6.37269 -6.37175	-6.38162 -6.38167 -6.38156 -6.38128 -6.38683 -6.38621 -6.37943 -6.37848	-6.38783 -6.38788 -6.38776 -6.38747 -6.38762 -6.38639 -6.38659 -6.38463	-0.39347 -6.39352 -6.39346 -6.39316 -6.39261 -6.39261 -6.39126 -6.39622	-6.39856 -6.39851 -6.39849 -6.39773 -6.39769 -6.39627 -6.39627	-6.46312 -6.46318 -6.46305 -6.46276 -6.46228 -6.46163 -6.39966	-6.46716 -6.46722 -6.46716 -6.46686 -6.46632 -6.46565 -6.46482 -6.46381	-6.41671 -6.41677 -6.41664 -6.41634 -6.46985 -6.46919 -6.46935 -6.46733
	2 3 4 5 6 7 8	-0.35951 -0.35956 -0.35946 -0.35919 -0.35818 -0.35745 -0.35855	-9.36748 -6.36753 -6.36742 -6.36671 -6.36612 -6.36636 -6.36445 -6.36337	-6.37484 -6.37489 -6.37478 -6.37466 -6.37346 -6.37269 -6.37175 -6.37666	-6.38162 -6.38167 -6.38128 -6.38128 -6.38683 -6.38621 -6.37943 -6.37848 -6.37736	-6.38783 -6.38788 -6.38776 -6.38747 -6.38782 -6.38639 -6.38659 -6.38463 -6.38349	-0.39347 -6.39352 -6.39346 -6.39265 -6.39261 -6.39126 -0.39622 -6.38967	-6.39856 -6.39861 -6.39849 -6.39829 -6.39773 -6.39769 -6.39627 -6.39627 -6.39411	-6.46312 -6.46318 -6.46365 -6.46276 -6.4628 -6.46163 -6.39986 -6.39862	-6.46716 -6.46722 -6.46716 -6.4688 -6.46586 -6.46586 -6.46482 -6.46381 -6.46262	-6.41671 -6.41677 -6.41664 -6.41634 -6.46985 -6.46919 -6.46835 -6.46733 -6.46612
r Line	2 3 4 5 6 7 8 9	-0.35951 -0.35956 -0.35946 -0.35919 -0.35818 -0.35745 -0.35656 -0.35556	-0.36748 -0.36753 -0.36742 -0.36714 -0.36671 -0.36632 -0.36636 -0.36337 -0.36337	-6.37484 -6.37489 -6.37478 -6.37456 -6.37346 -6.37269 -6.37175 -6.37866 -6.36946	-6.38162 -6.38167 -6.38156 -6.38128 -6.38683 -6.38621 -6.37943 -6.37736 -6.37736	-6.38783 -6.38788 -6.38776 -6.38747 -6.38639 -6.38659 -6.38463 -6.38349 -6.38319	-0.39347 -0.39352 -0.39346 -0.39311 -0.39265 -0.39261 -0.39126 -0.39622 -0.38967 -0.38775	-6.39856 -6.39861 -6.39849 -6.39820 -6.39773 -6.39769 -6.39627 -6.39627 -6.39411 -6.39277	-6.46312 -6.46316 -6.46306 -6.46228 -6.46163 -6.39986 -6.39862 -6.39727	-6.46716 -6.46722 -6.46716 -6.46686 -6.46682 -6.46686 -6.464881 -6.46262 -6.46262	-0.41671 -6.41677 -0.41664 -6.41634 -6.46919 -6.46919 -6.46733 -6.46733 -6.46733
er Line	2 3 4 5 6 7 8 9 18	-0.35951 -0.35956 -0.35919 -0.35919 -0.35818 -0.35745 -0.35656 -0.35656 -0.35429 -0.35293	-0.36748 -0.36753 -0.36742 -0.36714 -0.36671 -0.36612 -0.36636 -0.36337 -0.36337 -0.36375	-6.37484 -6.37489 -6.37456 -6.37456 -6.37466 -6.37346 -6.37176 -6.37176 -6.37666 -6.36946 -6.36946	-6.38162 -6.38156 -6.38156 -6.38128 -6.38083 -6.38021 -6.37943 -6.37848 -6.37736 -6.37668 -6.37463	-6.38783 -6.38788 -6.38776 -6.38747 -6.38762 -6.38639 -6.38659 -6.38459 -6.38219 -6.38219 -6.38672	-0.39347 -0.39362 -0.39346 -0.39311 -0.39265 -0.39281 -0.39120 -0.39622 -0.38967 -0.38775 -0.38626	-6.39856 -6.39861 -6.39849 -6.39829 -6.39773 -6.39769 -6.39627 -6.39627 -6.39277 -6.39277 -6.39277	-6.46312 -6.46336 -6.46276 -6.46228 -6.46163 -6.46986 -6.39986 -6.39962 -6.39727 -6.39574	-6.46716 -6.46722 -6.46716 -6.46686 -6.46686 -6.4666 -6.46482 -6.46381 -6.46262 -6.46125 -6.39971	-6.41671 -6.41674 -6.41664 -6.41634 -6.46985 -6.46919 -6.46835 -6.46612 -6.46612 -6.46475 -6.46319
ser Line	2 3 4 5 6 7 8 9 18 11	-0.35951 -0.35946 -0.35946 -0.35919 -0.35818 -0.35745 -0.35856 -0.35556 -0.35429 -0.35293 -0.35141	-0.36748 -0.36753 -0.36742 -0.36714 -0.36671 -0.36636 -0.36446 -0.36337 -0.36214 -0.36675 -0.36920	-6.37484 -6.37489 -6.37456 -6.37456 -6.37466 -6.37346 -6.37175 -6.37175 -6.36946 -6.36946 -6.36798 -6.36646	-6.38162 -6.38156 -6.38158 -6.38128 -6.38683 -6.38621 -6.37943 -6.37748 -6.3768 -6.37668 -6.37463 -6.37463	-6.38783 -6.38778 -6.38776 -6.38747 -6.38762 -6.38639 -6.38659 -6.38463 -6.38349 -6.38219 -6.38672 -6.37969	-0.39347 -0.39362 -6.39346 -6.39311 -6.39265 -6.39261 -6.39126 -0.39622 -6.38977 -6.38626 -6.38466	-6.39856 -6.39849 -6.39829 -6.39773 -6.39769 -6.39627 -6.39411 -6.39277 -6.39276 -6.39268	-6.46312 -6.46318 -6.46365 -6.46228 -6.46163 -6.46686 -6.39986 -6.39862 -6.39727 -6.39574 -6.39464	-6.46716 -6.46716 -6.46686 -6.46685 -6.46656 -6.46482 -6.46381 -6.46262 -6.46125 -6.39971 -6.39799	-6.41671 -6.41677 -6.41664 -6.41634 -6.46985 -6.46919 -6.46635 -6.46733 -6.46733 -6.46475 -6.46319 -6.46319
er Line	2 3 4 5 6 7 8 9 18 11 12 13	-0.35951 -0.35956 -0.35946 -0.35919 -0.35818 -0.35745 -0.35655 -0.35556 -0.35559 -0.35141 -0.34974	-0.36748 -0.36753 -0.36742 -0.36714 -0.36671 -0.36636 -0.3636 -0.3636 -0.36375 -0.36920 -0.36749	-6.37484 -6.37489 -6.37456 -6.37456 -6.37466 -6.37346 -6.37269 -6.37175 -6.37866 -6.36946 -6.36946 -6.36946 -6.36646 -6.36465	-6.38162 -6.38167 -6.38156 -6.38128 -6.38683 -6.38621 -6.37943 -6.37766 -6.37766 -6.37766 -6.37362 -6.37362	-6.38783 -6.38787 -6.38777 -6.38747 -6.38762 -6.38639 -6.38659 -6.38463 -6.38329 -6.38872 -6.37969 -6.37728	-0.39347 -0.39362 -0.39340 -0.39311 -0.39265 -0.39261 -0.39622 -0.38967 -0.38775 -0.38626 -0.38460 -0.38277	-6.39856 -6.39851 -6.39828 -6.39773 -6.39779 -6.39627 -6.39627 -6.39277 -6.39277 -6.39277	-6.46312 -6.46318 -6.46326 -6.46228 -6.46163 -6.46686 -6.39986 -6.39727 -6.39574 -6.39464 -6.39216	-6.46716 -6.46722 -6.46716 -6.46686 -6.46632 -6.46566 -6.46482 -6.46381 -6.46262 -6.39971 -6.39799 -6.39616	-6.41671 -6.41674 -6.41664 -6.41634 -6.46985 -6.46919 -6.46612 -6.46733 -6.46612 -6.46619 -6.46319 -6.46145 -6.39965
Riser Line	2 3 4 5 6 7 8 9 15 11 12 13 14	-0.35951 -0.35956 -0.35946 -0.35949 -0.35818 -0.35745 -0.35556 -0.35556 -0.35556 -0.3541 -0.35429 -0.35441 -0.34974 -0.34792	-0.36748 -0.36753 -0.36714 -0.36671 -0.36612 -0.36636 -0.36445 -0.36337 -0.36214 -0.36675 -0.36749 -0.36562	-6.37484 -6.37489 -6.37456 -6.37466 -6.37269 -6.37175 -6.37666 -6.36946 -6.36646 -6.36646 -6.36465 -6.36465	-6.38162 -6.38167 -6.38156 -6.38128 -6.38683 -6.38621 -6.37943 -6.37736 -6.37668 -6.37463 -6.37362 -6.37362 -6.37362	-6.38783 -6.38787 -6.38776 -6.38747 -6.38782 -6.38639 -6.38659 -6.38463 -6.38349 -6.38219 -6.38672 -6.37969 -6.37728 -6.37531	-0.39347 -0.39362 -0.39340 -0.39311 -0.39265 -0.39261 -0.39622 -0.38677 -0.38775 -0.38460 -0.38277 -0.38277	-6.39856 -6.39851 -6.39829 -6.39773 -6.39769 -6.39627 -6.39627 -6.39411 -6.39277 -6.39126 -6.38958 -6.38772 -6.38576	-6.46312 -6.46318 -6.46276 -6.46228 -6.46163 -6.39986 -6.39862 -6.39727 -6.39574 -6.39216 -6.39612	-6.46716 -6.46722 -6.46716 -6.46686 -6.46632 -6.46586 -6.46482 -6.46262 -6.46125 -6.39971 -6.39799 -6.39463	-6.41671 -6.41677 -6.41664 -6.41634 -6.46985 -6.46919 -6.46835 -6.46733 -6.46612 -6.46475 -6.46475 -6.46475
se Riser Line	2 3 4 5 6 7 8 9 18 11 12 13	-0.35951 -0.35956 -0.35946 -0.35919 -0.35818 -0.35745 -0.35655 -0.35556 -0.35559 -0.35141 -0.34974	-0.36748 -0.36753 -0.36742 -0.36714 -0.36671 -0.36636 -0.3636 -0.3636 -0.36375 -0.36920 -0.36749	-6.37484 -6.37489 -6.37456 -6.37456 -6.37466 -6.37346 -6.37269 -6.37175 -6.37866 -6.36946 -6.36946 -6.36946 -6.36646 -6.36465	-6.38162 -6.38167 -6.38156 -6.38128 -6.38683 -6.38621 -6.37943 -6.37766 -6.37766 -6.37766 -6.37362 -6.37362	-6.38783 -6.38787 -6.38777 -6.38747 -6.38762 -6.38639 -6.38659 -6.38463 -6.38329 -6.38872 -6.37969 -6.37728	-0.39347 -0.39362 -0.39340 -0.39311 -0.39265 -0.39261 -0.39622 -0.38967 -0.38775 -0.38626 -0.38460 -0.38277	-6.39856 -6.39851 -6.39828 -6.39773 -6.39779 -6.39627 -6.39627 -6.39277 -6.39277 -6.39277	-6.46312 -6.46318 -6.46305 -6.46228 -6.46163 -6.39986 -6.39986 -6.39727 -6.39464 -6.39216 -6.39216 -6.39612 -6.39612	-6.46716 -6.46722 -6.46716 -6.46686 -6.46632 -6.46586 -6.46482 -6.46262 -6.46125 -6.39971 -6.39799 -6.39463 -6.39463 -6.39179	-6.41671 -6.41677 -6.41664 -6.41664 -6.46985 -6.46919 -6.46935 -6.46733 -6.46612 -6.46475 -6.46319 -6.46319 -6.39965 -6.39746 -6.39746
se Riser Line	2 3 4 5 6 7 8 9 18 11 12 13 14 15	-0.35951 -0.35956 -0.35946 -0.35946 -0.35818 -0.35745 -0.35856 -0.35556 -0.35556 -0.355293 -0.3429 -0.34974 -0.34974 -0.34594	-0.36748 -0.36753 -0.36742 -0.36714 -0.36671 -0.36612 -0.36537 -0.36346 -0.3637 -0.36214 -0.36575 -0.36562 -0.355662 -0.355662	-6.37484 -6.37489 -6.37478 -6.37466 -6.37346 -6.37269 -6.37175 -6.37666 -6.36946 -6.36646 -6.36465 -6.36465 -6.36669	-6.38162 -6.38167 -6.38128 -6.38683 -6.38683 -6.37943 -6.37736 -6.37736 -6.37463 -6.37362 -6.37362 -6.37362 -6.37362 -6.37521	-6.38783 -6.38786 -6.38776 -6.38762 -6.38639 -6.38659 -6.38463 -6.38349 -6.38219 -6.38672 -6.37728 -6.37728 -6.37531 -6.37318	-0.39347 -0.39352 -0.39340 -0.39310 -0.39261 -0.39220 -0.39622 -0.38967 -0.38775 -0.38466 -0.38277 -0.38277 -0.38277	-6.39866 -6.39861 -6.39849 -6.39773 -6.39769 -6.39767 -6.39627 -6.39627 -6.39126 -6.38968 -6.38772 -6.38576 -6.38576	-6.46312 -6.46318 -6.46276 -6.46228 -6.46163 -6.39986 -6.39862 -6.39727 -6.39574 -6.39216 -6.39612	-6.46716 -6.46716 -6.46686 -6.46686 -6.46566 -6.46566 -6.46381 -6.46262 -6.46125 -6.39799 -6.39616 -6.39179 -6.38938	-6.41671 -6.41674 -6.41664 -6.40985 -6.46919 -6.46835 -6.46812 -6.46475 -6.46319 -6.46475 -6.39965 -6.39746 -6.39626 -6.39626 -6.39626
