

Experimental determination of lift and drag coefficients for the initial
stages of inflation of the X-38 parafoil

by

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ABSTRACT

The NASA X-38 Crew Return Vehicle (CRV) is a vehicle designed to act as an emergency lifeboat for the International Space Station (ISS) in the case of a medical emergency or the need to evacuate the structure. Modeled after the Martin Marietta X-23A lifting body, the vehicle employs a large parafoil to enable the craft to land safely and within a short distance of a designated area. A recently completed joint effort between ISU and NASA/JSC has provided preliminary experimental data dealing with the aerodynamic forces that act on the recovery parafoil. A hard cast model of one segment of the parafoil in a first stage deployment state was provided by JSC researchers to be tested in an ISU wind tunnel. Lift and drag forces were measured over a wide range of angles of attack for each of several Reynolds numbers. Wind tunnel tests indicate that the parafoil in a first stage deployment state behaves much like a flap plate. The results obtained in this effort will help researchers better understand parafoil inflation dynamics and provide comparative data for tuning CFD tools for future parafoil deployment simulations.

1. INTRODUCTION AND BACKGROUND

The X-38 Program

The NASA X-38 (Figure 1.1) is a vehicle designed to act as a lifeboat for the International Space Station (ISS) once it has been completed. It is modeled after the Martin Marietta X-23A lifting body, but will not have any propulsion beyond the capability to maneuver to enter the atmosphere. It will be 28.5 feet long with a 14.5 foot wingspan, and weigh approximately 16,000 pounds (DFRC.NASA.GOV,"X-38 Fact Sheet", 1999). The design was chosen for its good supersonic handling characteristics, high lift to drag ratio, and long cross range capabilities (around 800 miles), which will allow trajectories that

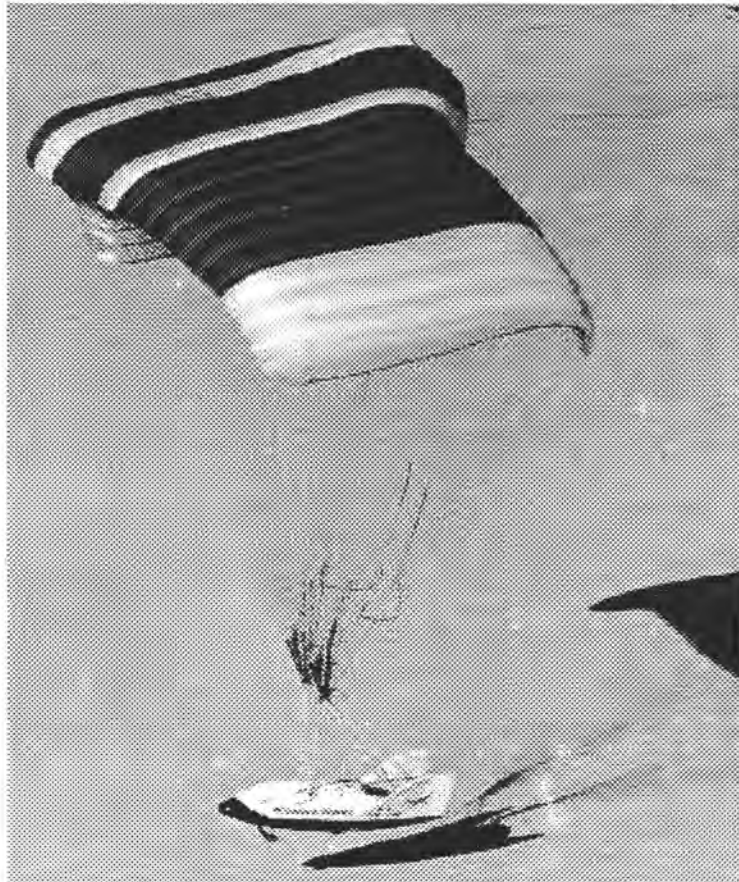


Figure 1.1 X-38 with fully inflated parafoil (JSC.NASA.GOV, 2000)

shorten the time between departure from the space station to atmospheric re-entry. Based on a preliminary number of possible landing areas, the maximum time required between deorbit opportunities is six hours. This is far less than the 30 hours required by other vehicles with lower L/D ratios (Campbell, 1996).

A major difficulty with the X-23A is that its landing speed is 290 MPH, which is far greater than the desired landing speed (Dornheim, 1998). Passengers onboard in need of medical attention could be subjected to additional trauma in such landings. In order to reduce the landing speed, a large parafoil will be deployed to enable the craft to land more slowly. The parafoil should make it possible for the X-38 to land in an area approximately the size of a football field.

A parafoil is a flexible structure, usually made of nylon, which acts as a wing when inflated (Figure 1.2). It consists of a series of ribs that hold the upper and lower surfaces together and gives the parafoil a semi-rigid shape when inflated. The region between successive ribs form chambers that have an inlet at the front and inflate when air is forced

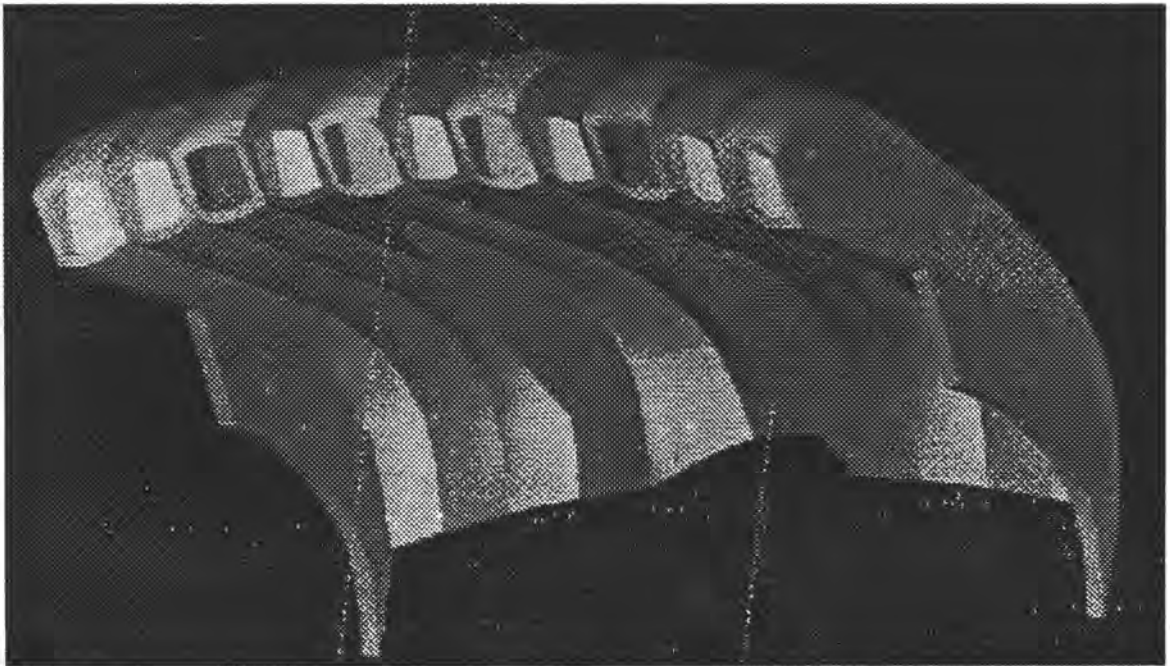


Figure 1.2 Computer image of a parafoil section.

into them. Parafoil steering is achieved by pulling down on the trailing edge of one side, creating more drag, which causes a lateral moment on the structure. The control lines and the lines that connect the parafoil to the X-38 are attached to the ribs.

The parafoil for the X-38 is made of a special rip-stop nylon and when fully deployed will have an area of approximately 7500 square feet, with a wingspan of 143 feet, one and a half times that of a Boeing 747. When the CRV is to return for refurbishment, or in the event of an emergency, the vehicle will detach from the ISS and a deorbit propulsion motor, which will be jettisoned upon re-entry, will move it into Earth's atmosphere. Once the vehicle has entered the atmosphere, a drogue chute will be deployed to slow its descent from a vertical airspeed of over 500 MPH to around 70 MPH. At approximately 20,000 feet, the parafoil will be deployed. The opening of the parafoil takes approximately 30 seconds and is completed in 5 steps (JSC.NASA.GOV, "NASA X-38 Team..." 1999). Since the parafoil is a flexible body, its aerodynamic characteristics vary due to rapidly changing dynamic conditions along the trajectory. When the parafoil is first deployed, it will emerge above and behind the X-38 and the airflow will be nearly perpendicular to the chord line. As the parafoil inflates, it will move to a position directly above the X-38 and the airflow will be parallel to the chord line. In intermediate stages, the parafoil will be oriented at various angles relative to the X-38 as it moves to a position of level flight.

Full-scale tests of the X-38 have already occurred. In one test, the X-38 landed at a downward speed of approximately 17 feet per second and a forward speed of approximately 56 feet per second (Domheim, 1998). Launch conditions for subsequent tests are expected to be approximately Mach 0.5 - 0.8 and 25,000 - 45,000 feet altitude. (DFRC.NASA.GOV, "X-38 Fact Sheet", 1999)

A major problem in the continued development of the X-38 parafoil system is the lack of knowledge of the aerodynamic forces generated by the parafoil. The parafoil structure is

large and does not maintain set shapes during inflation. Instead it grows in stages, each of which generates different aerodynamic forces. The size of the parafoil posed technical challenges for the X-38 team (JSC.NASA.GOV, "NASA x-38 Team...", 1999). "This parafoil is so big there is no way that it can all deploy at once," said Brian Anderson, X-38 Project Manager. "Because of its size, the dynamic forces on the parachute's structure are phenomenal."

Another problem encountered in past tests has been that the parafoil opens unevenly, which may lead to instabilities. One of the components of the instabilities is a tendency for the parafoil to twist before other sections can inflate. This twisting may cause tangling of the control lines which would render the parafoil uncontrollable and the X-38 may not be able to land safely (Chappell, 1999). To help the parachute open symmetrically and rapidly, the X-38 team developed a self-sealing floor vent system on the parafoil's underside. Subsequent testing showed that the parafoil opened to its full size evenly and in only 30 seconds.

Prior and Current Parafoil Research

Currently, very little research is available on the inflation dynamics of parafoils. Some work is being done simultaneously at Texas A&M and at the University of Minnesota, each on different stages of inflation. Most available information is on the final stage of inflation when the parafoil resembles a wing.

An early study was undertaken at the University of Michigan as a student project (Chappell, 1999). Models of the parafoil for the same orientation, but with slightly different configurations were investigated. Various models incorporated the addition of different types of ventral fins, which behave like the vertical stabilizer of an aircraft. The purpose of the study was to see if any of the different configurations would help stabilize the parafoil

during the initial stage of inflation. Yaw and rolling moment coefficients were measured to identify configurations that would exhibit the low moments over a range of angles of attack. Test results showed little effect on yawing and rolling moments and that the dominating parameter was the angle of attack.

Another early study was conducted at the University of Cambridge (Babinsky, 1999), where an investigation was undertaken to study the performance of small parafoils used for sport. The study focused on the drag forces that occur on a fully inflated parafoil. The first area of study included a look at the effect of the size and orientation of the air intake. Test results showed that the drag coefficient of a typical parafoil intake was on the order of $3 \text{ to } 5 \times 10^{-3}$. The second study area was an investigation of the flow separation on the trailing edge and just behind the intake. Flow visualization tests, showed that the stream-wise grooves formed by the ribs pull the separation bubble upstream. For an angle of attack of 8 degrees, the separation line was approximately 42% chord along the ribs as opposed to 80% along the center of the cells. The third area was the deformation of the parafoil and the relationship between the drag on a hard-cast model and a flexible model. This will be covered in more detail in later sections.

Another study on the use of parafoils was conducted by the Army (Sim, 1994). The research effort included the development of a precision-guided airdrop system using GPS navigation and automated controls for parafoils. Present air deployment of 100 paratroopers may spread them out over 3 miles. The research project goal was to enable delivery of a load from 25000 feet with a 12 mile offset to an area within 50 meters. Two models were incorporated with surface areas of 88 square feet and 3600 square feet, which carry a 175-pound and a 13000-pound load, respectively. Trajectory simulation allowed for variations of horizontal wind velocity and wind direction, but vertical components were not simulated due to a lack of vertical profile data.

Some modeling work has been done by Iosilevskii (1995) to explore the range of angles of attack that are limited by a loss of longitudinal stability and loss of control. Most of the work is based on lift and moment coefficients to determine minimum lift coefficients and maximum forward and rear positions of the center of gravity.

Current Work at Iowa State University

Iowa State University and Johnson Spacecraft Center are currently in a joint research effort to expand the knowledge base associated with the inflation dynamics of the X-38 parafoil. Long range plans of NASA-JSC appear to include the development of a computational simulation capability to determine parafoil inflation dynamics for utilization in a design mode for best parafoil development. Computation tools in the fluid dynamics, structural dynamics, and flight mechanics areas will be coupled to allow an accurate simulation of parafoil inflation and associated flow fields along a re-entry trajectory that is simultaneously computed. An important input in the overall study is a vast experimental database to be used in the tuning of the computational tools, thus ensuring the accuracy of the process. In particular, wind tunnel testing of representative parafoil shapes encountered during parafoil inflation is needed to provide comparative data for CFD simulations.

ISU has contracted to provide test data on one such shape. The parafoil shape of interest is the first parafoil inflation stage whereby the parafoil is oriented in a near normal chord position with respect to the free stream. That is, the velocity vector is nearly perpendicular to the parafoil chord and the parafoil is in a zero inflation state. Wind tunnel tests were run on a hard-cast model to calculate lift and drag coefficients at several angles of attack. NASA/JSC personnel provided the shape of the hard-cast model. Parafoil shape was derived from data acquired during a scale model drop. Details of the actual model tested will be discussed in following sections.

Original plans for the wind tunnel testing included the use of the ISU 3-D open circuit wind tunnel that has a large test section flow area when compared to the parafoil model. However, the wind tunnel was disassembled and moved to another facility and was not available at model test time. A much smaller closed circuit wind tunnel was substituted, which generated additional problems in testing due to the small size of test section with respect to model size. In particular, wind tunnel blockage corrections become much more important for small wind tunnel sections. Hence, a portion of the following material deals with techniques for blockage corrections.

A second area that had to be addressed was the model attachment and force transducer force measurement. This material is also covered in subsequent sections.

2. PARAFOIL TEST PROGRAM

Components of the Experiment

The Parafoil Model:

A scaled hard cast model representing a segment of the actual parafoil in a deflated state was provided by NASA/JSC personnel. The model, depicted in the Figure 2.1, has a square planform with dimensions of 4.5 x 4.5 inches and is properly oriented when the flow is perpendicular to the chord line with the inverted cup side exposed to the free stream. This configuration is representative of the first stage of deployment of the parafoil and is a contour of the bottom surface of the parafoil. In this configuration, the model closely resembles a flat plate.

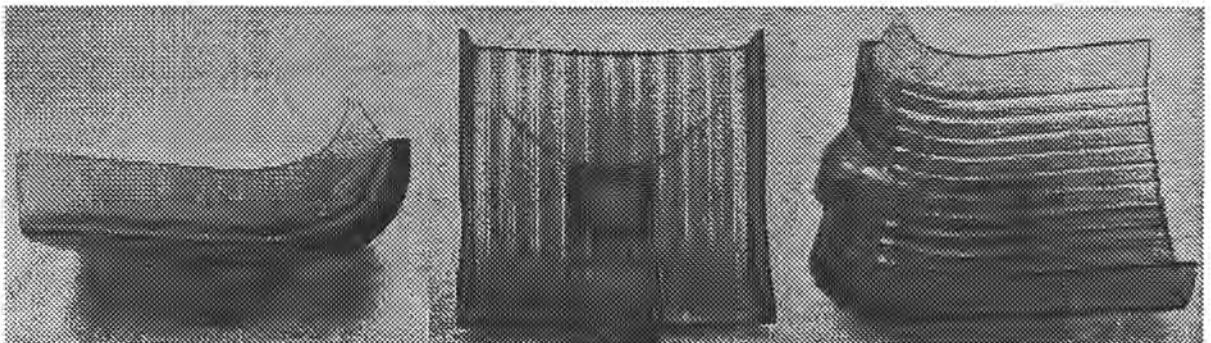


Figure 2.1 Front and side views of the hard-cast parafoil model

The Wind Tunnel:

The characteristics of the wind tunnel (Figure 2.2) are a 12 in X 12 in test section, a 4:1 contraction, a maximum velocity of 270 fps (without blockage), and velocity fluctuations of approximately 2% - 5%.

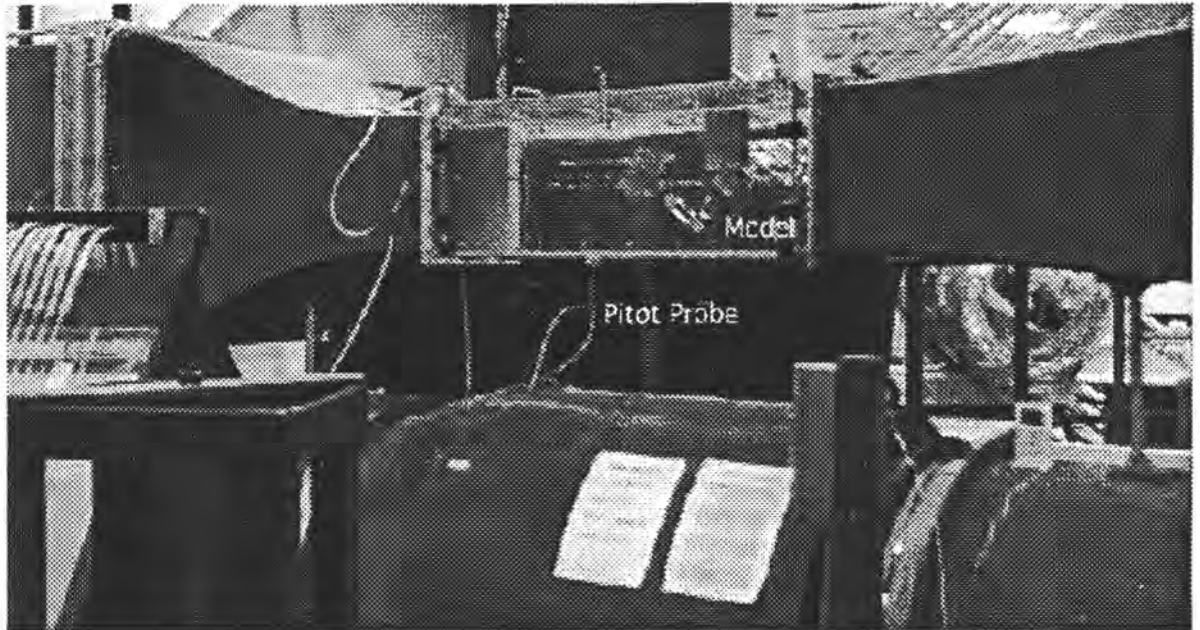


Figure 2.2 The recirculating wind tunnel used in the experiment

The Force Balance:

The force transducer used in the measurement of model loads, depicted in Figure 2.3, incorporated a pair of 4-bar aluminum frame components rigidly connected in a 90-degree orientation pattern. The beams in each 4-bar frame are designed to allow direct measurement of the axial and normal loads applied at the model attach point. In particular, the frame that is aligned along the model mounting axis is sensitive only to normal model loads and the orthogonal frame is sensitive only to axial model loads. Each frame contains 4 strain gages that are used in a wheatstone bridge arrangement for measuring applied loads.

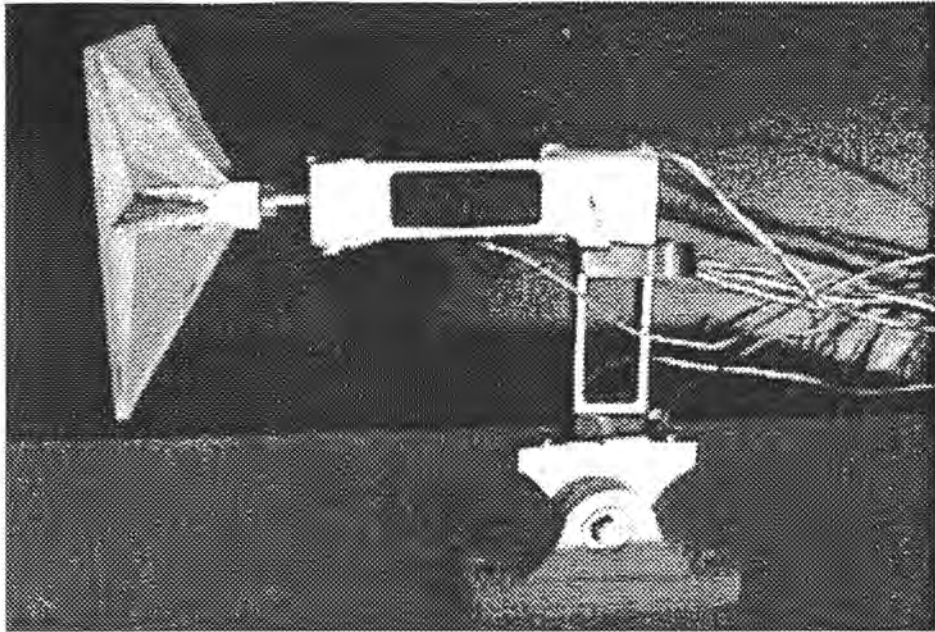


Figure 2.3 The force balance with flat plate attached

Force Transducer Output Signal Processing:

The primary response of the force transducer to applied axial and normal load components is a deformation in each of the 4-bar frames. These deformations are directly proportional to the applied loads. Vishay strain gage amplifiers are used to provide wheatstone bridge support for the transducer axial and normal components. The amplifiers supply excitation voltage for bridge activation, a bridge balancing circuit, and a bridge output voltage signal when the transducer components are loaded.

Analog output signals from the Vishay amplifiers are sent to the input bus of a National Instruments analog-to-digital data acquisition card where the input signal is digitized. The card is mounted in a laboratory PC. National Instruments LabView software is used to control the data acquisition card during wind tunnel tests, process the incoming data stream, and provide reduced data output. The LabView data acquisition software was

configured to record simultaneous signals from the force transducer normal and axial components. Data was acquired at a rate of 10000 Hz over $1/10^{\text{th}}$ of a second for a total of 1000 data points for each data stream. Different data acquisition rates were tried, but very little difference was seen in the results.

Test Section Dynamic Pressure Measurement:

An AXD 550 MicroManometer Digital Manometer was attached to a pitot probe to record the dynamic pressure within the wind tunnel test section. The resolution of the manometer is 0.002 inches of water and the accuracy is given as 1% of reading plus the resolution. Over the range of pressure differences in the experiment (approximately 0.725 inches of water to 5.4 inches of water), this amounts to an error in the pressure reading of slightly over 1%.

Force Transducer System Calibration

The physical output of the force transducer/amplifier/PC system for a force input is a voltage. A calibration process is required to map the voltage output to a force so that the aerodynamic characteristics of the model can be determined. The relationship between applied force and output voltage for the transducer system is accomplished by sequentially hanging a series of known weights from the mount point of the force transducer in each the axial and normal directions. System output voltages are recorded for each applied load. Calibration results for both the axial and normal force transducer components are depicted in Figure 2.4 below. Least squares linear curve fits were applied to each data set resulting in calibration coefficients of 34.421 mV/lb and 53.276 mV/lb for the axial and normal components respectively. The corresponding correlation coefficients were found to be

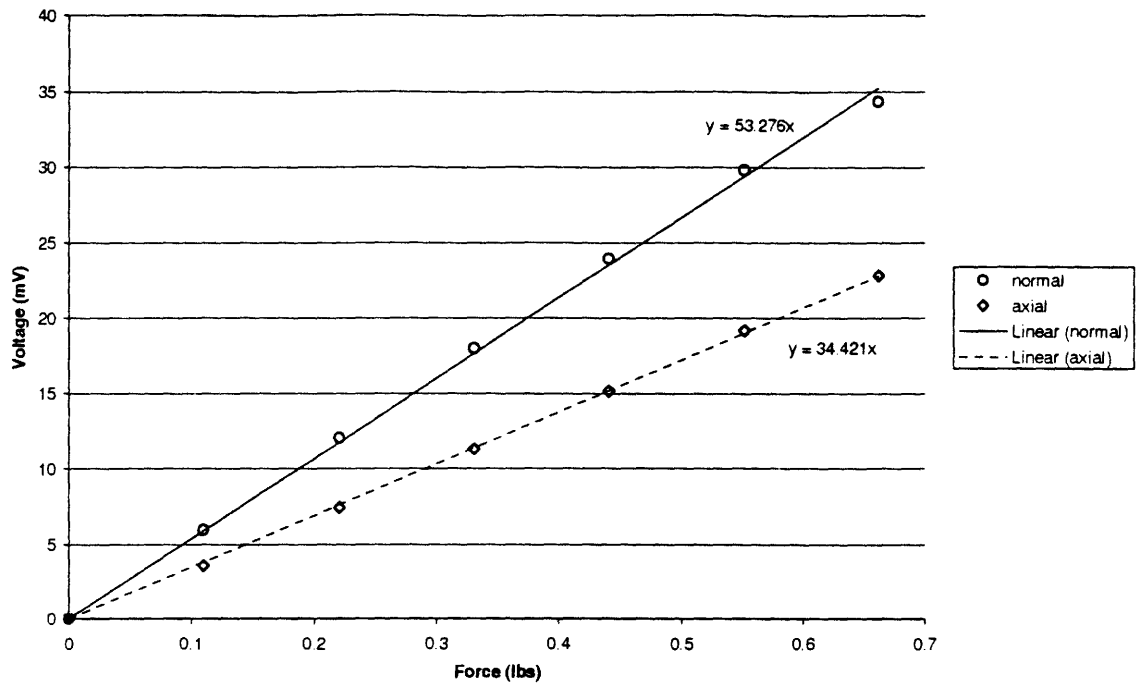


Figure 2.4 Amplifier calibration constants

0.9995 and 0.9977 respectively and indicate good agreement between the observed data and the averaged values.

