

# IPAC - Inlet Performance Analysis Code

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## Abstract

A series of analyses have been developed which permit the calculation of the performance of common inlet designs. The methods presented are useful for determining the inlet weight flows, total pressure recovery, and aerodynamic drag coefficients for given inlet geometric designs. Limited geometric input data is required to use this inlet performance prediction methodology. The analyses presented here may also be used to perform inlet preliminary design studies. The calculated inlet performance parameters may be used in subsequent engine cycle analyses or installed engine performance calculations for existing uninstalled engine data.

## Introduction

Propulsion installations can have a significant effect on the overall efficiency of airbreathing engine systems, particularly for supersonic and hypersonic flight vehicles. To assess the impact of an inlet design on the net thrust and specific fuel consumption for a given engine design, either the inlet performance characteristics must be known in advance, or they must be calculated from a simple geometric design, or in the worst case the inlet system must be designed from scratch and then analyzed to determine performance. This report describes a series of analyses which have been developed into a performance prediction methodology for engine inlet systems. The methodology can be used to predict performance for a given inlet geometric design. Additionally, the methodology can be employed to perform preliminary inlet system design, and subsequent performance analyses.

Inlet performance is typically comprised by determining three quantities: delivered engine airflow,  $W_2$ , total pressure recovery,  $P_{T2}/P_{T0}$ , and aerodynamic drag coefficient,  $C_D$ . It is also very important to be able to characterize inlet performance over the entire vehicle flight and engine operation range, not just at the inlet design point. The methodology presented covers the calculation procedures used to determine inlet performance, both on and off-design, for the broad classification of inlet geometries shown in Figure 1.

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The geometric input used for the analysis modeling is simple and flexible. This permits rapid performance calculations and quick turn-around times for inlet design assessments. The analyses are capable of modeling three broad inlet design classifications: pitot, axisymmetric, and two-dimensional.

### Method of Analysis

Figure 2 shows the basic modeling elements used to develop the inlet performance analysis methodology. The action of airflow ingestion through the inlet is broken up into a series of distinct processes. Changes in flow properties from the free stream flow station, 0, to the inlet local flow station,  $L$ , are modeled as vehicle effects. Flow changes through shock waves ahead of the cowl lip station, 1, are modeled as external compression. Flow changes within the cowl lip to the inlet throat station,  $TH$ , are modeled as internal compression. Flow changes downstream of the throat to the engine face station, 2, are modeled as subsonic diffusion.

Aerodynamic drags modeled include spillage, bleed, and bypass. Spillage drag is the sum of the momentum change incurred by air being diverted around the inlet lip, additive drag, and cowl lip suction, if present. Bleed drag results from the momentum change in air which is dumped overboard as required by inlet stability considerations and boundary layer control. Bypass drag results from the momentum change in air which is dumped overboard for inlet/engine weight flow matching requirements. Additional calculations for cowl lip and wave drag are also included.

The relative amounts of airflow ingested into the inlet, lost to bleed, bypass, or spillage are shown in Figure 2 as the free stream tube areas,  $A$ . These areas are usually presented in analyses as a ratio with respect to the forward projected cowl lip area,  $A_c$ .

Figure 3 shows the different modes of operation which are possible for mixed-compression inlets in supersonic flight. Of particular importance is the location of the normal shock wave since this will dramatically effect the inlet airflow capture characteristics. The top diagram in Figure 3 shows the inlet operating with the normal shock wave outside of the cowl lip. In this mode of operation the inlet can deliver less (or within limits more) air to the engine by spilling air around the lip as subsonic flow behind the normal shock wave. Thus the engine demand can influence the inlet operation and the location of the normal shock wave. This operation is called sub-critical and the inlet is unstarted. External compression inlets always operate sub-critical.

As the engine demands more airflow, the normal shock wave is drawn up to the cowl lip. When the normal shock wave just reaches the cowl lip, the inlet is ingesting the maximum airflow possible. The center diagram in Figure 3 shows this operation, called critical, but the inlet is still unstarted since the throat Mach number is subsonic. When the normal shock wave is swallowed and located downstream of the throat the operation is called super-critical and the inlet is now started since the throat Mach number is supersonic. The airflow captured by the inlet lip cannot be increased or decreased by the engine operation, but is

fixed by the external shock wave structure as shown in the bottom diagram of Figure 3. Inlet/engine airflow matching can only be accomplished in this mode using a bypass system.

### Engine Weight Flows

The primary function of an inlet is to deliver the proper amount of airflow to the engine. The amount of airflow delivered to the engine depends on many factors. The usual requirements for inlet design specify the desired altitude corrected weight flow delivered to the engine face as a function of flight Mach number. Equation 1 shows the relation between engine corrected weight flow and inlet performance and design variables. The leading term in Equation 1 is the inlet capture area,  $A_C$ . The larger the inlet the greater the engine weight flow. The second term is the free stream-tube area ratio and it is a strong function of the inlet design and mode of operation. Stream-tube area ratios will be discussed in a later section.

The inlet total pressure recovery is also an important factor in Equation 1, however, the corrected airflow is inversely proportional to recovery. A higher recovery will result in a lower specific corrected airflow at the engine face, and hence will necessitate a larger inlet,  $A_C$ . And this in turn will result in a propulsion system capturing more absolute airflow, resulting in greater thrust. A lower recovery results in a smaller inlet, less absolute airflow, and lower thrust.

Equations 2 through 8 show how the absolute engine weight flow,  $W_2$ , is calculated from the corrected weight flow. Equation 9 indicates that the free stream static pressure and temperature are known from standard atmosphere tables or curve fits. Equations 7 and 8 are the isentropic flow relations between total and static quantities as a function of Mach number. Equation 6 is a statement of the first law of thermodynamics, and is only valid if the inlet does not transfer heat or shaft work to or from the airflow. Equation 10 may be used to determine the actual weight flow directly from free stream static properties. Equations 1 through 10, as written, imply the use of English units.

### Real Gas Effects

Implicit in Equations 1 through 8 is the ideal gas assumption. This is usually valid for free stream Mach numbers below two. At higher flight speeds real gas effects need to be accounted for. Equations 11 through 15 are used for a calorically imperfect gas model. Primed values correspond to the real gas property. Equation 11 is used to calculate a real gas ratio of specific heats from the ideal gas  $\gamma$  and the static temperature. For a known flight Mach number Equation 12 is solved by iteration to yield a real gas total temperature. Equation 13 is used to determine the total pressure for the real gas model. These total quantities are used to replace the ideal gas values calculated by Equations 7 and 8. Equation 1 must also be modified for stream-tube area variations using Equation 14. Additional information on this real gas model can be found in reference 1.

## Inlet Mass Flow Ratios

Figure 2 shows a rather standard airflow accounting system in terms of idealized free stream-tube areas. If these stream-tube areas are normalized by the inlet capture area, a series of relations can be developed. Equations 16 through 18 show the stream-tube area build-up. These ratios are also called mass flow ratios, since the mass flow is equal to density times velocity times area. The density and velocity terms drop out in the ratio format. If there are no vehicle effects on the airflow ahead of the inlet, the right hand side of Equation 18 is equal to one. The airflow captured by the cowl lip and ingested into the inlet is represented by the mass flow ratio  $A_{0l}/A_C$ , while the airflow passed through the inlet throat is represented by the mass flow ratio  $A_0/A_C$ .

## Vehicle Effects

The effects of a vehicle flow field ahead of an inlet can be simply described as changes to the total pressure, Mach number, and stream-tube area between stations 0 and  $L$ . Equations 19 through 25 show the effects of Mach number and total pressure changes on the stream tube area. The analysis extends from the principle of conservation of mass in Equation 19. Equation 25 provides a simple expression for determining the right hand side of Equation 18 if the total pressure ratio and Mach number ratio are known from stations 0 to  $L$ .

All of the subsequent analyses are performed in the inlet local reference frame, as if there were no vehicle effects present and the inlet was simply in a free stream of different Mach number and total pressure. However, the overall inlet performance must be represented in the free stream reference, and thus all results from the inlet local reference must be adjusted. Equations 26 through 31 show how a drag coefficient calculated in the inlet local reference is adjusted to represent the same force described as a drag coefficient in the free stream reference frame.

## Vehicle Forebody Model

Figure 4 shows a simple vehicle forebody model employed in the methodology. This model can be used to represent vehicle underbody precompression surfaces, upperbody expansion surfaces, aircraft wings, or slender fuselages. The stream tube area shown in Figure 4 can be seen to decrease as the streamline crosses subsequent shock waves from the free stream to the inlet local stations. Equations 32 and 33 show how the ratios of total pressure and Mach number, from free stream to inlet local, are determined from the changes across each individual flow deflection region. Positive angles,  $\alpha$ , are modeled as oblique shock wave compression regions. Negative angles are modeled as discrete Prandtl-Meyer expansion regions. Conic shock waves are also an included option, in addition to the default planar shock wave calculations. Since shock wave calculations are a central part of the inlet performance methodology, a description of these types of calculations follows.

## Normal Shock Wave Relations

A shock wave is a very thin layer interaction between two distinct compressible flow regions. The simplest shock wave type is the normal shock wave, shown in the top diagram of Figure 5. Supersonic flow is shocked down to subsonic flow across a normal shock wave. All flow properties are determined by the upstream conditions. Equations 34-38 show the standard normal shock wave flow relations for Mach number, pressure, temperature, and density. Note that all of these relations are only a function of upstream Mach number, and are thus easy to apply.

## Oblique Shock Wave Relations

The center diagram in Figure 5 shows the elements of an oblique shock wave. A planar oblique shock wave is produced by a downstream boundary turning an incoming supersonic flow through an angle  $\theta$ . As a result, a shock wave forms, inclined to the incoming flow direction at an angle  $\beta$ . The components of the flow perpendicular to the oblique shock wave are described by the normal shock wave relations. The velocity components parallel to the shock wave are unchanged. Equation 39 gives a relation between the flow turning and shock wave angles. Typically the flow deflection angle is known, and the shock wave angle must be found. Although most references suggest solving Equation 39 iteratively, this is not necessary.

By some algebraic manipulation, Equation 39 can be rewritten in the form of a 6th order polynomial in terms of the sine of the shock wave angle, shown in Equation 40. The coefficient terms of the resulting polynomial are given in Equations 41 through 43. Since Equation 40 only has even power terms, a generalized solution for 3rd order polynomials can be employed. This gives a relation for the square of the sine of the shock wave angle as a function of the flow deflection angle and the upstream Mach number. Equations 44 and 45 show this direct solution. Once the shock wave angle is known, the normal components of the Mach number are found in Equations 46 and 47. The changes in flow properties are then calculated by application of the normal shock wave relations.

## Conical Supersonic Flow Relations

The calculations involved in determining supersonic flow in conical shock fields are a bit more complex. The elements in the conical shock wave problem are shown in the bottom diagram of Figure 5. Equation 48 gives the reduced differential equation describing the flow field between the conical shock wave and the cone surface. The dependent variable in Equation 48,  $V_r'$ , is the radial component of a non-dimensionalized velocity in the conic flow field. Equations 49 through 52 give definitions of the non-dimensional velocity components and their relation to the polar angle  $\phi$  and flow direction angle  $\theta$ . Equations 53 and 54 are the two required boundary conditions of tangent flow to the cone surface and the correct flow turning angle behind an oblique shock wave.

Equation 48 can be solved numerically by a scheme commonly known as the Taylor-Maccoll solution. A conic shock wave angle is first guessed, and with Equation 54 provides a value for the shock wave boundary condition. Equation 48 is then solved at small increments of  $\phi$  using standard Runge-Kutta integration schemes. The solution is then marched by  $\phi$  through the flow field to the cone angle  $\theta_c$ . If the tangent flow boundary condition, Equation 53 is satisfied, then the initial guess on the conic shock wave angle is correct. Otherwise another guess on the angle  $\beta$  is chosen, and the process is repeated, iterating to a correct solution. Once solved, the flow properties across the conic shock wave are determined from the oblique shock wave relations. Also, the flow velocity variations from the conic shock wave to the cone surface are known from the solution of Equation 48. Other flow properties can be then determined from the isentropic flow relations given below. Reference 2 is a good starting point for further information on calculating conical shock waves.

### Isentropic Flow Relations

Equations 55 through 59 are a series of often used isentropic flow relations found throughout the methodology, and are given here for convenience. Equations 55 through 57 calculate the static pressure, temperature, and density as functions of Mach number only. For example, the static pressure field behind the conic shock wave is determined by Equation 56, since the Mach number field is known from the solution to Equation 48 and the total pressure is a constant, whose value is determined from the oblique shock wave relations. Equation 58 describes the required stream-tube flow area as a function of Mach number, where  $A_*$  is the flow area at the sonic condition.

Equation 59 is the Prandtl-Meyer function and it is used to determine the change in Mach number as a supersonic flow isentropically expands through a turning angle. Typically an initial Mach number is known as well as the turning angle. Equation 59 determines the initial Prandtl-Meyer function value explicitly. By adding the expansion angle (in radians) a new Prandtl-Meyer function value is calculated, from which Equation 59 must be solved iteratively to yield a new value of the Mach number downstream of the expansion. This technique is used as part of the vehicle forebody model for supersonic flow expansions.

### Total Pressure Recovery

The total pressure recovery for the entire inlet is calculated as the product of a series of total pressure ratios across elements of the inlet system. Equation 60 shows this relation, where the terms on the right hand side are the total pressure ratios from: free stream to inlet local, inlet local to inlet lip, inlet lip to throat, and throat to engine face. Each of these terms is calculated in the subsequent modeling elements, with the exception of the free stream to inlet local term, which is calculated in the vehicle forebody model previously discussed.

## External Compression

The changes in flow properties from the inlet local station to the inlet lip are determined by models of the external compression processes for a given inlet design. Figure 6 shows the elements of the external compression models used in the methodology. Each basic inlet type must be modeled separately, since the external flow is highly dependent on the inlet geometry.

The top diagram in Figure 6 shows the elements of the external compression model for pitot inlets. The total pressure ratio from inlet local to inlet lip is given in Equation 61 and the total pressure loss is only generated by a normal shock wave at the inlet local Mach number. If the inlet local Mach number is subsonic, then the total pressure ratio is one. There is an incurred drag penalty for air which is spilled around the cowl lip called additive drag. Reference 3 gives a procedure for calculating this drag coefficient and Equations 62 through 64 summarize the analysis. The last term in Equation 62 is the mass flow ratio ingested by the inlet lip,  $A_{Li}/A_C$ , and this number is determined by the engine airflow requirements. Equations 63 and 64 result from conservation of mass and the isentropic flow functions.

The center diagram in Figure 6 shows the elements of the external compression model for axisymmetric inlets. This type of inlet is capable of operating either super-critical or sub-critical, and the model must distinguish the difference. Equations 65-67 pertain to the super-critical operation mode. The total pressure ratio is produced entirely by the inlet conic shock wave. The additive drag coefficient can be determined either by Equation 66 or 67. However, since the conic flow field is known for supersonic operation, Equation 67 is employed using numerical integration techniques. The integration path corresponds to the streamline intersecting the cowl lip. For subsonic flows Equation 66 must be used and the total pressure ratio is one.

For sub-critical operation, a normal shock wave exists outside of the inlet cowl lip. This results in a greater pressure loss, higher additive drag coefficient, and lower mass flow ratio. Equations 68 through 74 show these calculations for sub-critical inlet operation. The position of the normal shock wave outside of the cowl lip is approximated as standoff distance which is proportional to the inlet capture mass flow ratio relative to critical operation, as indicated by Equation 73. The proportionality factor,  $K$ , is a function of Mach number (indicated by Equation 74) and this function was determined from curve fits to data found in reference 4. The functional form of the shock wave standoff factor,  $K$ , is shown graphically in Figure 7.

The bottom diagram in Figure 6 shows the elements of the external compression model for multi-ramp two-dimensional inlets. These inlet types can also operate both sub-critical and super-critical. Equations 75-78 show the calculations for super-critical operation. The total pressure ratio in Equation 75 is the product of all the external oblique shock wave total pressure ratios. For sub-critical operation, Equations 79-82 show the calculations used in the model. A normal shock wave can exist outside of the cowl lip and the relations computing the total pressure ratio and additive drag need to account for the position of the normal shock wave, and on which ramp it is located.

### Internal Compression

Figure 8 shows the elements of the internal compression model. For started inlet operation, an oblique shock wave train is used to model the losses in the internal portion of the inlet from the cowl lip to the throat. The net turning angle is the sum of the last external surface angle and the internal cowl lip angle. The flow properties across each shock wave reflection are determined from the oblique shock wave relations previously discussed. Equation 83 shows the relation between the flow properties in the model and the geometric throat area constraint. Equation 83 is again a statement of conservation of mass for compressible flows.

The reflecting oblique shock wave model, Equations 85 through 87, is primarily used to determine the total pressure loss in the internal compression region. The model may also be used to determine a throat Mach number,  $M_{TH}$ , for a given throat area ratio,  $A_{TH}/A_C$ , by iterative solution of Equation 83. Often the throat Mach number is specified instead and the throat area ratio is then determined directly by Equation 83. If both the throat Mach number and throat area ratio are specified, then the inlet capture mass flow ratio,  $A_L/A_C$ , must then be determined from these constraints.

### Subsonic Diffusion

Figure 9 shows the elements of the subsonic diffusion model. Depending on the inlet operation mode, a terminal normal shock wave may or may not exist downstream of the inlet throat within the subsonic diffuser. Equations 88 through 94 show the calculation procedure for operation with subsonic flow at the inlet throat. The model used here closely follows that given in reference 5. For inlet operation with a subsonic throat, the throat Mach number and area are usually specified, consistent with the desired engine weight flow delivered. For inlet operation with a supersonic throat, or started operation, Equations 95 through 97 are used. The strength of the terminal normal shock wave can be used to provide inlet/engine corrected mass flow matching in some instances. Curve fits are used for the loss factor functions in Equations 90 and 94 corresponding to divergence and throat Mach number loss mechanisms. Figures 10 and 11 show the functional forms for the divergence and throat Mach number loss mechanisms graphically. The friction factor given in Equation 93 is a nominal value, and may be changed if desired.

### Bleed Drag

Bleed drag seems to be a necessary evil required for supersonic inlet designs. Since inlets produce large positive pressure gradients, some severe in shock wave interactions, the boundary layers are prone to separation. To alleviate this problem, portions of the boundary layer are removed through wall suction, and then dumped overboard. If done correctly, this usually results in improved inlet recoveries, however, a momentum drag is incurred. Equations 98 through 109 show the procedure used to calculate the bleed drag coefficient. These relations follow the procedures outlined in reference 6. Total pressure losses up to the bleed system plenum are modeled, as well as the effective bleed nozzle exit pressure and



flow area. Non-axial nozzle exit flow losses are also included.

A number of inputs must be specified for the design and operation of the bleed system. In a high speed inlet the bleed system is typically comprised of a series of discrete bleed regions, each having its own type of wall perforation, plenum, and exhaust nozzle. The total bleed drag is thus the sum of the individual bleed system elements. Equation 98 is used to describe the bleed drag for a discrete bleed element. The bleed mass flow ratio,  $A_{LBLE}/A_C$ , nozzle exhaust flow angle,  $\theta_x$ , and nozzle exhaust velocity coefficient,  $\eta_v$ , must all be specified. Additionally, the bleed plenum recovery,  $P_{TBL}/P_{TL}$ , must also be specified. To choose these values extensive experience in the design and operation of bleed systems is usually required. To alleviate this requirement default values have been implemented in the methodology.

Figure 12 shows typical bleed system operating characteristics which are incorporated as user selectable defaults for inputs to the bleed drag model. The bleed plenum recovery is shown as a function of inlet local Mach number for a variety of bleed system design wall perforations. The total bleed mass flow ratio required for typical inlet operation is also shown in Figure 12 over the same Mach number range. The data which comprises the basis for Figure 12 is taken from reference 7.

There are two additional empirical relations embedded within the bleed drag model. Equation 99 shows the functional dependence for the oblique exit nozzle drag factor,  $C_{TL}$ , and Figure 13 shows this functional relationship graphically. The relationship for the effective nozzle discharge pressure, Equation 103, is shown graphically in Figure 14. The bleed exhaust nozzle area ratio,  $A_x/A_{TH}$ , is the final input required for the bleed drag model. The nozzle area ratio should be chosen depending on the bleed exhaust nozzle pressure ratio. The operating pressure ratio for the bleed exhaust nozzle is given in Equation 102. Based on this value, Figure 15 can be used to pick the appropriate nozzle area ratio for the bleed element. Other area ratio choices will result in over or under expansion losses which will further increase the resulting bleed drag. Since bleed plenum recoveries are typically low this usually results in the use of convergent nozzles for bleed systems. Bypass systems can have much higher recoveries, and thus may be able to utilize convergent-divergent nozzle designs.

### Bypass Drag

Bypass flows are used to dump air overboard in the subsonic diffuser ahead of the engine face, and are typically employed for inlet/engine flow matching. The resulting drag coefficient is calculated in a manner analogous to that used for the bleed system. Equations 110 through 115 show the modifications made to the bleed drag relations required to model bypass flow. The required inputs to the bypass drag model parallel those necessary for the bleed drag model. As in the bleed system model, the bypass system can be comprised from a series of distinct bypass elements. Each element can be defined with different design and performance characteristics. The total bypass drag thus being the sum of the drags of all the distinct elements. The bypass plenum recovery is typically a function of the amount of

bypass flow dumped overboard. Figure 16 shows the methodology default for the relation of the bypass recovery,  $P_{TBP}/P_{T2}$ , as the bypass mass flow ratio,  $A_{LBYP}/A_C$ , varies. The data on which Figure 16 is based can be found from reference 7.

### Cowl Lip Suction

As a result of sub-critical airflow spillage around the inlet cowl lip, the static pressure over the cowl leading edges is decreased, thus reducing the effective cowl pressure drag. This effect, known as cowl lip suction, can be viewed as a correction to the additive drag calculation as presented previously in the external compression model. The net combination of the additive drag and cowl lip suction is the total inlet spillage drag. Equation 116 shows the definition of the cowl lip suction coefficient. This model for the cowl lip suction coefficient is based entirely on empirical relations which can be found in reference 6.

Equations 117 through 124 detail the empirical terms used in Equation 116. The functional form of Equation 117, the first cowl lip suction factor,  $K_\alpha$ , is shown graphically in Figure 17. The effective cowl lip angle correction factor,  $\sigma$ , defined in Equation 118 is shown graphically in Figure 18. The procedure for computing the effective cowl lip angle is given in Equations 119 through 121. Equation 119 is an approximation for the effective cowl lip angle, in degrees, determined from the integral parameter,  $\Omega$ , which is defined by Equation 120. This integral parameter evaluates the cowl surface curvature from the cowl lip leading edge to the maximum of the cowl forward projected area location. In Equations 120 and 121, the cowl profile is defined by coordinates  $(X,Y)$  and the cowl lip leading edge is located at  $(X_C, Y_C)$ .

The second cowl lip suction factor,  $K_\beta$ , defined in Equation 122 is shown graphically in Figure 19. The final empirical cowl lip suction factor,  $C_{D2}$ , is defined in Equation 123 and is also shown graphically in Figure 20. Once the cowl lip suction factors are determined from curve fits and the cowl lip suction coefficient calculated, the inlet spillage drag coefficient is then found by Equation 124.

### Cowl Lip and Wave Drag

The pressure drag acting on the inlet cowl surfaces can typically be broken into two parts; drag due to a blunt inlet lip and wave drag due to the area growth along the remainder of the cowl surfaces. Equation 125 shows this drag decomposition. For sharp lip inlets, the drag component due to a blunt lip is necessarily zero. For non-sharp lip inlets, the blunt leading edge will produce a pressure drag at supersonic local Mach numbers resulting from a detached normal shock wave which is formed over the leading edge radius of the cowl lip. Equation 126 shows the computation of the lip drag coefficient based on the assumption that an average pressure rise produced by a normal shock wave at the inlet local Mach number acts over the forward projected cowl lip surface area. This average pressure rise is modeled as the simple arithmetic mean of the stagnation and static pressures behind a normal shock wave. The forward projection of the blunt cowl lip area is denoted as  $A_x$  in Equation 126.

The pressure drag acting on the rest of the cowl surface area is wave drag. The wave drag coefficient is defined by Equation 127 for two-dimensional inlet geometries. If the cowl profile is comprised by a series of flat plates, the integration in Equation 127 can be replaced by a discrete summation as shown in Equation 128. The pressure acting on each cowl plate segment,  $P_i$ , is calculated by the shock wave and expansion models previously described. The forward facing projected area of each cowl segment plate is denoted as  $A_{xi}$  in Equation 128.

The computations of the wave drag for axisymmetric cowls are given in Equations 129 through 143. The wave drag coefficient is defined as an integration of the pressure coefficient over the cowl surface as shown in Equation 129. Equation 129 is an equivalent statement to Equation 127 which defined the wave drag coefficient for two-dimensional inlet geometries. The computation of the pressure coefficient,  $C_p$ , over an axisymmetric cowl geometry, however, is substantially more complex than the two-dimensional flat plate cowl model of Equation 128. The pressure coefficient in the axisymmetric wave drag model, given in Equation 130, is calculated by a first order approximation using the perturbation velocities determined from the solution of a linearized supersonic slender body theory.

The axisymmetric form of the governing partial differential equation for the perturbation velocity potential by supersonic slender body theory is given in Equation 131. The generalized solution of the perturbation velocity potential,  $\phi$ , and the axial and radial perturbation velocities,  $u$  and  $v$  respectively, are found in reference 8 and given in Equations 132 through 135. In Equations 133 and 134,  $f'(\xi)$  is a singularity distribution along the centerline axis which uniquely determines the flow field on and about the slender body surface. A statement that the flow is tangent to the body surface on the body surface can be used as a boundary condition to determine the singularity distribution for that body. A more detailed description of the analyses which follow can be found in reference 9.

If the axisymmetric cowl surface profile is described by the coordinate pairs  $(X,R)$  then the body surface tangent flow boundary condition can be written as Equation 136. Furthermore, if the cowl surface profile is discretized and the singularity distribution,  $f'$ , can be assumed piece-wise constant over a small interval  $[\xi_{i-1}, \xi_i]$ , then the discrete elements of the singularity distribution can be moved outside of the integration, as shown in Equation 137. The initial and final bounds of the piece-wise integrations are given in Equations 138 and 139 as they apply to Equation 137. The piece-wise integral is now readily evaluated in closed form, and the solution becomes Equation 140. A marching scheme can easily be developed to determine the value of a discrete singularity,  $f'_n$ , corresponding to a location  $(X_n, R_n)$  on the cowl surface in terms of a summation of all the upstream singularities, as shown in Equation 141. Therefore, the entire singularity distribution can be determined by simply marching down the cowl surface using Equation 141.