se Riser Line	2 3 4 5 6 7 8 9 18 11 12 13 14 15 16	-6.35951 -6.35946 -6.35919 -6.35818 -6.35746 -6.35656 -6.35656 -6.35656 -6.35656 -6.35429 -6.35429 -6.3429 -6.3429 -6.3429	-0.36748 -0.36753 -0.36742 -0.36714 -0.36612 -0.36636 -0.36445 -0.36337 -0.36214 -0.36675 -0.35562 -0.35366 -0.35366 -0.35366	-6.37484 -6.37489 -6.37456 -6.37456 -6.37466 -6.37269 -6.37156 -6.37566 -6.36946 -6.3646 -6.36669 -6.36847	-6.38162 -6.38156 -6.38128 -6.38083 -6.38083 -6.37943 -6.37736 -6.37736 -6.37736 -6.37463 -6.37463 -6.37463 -6.37463 -6.37463 -6.37463 -6.37463 -6.37463	-6.38783 -6.38788 -6.38776 -6.38747 -6.38762 -6.38639 -6.38659 -6.38449 -6.38219 -6.38219 -6.37531 -6.37531 -6.37531 -6.37588	-0.39347 -0.39362 -0.39346 -0.39311 -0.39265 -0.39261 -0.39622 -0.38967 -0.38466 -0.38277 -0.38775 -0.38626 -0.38775 -0.38775 -0.38777 -0.38777 -0.38777 -0.38777 -0.37861 -0.37628	-6.39856 -6.39849 -6.39829 -6.39773 -6.39769 -6.39627 -6.39411 -6.39277 -6.39426 -6.38776 -6.38776 -6.38576 -6.38351 -6.38115	-0.40312 -0.40315 -0.40305 -0.40228 -0.40228 -0.40080 -0.39986 -0.39727 -0.39674 -0.39464 -0.39674 -0.39674 -0.39674 -0.39674	-6.46716 -6.46722 -6.46716 -6.46686 -6.46632 -6.46586 -6.46482 -6.46262 -6.46125 -6.39971 -6.39799 -6.39463 -6.39463 -6.39179	-6.41671 -6.41677 -6.41664 -6.41664 -6.46985 -6.46919 -6.46935 -6.46733 -6.46612 -6.46475 -6.46319 -6.46319 -6.39965 -6.39746 -6.39746
se Riser Line	2 3 4 5 6 7 8 9 18 11 12 13 14 15 16 17	-0.35951 -0.35946 -0.35946 -0.35919 -0.35818 -0.35745 -0.35856 -0.35429 -0.35293 -0.35141 -0.34974 -0.34581 -0.34581 -0.34581	-0.36748 -0.36753 -0.36742 -0.36714 -0.36671 -0.36636 -0.36436 -0.36337 -0.36214 -0.36675 -0.35369 -0.35369 -0.35369 -0.35369	-6.37484 -6.37489 -6.37456 -6.37456 -6.37346 -6.37269 -6.37176 -6.37966 -6.36946 -6.36798 -6.36465 -6.36669 -6.36847 -6.35847 -6.35869	-6.38162 -6.38156 -6.38128 -6.38083 -6.38081 -6.37943 -6.37946 -6.37668 -6.37463 -6.37463 -6.37463 -6.37463 -6.37463 -6.37463 -6.37463 -6.37463 -6.37463 -6.37463 -6.37463 -6.37463 -6.37463 -6.37463 -6.37463 -6.37463	-6.38783 -6.38785 -6.38747 -6.38742 -6.38639 -6.38659 -6.38459 -6.384349 -6.38219 -6.38722 -6.37531 -6.37531 -6.37538 -6.37688 -6.36842	-0.39347 -0.39346 -0.39346 -0.39261 -0.39261 -0.39262 -0.38967 -0.38967 -0.38626 -0.38466 -0.38277 -0.38626 -0.38626 -0.37628 -0.37628 -0.37628	-6.39856 -6.39849 -6.39829 -6.39773 -6.39769 -6.39769 -6.39411 -6.39277 -6.39277 -6.38277 -6.38579 -6.38579 -6.38575 -6.38115 -6.37862	-0.40312 -0.40318 -0.40305 -0.40228 -0.40163 -0.40086 -0.39862 -0.39862 -0.39727 -0.39574 -0.39464 -6.39216 -0.387961 -6.38796 -6.38551 -6.38295	-6.46716 -6.46716 -6.46686 -6.46686 -6.46666 -6.46482 -6.46381 -6.46262 -6.46125 -6.39471 -6.39478 -6.39478 -6.39478 -6.39478	-6.41671 -6.41677 -6.41664 -6.41694 -6.46919 -6.46935 -6.46612 -6.46612 -6.46475 -6.46475 -6.39955 -6.39746 -6.39746 -6.39277 -6.39616
Riser Line	2 3 4 5 6 7 8 9 18 11 12 13 14 15 16 17 18 19 26	-0.35951 -0.35956 -0.35946 -0.35919 -0.35818 -0.35745 -0.35556 -0.35550 -0.35529 -0.35141 -0.34974 -0.34792 -0.34594 -0.34594 -0.33918 -0.33652 -0.33579	-0.36748 -0.36753 -0.36714 -0.36714 -0.36671 -0.36612 -0.36445 -0.36337 -0.36214 -0.36575 -0.36574 -0.35562 -0.35566 -0.34397 -0.34397 -0.34119	-6.37484 -6.37478 -6.37456 -6.37456 -6.37466 -6.37269 -6.37175 -6.37646 -6.36946 -6.36798 -6.36646 -6.36646 -6.36847 -6.36889 -6.358847 -6.35889 -6.35889 -6.35889	-6.38162 -6.38167 -6.38128 -6.38083 -6.38081 -6.37943 -6.37766 -6.37766 -6.37463 -6.37362 -6.37362 -6.36253 -6.36253 -6.36253 -6.36253 -6.36253	-6.38783 -6.38787 -6.38777 -6.38782 -6.38639 -6.38659 -6.38849 -6.38219 -6.38219 -6.37728 -6.37728 -6.37531 -6.37531 -6.37688 -6.36586 -6.36586 -6.36586	-0.39347 -0.39352 -0.39346 -0.39311 -0.39265 -0.39261 -0.39622 -0.389677 -0.38626 -0.38466 -0.38277 -0.38677 -0.38677 -0.37861 -0.37628 -0.37378 -0.37378	-6.39856 -6.39849 -6.39829 -6.39773 -6.39769 -6.39627 -6.39411 -6.39277 -6.39277 -6.38576 -6.38576 -6.38576 -6.38576 -6.37862 -6.37862 -6.37862 -6.37693	-0.40312 -0.40318 -0.40305 -0.40228 -0.40163 -0.40086 -0.39862 -0.39727 -0.39727 -0.39727 -0.39574 -0.39574 -0.39512 -0.38796 -0.38796 -0.38796 -0.38796 -0.38295 -0.38295	-6.46716 -6.46716 -6.4688 -6.4688 -6.4688 -6.46566 -6.46482 -6.46381 -6.46262 -6.46125 -6.39971 -6.3979 -6.39463 -6.39166 -6.38488 -6.38688 -6.38688	-6.41671 -6.41674 -6.41664 -6.40985 -6.40919 -6.40635 -6.40733 -6.40733 -6.4075 -6.40319 -6.40319 -6.39965 -6.39746 -6.39746 -6.39626 -6.39777 -6.39616 -6.38739
se Riser Line	2 3 4 5 6 7 8 9 11 12 13 14 15 17 18 19 22 21	-6.35951 -6.35946 -6.35919 -6.35818 -6.35746 -6.35656 -6.35656 -6.35656 -6.35656 -6.35656 -6.35429 -6.35429 -6.3494 -6.3498 -6.3498 -6.3498 -6.33918 -6.33379 -6.33892	-0.36748 -0.36753 -0.36742 -0.36714 -0.36671 -0.36636 -0.36446 -0.36337 -0.36214 -0.36975 -0.36562 -0.36562 -0.36562 -0.36569 -0.36461 -0.34397 -0.34419 -0.33825	-6.37484 -6.37489 -6.37456 -6.37456 -6.37269 -6.37156 -6.37566 -6.36946 -6.3646 -6.3646 -6.36275 -6.3689 -6.3689 -6.35887 -6.35887 -6.35887 -6.35887 -6.35887 -6.35887 -6.35887 -6.35887	-6.38162 -6.38156 -6.38128 -6.38083 -6.38081 -6.37943 -6.37848 -6.3736 -6.37463 -6.37463 -6.37463 -6.37463 -6.37463 -6.37463 -6.37463 -6.36721 -6.3695 -6.3695 -6.3695 -6.3695 -6.36432 -6.35432 -6.35432 -6.35432	-6.38783 -6.38776 -6.38777 -6.38747 -6.38762 -6.38639 -6.38659 -6.38463 -6.38349 -6.38219 -6.37728 -6.37728 -6.37531 -6.37688 -6.36842 -6.36586 -6.36586	-0.39347 -0.39362 -0.39346 -0.39311 -0.39265 -0.39261 -0.39622 -0.38977 -0.38626 -0.38466 -0.38277 -0.37861 -0.37628 -0.37628	-6.39856 -6.39849 -6.39828 -6.39773 -6.39779 -6.39527 -6.39527 -6.39277 -6.39277 -6.38578 -6.38772 -6.38578 -6.38785 -6.38785 -6.37862 -6.37862 -6.37862 -6.37367	-6.46312 -6.46318 -6.46228 -6.46228 -6.46163 -6.46686 -6.39862 -6.39727 -6.39574 -6.39574 -6.39512 -6.38551 -6.38523 -6.38623 -6.38794	-6.46716 -6.46726 -6.46686 -6.46682 -6.46566 -6.46482 -6.46381 -6.46262 -6.39971 -6.39971 -6.39463 -6.38464 -6.38686 -6.38464 -6.38464	-6.41671 -6.41674 -6.41664 -6.46985 -6.46919 -6.46835 -6.46733 -6.46733 -6.46819 -6.46819 -6.39955 -6.39746 -6.39626 -6.39616 -6.38739 -6.38739 -6.38739
se Riser Line	23456789111231156178922122	-0.35951 -0.35956 -0.35919 -0.35818 -0.35818 -0.35745 -0.35656 -0.35556 -0.35429 -0.35293 -0.35141 -0.34974 -0.34784 -0.34584 -0.34584 -0.34584 -0.34584 -0.34584 -0.34584 -0.33892 -0.33892 -0.33796	-0.36748 -0.36742 -0.36714 -0.36671 -0.36612 -0.36636 -0.36337 -0.36214 -0.36675 -0.355360 -0.355360 -0.3542 -0.35421 -0.34397 -0.344861 -0.34397 -0.34861 -0.34397 -0.33825 -0.3517	-6.37484 -6.37478 -6.37476 -6.37466 -6.37346 -6.37176 -6.37176 -6.36946 -6.3646 -6.36669 -6.3669 -6.36847 -6.3689 -6.35887 -6.35887 -6.35883 -6.34863 -6.34863 -6.34188	-6.38162 -6.38156 -6.38128 -6.38083 -6.37943 -6.37943 -6.37736 -6.3768 -6.37463 -6.37463 -6.37463 -6.37463 -6.37463 -6.37463 -6.37463 -6.36721 -6.36495 -6.36253 -6.36721 -6.36495 -6.36495 -6.36495 -6.36495 -6.36495 -6.36495 -6.36432 -6.36432 -6.36427 -6.36432	-6.38783 -6.38785 -6.38747 -6.38742 -6.38639 -6.38659 -6.38459 -6.38219 -6.38722 -6.37531 -6.37531 -6.37531 -6.36842 -6.36586 -6.36586 -6.36586 -6.36598 -6.36572	-0.39347 -0.39346 -0.39346 -0.39311 -0.39265 -0.39261 -0.39622 -0.38967 -0.38775 -0.38626 -0.38277 -0.37628 -0.37378 -0.37628 -0.36237 -0.36830 -0.36217 -0.35887	-6.39856 -6.39849 -6.39829 -6.39773 -6.39769 -6.39627 -6.39627 -6.39277 -6.39277 -6.38276 -6.38276 -6.38276 -6.38276 -6.38276 -6.38251 -6.37862 -6.37862 -6.37862 -6.37865 -6.36686 -6.36686 -6.36686	-6.40312 -6.40318 -6.40376 -6.40228 -6.40163 -6.39986 -6.39862 -6.39727 -6.39574 -6.39574 -6.39512 -6.38523 -6.38523 -6.37734 -6.37734	-6.46716 -6.46722 -6.46686 -6.46686 -6.46566 -6.46566 -6.46482 -6.46262 -6.39971 -6.39971 -6.39463 -6.39463 -6.38484 -6.38112 -6.3812 -6.37864	-6.41671 -6.41677 -6.41664 -6.46985 -6.46919 -6.46935 -6.46733 -6.46612 -6.46612 -6.46319 -6.46319 -6.39965 -6.39746 -6.39626 -6.3977 -6.39616 -6.3977 -6.39616 -6.38739 -6.38739 -6.38739
se Riser Line	2 3 4 5 6 7 8 9 11 12 13 14 15 17 18 19 22 21	-6.35951 -6.35946 -6.35919 -6.35818 -6.35746 -6.35656 -6.35656 -6.35656 -6.35656 -6.35656 -6.35429 -6.35429 -6.3494 -6.3498 -6.3498 -6.3498 -6.33918 -6.33379 -6.33892	-0.36748 -0.36753 -0.36742 -0.36714 -0.36671 -0.36636 -0.36446 -0.36337 -0.36214 -0.36975 -0.36562 -0.36562 -0.36562 -0.36569 -0.36461 -0.34397 -0.34419 -0.33825	-6.37484 -6.37489 -6.37456 -6.37456 -6.37269 -6.37156 -6.37566 -6.36946 -6.3646 -6.3646 -6.36275 -6.3689 -6.3689 -6.35887 -6.35887 -6.35887 -6.35887 -6.35887 -6.35887 -6.35887 -6.35887	-6.38162 -6.38156 -6.38128 -6.38083 -6.38081 -6.37943 -6.37848 -6.3736 -6.37463 -6.37463 -6.37463 -6.37463 -6.37463 -6.37463 -6.37463 -6.36721 -6.3695 -6.3695 -6.3695 -6.3695 -6.36432 -6.35432 -6.35432 -6.35432	-6.38783 -6.38788 -6.38776 -6.38747 -6.38762 -6.38659 -6.38463 -6.38219 -6.3872 -6.37531 -6.37531 -6.37531 -6.37588 -6.36842 -6.36586 -6.36586 -6.36586 -6.365888	-0.39347 -0.39346 -0.39346 -0.39311 -0.39265 -0.39261 -0.39462 -0.38967 -0.38626 -0.38466 -0.38277 -0.38877 -0.38877 -0.38877 -0.37861 -0.37378 -0.3718 -0.37528 -0.36532 -0.36532 -0.36532 -0.36532	-6.39856 -6.39849 -6.39873 -6.39773 -6.39769 -6.39627 -6.39411 -6.39277 -6.39415 -6.38576 -6.38576 -6.38576 -6.37565 -6.37565 -6.37565 -6.37565 -6.37565 -6.37666	-0.40312 -0.40318 -0.40305 -0.40228 -0.40228 -0.40080 -0.39986 -0.39727 -0.39574 -0.39464 -0.39612 -0.38796 -0.38651 -0.38651 -0.38651 -0.38796 -0.	-6.46716 -6.46716 -6.46686 -6.46686 -6.46686 -6.46566 -6.46488 -6.46262 -6.46262 -6.46262 -6.39971 -6.39799 -6.39463 -6.39463 -6.38468 -6.38464 -6.37478	-6.41671 -6.41674 -6.41684 -6.41685 -6.46919 -6.46835 -6.46733 -6.46612 -6.46319 -6.46319 -6.39956 -6.39956 -6.39746 -6.39616 -6.39746 -6.39733 -6.46319 -6.39746