Experimental Setup, Model Configurations, Procedures, and Test Conditions

Overview

Wind tunnel test section velocities included in the parafoil test ranged from 30% to 65% of full speed, which corresponds to approximately 60 to 150 feet per second (measured with blockage). Below 30%, excessive test section velocity fluctuations reduced the overall accuracy of the data, and above 65%, the force transducer mount would sometimes slip due to the forces on the model.

The force transducer was attached to the test section floor of the ISU water-cooled recirculating wind tunnel. The model was attached to the force transducer thus enabling the measurement of aerodynamic forces in the axial (transducer axis) and normal directions (Figure 2.5). Model lift and drag forces were measured at angles-of-attack in a range of ± 50 degrees, where 0 degrees represents the model orientation whereby the velocity vector is perpendicular to the model chord line (cupped face forward). The -90 degrees case represents the model orientation whereby the velocity vector is parallel to the chord line with the parafoil in a normal flight orientation (-90 degrees is level flight). Due to size constraints, the force transducer mount could only be rotated in one direction about the pitch axis to change model angle of attack. Therefore both positive and negative angles of attack data

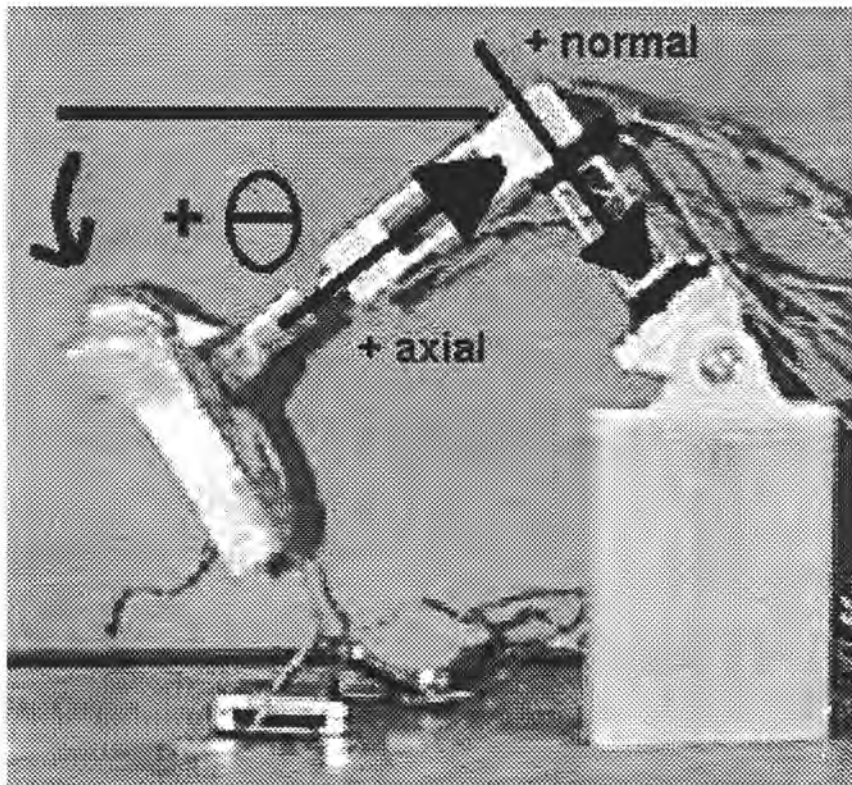


Figure 2.5 Force balance with parafoil showing directions of normal and axial forces and angle of attack

collection were enabled by simply testing two model configurations for each force transducer pitch orientation. That is, at each force transducer pitch orientation data were collected twice, once with the model upright and again with the model rotated about the model mounting axis 180 degrees.

Aerodynamic axial and normal force magnitudes at each test point in the parafoil test were obtained by continuously recording 1000 force transducer output levels over a period of 0.1 seconds. The data sets were averaged thus providing a single value for each aerodynamic force magnitude at the test point.

Test section dynamic pressure was obtained using a pitot tube connected to a digital manometer. The temperature inside the wind tunnel and barometric pressure were also recorded using appropriate instrumentation. Corresponding test section velocity was calculated from Bernoulli's equation ($\Delta p = 1/2 * \rho * V^2$). Density was obtained using the ideal gas equation ($\rho = P / RT$), and viscosity was calculated as $\mu = A * T^{3/2} / (B + T)$, where $A = 1.458 * 10^{-6}$ and $B = 110.4$ for air (Fox, 1992). A schematic of the entire test setup is provided in Figure 2.6

The axial and normal forces obtained at each test point in the parafoil test were converted to lift and drag forces. What was found from this was that the drag coefficients were much larger than expected. This was due to excessive blockage in the wind tunnel and therefore corrections needed to be applied.

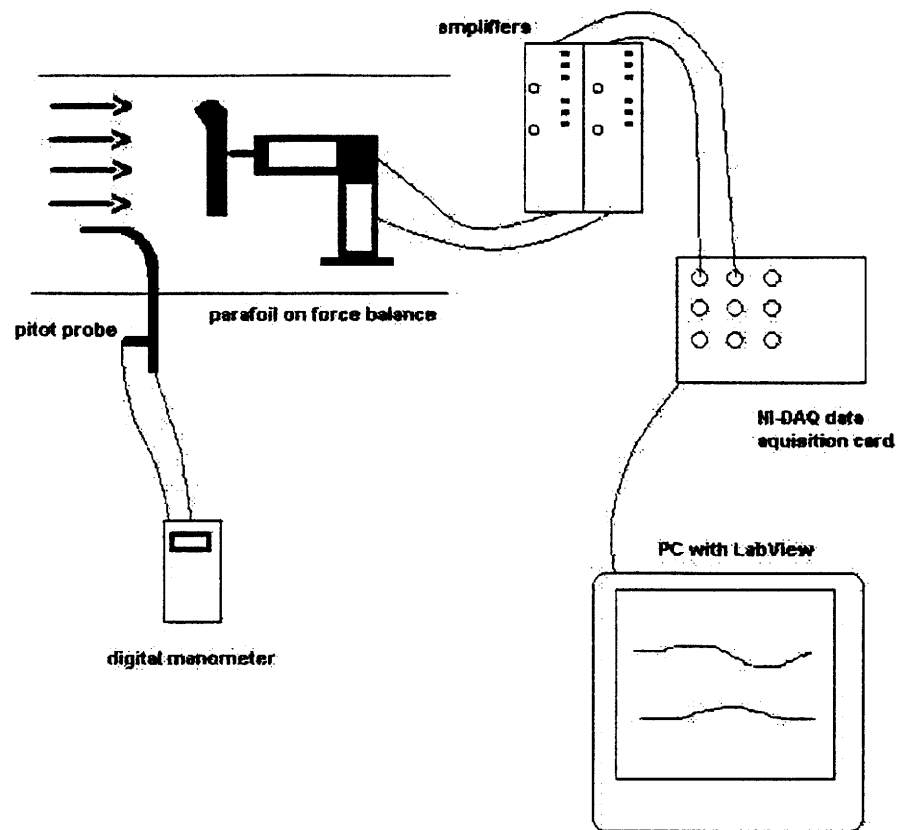


Figure 2.6 Schematic of experimental layout

3. WIND TUNNEL WALL CORRECTIONS

Wind tunnel aerodynamic force data obtained by subjecting model configurations in an enclosed test section to onset flows must be carefully scrutinized. The impact of wind tunnel walls in close proximity to model surfaces can cause significant errors in force data extracted from the tests. This is particularly true in the parafoil test under consideration. The parafoil model cross sectional area is large, by wind tunnel testing standards, when compared to the test section cross sectional area. Chappell (1999) reported values of approximately 1.2 for the case of flow perpendicular to the parafoil chord in their experiment while values of 2.7 were calculated in this experiment for the same orientation. Therefore, studies were undertaken to determine appropriate corrections for the force data.

Two areas of study were incorporated in the evaluation of correction factors for aerodynamic force data acquired in the ISU wind tunnel. In the first study, a series of flat plates were tested and the results were compared to accepted values based on extensive test data that has been acquired over many years. The second study included a literature search to uncover and investigate historical correction factors developed by past researchers. Each approach is discussed in the following sections.

Wind Tunnel Blockage Tests

A series of flat plates, depicted in Figure 3.1 were designed for testing in the ISU tunnel in an attempt to better understand the blockage that occurs during wind tunnel operation. The flat plates, which provided blockages from 5% to 20% (2.4 square inches and 5.35 square inches respectively) of the test section in 3% increments were alternately tested in the wind tunnel. The drag force on each plate was measured over a range of

velocities from 30% to 65% of maximum. The drag coefficients for each plate were calculated and then plotted versus percent blockage (see Figure 3.2). As expected, the drag coefficient would be larger than the expected value of 1.28 (Dommasch, 1957) and decrease toward the 1.28 value as the area of the plate decreased and the blockage effect becomes smaller. From this it should be possible to create a correction factor based on the percent blockage of the test section.

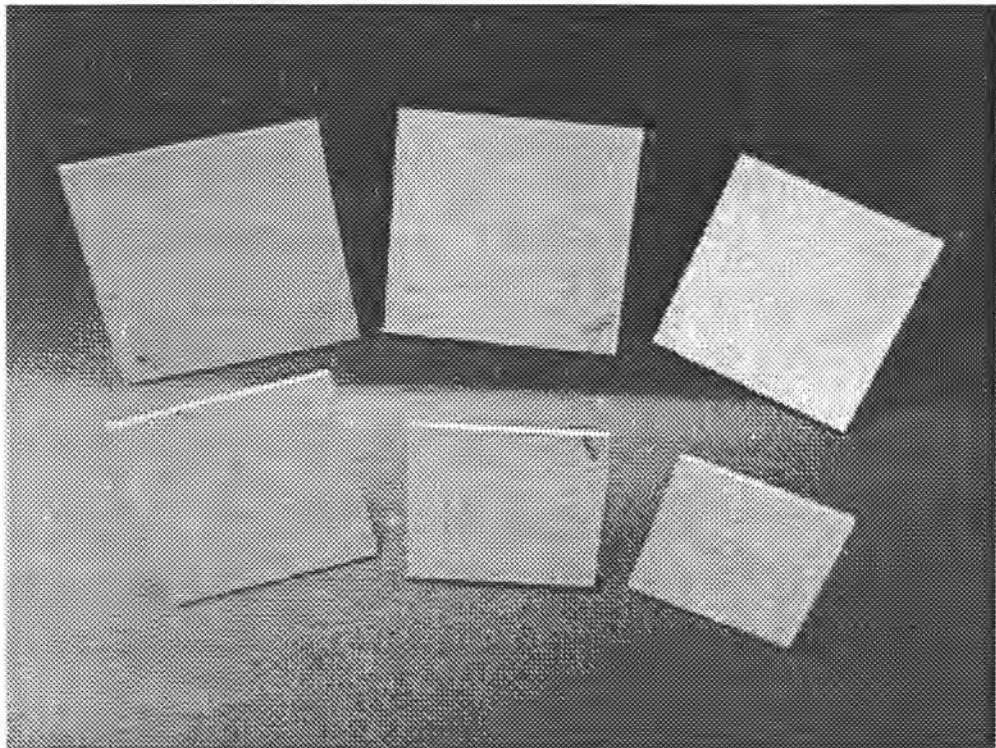


Figure 3.1 Flat plates used in blockage experiment.

The plot depicted in Figure 3.2 indicates that while the larger plates did have a drag coefficient greater than 1.28, the two smallest plates had drag coefficients much smaller than the accepted value. A quick check on the forces being generated by the small diameter plates showed that they were within the threshold range of the force transducer.

Hence, it is assumed that the small plates, which do not hide the force transducer from the free stream, act more like streamlined bodies, which have significantly lower drag coefficients.

Although the tests did not provide the blockage rules for correcting the ISU wind tunnel force data they did provide valuable flat plate drag data that could be used in testing traditional blockage rules generated in prior research.

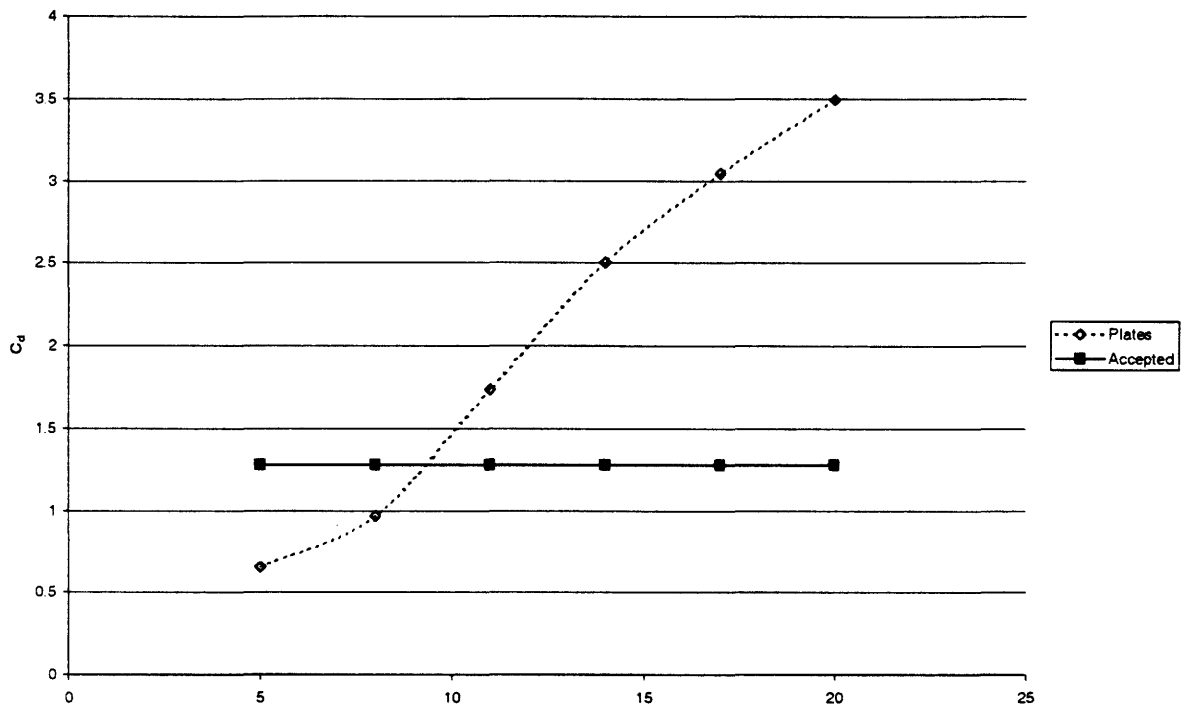


Figure 3.2 Uncorrected drag coefficient vs. percent blockage of the test section for a series of flat plates

Traditional Wind Tunnel Blockage Corrections

A widely used reference in generating wind tunnel correction factors is the book on wind tunnel testing by Rae and Pope (1984). Most of the information provided in the references for airfoils or streamlined bodies of revolution. Several of the proposed corrections were tried on the flat plate data generated in the blockage tests, but none proved to generate accurate drag values. In fact, the parafoil stage being used behaves more like a flat plate configuration rather than a streamlined lifting body. Hence, Rae and Pope's corrections were deemed inappropriate for the parafoil work.

A second source for blockage corrections was Wind Tunnel Modeling for Civil Engineers (Melbourne, 1982). In it, Melbourne gives a correction for the dynamic pressure, based on the aspect ratio of flat plates, $\Delta q/q = C_d * S/C * \epsilon$, where Δq is the increase in dynamic pressure due to the blockage, C_d is the measured drag coefficient, S is the model reference area, C is the test section area, and epsilon is a blockage factor based on the aspect ratio of the plate. For an aspect ratio of 1, epsilon is approximately 2.75 (Figure 3.3).

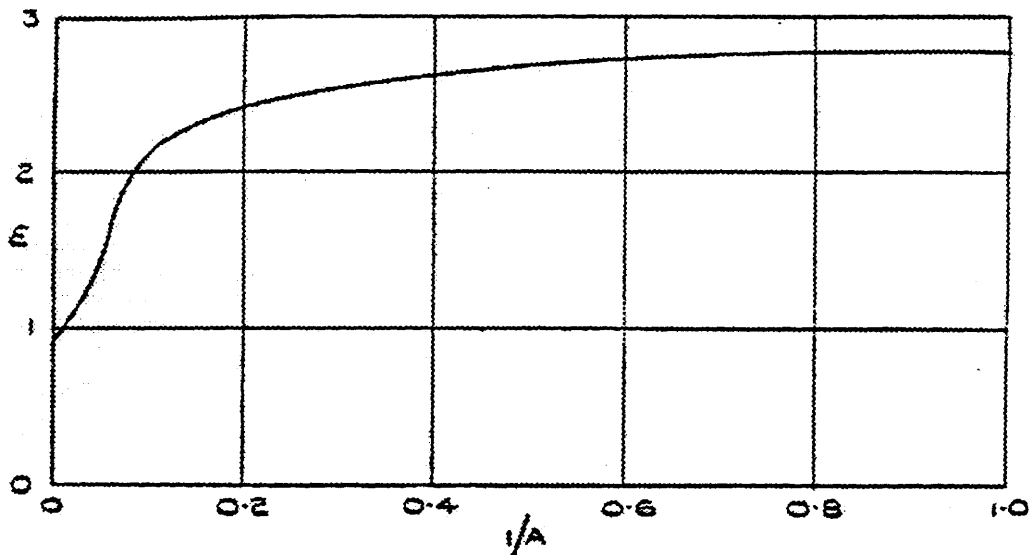


Figure 3.3 Values of epsilon based on aspect ratio of a flat plate (Melbourne, 1982)

The proposed corrections were tested using data collected in the flat plate tests. The uncorrected drag coefficient calculated for the flat plate with the same cross-sectional area as the parafoil (4.5 square inches) was 2.37. When the correction factor was applied, the drag coefficient was reduced to 1.27, which is much closer to the accepted value of 1.28. All data gathered for the series of flat plates was then corrected. The corrected drag coefficient for each plate was within a range of 1.13-1.27 for the larger plates (Figure 3.4).

These blockage correction procedures appear to produce acceptable results for flat plate type models and were subsequently incorporated in the parafoil tests.

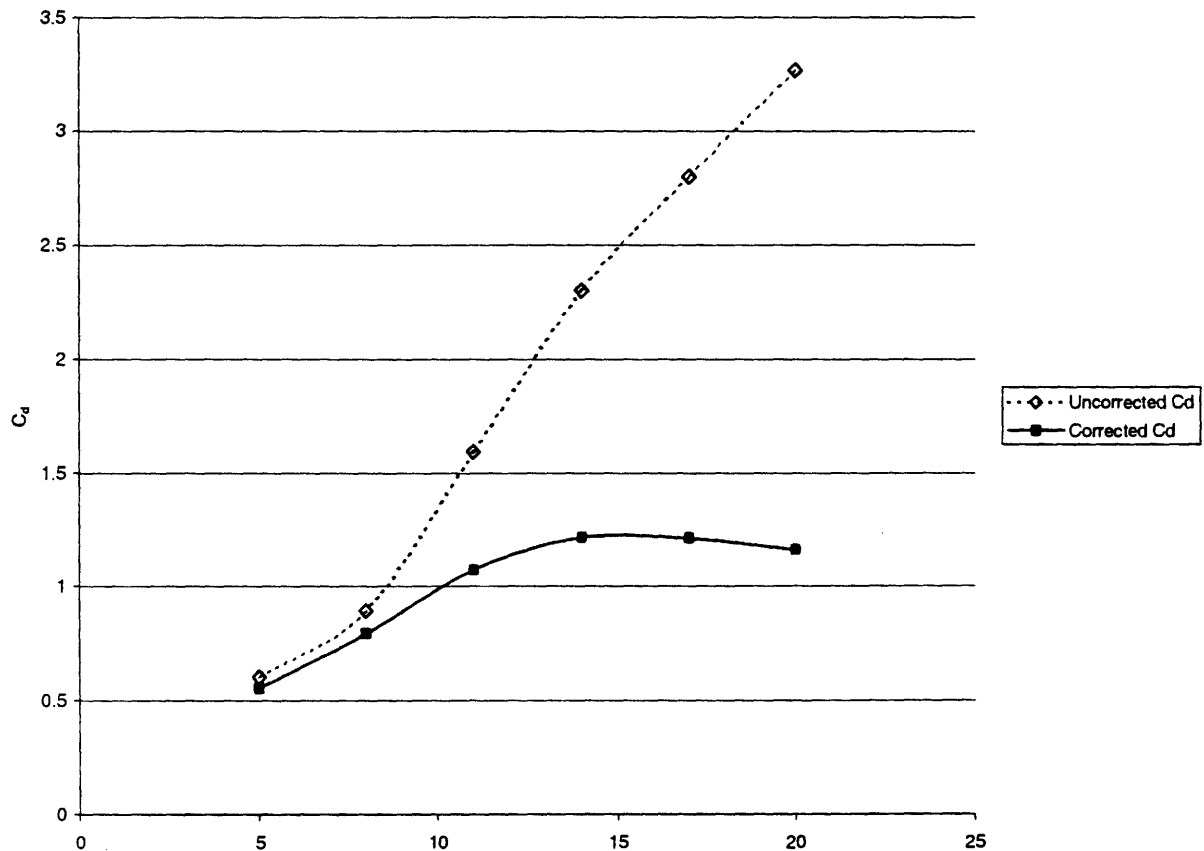


Figure 3.4 Drag coefficient vs. percent blockage of the test section for a series of flat plates

4. RESULTS

Results

Due to limitations imposed by the wind tunnel and the physical size of the model, tests were run at lower Reynolds numbers than those expected for the actual application. However, the parafoil model behaves much like a flat plate where flow separation lines on the body surface remain relatively unchanged with model orientation and onset velocity magnitude. Hence, Reynolds number variation shouldn't have as much impact on aerodynamic characteristics as is the case for more streamlined lifting bodies. Additional testing would be needed to verify this hypothesis.

The model was tested in a range of Reynolds numbers from 1.7×10^5 to 5.0×10^5 (velocities of 75 fps and 225 fps, respectively) and angles of attack of ± 50 degrees in 5 degree increments. For each angle of attack both lift and drag coefficients were nearly constant across the range of Reynolds numbers (Figures 4.1 and 4.2). Over the range of angles, the drag coefficient was parabolic, increasing from approximately 1.04 at -50 degrees to a maximum of approximately 1.30 at 0 degrees and decreased to 0.88 at $+50$ degrees. The lift coefficient decreased nearly linearly from 1.04 at -50 degrees to -1.20 at $+50$ degrees. The lift coefficient reached a value of 0 just below -5 degrees and the lift and drag coefficients were nearly equal values of 1.04 at $+50$ degrees. When the parafoil was perpendicular to the flow (0 degrees) the lift coefficient was -0.12 and the drag coefficient was 1.30 (Figure 4.3). All data for the lift and drag coefficient calculations is available in

appendix A, where the data that has been adjusted by the pressure correction is designated with an asterisk.

To investigate the accuracy of the data acquired, the standard deviation of the average corrected lift and drag coefficients for each test was examined. For the drag coefficients, the standard deviation was 0.04-0.09 for angles of attack between ± 30 degrees. For greater angles, the standard deviation decreased to 0.005-0.02. There was a larger standard deviation for the lift coefficients however and they showed no discernable trend. The deviations ranged from 0.05-0.12. The standard deviations for all velocities for each angle of attack are tabulated in appendix B.