Once the discrete singularity distribution is known, the pressure coefficient can be determined by an analogous procedure, as shown in Equation 142, which is developed from Equations 130 and 133. Again, the resulting piece-wise integral in Equation 142 can be evaluated in closed form, yielding Equation 143, and the pressure coefficient at discrete points along the cowl surface is subsequently known as a function of the discretized

singularity distribution. The axisymmetric wave drag coefficient is then determined by numerical integration of Equation 130 using the values found from Equation 143.

### Lip Losses

The inlet cowl lip can have additional effects on the inlet recovery, particularly at low speeds. At take-off conditions, the inlet must ingest mass by drawing a large volume of initially stationary air from the surroundings around the cowl lip and then into the engine face. For sharp lip inlets, as the airflow is drawn around the cowl lip, the flow will accelerate and separate as it turns, producing a subsequent fluid dynamic loss and drop in total pressure recovery. Equation 144 shows the total pressure recovery as produced by a theoretical sharp lip loss mechanism. Reference 10 presents the theoretical derivations of Equation 144. The Mach number at the cowl lip,  $M_1$ , can be determined from continuity. Equation 145 is solved iteratively to find the inlet lip Mach number as a function of the inlet throat Mach number and the contraction area ratio from the inlet lip to the inlet throat. For cowl lips which are not sharp, but have some degree of bluntness, Equation 146 has been developed by the author to account for the effects of a non-zero cowl lip radius on the lip loss recovery given by Equation 144. Data from reference 11 was used to determine the exponential damping constant used in Equation 146.

### Results

Results from the IPAC methodology are presented for three sample cases: a Mach 2.0 pitot inlet, a Mach 2.4 axisymmetric inlet, and a Mach 5.0 two-dimensional inlet. Example case output files, each containing copies of the respective input sets, can be found in Appendices II through IV. Additionally, a program User's Guide which describes the input set and program usage can be found in Appendix I.

The geometry of the pitot inlet sample case is shown in Figure 21. The pitot inlet is axisymmetric for this particular design and has a blunt cowl lip for improved low speed total pressure recoveries. Figure 22 shows a performance summary over the entire Mach number operating range for the inlet. The corrected airflow has been matched to a typical engine demand schedule, as shown in the top plot of Figure 22. The inlet throat Mach number was varied and used as an inlet control parameter in order to provide inlet/engine airflow matching. The resulting total pressure recovery and inlet drags are shown in the middle and lower plots in Figure 22. Note that the cowl drag is the dominant drag for this inlet design. This is an expected result of the blunt cowl lip feature of the inlet.

Figure 23 shows the design and variable geometry features for the axisymmetric sample case. Both internal cowl surface variable geometry and a translating centerbody are used to control the operation of this inlet. Figure 24 shows a performance summary for the axisymmetric sample case over the entire Mach number range of inlet operation. Again, the inlet was designed and operated in accordance with a typical engine airflow demand schedule. The axisymmetric inlet is a mixed compression design with a starting Mach number of 1.6. This

inlet also requires a boundary layer bleed system. The sharp inlet lip can be seen to result in relatively lower take-off total pressure recoveries for this particular design.

The inlet design and variable geometry features for the two-dimensional sample case is shown in Figure 25. This inlet uses a three ramp compression surface shock-on-lip design at Mach 5.0. The second and third ramps are movable and are used for inlet operation control. Figure 26 shows a performance summary for the two-dimensional design. The inlet employs both a boundary layer bleed system and an engine bypass system. The variable geometry ramp positions and bypass mass flow variations are used to provide matched airflow for a typical engine demand schedule. The inlet starting Mach number is 2.0 for this particular design. As is typical for high speed inlet systems, severe transonic drags are seen in the lower plot of Figure 26.

### Summary

A series of analyses have been developed which permit the calculation of the performance of common inlet designs. The methods presented are useful for determining the inlet weight flows, total pressure recovery, and aerodynamic drag coefficients for given inlet geometric designs. Limited geometric input data is required to use this inlet performance prediction methodology. The analyses presented here may also be used to perform inlet preliminary design studies. The calculated inlet performance parameters may be used in subsequent engine cycle analyses or installed engine performance calculations for existing uninstalled engine data.

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## List of Symbols

$A$	area, or cross-sectional flow area
$A_C$	inlet capture area
$C_D$	drag coefficient
$C_{D2}$	empirical cowl lip suction factor
$C_P$	pressure coefficient
$C_T$	oblique exit nozzle drag factor
$D$	drag force, or diameter
$f$	singularity distribution for the perturbation velocity potential
$f_D$	diffuser friction factor
$g$	gravitational constant
$K$	empirical normal shock wave standoff factor
$K_D$	empirical subsonic diffuser total pressure loss factor
$K_F$	empirical subsonic diffuser friction loss factor
$K_M$	empirical subsonic diffuser throat Mach number factor
$K_O$	empirical subsonic diffuser offset loss factor
$K_\alpha$	empirical cowl lip suction factor
$K_\beta$	empirical cowl lip suction factor
$L$	inlet local location, or axial length
$L_D$	diffuser axial length
$M$	Mach number
$N$	number of surface segments
$P$	pressure
$P_T$	total pressure
$q$	dynamic pressure
$r, R$	radial coordinate
$R$	gas constant
$T$	temperature
$T_T$	total temperature
$u$	axial perturbation velocity
$v$	radial perturbation velocity
$V$	velocity
$W$	weight flow rate
$x, X$	axial coordinate
$y, Y$	normal coordinate
$Y_O$	diffuser offset normal length
$\alpha$	forebody model angle
$\beta$	shock wave angle
$\gamma$	ratio of specific heats
$\eta_v$	discharge nozzle velocity coefficient
$\theta$	referenced total temperature, or a flow/surface angle
$\theta_D$	diffuser half-angle
$\Theta$	reference temperature for real gas model
$\delta$	referenced total pressure
$\rho$	density

$\lambda$	Mach number parameter in slender body theory
$\nu$	Prandtl-Meyer function
$\xi$	integration parameter in slender body theory
$\sigma$	correction factor for effective cowl angle
$\phi$	perturbation velocity potential, or a polar angle
$\Omega$	cowl curvature function

### Subscripts

0	free stream
1	upstream, or cowl lip
2	downstream, or engine face
<i>ADD</i>	additive
<i>BL</i>	boundary layer bleed
<i>BLD</i>	bleed
<i>BP</i>	engine bypass
<i>BYP</i>	bypass
<i>c</i>	cone
<i>C</i>	cowl lip
<i>CWL</i>	cowl
<i>cr</i>	critical operation
<i>e</i>	effective
<i>eff</i>	effective
<i>ENG</i>	engine flow
<i>i</i>	general index, or ideal condition
<i>I</i>	inlet capture
<i>L</i>	inlet local
<i>LIP</i>	inlet lip
<i>LS</i>	lip suction
<i>n</i>	general index, or inlet ramp number
<i>N</i>	normal component
<i>NS</i>	normal shock wave
<i>r</i>	radial component
<i>S</i>	centerbody or ramp surface
<i>sl</i>	sharp lip
<i>SPL</i>	spillage
<i>sub</i>	sub-critical operation, or subsonic throat
<i>sup</i>	supersonic throat
<i>SY</i>	centerbody or ramp surface behind unstarted inlet normal shock wave
<i>TH</i>	inlet throat, or discharge nozzle throat
<i>WAV</i>	wave
<i>x</i>	axial component
<i>X</i>	discharge nozzle exit
*	sonic conditions
$\phi$	polar component



## Superscripts

thermally perfect (non-ideal) gas property, or normalized velocity

## Equations

### Engine Weight Flows

$$\frac{W_2\sqrt{\theta_2}}{\delta_2} = A_C \left( \frac{A_{0ENG}}{A_C} \right) \left( \frac{P_{T2}}{P_{T0}} \right)^{-1} \frac{2116}{\sqrt{519}} \sqrt{\frac{\gamma g}{R}} M_0 \left[ 1 + \frac{\gamma-1}{2} M_0^2 \right]^{-\frac{\gamma+1}{2(\gamma-1)}} \quad (1)$$

$$W_2 = \left( \frac{W_2\sqrt{\theta_2}}{\delta_2} \right) \frac{\delta_2}{\sqrt{\theta_2}} \quad (2)$$

$$\delta_2 = \frac{P_{T2}}{2116} \quad (3)$$

$$\theta_2 = \frac{T_{T2}}{519} \quad (4)$$

$$P_{T2} = P_{T0} \left( \frac{P_{T2}}{P_{T0}} \right) \quad (5)$$

$$T_{T2} = T_{T0} \quad (6)$$

$$P_{T0} = P_0 \left[ 1 + \frac{\gamma-1}{2} M_0^2 \right]^{\frac{\gamma}{\gamma-1}} \quad (7)$$

$$T_{T0} = T_0 \left[ 1 + \frac{\gamma-1}{2} M_0^2 \right] \quad (8)$$

$$P_0, T_0 = f(alt) \quad (9)$$

$$W_2 = A_C \left( \frac{A_{0ENG}}{A_C} \right) \frac{P_0}{\sqrt{T_0}} \sqrt{\frac{\gamma g}{R}} M_0 \quad (10)$$

### Real Gas Effects

$$\gamma' = 1 + \frac{\gamma-1}{1 + (\gamma-1) \left[ \left( \frac{\Theta}{T} \right)^2 \frac{e^{\Theta/T}}{(e^{\Theta/T} - 1)^2} \right]} \quad (11)$$

$$M^2 = \frac{2}{\gamma'} \frac{T'}{T} \left[ \frac{\gamma}{\gamma-1} \left( 1 - \frac{T}{T'} \right) + \frac{\Theta}{T'} \left( \frac{1}{e^{\Theta/T_r'} - 1} - \frac{1}{e^{\Theta/T} - 1} \right) \right] \quad (12)$$

$$\frac{P}{P_{T'}} = \left( \frac{e^{\Theta/T_r'} - 1}{e^{\Theta/T} - 1} \right) \left( \frac{T}{T'} \right)^{\frac{\gamma}{\gamma-1}} \exp \left[ \left( \frac{\Theta}{T} \right) \frac{e^{\Theta/T}}{e^{\Theta/T} - 1} - \left( \frac{\Theta}{T'} \right) \frac{e^{\Theta/T_r'}}{e^{\Theta/T_r'} - 1} \right] \quad (13)$$

$$\frac{A}{A_*'} = \frac{1}{M} \sqrt{\frac{T_*'}{T}} \frac{\left( \frac{e^{\Theta/T_r'} - 1}{e^{\Theta/T_*'} - 1} \right) \left( \frac{T_*'}{T'} \right)^{\frac{\gamma}{\gamma-1}} \exp \left[ \left( \frac{\Theta}{T_*'} \right) \frac{e^{\Theta/T_*'}}{e^{\Theta/T_*'} - 1} - \left( \frac{\Theta}{T'} \right) \frac{e^{\Theta/T_r'}}{e^{\Theta/T_r'} - 1} \right]}{\left( \frac{e^{\Theta/T_r'} - 1}{e^{\Theta/T} - 1} \right) \left( \frac{T}{T'} \right)^{\frac{\gamma}{\gamma-1}} \exp \left[ \left( \frac{\Theta}{T} \right) \frac{e^{\Theta/T}}{e^{\Theta/T} - 1} - \left( \frac{\Theta}{T'} \right) \frac{e^{\Theta/T_r'}}{e^{\Theta/T_r'} - 1} \right]} \quad (14)$$

$$\Theta = 5,500^\circ \text{R} \quad (15)$$

Inlet Mass Flow Ratios

$$\frac{A_0}{A_C} = \frac{A_{0ENG}}{A_C} + \frac{A_{0BYP}}{A_C} \quad (16)$$

$$\frac{A_{0I}}{A_C} = \frac{A_0}{A_C} + \frac{A_{0BLD}}{A_C} \quad (17)$$

$$\frac{A_{0I}}{A_C} + \frac{A_{0SPL}}{A_C} = \left(\frac{A_L}{A_0}\right)^{-1} \quad (18)$$

Vehicle Effects

$$(\rho V A)_0 = (\rho V A)_L \quad (19)$$

$$\left(\frac{A_L}{A_0}\right) = \left(\frac{\rho_0}{\rho_L}\right) \left(\frac{V_0}{V_L}\right) \quad (20)$$

$$V = M \sqrt{\gamma R T} \quad (21)$$

$$\left(\frac{V_0}{V_L}\right) = \left(\frac{M_0}{M_L}\right) \left[ \frac{1 + \frac{\gamma-1}{2} M_0^2}{1 + \frac{\gamma-1}{2} M_L^2} \right]^{-\frac{1}{2}} \quad (22)$$

$$\rho = \frac{P}{RT} \quad (23)$$

$$\left(\frac{\rho_0}{\rho_L}\right) = \left(\frac{P_{TL}}{P_{T0}}\right)^{-1} \left[ \frac{1 + \frac{\gamma-1}{2} M_0^2}{1 + \frac{\gamma-1}{2} M_L^2} \right]^{-\frac{1}{\gamma-1}} \quad (24)$$

$$\left(\frac{A_L}{A_0}\right) = \left(\frac{M_L}{M_0}\right)^{-1} \left(\frac{P_{TL}}{P_{T0}}\right)^{-1} \left[ \frac{1 + \frac{\gamma-1}{2} M_0^2}{1 + \frac{\gamma-1}{2} M_L^2} \right]^{-\frac{\gamma+1}{2(\gamma-1)}} \quad (25)$$

$$C_D = \frac{D}{q A_C} \quad (26)$$

$$q = \frac{\gamma}{2} P M^2 \quad (27)$$

$$(C_D q A_C)_0 = (C_D q A_C)_L \quad (28)$$

$$C_{D0} = C_{DL} \left(\frac{P_L}{P_0}\right) \left(\frac{M_L}{M_0}\right)^2 \quad (29)$$

$$\left(\frac{P_L}{P_0}\right) = \left(\frac{P_{TL}}{P_{T0}}\right) \left[ \frac{1 + \frac{\gamma-1}{2} M_0^2}{1 + \frac{\gamma-1}{2} M_L^2} \right]^{\frac{\gamma}{\gamma-1}} \quad (30)$$

$$C_{D0} = C_{DL} \left(\frac{P_{TL}}{P_{T0}}\right) \left(\frac{M_L}{M_0}\right)^2 \left[ \frac{1 + \frac{\gamma-1}{2} M_0^2}{1 + \frac{\gamma-1}{2} M_L^2} \right]^{\frac{\gamma}{\gamma-1}} \quad (31)$$

Vehicle Forebody Model

$$\left(\frac{P_{TL}}{P_{T0}}\right) = \prod_{i=1}^n \left(\frac{P_{Ti}}{P_{Ti-1}}\right) \quad (32)$$

$$\left(\frac{M_L}{M_0}\right) = \prod_{i=1}^n \left(\frac{M_i}{M_{i-1}}\right) \quad (33)$$

Normal Shock Wave Relations

$$M_2 = \sqrt{\frac{(\gamma - 1) M_1^2 + 2}{2\gamma M_1^2 - (\gamma - 1)}} \quad (34)$$

$$\frac{P_2}{P_1} = \frac{2\gamma M_1^2 - (\gamma - 1)}{\gamma + 1} \quad (35)$$

$$\frac{P_{T2}}{P_{T1}} = \left[\frac{(\gamma + 1) M_1^2}{(\gamma - 1) M_1^2 + 2}\right]^{\frac{\gamma}{\gamma - 1}} \left[\frac{\gamma + 1}{2\gamma M_1^2 - (\gamma - 1)}\right]^{\frac{1}{\gamma - 1}} \quad (36)$$

$$\frac{T_2}{T_1} = \frac{[2\gamma M_1^2 - (\gamma - 1)] [(\gamma - 1) M_1^2 + 2]}{(\gamma + 1)^2 M_1^2} \quad (37)$$

$$\frac{\rho_2}{\rho_1} = \frac{(\gamma + 1) M_1^2}{(\gamma - 1) M_1^2 + 2} \quad (38)$$

Oblique Shock Wave Relations

$$\tan \theta = 2 \cot \beta \frac{M_1^2 \sin^2 \beta - 1}{M_1^2 (\gamma + \cos 2\beta) + 2} \quad (39)$$

$$\sin^6 \beta + b \sin^4 \beta + c \sin^2 \beta + d = 0 \quad (40)$$

$$b = -\frac{M_1^2 + 2}{M_1^2} - \gamma \sin^2 \theta \quad (41)$$

$$c = \frac{2M_1^2 + 1}{M_1^4} + \left[\frac{(\gamma + 1)^2}{4} + \frac{\gamma - 1}{M_1^2}\right] \sin^2 \theta \quad (42)$$

$$d = -\frac{\cos^2 \theta}{M_1^4} \quad (43)$$

$$\sin^2 \beta = -\frac{b}{3} + \frac{2}{3} \sqrt{b^2 - 3c} \cos \left(\frac{\psi + 4\pi}{3}\right) \quad (44)$$

$$\cos \psi = \frac{9bc - 2b^3 - 27d}{2\sqrt{(b^2 - 3c)^3}} \quad (45)$$

$$M_{1N} = M_1 \sin \beta \quad (46)$$

$$M_{2N} = M_2 \sin (\beta - \theta) \quad (47)$$

### Conical Supersonic Flow Relations

$$\frac{\gamma-1}{2} \left[ 1 - V_r'^2 - \left( \frac{dV_r'}{d\phi} \right)^2 \right] \left( 2V_r' + \frac{dV_r'}{d\phi} \cot \phi + \frac{d^2 V_r'}{d\phi^2} \right) - \frac{dV_r'}{d\phi} \left( V_r' \frac{dV_r'}{d\phi} + \frac{dV_r'}{d\phi} \frac{d^2 V_r'}{d\phi^2} \right) = 0 \quad (48)$$

$$V' = \sqrt{V_r'^2 + V_\phi'^2} \quad (49)$$

$$V_\phi' = \frac{dV_r'}{d\phi} \quad (50)$$

$$V' = \frac{1}{\sqrt{\frac{2}{(\gamma-1)M^2} + 1}} \quad (51)$$

$$\tan(\phi - \theta) = \frac{V_\phi'}{V_r'} \quad (52)$$

$$\left. \frac{dV_r'}{d\phi} \right|_{\phi=\theta_c} = 0 \quad (53)$$

$$\left. \frac{V_\phi'}{V_r'} \right|_{\phi=\beta} = \tan \beta \frac{(\gamma-1)M_1^2 \sin^2 \beta + 2}{(\gamma+1)M_1^2 \sin^2 \beta} \quad (54)$$

### Isentropic Flow Relations

$$\frac{T}{T_T} = \left[ 1 + \frac{\gamma-1}{2} M^2 \right]^{-1} \quad (55)$$

$$\frac{P}{P_T} = \left[ 1 + \frac{\gamma-1}{2} M^2 \right]^{-\frac{\gamma}{\gamma-1}} \quad (56)$$

$$\frac{\rho}{\rho_T} = \left[ 1 + \frac{\gamma-1}{2} M^2 \right]^{-\frac{1}{\gamma-1}} \quad (57)$$

$$\frac{A}{A_*} = \left( \frac{\gamma+1}{2} \right)^{-\frac{\gamma+1}{2(\gamma-1)}} \frac{1}{M} \left[ 1 + \frac{\gamma-1}{2} M^2 \right]^{\frac{\gamma+1}{2(\gamma-1)}} \quad (58)$$

$$\nu(M) = \sqrt{\frac{\gamma+1}{\gamma-1}} \tan^{-1} \sqrt{\frac{\gamma-1}{\gamma+1} (M^2 - 1)} - \tan^{-1} \sqrt{M^2 - 1} \quad (59)$$

### Total Pressure Recovery

$$\frac{P_{T2}}{P_{T0}} = \left( \frac{P_{TL}}{P_{T0}} \right) \left( \frac{P_{T1}}{P_{TL}} \right) \left( \frac{P_{TTH}}{P_{T1}} \right) \left( \frac{P_{T2}}{P_{TTH}} \right) \quad (60)$$

## External Compression

### Pitot Inlets

$$\frac{P_{T1}}{P_{TL}} = \left[ \frac{(\gamma + 1) M_L^2}{(\gamma - 1) M_L^2 + 2} \right]^{\frac{\gamma}{\gamma - 1}} \left[ \frac{\gamma + 1}{2\gamma M_L^2 - (\gamma - 1)} \right]^{\frac{1}{\gamma - 1}} \quad (61)$$

$$C_{D_{ADD}} = \frac{2}{\gamma M_L^2} \left[ \left( \frac{P_1}{P_L} \right) (1 + \gamma M_1^2) - 1 \right] - 2 \left( \frac{A_{LI}}{A_C} \right) \quad (62)$$

$$\left( \frac{A_{LI}}{A_C} \right) = \left( \frac{P_{T1}}{P_{TL}} \right) \left( \frac{M_1}{M_L} \right) \left[ \frac{1 + \frac{\gamma - 1}{2} M_1^2}{1 + \frac{\gamma - 1}{2} M_L^2} \right]^{-\frac{\gamma + 1}{2(\gamma - 1)}} \quad (63)$$

$$\left( \frac{P_1}{P_L} \right) = \left( \frac{P_{T1}}{P_{TL}} \right) \left[ \frac{1 + \frac{\gamma - 1}{2} M_1^2}{1 + \frac{\gamma - 1}{2} M_L^2} \right]^{-\frac{\gamma}{\gamma - 1}} \quad (64)$$

### Axisymmetric Inlets

$$\left. \frac{P_{T1}}{P_{TL}} \right|_{cr} = \left[ \frac{(\gamma + 1) M_L^2 \sin^2 \beta}{(\gamma - 1) M_L^2 \sin^2 \beta + 2} \right]^{\frac{\gamma}{\gamma - 1}} \left[ \frac{\gamma + 1}{2\gamma M_L^2 \sin^2 \beta - (\gamma - 1)} \right]^{\frac{1}{\gamma - 1}} \quad (65)$$

$$C_{D_{ADD}} \Big|_{cr} = \frac{2}{\gamma M_L^2} \left[ \frac{P_1}{P_L} \left( 1 - \frac{A_S}{A_C} \right) (1 + \gamma M_1^2) + \frac{P_S}{P_L} \frac{A_S}{A_C} - 1 \right] - 2 \left( \frac{A_{LI}}{A_C} \right) \quad (66)$$

$$C_{D_{ADD}} \Big|_{cr} = \frac{2}{\gamma M_L^2} \int_L^1 \left( \frac{P}{P_L} - 1 \right) \frac{dA}{A_C} \quad (67)$$

$$\left. \frac{P_{T1}}{P_{TL}} \right|_{sub} = \left. \frac{P_{T1}}{P_{TL}} \right|_{cr} \left[ \frac{(\gamma + 1) M_S^2}{(\gamma - 1) M_S^2 + 2} \right]^{\frac{\gamma}{\gamma - 1}} \left[ \frac{\gamma + 1}{2\gamma M_S^2 - (\gamma - 1)} \right]^{\frac{1}{\gamma - 1}} \quad (68)$$

$$C_{D_{ADD}} \Big|_{sub} = C_{D_{ADD}} \Big|_{cr} + \frac{2}{\gamma M_L^2} \left( \frac{\bar{P} - P_S}{P_L} \right) \frac{A_{SY}}{A_C} \quad (69)$$

$$\left( \frac{A_{LI}}{A_C} \right) \left( 1 - \frac{A_S}{A_C} \right) = \left. \frac{P_{T1}}{P_{TL}} \right|_{sub} \left( \frac{M_1}{M_L} \right) \left[ \frac{1 + \frac{\gamma - 1}{2} M_1^2}{1 + \frac{\gamma - 1}{2} M_L^2} \right]^{-\frac{\gamma + 1}{2(\gamma - 1)}} \quad (70)$$

$$\bar{P} = \frac{P_Y + P_1}{2} \quad (71)$$

$$\frac{P_Y}{P_S} = \frac{2\gamma M_S^2 - (\gamma - 1)}{\gamma + 1} \quad (72)$$

$$\frac{L_{SY}}{Y_C} = K \left[ 1 - \frac{\left( \frac{A_{LI}}{A_C} \right)}{\left( \frac{A_{LI}}{A_C} \right)_{cr}} \right] \quad (73)$$

$$K = f(M_L) \quad (74)$$

$$\frac{P_{T1}}{P_{TL}} \Big|_{cr} = \prod_{i=1}^n \left( \frac{P_{Ti}}{P_{Ti-1}} \right) \quad (75)$$

$$\left( \frac{P_{Ti}}{P_{Ti-1}} \right) = \left[ \frac{(\gamma+1) M_{i-1}^2 \sin^2 \beta_i}{(\gamma-1) M_{i-1}^2 \sin^2 \beta_i + 2} \right]^{\frac{\gamma}{\gamma-1}} \left[ \frac{\gamma+1}{2\gamma M_{i-1}^2 \sin^2 \beta_i - (\gamma-1)} \right]^{\frac{1}{\gamma-1}} \quad (76)$$

$$M_i = \frac{1}{\sin(\beta_i - \theta_i)} \sqrt{\frac{(\gamma-1) M_{i-1}^2 \sin^2 \beta_i + 2}{2\gamma M_{i-1}^2 \sin^2 \beta_i - (\gamma-1)}} \quad (77)$$

$$C_{D_{ADD}} \Big|_{cr} = \frac{2}{\gamma M_L^2} \left[ \frac{P_1}{P_L} \left( 1 - \sum_{i=1}^n \frac{A_{Si}}{A_C} \right) (1 + \gamma M_1^2) + \sum_{i=1}^n \frac{P_{Si}}{P_L} \frac{A_{Si}}{A_C} - 1 \right] - 2 \left( \frac{A_{LI}}{A_C} \right) \quad (78)$$

$$\frac{P_{T1}}{P_{TL}} \Big|_{sub} = \frac{P_{T1}}{P_{TL}} \Big|_{cr} \left[ \frac{(\gamma+1) M_n^2}{(\gamma-1) M_n^2 + 2} \right]^{\frac{\gamma}{\gamma-1}} \left[ \frac{\gamma+1}{2\gamma M_n^2 - (\gamma-1)} \right]^{\frac{1}{\gamma-1}} \quad (79)$$

$$C_{D_{ADD}} \Big|_{sub} = C_{D_{ADD}} \Big|_{cr} + \frac{2}{\gamma M_L^2} \left( \frac{\bar{P} - P_{Sn}}{P_L} \right) \frac{A_{SY}}{A_C} \quad (80)$$

$$\frac{\left( \frac{A_{LI}}{A_C} \right)}{\left( 1 - \sum_{i=1}^n \frac{A_{Si}}{A_C} \right)} = \frac{P_{T1}}{P_{TL}} \Big|_{sub} \left( \frac{M_1}{M_L} \right) \left[ \frac{1 + \frac{\gamma-1}{2} M_1^2}{1 + \frac{\gamma-1}{2} M_L^2} \right]^{-\frac{\gamma+1}{2(\gamma-1)}} \quad (81)$$

$$\frac{P_Y}{P_{Sn}} = \frac{2\gamma M_n^2 - (\gamma-1)}{\gamma+1} \quad (82)$$

## Internal Compression

$$\left( \frac{A_{TH}}{A_C} \right) = \left[ 1 - \left( \frac{A_{LBLD}}{A_C} \right) \left( \frac{A_{LI}}{A_C} \right)^{-1} \right] \left( \frac{A_{LI}}{A_C} \right) \left( \frac{P_{TTH}}{P_{TL}} \right)^{-1} \left( \frac{M_{TH}}{M_L} \right)^{-1} \left[ \frac{1 + \frac{\gamma-1}{2} M_{TH}^2}{1 + \frac{\gamma-1}{2} M_L^2} \right]^{\frac{\gamma+1}{2(\gamma-1)}} \quad (83)$$

$$\frac{P_{TTH}}{P_{TL}} = \left( \frac{P_{T1}}{P_{TL}} \right) \left( \frac{P_{TTH}}{P_{T1}} \right) \quad (84)$$

$$\frac{P_{TTH}}{P_{T1}} = \prod_{i=1}^n \left( \frac{P_{Ti}}{P_{Ti-1}} \right) \quad (85)$$

$$\left( \frac{P_{Ti}}{P_{Ti-1}} \right) = \left[ \frac{(\gamma+1) M_{i-1}^2 \sin^2 \beta_i}{(\gamma-1) M_{i-1}^2 \sin^2 \beta_i + 2} \right]^{\frac{\gamma}{\gamma-1}} \left[ \frac{\gamma+1}{2\gamma M_{i-1}^2 \sin^2 \beta_i - (\gamma-1)} \right]^{\frac{1}{\gamma-1}} \quad (86)$$

$$M_i = \frac{1}{\sin(\beta_i - \theta)} \sqrt{\frac{(\gamma-1) M_{i-1}^2 \sin^2 \beta_i + 2}{2\gamma M_{i-1}^2 \sin^2 \beta_i - (\gamma-1)}} \quad (87)$$