TABLE 5.3-16, CL1 (BASED ON INDIVIDUAL REF AREA)

OFFICE PAGE IS OF FOOR QUALITY

		1	2	3	4	5	6	7	8	9	16
			.		4 44459	-6.56661	-6.66663	-6.66666	-6.66669	-6.66671	-0.00073
	1	-6.86649	-6.00052	-0.66655	-6.00058 -6.00058	-6.88861	-8.86664	-8.88666	-6.66669	-6.00071	-6.006 73
	2	-6.86649	-6.66652	-6.00055 -6.00055	-0.00058	-0.00001	-0.00663	-0.66666	-6.86669	-6.80871	-0.00073
	3	-8.86649	-6.66652	-8.66655	-0.00058	-0.00061	-6.66663	-0.00066	-0.00068	-0.88871	-0.86673
0	4	-0.86649	-6.66652 -6.66652	-6. 666 55	-6.88858	-6.00061	-6.86663	-6.06666	-6.66668	-0.00071	-0.00073
Ž	5	-6.66649	-8.86652	-6.86655	-6.56658	-6.66661	-6.66663	-6. <i>666</i> 66	-0. <i>000</i> 68	-0.00071	-8.66673
a	5	-6.66649 -6.66649	-6.86652	-6.86655	-0.06058	-6.66666	-0.66663	-6. <i>666</i> 66	- 0.000 68	-0.00070	-0.00073
in	7	-8.56649	-6.86652	-6.66655	-6.66657	-0.00066	-6. <i>666</i> 63	-0.00065	-6 , 666 68	-6.00076	-6.86673
Ξ	8 9	-6.66649	-6.66652	-6.60654	-0.00057	-0.6666	-6.86063	-0.00065	-0.00068	-6.88678	-6.88672
ы	16	-6.66648	-0.00051	-6.50554	- 6.666 57	-0.00066	-0. <i>666</i> 62	-6.66665	-6.66667	-8.66678	-8.66672
er	11	-0.66648	-6.86651	-6.56654	-0.860 57	-0.00059	-6.0 00 62	-6. <i>666</i> 65	-0.00067	-6.66669	-6.86672 -6.86671
(A)	12	-6.50048	-6.86651	-6.56654	- 6.00 058	-0.00059	-6.86662	-6.66664	-6.00067	-6.66669	-6.86671
Ri	13	-6.86648	-6.00058	-6. 666 53	-0, 000 55	- 0.000 59	-0.60661	-6.66664	-0.00006	-0,00068 -0,00068	-6.86676
	14	-0.00047	-6.66656	-6. <i>866</i> 53	- 6.800 56	-0.00058	-6.86661	-6.66663	-6.66666 -6.66665	-6.86668	-6.00076
อ	15	-6.60047	-6,86658	- 0.566 53	- 6 . 866 55	-0.66658	-6.66661	-6.00063	-0.00005 -0.00055	-0.60067	-6.66669
1.6	18	-6.88847	-6.66649	-6. 666 52	-6.66655	-0.66657	-8.86668	-6.88882	-0.00004	-0.00007	-6.86669
3	17	-6.6 66 46	-6.66649	-6. 866 52	-6.66654	-6.66657	-6.66666	-6,66662 -6,66662	-6.00004	-6.88666	-6.66668
an	18	-6.00046	-6.00 6 49	-6.666 51	-0.00054	-6.00057	-0.00059	-6.00001	-0.00003	-0.00005	-6.66667
ď	19	-6.86645	-6. 566 48	-6.00051	- 6 , 866 53	-6.86658	-6.66658 -6.66658	-0.00000	-0.00062	-6.00065	-6.66667
S	25	-0.00045	-6. <i>666</i> 48	-6.86656	- 6.566 63	-6.86655	-6.66657	-6.90066	-6.88662	-0.00064	-6.66666
	21	~0.66645	-6.88847	-6.66656	-6.66652	-0.00055 -0.00054	-6.66656	-6.66669	-0.00061	-6.00063	-6.00005
	22	-8.06644	-8.86646	-6.86649	-0.00052	- 6 . 666 53	-6.66658	-6.66658	-0.00000	-6.6 00 62	-6.66664
	23	-6.06643	-8.86846	-6.66649	-0.00051 -0.00051	-6.66653	-6,86655	-6.86658	-8.88868	-6.88662	-6. 866 64
	24	-0.00043	-5.66646	-6. 566 48	-0.00001	-0.0000	•.••				
		11	12	13	14	15	16	17	18	19	20
	_		-6.88678	-6.56685	-ø. øøø 82	-0.00084	- 6.006 85	-6.00087	-6.86689	-8.86696	-6. 00 692
	1	-6.86676	-8.86678	-6.56686	-6.66682	-6.86684	- 6.566 85	- 6.000 87	-6.66689	~0.56696	-6.86692
	2	-6.66678 -6.66676	-6.66678	-6.00688	-6.66682	-6.55084	-0.66685	- 6 . 006 87	-6.86689	-6.66696	- 8 . 566 92
	4	-6.80075	-6.00678	-6.00080	-6.60682	-6.66683	-0. 666 85	-6.666 87	-6.66689		-6.66691
·	6	-6.00075	-6.96677	-6.86686	-6.86681	-Ø. 666 83	-6.666 85	- 6 . 666 87	-0.66688	-6.66696	-6.86691
ž	6	-6.56675	-6.56677	-6.66679	-6.55581	-0. 666 83	-6. 566 85	-6.56687	-0.66688	-6.66696	-0.66691
41	7	-8.86675	-6.56677	-6.86679	- 6.860 81	- 6.866 83	-0. 500 85	-6.66686	-6.56688	-6.56689	-6.56691 -6.56691
ine	8	-6.66675	-6.66677	-6.00679	- 6 . 000 81	-6.66683	-6.86684	-6.66686	-6.56688	-6.66689 -6.66689	-6.66696
•	9	-6.90075	-6.86677	-6.66679	-6,56681	-6.66682	-6.66684	-6.66686	-6.66687 -6.66687		-8.86696
1	16	-6.00074	-6. 866 78	- 5.666 78	-6.56686	-0.66682	-6. 666 84	-6. 866 85	-6.00087		-6,86696
54	11	-0.00074	-6.00676	~6.866 78	-6.86686		-6. 566 83	-6. 666 85	-6.66686		-6.66689
6 e	12	-6.866 73	6.866 76	-6.66678	-6.66679		-6.86683	-6.56685 -6.66684	-6.80086		-6.0008B
• ਜ	13	-6.660 73	-6. 666 75	-6.86677	-6.66679		-6.56682 -6.56682	-6.66684	-6.66685		-6.56688
α	14	-6.06073	-8.56675	-6.8 00 77	-6. 666 78		-6.66681	-6.56683	-Ø. 500 85		-0.00087
a	15	-6. 866 72	-6.88674	-6.56676			-6.00081	-6.86682	-6.66684		-8,86686
CO.	16	-6.00071	-6.66673	-6.86678			-6.86685	-6.66682	- 6 . 200 83		
.4	17	-6.66671	-6.00073	-6.00678		-	-6.66679	-0.00081	-Ø. 666 83		_
panwi	18	-6.86678	-6.88672	-6.88674			-6.66678	-8.00086	-6.66682		
Ø	19	-6.06669	-6.86671	- 6.866 73			-6.66678	-6.66679			-6.66683
Sp	29	-6.00069	-6.66671	-6.86673 -6.86672	_ .		-8.88677	-6.66679			-6.66683
	21	-6.86668	-6.96676				-8.88676		-6.00079	-6.66688	
	22	-6. 566 67	-6,86669 -6,86668				-8.86675		-6.66676		
	23 24	-6 , 966 65 -6 , 966 65	-0 . DCCC 8		·		-6.86674	-6.866 76	-6.50677	7 -0. 806 79	-6.00088
	24	-0 , 500 00									