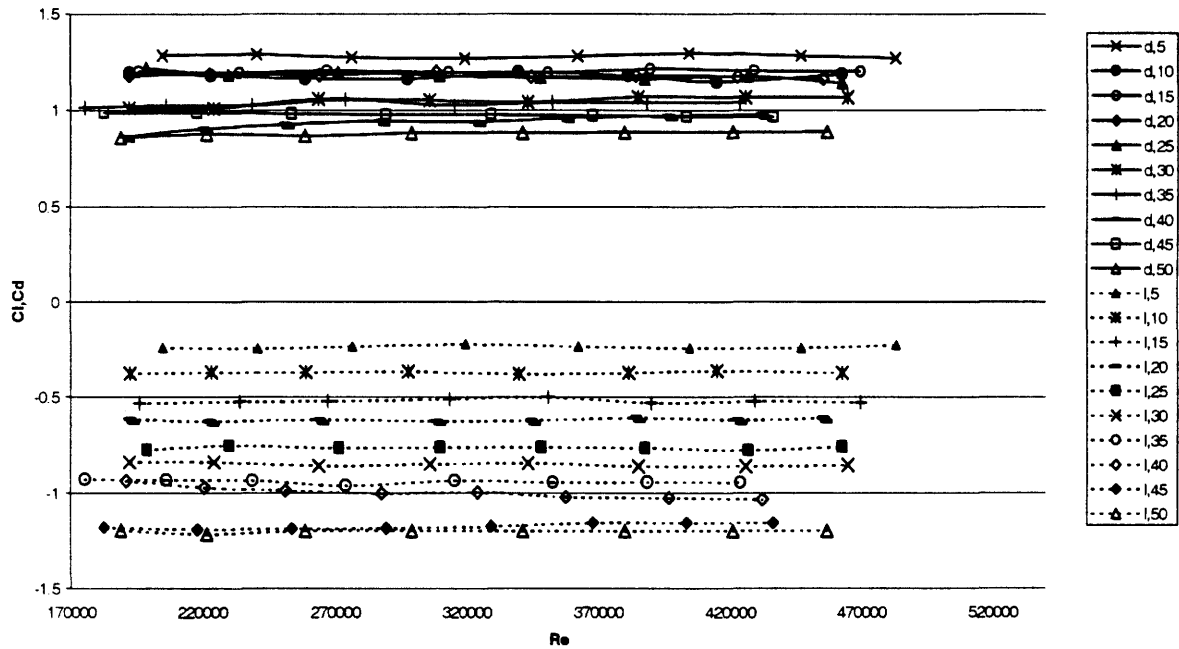


Figure 4.1 Lift and drag coefficients over a range of Reynolds numbers for positive angles of attack

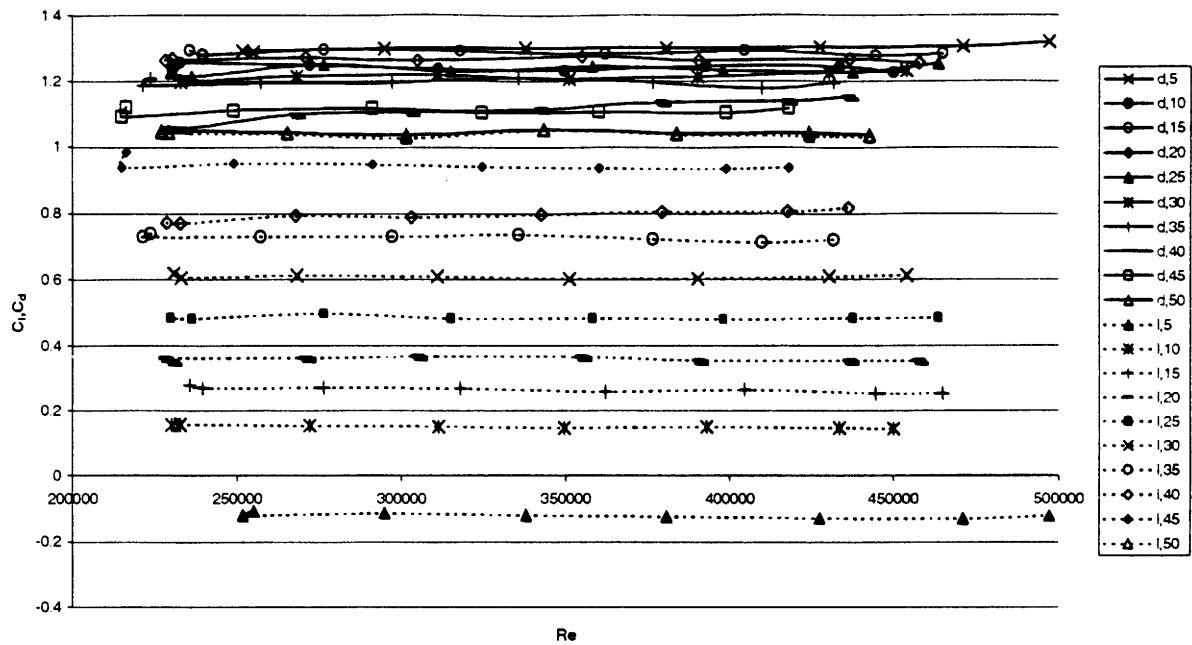


Figure 4.2 Lift and drag coefficients over a range of Reynolds numbers for negative angles of attack

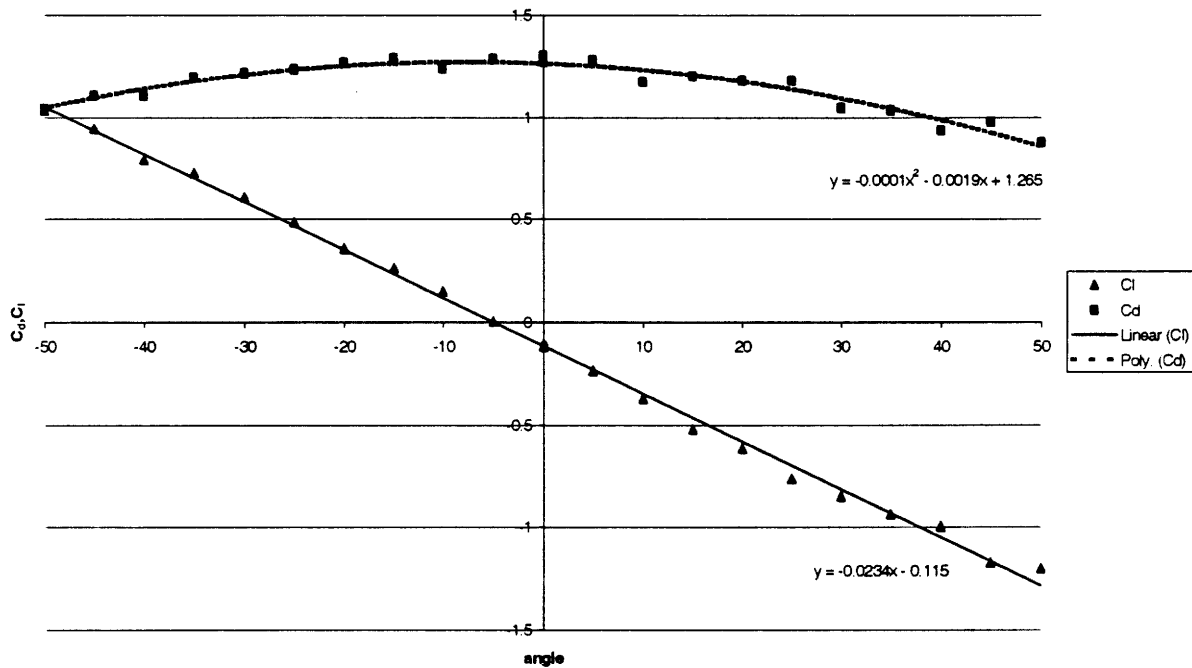


Figure 4.3 Average lift and drag coefficients over a range of angles of attack

Future Work

In the context of the total problem of computational simulation of parafoil inflation dynamics the ISU effort has been small. The lift and drag characteristics of a small hard cast model of one segment of the actual parafoil in an early stage of deployment have been investigated in wind tunnel tests. This work should be extended to include surface pressure measurements to allow a better insight into details of the parafoil flow field. An additional feature in surface pressure measurement is that the parafoil moment coefficient could be determined, a process that was not allowed using the present force transducer. The lift and drag data acquired and the proposed surface pressure surveys would provide a generous comparative database to be used in CFD simulations at corresponding test conditions. Hence, CFD flow field investigations would be a logical immediate extension for the parafoil research.

Future work must also include similar tests of hard cast models of remaining stages of parafoil deployment whereby the parafoil assumes different shapes over the deployment time.

Another area of future work would be to build and test flexible models to determine the impact of surface flexibility on aerodynamic characteristics throughout the range of operation for the parafoil. Babinsky (1999) measured the aerodynamic performance of paragliders used for sport. The research team investigated both a solid and flexible models. Results showed that the lift coefficient increased with angle of attack for both models, but it reached a maximum value of approximately one using the flexible model while it continued to increase on the solid model (Figure 4.4). The flexible model also exhibited lower lifts throughout the range of angles tested (Figure 4.5). Results also showed that drag coefficients were similar for both models, up to an angle of attack of approximately 9 degrees where the coefficient increased much faster for the flexible model (Figure 4.6).

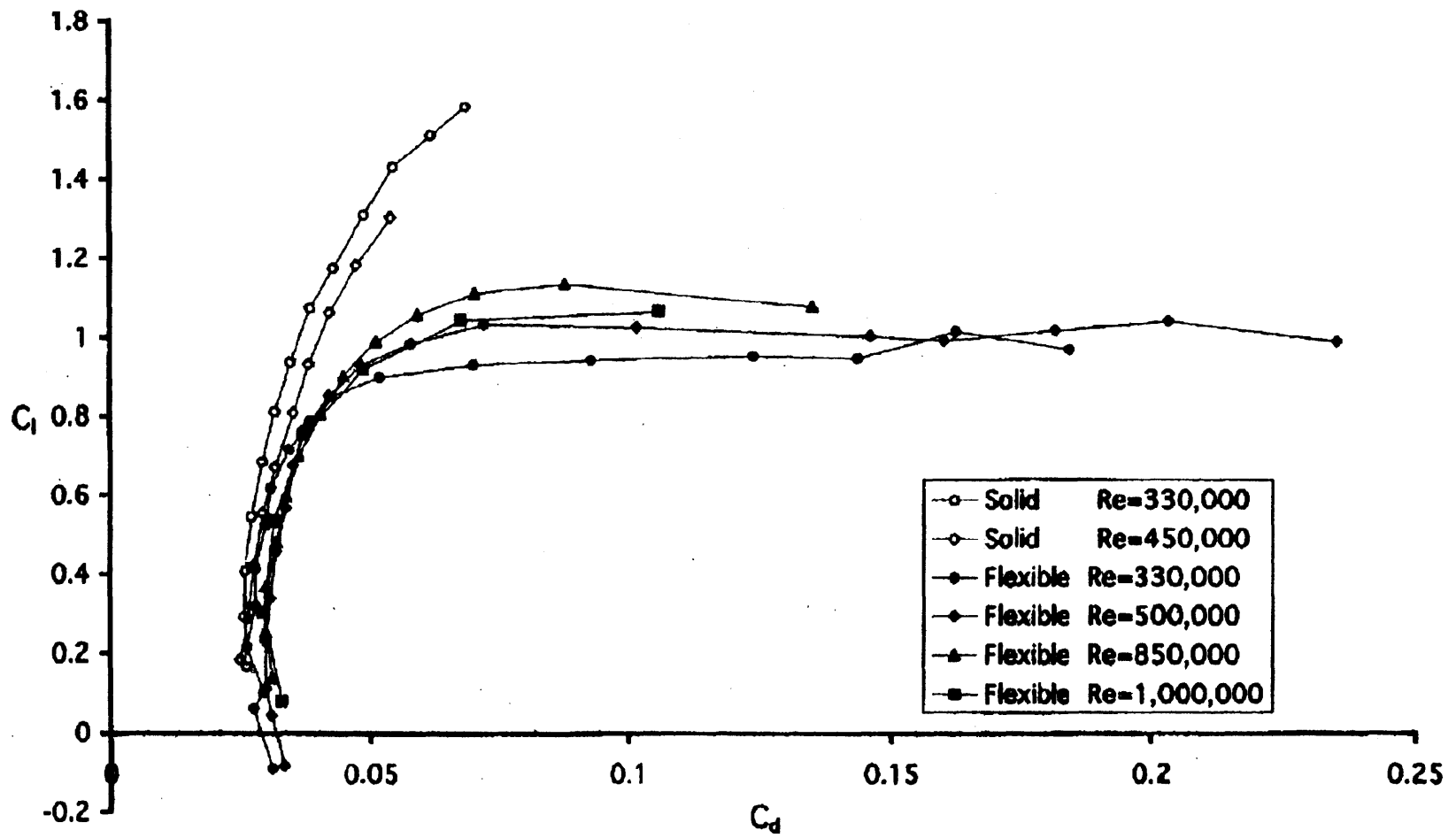


Figure 4.4 Comparisons of lift and drag coefficients for solid and flexible parafoil models

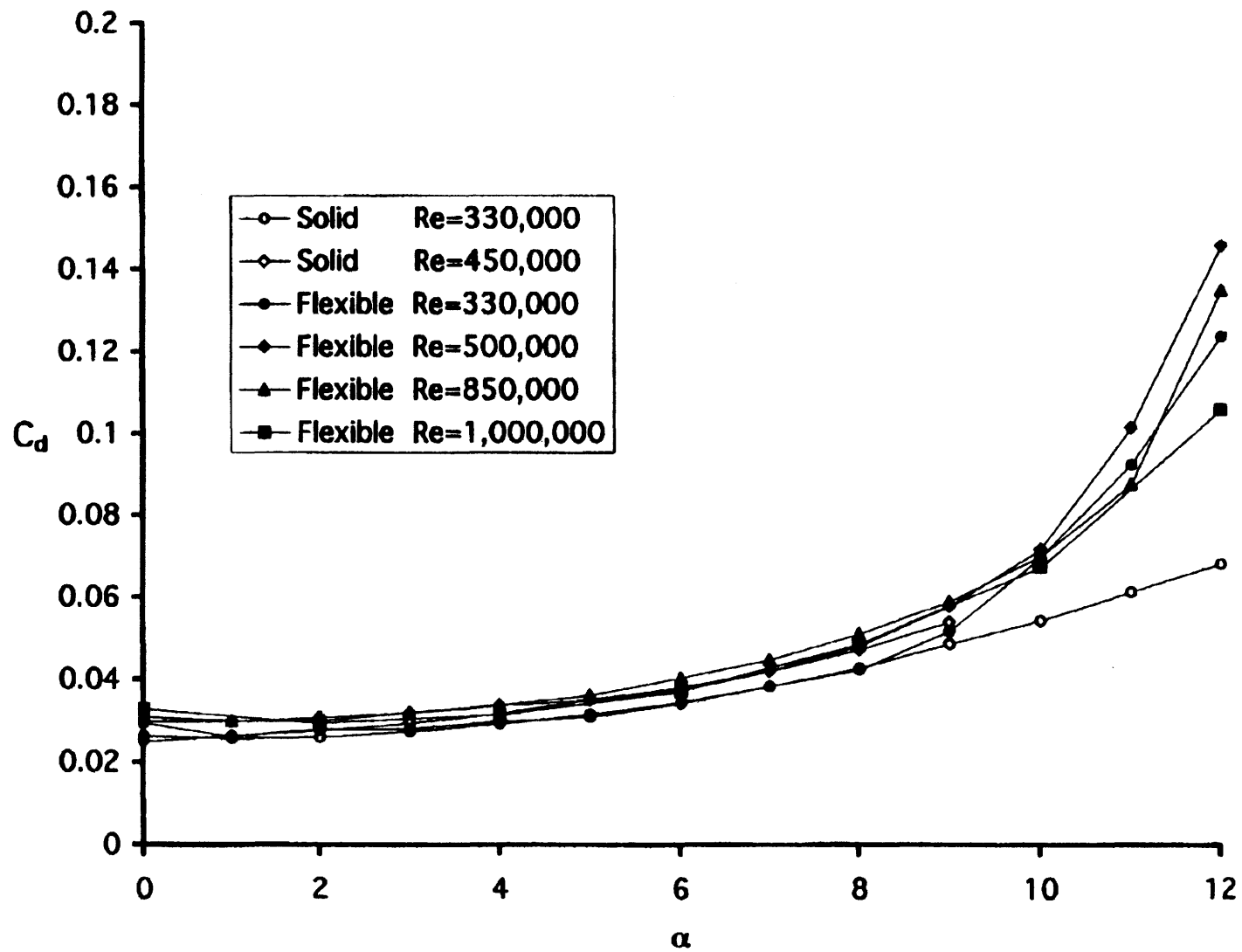


Figure 4.5 Comparisons of lift coefficients for solid and flexible parafoil models

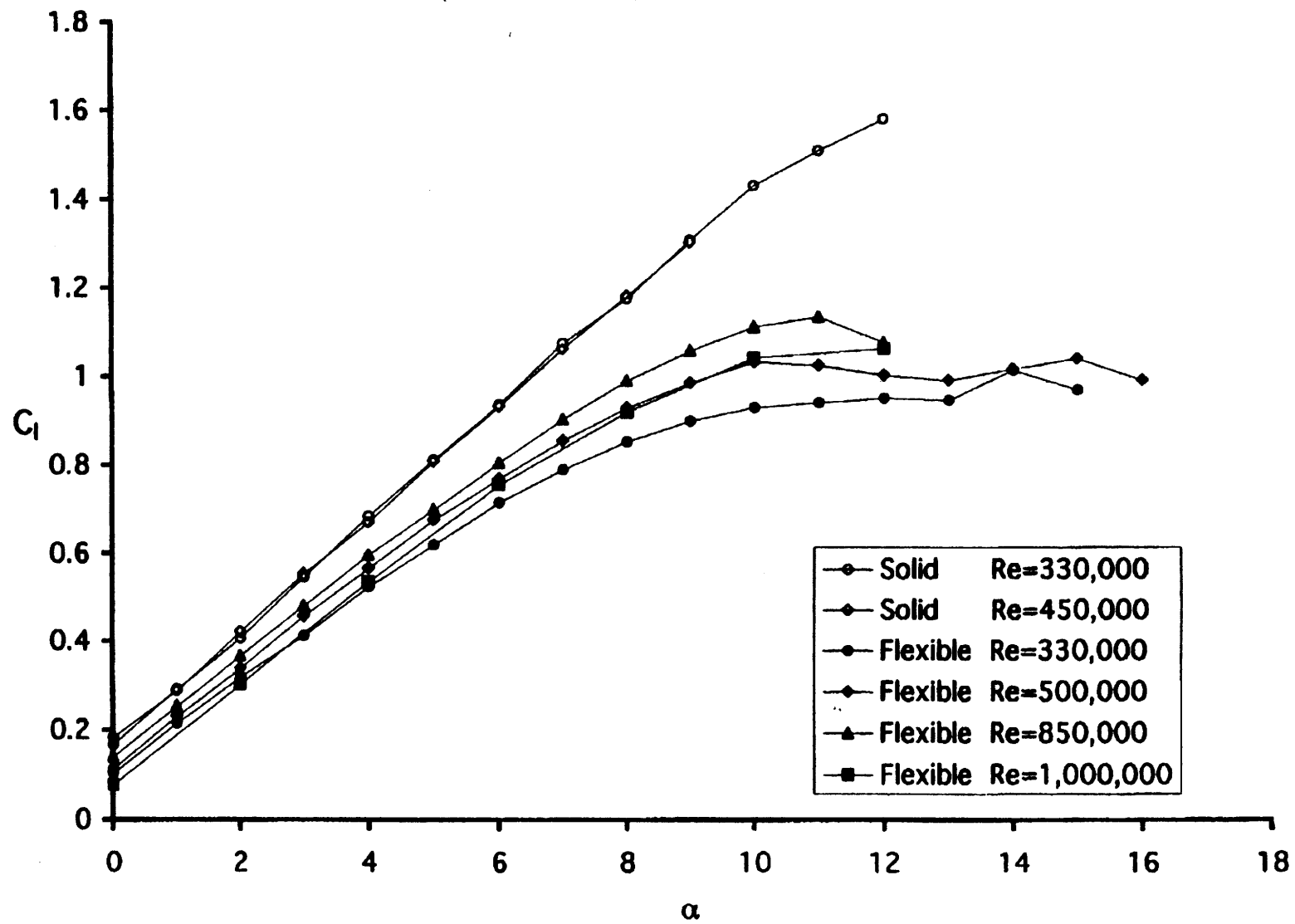


Figure 4.6 Comparisons of drag coefficients for solid and flexible parafoil models

Although their study was done for a paraglider in a fully inflated configuration with flow along the direction of the chord line, it shows that the numbers obtained in this study may only be accurate for the solid model and some corrections may be needed to compensate for the flexibility of the real parafoil.

APPENDIX A. DATA FOR LIFT AND DRAG COEFFICIENTS

Angle of Attack	Case	T(°F)	Patm (in. Hg)	dP (psf)	Normal Force (lbf)	Axial Force (lbf)	Density (slug/ft^3)	Viscosity (lbf-sec/ft^3)	V (fps)	Re	cn	ca	cl	cd	Correction Factor
0	1 1*	63.3	29.25	4.50 9.16	0.15	1.70	2.31E-03	3.76E-07	62.45 89.14	1.44E+05 2.05E+05	0.234 0.115	2.587 1.270	-0.234 -0.115	2.587 1.270	1.04
0	2 2*	59.7	29.25	6.44 13.40	0.25	2.53	2.32E-03	3.74E-07	74.52 107.47	1.73E+05 2.50E+05	0.263 0.126	2.693 1.295	-0.263 -0.126	2.693 1.295	1.08
0	3 3*	59.6	29.25	8.11 16.35	0.24	3.00	2.32E-03	3.74E-07	83.57 118.69	1.95E+05 2.76E+05	0.201 0.100	2.536 1.257	-0.201 -0.100	2.536 1.257	1.02
0	4 4*	60.4	29.25	10.71 22.18	0.40	4.17	2.32E-03	3.75E-07	96.11 138.35	2.23E+05 3.21E+05	0.258 0.124	2.673 1.290	-0.258 -0.124	2.673 1.290	1.07
0	5 5*	60.8	29.25	14.29 28.77	0.49	5.26	2.32E-03	3.75E-07	111.09 157.61	2.57E+05 3.65E+05	0.233 0.116	2.526 1.255	-0.233 -0.116	2.526 1.255	1.01
0	6 6*	61.5	29.25	17.88 36.10	0.55	6.63	2.31E-03	3.75E-07	124.33 176.67	2.88E+05 4.09E+05	0.212 0.105	2.541 1.259	-0.212 -0.105	2.541 1.259	1.02
0	7 7*	63.6	29.25	21.20 42.71	0.77	7.82	2.30E-03	3.76E-07	135.67 192.56	3.12E+05 4.42E+05	0.250 0.124	2.530 1.256	-0.250 -0.124	2.530 1.256	1.01
0	8 8*	64.2	29.25	25.05 51.02	0.86	9.44	2.30E-03	3.77E-07	147.55 210.57	3.38E+05 4.82E+05	0.236 0.116	2.585 1.269	-0.236 -0.116	2.585 1.269	1.04
0	9 9*	63	29.25	25.31 53.46	0.78	10.24	2.31E-03	3.76E-07	148.14 215.31	3.41E+05 4.95E+05	0.211 0.100	2.773 1.313	-0.211 -0.100	2.773 1.313	1.11
0	10 10*	64.8	29.25	21.10 42.83	0.73	7.90	2.30E-03	3.77E-07	135.50 193.03	3.10E+05 4.41E+05	0.236 0.117	2.567 1.265	-0.236 -0.117	2.567 1.265	1.03
0	11 11*	64.3	29.25	17.57 36.49	0.62	6.88	2.30E-03	3.77E-07	123.57 178.11	2.83E+05 4.08E+05	0.242 0.117	2.687 1.293	-0.242 -0.117	2.687 1.293	1.08
0	12 12*	63.9	29.25	14.24 29.12	0.51	5.41	2.30E-03	3.76E-07	111.22 159.03	2.55E+05 3.65E+05	0.244 0.119	2.605 1.274	-0.244 -0.119	2.605 1.274	1.04
0	13 13*	63	29.25	11.38 23.05	0.39	4.24	2.31E-03	3.76E-07	99.34 141.37	2.29E+05 3.25E+05	0.237 0.117	2.556 1.262	-0.237 -0.117	2.556 1.262	1.03
0	14 14*	61.7	29.25	8.58 17.15	0.27	3.12	2.31E-03	3.75E-07	86.12 121.80	1.99E+05 2.81E+05	0.218 0.109	2.494 1.247	-0.218 -0.109	2.494 1.247	1.00
0	15 15*	60.8	29.25	6.44 13.18	0.19	2.45	2.32E-03	3.75E-07	74.60 106.69	1.73E+05 2.47E+05	0.207 0.101	2.607 1.275	-0.207 -0.101	2.607 1.275	1.05
0	16 16*	60.1	29.25	4.47 9.16	0.13	1.70	2.32E-03	3.74E-07	62.12 88.87	1.44E+05 2.06E+05	0.204 0.100	2.610 1.275	-0.204 -0.100	2.610 1.275	1.05

Angle of Attack	Case	T(°F)	Patm (in. Hg)	dP (psf)	Normal Force (lbf)	Axial Force (lbf)	Density (slug/ft^3)	Viscosity (lbf-sec/ft^3)	V (fps)	Re	cn	ca	cl	cd	Correction Factor
-0	1 1*	59.2	29.25	4.65 9.69	-0.16	1.83	2.32E-03	3.74E-07	63.28 91.35	1.47E+05 2.13E+05	-0.234 -0.113	2.704 1.297	-0.234 -0.113	2.704 1.297	1.08
-0	2 2*	59.2	29.25	6.24 13.01	-0.22	2.46	2.32E-03	3.74E-07	73.27 105.83	1.71E+05 2.47E+05	-0.245 -0.117	2.708 1.298	-0.245 -0.117	2.708 1.298	1.09
-0	3 3*	59.4	29.25	8.68 18.11	-0.30	3.43	2.32E-03	3.74E-07	86.45 124.88	2.01E+05 2.91E+05	-0.240 -0.115	2.710 1.299	-0.240 -0.115	2.710 1.299	1.09
-0	4 4*	59.9	29.25	11.80 24.42	-0.44	4.59	2.32E-03	3.74E-07	100.84 145.08	2.34E+05 3.37E+05	-0.257 -0.124	2.668 1.289	-0.257 -0.124	2.668 1.289	1.07
-0	5 5*	60.8	29.25	14.66 30.49	-0.54	5.76	2.32E-03	3.75E-07	112.49 162.26	2.61E+05 3.76E+05	-0.254 -0.122	2.694 1.295	-0.254 -0.122	2.694 1.295	1.08
-0	6 6*	61.3	29.25	17.57 36.81	-0.68	7.00	2.31E-03	3.75E-07	123.22 178.36	2.85E+05 4.13E+05	-0.264 -0.126	2.731 1.304	-0.264 -0.126	2.731 1.304	1.10
-0	7 7*	62.2	29.25	22.14 46.20	-0.89	8.75	2.31E-03	3.76E-07	138.45 200.00	3.19E+05 4.61E+05	-0.276 -0.132	2.710 1.299	-0.276 -0.132	2.710 1.299	1.09
-0	8 8*	63.7	29.25	26.40 55.73	-0.98	10.67	2.30E-03	3.76E-07	151.40 219.98	3.48E+05 5.05E+05	-0.254 -0.120	2.770 1.312	-0.254 -0.120	2.770 1.312	1.11
-0	9 9*	61.2	29.25	26.51 56.55	-0.99	10.93	2.31E-03	3.75E-07	151.34 221.06	3.50E+05 5.12E+05	-0.257 -0.120	2.827 1.325	-0.257 -0.120	2.827 1.325	1.13
-0	10 10*	64	29.25	21.98 46.37	-0.86	8.87	2.30E-03	3.77E-07	138.20 200.72	3.17E+05 4.60E+05	-0.269 -0.127	2.766 1.311	-0.269 -0.127	2.766 1.311	1.11
-0	11 11*	63.7	29.25	18.09 37.83	-0.72	7.18	2.30E-03	3.76E-07	125.31 181.24	2.88E+05 4.16E+05	-0.274 -0.131	2.722 1.301	-0.274 -0.131	2.722 1.301	1.09
-0	12 12*	63.3	29.25	14.81 31.09	-0.56	5.92	2.31E-03	3.76E-07	113.36 164.24	2.61E+05 3.77E+05	-0.261 -0.124	2.741 1.306	-0.261 -0.124	2.741 1.306	1.10
-0	13 13*	62.4	29.25	11.49 24.29	-0.41	4.65	2.31E-03	3.76E-07	99.74 145.03	2.30E+05 3.34E+05	-0.245 -0.116	2.779 1.314	-0.245 -0.116	2.779 1.314	1.11
-0	14 14*	61.7	29.25	8.58 17.91	-0.29	3.40	2.31E-03	3.75E-07	86.12 124.47	1.99E+05 2.88E+05	-0.235 -0.112	2.715 1.300	-0.235 -0.112	2.715 1.300	1.09
-0	15 15*	60.8	29.25	6.08 12.53	-0.22	2.34	2.32E-03	3.75E-07	72.46 104.00	1.68E+05 2.41E+05	-0.249 -0.121	2.644 1.283	-0.249 -0.121	2.644 1.283	1.06
-0	16 16*	59.9	29.25	4.59 9.41	-0.14	1.75	2.32E-03	3.74E-07	62.89 90.08	1.46E+05 2.09E+05	-0.206 -0.100	2.622 1.278	-0.206 -0.100	2.622 1.278	1.05