Subsonic Diffusion

$$\frac{P_{T2}}{P_{TTH}} \Big|_{sub} = 1 - \left[ K_D \left( 1 - \frac{A_{TH}}{A_2} \right)^2 + K_O + K_F \right] K_M \left[ 1 - \left( 1 + \frac{\gamma-1}{2} M_{TH}^2 \right)^{-\frac{\gamma}{\gamma-1}} \right] \quad (88)$$

$$\frac{A_{TH}}{A_2} = \left( \frac{A_{TH}}{A_C} \right) \left( \frac{A_2}{A_C} \right)^{-1} \quad (89)$$

$$K_D = f(2\theta_D) \quad (90)$$

$$K_O \simeq 1.2 \left( \frac{Y_O}{L_D} \right) \quad (91)$$

$$K_F = 4f_D \left( \frac{L_D}{D_2} \right) \quad (92)$$

$$f_D \simeq 0.0025 \quad (93)$$

$$K_M = f(M_{TH}) \quad (94)$$

$$\begin{aligned} \frac{P_{T2}}{P_{TTH}} \Big|_{sup} &= 1 - \left[ K_D \left( 1 - \frac{A_{TH}}{A_2} \right)^2 + K_O + K_F \right] K_M \\ &\times \left[ 1 - \left( 1 + \frac{(\gamma-1)^2 M_{TH}^2 + 2(\gamma-1)}{4\gamma M_{TH}^2 - 2(\gamma-1)} \right)^{-\frac{\gamma}{\gamma-1}} \right] \left( \frac{P_{T2}}{P_{T1}} \right)_{NS} \end{aligned} \quad (95)$$

$$K_M = f \left( \sqrt{\frac{(\gamma-1) M_{TH}^2 + 2}{2\gamma M_{TH}^2 - (\gamma-1)}} \right) \quad (96)$$

$$\left( \frac{P_{T2}}{P_{T1}} \right)_{NS} = \left[ \frac{(\gamma+1) M_{NS}^2}{(\gamma-1) M_{NS}^2 + 2} \right]^{\frac{\gamma}{\gamma-1}} \left[ \frac{\gamma+1}{2\gamma M_{NS}^2 - (\gamma-1)} \right]^{\frac{1}{\gamma-1}} \quad (97)$$

Bleed Drag

$$C_{DBLD} = 2 \left( \frac{A_{LBD}}{A_C} \right) \left[ 1 - C_{TL} \cos \theta_X \eta_v C_T \left( \frac{V_{Xi}}{V_L} \right) \right] \quad (98)$$

$$C_{TL} = f \left( M_L, \frac{A_X}{A_{TH}}, \theta_X \right) \quad (99)$$

$$C_T = \frac{1}{\gamma M_{Xieff}^2} \left( \frac{A_X}{A_{Xieff}} \right) \left[ \left( \frac{P_X}{P_{Leff}} \right) (1 + \gamma M_X^2) - 1 \right] \quad (100)$$

$$M_{Xieff} = \sqrt{\frac{2}{\gamma-1} \left[ \left( \frac{P_{TBL}}{P_{Leff}} \right)^{\frac{\gamma-1}{\gamma}} - 1 \right]} \quad (101)$$

$$\frac{P_{TBL}}{P_{Leff}} = \left( \frac{P_{TBL}}{P_{TL}} \right) \left[ 1 + \frac{\gamma-1}{2} M_L^2 \right]^{\frac{\gamma}{\gamma-1}} \left( \frac{P_L}{P_{Leff}} \right) \quad (102)$$



$$\frac{P_L}{P_{Leff}} = f(M_L, \theta_X) \quad (103)$$

$$\frac{A_X}{A_{Xieff}} = \left(\frac{A_X}{A_{TH}}\right) \left(\frac{\gamma+1}{2}\right)^{\frac{\gamma+1}{2(\gamma-1)}} M_{Xieff} \left[1 + \frac{\gamma-1}{2} M_{Xieff}^2\right]^{-\frac{\gamma+1}{2(\gamma-1)}} \quad (104)$$

$$\left(\frac{A_X}{A_{TH}}\right) = \left(\frac{\gamma+1}{2}\right)^{-\frac{\gamma+1}{2(\gamma-1)}} \frac{1}{M_X} \left[1 + \frac{\gamma-1}{2} M_X^2\right]^{\frac{\gamma+1}{2(\gamma-1)}} \quad (105)$$

$$\frac{P_X}{P_{Leff}} = \left(\frac{P_{TBL}}{P_{Leff}}\right) \left[1 + \frac{\gamma-1}{2} M_X^2\right]^{-\frac{\gamma}{\gamma-1}} \quad (106)$$

$$\frac{V_{Xi}}{V_L} = \left(\frac{M_{Xi}}{M_L}\right) \left[\frac{1 + \frac{\gamma-1}{2} M_{Xi}^2}{1 + \frac{\gamma-1}{2} M_L^2}\right]^{-\frac{1}{2}} \quad (107)$$

$$M_{Xi} = \sqrt{\frac{2}{\gamma-1} \left[ \left(\frac{P_{TBL}}{P_L}\right)^{\frac{\gamma-1}{\gamma}} - 1 \right]} \quad (108)$$

$$\frac{P_{TBL}}{P_L} = \left(\frac{P_{TBL}}{P_{Leff}}\right) \left(\frac{P_{Leff}}{P_L}\right) \quad (109)$$

#### Bypass Drag

$$C_{D_{BYP}} = 2 \left(\frac{A_{LBYP}}{A_C}\right) \left[1 - C_{TL} \cos \theta_X \eta_v C_T \left(\frac{V_{Xi}}{V_L}\right)\right] \quad (110)$$

$$M_{Xieff} = \sqrt{\frac{2}{\gamma-1} \left[ \left(\frac{P_{TBP}}{P_{Leff}}\right)^{\frac{\gamma-1}{\gamma}} - 1 \right]} \quad (111)$$

$$\frac{P_{TBP}}{P_{Leff}} = \left(\frac{P_{TBP}}{P_{T2}}\right) \left(\frac{P_{T2}}{P_{TL}}\right) \left[1 + \frac{\gamma-1}{2} M_L^2\right]^{\frac{\gamma}{\gamma-1}} \left(\frac{P_L}{P_{Leff}}\right) \quad (112)$$

$$\frac{P_X}{P_{Leff}} = \left(\frac{P_{TBP}}{P_{Leff}}\right) \left[1 + \frac{\gamma-1}{2} M_X^2\right]^{-\frac{\gamma}{\gamma-1}} \quad (113)$$

$$M_{Xi} = \sqrt{\frac{2}{\gamma-1} \left[ \left(\frac{P_{TBP}}{P_L}\right)^{\frac{\gamma-1}{\gamma}} - 1 \right]} \quad (114)$$

$$\frac{P_{TBP}}{P_L} = \left(\frac{P_{TBP}}{P_{Leff}}\right) \left(\frac{P_{Leff}}{P_L}\right) \quad (115)$$

### Cowl Lip Suction

$$C_{LS} = (1 - K_\alpha) C_{D_{ADD}} - (K_\beta - K_\alpha) C_{D2} \quad (116)$$

$$K_\alpha = f(\sigma \theta_e, M_L) \quad (117)$$

$$\sigma = \begin{cases} 1, & M_L > 0.8 \\ f\left(\frac{A_{LI}}{A_C}, \theta_e\right), & M_L \leq 0.8 \end{cases} \quad (118)$$

$$\theta_e \approx \sqrt{2}\Omega \quad (119)$$

$$\Omega = \int_1^{\max} \frac{\left(\frac{Y}{Y_C}\right) \cos \bar{\psi}}{1 + 2\pi \left(\frac{X - X_C}{Y_C}\right)^2} d\left(\frac{Y}{Y_C}\right) \quad (120)$$

$$\bar{\psi} = \tan^{-1} \left( \frac{Y - Y_C}{X - X_C} \right) \quad (121)$$

$$K_\beta = \begin{cases} f(\theta_e, M_L), & M_L \geq 1 \\ 0, & M_L < 1 \end{cases} \quad (122)$$

$$C_{D2} = \begin{cases} f\left(\frac{A_{LI}}{A_C}, M_L\right), & M_L > 1 \\ 0, & M_L \leq 1 \end{cases} \quad (123)$$

$$C_{D_{SPL}} = C_{D_{ADD}} - C_{LS} \quad (124)$$

### Cowl Lip and Wave Drag

$$C_{D_{CWL}} = C_{D_{LIP}} + C_{D_{WAV}} \quad (125)$$

$$C_{D_{LIP}} = \frac{2}{\gamma M_L^2} \left\{ \frac{1}{2} \left[ \frac{(\gamma + 1) M_L^2}{2} \right]^{\frac{\gamma}{\gamma-1}} \left[ \frac{\gamma + 1}{2\gamma M_L^2 - (\gamma - 1)} \right]^{\frac{1}{\gamma-1}} + \frac{1}{2} \left[ \frac{2\gamma M_L^2 - (\gamma - 1)}{\gamma + 1} \right] - 1 \right\} \frac{A_x}{A_C} \quad (126)$$

### Two-Dimensional Inlets

$$C_{D_{WAV}} = \frac{2}{\gamma M_L^2} \int \left( \frac{P}{P_L} - 1 \right) \frac{dA_x}{A_C} \quad (127)$$

$$C_{D_{WAV}} = \frac{2}{\gamma M_L^2} \sum_i^{N_C} \left( \frac{P_i}{P_L} - 1 \right) \frac{A_{xi}}{A_C} \quad (128)$$

### Axisymmetric Inlets

$$C_{D_{WAV}} = \int C_P \frac{dA_x}{A_C} \quad (129)$$

$$C_P = -2u = -2 \frac{\partial \phi}{\partial x} \quad (130)$$

$$(1 - M_L^2) \frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial r^2} + \frac{1}{r} \frac{\partial \phi}{\partial r} = 0 \quad (131)$$

$$\phi(x, r) = \int_0^{x-\lambda r} \frac{f(\xi) d\xi}{\sqrt{(x-\xi)^2 - \lambda^2 r^2}} \quad (132)$$

$$u(x, r) = \int_0^{x-\lambda r} \frac{f'(\xi) d\xi}{\sqrt{(x-\xi)^2 - \lambda^2 r^2}} \quad (133)$$

$$v(x, r) = -\frac{1}{r} \int_0^{x-\lambda r} \frac{(x-\xi) f'(\xi) d\xi}{\sqrt{(x-\xi)^2 - \lambda^2 r^2}} \quad (134)$$

$$\lambda^2 = M_L^2 - 1 \quad (135)$$

$$\frac{dR}{dX} = R'(X) = -\frac{1}{R} \int_0^{X-\lambda R} \frac{(X-\xi) f'(\xi) d\xi}{\sqrt{(X-\xi)^2 - \lambda^2 R^2}} \quad (136)$$

$$-R'_n R_n = \sum_{i=1}^n f'_i \frac{1}{R_n} \int_{\xi_{i-1}}^{\xi_i} \frac{(X_n - \xi) d\xi}{\sqrt{(X_n - \xi)^2 - \lambda^2 R_n^2}} \quad (137)$$

$$\xi_0 = 0 \quad (138)$$

$$\xi_n = X_n - \lambda R_n \quad (139)$$

$$-R'_n R_n = -\sum_{i=1}^n f'_i \left( \sqrt{(X_n - \xi_i)^2 - \lambda^2 R_n^2} - \sqrt{(X_n - \xi_{i-1})^2 - \lambda^2 R_n^2} \right) \quad (140)$$

$$f'_n = \frac{-R'_n R_n + \sum_{i=1}^{n-1} f'_i \left( \sqrt{(X_n - \xi_i)^2 - \lambda^2 R_n^2} - \sqrt{(X_n - \xi_{i-1})^2 - \lambda^2 R_n^2} \right)}{\sqrt{(X_n - \xi_{n-1})^2 - \lambda^2 R_n^2}} \quad (141)$$

$$C_P = -2 \sum_{i=1}^n f'_i \int_{\xi_{i-1}}^{\xi_i} \frac{d\xi}{\sqrt{(X_n - \xi)^2 - \lambda^2 R_n^2}} \quad (142)$$

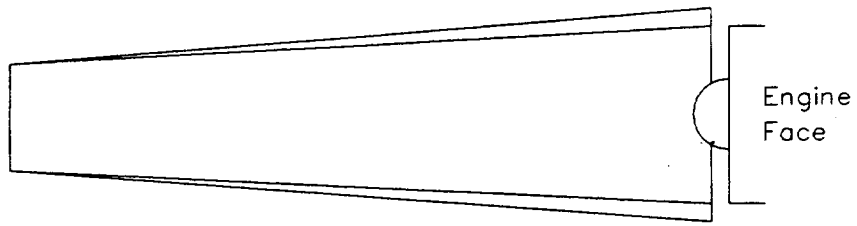
$$C_P = -2 \sum_{i=1}^n f'_i \ln \left[ \frac{X_n - \xi_{i-1} + \sqrt{(X_n - \xi_{i-1})^2 - \lambda^2 R_n^2}}{X_n - \xi_i + \sqrt{(X_n - \xi_i)^2 - \lambda^2 R_n^2}} \right] \quad (143)$$

Lip Losses

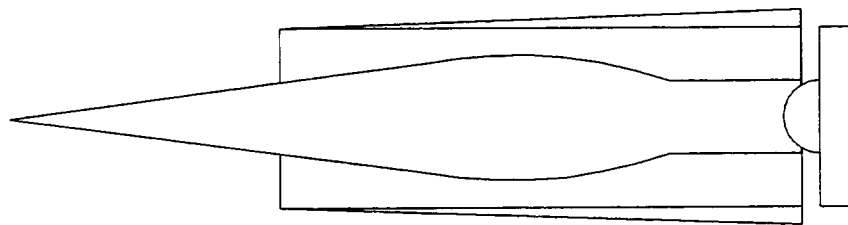
$$\frac{P_{T1}}{P_{TL}} \Big|_{sl} = \frac{\left[ \frac{1 + \frac{\gamma-1}{2} M_1^2}{1 + \frac{\gamma-1}{2} M_L^2} \right]^{\frac{\gamma+1}{2(\gamma-1)}}}{(1 + \gamma M_1^2) \left[ \frac{1 + \frac{\gamma-1}{2} M_1^2}{1 + \frac{\gamma-1}{2} M_L^2} \right]^{-\frac{1}{2}} - \gamma M_1 M_L} \quad (144)$$

$$\frac{1}{M_1} \left[ 1 + \frac{\gamma-1}{2} M_1^2 \right]^{\frac{\gamma+1}{2(\gamma-1)}} = \left( \frac{A_{TH}}{A_1} \right)^{-1} \frac{1}{M_{TH}} \left[ 1 + \frac{\gamma-1}{2} M_{TH}^2 \right]^{\frac{\gamma+1}{2(\gamma-1)}} \quad (145)$$

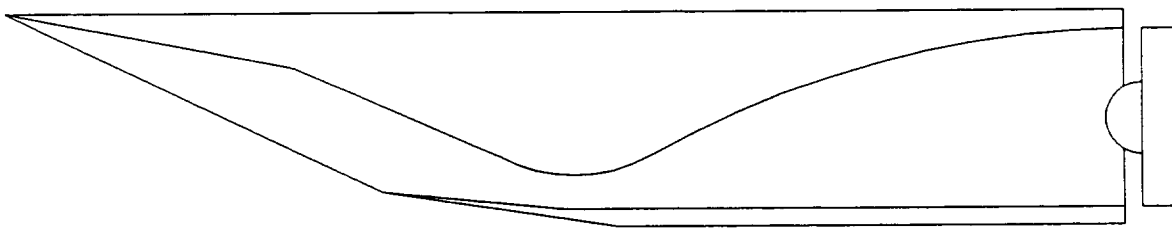
$$\frac{P_{T1}}{P_{TL}} = \frac{1}{1 + \exp^{-1} \left[ 4.66 \left( \frac{r_C}{Y_C} \right) \right] \left[ \left( \frac{P_{T1}}{P_{TL}} \Big|_{sl} \right)^{-1} - 1 \right]} \quad (146)$$