TABLE 5.3-17, CL2 (BASED ON LINE REF AREA)

		1	2	3	4	6	6	7	8	9	16
	1	-6.86664	-6.80665	-6.66665	-0.80005	-8.86665					
	2	-6.06664	-6.00005	-6.86665	-8.88865	-0.00005	-0.00006 -0.00006	-6.00066	-6.00006	-0 . 00006	-0 . 8066 6
	3	-8.88684	- 8 . 8068 5	-6.00006	-8.88885	-8.86665	-0.50000	-8.88666 -8.88666	-6.00006	-0.66668	-6 . 6666 6
	4	-0. 8000 4	- 0 .00005	-0.00065	-0.00005	-0.00005	-0.00000	-6.86866	-0.00006 -0.00006	-8.55556	-0.00000
·	5	-6. <i>5</i> 6664	- 0 .86665	-0.00005	- 0.0000 5	-0.00005	-8.00006	-8.00006	-0.00000 -0.00000	-0.00006	-0.00000
ž	6	-0.66664	-0. 8060 6	-6. 8606 5	- 0 .00005	-0.00005	-8.88888	-8.88888	-0.00006	-0.00006 -0.00066	-8.86666
a	7	-0.00004	-0.00005	-6. 8666 5	-0. <i>000</i> 05	-8. 8888 5	-0.00006	-6.00000	-8.86666	-0.00000	-8.00066
ű	8	-8.66664	-6.66665	-6 . 56 666	-0.0 00 05	-0.00005	-8.86668	-6.66666	-0.00000	-0.00000	-0.00006 -0.00006
•-	9 1 6	-8.00004	-6.66666	-6 . 5000 6	-0.00005	-0.00065	-8.88866	-6.00006	-6.66666	-0.00006	-0.00000 -0.00000
_	11	-8.86664 -8.86664	-8.66665	-6.66665	-0.00005	-0. 0000 5	-0.00005	-8.86666	-6.88886	-6.60000	-0.00000
14	12	-0.00004	-6.86665	-0.00005	-0.00005	-0.0 00 65	-8.00005	-0.00006	-6.88888	-0.00006	-0.00000
s e	13	-8.88884	-6.86664	-8.86665	-0.00005	- 6 . 8666 5	-0.00005	-Ø . 8666 6	-6.00006	-6.00008	-6.66666
٠.	14	-8.86684	-0.86664 -0.86664	-6.86665	-0.00005	-0.00005	-0.0 066 5	-0 . 6066 6	-6.66666	-6.00008	-0.00000
α	15	-8.56664	-6.86664	-6.86665 -6.86665	-6.88865	-0.00005	-0.8 000 6	-0 . 200 06	-8.88866	-6.66666	-8.00066
a	16	-6.00064	-6.00064	-6.00065	-6.80605	-8.86666	-6.66666	-6 . <i>5606</i> 6	-0 . 56666	-0. <i>8666</i> 6	-0. 000 66
CO.	17	-8.88884	-8.88684	-6.86665	-0.00005 -0.00005	-0.00005	-8.66665	-6.66666	-0.00006	-0 . 8686 8	-Ø. 6666 6
¥.	18	-6.86664	-6.86684	-6.86665	-0.00005	-0.00005 -0.00005	-8.55665	-6.00005	-6 . 6666 6	-8 . 86666	-8. 6666 6
C	19	-6.86664	-6.56664	-8.56664	-6.86665	- 6.6666 6	-6.88665	-0.00005	-8 . 86666	-8 . 8 86 66	-8 . 8666 6
pa	29	-6.56684	-6.56684	-6.50064	-6.00005	-6. 6666 5	-0.00065	-0.86665	-8.00006	-0 . 8066 6	-0 . 6666 6
S	21	-6.8 666 4	-8.86664	-6.56664	-6. 566 65	-0.60665	-8.66665 -8.66665	-6.66665	-6.00006	-6 . <i>666</i> 66	-8 . 8666 6
	22	-6.86664	-8.86664	-6.86664	-0.00005	-0.50005	-0.66665	-0.00005	-0.00005	-0.66666	-0 . 6006 6
	23	-6.96064	-6. <i>566</i> 64	-6.86664	-0.00005	-6.86665	-0.86665	-6.66665 -6.66665	-6.66665	-0.00006	-0.00006
	24	-8. 566 84	-8.86664	-8.66664	-6.56664	-0.50005	-0.66665	-0.00005 -0.00005	-0.00005 -0.00005	-6.88886	-8.86666
								0.0000	-0.00000	-6. 5600 5	-0.0 000 6
		11									
	•	11	12	13	14	15	16	17	18	19	28
	1	- 6 . 6666 7	-Ø. 9006 7	-6.06667	-0.06667	15 -6.56667	16 -0.50008	17 -5.5568	18 -6.5666B		
•	2	-0.86667 -6.86667	-0.00067 -0.00087	-6.00007 -6.00007	-0.00007 -0.00007					- 6 . 8000 8	-6 . 5666 8
No.	_	-0.66667 -6.66667 -0.66667	-0.00067 -0.00067 -0.00067	-6.06667 -6.06667 -6.56667	-8.86667 -6.86667 -6.86667	-6.86667 -6.86667 -6.66667	-6.86668 -6.86668 -6.66668	-6.66668	-6.5666B		-6.86668 -6.86668
Ž	2	-8.86667 -6.86667 -6.86667	-0.90067 -0.96067 -0.96067 -6.96667	-6.06667 -6.06667 -6.06667	-0.00007 -0.00007 -0.00007	-6.86667 -6.86667 -6.86667 -6.86667	-0.00008 -0.00008 -0.00008 -0.00068	-6.56668 -6.56668	-6.66668	-6.80008 -6.80008	-6 . 5666 8
Š e	2 3 4	-0.00007 -0.00007 -0.00007 -0.00007 -0.00007	-0.00067 -0.00067 -0.00067 -0.00067 -6.00067	-6.06067 -6.06067 -6.06067 -6.06067 -6.06067	-0.00007 -0.00007 -0.00007 -6.00007 -6.00007	-6.96667 -6.96667 -6.96667 -6.96667 -6.96667	-6.56668 -6.56668 -6.56668 -6.56668	-6.56668 -6.56668	-6.56668 -6.56668 -6.6668	-6.80668 -6.86668 -6.86668	-6.56668 -6.56668 -6.6668
ine N	2 3 4 5	-8.86667 -6.86667 -6.86667	-8.86667 -8.86667 -8.86667 -8.86667 -8.86667 -8.86667	-6.06007 -6.06007 -6.06007 -6.00007 -6.00007	-0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007	-6.56667 -6.96667 -6.96667 -6.96667 -6.56667 -6.56667	-0.00008 -0.00008 -0.00008 -0.00008 -0.00008 -0.00008	-6.50008 -6.50008 -6.60008 -6.50008 -6.50008	-6.56668 -6.66668 -6.66668 -6.56668 -6.56668	-6.86668 -6.86668 -6.86668	-6.56668 -6.56668 -6.56668
ne N	2 3 4 5 6	-6.50067 -6.50007 -6.50007 -6.50007 -6.50007 -6.50007	-0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007	-6.06007 -6.06007 -6.06007 -6.06007 -6.06007 -6.06007	-0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007	-8.56667 -6.86667 -6.86667 -6.86667 -6.86667 -6.86667 -6.86667	-0.00008 -0.00008 -0.00008 -0.00008 -0.00068 -0.00068 -0.00067	-6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008	-6.00008 -6.00008 -6.00008 -6.00008 -6.00008 -6.00068 -6.00068	-0.80008 -0.80008 -0.80008 -0.80008 -0.80008	-6.56668 -6.56668 -6.56668 -6.56668
ine N	2 3 4 5 6 7	-0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007	-0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007	-6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067	-0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007	-6.56667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667	-6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56667 -6.56667	-6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668	-6.00068 -6.00068 -6.0008 -6.0008 -6.0008 -6.0008 -6.0008	-6.80008 -6.90008 -6.90008 -6.90008 -6.50008 -6.50008 -6.50008	-6.50068 -6.50068 -6.50068 -6.50068 -6.50068
er Line N	2 3 4 5 6 7	-0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007	-8.86667 -6.86667 -6.86667 -6.86667 -6.86667 -6.86667 -6.86667	-6.06007 -6.06007 -6.06007 -6.06007 -6.06007 -6.06007	-0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007	-8.56667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667	-6.56668 -6.06668 -6.06668 -6.56668 -6.56668 -6.56667 -6.56667 -6.56667	-6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068	-6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668	-6.80008 -6.90008 -6.90008 -6.90008 -6.50008 -6.50008 -6.50008 -6.50008	-6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068
r Line N	2 3 4 5 6 7 8	-0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007	-8.86667 -8.96667 -8.96667 -6.96667 -8.86667 -6.86667 -6.86667	-6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067	-0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007	-8.56667 -6.06667 -6.06667 -6.06667 -6.06667 -6.06667 -6.06667 -6.06667 -6.06667	-6.56668 -6.06668 -6.06668 -6.56668 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667	-6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008	-6.56668 -6.56668 -6.56688 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668	-6.80008 -6.90008 -6.90008 -6.90008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008	-6.80068 -6.90669 -6.90669 -6.9068 -6.9068 -6.90668 -6.90668 -6.90668 -6.90668
ser Line N	2 3 4 5 6 7 8 9 10 11 12	-0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007	-6.86667 -6.96667 -6.96667 -6.96667 -6.86667 -6.86667 -6.86667 -6.86667 -6.86667	-6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067	-0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007	-6.56067 -6.56067 -6.56067 -6.56067 -6.56067 -6.56067 -6.56067 -6.56067 -6.56067 -6.56067 -6.56067	-6.56668 -6.56668 -6.56668 -6.56668 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667	-6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068	-6.50068 -6.5008 -6.5008 -6.5008 -6.5008 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068	-6.0008 -6.0008 -6.0008 -6.0008 -6.5008 -6.5008 -6.5008 -6.5008 -6.5008 -6.5008 -6.5008	-6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008
Riser Line N	2 3 4 5 6 7 8 9 18 11 12 13	-0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.000007 -0.000007	-0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067	-6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067	-6.00007 -6.00007 -6.00007 -6.00007 -6.00007 -6.00007 -6.00007 -6.00007 -6.00007 -6.00007	-8.56667 -6.06667 -6.06667 -6.06667 -6.56667 -6.56667 -6.56667 -6.66667 -6.66667	-6.56668 -6.96668 -6.66668 -6.56668 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667	-6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068	-6.00068 -6.00068 -6.00068 -6.00068 -6.00068 -6.00068 -6.00068 -6.00068 -6.00068 -6.00068	-6.80008 -6.90008 -6.80008 -6.80008 -6.80008 -6.80008 -6.80008 -6.90008 -6.90008 -6.90008 -6.90008	-6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008
iser Line N	2 3 4 5 6 7 8 9 1# 11 12 13	-0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007	-8.80067 -8.80067 -8.80067 -6.80067 -6.80067 -6.80067 -6.80067 -6.80067 -6.80067 -6.80067	-6.06067 -6.06067 -6.06067 -6.00067 -6.00067 -6.00067 -6.00067 -6.00067 -6.00067 -6.00067 -6.00067	-0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007	-6.56667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667	-6.56668 -6.00668 -6.06668 -6.56668 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667	-6.50068 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008	-6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668	-6.80668 -6.9068 -6.8668 -6.8668 -6.8668 -6.8668 -6.8668 -6.8668 -6.8668 -6.8668 -6.8668 -6.8668 -6.8668	-6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008
ise Riser Line N	2 3 4 5 6 7 8 9 1 1 1 1 2 1 3 1 4 1 5	-0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.0000000000	-0.00007 -0.00007	-6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067	-0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007	-6.56667 -6.96667 -6.96667 -6.96667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667	-6.56668 -6.96668 -6.66668 -6.56668 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667	-6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008	-6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668	-6.80008 -6.90008 -6.90008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008	-6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008
se Riser Line N	2 3 4 5 6 7 8 9 10 11 12 13 14 15 16	-0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00066 -0.00066 -0.00066	-0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067	-6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067	-0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007	-6.56667 -6.96667 -6.96667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667	-6.56668 -6.06668 -6.06668 -6.56668 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667	-6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56668 -6.56667 -6.56667 -6.56667	-6.00068 -6.00068 -6.00068 -6.00068 -6.00068 -6.00068 -6.00068 -6.00068 -6.00068 -6.00068 -6.00068 -6.00068	-6.80008 -6.90008 -6.90008 -6.90008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008	-6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008
anwise Riser Line N	2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17	-0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00066 -0.00066 -0.00066	-8.86667 -8.86667 -8.86667 -8.86667 -6.86667 -6.86667 -6.86667 -6.86667 -6.86667 -6.86667 -6.86667 -6.86667 -6.86667 -6.86667 -6.86667 -6.86667 -6.86667 -6.866667 -6.866667	-6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067	-0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007	-6.56667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667	-6.56668 -6.56668 -6.56668 -6.56668 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667	-6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008	-6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068	-6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068	-6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008
panwise Riser Line N	2 3 4 5 6 7 8 9 11 12 12 14 15 16 17 18	-0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.000007 -0.0000000000	-8.80067 -8.80067 -8.80067 -8.80067 -6.80066	-6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067 -6.06067	-0.00007 -0.00007	-6.56067 -6.96067 -6.96067 -6.96067 -6.96067 -6.96067 -6.96067 -6.96067 -6.96067 -6.96067 -6.96067 -6.96067 -6.96067 -6.96067 -6.96067 -6.96067	-6.56668 -6.56668 -6.56668 -6.56668 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667	-6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50067 -6.50067 -6.50067 -6.50067 -6.50067	-6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068	-6.80008 -6.90008 -6.60008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008	-6.50008 -6.50008
anwise Riser Line N	2 3 4 5 6 7 8 9 11 12 13 14 15 16 17 18	-0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.0000000000	-8.80067 -8.80067 -8.80067 -8.80067 -8.80067 -8.80067 -6.80066	-6.06067 -6.06067	-0.00007 -0.000007	-6.56067 -6.90067 -6.90067 -6.90067 -6.50067 -6.50067 -6.50067 -6.50067 -6.50067 -6.90067 -0.90067 -0.90067 -0.90067 -0.90067 -0.90067 -0.90067 -0.90067 -0.90067 -0.90067 -0.90067 -0.90067 -0.90067	-6.56668 -6.96668 -6.66668 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667	-6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50067 -6.50067 -6.50067 -6.50067 -6.50067	-6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068	-6.80008 -6.90008 -6.60008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008	-6.50008 -6.50008
panwise Riser Line N	2 3 4 5 6 7 8 9 11 12 13 14 15 16 17 18 19 29	-0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00006 -0.00006 -0.00006 -0.00006 -0.00006 -0.00006 -0.00006	-8.86667 -8.86667 -8.86667 -8.86667 -8.86667 -6.86667 -6.86667 -6.86667 -6.86667 -6.86667 -6.86667 -6.86667 -6.86667 -6.86667 -6.86667 -6.86667 -6.86667 -6.86666 -6.86666 -6.86666	-6.06667 -6.06667	-0.00007 -0.00007	-6.56667 -6.06667 -6.06667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667 -6.96667	-6.56668 -6.96668 -6.66668 -6.56668 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667	-6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50067 -6.50067 -6.50067 -6.50067 -6.50067 -6.50067	-6.00068 -6.00068 -6.00068 -6.00068 -6.00068 -6.00068 -6.00068 -6.00068 -6.00068 -6.00068 -6.00068 -6.00068 -6.00068 -6.00068 -6.00068 -6.00068	-6.80008 -6.90008 -6.90008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008	-6.50008 -6.50008
panwise Riser Line N	2 3 4 5 6 7 8 9 11 12 13 14 15 16 17 18 19 22 1	-0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00066 -0.00066 -0.00066 -0.00066 -0.00066 -0.00066 -0.00066 -0.00066 -0.00066 -0.00066 -0.00066	-0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.000007 -0.000007 -0.000007 -0.000007 -0.000007 -0.000007 -0.000000 -0.000000000000000000000000	-6.06067 -6.56067	-6.00007 -6.000007 -6.00007 -6.00007 -6.00007	-6.56067 -6.96067	-6.56668 -6.56668 -6.56668 -6.56668 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667	-6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50067 -6.50067 -6.50067 -6.50067 -6.50067 -6.50067 -6.50067 -6.50067 -6.50067	-6.00008 -6.00008 -6.00008 -6.00008 -6.00008 -6.00008 -6.00008 -6.00008 -6.00008 -6.00008 -6.00008 -6.00008 -6.00008 -6.00008 -6.00008 -6.00007 -6.00007 -6.00007 -6.00007	-6.80008 -6.90008 -6.60008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008	-6.50008 -6.50008
panwise Riser Line N	23456789#1123456789#11234567189#2122	-0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00066 -0.00066 -0.00066 -0.00066 -0.00066 -0.00066 -0.00066 -0.00066 -0.00066 -0.00066 -0.00066	-0.00067 -0.00066 -0.00066 -0.00066 -0.00066 -0.00066 -0.00066	-6.06067 -6.06067	-0.00007 -0.000007 -0.000007 -0.000007 -0.000007 -0.000007 -0.000007 -0.000007 -0.000007 -0.000007 -0.000007 -0.000007 -0.000007 -0.000007	-6.56067 -6.90067 -6.90067 -6.90067 -6.50067 -6.50067 -6.50067 -6.50067 -6.50067 -6.90067	-6.56668 -6.96668 -6.66668 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667	-6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50067	-6.00008 -6.00008 -6.00008 -6.00008 -6.00008 -6.00008 -6.00008 -6.00008 -6.00008 -6.00008 -6.00008 -6.00008 -6.00008 -6.00007 -6.00007 -6.00007 -6.00007 -6.00007 -6.00007 -6.00007 -6.00007	-6.80008 -6.90008 -6.90008 -6.90008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008 -6.50008	-6.50008 -6.50008
panwise Riser Line N	2 3 4 5 6 7 8 9 11 12 13 14 15 16 17 18 19 22 1	-0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00067 -0.00066 -0.00066 -0.00066 -0.00066 -0.00066 -0.00066 -0.00066 -0.00066 -0.00066 -0.00066 -0.00066	-0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.00007 -0.000007 -0.000007 -0.000007 -0.000007 -0.000007 -0.000007 -0.000000 -0.000000000000000000000000	-6.06067 -6.56067	-6.00007 -6.000007 -6.00007 -6.00007 -6.00007	-6.56067 -6.96067	-6.56668 -6.56668 -6.56668 -6.56668 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667 -6.56667	-6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50067 -6.50067 -6.50067 -6.50067	-6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50068 -6.50067 -6.50067 -6.50067	-6.80068 -6.90068 -6.80068 -6.80068 -6.80068 -6.80068 -6.80068 -6.80068 -6.90068 -6.90068 -6.90068 -6.90068 -6.90068 -6.90068	-6.50008 -6.50008