Angle of Attack	Case	T(°F)	Patm (in. Hg)	dP (psf)	Normal Force (lbf)	Axial Force (lbf)	Density (slug/ft^3)	Viscosity (lbf-sec/ft^3)	V (fps)	Re	cn	ca	cl	cd	Correction Factor
-5	1 1*	59.5	29.25	4.60 9.45	-0.16	1.76	2.32E-03	3.74E-07	62.94 90.22	1.47E+05 2.10E+05	-0.232 -0.113	2.620 1.275	-0.002 -0.001	2.630 1.280	1.05
-5	2 2*	59.4	29.25	6.39 13.19	-0.24	2.46	2.32E-03	3.74E-07	74.19 106.59	1.73E+05 2.48E+05	-0.255 -0.124	2.641 1.280	-0.024 -0.012	2.653 1.285	1.06
-5	3 3*	59.7	29.25	8.94 18.68	-0.32	3.53	2.32E-03	3.74E-07	87.76 126.87	2.04E+05 2.95E+05	-0.245 -0.117	2.707 1.295	-0.009 -0.004	2.718 1.300	1.09
-5	4 4*	60.1	29.25	11.59 23.59	-0.39	4.35	2.32E-03	3.74E-07	99.97 142.63	2.32E+05 3.31E+05	-0.230 -0.113	2.572 1.264	-0.005 -0.003	2.582 1.269	1.04
-5	5 5*	60.8	29.25	15.23 31.68	-0.55	5.96	2.32E-03	3.75E-07	114.67 165.39	2.66E+05 3.83E+05	-0.250 -0.120	2.682 1.289	-0.015 -0.007	2.694 1.295	1.08
-5	6 6*	61.5	29.25	18.50 38.85	-0.65	7.37	2.31E-03	3.75E-07	126.48 183.27	2.92E+05 4.24E+05	-0.240 -0.114	2.731 1.301	-0.001 0.000	2.742 1.306	1.10
-5	7 7*	62.4	29.25	24.01 49.49	-0.91	9.22	2.31E-03	3.76E-07	144.21 207.04	3.32E+05 4.77E+05	-0.260 -0.126	2.634 1.278	-0.030 -0.014	2.646 1.284	1.06
-5	8 8*	63.7	29.25	27.86 58.40	-0.95	11.07	2.30E-03	3.76E-07	155.52 225.18	3.57E+05 5.17E+05	-0.233 -0.111	2.724 1.299	0.005 0.002	2.734 1.304	1.10
-5	9 9*	62.2	29.25	27.75 58.31	-1.00	11.07	2.31E-03	3.76E-07	155.01 224.68	3.58E+05 5.18E+05	-0.246 -0.117	2.734 1.301	-0.007 -0.003	2.745 1.307	1.10
-5	10 10*	64.2	29.25	23.23 48.78	-0.86	9.25	2.30E-03	3.77E-07	142.09 205.90	3.26E+05 4.72E+05	-0.255 -0.121	2.731 1.300	-0.016 -0.007	2.742 1.306	1.10
-5	11 11*	64.2	29.25	19.23 40.52	-0.69	7.71	2.30E-03	3.77E-07	129.28 187.66	2.96E+05 4.30E+05	-0.246 -0.117	2.750 1.305	-0.005 -0.002	2.761 1.310	1.11
-5	12 12*	63.5	29.25	15.33 31.71	-0.57	5.93	2.30E-03	3.76E-07	115.35 165.90	2.65E+05 3.81E+05	-0.256 -0.124	2.652 1.282	-0.024 -0.011	2.664 1.288	1.07
-5	13 13*	63	29.25	12.32 25.42	-0.46	4.74	2.31E-03	3.76E-07	103.35 148.48	2.38E+05 3.42E+05	-0.254 -0.123	2.641 1.280	-0.022 -0.011	2.653 1.285	1.06
-5	14 14*	61.7	29.25	8.99 18.66	-0.32	3.50	2.31E-03	3.75E-07	88.19 127.03	2.04E+05 2.94E+05	-0.244 -0.118	2.669 1.286	-0.010 -0.005	2.680 1.292	1.07
-5	15 15*	60.8	29.25	7.22 14.02	-0.20	2.46	2.32E-03	3.75E-07	78.98 110.01	1.83E+05 2.55E+05	-0.189 -0.098	2.337 1.204	0.015 0.008	2.345 1.208	0.94
-5	16 16*	60.1	29.25	4.66 9.65	-0.15	1.81	2.32E-03	3.74E-07	63.40 91.21	1.47E+05 2.12E+05	-0.220 -0.106	2.658 1.284	0.013 0.006	2.667 1.289	1.07

Angle of Attack	Case	T(°F)	Patm (in. Hg)	dP (psf)	Normal Force (lbf)	Axial Force (lbf)	Density (slug/ft ³)	Viscosity (lbf-sec/ft ²)	V (fps)	Re	cn	ca	cl	cd	Correction Factor
5	1 1*	59.2	29.25	4.30	0.16	1.69	2.32E-03	3.74E-07	60.83	1.42E+05	0.260	2.703	-0.494	2.670	1.07
				8.90					87.53	2.04E+05	0.125	1.305	-0.239	1.289	
5	2 2*	59.2	29.25	5.92	0.24	2.41	2.32E-03	3.74E-07	71.41	1.66E+05	0.283	2.785	-0.524	2.750	1.10
				12.46					103.56	2.41E+05	0.134	1.324	-0.249	1.308	
5	3 3*	59.5	29.25	8.00	0.28	3.10	2.32E-03	3.74E-07	83.03	1.93E+05	0.240	2.656	-0.471	2.625	1.05
				16.43					118.96	2.77E+05	0.117	1.294	-0.229	1.279	
5	4 4*	60.1	29.25	10.91	0.35	4.12	2.32E-03	3.74E-07	97.01	2.25E+05	0.218	2.591	-0.443	2.562	1.03
				22.13					138.14	3.21E+05	0.107	1.278	-0.218	1.264	
5	5 5*	61	29.25	14.03	0.52	5.35	2.32E-03	3.75E-07	110.09	2.55E+05	0.252	2.613	-0.479	2.581	1.04
				28.56					157.06	3.64E+05	0.124	1.284	-0.235	1.268	
5	6 6*	61.3	29.25	17.25	0.64	6.77	2.31E-03	3.75E-07	122.12	2.83E+05	0.254	2.690	-0.488	2.658	1.07
				35.65					175.52	4.06E+05	0.123	1.302	-0.236	1.287	
5	7 7*	62.6	29.25	21.41	0.85	8.35	2.31E-03	3.76E-07	136.21	3.14E+05	0.271	2.673	-0.503	2.639	1.06
				44.08					195.42	4.50E+05	0.131	1.299	-0.244	1.282	
5	8 8*	64.8	29.25	24.95	0.93	9.70	2.30E-03	3.77E-07	147.33	3.37E+05	0.256	2.665	-0.487	2.633	1.06
				51.29					211.24	4.83E+05	0.124	1.296	-0.237	1.281	
5	9 9*	61.7	29.25	25.10	0.80	9.39	2.31E-03	3.75E-07	147.35	3.41E+05	0.217	2.564	-0.440	2.535	1.02
				50.63					209.26	4.84E+05	0.108	1.271	-0.218	1.257	
5	10 10*	64.2	29.25	21.00	0.80	8.19	2.30E-03	3.77E-07	135.08	3.10E+05	0.260	2.674	-0.492	2.641	1.06
				43.23					193.84	4.44E+05	0.126	1.298	-0.239	1.283	
5	11 11*	64.2	29.25	16.99	0.68	6.84	2.30E-03	3.77E-07	121.53	2.78E+05	0.276	2.761	-0.516	2.727	1.09
				35.58					175.85	4.03E+05	0.132	1.319	-0.246	1.302	
5	12 12*	63.7	29.25	13.77	0.52	5.45	2.30E-03	3.76E-07	109.35	2.51E+05	0.257	2.711	-0.493	2.678	1.07
				28.57					157.49	3.61E+05	0.124	1.307	-0.238	1.291	
5	13 13*	63.1	29.25	10.86	0.37	4.13	2.31E-03	3.76E-07	97.06	2.23E+05	0.233	2.607	-0.459	2.577	1.03
				22.09					138.40	3.18E+05	0.115	1.282	-0.226	1.267	
5	14 14*	62.2	29.25	8.16	0.31	3.09	2.31E-03	3.76E-07	84.05	1.94E+05	0.263	2.600	-0.488	2.567	1.03
				16.56					119.74	2.76E+05	0.130	1.281	-0.241	1.265	
5	15 15*	61.2	29.25	6.13	0.24	2.34	2.31E-03	3.75E-07	72.80	1.69E+05	0.270	2.621	-0.498	2.587	1.04
				12.50					103.91	2.41E+05	0.133	1.286	-0.244	1.270	
5	16 16*	60.6	29.25	4.47	0.18	1.73	2.32E-03	3.75E-07	62.15	1.44E+05	0.274	2.656	-0.504	2.622	1.05
				9.18					89.02	2.06E+05	0.133	1.295	-0.246	1.278	

Angle of Attack	Case	T(°F)	Patm (in. Hg)	dP (psf)	Normal Force (lbf)	Axial Force (lbf)	Density (slug/ft ³)	Viscosity (lbf-sec/ft ²)	V (fps)	Re	cn	ca	cl	cd	Correction Factor
10	1 1*	59.5	29.2	4.23 8.09	0.19	1.46	2.32E-03	3.74E-07	60.38 83.57	1.40E+05 1.94E+05	0.306 0.160	2.373 1.239	-0.714 -0.373	2.284 1.192	0.92
10	2 2*	59	29.2	5.46 10.47	0.25	1.89	2.32E-03	3.74E-07	68.58 94.97	1.60E+05 2.21E+05	0.309 0.161	2.378 1.240	-0.718 -0.374	2.288 1.193	0.92
10	3 3*	59.4	29.2	7.64 14.28	0.33	2.51	2.32E-03	3.74E-07	81.18 111.00	1.89E+05 2.58E+05	0.295 0.158	2.254 1.205	-0.682 -0.365	2.168 1.160	0.87
10	4 4*	59.9	29.2	10.24 19.53	0.46	3.51	2.32E-03	3.74E-07	94.02 129.87	2.18E+05 3.01E+05	0.305 0.160	2.353 1.233	-0.709 -0.371	2.264 1.187	0.91
10	5 5*	60.6	29.2	12.94 25.17	0.59	4.62	2.31E-03	3.75E-07	105.78 147.51	2.45E+05 3.42E+05	0.315 0.162	2.448 1.259	-0.735 -0.378	2.356 1.211	0.94
10	6 6*	61.3	29.2	16.94 31.71	0.74	5.58	2.31E-03	3.75E-07	121.11 165.70	2.80E+05 3.83E+05	0.299 0.160	2.260 1.207	-0.687 -0.367	2.174 1.161	0.87
10	7 7*	62.4	29.2	20.32 37.53	0.87	6.51	2.31E-03	3.76E-07	132.78 180.45	3.06E+05 4.15E+05	0.294 0.159	2.196 1.189	-0.671 -0.363	2.112 1.143	0.85
10	8 8*	64	29.2	24.43 46.66	1.13	8.41	2.30E-03	3.77E-07	145.80 201.51	3.34E+05 4.61E+05	0.316 0.166	2.361 1.236	-0.721 -0.378	2.270 1.188	0.91
10	9 9*	61.7	29.2	24.58 46.74	1.07	8.37	2.31E-03	3.75E-07	145.94 201.25	3.37E+05 4.64E+05	0.299 0.157	2.335 1.228	-0.700 -0.368	2.248 1.182	0.90
10	10 10*	64.4	29.2	20.37 37.83	0.87	6.60	2.30E-03	3.77E-07	133.20 181.50	3.04E+05 4.15E+05	0.293 0.158	2.221 1.196	-0.675 -0.363	2.136 1.151	0.86
10	11 11*	64	29.2	16.53 31.74	0.77	5.75	2.30E-03	3.77E-07	119.93 166.19	2.75E+05 3.80E+05	0.321 0.167	2.387 1.243	-0.731 -0.380	2.295 1.195	0.92
10	12 12*	63.5	29.2	13.20 25.10	0.61	4.50	2.30E-03	3.76E-07	107.13 147.72	2.46E+05 3.39E+05	0.319 0.168	2.339 1.230	-0.720 -0.379	2.248 1.182	0.90
10	13 13*	62.6	29.2	10.29 18.89	0.44	3.25	2.30E-03	3.76E-07	94.50 128.05	2.17E+05 2.94E+05	0.293 0.159	2.168 1.181	-0.665 -0.362	2.084 1.135	0.84
10	14 14*	61.5	29.2	7.80 14.67	0.36	2.60	2.31E-03	3.75E-07	82.17 112.74	1.90E+05 2.60E+05	0.317 0.168	2.290 1.217	-0.710 -0.377	2.200 1.169	0.88
10	15 15*	60.4	29.2	5.87 11.01	0.26	1.94	2.31E-03	3.75E-07	71.24 97.56	1.65E+05 2.26E+05	0.300 0.160	2.269 1.210	-0.690 -0.368	2.183 1.164	0.88
10	16 16*	59.7	29.2	4.12 7.89	0.19	1.42	2.32E-03	3.74E-07	59.64 82.50	1.39E+05 1.92E+05	0.321 0.168	2.370 1.238	-0.728 -0.380	2.278 1.190	0.91

Angle of Attack	Case	T(°F)	Patm (in. Hg)	dP (psf)	Normal Force (lbf)	Axial Force (lbf)	Density (slug/ft^3)	Viscosity (lbf-sec/ft^3)	V (fps)	Re	cn	ca	cl	cd	Correction Factor
-10	1 1*	59.5	29.2	4.25	-0.07	1.57	2.32E-03	3.74E-07	60.53	1.41E+05	-0.118	2.538	0.325	2.520	1.01
				8.54					85.82	1.99E+05	-0.059	1.262	0.161	1.253	
-10	2 2*	59.4	29.2	5.82	-0.11	2.11	2.32E-03	3.74E-07	70.86	1.65E+05	-0.125	2.486	0.309	2.469	0.99
				11.59					99.97	2.32E+05	-0.063	1.249	0.155	1.241	
-10	3 3*	59.9	29.2	8.21	-0.15	2.94	2.32E-03	3.74E-07	84.20	1.95E+05	-0.127	2.456	0.302	2.440	0.98
				16.25					118.44	2.75E+05	-0.064	1.241	0.153	1.233	
-10	4 4*	60.3	29.2	10.50	-0.21	3.81	2.31E-03	3.74E-07	95.24	2.21E+05	-0.139	2.489	0.295	2.475	0.99
				20.92					134.45	3.12E+05	-0.070	1.249	0.148	1.242	
-10	5 5*	60.4	29.2	13.62	-0.27	4.94	2.31E-03	3.75E-07	108.48	2.51E+05	-0.138	2.489	0.297	2.475	0.99
				27.13					153.14	3.55E+05	-0.069	1.249	0.149	1.242	
-10	6 6*	61.5	29.2	16.84	-0.35	6.18	2.31E-03	3.75E-07	120.76	2.79E+05	-0.142	2.518	0.297	2.505	1.00
				33.75					170.98	3.95E+05	-0.071	1.256	0.148	1.250	
-10	7 7*	63	29.2	20.58	-0.41	7.25	2.30E-03	3.76E-07	133.70	3.07E+05	-0.137	2.417	0.284	2.404	0.96
				40.42					187.38	4.30E+05	-0.070	1.231	0.145	1.224	
-10	8 8*	64	29.2	24.58	-0.51	8.72	2.30E-03	3.77E-07	146.26	3.35E+05	-0.143	2.432	0.281	2.420	0.97
				48.44					205.31	4.70E+05	-0.073	1.234	0.143	1.228	
-10	9 9*	62.1	29.2	24.48	-0.52	8.79	2.31E-03	3.75E-07	145.69	3.36E+05	-0.146	2.463	0.283	2.451	0.98
				48.54					205.15	4.73E+05	-0.074	1.242	0.143	1.236	
-10	10 10*	64.4	29.2	20.37	-0.41	7.48	2.30E-03	3.77E-07	133.20	3.04E+05	-0.139	2.517	0.300	2.503	1.00
				40.82					188.55	4.31E+05	-0.069	1.256	0.150	1.249	
-10	11 11*	64.6	29.2	16.89	-0.33	5.92	2.30E-03	3.77E-07	121.31	2.77E+05	-0.136	2.404	0.284	2.391	0.96
				33.09					169.79	3.88E+05	-0.069	1.227	0.145	1.221	
-10	12 12*	63.7	29.2	13.36	-0.27	4.81	2.30E-03	3.76E-07	107.78	2.47E+05	-0.139	2.470	0.292	2.457	0.99
				26.52					151.87	3.48E+05	-0.070	1.244	0.147	1.238	
-10	13 13*	62.8	29.2	10.55	-0.21	3.91	2.30E-03	3.76E-07	95.71	2.20E+05	-0.139	2.539	0.304	2.524	1.01
				21.23					135.77	3.12E+05	-0.069	1.262	0.151	1.254	
-10	14 14*	61.9	29.2	7.64	-0.16	2.84	2.31E-03	3.75E-07	81.37	1.88E+05	-0.140	2.547	0.305	2.532	1.02
				15.40					115.53	2.66E+05	-0.069	1.264	0.151	1.256	
-10	15 15*	61	29.2	5.77	-0.10	2.08	2.31E-03	3.75E-07	70.65	1.63E+05	-0.123	2.478	0.309	2.462	0.99
				11.46					99.60	2.30E+05	-0.062	1.247	0.156	1.239	
-10	16 16*	60.1	29.2	4.26	-0.08	1.52	2.32E-03	3.74E-07	60.63	1.41E+05	-0.122	2.441	0.303	2.425	0.97
				8.40					85.16	1.98E+05	-0.062	1.237	0.154	1.229	

Angle of Attack	Case	T(°F)	Patm (in. Hg)	dP (psf)	Normal Force (lbf)	Axial Force (lbf)	Density (slug/ft^3)	Viscosity (lbf-sec/ft^3)	V (fps)	Re	cn	ca	cl	cd	Correction Factor
15	1 1*	59.5	29.2	4.24 8.22	0.24	1.56	2.32E-03	3.74E-07	60.45 84.21	1.41E+05 1.96E+05	0.383 0.198	2.530 1.304	-1.025 -0.528	2.345 1.208	0.94
15	2 2*	59.7	29.2	6.18 11.81	0.34	2.21	2.32E-03	3.74E-07	73.06 100.97	1.70E+05 2.35E+05	0.373 0.195	2.449 1.282	-0.994 -0.521	2.269 1.188	0.91
15	3 3*	59.9	29.2	7.95 15.32	0.42	2.88	2.32E-03	3.74E-07	82.86 115.00	1.92E+05 2.67E+05	0.360 0.187	2.488 1.291	-0.991 -0.515	2.310 1.199	0.93
15	4 4*	60.3	29.2	11.17 21.30	0.53	3.95	2.31E-03	3.74E-07	98.26 135.65	2.28E+05 3.14E+05	0.326 0.171	2.426 1.273	-0.943 -0.495	2.259 1.185	0.91
15	5 5*	60.8	29.2	13.98 26.88	0.72	5.05	2.31E-03	3.75E-07	109.96 152.48	2.54E+05 3.53E+05	0.354 0.184	2.477 1.288	-0.983 -0.511	2.301 1.197	0.92
15	6 6*	61.7	29.2	17.25 33.72	0.95	6.46	2.31E-03	3.75E-07	122.27 170.94	2.82E+05 3.94E+05	0.379 0.194	2.566 1.313	-1.031 -0.527	2.380 1.218	0.95
15	7 7*	63	29.2	21.15 41.31	1.16	7.90	2.30E-03	3.76E-07	135.55 189.41	3.11E+05 4.35E+05	0.375 0.192	2.560 1.311	-1.025 -0.525	2.376 1.217	0.95
15	8 8*	64.6	29.2	25.36 48.48	1.38	9.07	2.30E-03	3.77E-07	148.65 205.51	3.40E+05 4.69E+05	0.374 0.196	2.453 1.283	-0.996 -0.521	2.273 1.189	0.91
15	9 9*	60.8	29.2	24.58 47.79	1.41	9.12	2.31E-03	3.75E-07	145.82 203.32	3.37E+05 4.70E+05	0.394 0.202	2.543 1.308	-1.038 -0.534	2.354 1.211	0.94
15	10 10*	61.9	29.2	20.37 38.99	1.09	7.30	2.31E-03	3.75E-07	132.88 183.83	3.06E+05 4.24E+05	0.366 0.191	2.457 1.284	-0.989 -0.517	2.278 1.191	0.91
15	11 11*	61.2	29.2	16.58 32.20	0.94	6.13	2.31E-03	3.75E-07	119.79 166.95	2.77E+05 3.86E+05	0.390 0.201	2.537 1.306	-1.033 -0.532	2.349 1.210	0.94
15	12 12*	60.4	29.2	13.77 26.34	0.63	4.90	2.31E-03	3.75E-07	109.10 150.87	2.53E+05 3.50E+05	0.314 0.164	2.439 1.275	-0.934 -0.489	2.275 1.190	0.91
15	13 13*	59.9	29.2	10.86 21.01	0.60	3.98	2.32E-03	3.74E-07	96.84 134.69	2.25E+05 3.13E+05	0.378 0.195	2.513 1.299	-1.015 -0.525	2.330 1.204	0.93
15	14 14*	58.4	29.2	7.90 15.32	0.44	2.91	2.32E-03	3.73E-07	82.47 114.84	1.92E+05 2.68E+05	0.383 0.198	2.527 1.303	-1.024 -0.528	2.342 1.208	0.94
15	15 15*	58.7	29.2	6.08 11.70	0.34	2.21	2.32E-03	3.74E-07	72.37 100.41	1.69E+05 2.34E+05	0.383 0.199	2.490 1.294	-1.015 -0.527	2.306 1.198	0.92
15	16 16*	57.4	29.2	4.31 8.26	0.25	1.55	2.33E-03	3.73E-07	60.85 84.25	1.42E+05 1.97E+05	0.396 0.207	2.474 1.290	-1.023 -0.534	2.287 1.193	0.92