Pitot



Axisymmetric

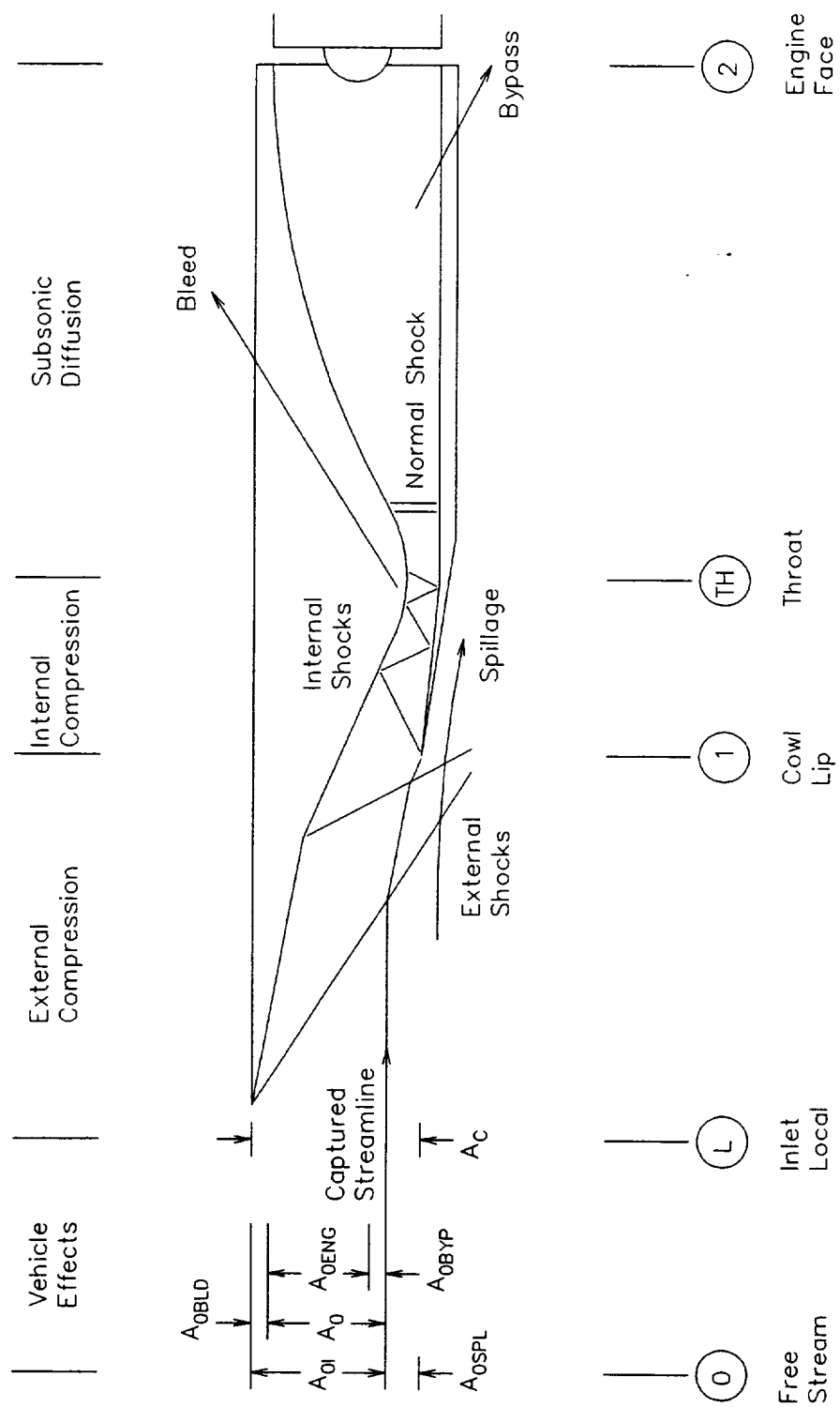


Two-Dimensional

Figure 1

Common Inlet Geometric Types

# Basic Inlet Modeling Elements



## Inlet Flow Stations

Figure 2

Basic Inlet Modeling Elements Incorporated in the Analyses

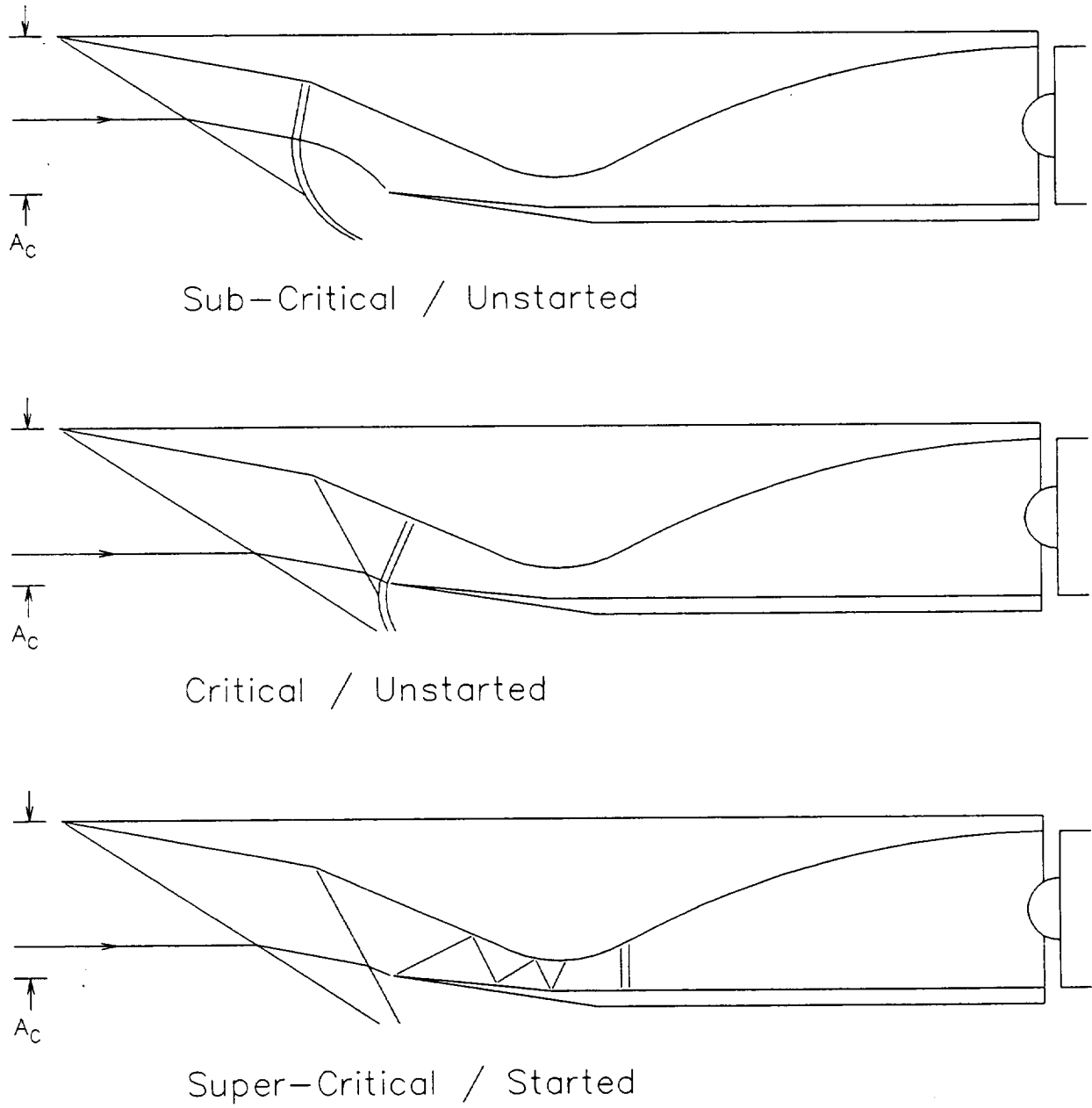


Figure 3

Mixed-Compression Inlet Modes of Operation

# Vehicle Forebody Model

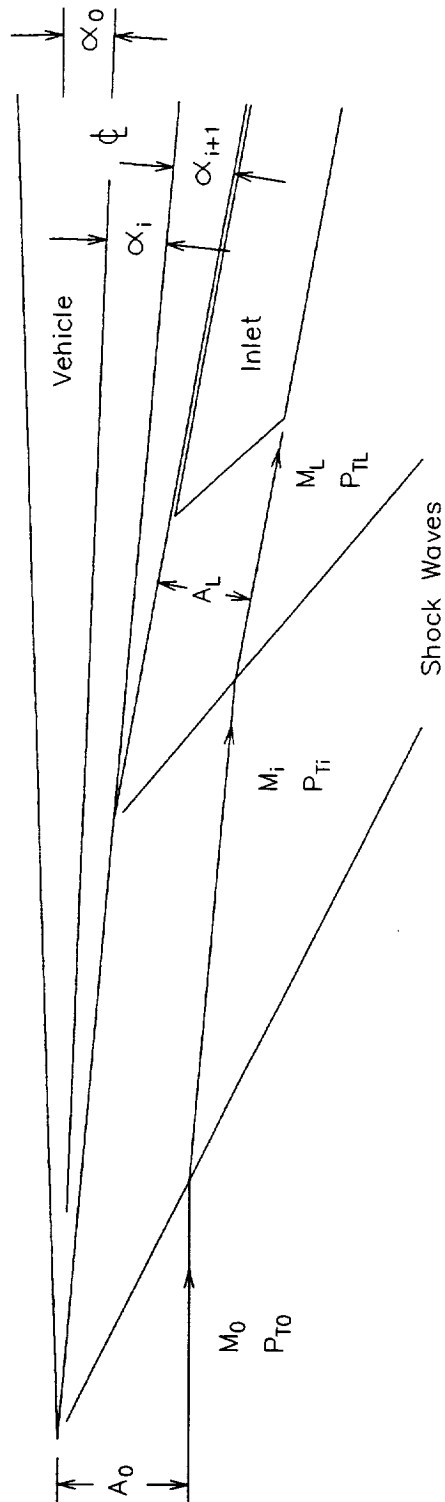


Figure 4

Vehicle Forebody Modeling Elements



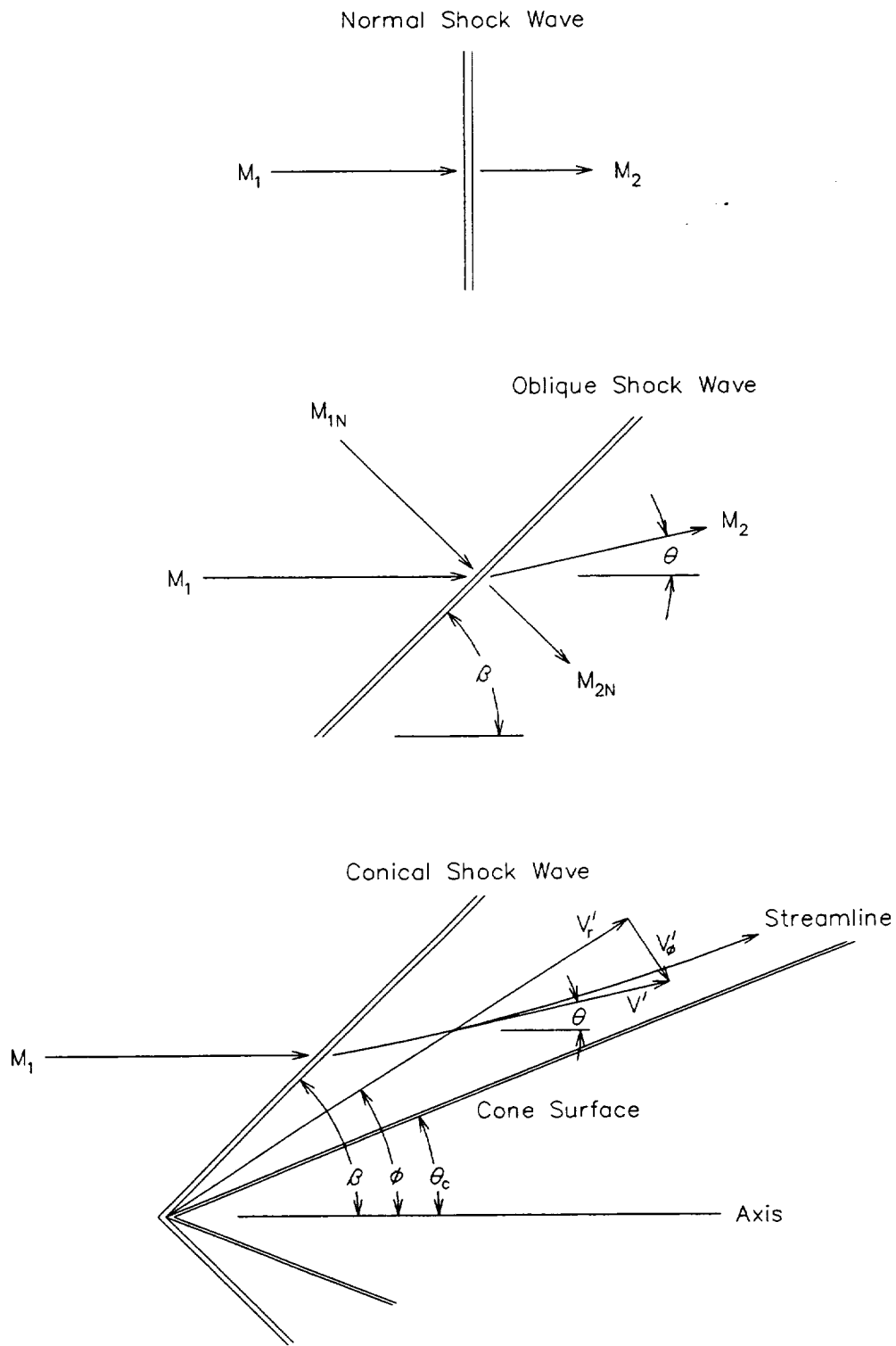


Figure 5

Basic Shock Wave Types Incorporated in the Analyses

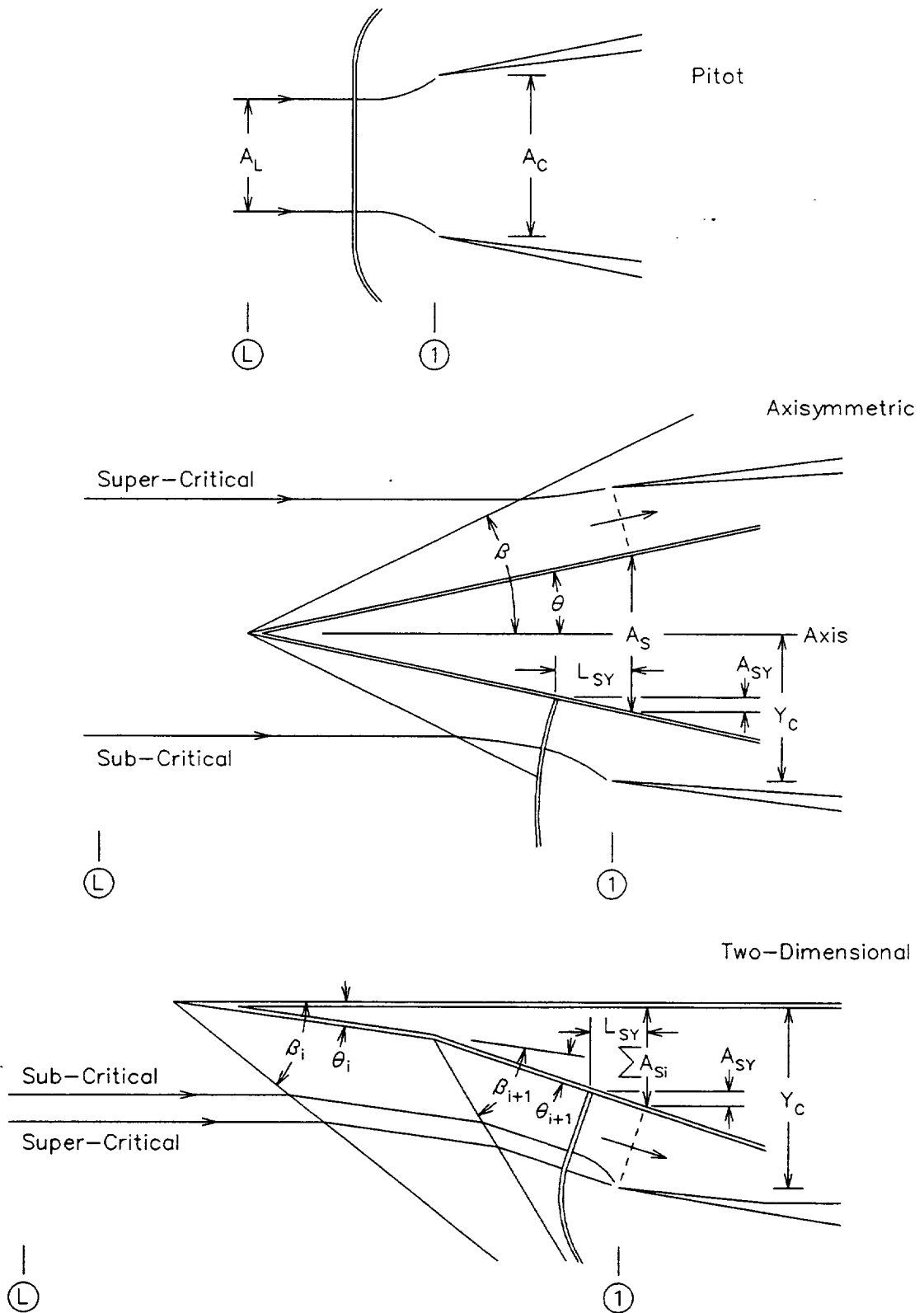


Figure 6 External Compression Modeling Elements

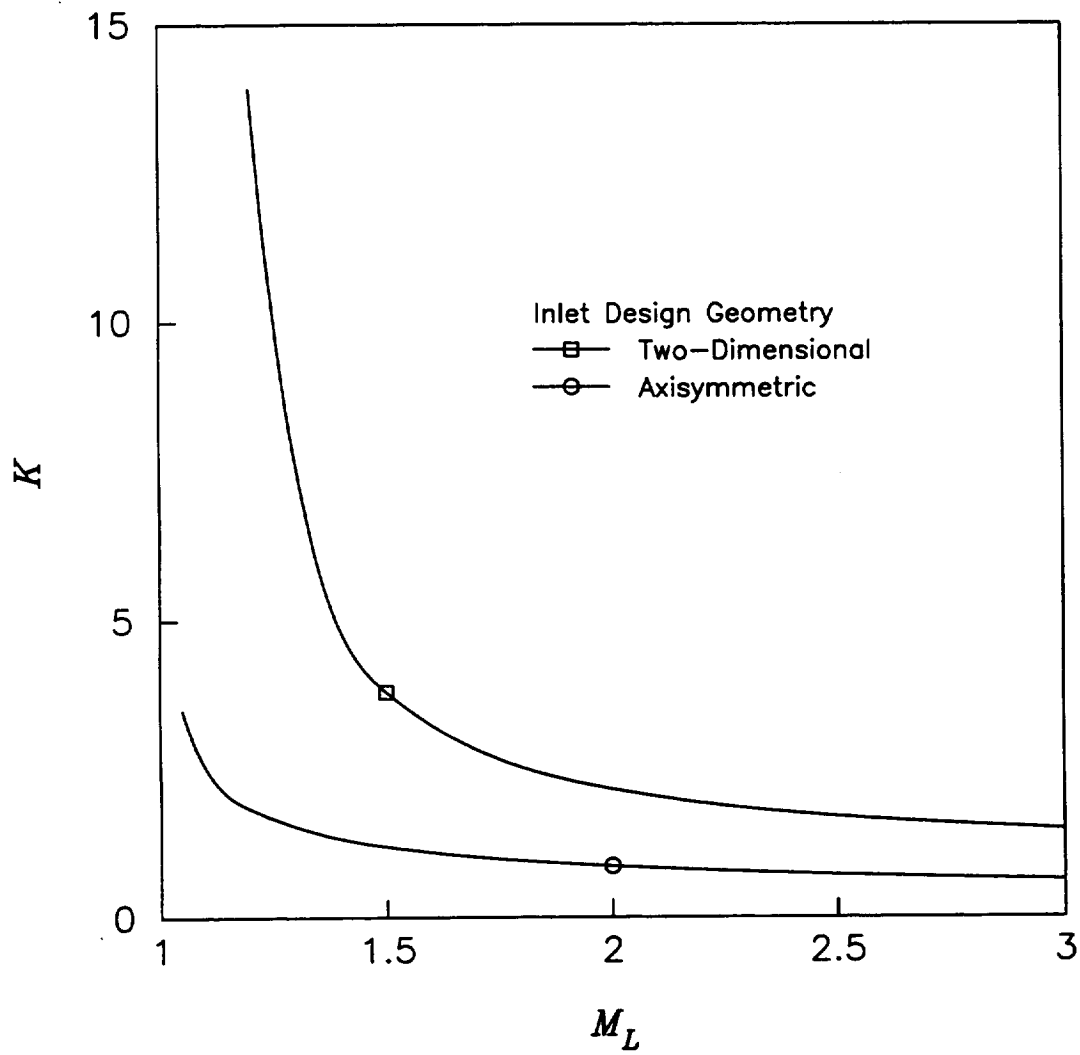


Figure 7

Unstarted Inlet Shock Wave Standoff Factor,  $K$

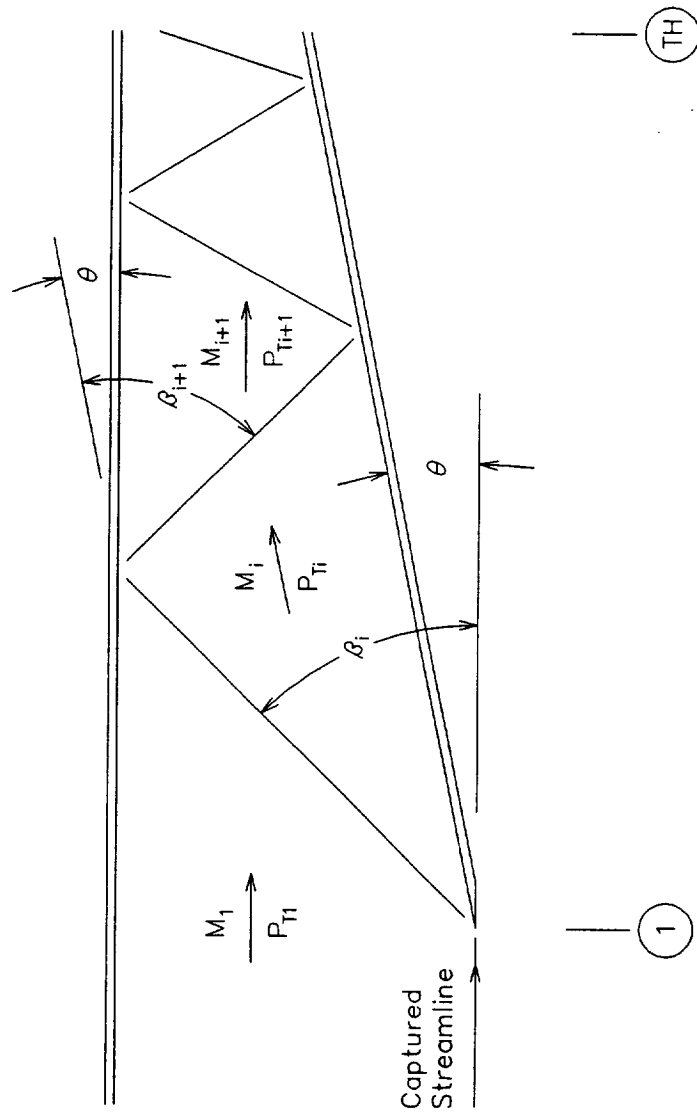


Figure 8

Internal Compression Modeling Elements

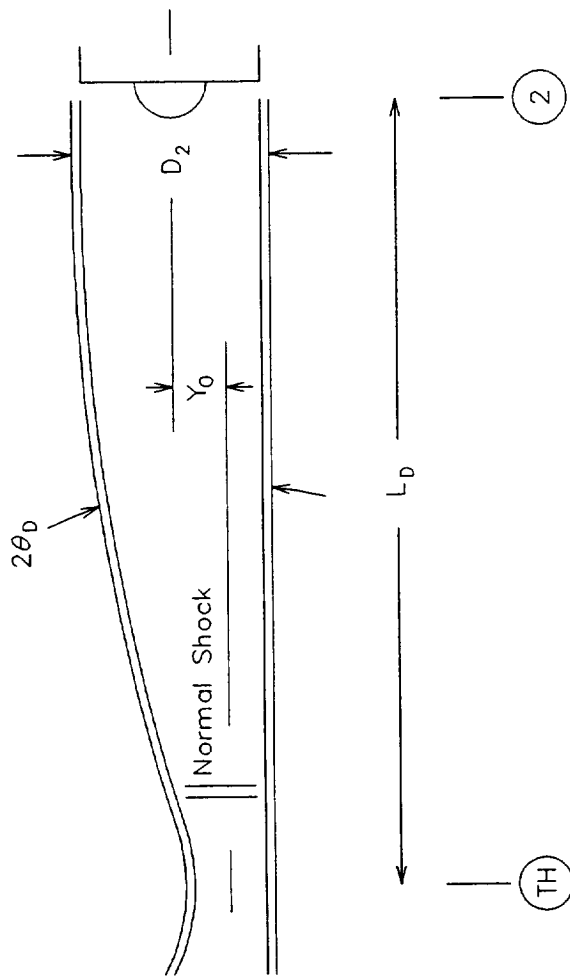


Figure 9

Subsonic Diffusion Modeling Elements

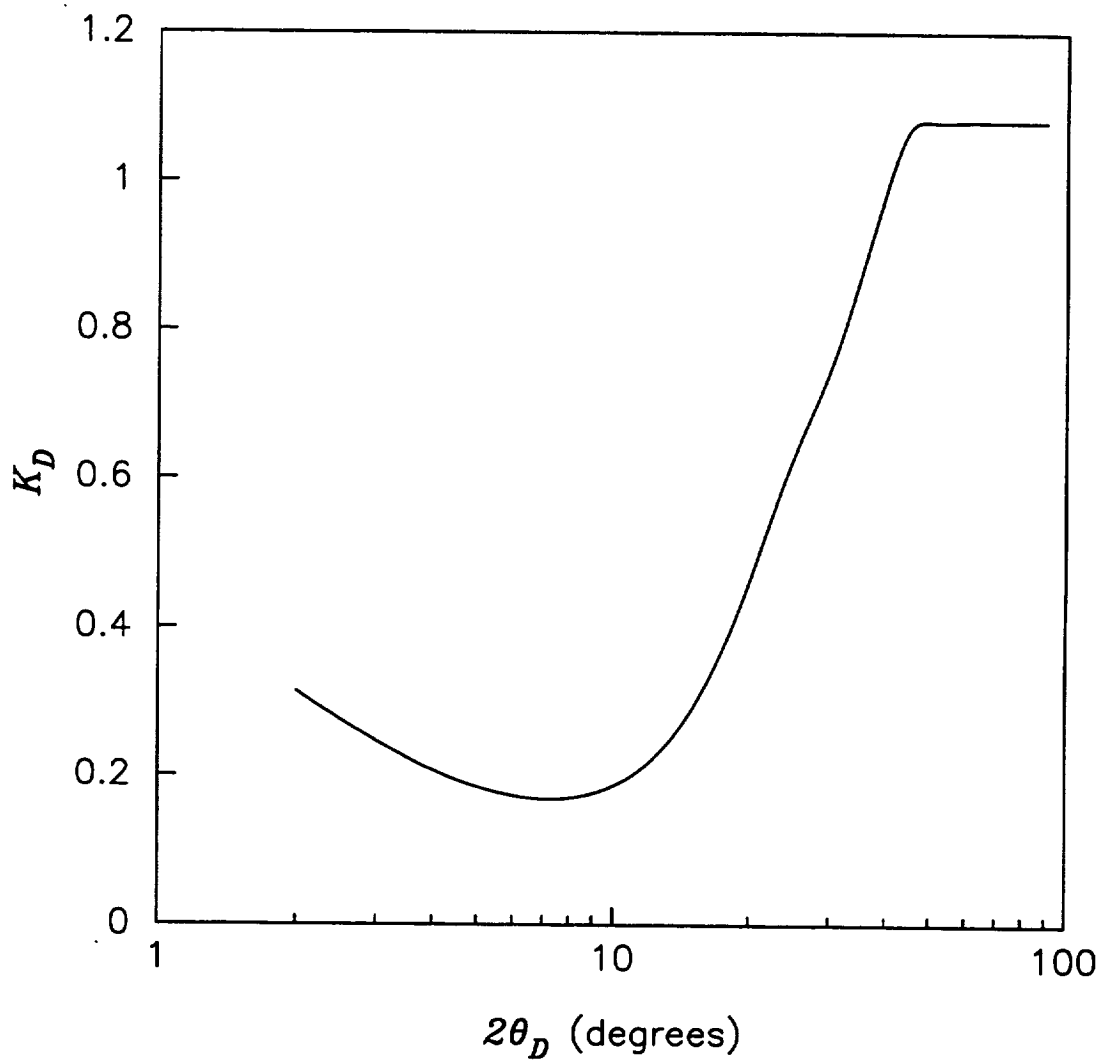


Figure 10

Subsonic Diffuser Total Pressure Loss Factor,  $K_D$

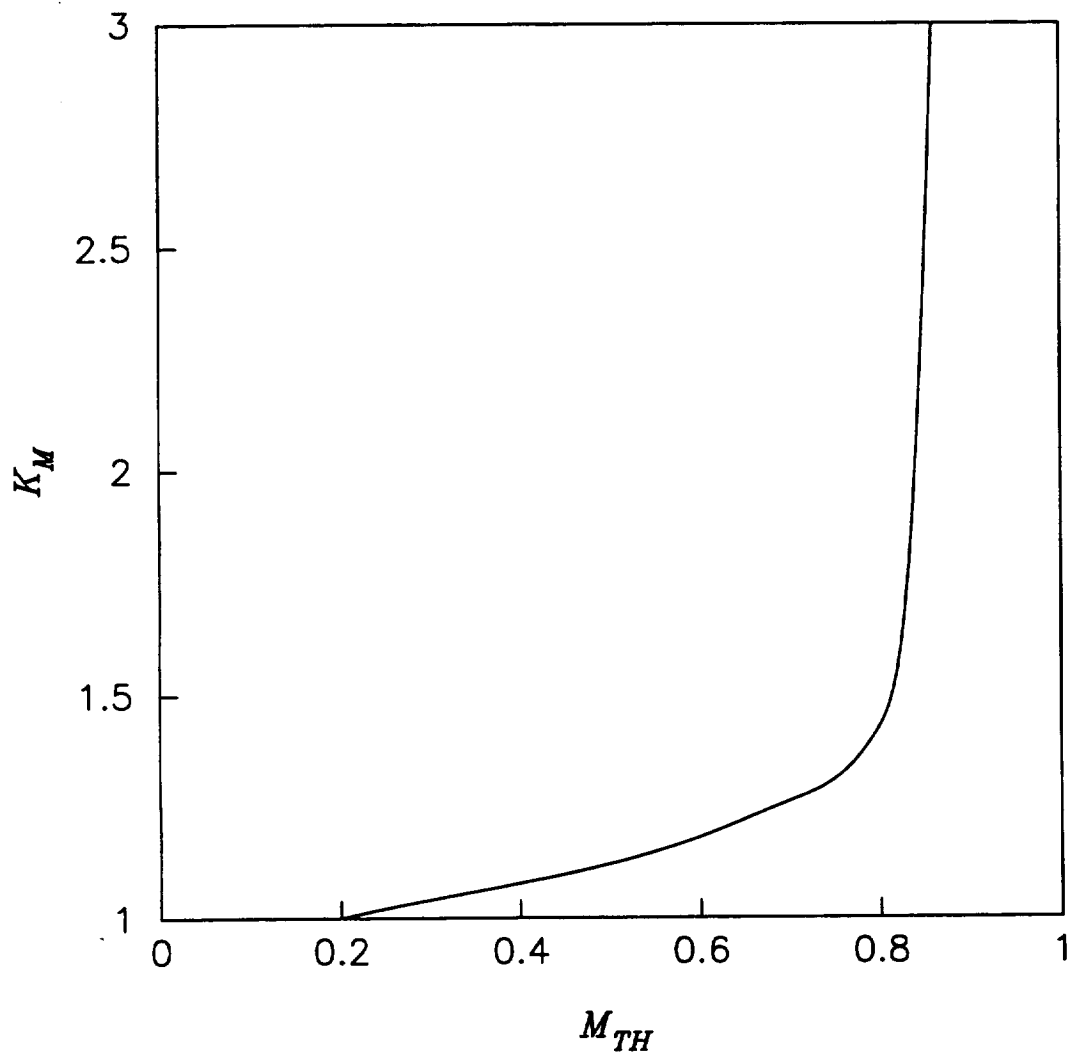


Figure 11

Subsonic Diffuser Throat Mach Number Factor,  $K_M$

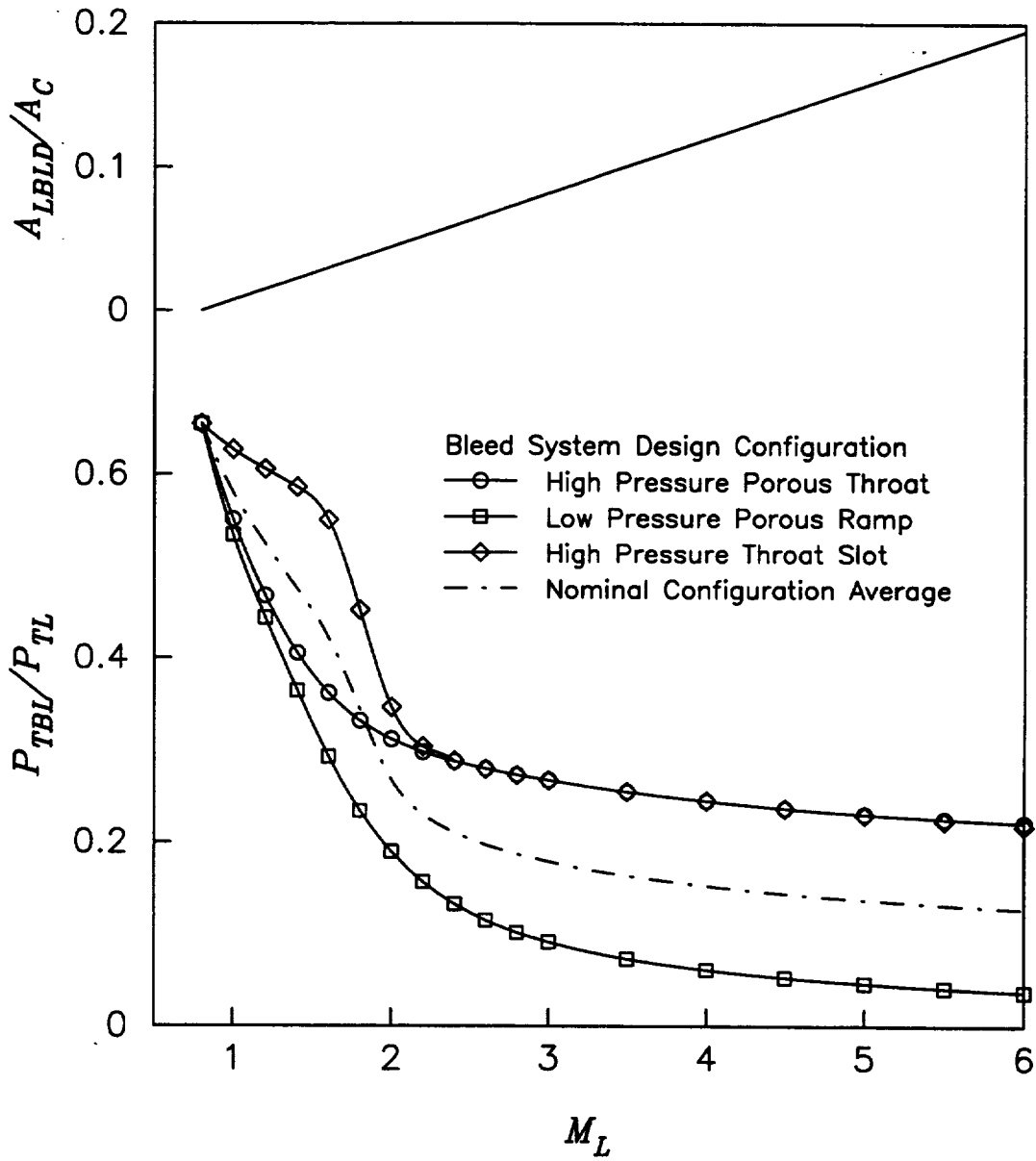


Figure 12

Bleed System Operating Characteristics



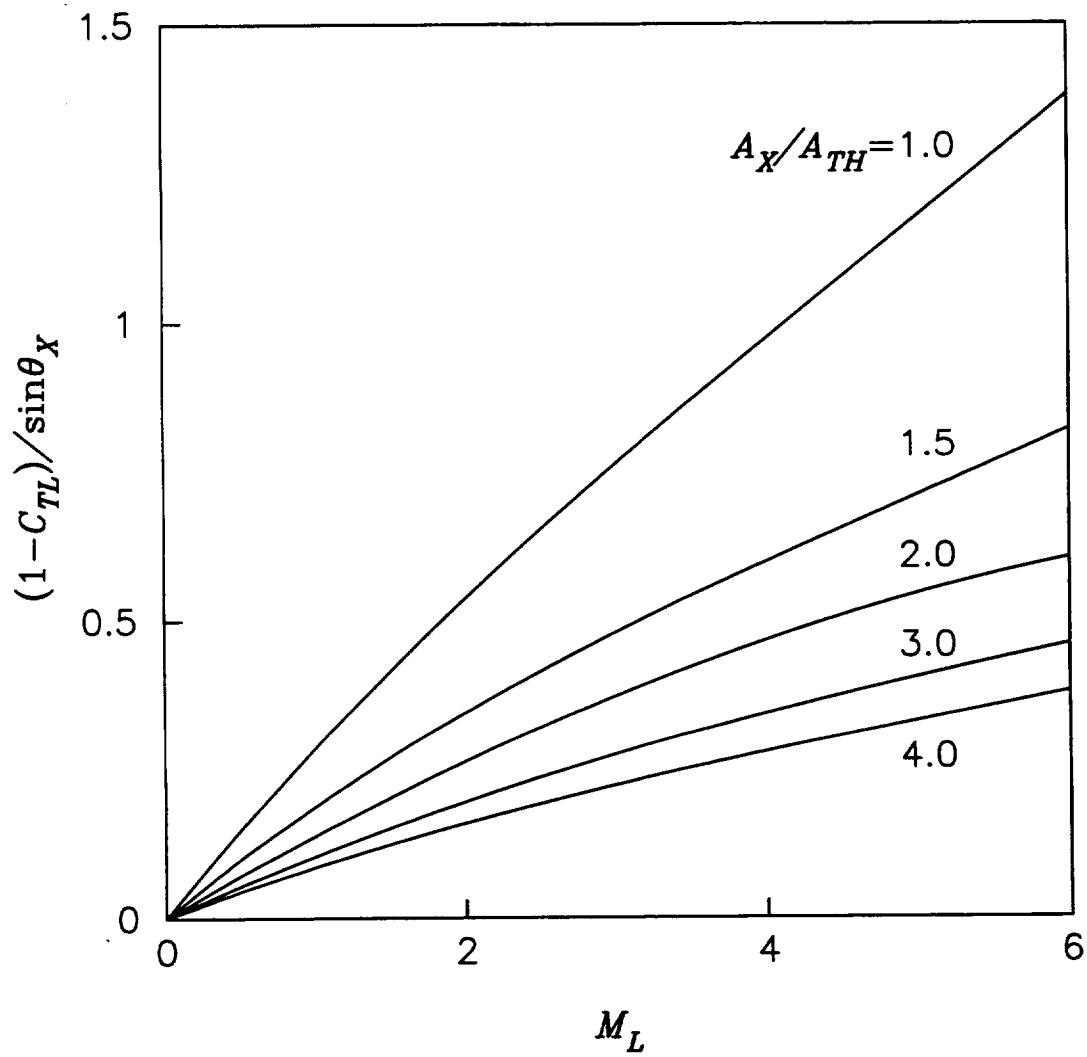


Figure 13

Oblique Exit Nozzle Drag Factor

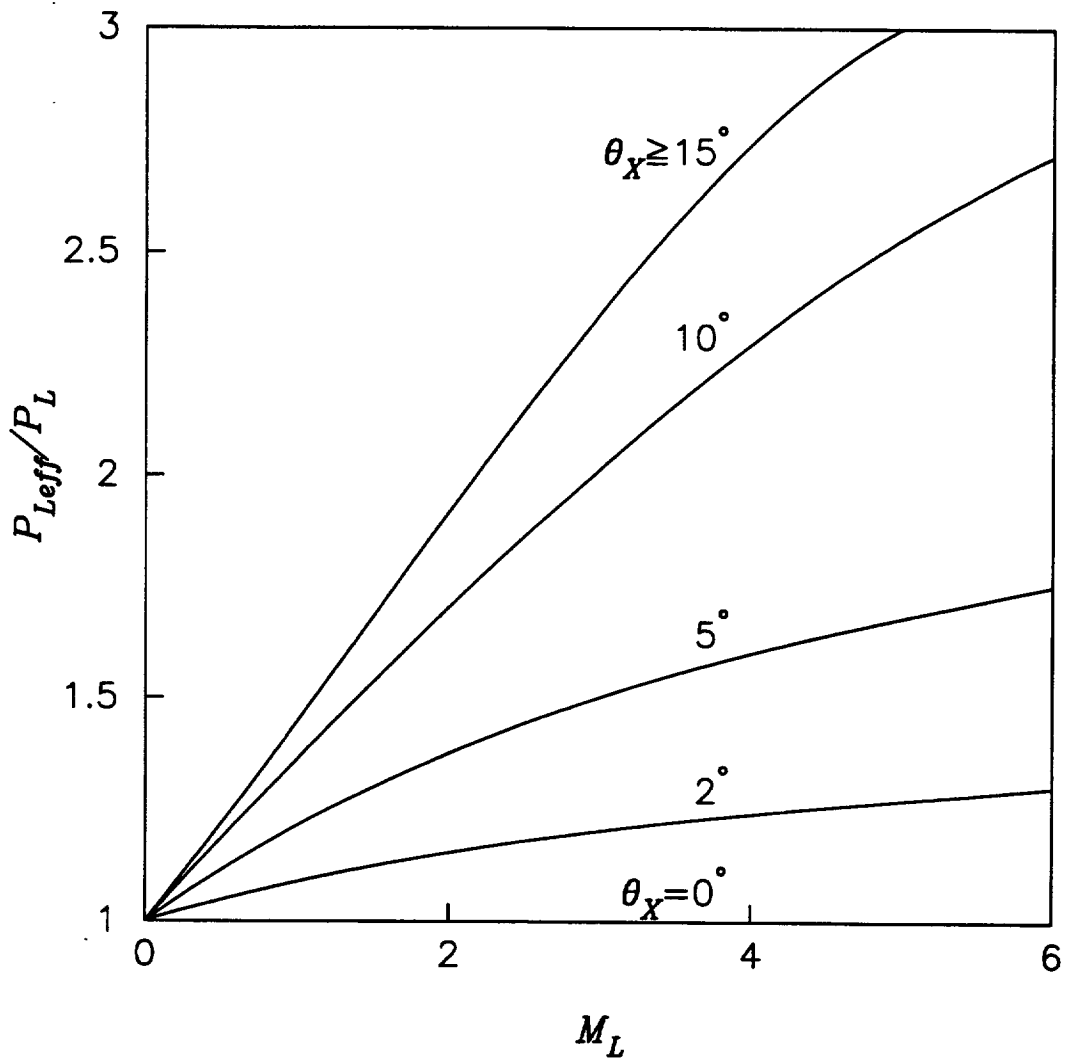


Figure 14

Effective Nozzle Discharge Pressure for Oblique Exits

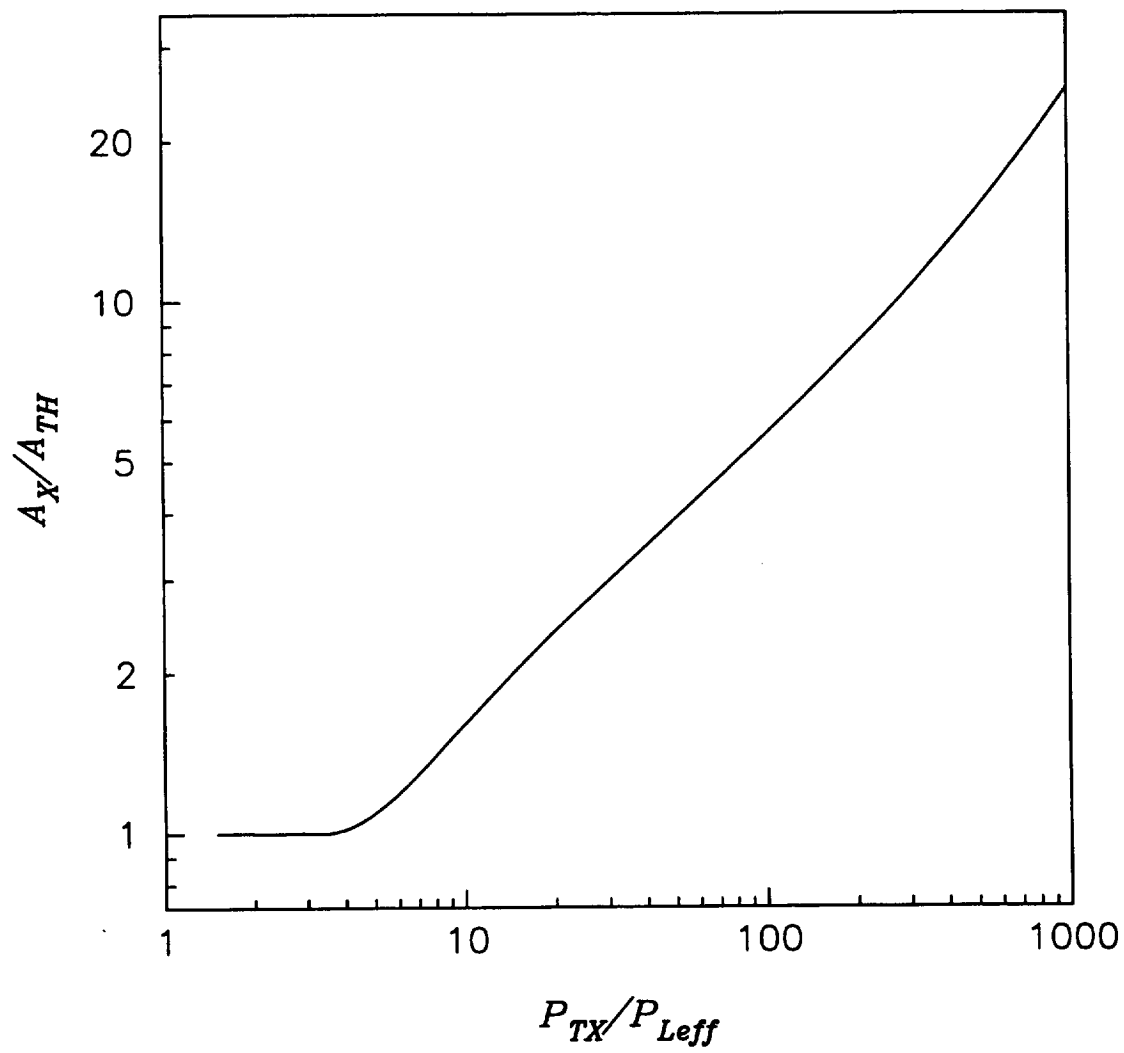


Figure 15

Bleed and Bypass System Nozzle Exit Area Ratio

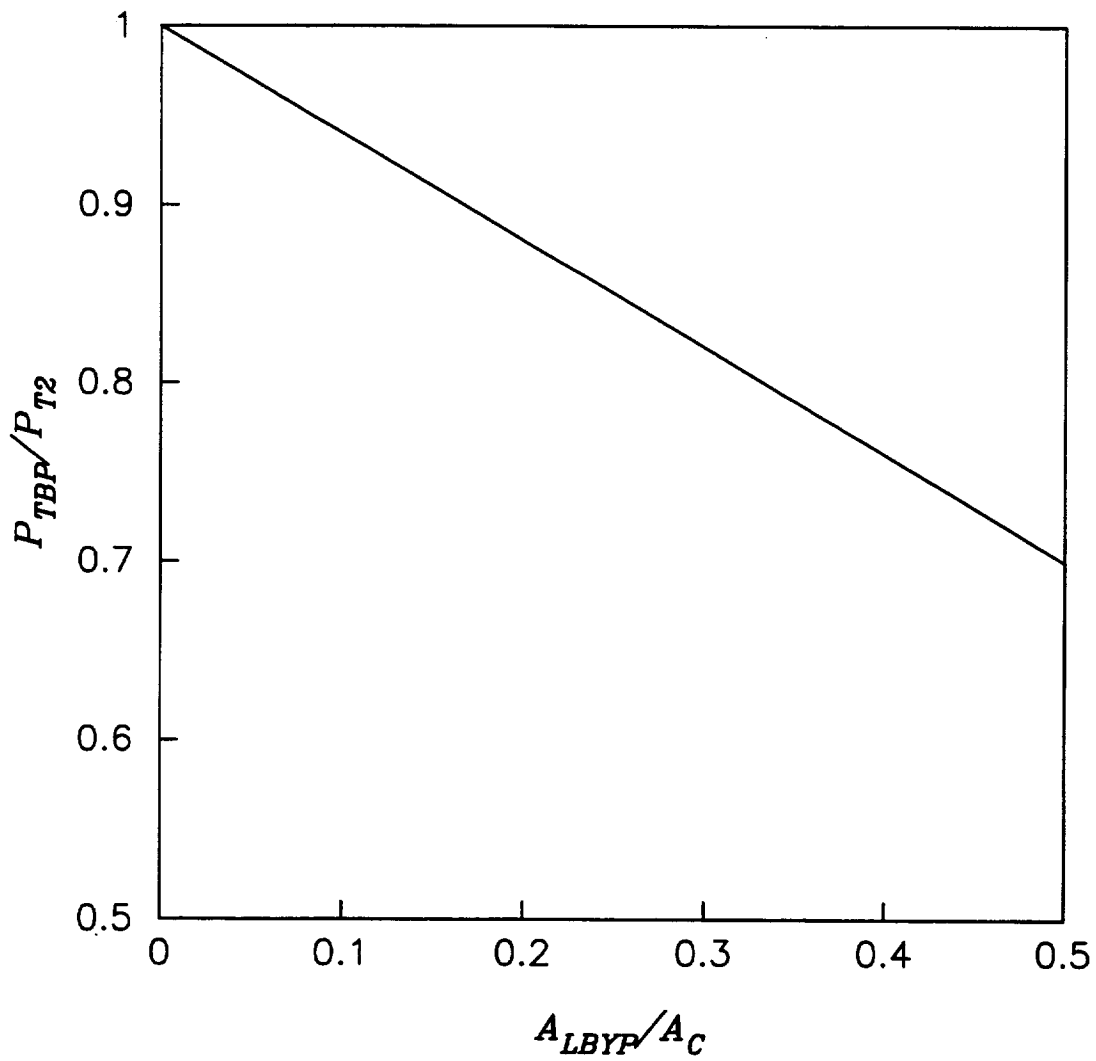


Figure 16

Bypass System Total Pressure Loss

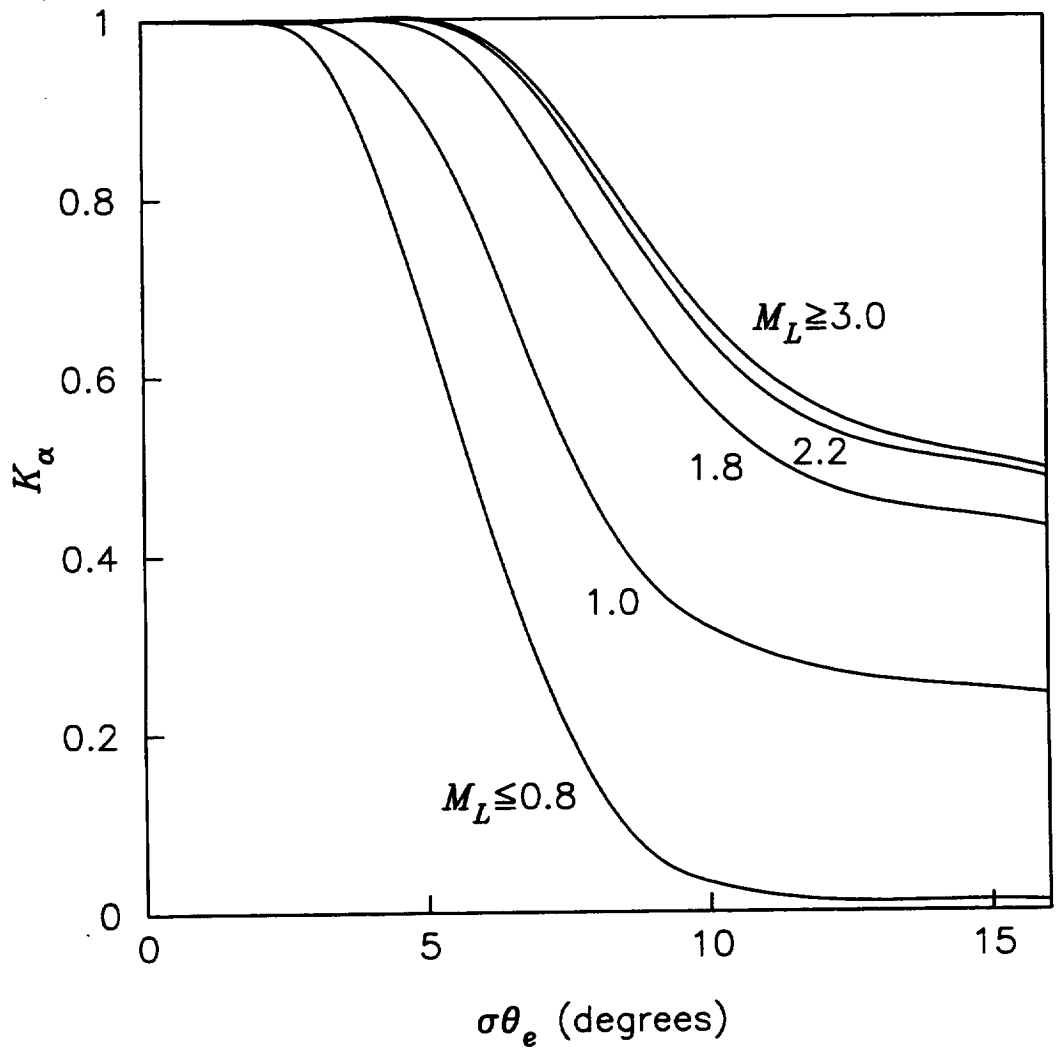


Figure 17

Cowl Lip Suction Factor,  $K_\alpha$

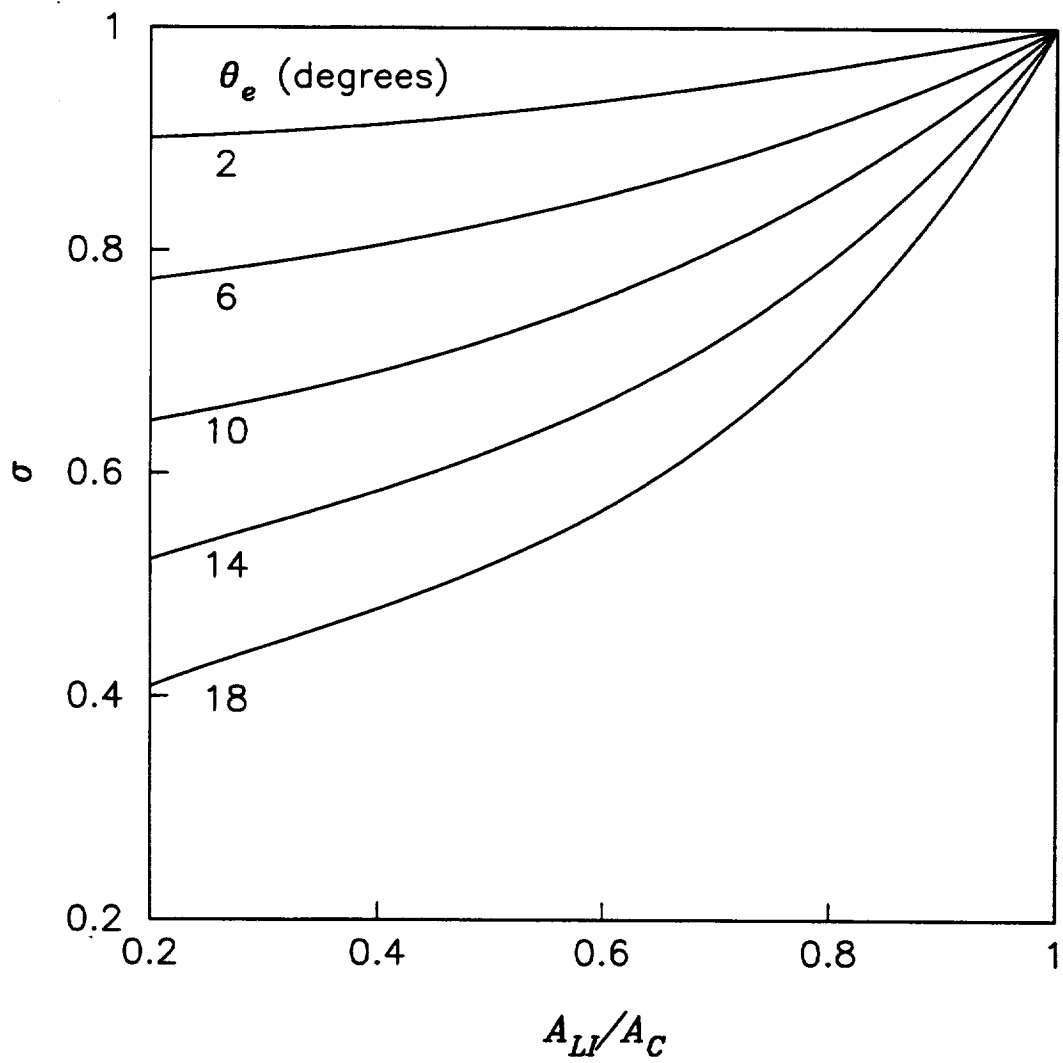


Figure 18 Cowl Lip Angle Correction Factor,  $\sigma$

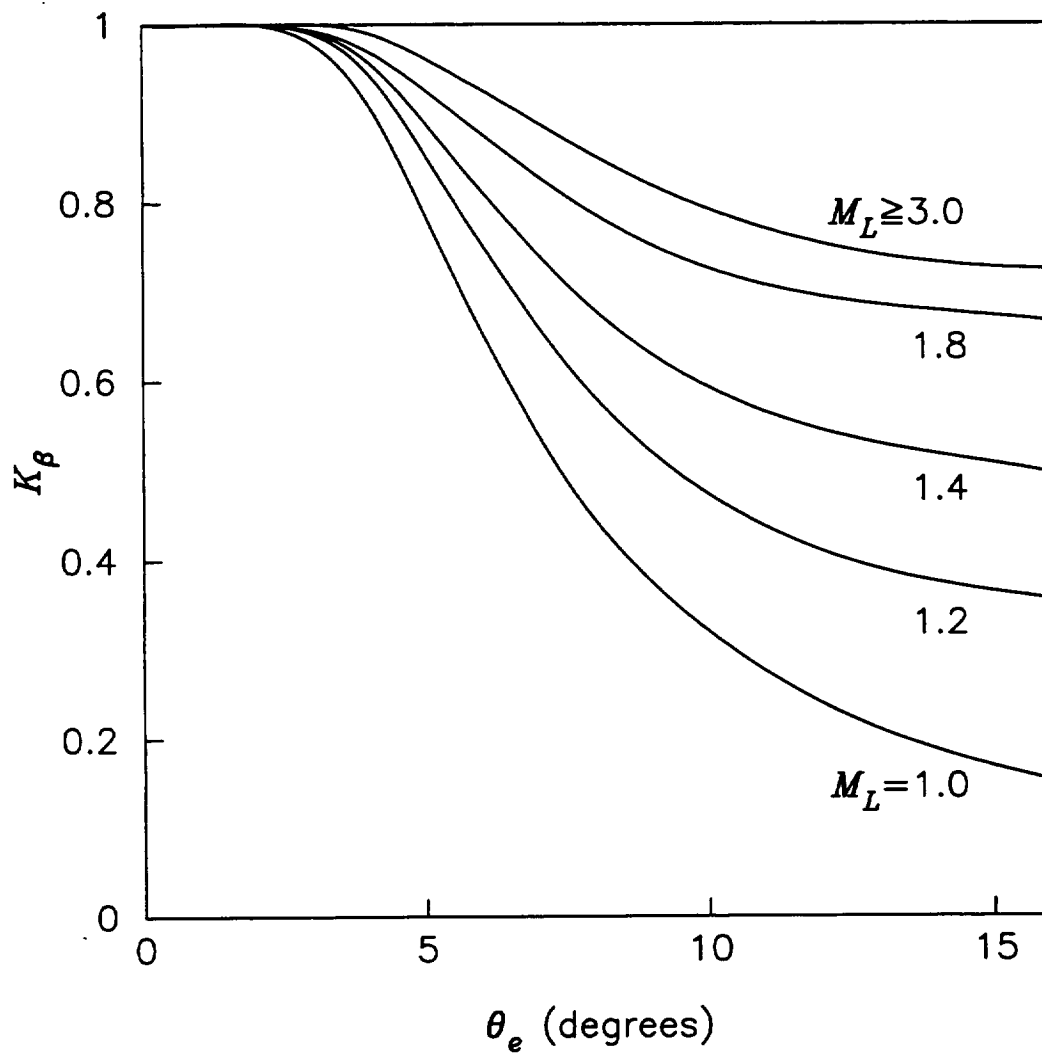


Figure 19

Cowl Lip Suction Factor,  $K_\beta$

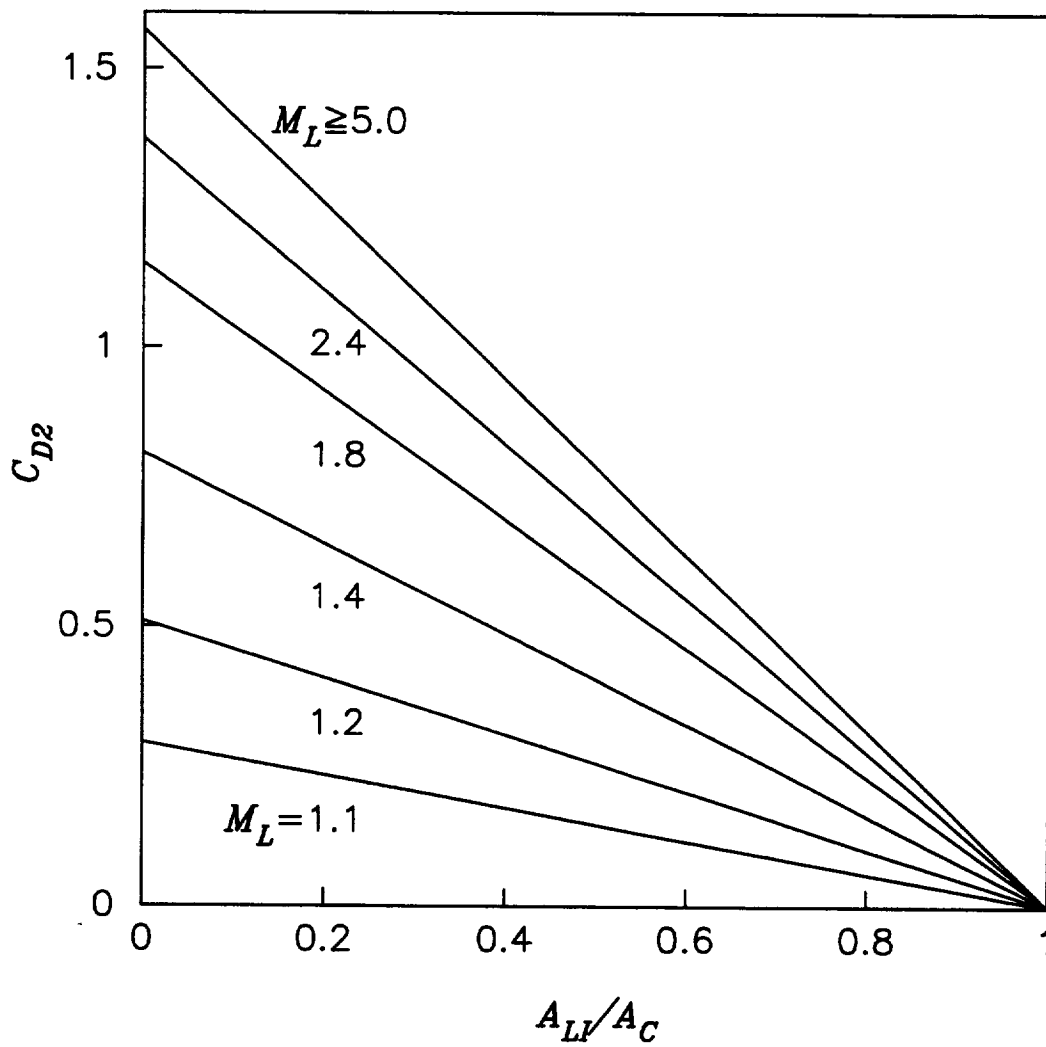


Figure 20 Cowl Lip Suction Factor,  $C_{D2}$



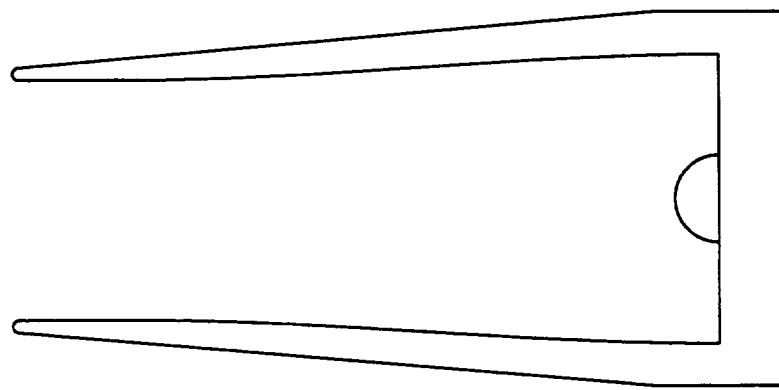


Figure 21

Pitot Inlet Geometry

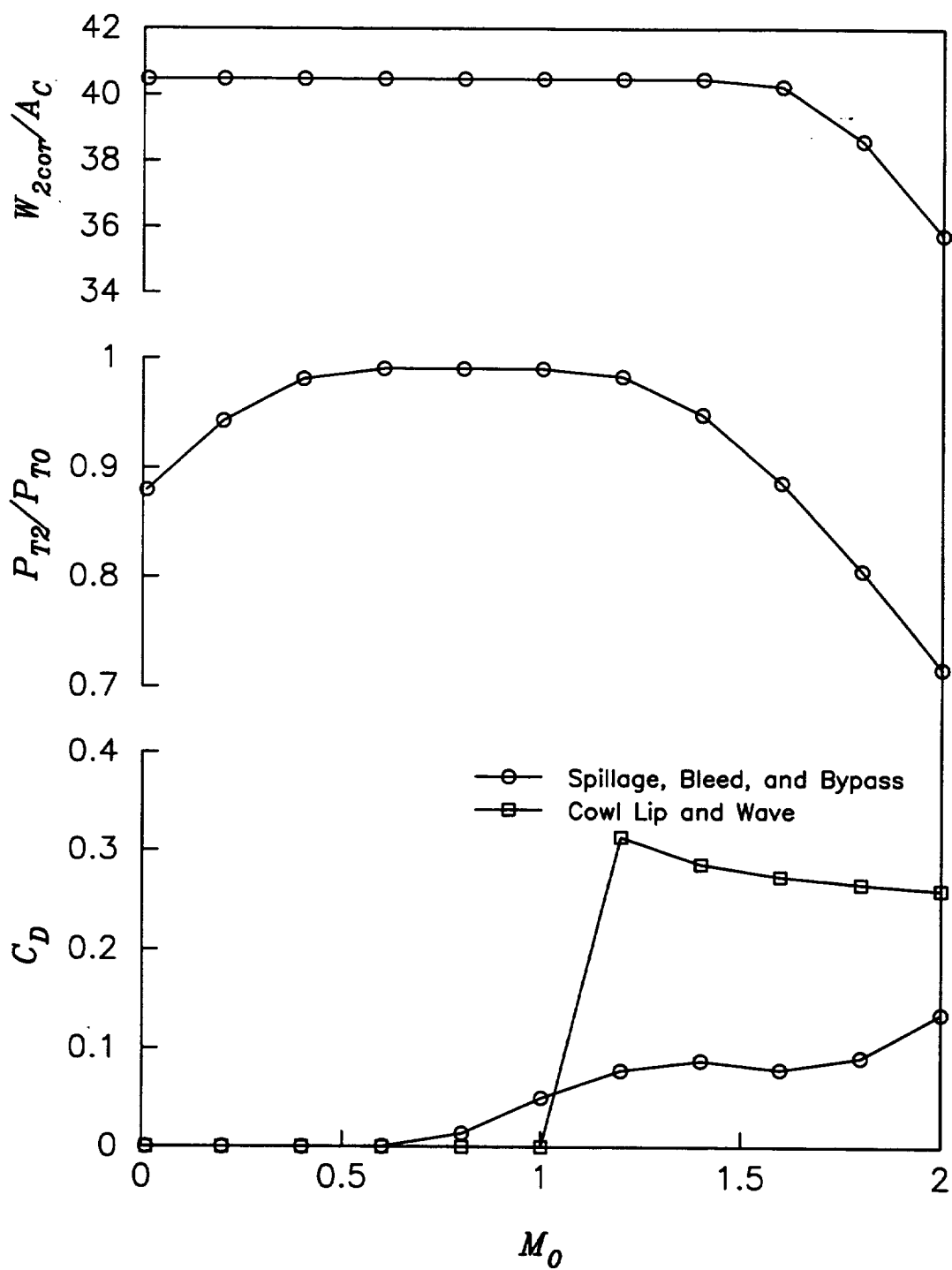


Figure 22 Pitot Inlet Performance Summary

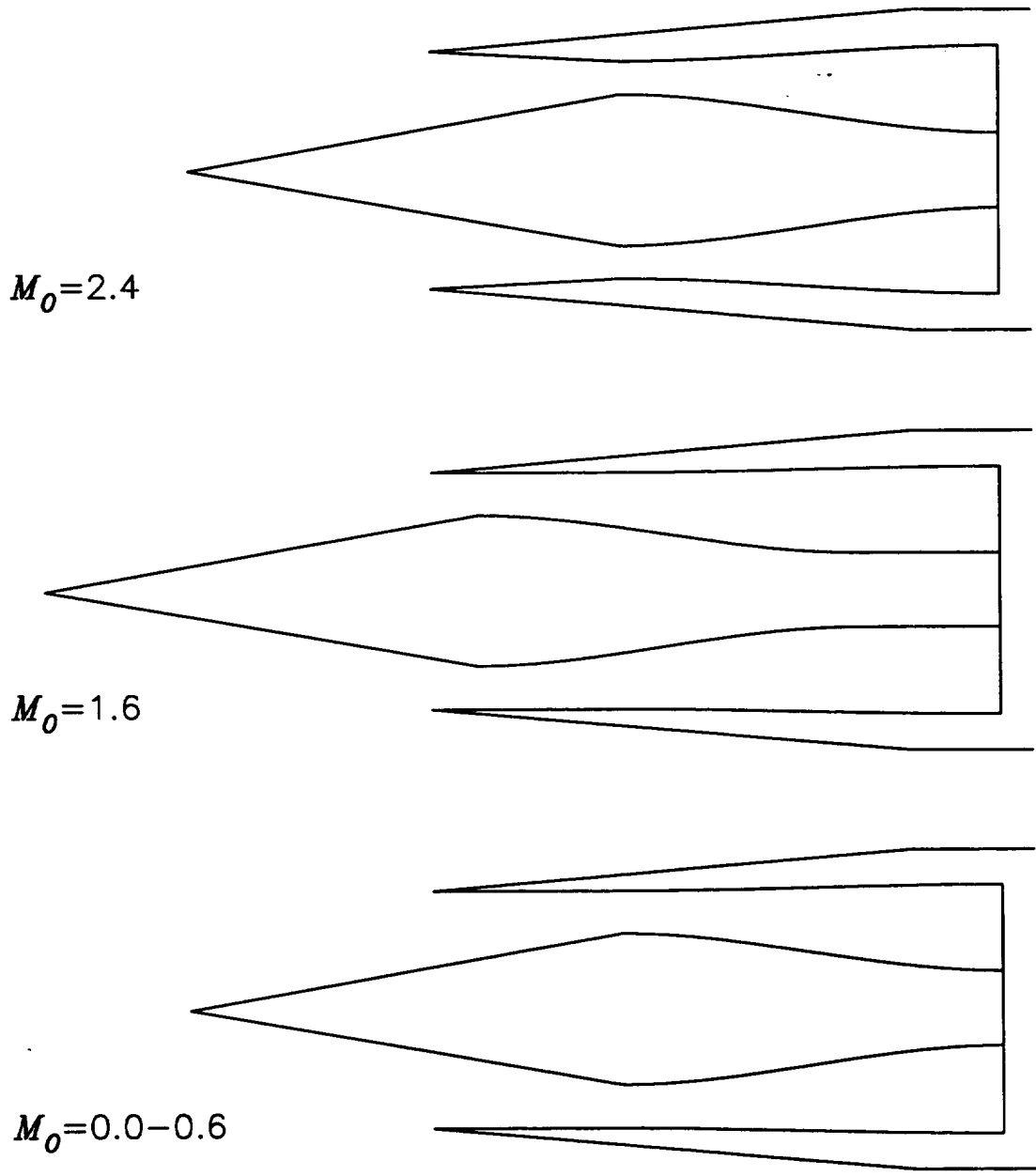


Figure 23

Axisymmetric Inlet Variable Geometry

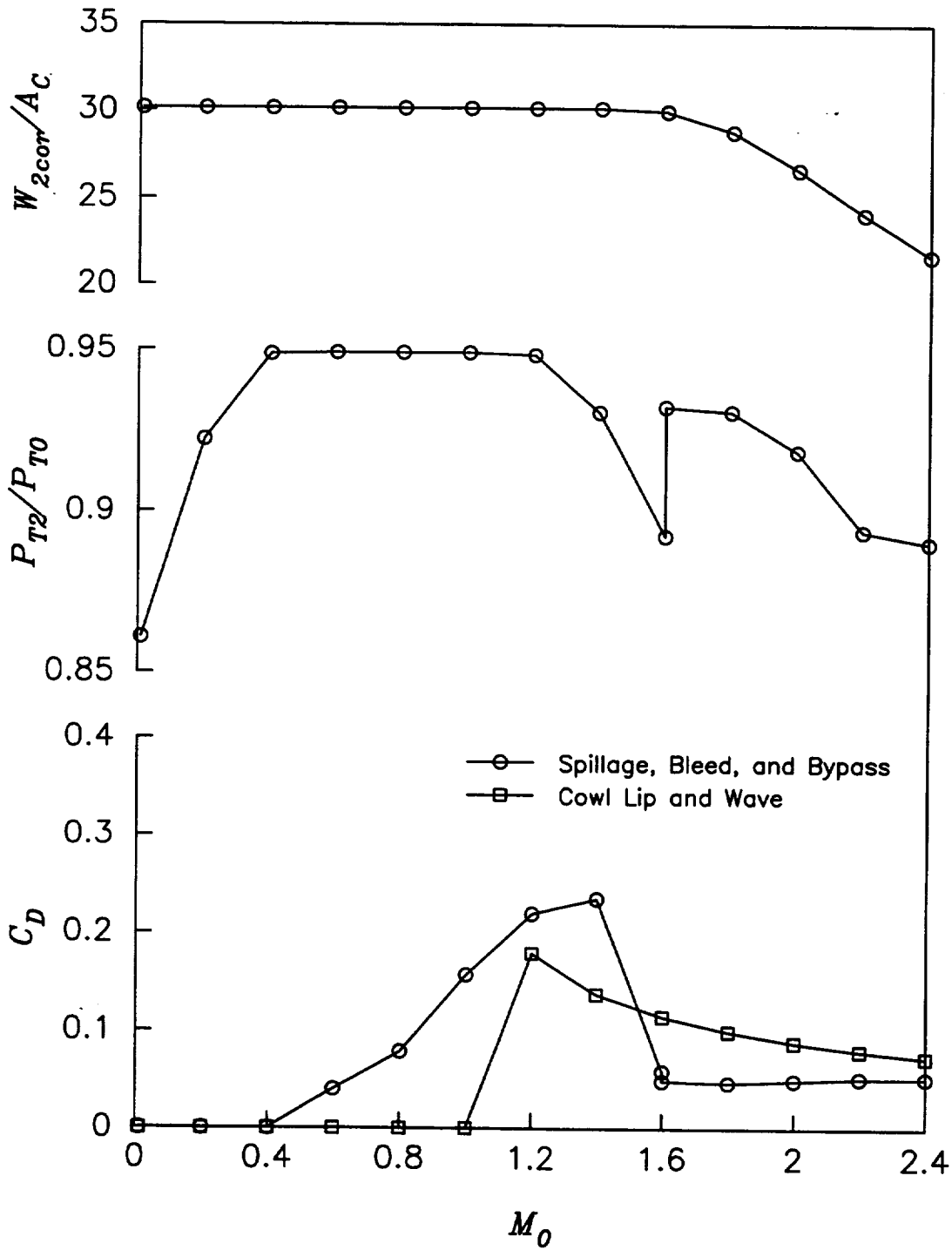


Figure 24

Axisymmetric Inlet Performance Summary

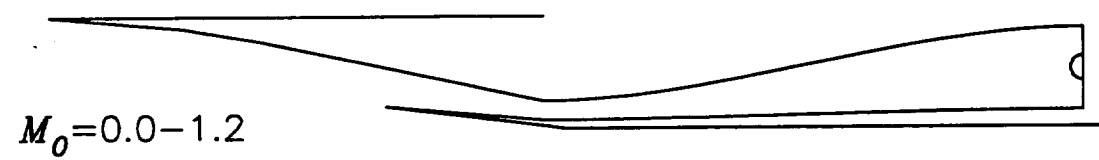
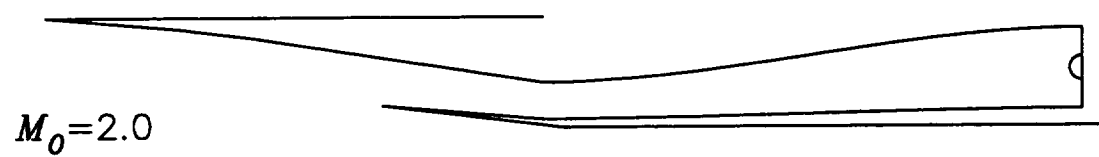


Figure 25

Two-Dimensional Inlet Variable Geometry

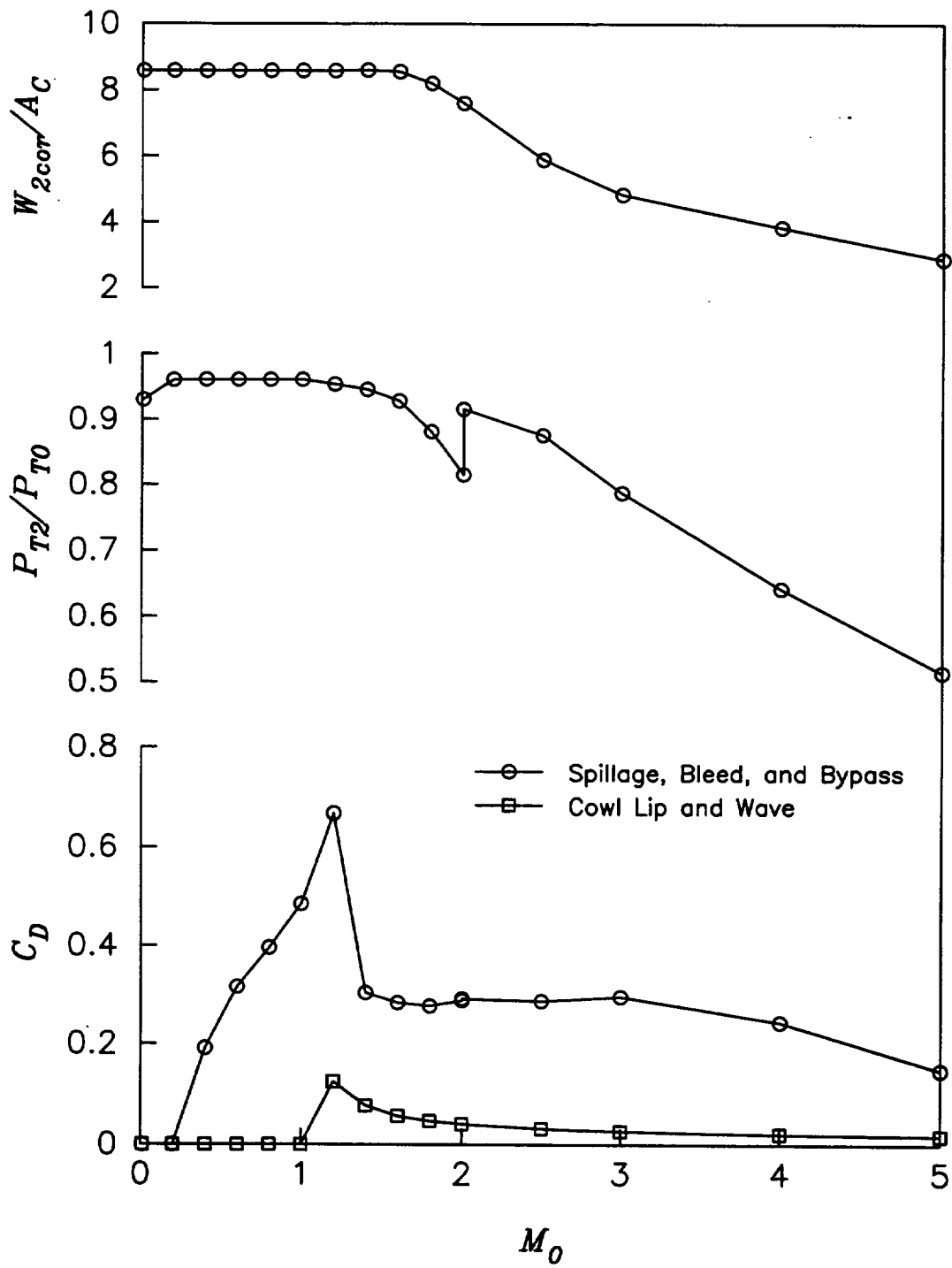


Figure 26 Two-Dimensional Inlet Performance Summary

Appendix I

**IPAC User's Guide**

## IPAC - Inlet Performance Analysis Code

### Input List Description

All variables are defined as implicit real\*4 (a-h,o-z) unless otherwise noted in the following description. Variables beginning with the letters i-n are defined as integer unless otherwise noted. Any array variables are noted below with dimensions, ie. var(10). Default values are listed in the given assignments below.