TABLE 5.3-18, CL3 (BASED ON PARAFOIL REF AREA)

5.4 LATERAL STABILITY STUDY

When the 20 x 60 ft parafoil was tested in the NASA-Ames wind tunnel, four tether lines were attached to constrain the model in roll and yaw, as shown in Figure 5.4-1. Aerodynamic forces and moments were measured through the balance located in the tunnel floor. Missing from these balance measurements were the forces transmitted via the tether lines. The purpose of this study is to include these forces and their contributions to aerodynamic force and moment coefficients.

5.4.1 Resolving Tether Forces

During the wind tunnel test, a load cell was placed on each of the tether lines to measure line tension. To simplify the process of solving for these forces, the first step is to resolve the direction of the lines into unit vectors (UV1, UV2, UV3, UV4) as shown in Figure 5.4-1. As previously mentioned, the model was constrained in roll and yaw; however, it was allowed to move in pitch with this assumption; the unit vectors are functions of α and the forces are resolved as follows:

$$T_1 \cdot UV_1(\alpha) = T_1x + T_1y + T_1z$$

 $T_2 \cdot UV_2(\alpha) = T_2x + T_2y + T_2z$
 $T_3 \cdot UV_3(\alpha) = T_3x + T_3y + T_3z$
 $T_4 \cdot UV_4(\alpha) = T_4x + T_4y + T_4z$

where T_1 to T_4 are the line tensions, UV_1 to UV_4 the unit vectors, and Tx, Ty and Tz the component forces. (See Figure 5.4-2 for a depiction of these forces.)

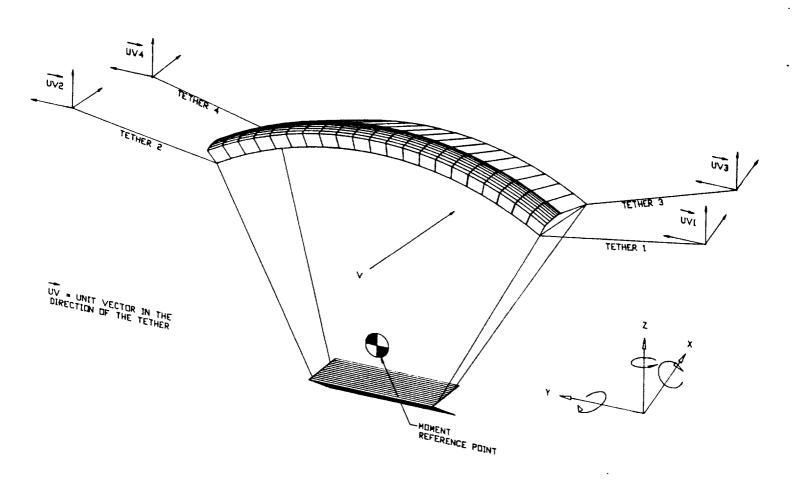


FIGURE 5.4-1, TETHER NOMENCLATURE

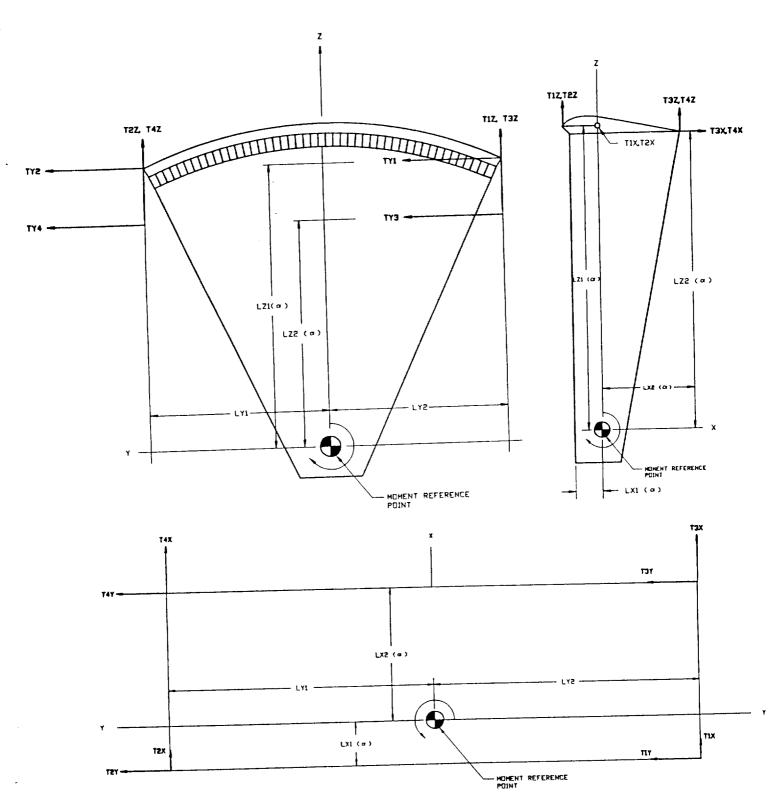


FIGURE 5.4-2, TETHER FORCE AND MOMENT COMPONENTS

5.4.2 Tether Aerodynamic Force Contributions

To add the tether force increments to the measured aerodynamic force obtained from the wind tunnel test the following is used:

$$\Delta D_T = T_1x + T_2x + T_3x + T_4x (\Delta Drag)$$

 $\Delta L_T = T_1z + T_2z + T_3z + T_4z (\Delta Lift)$
 $\Delta S_T = T_1y + T_2y + T_3y + T_4y (\Delta Side Force)$

To translate into coefficient form:

 $C_{DT} = \Delta D_T/qA_{REF}$ $C_{LT} = \Delta L_T/qA_{REF}$ $C_{ST} = \Delta S_T/qA_{REF}$

where q is the dynamic pressure and AREF the reference area of the parafoil (1200 ft²).