Angle of Attack	Case	T(°F)	Patm (in. Hg)	dP (psf)	Normal Force (lbf)	Axial Force (lbf)	Density (slug/ft ³)	Viscosity (lbf-sec/ft ²)	V (fps)	Re	cn	ca	cl	cd	Correction Factor
-15	1 1*	56.5	29.2	4.21 8.72	-0.07	1.68	2.33E-03	3.72E-07	60.13 86.50	1.41E+05 2.03E+05	-0.119 -0.057	2.729 1.319	0.591 0.286	2.666 1.289	1.07
-15	2 2*	56.3	29.2	5.61 11.66	-0.11	2.25	2.33E-03	3.72E-07	69.37 100.00	1.63E+05 2.35E+05	-0.132 -0.064	2.747 1.322	0.583 0.281	2.687 1.293	1.08
-15	3 3*	56.5	29.2	7.80 16.20	-0.16	3.12	2.33E-03	3.72E-07	81.77 117.90	1.92E+05 2.77E+05	-0.140 -0.067	2.747 1.322	0.576 0.277	2.690 1.294	1.08
-15	4 4*	57.2	29.2	10.55 21.81	-0.24	4.17	2.33E-03	3.73E-07	95.19 136.86	2.23E+05 3.21E+05	-0.157 -0.076	2.712 1.312	0.550 0.266	2.660 1.287	1.07
-15	5 5*	57.6	29.2	13.72 28.38	-0.34	5.43	2.33E-03	3.73E-07	108.60 156.19	2.54E+05 3.65E+05	-0.171 -0.083	2.712 1.311	0.537 0.259	2.664 1.288	1.07
-15	6 6*	58.1	29.2	16.84 34.67	-0.42	6.60	2.32E-03	3.73E-07	120.37 172.72	2.81E+05 4.03E+05	-0.171 -0.083	2.688 1.306	0.531 0.258	2.641 1.283	1.06
-15	7 7*	59	29.2	20.58 42.72	-0.53	8.19	2.32E-03	3.74E-07	133.19 191.88	3.10E+05 4.47E+05	-0.178 -0.086	2.729 1.315	0.535 0.258	2.682 1.292	1.08
-15	8 8*	60.3	29.2	24.58 50.28	-0.66	9.50	2.31E-03	3.74E-07	145.74 208.44	3.38E+05 4.83E+05	-0.183 -0.090	2.650 1.295	0.509 0.249	2.607 1.274	1.05
-15	9 9*	58.8	29.2	24.74 50.53	-0.66	9.53	2.32E-03	3.74E-07	146.00 208.65	3.40E+05 4.86E+05	-0.182 -0.089	2.642 1.294	0.508 0.249	2.600 1.273	1.04
-15	10 10*	60.4	29.2	20.37 42.45	-0.48	8.18	2.31E-03	3.75E-07	132.69 191.54	3.07E+05 4.44E+05	-0.162 -0.078	2.754 1.322	0.557 0.267	2.702 1.297	1.08
-15	11 11*	60.1	29.2	17.10 35.08	-0.46	6.65	2.32E-03	3.74E-07	121.53 174.08	2.82E+05 4.04E+05	-0.185 -0.090	2.666 1.299	0.511 0.249	2.623 1.278	1.05
-15	12 12*	59	29.2	13.36 27.65	-0.34	5.29	2.32E-03	3.74E-07	107.30 154.38	2.50E+05 3.59E+05	-0.174 -0.084	2.716 1.312	0.535 0.258	2.669 1.289	1.07
-15	13 13*	58.5	29.2	10.34 21.59	-0.27	4.16	2.32E-03	3.73E-07	94.37 136.34	2.20E+05 3.18E+05	-0.180 -0.086	2.759 1.322	0.541 0.259	2.711 1.299	1.09
-15	14 14*	57.6	29.2	7.95 16.21	-0.20	3.06	2.33E-03	3.73E-07	82.68 118.05	1.93E+05 2.76E+05	-0.174 -0.085	2.635 1.292	0.514 0.252	2.590 1.271	1.04
-15	15 15*	57	29.2	5.66 11.78	-0.12	2.27	2.33E-03	3.73E-07	69.74 100.56	1.63E+05 2.36E+05	-0.140 -0.067	2.748 1.322	0.576 0.277	2.690 1.294	1.08
-15	16 16*	55.8	29.2	4.26 8.73	-0.08	1.66	2.33E-03	3.72E-07	60.38 86.46	1.42E+05 2.04E+05	-0.136 -0.066	2.675 1.305	0.561 0.274	2.619 1.277	1.05

Angle of Attack	Case	T(°F)	Patm (in. Hg)	dP (psf)	Normal Force (lbf)	Axial Force (lbf)	Density (slug/ft^3)	Viscosity (lbf-sec/ft^3)	V (fps)	Re	cn	ca	cl	cd	Correction Factor
20	1	55.4	29.45	4.11	0.19	1.51	2.36E-03	3.72E-07	59.07	1.40E+05	0.311	2.521	-1.155	2.263	0.91
	1*			7.84					81.58	1.94E+05	0.163	1.322	-0.605	1.186	
20	2	55	29.45	5.51	0.27	2.09	2.36E-03	3.71E-07	68.35	1.63E+05	0.337	2.606	-1.208	2.333	0.94
	2*			10.66					95.10	2.26E+05	0.174	1.346	-0.624	1.205	
20	3	55	29.45	7.64	0.36	2.83	2.36E-03	3.71E-07	80.49	1.92E+05	0.326	2.544	-1.177	2.279	0.91
	3*			14.62					111.36	2.65E+05	0.170	1.329	-0.615	1.191	
20	4	55.2	29.45	10.34	0.52	3.91	2.36E-03	3.72E-07	93.67	2.23E+05	0.344	2.594	-1.210	2.320	0.93
	4*			19.97					130.15	3.10E+05	0.178	1.344	-0.627	1.202	
20	5	55.9	29.45	12.89	0.63	4.80	2.35E-03	3.72E-07	104.64	2.48E+05	0.335	2.554	-1.188	2.286	0.92
	5*			24.70					144.87	3.44E+05	0.175	1.333	-0.620	1.193	
20	6	56.5	29.45	16.32	0.78	5.99	2.35E-03	3.72E-07	117.81	2.79E+05	0.327	2.518	-1.168	2.255	0.90
	6*			31.07					162.57	3.85E+05	0.172	1.322	-0.614	1.184	
20	7	57.6	29.45	20.01	0.97	7.24	2.35E-03	3.73E-07	130.59	3.08E+05	0.332	2.481	-1.160	2.218	0.89
	7*			37.81					179.51	4.24E+05	0.175	1.313	-0.614	1.174	
20	8	58.5	29.45	23.39	1.11	8.39	2.34E-03	3.73E-07	141.31	3.32E+05	0.324	2.461	-1.146	2.202	0.88
	8*			44.04					193.90	4.56E+05	0.172	1.307	-0.609	1.169	
20	9	58.5	29.45	23.54	1.14	8.26	2.34E-03	3.73E-07	141.78	3.33E+05	0.331	2.406	-1.134	2.148	0.86
	9*			43.82					193.44	4.55E+05	0.178	1.293	-0.609	1.154	
20	10	59	29.45	20.06	1.01	7.26	2.34E-03	3.74E-07	130.94	3.07E+05	0.346	2.482	-1.174	2.214	0.89
	10*			37.87					179.91	4.22E+05	0.183	1.315	-0.622	1.173	
20	11	58.8	29.45	16.58	0.73	5.95	2.34E-03	3.74E-07	119.01	2.80E+05	0.303	2.461	-1.126	2.209	0.89
	11*			31.26					163.43	3.84E+05	0.161	1.305	-0.597	1.171	
20	12	57.9	29.45	13.56	0.70	4.77	2.35E-03	3.73E-07	107.55	2.54E+05	0.356	2.413	-1.160	2.146	0.86
	12*			25.24					146.71	3.46E+05	0.191	1.297	-0.623	1.153	
20	13	57.2	29.45	10.39	0.51	3.89	2.35E-03	3.73E-07	94.09	2.22E+05	0.336	2.565	-1.194	2.295	0.92
	13*			19.96					130.39	3.08E+05	0.175	1.336	-0.621	1.195	
20	14	56.3	29.45	7.74	0.39	2.78	2.35E-03	3.72E-07	81.14	1.92E+05	0.342	2.465	-1.164	2.199	0.88
	14*			14.57					111.31	2.64E+05	0.182	1.310	-0.619	1.168	
20	15	55.4	29.45	5.35	0.28	1.93	2.36E-03	3.72E-07	67.40	1.60E+05	0.354	2.476	-1.179	2.206	0.88
	15*			10.09					92.53	2.20E+05	0.188	1.314	-0.626	1.170	
20	16	54.7	29.45	4.06	0.21	1.46	2.36E-03	3.71E-07	58.65	1.40E+05	0.351	2.473	-1.175	2.204	0.88
	16*			7.65					80.50	1.92E+05	0.186	1.313	-0.624	1.170	

Angle of Attack	Case	T(°F)	Patm (in. Hg)	dP (psf)	Normal Force (lbf)	Axial Force (lbf)	Density (slug/ft ³)	Viscosity (lbf-sec/ft ²)	V (fps)	Re	cn	ca	cl	cd	Correction Factor
-20	1 1*	59	29.45	3.78 7.64	-0.08	1.46	2.34E-03	3.74E-07	56.82 80.78	1.33E+05 1.90E+05	-0.140 -0.069	2.658 1.315	0.778 0.385	2.546 1.260	1.02
-20	2 2*	56.8	29.45	5.46 11.05	-0.13	2.12	2.35E-03	3.72E-07	68.15 96.99	1.61E+05 2.29E+05	-0.160 -0.079	2.663 1.315	0.761 0.376	2.557 1.262	1.03
-20	3 3*	57	29.45	6.96 14.20	-0.16	2.74	2.35E-03	3.73E-07	77.00 109.95	1.82E+05 2.60E+05	-0.160 -0.078	2.699 1.324	0.773 0.379	2.591 1.271	1.04
-20	4 4*	57.4	29.45	10.08 20.69	-0.25	4.01	2.35E-03	3.73E-07	92.68 132.76	2.19E+05 3.13E+05	-0.168 -0.082	2.730 1.330	0.776 0.378	2.623 1.278	1.05
-20	5 5*	57.9	29.45	12.63 25.61	-0.35	4.90	2.35E-03	3.73E-07	103.78 147.79	2.45E+05 3.48E+05	-0.191 -0.094	2.658 1.311	0.730 0.360	2.563 1.264	1.03
-20	6 6*	58.3	29.45	15.90 32.38	-0.49	6.20	2.34E-03	3.73E-07	116.50 166.23	2.74E+05 3.91E+05	-0.210 -0.103	2.672 1.313	0.716 0.352	2.583 1.269	1.04
-20	7 7*	59	29.45	19.70 39.61	-0.59	7.49	2.34E-03	3.74E-07	129.74 183.98	3.05E+05 4.32E+05	-0.206 -0.102	2.607 1.297	0.699 0.347	2.520 1.253	1.01
-20	8 8*	59.4	29.45	24.63 49.70	-0.67	9.46	2.34E-03	3.74E-07	145.15 206.18	3.40E+05 4.84E+05	-0.188 -0.093	2.632 1.305	0.724 0.359	2.538 1.258	1.02
-20	9 9*	59	29.45	24.32 49.35	-0.72	9.42	2.34E-03	3.74E-07	144.18 205.37	3.39E+05 4.82E+05	-0.203 -0.100	2.657 1.309	0.718 0.354	2.566 1.265	1.03
-20	10 10*	59.5	29.45	19.70 39.83	-0.60	7.58	2.34E-03	3.74E-07	129.81 184.60	3.04E+05 4.33E+05	-0.208 -0.103	2.637 1.304	0.707 0.349	2.549 1.261	1.02
-20	11 11*	59.2	29.45	16.37 33.43	-0.51	6.42	2.34E-03	3.74E-07	118.31 169.07	2.78E+05 3.97E+05	-0.212 -0.104	2.688 1.316	0.720 0.353	2.599 1.273	1.04
-20	12 12*	58.5	29.45	12.94 25.98	-0.36	4.91	2.34E-03	3.73E-07	105.11 148.94	2.47E+05 3.50E+05	-0.193 -0.096	2.604 1.297	0.710 0.353	2.513 1.252	1.01
-20	13 13*	57.6	29.45	10.03 20.62	-0.33	3.98	2.35E-03	3.73E-07	92.46 132.56	2.18E+05 3.13E+05	-0.227 -0.111	2.718 1.322	0.716 0.348	2.632 1.280	1.06
-20	14 14*	56.8	29.45	7.38 14.98	-0.25	2.85	2.35E-03	3.72E-07	79.25 112.92	1.88E+05 2.67E+05	-0.234 -0.115	2.649 1.305	0.686 0.338	2.569 1.265	1.03
-20	15 15*	55.9	29.45	5.46 11.10	-0.17	2.12	2.35E-03	3.72E-07	68.09 97.13	1.62E+05 2.31E+05	-0.210 -0.103	2.670 1.312	0.716 0.352	2.581 1.268	1.03
-20	16 16*	55.2	29.45	3.99 8.04	-0.13	1.52	2.36E-03	3.72E-07	58.15 82.58	1.38E+05 1.96E+05	-0.220 -0.109	2.618 1.298	0.689 0.342	2.535 1.257	1.02

Angle of Attack	Case	T(°F)	Patm (in. Hg)	dP (psf)	Normal Force (lbf)	Axial Force (lbf)	Density (slug/ft ³)	Viscosity (lbf-sec/ft ²)	V (fps)	Re	cn	ca	cl	cd	Correction Factor
25	1 1*	54.7	29.45	4.34 8.37	0.23	1.73	2.36E-03	1.46E-01	60.65 84.24	1.45E+05 2.01E+05	0.361 0.187	2.726 1.413	-1.480 -0.767	2.318 1.201	0.93
25	2 2*	54.9	29.45	5.87 11.12	0.30	2.24	2.36E-03	-1.19E-01	70.56 97.10	1.68E+05 2.31E+05	0.349 0.184	2.621 1.384	-1.424 -0.752	2.228 1.177	0.89
25	3 3*	55	29.45	8.00 15.16	0.41	3.06	2.36E-03	-3.83E-01	82.38 113.38	1.96E+05 2.70E+05	0.352 0.186	2.624 1.386	-1.429 -0.754	2.230 1.177	0.89
25	4 4*	55.4	29.45	10.39 19.53	0.54	3.92	2.36E-03	-6.48E-01	93.92 128.73	2.23E+05 3.06E+05	0.358 0.191	2.584 1.376	-1.417 -0.754	2.191 1.166	0.88
25	5 5*	55.9	29.45	13.56 25.22	0.71	5.01	2.35E-03	-9.12E-01	107.35 146.37	2.55E+05 3.47E+05	0.359 0.193	2.531 1.362	-1.395 -0.750	2.143 1.152	0.86
25	6 6*	56.5	29.45	16.27 30.04	0.89	5.94	2.35E-03	-1.18E+00	117.62 159.85	2.79E+05 3.79E+05	0.376 0.204	2.506 1.357	-1.400 -0.758	2.112 1.143	0.85
25	7 7*	57.6	29.45	20.27 38.29	1.14	7.76	2.35E-03	-1.44E+00	131.44 180.66	3.10E+05 4.26E+05	0.385 0.204	2.626 1.390	-1.458 -0.772	2.217 1.174	0.89
25	8 8*	58.5	29.45	24.53 45.72	1.37	9.14	2.34E-03	-1.71E+00	144.72 197.57	3.40E+05 4.65E+05	0.384 0.206	2.555 1.371	-1.428 -0.766	2.154 1.156	0.86
25	9 9*	57.7	29.45	24.48 44.79	1.32	8.76	2.35E-03	-1.97E+00	144.46 195.40	3.41E+05 4.61E+05	0.369 0.202	2.454 1.342	-1.371 -0.750	2.069 1.131	0.83
25	10 10*	58.5	29.45	20.48 38.72	1.18	7.87	2.34E-03	-2.24E+00	132.22 181.81	3.11E+05 4.28E+05	0.396 0.209	2.635 1.394	-1.473 -0.779	2.221 1.175	0.89
25	11 11*	58.1	29.45	17.57 33.28	0.98	6.76	2.34E-03	-2.50E+00	122.42 168.51	2.88E+05 3.97E+05	0.381 0.201	2.639 1.393	-1.461 -0.771	2.231 1.177	0.89
25	12 12*	57.2	29.45	13.51 25.73	0.74	5.25	2.35E-03	-2.76E+00	107.28 148.02	2.53E+05 3.50E+05	0.377 0.198	2.663 1.399	-1.467 -0.771	2.254 1.184	0.90
25	13 13*	56.5	29.45	10.81 20.67	0.58	4.23	2.35E-03	-3.03E+00	95.89 132.60	2.27E+05 3.14E+05	0.368 0.193	2.682 1.403	-1.468 -0.767	2.275 1.190	0.91
25	14 14*	55.8	29.45	8.00 15.58	0.43	3.24	2.35E-03	-3.29E+00	82.45 115.03	1.96E+05 2.73E+05	0.370 0.190	2.777 1.427	-1.509 -0.775	2.360 1.213	0.95
25	15 15*	55.2	29.45	5.72 10.93	0.29	2.23	2.36E-03	-3.56E+00	69.64 96.31	1.66E+05 2.29E+05	0.345 0.180	2.671 1.397	-1.441 -0.754	2.275 1.190	0.91
25	16 16*	54.5	29.45	4.08 8.10	0.22	1.71	2.36E-03	-3.82E+00	58.79 82.84	1.40E+05 1.98E+05	0.362 0.182	2.880 1.451	-1.545 -0.778	2.457 1.237	0.99

Angle of Attack	Case	T(°F)	Patm (in. Hg)	dP (psf)	Normal Force (lbf)	Axial Force (lbf)	Density (slug/ft^3)	Viscosity (lbf-sec/ft^2)	V (fps)	Re	cn	ca	cl	cd	Correction Factor
-25	1 1*	54.3	29.45	4.24 8.01	-0.08	1.48	2.36E-03	3.71E-07	59.89 82.36	1.43E+05 1.97E+05	-0.125 -0.066	2.393 1.265	0.898 0.475	2.222 1.175	0.89
-25	2 2*	54.3	29.45	5.82 11.69	-0.13	2.29	2.36E-03	3.71E-07	70.21 99.48	1.68E+05 2.37E+05	-0.156 -0.078	2.699 1.344	0.999 0.498	2.512 1.251	1.01
-25	3 3*	54.5	29.45	8.00 15.60	-0.18	2.96	2.36E-03	3.71E-07	82.34 114.95	1.96E+05 2.74E+05	-0.158 -0.081	2.537 1.302	0.929 0.477	2.366 1.214	0.95
-25	4 4*	55	29.45	10.39 20.91	-0.28	4.09	2.36E-03	3.71E-07	93.89 133.17	2.24E+05 3.17E+05	-0.188 -0.093	2.697 1.340	0.969 0.482	2.523 1.254	1.01
-25	5 5*	55.9	29.45	13.67 26.45	-0.29	4.99	2.35E-03	3.72E-07	107.76 149.91	2.56E+05 3.56E+05	-0.146 -0.076	2.505 1.294	0.926 0.478	2.332 1.205	0.94
-25	6 6*	56.3	29.45	16.89 33.54	-0.40	6.49	2.35E-03	3.72E-07	119.83 168.85	2.84E+05 4.00E+05	-0.162 -0.082	2.636 1.328	0.967 0.487	2.457 1.238	0.99
-25	7 7*	57.2	29.45	20.68 41.37	-0.54	8.04	2.35E-03	3.73E-07	132.73 187.70	3.14E+05 4.43E+05	-0.181 -0.090	2.667 1.333	0.963 0.482	2.493 1.247	1.00
-25	8 8*	58.6	29.45	24.53 49.52	-0.64	9.73	2.34E-03	3.73E-07	144.73 205.65	3.40E+05 4.84E+05	-0.179 -0.089	2.720 1.347	0.987 0.489	2.541 1.258	1.02
-25	9 9*	58.1	29.45	24.43 47.72	-0.56	9.08	2.34E-03	3.73E-07	144.36 201.76	3.40E+05 4.75E+05	-0.158 -0.081	2.549 1.305	0.934 0.478	2.377 1.217	0.95
-25	10 10*	59	29.45	20.37 41.16	-0.57	8.08	2.34E-03	3.74E-07	131.95 187.56	3.10E+05 4.40E+05	-0.191 -0.095	2.718 1.345	0.976 0.483	2.544 1.259	1.02
-25	11 11*	58.8	29.45	17.10 33.85	-0.41	6.53	2.34E-03	3.74E-07	120.86 170.06	2.84E+05 4.00E+05	-0.165 -0.083	2.619 1.323	0.957 0.484	2.443 1.234	0.98
-25	12 12*	57.9	29.45	13.46 26.81	-0.32	5.21	2.35E-03	3.73E-07	107.14 151.21	2.53E+05 3.56E+05	-0.164 -0.082	2.652 1.332	0.972 0.488	2.473 1.242	0.99
-25	13 13*	57.2	29.45	10.45 20.95	-0.24	4.10	2.35E-03	3.73E-07	94.32 133.59	2.23E+05 3.16E+05	-0.156 -0.078	2.695 1.343	0.997 0.497	2.508 1.250	1.01
-25	14 14*	56.3	29.45	7.95 15.98	-0.20	3.13	2.35E-03	3.72E-07	82.22 116.56	1.95E+05 2.76E+05	-0.169 -0.084	2.699 1.343	0.987 0.491	2.518 1.253	1.01
-25	15 15*	55.8	29.45	5.61 11.04	-0.13	2.12	2.35E-03	3.72E-07	69.05 96.84	1.64E+05 2.30E+05	-0.154 -0.078	2.589 1.316	0.955 0.485	2.411 1.226	0.97
-25	16 16*	55.2	29.45	4.30 8.58	-0.10	1.67	2.36E-03	3.72E-07	60.38 85.30	1.44E+05 2.03E+05	-0.154 -0.077	2.667 1.336	0.987 0.495	2.482 1.244	1.00

Angle of Attack	Case	T(°F)	Patm (in. Hg)	dP (psf)	Normal Force (lbf)	Axial Force (lbf)	Density (slug/ft^3)	Viscosity (lbf-sec/ft^3)	V (fps)	Re	cn	ca	cl	cd	Correction Factor
-30	1 1*	54	29.4	4.37 8.34	-0.09	1.62	2.36E-03	3.71E-07	60.84 84.08	1.45E+05 2.01E+05	-0.137 -0.072	2.541 1.330	1.152 0.603	2.269 1.188	0.91
-30	2 2*	54	29.4	5.56 10.86	-0.11	2.16	2.36E-03	3.71E-07	68.66 95.94	1.64E+05 2.29E+05	-0.139 -0.071	2.662 1.364	1.211 0.620	2.375 1.216	0.95
-30	3 3*	54.3	29.4	7.74 15.02	-0.18	2.95	2.36E-03	3.71E-07	81.05 112.86	1.93E+05 2.69E+05	-0.159 -0.082	2.612 1.347	1.168 0.602	2.341 1.208	0.94
-30	4 4*	54.7	29.4	10.60 20.30	-0.24	3.94	2.36E-03	3.71E-07	94.87 131.28	2.26E+05 3.12E+05	-0.152 -0.080	2.546 1.330	1.141 0.596	2.281 1.191	0.91
-30	5 5*	55.4	29.4	13.36 25.96	-0.33	5.10	2.35E-03	3.72E-07	106.56 148.57	2.53E+05 3.53E+05	-0.168 -0.086	2.621 1.348	1.165 0.599	2.353 1.211	0.94
-30	6 6*	55.9	29.4	16.22 31.91	-0.39	6.37	2.35E-03	3.72E-07	117.47 164.79	2.78E+05 3.90E+05	-0.164 -0.084	2.692 1.368	1.204 0.612	2.414 1.227	0.97
-30	7 7*	59.7	29.4	20.22 39.66	-0.50	7.87	2.33E-03	3.74E-07	131.65 184.38	3.08E+05 4.31E+05	-0.170 -0.087	2.671 1.361	1.188 0.606	2.398 1.222	0.96
-30	8 8*	57.9	29.4	24.22 48.14	-0.59	9.70	2.34E-03	3.73E-07	143.84 202.78	3.38E+05 4.77E+05	-0.167 -0.084	2.747 1.382	1.229 0.618	2.463 1.239	0.99
-30	9 9*	57.6	29.4	23.85 46.75	-0.58	9.28	2.34E-03	3.73E-07	142.71 199.78	3.36E+05 4.71E+05	-0.167 -0.085	2.667 1.361	1.189 0.607	2.393 1.221	0.96
-30	10 10*	58.6	29.4	19.91 38.84	-0.47	7.68	2.34E-03	3.73E-07	130.49 182.27	3.06E+05 4.28E+05	-0.163 -0.084	2.644 1.355	1.181 0.605	2.372 1.216	0.95
-30	11 11*	58.3	29.4	16.47 32.29	-0.40	6.41	2.34E-03	3.73E-07	118.68 166.14	2.79E+05 3.90E+05	-0.166 -0.085	2.667 1.361	1.190 0.607	2.393 1.221	0.96
-30	12 12*	57.7	29.4	13.41 26.37	-0.31	5.26	2.34E-03	3.73E-07	107.00 150.06	2.52E+05 3.53E+05	-0.158 -0.080	2.692 1.369	1.209 0.615	2.410 1.226	0.97
-30	13 13*	57	29.4	10.24 19.94	-0.24	3.94	2.35E-03	3.73E-07	93.44 130.41	2.21E+05 3.08E+05	-0.162 -0.083	2.636 1.353	1.178 0.605	2.363 1.213	0.95
-30	14 14*	56.3	29.4	7.64 14.80	-0.16	2.91	2.35E-03	3.72E-07	80.66 112.27	1.91E+05 2.66E+05	-0.145 -0.075	2.614 1.350	1.181 0.610	2.337 1.206	0.94
-30	15 15*	55.2	29.4	5.66 11.12	-0.12	2.22	2.35E-03	3.72E-07	69.38 97.19	1.65E+05 2.31E+05	-0.145 -0.074	2.686 1.369	1.217 0.620	2.399 1.223	0.96
-30	16 16*	54.5	29.4	4.41 8.60	-0.10	1.70	2.36E-03	3.71E-07	61.19 85.41	1.46E+05 2.03E+05	-0.157 -0.081	2.640 1.355	1.184 0.607	2.365 1.214	0.95