&ipac           - namelist input set identifier, required

table='ipac.dat' - tabular output data file name, character\*80

title=' '       - input case title, character\*80

echo=0         - echo flag, echoes input set to output if =1,  
                  integer

iout=4\*1       - output control flag array, setting each element of  
                  iout =1 writes additional data to output file,  
                  iout(1)    program execution status messages  
                  iout(2)    formatted performance summary pages  
                  iout(3)    inlet flow station properties table  
                  iout(4)    inlet geometry data summary  
                  iout(5)

figure=0       - figure output flag, writes inlet figure data and  
                  output files if =1, integer

npts=10,20     - number of points defining the engine face spinner  
                  or blunt cowl lip, npts(1), and subsonic diffuser  
                  contours, npts(2), when output is written using  
                  the figure=1 option, npts(2)

xmach0=0.01    - flight free stream Mach number

alt=0.0        - flight altitude (ft)

alpha0=0.0     - flight vehicle angle of attack (degrees)

gama=1.4       - ratio of specific heats for atmosphere

igas=0         - real gas effects flag, real gas calculations are  
                  performed if =1, typically only needed if xmach0  
                  is greater than 2.0

forbdy=0       - vehicle forebody effects flag, no forebody if =0,  
                  initial conic forebody if =1, initial ramp  
                  forebody if =2, if =-1 then forebody effects are



directly input through variables `xm1m0` and `pt1pt0`, integer

`alpha_i=0.0` - array of forebody relative angles (degrees) used if `forbdy = 1` or `2`,  
`alpha_i(10) [=1st_angle,2nd_angle,...]`

`xm1m0=1.0` - ratio of inlet local to free stream Mach numbers, used only if `forbdy=-1`

`pt1pt0=1.0` - total pressure recovery ahead of inlet, used only if `forbdy=-1`

`idim=1` - inlet type flag, symmetric 2-D pitot if `=-1`, axisymmetric pitot if `=0`, 2-D pitot if `=1`, 2-dimensional if `=2`, axisymmetric if `=3`, bifurcated 2-dimensional if `=4`

`ac=1.0` - inlet capture area (ft\*\*2), area will be computed if `=-1` and engine corrected weight flow data is supplied

`ar=1.0` - inlet capture area aspect ratio, square or circular if `=1`

`ramps=0` - number of external 2-D inlet ramps (max 10), or for an axisymmetric inlet conic centerbody set `=1`, integer

`theta=0.0` - array of relative angles (degrees) of 2-D inlet ramps, or for an axisymmetric inlet conic centerbody set equal to the cone half-angle,  
`theta(10) [=1st_angle,2nd_angle,...]`

`rleng=0.0` - array of radial lengths (ft) of 2-D inlet ramps, or the axisymmetric inlet conic centerbody length, do not use if the variable `xleng` is used,  