5.4.3 Tether Aerodynamic Moment Contributions

To add the tether moment increments to the measured values obtained from the test the following is used:

$$\Delta MxT = -(T_1y + T_2y)Lz_1(\alpha) - (T_3y + T_4y)Lz_2(\alpha) + (T_2z + T_4z)Ly_1 - (T_1z + T_3z)Ly_2$$

$$\Delta MyT = (T_1x + T_2x)Lz_1(\alpha) + (T_3x + T_4x)Lz_2(\alpha) + (T_1z + T_2z)Lx_1(\alpha) - (T_3z + T_4z)Lx_2(\alpha)$$

$$\Delta MzT = (T_3x + T_1x)Ly_2 - (T_2x + T_4x)Ly_1 + (T_3y + T_4y)Lx_2(\alpha) - (T_2y + T_1y)Lx_1(\alpha)$$

To translate into coefficient form:

 $C_{MxT} = \Delta MxT/(q \text{ Aref Lref})$ $C_{MyT} = \Delta MyT/(q \text{ Aref Lref})$ $C_{MZT} = \Delta MzT/(q \text{ Aref Lref})$

where q is the dynamic pressure, AREF the parafoil reference area $(1200 \ \text{ft}^2)$ and LREF the reference length of 20 ft for lateral and 60 ft for longitudinal.

5.4.4 Moment Arm Determination

This section follows the development of equations used in determining the moment arms, as seen in Figure 5.4-2. As stated previously, the model is assumed to be constrained in roll and yaw, but is free to pitch. The moment arms Lz₁, Lz₂, Lx₁ and Lx₂ are therefore all functions of θ_1 , θ_2 , α and α p. The moment arms Ly₁ and Ly₂ are assumed constant. For the remainder of this section follow Figures 5.4-3 and 5.4-4. Given:

cx, xx, LL, b, R, LL (Constant) αp , ϕ , δp , XCG1, XCG2 (Per Test Basis)

Calculated:

a =
$$(Fu^2 + xx^2 - 2 Fu xx Cos \theta)^{1/2}$$

 $\theta_1 = Cos^{-1}((Fu^2 + a^2 - xx^2)/(2 Fu a))$
 $\theta_2 = Cos^{-1}((Cx^2 + a^2 - Ru^2)/(2 Cx a))$
 $\alpha = \alpha p - \phi + (180 - \theta_1 - \theta_2)$

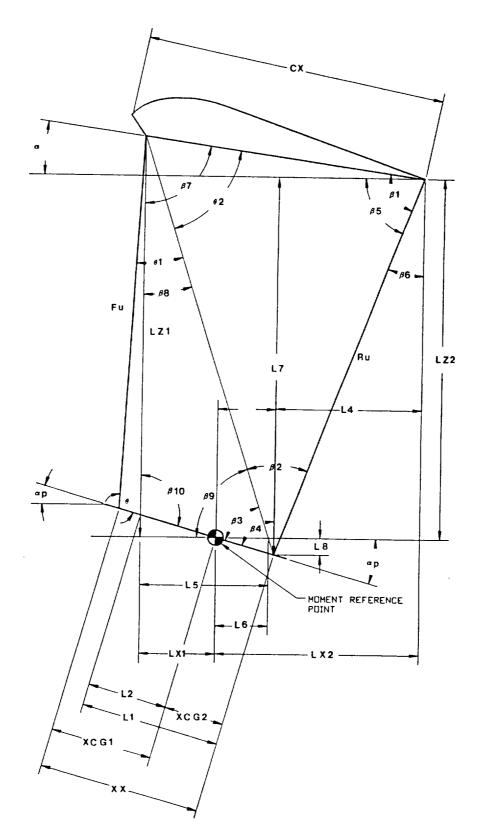


FIGURE 5.4-3, MOMENT ARM GEOMETRY

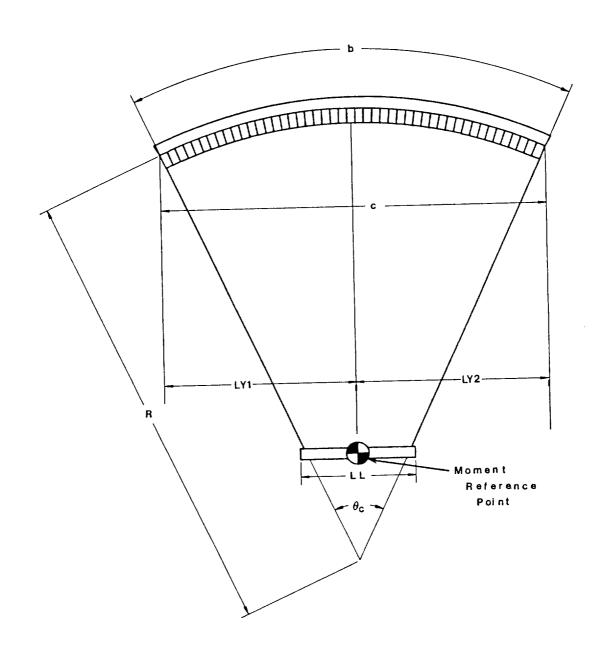


FIGURE 5.4-4, MOMENT ARM GEOMETRY

where the values of Fu, length of forward most suspension line and Ru, length of the rearmost suspension line were defined in a previous study as:

Ru =
$$53.995 - (.3403 + 2(4.1285)^2 - 2(4.1285)(.3403 + (4.1285)^2)^{1/2} \cos((\delta p + 5) + \tan^{-1} (.5833/4.1285)))^{1/2} + .0833$$

Fu = $48.209 - (.3403 + 2(.3942)^2 - 2(.3942)(.3403 + (.3942)^2)^{1/2}\cos((\delta p + 5) + \tan^{-1} (.5833/.3942)))^{1/2} + .0833$

Continuing for the b angles and using the law of sines:

$$\alpha/\sin \beta_1 = Cx/\sin \beta_2 = Ru/\sin \theta_2$$

 $\alpha/\sin \theta = xx/\sin \theta_1 = Fu/\sin \beta_3$
 $\beta_1 = \sin^{-1}((a \sin \theta_2)/Ru)$
 $\beta_2 = \sin^{-1}((Cx \sin \theta_2)/Ru)$
 $\beta_3 = \sin^{-1}((Fu \sin \theta_1)/XX)$
 $\beta_4 = 90 - \alpha\rho$
 $\beta_5 = \beta_1 - \alpha$
 $\beta_6 = 90 - \beta_5$
 $\beta_7 = 90 - \alpha$
 $\beta_8 = \beta_7 - \theta_2$
 $\beta_9 = 90 - \beta_8$
 $\beta_{10} = 180 - \beta_3 - \beta_8$

For the length calculations and using the law of sines:

$$\alpha/\sin\beta_{10} = L_1/\sin\beta_8$$
 $L_1 = (a \sin\beta_8)/\sin\beta_{10}$
 $L_2 = L_1 - XCG_2$
 $L_3 = LCG_2 \cos\alpha\beta$
 $L_4 = Ru \cos\beta_5$
 $L_5 = a \sin\beta_8$
 $L_6 = L_5 - L_2 \cos\alpha\beta$
 $\Lambda_7 = Ru \sin\beta_5$
 $L_8 = XCG_2 \sin\alpha\beta$
 $\theta = b/R$
 $\theta = b/R$
 $\theta = 2R \sin(\theta C/2)$

Solving for the moment arms:

$$Lx_1 = L_2 \cos \alpha p$$

 $Lx_2 = L_3 + L_4$
 $Lz_1 = (L_5^2 + a^2)^{1/2}$
 $Lz_2 = L_7 - L_8$
 $Ly_1 = c/2$
 $Ly_2 = c/2$

Solving and substituting in terms of the "given" values:

Lx₁ =
$$((a \sin (90 - \alpha - \theta 2))/(\sin (90 - \sin^{-1}(Fu \sin \theta 1/xx)) + \alpha + \theta 2)$$

- XCG2) cos (α p)
Lx₂ = XCG2 cos α p + Ru cos ($\sin^{-1}(a \sin \theta 2/Ru) - \alpha$)
Lz₁ = $((a \sin (90 - \alpha - \theta 2))^2 + a^2)^{1/2}$
Lz₂ = Ru sin ($\sin^{-1}(Fu \sin \theta 2/xx) - \alpha$) - XCG2 sin α p
Ly₁ = R sin (θ c/2)
Ly₂ = R sin (θ c/2)

5.5 PARAFOIL SCALING EFFECTS

During the Advanced Recovery System (ARS) wind tunnel test at the National Full-scale Aerodynamic Complex, two different parafoils were tested. The largest of the two (20' x 60') was the primary model and was so chosen in order to have the majority of the measured data as close to the full scale drop test size as is possible in the confines of the 80' x 120' test section. The smaller parafoil model was sized in order to be able to evaluate the effects of different size. This would allow corrections to be calculated to properly estimate full scale flight values using the data from the larger parafoil mode.

During the test it was observed that the parafoil assumed a shape that was different from the original design contours. Although not entirely unexpected, it was concluded the magnitude of these distortions precluded the test article from properly modeling the intended design. This in itself is not detrimental because it can be assumed that the full scale parafoil will also distort under load. The problem is that the models and the full scale parafoils may not distort in the same way or in the same

relative amount. Comparison between the two different size models can give insight to this.

It can be concluded that if the two models did not distort in the same way, a proper analysis of the scaling effects cannot be done without determining the effects (parametrically in the wind tunnel) of each of the different distortions. Since it is impractical to measure actual distortions and impossible, from the data obtained, to derive individual contributions, an analytical approach was taken to evaluating the effect of the parafoil model distortions.

5.5.1 Configuration Changes

During the test of the parafoil models, there were seven different distortions identified. The cause of each distortion was determined as was the effect of each distortion.

5.5.1.1 Leading Edge Distortion

During the test the leading edge of the parafoil was observed to be deflected up (Figure 5.5-1). The condition seemed to be worse at higher dynamic pressures. Because of the parafoil configuration and suspension line attachment location the front suspension line of each chordwise row had approximately twice the load as the next several lines behind it. This is verified by the load cell data. The front suspension line has approximately two times the surface area acting upon it as do any of the other lines.

Although the Kevlar lines that were used have a very low modulus of elasticity, they did stretch and the difference in stretch between the front lines and the ones behind them, allowed the leading edge to deflect up.

Line stretch is dependent on the load being applied and the elasticity of the line.

Aerodynamic load is the function of dynamic pressure (q) and characteristic area (S).

The intent during the test was for q to be the same for both parafoil models (sizes) and data are available for comparisons at equal q.

S is four times as large for the larger parafoil as it is for the smaller parafoil.

Line elasticity is dependent on the material, the line diameter and the style or weave. All three of these were identical for the two parafoil models.

Therefore, the leading edge deflection is four times as much for the larger parafoil as it is for the smaller parafoil though the linear dimension is only twice as large. The relative distortion is therefore twice as much in the larger parafoil as it is in the smaller one.

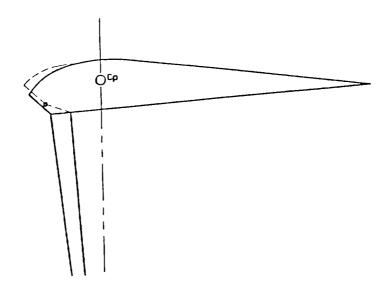


FIGURE 5.5-1, LEADING EDGE DISTORTION

5.5.1.2 Chordwise Foreshortening

Parafoils are rigged such that the payload is positioned forward and the front suspension lines are much closer to being perpendicular to the bottom surface which causes the parafoil to foreshorten (Figure 5.5-2). The foreshortening in turn allows the lines to reach above the nominal attach point producing a convex curve to the bottom surface of the parafoil.

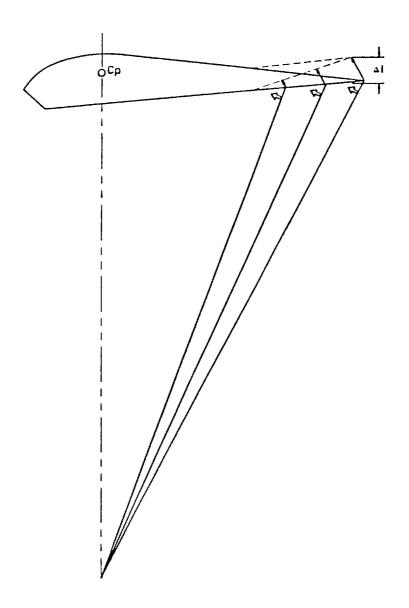


FIGURE 5.5-2, CHORDWISE FORESHORTENING

Prior to Run 5, the suspension lines were rerigged to try and compensate for this. To make the small parafoil similar to the large one, an equivalent/proportional change in rigging was used throughout the time the small parafoil was being tested.

Chordwise foreshortening is a function of suspension line load, line attach angle, rigging and rigidity of the parafoil.

Line Load is dependent on q and S.

q can be selected the same for comparing data and can therefore be considered equal.

S is four times as large for the larger parafoil. Therefore line load would be four times as great.

Rigging was as near identical as could be achieved.