Angle of Attack	Case	T(°F)	Patm (in. Hg)	dP (psf)	Normal Force (lbf)	Axial Force (lbf)	Density (slug/ft ³)	Viscosity (lbf-sec/ft ²)	V (fps)	Re	cn	ca	cl	cd	Correction Factor
30	1 1*	54.5	29.4	4.58 7.78	0.23	1.48	2.36E-03	3.71E-07	62.34 81.23	1.48E+05 1.93E+05	0.351 0.206	2.213 1.303	-1.410 -0.830	1.741 1.025	0.70
30	2 2*	54.5	29.4	6.34 10.75	0.32	2.03	2.36E-03	3.71E-07	73.35 95.51	1.75E+05 2.27E+05	0.344 0.203	2.200 1.298	-1.398 -0.825	1.734 1.023	0.70
30	3 3*	55	29.4	8.32 14.57	0.44	2.88	2.35E-03	3.71E-07	84.05 111.25	2.00E+05 2.64E+05	0.359 0.205	2.373 1.354	-1.497 -0.855	1.875 1.070	0.75
30	4 4*	55.2	29.4	11.43 19.82	0.59	3.86	2.35E-03	3.72E-07	98.57 129.79	2.34E+05 3.08E+05	0.352 0.203	2.315 1.336	-1.462 -0.844	1.829 1.055	0.73
30	5 5*	55.9	29.4	14.76 25.03	0.74	4.74	2.35E-03	3.72E-07	112.07 145.95	2.66E+05 3.46E+05	0.342 0.202	2.202 1.298	-1.397 -0.824	1.736 1.023	0.70
30	6 6*	56.7	29.4	17.98 31.28	0.94	6.13	2.35E-03	3.72E-07	123.80 163.27	2.93E+05 3.86E+05	0.360 0.207	2.337 1.343	-1.480 -0.851	1.844 1.060	0.74
30	7 7*	57.6	29.4	21.98 38.33	1.18	7.54	2.34E-03	3.73E-07	137.00 180.89	3.23E+05 4.26E+05	0.367 0.210	2.352 1.349	-1.494 -0.857	1.854 1.063	0.74
30	8 8*	58.6	29.4	26.09 45.67	1.36	9.01	2.34E-03	3.73E-07	149.39 197.65	3.51E+05 4.64E+05	0.358 0.205	2.367 1.352	-1.494 -0.853	1.871 1.069	0.75
30	9 9*	57.9	29.4	26.30 45.92	1.38	9.04	2.34E-03	3.73E-07	149.88 198.07	3.53E+05 4.66E+05	0.359 0.206	2.356 1.349	-1.489 -0.853	1.861 1.066	0.75
30	10 10*	59	29.4	21.98 38.52	1.20	7.64	2.34E-03	3.74E-07	137.19 181.60	3.22E+05 4.26E+05	0.373 0.213	2.382 1.359	-1.514 -0.864	1.876 1.071	0.75
30	11 11*	58.8	29.4	17.88 31.46	0.99	6.27	2.34E-03	3.74E-07	123.69 164.08	2.90E+05 3.85E+05	0.378 0.215	2.406 1.367	-1.530 -0.870	1.894 1.076	0.76
30	12 12*	57.9	29.4	14.14 24.61	0.78	4.85	2.34E-03	3.73E-07	109.89 145.00	2.59E+05 3.41E+05	0.380 0.219	2.353 1.352	-1.506 -0.865	1.848 1.061	0.74
30	13 13*	57.2	29.4	11.28 19.45	0.61	3.79	2.34E-03	3.73E-07	98.09 128.83	2.31E+05 3.04E+05	0.372 0.216	2.303 1.335	-1.474 -0.854	1.808 1.048	0.73
30	14 14*	56.5	29.4	8.47 14.60	0.47	2.84	2.35E-03	3.72E-07	84.95 111.52	2.01E+05 2.64E+05	0.382 0.222	2.303 1.336	-1.482 -0.860	1.803 1.046	0.72
30	15 15*	55.8	29.4	6.18 10.30	0.36	1.94	2.35E-03	3.72E-07	72.54 93.60	1.72E+05 2.22E+05	0.400 0.240	2.145 1.289	-1.419 -0.852	1.658 0.996	0.66
30	16 16*	55.2	29.4	4.61 7.69	0.26	1.44	2.35E-03	3.72E-07	62.59 80.82	1.49E+05 1.92E+05	0.390 0.234	2.147 1.288	-1.412 -0.847	1.664 0.998	0.67

Angle of Attack	Case	T(°F)	Patm (in. Hg)	dP (psf)	Normal Force (lbf)	Axial Force (lbf)	Density (slug/ft^3)	Viscosity (lbf-sec/ft^3)	V (fps)	Re	cn	ca	cl	cd	Correction Factor
-35	1	56.8	28.65	3.93	-0.07	1.52	2.29E-03	3.72E-07	58.66	1.35E+05	-0.130	2.641	1.409	2.238	0.90
	1*			7.46					80.81	1.86E+05	-0.068	1.392	0.742	1.179	
-35	2	56.3	28.65	5.25	-0.13	2.08	2.29E-03	3.72E-07	67.73	1.56E+05	-0.166	2.719	1.424	2.323	0.93
	2*			10.14					94.13	2.17E+05	-0.086	1.408	0.737	1.203	
-35	3	56.5	28.65	7.43	-0.17	2.81	2.29E-03	3.72E-07	80.61	1.86E+05	-0.160	2.593	1.357	2.216	0.89
	3*			14.04					110.77	2.55E+05	-0.084	1.373	0.718	1.173	
-35	4	56.8	28.65	9.77	-0.23	3.95	2.29E-03	3.72E-07	92.45	2.13E+05	-0.162	2.775	1.459	2.366	0.95
	4*			19.04					129.06	2.97E+05	-0.083	1.424	0.749	1.214	
-35	5	57	28.65	12.73	-0.33	4.93	2.29E-03	3.73E-07	105.56	2.43E+05	-0.177	2.656	1.379	2.277	0.91
	5*			24.36					146.01	3.36E+05	-0.092	1.388	0.721	1.190	
-35	6	57.9	28.65	15.75	-0.39	5.97	2.28E-03	3.73E-07	117.49	2.69E+05	-0.171	2.599	1.351	2.228	0.89
	6*			29.82					161.67	3.71E+05	-0.090	1.373	0.713	1.177	
-35	7	58.3	28.65	19.13	-0.50	7.41	2.28E-03	3.73E-07	129.53	2.97E+05	-0.179	2.657	1.377	2.279	0.91
	7*			36.61					179.21	4.10E+05	-0.094	1.388	0.719	1.191	
-35	8	59.2	28.65	23.34	-0.61	9.13	2.28E-03	3.74E-07	143.20	3.27E+05	-0.179	2.683	1.393	2.301	0.92
	8*			44.87					198.57	4.53E+05	-0.093	1.396	0.724	1.197	
-35	9	57.9	28.65	23.13	-0.58	8.76	2.28E-03	3.73E-07	142.39	3.27E+05	-0.171	2.596	1.349	2.225	0.89
	9*			43.76					195.86	4.49E+05	-0.090	1.372	0.713	1.176	
-35	10	59.2	28.65	19.75	-0.53	7.75	2.28E-03	3.74E-07	131.74	3.01E+05	-0.182	2.689	1.393	2.308	0.93
	10*			38.03					182.81	4.17E+05	-0.095	1.397	0.724	1.198	
-35	11	58.8	28.65	15.85	-0.43	6.25	2.28E-03	3.74E-07	117.98	2.70E+05	-0.187	2.702	1.397	2.321	0.93
	11*			30.60					163.94	3.75E+05	-0.097	1.400	0.724	1.202	
-35	12	58.3	28.65	12.84	-0.33	5.18	2.28E-03	3.73E-07	106.12	2.43E+05	-0.175	2.769	1.445	2.369	0.95
	12*			25.03					148.19	3.39E+05	-0.090	1.420	0.741	1.215	
-35	13	57.4	28.65	10.03	-0.24	3.86	2.28E-03	3.73E-07	93.73	2.15E+05	-0.165	2.638	1.378	2.255	0.90
	13*			19.10					129.34	2.97E+05	-0.086	1.385	0.724	1.184	
-35	14	56.7	28.65	7.43	-0.20	2.89	2.29E-03	3.72E-07	80.62	1.86E+05	-0.187	2.664	1.375	2.290	0.92
	14*			14.26					111.66	2.57E+05	-0.097	1.389	0.717	1.194	
-35	15	56.1	28.65	5.56	-0.14	2.22	2.29E-03	3.72E-07	69.70	1.61E+05	-0.168	2.741	1.435	2.342	0.94
	15*			10.78					97.06	2.24E+05	-0.087	1.414	0.740	1.208	
-35	16	55.4	28.65	4.14	-0.10	1.58	2.29E-03	3.72E-07	60.11	1.39E+05	-0.170	2.616	1.361	2.241	0.90
	16*			7.86					82.83	1.92E+05	-0.090	1.378	0.717	1.180	

Angle of Attack	Case	T(°F)	Patm (in. Hg)	dP (psf)	Normal Force (lbf)	Axial Force (lbf)	Density (slug/ft ³)	Viscosity (lbf-sec/ft ²)	V (fps)	Re	cn	ca	cl	cd	Correction Factor
35	1 1*	61.5	28.65	3.97	0.16	1.28	2.27E-03	3.75E-07	59.16	1.34E+05	0.281	2.218	-1.503	1.655	0.66
				6.60					76.32	1.73E+05	0.169	1.333	-0.903	0.995	
35	2 2*	59.5	28.65	5.46	0.23	1.86	2.27E-03	3.74E-07	69.27	1.58E+05	0.286	2.333	-1.573	1.747	0.70
				9.28					90.34	2.06E+05	0.168	1.372	-0.925	1.027	
35	3 3*	59.7	28.65	7.28	0.30	2.47	2.27E-03	3.74E-07	80.00	1.82E+05	0.286	2.325	-1.568	1.741	0.70
				12.36					104.25	2.38E+05	0.168	1.369	-0.923	1.025	
35	4 4*	59.9	28.65	9.30	0.42	3.33	2.27E-03	3.74E-07	90.48	2.06E+05	0.313	2.453	-1.663	1.830	0.73
				16.13					119.14	2.71E+05	0.180	1.415	-0.959	1.055	
35	5 5*	60.4	28.65	12.78	0.54	4.33	2.27E-03	3.75E-07	106.12	2.41E+05	0.291	2.324	-1.572	1.737	0.70
				21.69					138.23	3.14E+05	0.172	1.370	-0.926	1.024	
35	6 6*	61	28.65	16.06	0.70	5.59	2.27E-03	3.75E-07	119.00	2.70E+05	0.297	2.388	-1.614	1.786	0.72
				27.56					155.90	3.54E+05	0.173	1.392	-0.940	1.041	
35	7 7*	61.7	28.65	19.07	0.80	6.56	2.26E-03	3.75E-07	129.78	2.94E+05	0.288	2.360	-1.590	1.768	0.71
				32.60					169.66	3.84E+05	0.169	1.381	-0.930	1.034	
35	8 8*	62.8	28.65	23.13	1.03	8.01	2.26E-03	3.76E-07	143.06	3.23E+05	0.305	2.376	-1.612	1.771	0.71
				39.55					187.09	4.22E+05	0.178	1.389	-0.943	1.036	
35	9 9*	61	28.65	23.28	1.04	8.14	2.27E-03	3.75E-07	143.29	3.25E+05	0.306	2.397	-1.626	1.788	0.72
				39.98					187.77	4.26E+05	0.178	1.396	-0.947	1.041	
35	10 10*	62.2	28.65	19.85	0.90	7.03	2.26E-03	3.76E-07	132.47	2.99E+05	0.312	2.428	-1.649	1.810	0.73
				34.26					174.03	3.93E+05	0.181	1.407	-0.955	1.049	
35	11 11*	61.7	28.65	15.96	0.73	5.59	2.26E-03	3.75E-07	118.70	2.69E+05	0.312	2.405	-1.635	1.791	0.72
				27.41					155.59	3.52E+05	0.181	1.399	-0.951	1.042	
35	12 12*	60.8	28.65	12.99	0.59	4.46	2.27E-03	3.75E-07	107.02	2.43E+05	0.310	2.355	-1.605	1.751	0.70
				22.12					139.63	3.17E+05	0.182	1.383	-0.943	1.029	
35	13 13*	60.3	28.65	9.72	0.46	3.48	2.27E-03	3.74E-07	92.52	2.10E+05	0.321	2.454	-1.671	1.826	0.73
				16.83					121.76	2.77E+05	0.186	1.417	-0.965	1.054	
35	14 14*	59.2	28.65	7.43	0.34	2.54	2.28E-03	3.74E-07	80.82	1.84E+05	0.316	2.348	-1.606	1.742	0.70
				12.62					105.33	2.40E+05	0.186	1.382	-0.945	1.026	
35	15 15*	58.3	28.65	5.51	0.25	1.87	2.28E-03	3.73E-07	69.52	1.59E+05	0.308	2.333	-1.591	1.734	0.70
				9.34					90.52	2.07E+05	0.182	1.376	-0.938	1.023	
35	16 16*	57.4	28.65	4.03	0.19	1.40	2.28E-03	3.73E-07	59.39	1.36E+05	0.322	2.381	-1.630	1.766	0.71
				6.88					77.62	1.78E+05	0.189	1.394	-0.954	1.034	

Angle of Attack	Case	T(°F)	Patm (in. Hg)	dP (psf)	Normal Force (lbf)	Axial Force (lbf)	Density (slug/ft^3)	Viscosity (lbf-sec/ft^3)	V (fps)	Re	cn	ca	cl	cd	Correction Factor
40	1	56.7	28.6	5.13	0.19	1.49	2.28E-03	3.72E-07	67.04	1.54E+05	0.248	1.989	-1.469	1.364	0.55
	1*			7.94					83.38	1.92E+05	0.161	1.286	-0.950	0.882	
40	2	55.6	28.6	6.65	0.25	2.11	2.29E-03	3.72E-07	76.26	1.76E+05	0.253	2.171	-1.589	1.500	0.60
	2*			10.65					96.51	2.23E+05	0.158	1.355	-0.992	0.937	
40	3	55.8	28.6	8.26	0.30	2.56	2.29E-03	3.72E-07	85.01	1.96E+05	0.246	2.128	-1.556	1.472	0.59
	3*			13.14					107.20	2.47E+05	0.155	1.338	-0.978	0.925	
40	4	55.9	28.6	11.02	0.42	3.72	2.29E-03	3.72E-07	98.17	2.26E+05	0.261	2.313	-1.687	1.604	0.64
	4*			18.11					125.85	2.90E+05	0.159	1.407	-1.026	0.976	
40	5	56.5	28.6	14.08	0.53	4.59	2.28E-03	3.72E-07	111.06	2.55E+05	0.256	2.236	-1.633	1.548	0.62
	5*			22.83					141.40	3.25E+05	0.158	1.379	-1.007	0.955	
40	6	57.2	28.6	16.99	0.67	5.71	2.28E-03	3.73E-07	122.08	2.80E+05	0.271	2.306	-1.690	1.592	0.64
	6*			27.84					156.26	3.59E+05	0.166	1.407	-1.031	0.972	
40	7	57.9	28.6	20.84	0.81	7.07	2.28E-03	3.73E-07	135.28	3.10E+05	0.267	2.325	-1.699	1.609	0.65
	7*			34.29					173.53	3.97E+05	0.162	1.413	-1.033	0.978	
40	8	58.8	28.6	25.00	0.98	8.43	2.27E-03	3.74E-07	148.29	3.38E+05	0.270	2.313	-1.693	1.598	0.64
	8*			41.02					189.96	4.34E+05	0.164	1.409	-1.032	0.974	
40	9	58.3	28.6	24.53	0.98	8.37	2.28E-03	3.73E-07	146.83	3.36E+05	0.274	2.339	-1.713	1.615	0.65
	9*			40.42					188.47	4.31E+05	0.166	1.419	-1.040	0.980	
40	10	59.2	28.6	21.10	0.82	7.00	2.27E-03	3.74E-07	136.29	3.11E+05	0.265	2.274	-1.665	1.572	0.63
	10*			34.40					174.03	3.97E+05	0.162	1.395	-1.021	0.964	
40	11	58.8	28.6	17.25	0.67	5.60	2.27E-03	3.74E-07	123.20	2.81E+05	0.267	2.224	-1.634	1.532	0.61
	11*			27.86					156.54	3.57E+05	0.165	1.377	-1.012	0.949	
40	12	57.9	28.6	14.29	0.54	4.44	2.28E-03	3.73E-07	112.03	2.56E+05	0.259	2.129	-1.567	1.464	0.59
	12*			22.68					141.14	3.23E+05	0.163	1.341	-0.987	0.923	
40	13	57.2	28.6	11.17	0.42	3.43	2.28E-03	3.73E-07	98.99	2.27E+05	0.258	2.104	-1.550	1.445	0.58
	13*			17.65					124.42	2.85E+05	0.164	1.332	-0.981	0.915	
40	14	56.7	28.6	8.89	0.34	2.79	2.28E-03	3.72E-07	88.24	2.03E+05	0.266	2.151	-1.586	1.477	0.59
	14*			14.15					111.35	2.56E+05	0.167	1.351	-0.996	0.928	
40	15	55.9	28.6	6.70	0.25	1.93	2.29E-03	3.72E-07	76.58	1.77E+05	0.254	1.969	-1.461	1.345	0.54
	15*			10.32					95.01	2.19E+05	0.165	1.279	-0.949	0.874	
40	16	55.2	28.6	5.19	0.19	1.41	2.29E-03	3.72E-07	67.35	1.56E+05	0.253	1.869	-1.395	1.269	0.51
	16*			7.83					82.73	1.91E+05	0.168	1.238	-0.925	0.841	

Angle of Attack	Case	T(°F)	Palm (in. Hg)	dP (psf)	Normal Force (lbf)	Axial Force (lbf)	Density (slug/ft^3)	Viscosity (lbf-sec/ft^3)	V (fps)	Re	cn	ca	cl	cd	Correction Factor
-40	1 1*	56.1	28.6	5.05	-0.09	1.58	2.29E-03	3.72E-07	66.45	1.53E+05	-0.124	2.140	1.281	1.719	0.69
				8.53					86.38	1.99E+05	-0.073	1.267	0.758	1.018	
-40	2 2*	55.6	28.6	6.39	-0.15	2.20	2.29E-03	3.72E-07	74.76	1.72E+05	-0.164	2.359	1.390	1.913	0.77
				11.30					99.37	2.29E+05	-0.093	1.335	0.787	1.082	
-40	3 3*	55.8	28.6	8.63	-0.23	2.95	2.29E-03	3.72E-07	86.86	2.00E+05	-0.186	2.344	1.364	1.915	0.77
				15.25					115.50	2.66E+05	-0.105	1.326	0.772	1.083	
-40	4 4*	55.9	28.6	10.97	-0.30	4.00	2.29E-03	3.72E-07	97.94	2.26E+05	-0.189	2.500	1.462	2.036	0.82
				19.92					132.01	3.04E+05	-0.104	1.376	0.805	1.121	
-40	5 5*	56.5	28.6	13.67	-0.39	5.03	2.28E-03	3.72E-07	109.41	2.52E+05	-0.195	2.525	1.473	2.060	0.83
				24.96					147.85	3.40E+05	-0.107	1.383	0.807	1.128	
-40	6 6*	56.8	28.6	17.41	-0.51	6.35	2.28E-03	3.72E-07	123.52	2.84E+05	-0.201	2.500	1.454	2.044	0.82
				31.68					166.63	3.83E+05	-0.110	1.374	0.799	1.123	
-40	7 7*	57.6	28.6	20.53	-0.62	7.74	2.28E-03	3.73E-07	134.23	3.08E+05	-0.207	2.585	1.503	2.113	0.85
				37.93					182.45	4.18E+05	-0.112	1.399	0.813	1.144	
-40	8 8*	58.5	28.6	24.11	-0.76	9.31	2.27E-03	3.73E-07	145.61	3.33E+05	-0.216	2.647	1.536	2.166	0.87
				45.07					199.05	4.55E+05	-0.115	1.416	0.822	1.159	
-40	9 9*	57.6	28.6	23.91	-0.76	9.11	2.28E-03	3.73E-07	144.85	3.32E+05	-0.218	2.613	1.512	2.142	0.86
				44.44					197.50	4.53E+05	-0.117	1.406	0.814	1.152	
-40	10 10*	58.8	28.6	20.74	-0.65	7.76	2.27E-03	3.74E-07	135.06	3.08E+05	-0.215	2.566	1.485	2.104	0.84
				38.24					183.40	4.19E+05	-0.117	1.392	0.805	1.141	
-40	11 11*	58.6	28.6	17.62	-0.50	6.25	2.27E-03	3.73E-07	124.47	2.84E+05	-0.194	2.434	1.416	1.989	0.80
				31.67					166.88	3.81E+05	-0.108	1.354	0.788	1.106	
-40	12 12*	58.1	28.6	13.77	-0.39	5.06	2.28E-03	3.73E-07	110.00	2.52E+05	-0.192	2.521	1.473	2.055	0.82
				25.12					148.56	3.40E+05	-0.106	1.382	0.808	1.127	
-40	13 13*	57.4	28.6	11.28	-0.31	4.05	2.28E-03	3.73E-07	99.47	2.28E+05	-0.187	2.465	1.441	2.009	0.81
				20.36					133.66	3.06E+05	-0.103	1.365	0.798	1.112	
-40	14 14*	56.7	28.6	8.68	-0.22	3.00	2.28E-03	3.72E-07	87.20	2.00E+05	-0.176	2.372	1.390	1.931	0.77
				15.40					116.15	2.67E+05	-0.099	1.337	0.783	1.088	
-40	15 15*	55.9	28.6	6.50	-0.14	2.14	2.29E-03	3.72E-07	75.38	1.74E+05	-0.148	2.262	1.340	1.828	0.73
				11.26					99.24	2.29E+05	-0.086	1.305	0.773	1.055	
-40	16 16*	55.2	28.6	5.18	-0.09	1.58	2.29E-03	3.72E-07	67.28	1.55E+05	-0.125	2.089	1.247	1.681	0.67
				8.68					87.05	2.01E+05	-0.075	1.248	0.745	1.004	

Angle of Attack	Case	T(°F)	Patm (in. Hg)	dP (psf)	Normal Force (lbf)	Axial Force (lbf)	Density (slug/ft ³)	Viscosity (lbf-sec/ft ²)	V (fps)	Re	cn	ca	cl	cd	Correction Factor
45	1 1*	55.4	28.55	4.37 7.24	0.16	1.64	2.28E-03	3.72E-07	61.86 79.64	1.43E+05 1.84E+05	0.249 0.151	2.568 1.549	-1.992 -1.202	1.640 0.989	0.66
45	2 2*	55	28.55	6.24 10.30	0.23	2.32	2.29E-03	3.71E-07	73.86 94.90	1.70E+05 2.19E+05	0.256 0.155	2.551 1.545	-1.984 -1.202	1.623 0.983	0.65
45	3 3*	55.4	28.55	8.52 14.01	0.33	3.15	2.28E-03	3.72E-07	86.38 110.74	1.99E+05 2.55E+05	0.263 0.160	2.532 1.541	-1.977 -1.203	1.605 0.976	0.64
45	4 4*	55.8	28.55	11.12 18.21	0.42	4.07	2.28E-03	3.72E-07	98.71 126.31	2.27E+05 2.91E+05	0.260 0.159	2.507 1.531	-1.957 -1.195	1.589 0.971	0.64
45	5 5*	56.3	28.55	14.40 23.83	0.50	5.35	2.28E-03	3.72E-07	112.36 144.56	2.58E+05 3.32E+05	0.236 0.143	2.547 1.539	-1.968 -1.189	1.634 0.987	0.66
45	6 6*	57	28.55	18.03 29.51	0.57	6.47	2.28E-03	3.73E-07	125.84 160.99	2.88E+05 3.69E+05	0.216 0.132	2.460 1.503	-1.892 -1.156	1.587 0.970	0.64
45	7 7*	57.6	28.55	21.98 36.00	0.69	7.90	2.27E-03	3.73E-07	139.02 177.91	3.18E+05 4.07E+05	0.217 0.132	2.465 1.505	-1.896 -1.158	1.590 0.971	0.64
45	8 8*	58.5	28.55	25.10 41.15	0.80	9.06	2.27E-03	3.73E-07	148.69 190.38	3.39E+05 4.34E+05	0.219 0.134	2.474 1.509	-1.905 -1.162	1.594 0.973	0.64
45	9 9*	58.1	28.55	25.83 41.96	0.83	9.13	2.27E-03	3.73E-07	150.77 192.16	3.44E+05 4.39E+05	0.222 0.136	2.423 1.492	-1.870 -1.151	1.557 0.958	0.62
45	10 10*	59	28.55	21.52 35.06	0.69	7.66	2.27E-03	3.74E-07	137.72 175.82	3.14E+05 4.00E+05	0.221 0.136	2.442 1.498	-1.883 -1.155	1.570 0.963	0.63
45	11 11*	58.8	28.55	18.03 29.52	0.58	6.48	2.27E-03	3.74E-07	126.06 161.27	2.87E+05 3.67E+05	0.220 0.134	2.465 1.506	-1.898 -1.160	1.587 0.970	0.64
45	12 12*	58.1	28.55	14.24 23.30	0.46	5.12	2.27E-03	3.73E-07	111.95 143.18	2.56E+05 3.27E+05	0.223 0.137	2.466 1.507	-1.901 -1.162	1.586 0.969	0.64
45	13 13*	56.3	28.55	10.86 17.94	0.36	4.00	2.28E-03	3.72E-07	97.60 125.44	2.24E+05 2.88E+05	0.224 0.136	2.523 1.527	-1.942 -1.176	1.625 0.984	0.65
45	14 14*	55.9	28.55	8.32 13.78	0.26	3.07	2.28E-03	3.72E-07	85.36 109.87	1.96E+05 2.53E+05	0.214 0.129	2.530 1.527	-1.941 -1.171	1.637 0.988	0.66
45	15 15*	55.8	28.55	6.13 10.20	0.20	2.29	2.28E-03	3.72E-07	73.30 94.54	1.69E+05 2.18E+05	0.220 0.132	2.560 1.539	-1.966 -1.182	1.655 0.995	0.66
45	16 16*	55.2	28.55	4.32 7.16	0.13	1.59	2.29E-03	3.72E-07	61.51 79.15	1.42E+05 1.83E+05	0.203 0.123	2.515 1.519	-1.922 -1.161	1.634 0.987	0.66