`rleng(10) [=1st_length,2nd_length,...]`

`xleng=0.0` - array of axial lengths (ft) of 2-D inlet ramps, or the axisymmetric inlet conic centerbody length, do not use if the variable `rleng` is used,  
`xleng(10) [=1st_length,2nd_length,...]`

`xcowl=0.0` - cowl lip axial distance from inlet origin (ft)

`ycowl=1.0` - cowl lip normal distance from inlet origin (ft)

`cowls=0` - number of segments defining the external cowl surface (max 10), integer

`cowlth=0.0` - relative angles (degrees) of external cowl surfaces, `cowlth(10) [=1st_angle,2nd_angle,...]`

cowlr1=0.0 - normalized radial lengths of external cowl surfaces, do not use if the input variable cowlx1 is used, cowlr1(10) [=1st\_length,2nd\_length,...]

cowlx1=0.0 - normalized axial lengths of external cowl surfaces, do not use if the input variable cowlr1 is used, cowlx1(10) [=1st\_length,2nd\_length,...]

rclip=0.0 - normalized cowl lip radius, sharp lip =0

a2ac=1.0 - engine face flow area to inlet capture area ratio

xlDD2=3.0 - subsonic diffuser axial length to engine face diameter ratio

cloff=0.0 - normalized inlet origin to engine face centerline offset distance

hubtip=0.3 - engine face spinner to fan tip radius ratio

thetac=0.0 - cowl lip internal angle (degrees)

nishck=-1 - number of inlet internal shock wave reflections, calculate number of shocks if =-1

xlipth=-1 - normalized length of inlet internal duct from cowl lip to throat, calculate length if =-1

athac=-1 - inlet throat area to inlet capture area ratio, calculate if =-1

xmth=1.3 - inlet throat Mach number, calculate throat Mach number if =-1

xmns=1.35 - inlet supercritical normal shock Mach number

xtrans=0.0 - normalized centerbody translation distance

a0ac=1.0 - stream tube capture area ratio, usually calculated and not used as an input variable

athal=-1 - inlet throat area to cowl lip flow area ratio, calculate if =-1

ptreb=-1 - inlet total pressure recovery, calculate if =-1

ptrob=-1 - total pressure recovery across oblique shock waves, calculate if =-1

ptreb=-1 - total pressure recovery across external oblique shock waves, calculate if =-1

ptrib=-1 - total pressure recovery across internal oblique shock waves, calculate if =-1

ptrns=-1 - total pressure recovery across normal shock wave, calculate if =-1

ptrfr=-1 - total pressure recovery factor resulting from inlet surface friction ahead of the throat, calculate if =-1

ptrdf=-1 - total pressure recovery factor resulting from subsonic diffuser behind the inlet throat, calculate if =-1

ptrlp=-1 - total pressure recovery factor resulting from cowl lip flow losses, calculate if =-1

fd=0.0025 - subsonic diffuser friction loss factor

bleed=0.0 - array of inlet bleed flow mass fractions for each bleed system, up to 10 separate bleed systems can be defined, bleed(10) [=1st\_sys\_frac,2nd\_sys\_frac,...]