Rigidity of the parafoil is a function of the stiffness of the fabric and the difference in pressure DEL P across the boundaries of the cells.

Assuming no or identical flow separation (which is hard to determine in this situation) the DEL P would be the same.

The parafoil fabric was the same density for both parafoils. Therefore the smaller one was proportionally more stiff. This would lead us to believe that the smaller parafoil should be relatively more rigid. But this was hard to verify by observation of cell shape as will be discussed later.

Therefore, with four times the line load and a linear scale of two, it can be assumed that the relative chordwise foreshortening would be twice as great in the larger parafoil as in the smaller one.

5.5.1.3 Trailing Edge Configuration

In order to ease fabrication of the parafoils, the gore between the parafoil cells was terminated forward of the trailing edge. Therefore there was no attachment between the upper and lower surfaces of the parafoil near the trailing edge. The result was a parafoil which looked like it had a tube running along the trailing edge in the spanwise direction (Figure 5.5-3). In effect, it did.

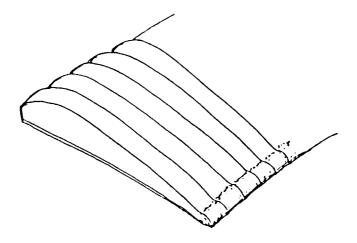


FIGURE 5.5-3, TRAILING EDGE CONFIGURATION

Ignoring the problem of configurational integrity, the concern settles on whether the two different size parafoils had equivalent configurations.

This trailing edge configuration anomaly is dependent on the gore length/attachment and the differential pressure across the fabric.

The gore length/attachment was modeled identically.

Assuming all other factors are the same (which seems to be a poor assumption, but one without an alternative since we do not have pressure data), the pressure differential will be the same, therefore the trailing edge configurations can be considered to be correctly scaled from one model to the other.

5.5.1.4 Trailing Edge Deflection

Parafoils are designed such that local loads are opposed by tension on the individual suspension lines. Under great load the lines are pulled taut. Under light loads, other factors such as line drag can become significant. Near the trailing edge the load distribution goes to near zero. This provides little tension on the trailing edge suspension lines. As could be observed during the test, there was considerably more drag produced bow in the trailing edge lines than in those lines closer to the leading edge. The result of this was that the trailing edge of the parafoil was deflected downward, enough to be noticeable even with the curve up caused by the chordwise foreshortening (Figure 5.5-4). The trailing edge deflection is a function of local parafoil load on the line and of aerodynamic drag acting on the line.



FIGURE 5.5-4, TRAILING EDGE DEFLECTION

As discussed previously, the distributed load is four times as great for the larger parafoil as it is for the smaller one.

The line drag is a function of line diameter, line length and q.

Choosing data for comparison at equal q eliminates q as a consideration.

The line lengths are linearly scaled between the two parafoils although a larger percentage of the length may be exposed to the flow in the test set up of the larger parafoil.

Line diameter is identical for the two sizes of parafoil, which means the line drag would be relatively twice as large for the half linear scale smaller parafoil as it would be for the larger parafoil.

5.5.1.5 Flow Angle

In order to keep flow from impinging on the Parafoil Attitude Control System (PACS) and other attachment hardware, and therefore causing erroneous measurements by the primary balance, a six foot high flow deflector was positioned upstream of the PACS (Figure 5.5-5). This was of little concern with the large parafoil which when being tested was positioned somewhat above the center line of the 80 foot tall test section. With the small parafoil however, there was some concern that the flow deflector could be causing a change in local flow angle and therefore a different and erroneous angle of attack. The test data seem to support this theory. The suspension lines of the smaller (half linear scale) parafoil were half the length of those of the larger parafoil. The effect of this is hard to determine.

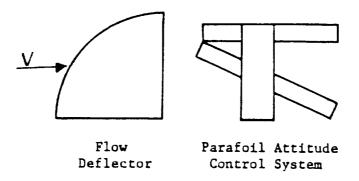


FIGURE 5.5-5, HARDWARE TEST ARRANGEMENT

5.5.1.6 Cell Shape

When a parafoil is in flight the pressure at the open leading edge is at or near the total pressure of the system. Since there are no other air passages, total pressure acts over the entire interior of the parafoil. Since virtually none of the external surfaces are at that high of a pressure, the pressure differential from the outside to the inside is always positive and this causes the parafoil to take its' intended shape. The greater the differential the more "round" the surface of either the top or the bottom of each cell (Figure 5.5-6). Different cell shapes might cause different flow over the parafoil and therefore create different loads. Cell shape is a function of fabric stiffness, and the relationship between pressure differential and spanwise tension.

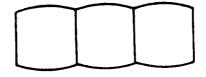


FIGURE 5.5-6, PARAFOIL CELL SHAPE

The fabric weights (stiffness) are the same for both size parafoils, therefore the smaller parafoil is relatively twice as thick and stiff as is the larger one.

At identical q's, the interior pressures will be the same. Assuming the configuration is the same (which again may be a poor assumption), the external pressures will also be the same. Therefore the pressure differentials across the parafoil fabric will be relatively the same.

The spanwise tension is dependent on q, the wing area (S), wing span (b), and distributed pressures.

q can be chosen to be identical.

S and b are linearly scaled between the two different size parafoils.

Again assuming similar configurations, the pressure distribution should be similar.

The spanwise tension should therefore be properly scaled.

Therefore the only difference in cell shape would be caused by the fabric which should have little or no affect.

5.5.1.7 Spanwise Shape/Length

The spanwise shape of the parafoil is defined by the suspension line length and attach location (Figure 5.5-7). This was properly scaled. Shape can also be affected by any spanwise foreshortening. Spanwise foreshortening would be a direct result of changes of shape in all the individual cells. As was discussed above, it is not believed that cell shape was different between the two sizes of parafoil.

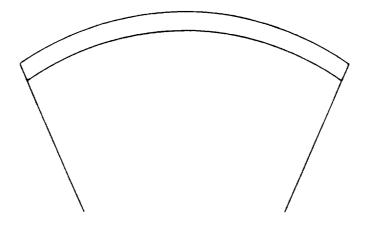


FIGURE 5.5-7, PARAFOIL SPANWISE SHAPE

5.5.2 Summary

The nose shape distortion was relatively twice as great for the large parafoil as it was for the small one. The chordwise foreshortening was also relatively twice as great for the large parafoil. The trailing edge deflection was relatively only half as great for the large parafoil as it was for the small parafoil. Recorded attitudes give cause to believe that the small parafoil was in local flow which was not parallel to the test section floor due to the effects of the flow deflector. Table 5.5-8 gives a summary of parafoil scaling effects.

5.5.3 Conclusion

The trailing edge deflection problem has the least effect due to the small loads in that area. The leading edge shape and chordwise foreshortening, however, are in critical areas and as can be seen in photographs and videos of the test, had significant distortions. Even ignoring potential problems resulting from flow angularity when testing the small parafoil, there were enough differences in configuration between the large (20' x 60') and the small (10' x 30') parafoils to preclude a proper evaluation of the effects of scaling.

5.5.4 Recommendations

Data from tests of the larger parafoil should be used in simulations of the full scale ARS parafoils. This is because they are closer to the correct size and also they are not affected by any potential flow angularity problems.

Future models of full scale flight articles should be designed so that distortions will be representative of distortions of the fullscale configuration, taking into account differences in load, fabric stiffness, line stretch, etc.

Parametric tests should be conducted and should use models in some kind of boilerplate configuration.

TABLE 5.5-8, SUMMARY OF PARAFOIL SCALING EFFECTS

EFFECT	SCALING FACTOR		
	Large	Small	
	(20' x 60' Model)	(10' x 30' Model)	
Leading Edge Distribution	4 times small	1	
Chordwise Foreshortening	2 times small	1	
Trailing Edge Configuration	No effect	No effect	
Trailing Edge Deflection	1	2 times large	
Flow Angle	Indeterminant	Indeterminant	
Cell Shape	Little effect	Little effect	
Spanwise Shape	No effect	No effect	

5.6 Sample Results

The information contained in this section is selected examples of the wind tunnel test reduced data. Due to the large quantity of data taken explanations can not be provided for every run, therefore selected examples have been provided to give a overview of the complete results.

The Appendices contain the complete set of results.

5.6.1 Longitudinal Aerodynamics

The aerodynamic data taken during this test was obtained by tether testing techniques to simulate a free flight environment. The data in this report is presented with no correction factors applied to C_L or C_D due to wall interference. Computations were done using a 3-D panel code which is a potential flow simulation of the

aerodynamics. The lift correction for the 20' x 60' wing is approximately 7% for C_{Lmax} in flare.

The 20'x 60' parafoil was tested using tether testing techniques where the parafoil was allowed to fly in the wind tunnel. The angle of attack was adjusted by changing the parafoils rigging angle and establishing a new stable trim point. The longitudinal aerodynamic coefficients are an average value taken over a finite period of time. Figure 6.5-1 shows the longitudinal aerodynamic coefficients CL, CD and CM as a function of angle of attack (α) for various dynamic pressures.

The airfoil distortion associated with increasing dynamic pressure caused a decreased lift coefficient and increased drag coefficient.

The angle of attack at which the parafoil stalled was directly related to the dyamic pressure. The parafoil would stall at lower angles of attack with increasing dynamic pressure. This effect can be related with airfoil distortion associated with increasing dynamic pressure. The effects of the parafoil distortion can be seen graphically from the L/D versus angle of attack plots (Figure 6.5-2). The L/D decreases with increasing dynamic pressure and the curves tend to shift to the left with the increasing dynamic pressure. The L/D_{max} can be calculated from the drag polar (Figure 5.6-3). The L/D_{max} of 2.7 is less than the L/D_{max} of 3 that was predicted. An equation for the drag can be obtained from the plot of C_D versus C_L^2 as in Figure 5.6-4. The parasite drag increases for increasing dynamic pressure while the induced drag remains almost constant.

5.6.2 Flare Aerodynamics

The flare maneuver was accomplished by symmetrically deflecting the trailing edge of the parafoil at a constant angle of attack. Figure 5.6-5 shows how the control force varies with deflection, dynamic pressure and angle of attack. From Figure 5.6-6, it can be seen that both CL and CD increase with deflection. The L/D decreased when the wing is flying at high angles of attack; and

L/D increased with deflection at low angles of attack, showing that the flare can be optimized when initiated at low angles of attack.

5.6.3 Load Cell Data

The distributed load across the span of the parafoil was measured by five load cells located along the quarter chord and half the span of the wing. The data points were mirror imaged and a third order curve fit used to determine the spanwise load distribution (Figure 5.6-7). The spanwise load distribution shows how the load increases with increasing dynamic pressure.

The chordwise load distribution was measured by placing twelve load cells along a center span keel. A third order curve fit was used to plot the chordwise load distribution (Figure 5.6-8). The chordwise load distribution can be used to calculate the localized center of pressure location by integrating the load distribution curve and iterating until Xcp is found as in the following equations:

Load =
$$\int_{0}^{c} f(x)dx$$

Load/2 =
$$\int_{0}^{Xcp} f(x)dx$$

Once the center of pressure is found, the lift and drag can be transferred to the quarter chord location and the moment about the quarter chord calculated. Figure 5.6-9 shows plots of Xcp and C_M quarter chord versus angle of attack.

5.6.4 Lateral Aerodynamics

Lateral aerodynamic data was acquired for two different assymetrical control deflections. Figure 5.6-10 shows how the control force is a function of deflection for airfoil local distortion and trailing edge deflection. It can be seen from this graph that the

control force required is approximately equal for both methods. Figure 5.6-11 shows the yawing moment and rolling moment for right side control line deflections. The airfoil local distortion has very little yawing moment and a large rolling moment in the positive right direction. The trailing edge deflection causes the parafoil to yaw in the positive direction and roll in a negative or left direction. This is known as the adverse rolling tendency and is usually associated with large parafoils.