Angle of Attack	Case	T(°F)	Patm (in. Hg)	dP (psf)	Normal Force (lbf)	Axial Force (lbf)	Density (slug/ft ³)	Viscosity (lbf-sec/ft ²)	V (fps)	Re	cn	ca	cl	cd	Correction Factor
-45	1 1*	56.7	29.7	3.84	-0.11	1.46	2.37E-03	3.72E-07	56.92	1.36E+05	-0.200	2.608	1.702	1.986	0.80
				6.90					76.29	1.82E+05	-0.111	1.452	0.948	1.105	
-45	2 2*	55.8	29.7	5.11	-0.15	1.91	2.37E-03	3.72E-07	65.59	1.57E+05	-0.197	2.569	1.677	1.956	0.78
				9.12					87.62	2.10E+05	-0.110	1.440	0.940	1.096	
-45	3 3*	55.8	29.7	7.22	-0.23	2.73	2.37E-03	3.72E-07	78.00	1.87E+05	-0.216	2.594	1.682	1.987	0.80
				12.98					104.55	2.50E+05	-0.120	1.444	0.936	1.106	
-45	4 4*	55.9	29.7	9.51	-0.29	3.63	2.37E-03	3.72E-07	89.51	2.14E+05	-0.211	2.614	1.699	1.998	0.80
				17.13					120.12	2.88E+05	-0.117	1.451	0.943	1.109	
-45	5 5*	56.5	29.7	11.85	-0.36	4.51	2.37E-03	3.72E-07	99.97	2.39E+05	-0.206	2.609	1.699	1.991	0.80
				21.31					134.06	3.20E+05	-0.115	1.451	0.945	1.107	
-45	6 6*	56.5	29.7	14.71	-0.46	5.68	2.37E-03	3.72E-07	111.37	2.66E+05	-0.216	2.648	1.720	2.025	0.81
				26.65					149.93	3.58E+05	-0.119	1.461	0.949	1.118	
-45	7 7*	57.2	29.7	18.19	-0.59	6.88	2.37E-03	3.73E-07	123.94	2.95E+05	-0.222	2.594	1.677	1.992	0.80
				32.72					166.22	3.96E+05	-0.124	1.442	0.932	1.107	
-45	8 8*	58.1	29.7	22.30	-0.75	8.65	2.36E-03	3.73E-07	137.34	3.26E+05	-0.231	2.660	1.717	2.044	0.82
				40.57					185.27	4.40E+05	-0.127	1.462	0.944	1.123	
-45	9 9*	58.1	29.7	22.87	-0.70	8.39	2.36E-03	3.73E-07	139.09	3.30E+05	-0.211	2.517	1.631	1.929	0.77
				40.56					185.22	4.40E+05	-0.119	1.419	0.919	1.088	
-45	10 10*	57.7	29.7	18.71	-0.61	7.01	2.37E-03	3.73E-07	125.76	2.99E+05	-0.223	2.571	1.660	1.975	0.79
				33.53					168.35	4.00E+05	-0.124	1.434	0.926	1.102	
-45	11 11*	57.4	29.7	15.33	-0.45	5.74	2.37E-03	3.73E-07	113.81	2.71E+05	-0.202	2.565	1.671	1.957	0.78
				27.36					152.04	3.62E+05	-0.113	1.437	0.936	1.096	
-45	12 12*	56.7	29.7	12.58	-0.39	4.94	2.37E-03	3.72E-07	103.01	2.46E+05	-0.214	2.691	1.751	2.054	0.82
				22.94					139.11	3.32E+05	-0.117	1.475	0.960	1.126	
-45	13 13*	55.9	29.7	9.46	-0.29	3.70	2.37E-03	3.72E-07	89.26	2.14E+05	-0.208	2.680	1.748	2.042	0.82
				17.20					120.38	2.88E+05	-0.114	1.473	0.961	1.123	
-45	14 14*	55.2	29.7	7.22	-0.19	2.63	2.38E-03	3.72E-07	77.95	1.87E+05	-0.183	2.496	1.635	1.894	0.76
				12.71					103.41	2.48E+05	-0.104	1.418	0.929	1.076	
-45	15 15*	54.3	29.7	5.30	-0.14	2.09	2.38E-03	3.71E-07	66.72	1.61E+05	-0.175	2.704	1.789	2.036	0.82
				9.63					89.92	2.16E+05	-0.096	1.489	0.985	1.121	
-45	16 16*	53.8	29.7	3.88	-0.10	1.54	2.38E-03	3.71E-07	57.07	1.38E+05	-0.169	2.714	1.800	2.039	0.82
				7.06					76.94	1.86E+05	-0.093	1.493	0.990	1.122	

Angle of Attack	Case	T(°F)	Patm (in. Hg)	dP (psf)	Normal Force (lbf)	Axial Force (lbf)	Density (slug/ft^3)	Viscosity (lbf-sec/ft^3)	V (fps)	Re	cn	ca	cl	cd	Correction Factor
50	1 1*	54	29.7	4.74	0.10	1.55	2.38E-03	3.71E-07	63.11	1.52E+05	0.146	2.246	-1.814	1.332	0.53
				7.28					78.16	1.88E+05	0.095	1.464	-1.183	0.868	
50	2 2*	53.4	29.7	6.50	0.15	2.21	2.39E-03	3.71E-07	73.80	1.78E+05	0.154	2.332	-1.885	1.381	0.55
				10.10					91.99	2.22E+05	0.099	1.501	-1.213	0.889	
50	3 3*	53.8	29.7	8.78	0.19	2.87	2.38E-03	3.71E-07	85.84	2.07E+05	0.151	2.241	-1.814	1.325	0.53
				13.45					106.23	2.56E+05	0.098	1.463	-1.184	0.865	
50	4 4*	54.1	29.7	11.85	0.24	3.99	2.38E-03	3.71E-07	99.73	2.40E+05	0.136	2.310	-1.858	1.381	0.55
				18.41					124.31	2.99E+05	0.088	1.487	-1.196	0.889	
50	5 5*	54.7	29.7	15.54	0.33	5.16	2.38E-03	3.71E-07	114.28	2.75E+05	0.146	2.276	-1.837	1.351	0.54
				23.96					141.90	3.41E+05	0.095	1.476	-1.191	0.876	
50	6 6*	55.2	29.7	19.33	0.42	6.53	2.38E-03	3.72E-07	127.53	3.06E+05	0.148	2.316	-1.870	1.375	0.55
				30.00					158.85	3.81E+05	0.095	1.493	-1.205	0.886	
50	7 7*	55.8	29.7	23.96	0.50	7.97	2.37E-03	3.72E-07	142.05	3.40E+05	0.143	2.281	-1.839	1.357	0.54
				37.00					176.52	4.23E+05	0.093	1.477	-1.191	0.879	
50	8 8*	56.8	29.7	27.91	0.58	9.25	2.37E-03	3.72E-07	153.46	3.66E+05	0.143	2.274	-1.834	1.352	0.54
				43.04					190.57	4.55E+05	0.093	1.474	-1.189	0.877	
50	9 9*	56.3	29.7	27.96	0.55	9.61	2.37E-03	3.72E-07	153.53	3.67E+05	0.134	2.356	-1.891	1.412	0.57
				43.79					192.14	4.59E+05	0.086	1.504	-1.207	0.901	
50	10 10*	57.6	29.7	23.59	0.47	8.03	2.37E-03	3.73E-07	141.21	3.36E+05	0.136	2.335	-1.876	1.396	0.56
				36.81					176.38	4.20E+05	0.087	1.497	-1.203	0.895	
50	11 11*	57	29.7	19.33	0.39	6.49	2.37E-03	3.73E-07	127.75	3.05E+05	0.140	2.300	-1.852	1.371	0.55
				29.97					159.05	3.79E+05	0.090	1.484	-1.195	0.885	
50	12 12*	56.3	29.7	15.64	0.34	5.29	2.37E-03	3.72E-07	114.84	2.74E+05	0.149	2.320	-1.873	1.378	0.55
				24.29					143.08	3.42E+05	0.096	1.495	-1.207	0.887	
50	13 13*	55.6	29.7	12.01	0.27	4.01	2.38E-03	3.72E-07	100.53	2.41E+05	0.155	2.289	-1.853	1.352	0.54
				18.52					124.86	2.99E+05	0.100	1.484	-1.201	0.877	
50	14 14*	55	29.7	9.20	0.23	3.07	2.38E-03	3.71E-07	87.95	2.11E+05	0.173	2.286	-1.862	1.337	0.54
				14.13					109.01	2.62E+05	0.112	1.488	-1.212	0.870	
50	15 15*	54.5	29.7	6.60	0.18	2.19	2.38E-03	3.71E-07	74.46	1.79E+05	0.183	2.277	-1.862	1.324	0.53
				10.10					92.13	2.22E+05	0.119	1.488	-1.216	0.865	
50	16 16*	53.8	29.7	4.90	0.14	1.60	2.38E-03	3.71E-07	64.12	1.55E+05	0.194	2.234	-1.836	1.287	0.52
				7.43					78.96	1.90E+05	0.128	1.473	-1.211	0.849	

Angle of Attack	Case	T(°F)	Patm (in. Hg)	dP (psf)	Normal Force (lbf)	Axial Force (lbf)	Density (slug/ft^3)	Viscosity (lbf-sec/ft^3)	V (fps)	Re	cn	ca	cl	cd	Correction Factor
-50	1 1*	54.1	29.7	4.43 7.74	-0.16	1.68	2.38E-03	3.71E-07	61.00 80.62	1.47E+05 1.94E+05	-0.245 -0.140	2.603 1.491	1.837 1.052	1.861 1.066	0.75
-50	2 2*	54	29.7	6.24 10.72	-0.21	2.29	2.38E-03	3.71E-07	72.35 94.86	1.74E+05 2.29E+05	-0.230 -0.134	2.515 1.463	1.779 1.035	1.793 1.043	0.72
-50	3 3*	54	29.7	8.11 13.76	-0.27	2.87	2.38E-03	3.71E-07	82.49 107.45	1.99E+05 2.59E+05	-0.231 -0.136	2.427 1.430	1.711 1.008	1.737 1.024	0.70
-50	4 4*	54.3	29.7	11.02 19.21	-0.37	4.19	2.38E-03	3.71E-07	96.19 127.02	2.32E+05 3.06E+05	-0.231 -0.132	2.610 1.497	1.851 1.062	1.855 1.064	0.74
-50	5 5*	54.9	29.7	14.03 24.06	-0.46	5.13	2.38E-03	3.71E-07	108.62 142.22	2.61E+05 3.42E+05	-0.224 -0.131	2.505 1.461	1.775 1.035	1.782 1.039	0.71
-50	6 6*	55.2	29.7	17.83 30.63	-0.58	6.54	2.38E-03	3.72E-07	122.46 160.51	2.94E+05 3.85E+05	-0.225 -0.131	2.518 1.465	1.784 1.038	1.791 1.042	0.72
-50	7 7*	55.9	29.7	21.67 37.06	-0.70	7.87	2.37E-03	3.72E-07	135.11 176.68	3.23E+05 4.23E+05	-0.221 -0.129	2.490 1.456	1.765 1.032	1.770 1.035	0.71
-50	8 8*	57	29.7	26.09 44.60	-0.86	9.45	2.37E-03	3.73E-07	148.40 194.04	3.54E+05 4.63E+05	-0.226 -0.132	2.483 1.453	1.757 1.028	1.769 1.035	0.71
-50	9 9*	57	29.7	26.09 44.79	-0.90	9.51	2.37E-03	3.73E-07	148.40 194.45	3.54E+05 4.64E+05	-0.235 -0.137	2.500 1.456	1.764 1.027	1.787 1.041	0.72
-50	10 10*	57.6	29.7	22.09 37.94	-0.72	8.10	2.37E-03	3.73E-07	136.63 179.06	3.25E+05 4.26E+05	-0.225 -0.131	2.516 1.465	1.783 1.038	1.789 1.042	0.72
-50	11 11*	57.2	29.7	17.67 30.31	-0.57	6.47	2.37E-03	3.73E-07	122.16 159.99	2.91E+05 3.81E+05	-0.222 -0.129	2.510 1.463	1.780 1.038	1.784 1.040	0.72
-50	12 12*	56.5	29.7	14.29 24.64	-0.48	5.28	2.37E-03	3.72E-07	109.79 144.14	2.62E+05 3.44E+05	-0.228 -0.132	2.536 1.471	1.796 1.042	1.805 1.047	0.72
-50	13 13*	55.8	29.7	11.02 18.92	-0.35	4.05	2.37E-03	3.72E-07	96.33 126.23	2.31E+05 3.02E+05	-0.220 -0.128	2.520 1.467	1.789 1.042	1.788 1.041	0.72
-50	14 14*	55	29.7	8.21 13.98	-0.26	2.96	2.38E-03	3.71E-07	83.10 108.44	2.00E+05 2.60E+05	-0.215 -0.126	2.471 1.451	1.755 1.030	1.753 1.029	0.70
-50	15 15*	54.3	29.7	6.29 10.82	-0.20	2.32	2.38E-03	3.71E-07	72.67 95.32	1.75E+05 2.29E+05	-0.224 -0.130	2.529 1.470	1.793 1.042	1.797 1.044	0.72
-50	16 16*	53.8	29.7	4.53 7.77	-0.13	1.68	2.38E-03	3.71E-07	61.62 80.74	1.49E+05 1.95E+05	-0.203 -0.119	2.538 1.478	1.813 1.056	1.787 1.041	0.72

APPENDIX B. STANDARD DEVIATIONS OF LIFT AND DRAG COEFFICIENTS

Angle of Attack	case	Re	V (fps)	Cl	Cd	Cl standard deviation	Cd standard deviation
50	1	1.88E+05	78.16	-1.183	0.868	1.06E-01	7.88E-03
50	2	2.22E+05	91.99	-1.213	0.889	8.00E-02	7.26E-03
50	3	2.56E+05	106.23	-1.184	0.865	6.19E-02	2.41E-03
50	4	2.99E+05	124.31	-1.196	0.889	6.45E-02	4.30E-03
50	5	3.41E+05	141.90	-1.191	0.876	5.82E-02	2.57E-03
50	6	3.81E+05	158.85	-1.205	0.886	3.88E-02	9.17E-04
50	7	4.23E+05	176.52	-1.191	0.879	3.57E-02	1.16E-03
50	8	4.55E+05	190.57	-1.189	0.877	3.88E-02	9.81E-04
50	9	4.59E+05	192.14	-1.207	0.901	3.94E-02	5.65E-04
50	10	4.20E+05	176.38	-1.203	0.895	4.19E-02	4.36E-03
50	11	3.79E+05	159.05	-1.195	0.885	3.99E-02	8.04E-03
50	12	3.42E+05	143.08	-1.207	0.887	4.10E-02	8.16E-03
50	13	2.99E+05	124.86	-1.201	0.877	4.26E-02	4.40E-03
50	14	2.62E+05	109.01	-1.212	0.870	5.76E-02	7.35E-04
50	15	2.22E+05	92.13	-1.216	0.865	8.49E-02	6.64E-03
50	16	1.90E+05	78.96	-1.211	0.849	9.59E-02	6.29E-03
	average			-1.200	0.879	5.79E-02	4.17E-03
Angle of Attack	case	Re	V (fps)	Cl	Cd	Cl standard deviation	Cd standard deviation
-50	1	1.94E+05	80.62	1.052	1.066	8.73E-02	1.67E-03
-50	2	2.29E+05	94.86	1.035	1.043	8.26E-02	6.95E-03
-50	3	2.59E+05	107.45	1.008	1.024	6.61E-02	5.51E-04
-50	4	3.06E+05	127.02	1.062	1.064	5.34E-02	5.41E-03
-50	5	3.42E+05	142.22	1.035	1.039	5.15E-02	1.89E-03
-50	6	3.85E+05	160.51	1.038	1.042	4.50E-02	1.63E-03
-50	7	4.23E+05	176.68	1.032	1.035	4.85E-02	5.09E-03
-50	8	4.63E+05	194.04	1.028	1.035	4.85E-02	3.43E-03
-50	9	4.64E+05	194.45	1.027	1.041	5.46E-02	1.20E-02
-50	10	4.26E+05	179.06	1.038	1.042	4.41E-02	3.38E-03
-50	11	3.81E+05	159.99	1.038	1.040	4.28E-02	1.73E-04
-50	12	3.44E+05	144.14	1.042	1.047	6.16E-02	9.72E-03
-50	13	3.02E+05	126.23	1.042	1.041	4.46E-02	2.81E-03
-50	14	2.60E+05	108.44	1.030	1.029	5.49E-02	2.67E-03
-50	15	2.29E+05	95.32	1.042	1.044	9.49E-02	1.54E-02
-50	16	1.95E+05	80.74	1.056	1.041	8.37E-02	6.79E-03
	average			1.038	1.042	6.02E-02	4.97E-03

Angle of Attack	case	Re	V (fps)	Cl	Cd	Cl standard deviation	Cd standard deviation
45	1	1.84E+05	79.64	-1.202	0.989	9.79E-02	1.45E-02
45	2	2.19E+05	94.90	-1.202	0.983	9.21E-02	1.71E-02
45	3	2.55E+05	110.74	-1.203	0.976	6.71E-02	4.82E-03
45	4	2.91E+05	126.31	-1.195	0.971	7.32E-02	1.99E-02
45	5	3.32E+05	144.56	-1.189	0.987	6.50E-02	6.62E-03
45	6	3.69E+05	160.99	-1.156	0.970	5.77E-02	7.66E-03
45	7	4.07E+05	177.91	-1.158	0.971	4.21E-02	3.39E-03
45	8	4.34E+05	190.38	-1.162	0.973	6.44E-02	6.23E-03
45	9	4.39E+05	192.16	-1.151	0.958	6.75E-02	5.18E-03
45	10	4.00E+05	175.82	-1.155	0.963	5.13E-02	8.22E-03
45	11	3.67E+05	161.27	-1.160	0.970	7.47E-02	1.09E-02
45	12	3.27E+05	143.18	-1.162	0.969	6.69E-02	8.29E-05
45	13	2.88E+05	125.44	-1.176	0.984	8.34E-02	1.54E-02
45	14	2.53E+05	109.87	-1.171	0.988	8.02E-02	1.26E-02
45	15	2.18E+05	94.54	-1.182	0.995	8.81E-02	4.49E-03
45	16	1.83E+05	79.15	-1.161	0.987	1.06E-01	2.80E-02
	average			-1.174	0.977	7.36E-02	1.03E-02
Angle of Attack	case	Re	V (fps)	Cl	Cd	Cl standard deviation	Cd standard deviation
-45	1	1.82E+05	76.29	0.948	1.105	1.28E-01	7.74E-03
-45	2	2.10E+05	87.62	0.940	1.096	1.03E-01	6.03E-03
-45	3	2.50E+05	104.55	0.936	1.106	1.21E-01	2.13E-02
-45	4	2.88E+05	120.12	0.943	1.109	7.60E-02	1.60E-02
-45	5	3.20E+05	134.06	0.945	1.107	1.19E-01	2.84E-02
-45	6	3.58E+05	149.93	0.949	1.118	9.25E-02	3.93E-02
-45	7	3.96E+05	166.22	0.932	1.107	8.40E-02	1.85E-02
-45	8	4.40E+05	185.27	0.944	1.123	7.17E-02	1.85E-02
-45	9	4.40E+05	185.22	0.919	1.088	5.70E-02	1.19E-02
-45	10	4.00E+05	168.35	0.926	1.102	6.96E-02	1.10E-02
-45	11	3.62E+05	152.04	0.936	1.096	9.51E-02	2.71E-02
-45	12	3.32E+05	139.11	0.960	1.126	1.16E-01	2.10E-02
-45	13	2.88E+05	120.38	0.961	1.123	1.58E-01	5.71E-02
-45	14	2.48E+05	103.41	0.929	1.076	1.11E-01	3.21E-02
-45	15	2.16E+05	89.92	0.985	1.121	1.35E-01	1.93E-02
-45	16	1.86E+05	76.94	0.990	1.122	1.45E-01	1.26E-02
	average			0.947	1.108	1.05E-01	2.17E-02

Angle of Attack	case	Re	V (fps)	Cl	Cd	Cl standard deviation	Cd standard deviation
40	1	1.92E+05	83.38	-0.950	0.882	9.89E-02	1.40E-02
40	2	2.23E+05	96.51	-0.992	0.937	7.67E-02	1.99E-02
40	3	2.47E+05	107.20	-0.978	0.925	7.25E-02	2.13E-02
40	4	2.90E+05	125.85	-1.026	0.976	6.57E-02	2.10E-02
40	5	3.25E+05	141.40	-1.007	0.955	4.25E-02	1.05E-02
40	6	3.59E+05	156.26	-1.031	0.972	5.01E-02	1.74E-02
40	7	3.97E+05	173.53	-1.033	0.978	5.17E-02	1.15E-02
40	8	4.34E+05	189.96	-1.032	0.974	4.49E-02	8.93E-03
40	9	4.31E+05	188.47	-1.040	0.980	6.47E-02	1.20E-02
40	10	3.97E+05	174.03	-1.021	0.964	5.11E-02	6.41E-03
40	11	3.57E+05	156.54	-1.012	0.949	4.73E-02	7.45E-03
40	12	3.23E+05	141.14	-0.987	0.923	6.94E-02	2.48E-02
40	13	2.85E+05	124.42	-0.981	0.915	6.88E-02	6.94E-03
40	14	2.56E+05	111.35	-0.996	0.928	1.33E-01	4.94E-02
40	15	2.19E+05	95.01	-0.949	0.874	6.87E-02	6.81E-03
40	16	1.91E+05	82.73	-0.925	0.841	9.82E-02	2.60E-02
	average			-0.998	0.936	6.90E-02	1.65E-02
Angle of Attack	case	Re	V (fps)	Cl	Cd	Cl standard deviation	Cd standard deviation
-40	1	1.99E+05	86.38	0.758	1.018	9.44E-02	2.90E-02
-40	2	2.29E+05	99.37	0.787	1.082	1.43E-01	5.21E-02
-40	3	2.66E+05	115.50	0.772	1.083	1.13E-01	3.38E-02
-40	4	3.04E+05	132.01	0.805	1.121	8.66E-02	2.79E-02
-40	5	3.40E+05	147.85	0.807	1.128	9.92E-02	2.79E-02
-40	6	3.83E+05	166.63	0.799	1.123	7.39E-02	1.69E-02
-40	7	4.18E+05	182.45	0.813	1.144	9.55E-02	3.13E-02
-40	8	4.55E+05	199.05	0.822	1.159	6.47E-02	2.00E-02
-40	9	4.53E+05	197.50	0.814	1.152	6.53E-02	1.70E-02
-40	10	4.19E+05	183.40	0.805	1.141	9.96E-02	3.81E-02
-40	11	3.81E+05	166.88	0.788	1.106	6.66E-02	1.44E-02
-40	12	3.40E+05	148.56	0.808	1.127	7.00E-02	2.70E-02
-40	13	3.06E+05	133.66	0.798	1.112	1.08E-01	5.18E-02
-40	14	2.67E+05	116.15	0.783	1.088	1.28E-01	1.78E-02
-40	15	2.29E+05	99.24	0.773	1.055	1.24E-01	2.27E-02
-40	16	2.01E+05	87.05	0.745	1.004	9.14E-02	2.42E-02
	average			0.792	1.103	9.52E-02	2.82E-02

Angle of Attack	case	Re	V (fps)	Cl	Cd	Cl standard deviation	Cd standard deviation
35	1	1.73E+05	76.32	-0.903	0.995	1.04E-01	1.50E-02
35	2	2.06E+05	90.34	-0.925	1.027	1.01E-01	2.02E-02
35	3	2.38E+05	104.25	-0.923	1.025	7.36E-02	2.15E-02
35	4	2.71E+05	119.14	-0.959	1.055	6.20E-02	2.70E-02
35	5	3.14E+05	138.23	-0.926	1.024	6.19E-02	2.31E-02
35	6	3.54E+05	155.90	-0.940	1.041	4.83E-02	1.36E-02
35	7	3.84E+05	169.66	-0.930	1.034	3.83E-02	7.88E-03
35	8	4.22E+05	187.09	-0.943	1.036	8.20E-02	1.94E-02
35	9	4.26E+05	187.77	-0.947	1.041	7.19E-02	2.72E-02
35	10	3.93E+05	174.03	-0.955	1.049	5.68E-02	1.49E-02
35	11	3.52E+05	155.59	-0.951	1.042	5.36E-02	2.36E-02
35	12	3.17E+05	139.63	-0.943	1.029	5.88E-02	1.24E-02
35	13	2.77E+05	121.76	-0.965	1.054	5.71E-02	2.80E-02
35	14	2.40E+05	105.33	-0.945	1.026	7.50E-02	2.33E-02
35	15	2.07E+05	90.52	-0.938	1.023	7.91E-02	1.75E-02
35	16	1.78E+05	77.62	-0.954	1.034	1.03E-01	2.35E-02
	average			-0.940	1.033	7.04E-02	1.99E-02
Angle of Attack	case	Re	V (fps)	Cl	Cd	Cl standard deviation	Cd standard deviation
-35	1	1.86E+05	80.81	0.742	1.179	1.40E-01	7.34E-02
-35	2	2.17E+05	94.13	0.737	1.203	9.95E-02	3.56E-02
-35	3	2.55E+05	110.77	0.718	1.173	1.18E-01	3.12E-02
-35	4	2.97E+05	129.06	0.749	1.214	7.59E-02	2.91E-02
-35	5	3.36E+05	146.01	0.721	1.190	8.81E-02	4.98E-02
-35	6	3.71E+05	161.67	0.713	1.177	7.52E-02	4.01E-02
-35	7	4.10E+05	179.21	0.719	1.191	1.02E-01	7.38E-02
-35	8	4.53E+05	198.57	0.724	1.197	8.33E-02	4.91E-02
-35	9	4.49E+05	195.86	0.713	1.176	7.26E-02	3.52E-02
-35	10	4.17E+05	182.81	0.724	1.198	1.12E-01	6.97E-02
-35	11	3.75E+05	163.94	0.724	1.202	1.16E-01	6.23E-02
-35	12	3.39E+05	148.19	0.741	1.215	9.80E-02	3.25E-02
-35	13	2.97E+05	129.34	0.724	1.184	8.08E-02	3.57E-02
-35	14	2.57E+05	111.66	0.717	1.194	1.09E-01	3.40E-02
-35	15	2.24E+05	97.06	0.740	1.208	9.19E-02	3.27E-02
-35	16	1.92E+05	82.83	0.717	1.180	1.28E-01	5.31E-02
	average			0.726	1.192	9.94E-02	4.61E-02