pblpt0=0.0 - array of total pressure recovery in bleed plenum to freestream for each separate bleed system, pblpt0(10) [=1st\_sys\_rec,2nd\_sys\_rec,...]

thexbl=15.0 - array of bleed flow discharge angles (degrees) relative to freestream for each bleed system, thexbl(10) [=1st\_sys\_angle,2nd\_sys\_angle,...]

nvbl=0.98 - array of bleed flow discharge nozzle velocity coefficients for each separate bleed system, real\*4 nvbl(10) [=1st\_sys\_coef,2nd\_sys\_coef,...]

nozzbl=1 - array of the type of bleed flow discharge nozzle used for each separate bleed system, convergent nozzle if =1, convergent-divergent nozzle if =2, nozzbl(10) [=1st\_sys\_type,2nd\_sys\_type,...]

axthbl=1.0 - array of bleed flow discharge nozzle exit area to nozzle throat area ratio for each separate bleed system, set =1 if the nozzle is convergent, axthbl(10) [=1st\_sys\_ratio,2nd\_sys\_ratio,...]

bypass=0.0 - array of inlet bypass flow mass fractions for each bypass system, up to 10 separate bypass systems can be defined, bypass(10) [=1st\_sys\_frac,2nd\_sys\_frac,...]

pbppt2=0.0 - array of total pressure recovery in bypass plenum to engine face for each separate bypass system, pbppt2(10) [=1st\_sys\_rec,2nd\_sys\_rec,...]

thexbp=15.0 - array of bypass flow discharge angles (degrees) relative to freestream for each bypass system,

`thexbp(10) [=1st_sys_angle,2nd_sys_angle,...]`  
`nvbp=0.98` - array of bypass flow discharge nozzle velocity coefficients for each separate bypass system, `real*4 nvbp(10) [=1st_sys_coef,2nd_sys_coef,...]`  
`nozzbp=1` - array of the type of bypass flow discharge nozzle used for each separate bypass system, convergent nozzle if =1, convergent-divergent nozzle if =2, `nozzbp(10) [=1st_sys_type,2nd_sys_type,...]`  
`axthbp=1.0` - array of bypass flow discharge nozzle exit area to nozzle throat area ratio for each separate bypass system, set =1 if the nozzle is convergent, `axthbp(10) [=1st_sys_ratio,2nd_sys_ratio,...]`  
`cdcowl=-1` - cowl drag coefficient, sum of lip and wave drags, calculate if =-1  
`refcd=-1` - reference inlet drag coefficient, will be set equal to `-cdcowl` if =-1  
`etype=0` - array of engine type for each engine in an engine module, up to 10 engines per module, set =1 for a ramjet engine, set =2 for a turbojet engine, integer `etype(10) [=1st_eng_typ,2nd_eng_typ,...]`  
`escale=1.0` - array of sizing scale factors for each engine, `escale(10) [=1st_eng_size,2nd_eng_size,...]`  
`fn=0.0` - array of the uninstalled net thrust (lb) for each engine in an engine module, `fn(10) [=1st_eng_thrust,2nd_eng_thrust,...]`  
`sfc=0.0` - array of the uninstalled specific fuel consumption (lbm/hr/lbf) for each engine in an engine module, `sfc(10) [=1st_eng_sfc,2nd_eng_sfc,...]`  
`w2cor=0.0` - array of the uninstalled engine face corrected weight flow (lb/s) for each engine, `w2cor(10) [=1st_eng_flow,2nd_eng_flow,...]`  
`w2abs=0.0` - array of the uninstalled engine face absolute weight flow (lb/s) for each engine, `w2abs(10) [=1st_eng_flow,2nd_eng_flow,...]`  
`pt8pt2=1.0` - array of the total pressure ratio across the engine, from nozzle throat to engine face, `pt8pt2(10) [=1st_eng_ratio,2nd_eng_ratio,...]`  
`refrec=-1` - array of the reference total pressure recovery used for each engine, set =-1 for MIL-SPEC, `refrec(10) [=1st_eng_rec,2nd_eng_rec,...]`

```

nozzle      - array of engine module nozzle data, real*4
              nozzle(1)  uninstalled engine data Cfg
              nozzle(2)  actual nozzle gross thrust coefficient
              nozzle(3)  actual nozzle drag coefficient
              nozzle(4)  reference area (ft**2) for nozzle Cd

noeng=1     - number of engine modules on vehicle

aero        - array of the flight vehicle aerodynamic data
              aero(1)    lift coefficient
              aero(2)    drag coefficient
              aero(3)    angle of attack
              aero(4)    reference area (ft**2) for Cl and Cd

&end        - namelist identifier, required

```

### Notes on Input Usage

The input and output filenames may be specified on the command line after the program name. The extensions .in and .out may be left off the filenames and will automatically be appended.

```
system_prompt> ipac ipac.in ipac.out
```

The program IPAC reads the namelist input set from an input file (the default is ipac.in) and executes the required calculations for that case. The output is written to an output file (the default is ipac.out) and to another tabular data file specified by the input variable **table** in the namelist input set. If there are subsequent namelist input sets in the file, they in turn are executed, and in this manner numerous cases can be run to design and/or analyze an inlet system over a range of operating conditions. Since the program uses namelist input reads, if a variable is defined once in an input set, it is not necessary to redefine it again in subsequent input sets, unless the value changes. Also, since nearly all of the input variables have predefined defaults, it is usually only necessary to assign values to a few variables to run the program properly. The character string pairs `/* ...comments... */` are parsed and discarded by the input set read routine, thus allowing for the inclusion of comments, or the exclusion of commented out inputs, in the input file.

There are a few subtleties which the user needs to be aware of to effectively use IPAC. The following paragraphs describe some of the ways the various input variables are used to model inlet systems.

General Output Control: The first 6 variables listed above determine the output features for IPAC. The data file defined by the **table** variable will contain a summary tabular dataset of inlet operation and performance quantities such as: pressure recovery, mass flow ratios, and drag coefficients. These

quantities are sufficient to compose a set of inlet performance maps. To facilitate the generation of performance maps, more than one data file can be defined by the **table** variable in subsequent namelist input sets. Thus, a range of inlet operating points can be written to different tabular datasets. The user must then re-format these datasets to construct inlet map files appropriate for other analysis codes.

The **title** variable is printed for each output case if defined. The **echo** variable can, and is recommended, to be set to 1. This will print the namelist input set ahead of each output case. Additionally, if **echo** is set to 2 then the entire input file will be printed at the top of the output file. The array variable **iout** is used to control the level of data written to the output file, **ipac.out**. Setting the elements of **iout** =1 will result in additional output data. Currently there are 4 elements in **iout** which can be used for output control. Status messages of program execution information are enabled/disabled by **iout(1)** =1/0. These single line printouts of pertinent variable values from each major analysis segment (as the code executes) are useful for quickly assessing the progress of the inlet design, operation, and performance modeling. Printout of formatted inlet performance summary data is enabled/disabled by **iout(2)** =1/0. A formatted data table of flow properties at each of the inlet flow stations is enabled/disabled by **iout(3)** = 1/0. A brief inlet geometry data summary is enabled/disabled by **iout(4)** = 1/0. The program defaults will print all of the above information for each input case. Complete inlet performance data is written to 4 other tabular datasets \*.dat for all input cases executed. This information is very easily graphed by a plotting package of the user's choice.

Printout of the inlet geometry contours is enabled by setting the **figure** variable =1. Additional output files \*.fig are written which contain (x,y) coordinate pairs that can be used to construct a simple line drawing of the inlet geometry, and which can be viewed by the user's own plotting package of choice. The **figure** variable should be set to 1 in only one input set, and then reset to 0 for the rest of the cases since the \*.fig output files are overwritten for each case. The array input variable **npts** can be used to increase the number of points written which define the subsonic diffuser, blunt cowl lips, and engine face segments of the figure. This allows for greater resolution of the curved surfaces in the geometry.

Flight Conditions: The Mach number and altitude for flight are set in variables **xmach0** and **alt**. If a positive number is assigned to **alt** then the program will use that value for the altitude in ft. If **alt** is assigned a negative number, then the program will assume that the user has entered a flight dynamic pressure (in psf) instead, and will find an appropriate altitude for the specified flight Mach number. This is a convenient feature for finding constant Q flight paths. If the vehicle is situated at an angle of attack to the freestream, the variable

**alpha0** should be used. If the user feels it is necessary to adjust the ratio of specific heats constant for the atmosphere, the variable **gama** can be used. If flight conditions exceed Mach 2.0, it is recommended that **igas** be set to 1 to adjust ideal gas assumptions for real gas effects which become important for high speed flight.

Vehicle Effects: If the inlet is located close to the body/wing of the vehicle it may be necessary to account for changes in flow conditions entering the inlet as a result of vehicle effects. The variable **forbdy** controls how the vehicle effects are modeled. Values of 1 or 2 assigned to **forbdy** can model simple combinations of conic and ramp configurations. The necessary relative angles (degrees) are input through the array variable **alpha\_i**. Compressive turning is denoted by a positive angle, and expansions are denoted by a negative angle. If a very complex flowfield is produced by the vehicle, the changes in Mach number and total pressure can be directly input in variables **xm1m0** and **ptlpt0** (provided these values are known) if **forbdy** is set to -1.

Inlet Geometry: A number of variables are used to describe the inlet geometry to be modeled. The first is **idim** which specifies the basic inlet type: pitot, axisymmetric, or 2-dimensional. The permitted values of **idim** follow.

<b>idim</b> =-1	symmetric 2-D pitot inlet
0	axisymmetric pitot inlet
1	2-D pitot inlet
2	2-dimensional inlet
3	axisymmetric inlet
4	bifurcated 2-dimensional inlet

If the inlet is 2-D the aspect ratio, variable **ar**, is the inlet width divided by height. If the inlet is axisymmetric then **ar** is interpreted as fraction of a full-circle. Thus, for a hemi-circular axisymmetric inlet, **ar** would be set to 0.5. The variable determining the gross size of the inlet is the capture area, **ac** in square ft. This can be simply set to 1 for easy normalizations, any physical size in square feet, or if set to -1 will be calculated and automatically sized to match the engine demand airflow requirements if this data is supplied.

External Compression Surfaces: The variables **ramps**, **theta**, **rleng**, and **xleng** define the inlet external compression surfaces for axisymmetric and 2-D inlets. For axisymmetric inlets, **ramps** must be set to 1, and **theta** is set to the conic centerbody half-angle. Either **rleng** or **xleng**, in ft, can be used to define the centerbody length, but not both. For 2-D inlets, **ramps** can be set up to a maximum of 10, and **theta** is then set to the relative angles (degrees) of each ramp. Either **rleng** or **xleng** can be used to define the lengths of each ramp, but not both. It is recommended that **rleng** be used since it does not change as the ramp angles are varied.

**Cowl Lip & Shock-On-Lip Design Feature:** The location of the cowl lip is specified by variables **xcowl** and **ycowl** in ft. These variables are used in both axisymmetric and 2-D inlets. For axisymmetric inlets **ycowl** is the radial distance from the inlet centerline. There is a feature in IPAC which will automatically calculate the location of the cowl lip for the shock-on-lip condition. Also, this feature will calculate the ramp lengths for multiple ramp 2-D inlets, placing all of the shock waves on the cowl lip, provided that the ramp angles are specified. This is a very useful design feature. To use this automatic design capability do the following in the very first namelist input set.

- (1) set **ramps** to the number of ramps or 1 for a centerbody
- (2) set **theta** to the ramp or centerbody relative angle(s)
- (3) set **rleng** and **xleng** to 0.0, this is the program default
- (4) set **xcowl** =0 and **ycowl** =1, also the program default

IPAC will then calculate the location of the cowl lip, and the lengths of all the ramps for shocks-on-lip for the specified flight Mach number, **xmach0**. These results will be remembered for subsequent cases, and there is no need to input these values by hand.

**External Cowl Surfaces:** The variables **cowls**, **cowlth**, **cowlrl**, and **cowlxl** define the external contour of the inlet cowl surface. The number of segments is specified in **cowls**, the relative angles (degrees) in **cowlth**, and the lengths in either **cowlrl** or **cowlxl**. The lengths are normalized by **ycowl** and thus specified as multiples of **ycowl**. A blunt cowl lip radius can be specified by the variable **rclip** and this radius is also normalized by the length **ycowl**.

**Subsonic Diffuser:** There are 4 input variables which are used to define the geometry of the subsonic diffuser element in an inlet. The engine face flow area is defined as a ratio relative to the inlet capture area through the variable **a2ac**. The axial length of the diffuser is defined as a ratio relative to the engine face diameter through the variable **xldd2**. The vertical offset location of the engine face is defined as a normalized distance from the inlet origin to the engine centerline, through the variable **cloff**, as a multiple of the distance **ycowl**. The variable **hubtip** performs a number of functions. If **hubtip** is a positive number then it defines the engine face spinner to fan tip radius ratio. If **hubtip** equals 0.0 then no engine spinner exists but the engine face is still assumed to be circular. If **hubtip** is a negative number then the program will recognize that the user has indicated that the engine face is not circular, but rather 2-dimensional, and that the value specified in **hubtip** is now the aspect ratio for the 2-D engine face duct area.

**Internal Shocks:** For supercritical operation of mixed compression inlets, internal shock waves are formed between the cowl lip and the inlet throat. The model used in IPAC is relatively simple for this internal supersonic duct. A



constantly converging channel is used to model the flow from inlet cowl lip to throat regions. The difference between the internal cowl lip angle (degrees), **thetac**, and the last external ramp angle forms the net convergence angle for the duct model. A single shock wave train, reflecting off each duct wall, is used to model the supersonic flow. The variable **nishck** is used to specify how many shock waves will be permitted in the duct, and this value will be calculated if set to -1. The variable **xlipth** is the normalized length (multiple of **ycowl**) of the duct from the cowl lip to the throat, and will also be calculated if set to -1. The variable **athac** is the inlet throat area to capture area ratio. This variable is critical in determining the inlet operation. If **athac** is set to -1 this ratio will be calculated. The variable **xmth** is the inlet throat Mach number. By specifying an inlet throat Mach number and area, the mass flow of the inlet is uniquely determined.

In a typical design point calculation it is easiest to specify the throat Mach number, **xmth**, and then for supercritical operation the rest of the variables, **nishck**, **xlipth**, and **athac** will be determined. For subsequent calculations, the inlet throat area will then be determined from the inlet geometry, and the throat Mach number will in turn be calculated. The variable **xmns** is the Mach number ahead of the internal terminal normal shock. Note that for supercritical operation **xmns** must be greater than the throat Mach number **xmth**. As the normal shock Mach number is increased, the shock will be pulled further downstream from the inlet throat into the subsonic diffuser. This will also decrease the inlet recovery. Specifying **xmns** is another control variable which can be used to match the inlet supply corrected airflow to the engine demand. If **xmns** is set =0 and the inlet is operating supercritical, then the flow at the engine face will be calculated as supersonic flow. This permits the modeling of supersonic through-flow fan and scramjet inlets.

Variable Geometry: After the inlet design point is calculated in the first namelist input set, the throat area can be increased or decreased by variable geometry features for off-design operation. For multi-ramp inlets, the ramp angles **theta** can be redefined by the user in subsequent namelist input sets. The cowl internal angle **thetac** can also be changed. A very common variable geometry mechanism for axisymmetric inlets is the translating centerbody, and the input variable **xtrans** can be used to move the centerbody forward a specified distance which is a multiple of **ycowl**. Note that **xtrans** works only for axisymmetric inlets, and produces no translation for two-dimensional inlets.

Two additional, although not typically used, input variables are the stream tube capture area ratio, **a0ac**, and the throat to cowl lip flow area ratio, **athal**. The stream tube capture area ratio is usually calculated by the program, however, it is possible that for some inlets the capture area ratio can be defined, and then for a given geometry the inlet throat Mach number would be calculated.

Recovery Overrides: All of the input variables beginning with **ptr\_\_** are the total pressure ratios for various loss producing mechanisms and are normally calculated in the program. The user has the option of overriding these calculations and directly entering values for any and all of these terms. Normally this is not done, however, if other more complex analyses have been performed for an inlet design, then the user can use those values instead of the ones that IPAC would normally calculate.

An additional input variable is the friction loss factor, **fd**, which is used in the subsonic diffuser loss model. The default value is 0.0025 and this value is suitable for most typical subsonic diffuser designs.

Bleed and Bypass Systems: Boundary layer bleed is a necessary component for all high speed inlet systems. In order to stabilize the shock wave boundary layer interactions, a small amount of air is removed through the walls of the inlet. This air is then dumped overboard and a momentum drag is incurred. Mass removed and dumped ahead of the inlet throat is called bleed, and is necessary for inlet operation. Mass removed and dumped behind the throat is called bypass, and is sometimes necessary for inlet/engine matching. Up to ten independent bleed and ten independent bypass systems can be defined. Both bleed and bypass inputs work the same way, and therefore, only the bleed variables will be directly discussed. The user must specify the variable **bleed**, the fraction of captured airflow which is to be dumped. The variable **pblpt0** is the total pressure ratio (bleed plenum to freestream) for the bleed system and must also be chosen. The rest of the variables, **thexbl**, **nvbl**, **nozzbl**, and **axthbl** may be left at the default values. For bypass systems, since there is typically much more pressure available for expansion, a convergent-divergent nozzle may be used.

The input variable **bleed** can be defaulted to any negative number to automatically calculate the amount of boundary layer bleed as a function of inlet local Mach number. If **bleed** set = -1, then a single bleed system will use the default bleed rate. If **bleed** is set = -0.8, then a single bleed system will use 80% of the default bleed rate. If **bleed** is = -1.5, then a single bleed system will use 150% of the default bleed rate. If **bleed** = -0.4, -0.5, then two bleed systems will use a total of 90% of the default bleed rate. The bleed plenum total pressure recovery variable, **pblpt0**, can also be defaulted to an internal calculation, again as a function of inlet local Mach number. Set **pblpt0** to: -1 for the nominal average recovery, -2 for the high pressure porous recovery, -3 for the low pressure porous recovery, and -4 for the throat slot recovery. Each individual bleed system can use any appropriate bleed configuration recovery.

For the bypass system, the total pressure recovery in the bypass duct, **pbppt2**, can be calculated from a bypass duct loss as a function of bypass fraction. To calculate, set **pbppt2** = -1. Typically, when matching inlet supply and engine demand the inlet

provides excess airflow which must be bypassed. If engine data is supplied, and the inlet has excess airflow capacity, set **bypass** =-1 to automatically match the inlet and engine airflows by adjusting the bypass fraction. This feature only works on the first bypass system, the other bypass systems if defined cannot be automatically matched but must be directly input.

Drag Accounting: The exact details of which inlet drag components should be charged to propulsion or airframe are a subject of continual debate. Most notable is the cowl drag, which is comprised of cowl blunt lip and cowl wave drags. IPAC calculates these drag components if the input variable **cdcowl** is set =-1, the program default. If any other positive value is assigned to **cdcowl** that value will be used, and the lip and wave drag calculations will be skipped. Since the external drag on an engine nacelle is often accounted for in the vehicle aerodynamic performance, another input variable **refcd** has been included. This variable represents the reference drag coefficient for the inlet installation, and thus part of the inlet drag can be accounted for in the vehicle aerodynamic data.

The net inlet drag at an engine operating point is called the power setting drag, and the power setting drag is equal to the total of all the inlet drags (spillage, bleed, bypass, cowl lip and wave) less the reference drag. Often the cowl drag components are accounted for in the vehicle aerodynamic data. If **refcd** is set =-1, then the reference drag will be set equal to the inlet cowl drag. This will result in an inlet power setting drag comprised of only spillage, bleed, and bypass drags. This is the default for the program, where **refcd** is =-1.

Engine Data: Engine data can be supplied to the program, and IPAC will perform installation calculations and re-calculate engine data if desired. It is assumed that engines are in separate modules, and there can be more than one engine (up to 10) in a module. However, each module has a single inlet, and possibly a common nozzle. The variable **etype** specifies the types of engines in a module. The only types are turbojet and ramjet at this time. A turbofan can be modeled as two separate turbojets, one with and one without fuel. The variable **escale** can be used to adjust the size of the engines for inlet/engine matching and sizing studies.

Each engine in the engine module is specified as an element in the array variables: **fn**, **sfc**, **w2cor**, **w2abs**, **pt8pt2**, and **refrec**. The engine net thrust and specific fuel consumption are specified by the input variables **fn** and **sfc**. To perform the installation calculations the total pressure ratio across the engine, **pt8pt2**, and the inlet recovery used in determining the uninstalled engine data, **refrec**, must also be supplied. The user may specify that a MIL-SPEC inlet recovery was used in the uninstalled engine data by setting **refrec** =-1, which is the program default. The absolute engine weight flow must be specified in the input variable **w2abs** in lb/s. The corrected engine airflow is also

required in the variable **w2cor** in lb/s. To perform engine installation calculations correctly, the uninstalled engine corrected weight flow must be the same as the inlet supply corrected weight flow.

The equality of inlet supply and engine demand corrected weight flow is called inlet/engine matching. All proper inlet designs must be matched to an engine demand corrected airflow schedule. If the user is designing an inlet and there is no engine data available, the program will construct an engine demand corrected weight flow schedule automatically for a "typical" engine. If **w2cor** is set =-1 at the inlet design point, then the program will automatically calculate an engine demand corrected weight flow which matches the inlet supply corrected weight flow. By leaving **w2cor** =-1 for the rest of the inlet operating points, the program will calculate the "typical" engine demand corrected weight flow schedule as a function of flight Mach number. The user may then use this schedule of engine demand corrected weight flow for inlet/engine matching over the off-design operating points.

The installed thrust for the engine module will be equal to the uninstalled engine thrust adjusted for the actual inlet recovery less the inlet power setting drag. Note that engine data that is installed but not properly matched with the inlet supply corrected weight flow is fundamentally incorrect since conservation of mass will be violated.

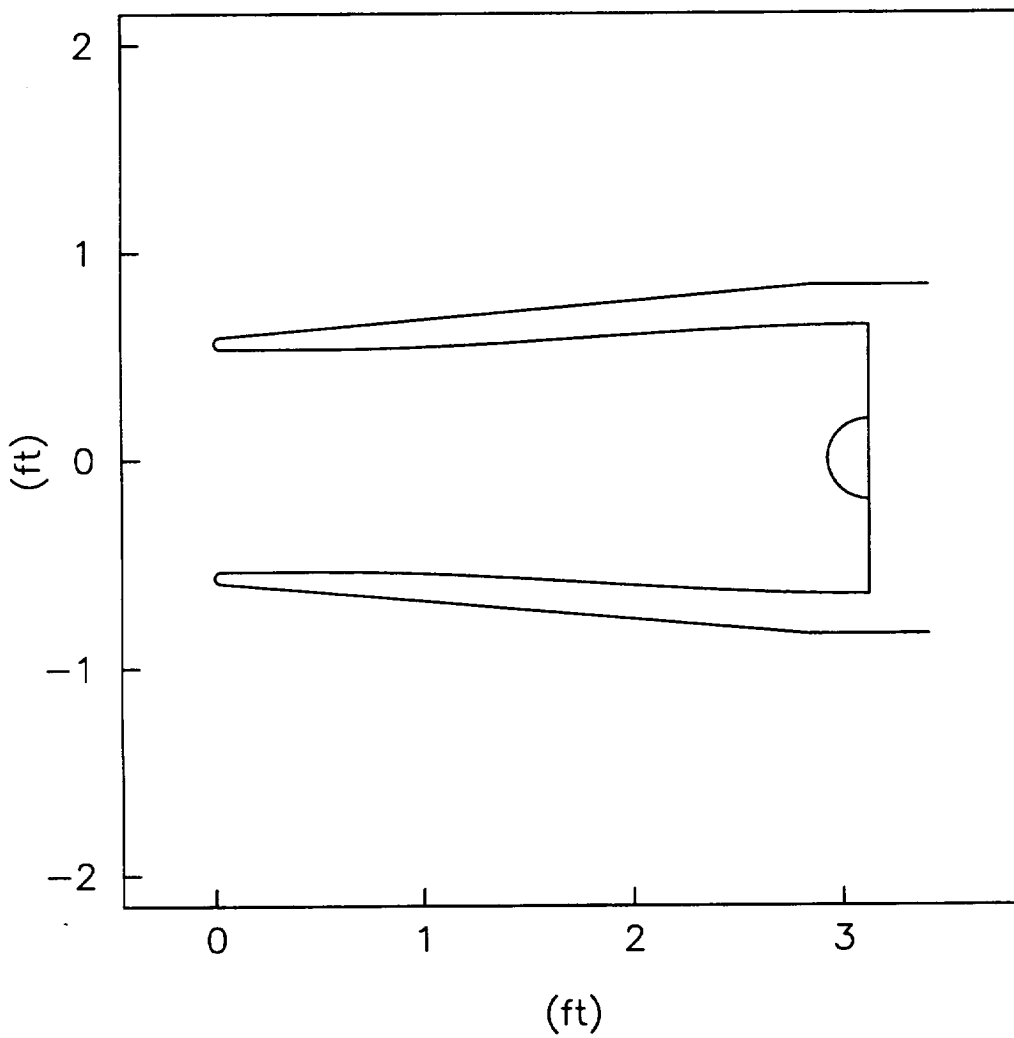
Nozzle Data: If nozzle data is available, the installation calculations will also adjust the engine data for nozzle effects. The inputs are in the array variable **nozzle**, and include the gross thrust coefficient used in the engine data, the actual gross thrust coefficient for the nozzle used, a drag coefficient for the nozzle, and a reference area. Note that when using the **nozzle** input variable it is assumed that only one nozzle is used for each engine module, even though more than one engine can be in a module.

Vehicle Data: Since it is often of interest to see how engine systems size on the vehicle, IPAC can accept vehicle aerodynamic data. Thus engine sizing studies can also be performed. The variable **noeng** sets the number of engine modules on the vehicle. The array variable **aero** contains the vehicle lift and drag coefficients, angle of attack, and reference area. Thus, the program can install engines with an inlet design, and can then determine if the propulsion system is capable of powering the aircraft throughout the flight regime.