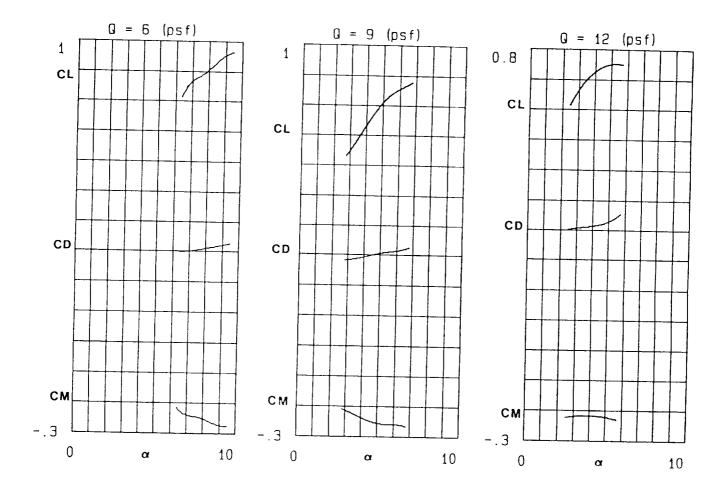


FIGURE 5.6-1, C_L , C_D , AND C_M AS FUNCTIONS OF ALPHA (lpha) FOR VARIOUS WING LOADINGS

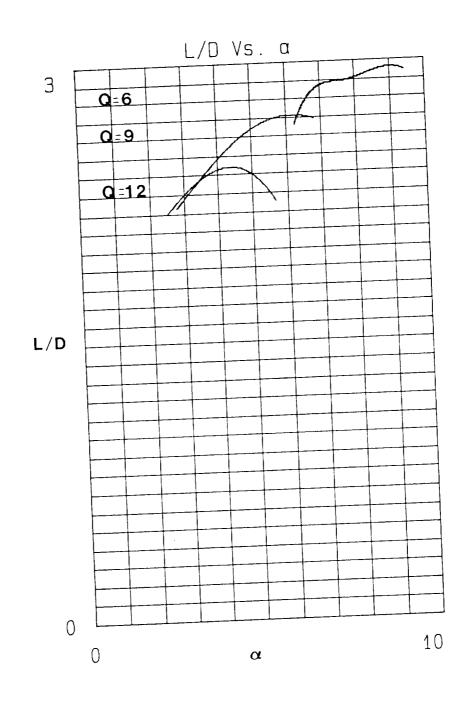


FIGURE 5.6-2, LIFT-DRAG RATIO (L/D) DECREASE WITH INCREASING DYNAMIC PRESSURE

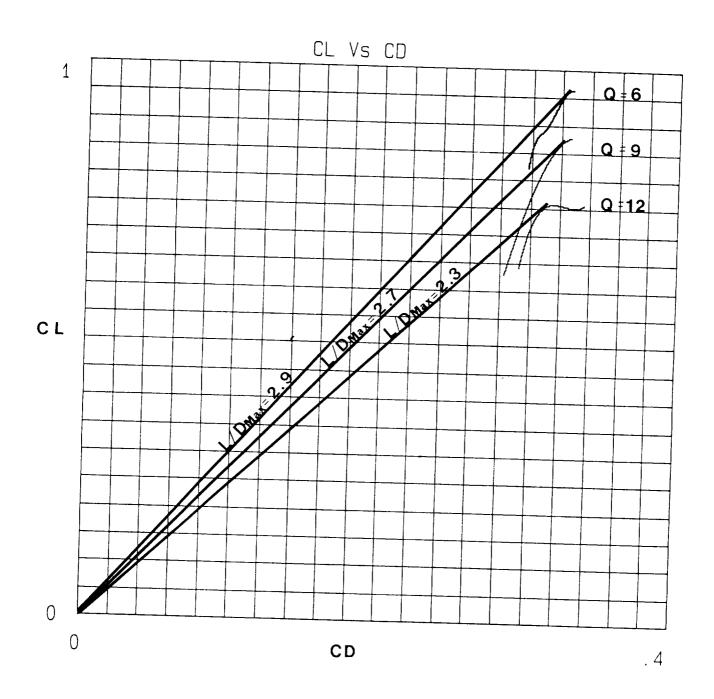


FIGURE 5.6-3, LIFT-DRAG RATIO (L/D) MAXIMUM FROM PLOTS OF C_L VS. C_D

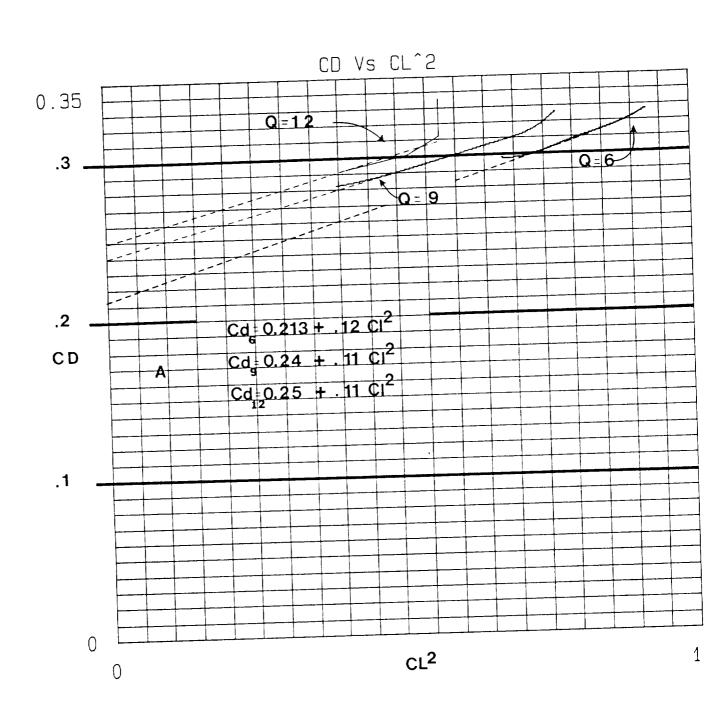


FIGURE 5.6-4, CD VS CL2

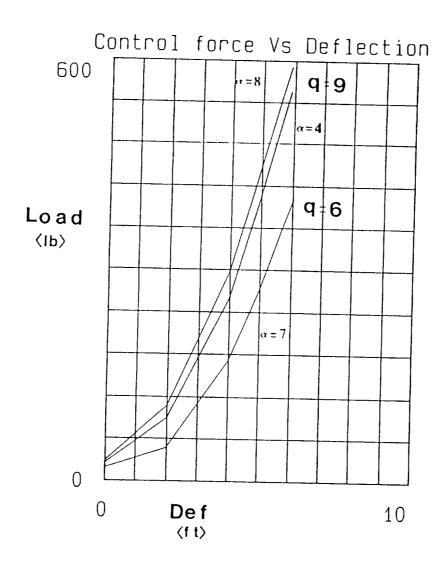


FIGURE 5.6-5, CONTROL FORCE VS. DEFLECTION FOR FLARE MANEUVER

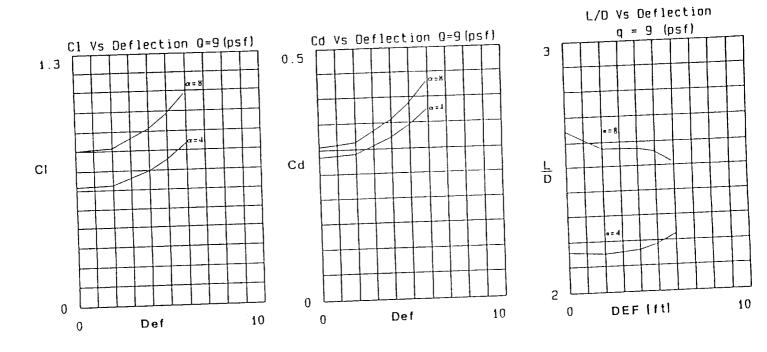


FIGURE 5.6-6, VARIATIONS IN C_L , C_D , AND L/D WITH DIFFERENT DEFLECTIONS AND DYNAMIC PRESSURES

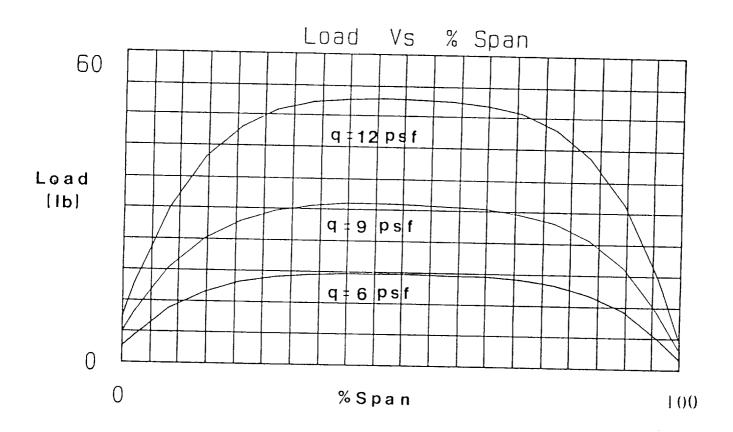


FIGURE 5.6-7, SPANWISE LOAD DISTRIBUTION AT VARIOUS WING LOADINGS

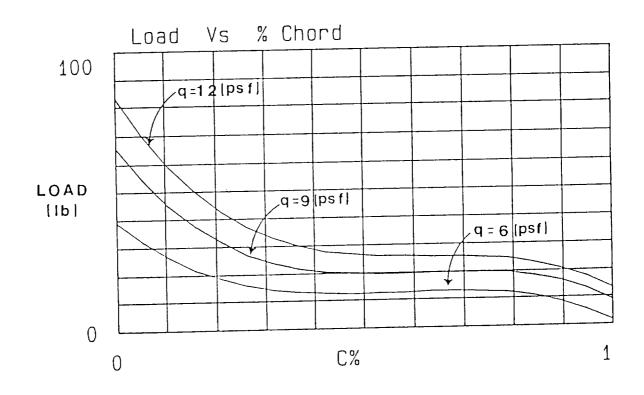


FIGURE 5.6-8, CHORDWISE LOAD DISTRIBUTION AT VARIOUS WING LOADINGS

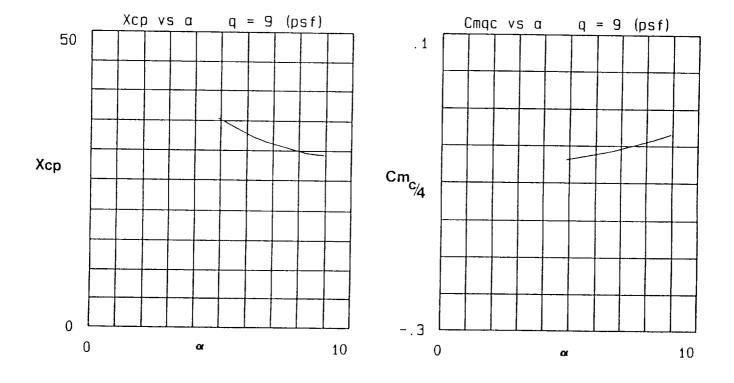


FIGURE 5.6-9, XCP AND CM VS. ANGLE OF ATTACK (α)

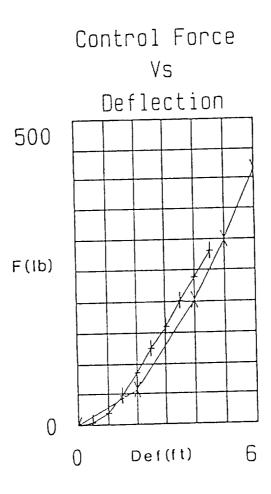


FIGURE 5.6-10, CONTROL VS. DEFLECTIONS FOR TWO CONTROL METHODS

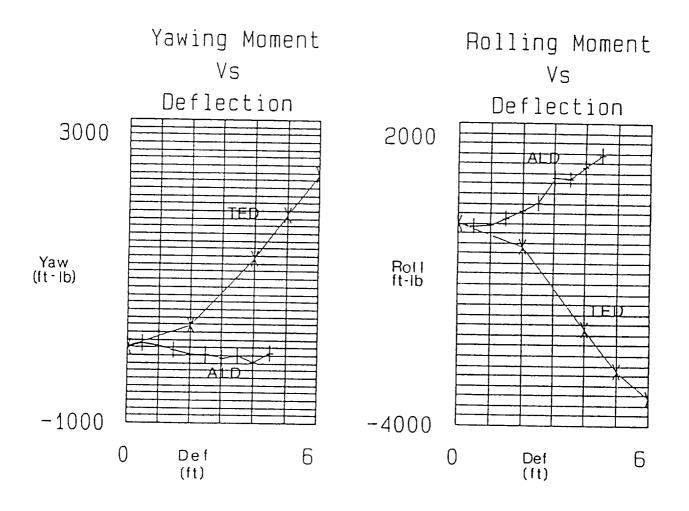


FIGURE 5.6-11, YAWING AND ROLLING MOMENT DATA VS. CONTROL LINE DEFLECTION

6.0 Conclusions and Recommendations

The success of the ARS Phase 2 wind tunnel test exceeded previous expectations. Although scaling effects could not be evaluated aerodynamic data was obtained to support airdrop testing and full-scale development of the advanced recovery system.

Interface hardware, instrumentation and testing procedures have been validated. Structural, operational and safety issues have been addressed.

The major conclusion of phase two testing was that wind tunnel testing of large scale parafoils is practical and useful. Additional testing should be implemented to expand a high glide parafoil data base.

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