Angle of Attack	case	Re	V (fps)	Cl	Cd	Cl standard deviation	Cd standard deviation
30	1	1.93E+05	81.23	-0.830	1.025	1.18E-01	5.34E-02
30	2	2.27E+05	95.51	-0.825	1.023	6.88E-02	3.72E-02
30	3	2.64E+05	111.25	-0.855	1.070	1.29E-01	4.71E-02
30	4	3.08E+05	129.79	-0.844	1.055	1.02E-01	3.87E-02
30	5	3.46E+05	145.95	-0.824	1.023	8.01E-02	3.40E-02
30	6	3.86E+05	163.27	-0.851	1.060	8.18E-02	4.51E-02
30	7	4.26E+05	180.89	-0.857	1.063	9.28E-02	5.37E-02
30	8	4.64E+05	197.65	-0.853	1.069	6.64E-02	3.33E-02
30	9	4.66E+05	198.07	-0.853	1.066	5.46E-02	2.30E-02
30	10	4.26E+05	181.60	-0.864	1.071	1.08E-01	7.46E-02
30	11	3.85E+05	164.08	-0.870	1.076	8.35E-02	4.82E-02
30	12	3.41E+05	145.00	-0.865	1.061	9.40E-02	4.88E-02
30	13	3.04E+05	128.83	-0.854	1.048	1.07E-01	4.32E-02
30	14	2.64E+05	111.52	-0.860	1.046	6.16E-02	4.02E-02
30	15	2.22E+05	93.60	-0.852	0.996	8.92E-02	3.89E-02
30	16	1.92E+05	80.82	-0.847	0.998	9.99E-02	4.68E-02
	average			-0.850	1.047	8.98E-02	4.41E-02
Angle of Attack	case	Re	V (fps)	Cl	Cd	Cl standard deviation	Cd standard deviation
-30	1	2.01E+05	84.08	0.603	1.188	9.89E-02	6.71E-02
-30	2	2.29E+05	95.94	0.620	1.216	1.23E-01	6.90E-02
-30	3	2.69E+05	112.86	0.602	1.208	1.86E-01	7.93E-02
-30	4	3.12E+05	131.28	0.596	1.191	7.74E-02	3.92E-02
-30	5	3.53E+05	148.57	0.599	1.211	9.68E-02	5.41E-02
-30	6	3.90E+05	164.79	0.612	1.227	8.43E-02	4.65E-02
-30	7	4.31E+05	184.38	0.606	1.222	1.46E-01	1.30E-01
-30	8	4.77E+05	202.78	0.618	1.239	1.21E-01	9.78E-02
-30	9	4.71E+05	199.78	0.607	1.221	1.50E-01	1.36E-01
-30	10	4.28E+05	182.27	0.605	1.216	1.31E-01	1.05E-01
-30	11	3.90E+05	166.14	0.607	1.221	1.35E-01	1.01E-01
-30	12	3.53E+05	150.06	0.615	1.226	1.22E-01	7.79E-02
-30	13	3.08E+05	130.41	0.605	1.213	1.27E-01	2.92E-02
-30	14	2.66E+05	112.27	0.610	1.206	8.66E-02	5.55E-02
-30	15	2.31E+05	97.19	0.620	1.223	1.46E-01	5.80E-02
-30	16	2.03E+05	85.41	0.607	1.214	1.50E-01	7.56E-02
	average			0.608	1.215	1.24E-01	7.64E-02

Angle of Attack	case	Re	V (fps)	Cl	Cd	Cl standard deviation	Cd standard deviation
25	1	2.01E+05	84.24	-0.767	1.201	9.31E-02	4.93E-02
25	2	2.31E+05	97.10	-0.752	1.177	8.94E-02	5.45E-02
25	3	2.70E+05	113.38	-0.754	1.177	1.19E-01	5.97E-02
25	4	3.06E+05	128.73	-0.754	1.166	1.12E-01	6.47E-02
25	5	3.47E+05	146.37	-0.750	1.152	7.96E-02	4.88E-02
25	6	3.79E+05	159.85	-0.758	1.143	8.22E-02	5.08E-02
25	7	4.26E+05	180.66	-0.772	1.174	6.73E-02	4.01E-02
25	8	4.65E+05	197.57	-0.766	1.156	1.07E-01	6.45E-02
25	9	4.61E+05	195.40	-0.750	1.131	8.28E-02	3.31E-02
25	10	4.28E+05	181.81	-0.779	1.175	1.23E-01	9.78E-02
25	11	3.97E+05	168.51	-0.771	1.177	9.54E-02	4.03E-02
25	12	3.50E+05	148.02	-0.771	1.184	7.89E-02	4.39E-02
25	13	3.14E+05	132.60	-0.767	1.190	6.78E-02	3.13E-02
25	14	2.73E+05	115.03	-0.775	1.213	1.14E-01	8.21E-02
25	15	2.29E+05	96.31	-0.754	1.190	8.22E-02	4.40E-02
25	16	1.98E+05	82.84	-0.778	1.237	1.19E-01	4.99E-02
	average			-0.764	1.178	9.45E-02	5.34E-02
Angle of Attack	case	Re	V (fps)	Cl	Cd	Cl standard deviation	Cd standard deviation
-25	1	1.97E+05	82.36	0.475	1.175	9.39E-02	5.68E-02
-25	2	2.37E+05	99.48	0.498	1.251	1.14E-01	6.78E-02
-25	3	2.74E+05	114.95	0.477	1.214	8.15E-02	4.07E-02
-25	4	3.17E+05	133.17	0.482	1.254	9.46E-02	5.57E-02
-25	5	3.56E+05	149.91	0.478	1.205	6.89E-02	4.00E-02
-25	6	4.00E+05	168.85	0.487	1.238	8.68E-02	5.77E-02
-25	7	4.43E+05	187.70	0.482	1.247	1.72E-01	1.60E-01
-25	8	4.84E+05	205.65	0.489	1.258	1.37E-01	1.44E-01
-25	9	4.75E+05	201.76	0.478	1.217	6.85E-02	5.47E-02
-25	10	4.40E+05	187.56	0.483	1.259	1.34E-01	1.13E-01
-25	11	4.00E+05	170.06	0.484	1.234	8.14E-02	5.66E-02
-25	12	3.56E+05	151.21	0.488	1.242	6.58E-02	5.46E-02
-25	13	3.16E+05	133.59	0.497	1.250	8.55E-02	6.63E-02
-25	14	2.76E+05	116.56	0.491	1.253	1.09E-01	2.52E-02
-25	15	2.30E+05	96.84	0.485	1.226	7.72E-02	4.96E-02
-25	16	2.03E+05	85.30	0.495	1.244	9.63E-02	6.42E-02
	average			0.485	1.235	9.79E-02	6.92E-02

Angle of Attack	case	Re	V (fps)	Cl	Cd	Cl standard deviation	Cd standard deviation
20	1	1.94E+05	81.58	-0.605	1.186	7.51E-02	5.22E-02
20	2	2.26E+05	95.10	-0.624	1.205	7.57E-02	6.57E-02
20	3	2.65E+05	111.36	-0.615	1.191	9.83E-02	6.98E-02
20	4	3.10E+05	130.15	-0.627	1.202	1.20E-01	6.10E-02
20	5	3.44E+05	144.87	-0.620	1.193	1.19E-01	5.98E-02
20	6	3.85E+05	162.57	-0.614	1.184	1.08E-01	6.03E-02
20	7	4.24E+05	179.51	-0.614	1.174	8.41E-02	5.95E-02
20	8	4.56E+05	193.90	-0.609	1.169	7.27E-02	5.29E-02
20	9	4.55E+05	193.44	-0.609	1.154	5.68E-02	4.67E-02
20	10	4.22E+05	179.91	-0.622	1.173	1.01E-01	8.03E-02
20	11	3.84E+05	163.43	-0.597	1.171	9.61E-02	6.56E-02
20	12	3.46E+05	146.71	-0.623	1.153	1.20E-01	5.14E-02
20	13	3.08E+05	130.39	-0.621	1.195	1.11E-01	4.02E-02
20	14	2.64E+05	111.31	-0.619	1.168	1.14E-01	6.19E-02
20	15	2.20E+05	92.53	-0.626	1.170	9.76E-02	4.53E-02
20	16	1.92E+05	80.50	-0.624	1.170	9.50E-02	6.05E-02
	average			-0.617	1.179	9.65E-02	5.83E-02
Angle of Attack	case	Re	V (fps)	Cl	Cd	Cl standard deviation	Cd standard deviation
-20	1	1.90E+05	80.78	0.385	1.260	8.80E-02	6.03E-02
-20	2	2.29E+05	96.99	0.376	1.262	9.96E-02	9.09E-02
-20	3	2.60E+05	109.95	0.379	1.271	1.49E-01	5.05E-02
-20	4	3.13E+05	132.76	0.378	1.278	8.19E-02	4.40E-02
-20	5	3.48E+05	147.79	0.360	1.264	8.27E-02	4.26E-02
-20	6	3.91E+05	166.23	0.352	1.269	9.07E-02	5.51E-02
-20	7	4.32E+05	183.98	0.347	1.253	5.58E-02	5.18E-02
-20	8	4.84E+05	206.18	0.359	1.258	8.13E-02	6.20E-02
-20	9	4.82E+05	205.37	0.354	1.265	8.88E-02	8.38E-02
-20	10	4.33E+05	184.60	0.349	1.261	7.73E-02	5.20E-02
-20	11	3.97E+05	169.07	0.353	1.273	9.57E-02	5.06E-02
-20	12	3.50E+05	148.94	0.353	1.252	7.42E-02	4.69E-02
-20	13	3.13E+05	132.56	0.348	1.280	9.68E-02	6.01E-02
-20	14	2.67E+05	112.92	0.338	1.265	8.76E-02	7.69E-02
-20	15	2.31E+05	97.13	0.352	1.268	7.73E-02	6.11E-02
-20	16	1.96E+05	82.58	0.342	1.257	8.57E-02	4.13E-02
	average			0.358	1.265	8.83E-02	5.81E-02

Angle of Attack	case	Re	V (fps)	Cl	Cd	Cl standard deviation	Cd standard deviation
15	1	1.96E+05	84.21	-0.528	1.208	9.28E-02	8.20E-02
15	2	2.35E+05	100.97	-0.521	1.188	8.46E-02	8.77E-02
15	3	2.67E+05	115.00	-0.515	1.199	1.03E-01	1.08E-01
15	4	3.14E+05	135.65	-0.495	1.185	1.14E-01	9.62E-02
15	5	3.53E+05	152.48	-0.511	1.197	9.64E-02	6.61E-02
15	6	3.94E+05	170.94	-0.527	1.218	7.06E-02	7.04E-02
15	7	4.35E+05	189.41	-0.525	1.217	7.05E-02	6.51E-02
15	8	4.69E+05	205.51	-0.521	1.189	8.67E-02	8.30E-02
15	9	4.70E+05	203.32	-0.534	1.211	7.45E-02	6.36E-02
15	10	4.24E+05	183.83	-0.517	1.191	8.05E-02	5.86E-02
15	11	3.86E+05	166.95	-0.532	1.210	6.18E-02	5.68E-02
15	12	3.50E+05	150.87	-0.489	1.190	1.11E-01	5.78E-02
15	13	3.13E+05	134.69	-0.525	1.204	9.92E-02	6.90E-02
15	14	2.68E+05	114.84	-0.528	1.208	1.04E-01	7.48E-02
15	15	2.34E+05	100.41	-0.527	1.198	8.47E-02	6.44E-02
15	16	1.97E+05	84.25	-0.534	1.193	9.31E-02	8.04E-02
	average			-0.521	1.200	8.92E-02	7.40E-02
Angle of Attack	case	Re	V (fps)	Cl	Cd	Cl standard deviation	Cd standard deviation
-15	1	2.03E+05	86.50	0.286	1.289	8.46E-02	9.17E-02
-15	2	2.35E+05	100.00	0.281	1.293	1.19E-01	8.17E-02
-15	3	2.77E+05	117.90	0.277	1.294	1.64E-01	8.00E-02
-15	4	3.21E+05	136.86	0.266	1.287	1.11E-01	7.84E-02
-15	5	3.65E+05	156.19	0.259	1.288	7.68E-02	7.41E-02
-15	6	4.03E+05	172.72	0.258	1.283	5.20E-02	5.48E-02
-15	7	4.47E+05	191.88	0.258	1.292	1.05E-01	1.07E-01
-15	8	4.83E+05	208.44	0.249	1.274	7.54E-02	1.01E-01
-15	9	4.86E+05	208.65	0.249	1.273	7.73E-02	8.98E-02
-15	10	4.44E+05	191.54	0.267	1.297	1.43E-01	1.23E-01
-15	11	4.04E+05	174.08	0.249	1.278	7.37E-02	6.31E-02
-15	12	3.59E+05	154.38	0.258	1.289	6.33E-02	6.06E-02
-15	13	3.18E+05	136.34	0.259	1.299	1.06E-01	3.50E-02
-15	14	2.76E+05	118.05	0.252	1.271	1.25E-01	6.75E-02
-15	15	2.36E+05	100.56	0.277	1.294	8.25E-02	8.48E-02
-15	16	2.04E+05	86.46	0.274	1.277	6.33E-02	5.43E-02
	average			0.264	1.286	9.52E-02	7.80E-02

Angle of Attack	case	Re	V (fps)	Cl	Cd	Cl standard deviation	Cd standard deviation
10	1	1.94E+05	83.57	-0.373	1.192	6.69E-02	6.61E-02
10	2	2.21E+05	94.97	-0.374	1.193	6.40E-02	6.32E-02
10	3	2.58E+05	111.00	-0.365	1.160	6.53E-02	5.98E-02
10	4	3.01E+05	129.87	-0.371	1.187	4.19E-02	4.61E-02
10	5	3.42E+05	147.51	-0.378	1.211	4.01E-02	3.60E-02
10	6	3.83E+05	165.70	-0.367	1.161	3.67E-02	5.48E-02
10	7	4.15E+05	180.45	-0.363	1.143	3.70E-02	4.24E-02
10	8	4.61E+05	201.51	-0.378	1.188	4.52E-02	3.50E-02
10	9	4.64E+05	201.25	-0.368	1.182	4.15E-02	3.98E-02
10	10	4.15E+05	181.50	-0.363	1.151	2.91E-02	3.65E-02
10	11	3.80E+05	166.19	-0.380	1.195	5.78E-02	4.42E-02
10	12	3.39E+05	147.72	-0.379	1.182	3.48E-02	3.46E-02
10	13	2.94E+05	128.05	-0.362	1.135	4.72E-02	5.34E-02
10	14	2.60E+05	112.74	-0.377	1.169	4.61E-02	4.76E-02
10	15	2.26E+05	97.56	-0.368	1.164	5.49E-02	4.58E-02
10	16	1.92E+05	82.50	-0.380	1.190	6.45E-02	6.27E-02
	average			-0.372	1.175	4.83E-02	4.80E-02
Angle of Attack	case	Re	V (fps)	Cl	Cd	Cl standard deviation	Cd standard deviation
-10	1	1.99E+05	85.82	0.161	1.253	5.40E-02	5.34E-02
-10	2	2.32E+05	99.97	0.155	1.241	8.99E-02	6.75E-02
-10	3	2.75E+05	118.44	0.153	1.233	3.92E-02	3.86E-02
-10	4	3.12E+05	134.45	0.148	1.242	4.65E-02	3.24E-02
-10	5	3.55E+05	153.14	0.149	1.242	3.71E-02	2.41E-02
-10	6	3.95E+05	170.98	0.148	1.250	3.27E-02	3.78E-02
-10	7	4.30E+05	187.38	0.145	1.224	5.15E-02	4.62E-02
-10	8	4.70E+05	205.31	0.143	1.228	4.47E-02	2.62E-02
-10	9	4.73E+05	205.15	0.143	1.236	5.34E-02	5.38E-02
-10	10	4.31E+05	188.55	0.150	1.249	5.20E-02	3.59E-02
-10	11	3.88E+05	169.79	0.145	1.221	4.61E-02	3.93E-02
-10	12	3.48E+05	151.87	0.147	1.238	4.47E-02	3.66E-02
-10	13	3.12E+05	135.77	0.151	1.254	3.59E-02	3.40E-02
-10	14	2.66E+05	115.53	0.151	1.256	5.35E-02	4.04E-02
-10	15	2.30E+05	99.60	0.156	1.239	5.23E-02	4.93E-02
-10	16	1.98E+05	85.16	0.154	1.229	6.56E-02	7.20E-02
	average			0.150	1.240	4.99E-02	4.30E-02

Angle of Attack	case	Re	V (fps)	Cl	Cd	Cl standard deviation	Cd standard deviation
5	1	2.04E+05	87.53	-0.239	1.289	5.19E-02	7.22E-02
5	2	2.41E+05	103.56	-0.249	1.308	5.97E-02	1.13E-01
5	3	2.77E+05	118.96	-0.229	1.279	5.50E-02	9.33E-02
5	4	3.21E+05	138.14	-0.218	1.264	4.06E-02	4.52E-02
5	5	3.64E+05	157.06	-0.235	1.268	4.77E-02	6.01E-02
5	6	4.06E+05	175.52	-0.236	1.287	8.86E-02	9.71E-02
5	7	4.50E+05	195.42	-0.244	1.282	3.72E-02	6.08E-02
5	8	4.83E+05	211.24	-0.237	1.281	4.96E-02	7.44E-02
5	9	4.84E+05	209.26	-0.218	1.257	6.59E-02	5.71E-02
5	10	4.44E+05	193.84	-0.239	1.283	4.80E-02	5.54E-02
5	11	4.03E+05	175.85	-0.246	1.302	8.23E-02	8.02E-02
5	12	3.61E+05	157.49	-0.238	1.291	7.80E-02	1.01E-01
5	13	3.18E+05	138.40	-0.226	1.267	4.51E-02	6.38E-02
5	14	2.76E+05	119.74	-0.241	1.265	8.23E-02	1.15E-01
5	15	2.41E+05	103.91	-0.244	1.270	6.72E-02	1.19E-01
5	16	2.06E+05	89.02	-0.246	1.278	8.04E-02	1.27E-01
	average			-0.237	1.279	6.12E-02	8.34E-02
Angle of Attack	case	Re	V (fps)	Cl	Cd	Cl standard deviation	Cd standard deviation
-5	1	2.10E+05	90.22	-0.001	1.280	8.18E-02	7.74E-02
-5	2	2.48E+05	106.59	-0.012	1.285	6.20E-02	4.70E-02
-5	3	2.95E+05	126.87	-0.004	1.300	6.22E-02	1.31E-01
-5	4	3.31E+05	142.63	-0.003	1.269	5.67E-02	8.22E-02
-5	5	3.83E+05	165.39	-0.007	1.295	7.70E-02	7.19E-02
-5	6	4.24E+05	183.27	0.000	1.306	5.72E-02	1.01E-01
-5	7	4.77E+05	207.04	-0.014	1.284	6.85E-02	1.19E-01
-5	8	5.17E+05	225.18	0.002	1.304	5.62E-02	1.08E-01
-5	9	5.18E+05	224.68	-0.003	1.307	7.41E-02	1.13E-01
-5	10	4.72E+05	205.90	-0.007	1.306	7.24E-02	8.71E-02
-5	11	4.30E+05	187.66	-0.002	1.310	5.30E-02	8.32E-02
-5	12	3.81E+05	165.90	-0.011	1.288	4.55E-02	6.17E-02
-5	13	3.42E+05	148.48	-0.011	1.285	1.04E-01	7.23E-02
-5	14	2.94E+05	127.03	-0.005	1.292	5.37E-02	5.08E-02
-5	15	2.55E+05	110.01	0.008	1.208	5.41E-02	7.13E-02
-5	16	2.12E+05	91.21	0.006	1.289	1.10E-01	1.01E-01
	average			-0.004	1.288	6.80E-02	8.61E-02

Angle of Attack	case	Re	V (fps)	Cl	Cd	Cl standard deviation	Cd standard deviation
0	1	2.05E+05	89.14	-0.115	1.270	5.42E-02	6.70E-02
0	2	2.50E+05	107.47	-0.126	1.295	4.91E-02	9.70E-02
0	3	2.76E+05	118.69	-0.100	1.257	8.62E-02	6.00E-02
0	4	3.21E+05	138.35	-0.124	1.290	4.57E-02	9.56E-02
0	5	3.65E+05	157.61	-0.116	1.255	3.75E-02	5.13E-02
0	6	4.09E+05	176.67	-0.105	1.259	5.10E-02	6.03E-02
0	7	4.42E+05	192.56	-0.124	1.256	4.80E-02	6.08E-02
0	8	4.82E+05	210.57	-0.116	1.269	5.11E-02	5.06E-02
0	9	4.95E+05	215.31	-0.100	1.313	3.72E-02	8.97E-02
0	10	4.41E+05	193.03	-0.117	1.265	4.01E-02	5.00E-02
0	11	4.08E+05	178.11	-0.117	1.293	4.21E-02	5.74E-02
0	12	3.65E+05	159.03	-0.119	1.274	4.36E-02	5.82E-02
0	13	3.25E+05	141.37	-0.117	1.262	5.15E-02	5.63E-02
0	14	2.81E+05	121.80	-0.109	1.247	4.89E-02	5.88E-02
0	15	2.47E+05	106.69	-0.101	1.275	4.19E-02	4.35E-02
0	16	2.06E+05	88.87	-0.100	1.275	4.77E-02	6.43E-02
	average			-0.113	1.272	4.85E-02	6.38E-02
Angle of Attack	case	Re	V (fps)	Cl	Cd	Cl standard deviation	Cd standard deviation
-0	1	2.13E+05	91.35	-0.113	1.297	5.86E-02	6.16E-02
-0	2	2.47E+05	105.83	-0.117	1.298	4.01E-02	8.08E-02
-0	3	2.91E+05	124.88	-0.115	1.299	5.66E-02	7.35E-02
-0	4	3.37E+05	145.08	-0.124	1.289	2.98E-02	5.86E-02
-0	5	3.76E+05	162.26	-0.122	1.295	3.77E-02	5.76E-02
-0	6	4.13E+05	178.36	-0.126	1.304	4.95E-02	4.56E-02
-0	7	4.61E+05	200.00	-0.132	1.299	4.95E-02	6.55E-02
-0	8	5.05E+05	219.98	-0.120	1.312	3.18E-02	4.52E-02
-0	9	5.12E+05	221.06	-0.120	1.325	5.52E-02	5.73E-02
-0	10	4.60E+05	200.72	-0.127	1.311	4.69E-02	5.67E-02
-0	11	4.16E+05	181.24	-0.131	1.301	3.32E-02	4.36E-02
-0	12	3.77E+05	164.24	-0.124	1.306	4.26E-02	6.35E-02
-0	13	3.34E+05	145.03	-0.116	1.314	4.23E-02	5.35E-02
-0	14	2.88E+05	124.47	-0.112	1.300	5.30E-02	1.09E-01
-0	15	2.41E+05	104.00	-0.121	1.283	6.44E-02	5.81E-02
-0	16	2.09E+05	90.08	-0.100	1.278	7.00E-02	6.63E-02
	average			-0.120	1.301	4.76E-02	6.23E-02

REFERENCES

- Babinsky, H., "Aerodynamic Performance of Paragliders", *Aeronautical Journal* **103**(1027), pp. 421-428, 1999.
- Campbell, C.H., Joosten, K.B., Meyerson, R.E., "Johnson Space Center Crew Return Vehicle Activities," *Proceedings of the 1996 5th International Conference on Engineering, Construction, and Operations in Space*, pp. 392-398, Albuquerque, NM, June 1996.
- Chappell, C.J., Deuling, J., Joseph, S., Meyers, S., "X-38 Parafoil Project, Negating the Downward Spiral," Unpublished report, April 1999.
- DFRC.NASA.GOV, "X-38 Fact Sheet", October 1999,
<http://www.dfrc.nasa.gov/PAO/PAIS/HTML/FS-038-DFRC.html>
- DFRC.NASA.GOV, "Program Goals and Objectives", October 1999,
<http://www.dfrc.nasa.gov/Projects/X38/phase3.html>
- Dommasch, D.O., Sherby, S.S. and Connolly, T.F., *Airplane Aerodynamics*, Pitman Publishing Corporation, New York, 1957.
- Dornheim, M.A., "X-38 Transitions From Lifting Body to Parafoil", *Aviation Week and Space Technology*, **148**(12), pp. 92-93, March 23 1998.
- Fox, R.W. and McDonald, A.T. *Introduction to Fluid Mechanics, Fourth Edition*, John Wiley & Sons, New York, 1992.
- Iosilevskii, G., "Center of Gravity and Minimal Lift Coefficient Limits of a Gliding Parachute," *Journal of Aircraft*, **32**(6), pp. 1297-1302, November-December 1995.
- JSC.NASA.GOV, "NASA X-38 Team Flies Largest Parafoil Parachute in History," February 2000, <http://www.jsc.nasa.gov/pao/media/rel/2000/J00-9.html>

JSC.NASA.GOV, "The X-38 second prototype flares to a landing over the lakebed at the end of its fifth flight at Edwards Air Force Base," February 2000, <http://www.dfrc.nasa.gov/gallery/photo/X-38/HTML/EC00-0096-77.html>

Melbourne, W.H., "Wind Tunnel Blockage Effects and Corrections", *Wind Tunnel Modeling for Civil Engineering Applications, Proceedings of the International Workshop on Wind Tunnel Modeling Criteria and Techniques in Civil Engineering Applications, April 1982*, Cambridge University Press, Cambridge, Reinhold, editor, pp. 197-216, 1982.

Rae, W.H. and Pope, A, *Low-Speed Wind Tunnel Testing*, John Wiley & Sons, New York, 1984.

Sim, A.G., Murray, J.E., Neufeld, D.C., and Reed, R.D., "Development and Flight Test of a Deployable Precision Landing System," *Journal of Aircraft*, **31**(5) pp.1101-1108 September-October 1994.