Appendix II

Mach 2.0 Pitot Inlet

Example Case



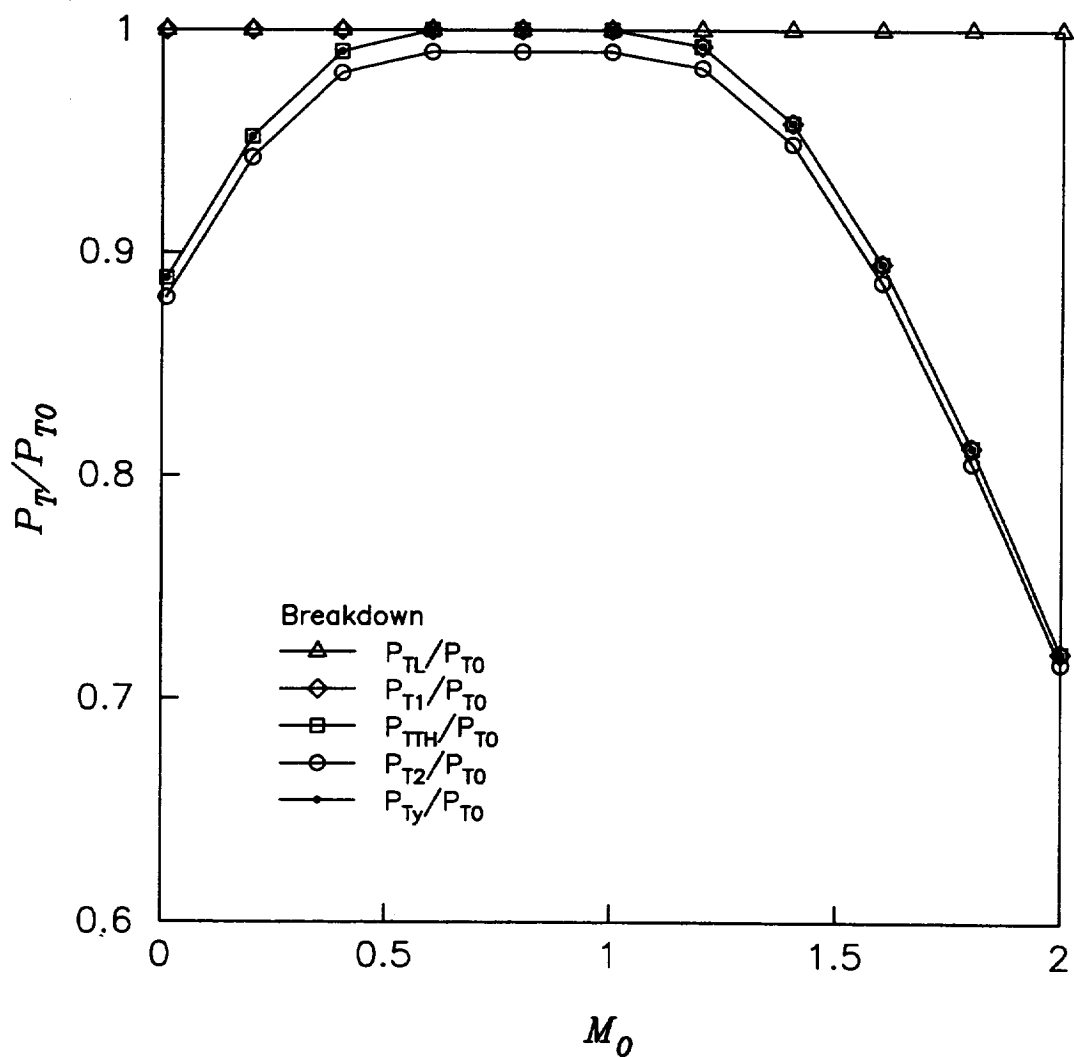


Figure II.1 Total Pressure Recoveries

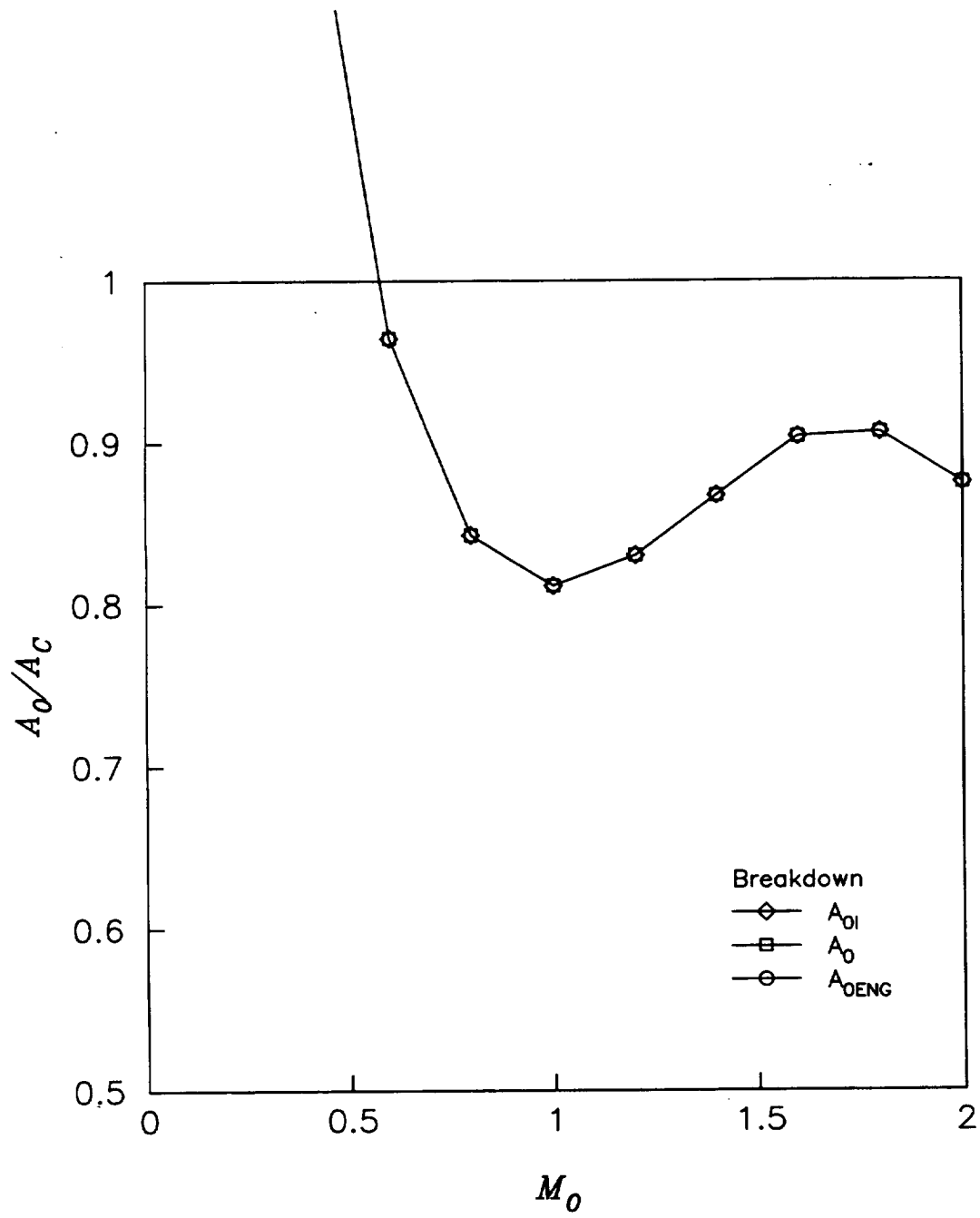


Figure II.2 Mass Flow Ratios

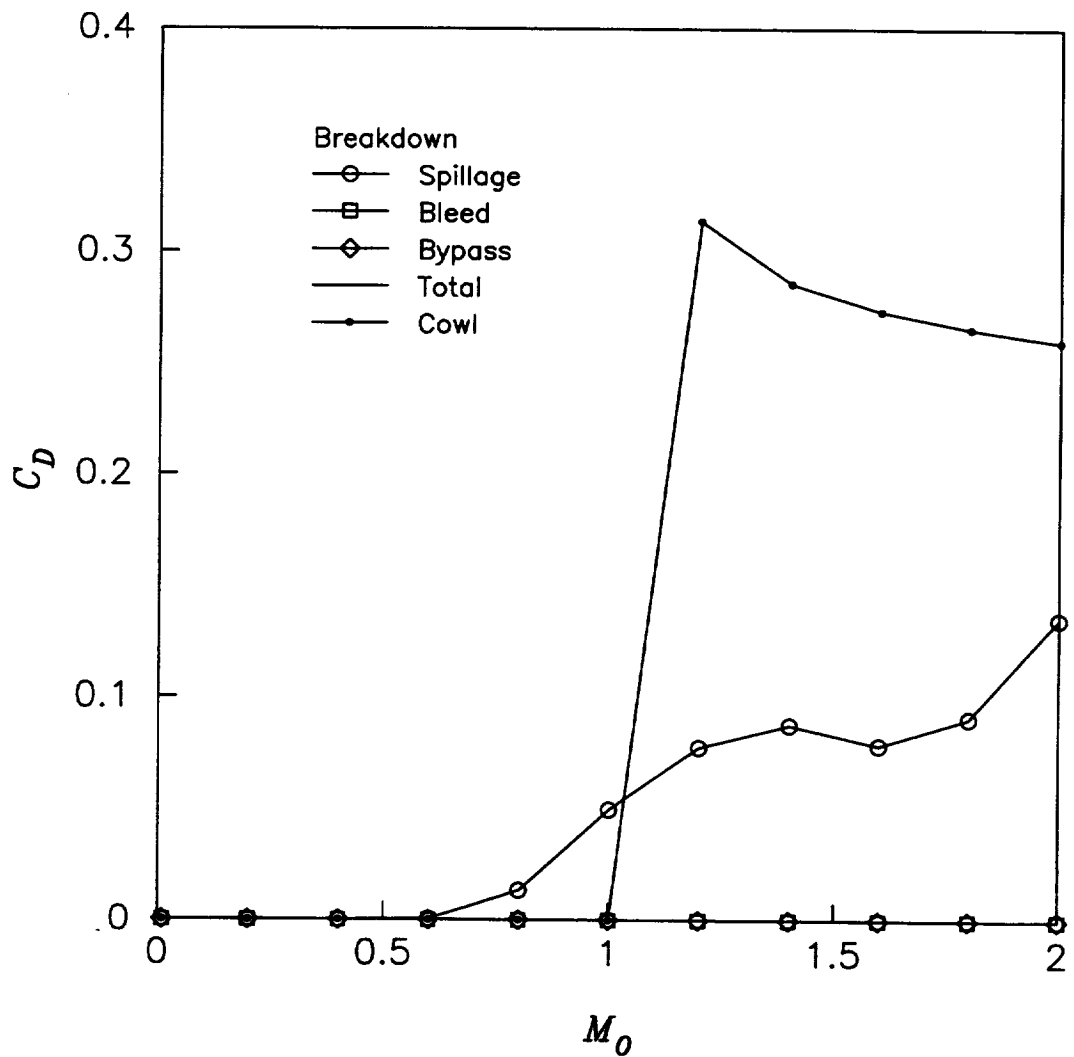


Figure II.3 Drag Coefficients



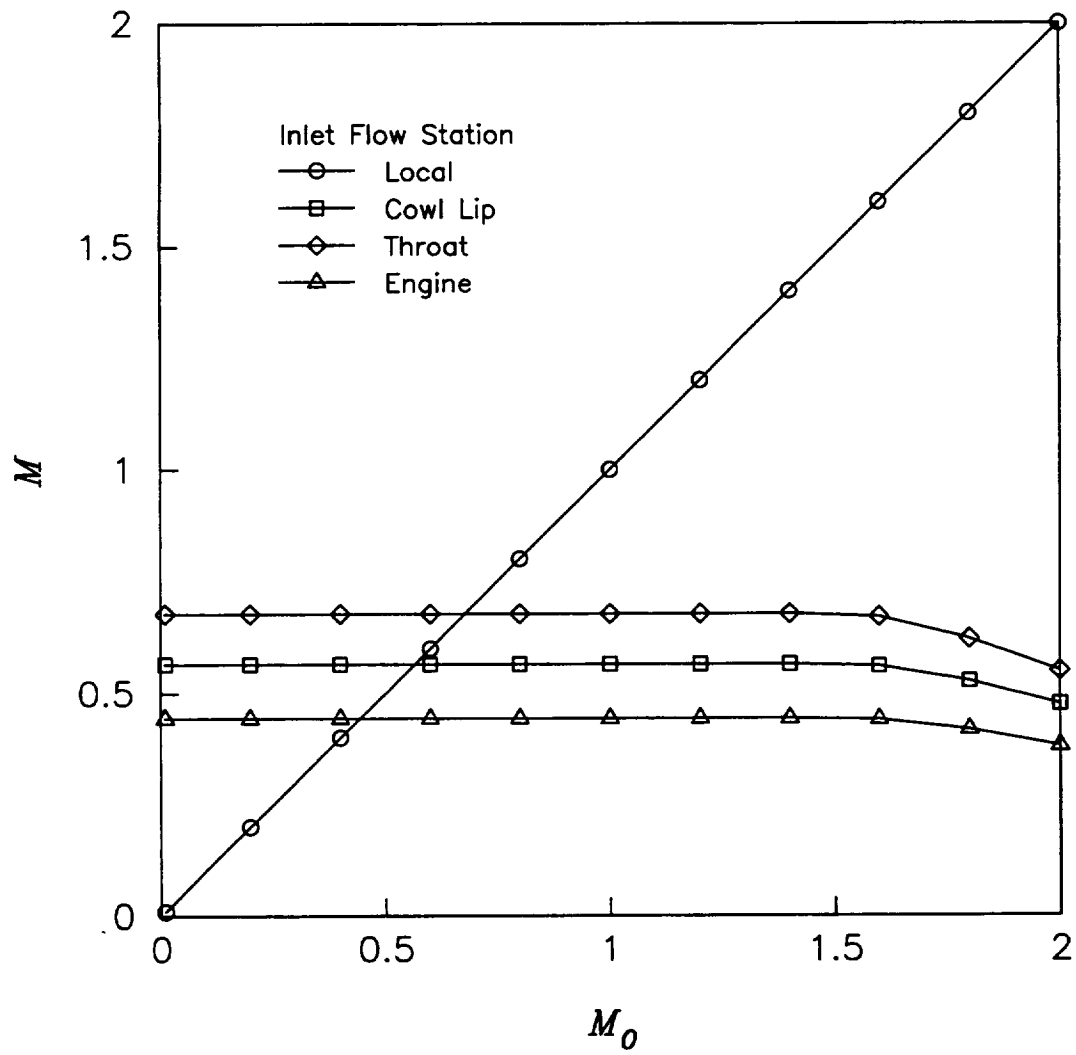


Figure II.4 Mach Numbers

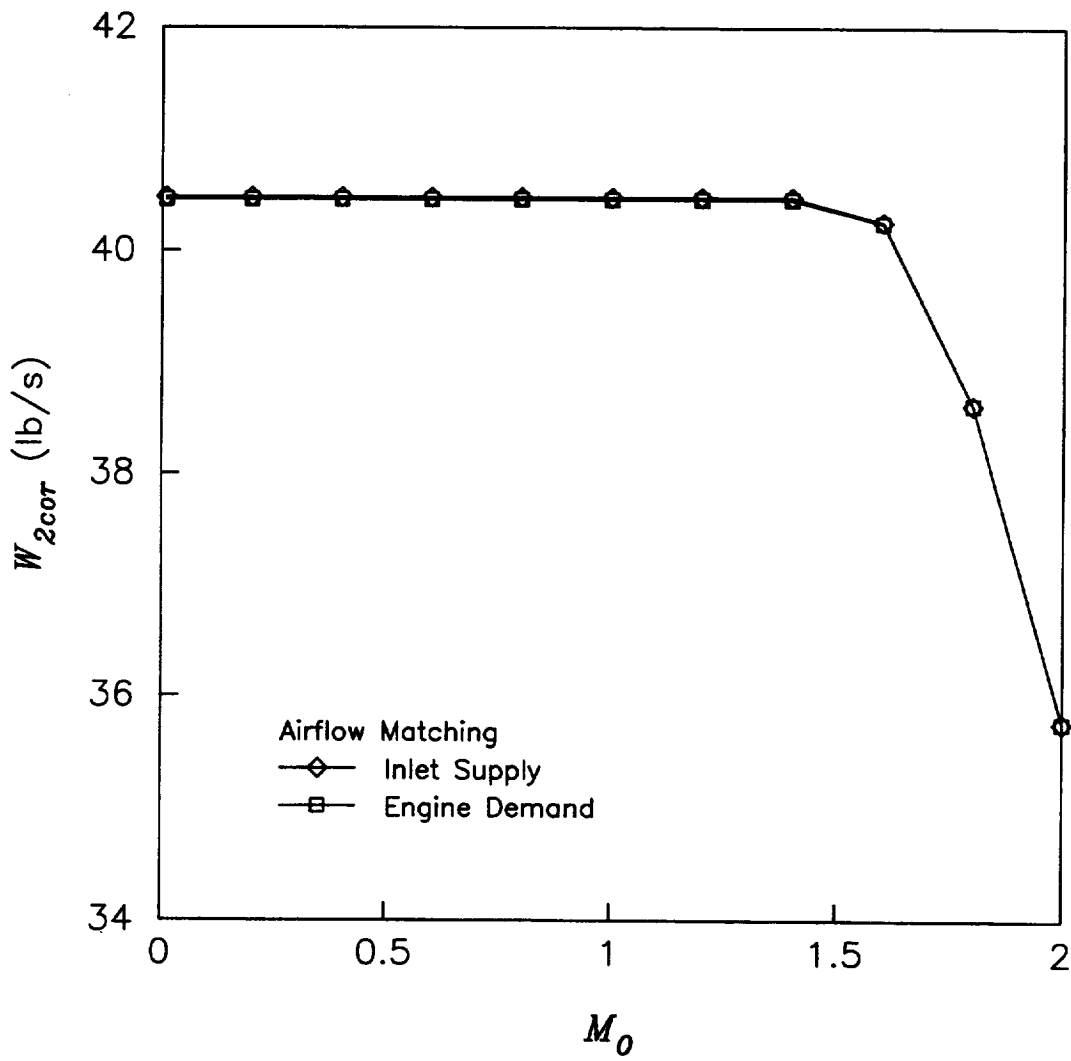


Figure II.5 Corrected Airflows

```

1 &ipac
2 title='pitot Inlet Example Case',
3 echo=1,figure=1,npts=10,20,iout=1,1,1,1,
4 xmach0=2.0,alt=-1000,
5 idim=0,ac=1.0,
6 rclip=0.05,xlipth=1.0,theta=0.0,
7 cowls=2,cowlth=5,-5,cowlx1=5,1,
8 a2ac=1.20,xladd2=2.0,hubtip=0.3,
9 w2cor=-1,
10 xnth=0.550,
11 &end
12
13 forebd: xmachx= 2.000E+00,xmach0= 2.000E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
14 cdpito: xmach0= 2.000E+00, a0iac= 1.000E+00,xmach1= 5.774E-01,ptlpt0= 7.209E-01, cda=-5.079E-07,
15 cdpito: xmach0= 2.000E+00, a0iac= 9.990E-01,xmach1= 5.764E-01,ptlpt0= 7.209E-01, cda= 1.250E-03,
16 ptrcv: xmach0= 2.000E+00, a0ac= 8.748E-01, xmns= 1.300E+00,pt2pt0= 7.160E-01,thetad= 2.472E+00,
17 : xnth= 5.500E-01, athac= 9.025E-01,nishck=-1.000E+00,pthpt0= 7.209E-01,xlipth= 1.000E+00,
18 cdpito: xmach0= 2.000E+00, a0iac= 8.748E-01,xmach1= 4.751E-01,ptlpt0= 7.209E-01, cda= 1.646E-01,
19 cdwave: xmach0= 2.000E+00, cdwav= 1.101E-01,
20 cdblup: xmach0= 2.000E+00, cdlip= 1.490E-01,
21 clsuc: xmach0= 2.000E+00, a0iac= 8.748E-01, cls= 2.960E-02, cdspl= 1.350E-01,thetae= 7.682E+00,
22 : xmach0= 2.000E+00, a0iac= 8.748E-01, cdtot= 1.350E-01, cdspl= 1.350E-01, cdref= 2.591E-01,
23 : xmach0= 2.000E+00,a0enac= 8.748E-01, w2C= 3.576E+01, w2= 2.913E+01,
24 : xmachx= 2.000E+00,a0enac= 8.748E-01,w2ceng= 3.576E+01,
25
26 IPAC Pitot Inlet Example Case
27
28 Flight Conditions
29
30 Mach number 2.000E+00
31
32 altitude (ft) 4.189E+04
33
34 ambient total
35
36 pressure (lbf/ft**2) 3.578E+02 2.800E+03
37 temperature (R) 3.900E+02 7.019E+02
38 dynamic pressure (lbf/ft**2) 1.002E+03
39
40 Vehicle Effects
41
42 ML/MO 1.000E+00
43 PTL/PTO 1.000E+00
44 AL/AO 1.000E+00
45
46 Inlet Mass Flow Ratios

```



93									
94	flow area (ft**2)	8.748E-01	8.748E-01	1.000E+00	9.025E-01	1.200E+00			
95	Mach number	2.000E+00	2.000E+00	4.751E-01	5.500E-01	3.804E-01			
96	pressure (lbf/ft**2)	3.578E+02	3.578E+02	1.729E+03	1.643E+03	1.814E+03			
97	temperature (R)	3.900E+02	3.900E+02	6.716E+02	6.619E+02	6.822E+02			
98	density (slg/ft**3)	5.346E-04	5.346E-04	1.500E-03	1.446E-03	1.549E-03			
99	velocity (ft/s)	1.936E+03	1.936E+03	6.036E+02	6.936E+02	4.870E+02			
100	total pressure (lbf/ft**2)	2.800E+03	2.800E+03	2.018E+03	2.018E+03	2.004E+03			
101	total temperature (R)	7.019E+02	7.019E+02	7.019E+02	7.019E+02	7.019E+02			
102	weight flow (lbm/s)	3.330E+01	3.330E+01	2.913E+01	2.913E+01	2.913E+01			
103	corrected weight flow (lbm/s)	2.927E+01	2.927E+01	3.552E+01	3.552E+01	3.576E+01			
104	Geometry Data for Axisymmetric Pitot Inlet								
105	inlet capture, AC (ft**2)	1.000E+00							
106	wrap angle (degrees)	3.600E+02							
107	radius (ft)	5.642E-01							
108	engine face, A2 (ft**2)	1.200E+00							
109	diameter (ft)	1.296E+00							
110	H/T	3.000E-01							
111	Figure Data for Inlet Geometry								
112	internal cowl surface (ft)								
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5.360E-01 5.360E-01  
6.724E-01 5.369E-01  
8.088E-01 5.394E-01  
9.452E-01 5.435E-01  
1.082E+00 5.488E-01  
1.218E+00 5.551E-01  
1.354E+00 5.624E-01  
1.491E+00 5.704E-01  
1.627E+00 5.788E-01  
1.764E+00 5.875E-01  
1.900E+00 5.963E-01  
2.036E+00 6.051E-01  
2.173E+00 6.135E-01  
2.309E+00 6.215E-01  
2.446E+00 6.287E-01  
2.582E+00 6.351E-01  
2.718E+00 6.404E-01  
2.855E+00 6.444E-01  
2.991E+00 6.470E-01  
3.128E+00 6.479E-01

external cowl surface (ft)

X Y

0.000E-01 5.642E-01  
3.824E-04 5.688E-01  
1.519E-03 5.733E-01  
3.379E-03 5.776E-01  
5.913E-03 5.815E-01  
9.051E-03 5.849E-01  
1.271E-02 5.878E-01  
1.679E-02 5.900E-01  
2.117E-02 5.915E-01  
2.575E-02 5.923E-01  
2.847E+00 8.391E-01  
3.411E+00 8.391E-01

engine face spinner (ft)

X Y

3.128E+00 1.944E-01  
3.094E+00 1.914E-01  
3.061E+00 1.826E-01  
3.030E+00 1.683E-01  
3.003E+00 1.489E-01  
2.979E+00 1.249E-01  
2.959E+00 9.718E-02  
2.945E+00 6.648E-02

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2.936E+00 3.375E-02  
2.933E+00 0.000E-01  
2.936E+00 -3.375E-02  
2.945E+00 -6.648E-02  
2.959E+00 -9.718E-02  
2.979E+00 -1.249E-01  
3.003E+00 -1.489E-01  
3.030E+00 -1.683E-01  
3.061E+00 -1.826E-01  
3.094E+00 -1.914E-01  
3.128E+00 -1.944E-01

&ipac xmach0=1.8,xmth=0.621, figure=0,iout=1,1,0,0, &end

forebd: xmachx= 1.800E+00,xmach0= 1.800E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,  
cdpito: xmach0= 1.800E+00, aoiac= 1.000E+00,xmach1= 6.165E-01,pt1pt0= 8.127E-01, cda=-3.233E-07,  
cdpito: xmach0= 1.800E+00, aoiac= 9.990E-01,xmach1= 6.154E-01,pt1pt0= 8.127E-01, cda= 1.152E-03,  
ptrcv: xmach0= 1.800E+00, aoiac= 9.063E-01, xmns= 1.300E+00,pt2pt0= 8.057E-01,thetad= 2.472E+00,  
xmth= 6.210E-01, athac= 9.025E-01,nishck=-1.000E+00,pthpt0= 8.127E-01,xlipth= 1.000E+00,  
cdpito: xmach0= 1.800E+00, aoiac= 9.063E-01,xmach1= 5.276E-01,pt1pt0= 8.127E-01, cda= 1.136E-01,  
cdwave: xmach0= 1.800E+00, cdwav= 1.231E-01,  
cdblip: xmach0= 1.800E+00, cdlip= 1.420E-01,  
clsuc: xmach0= 1.800E+00, aoiac= 9.063E-01, cls= 2.273E-02, cdspl= 9.085E-02,thetae= 7.682E+00,  
: xmach0= 1.800E+00, aoiac= 9.063E-01, cdtot= 9.085E-02, cdspl= 9.085E-02, cdref= 2.651E-01,  
: xmach0= 1.800E+00,aoenac= 9.063E-01, w2C= 3.861E+01, w2= 3.389E+01,  
: xmachx= 1.800E+00,aoenac= 9.063E-01,w2ceng= 3.861E+01,

IPAC Pitot Inlet Example Case

Flight Conditions

Mach number 1.800E+00

altitude (ft) 3.729E+04

ambient total

pressure (lbf/ft\*\*2) 4.464E+02 2.565E+03

temperature (R) 3.900E+02 6.427E+02

dynamic pressure (lbf/ft\*\*2) 1.012E+03

Vehicle Effects

ML/MO 1.000E+00

PTL/PTO 1.000E+00

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AL/A0  
1.000E+00

Inlet Mass Flow Ratios  
A0I/AC 9.063E-01  
A0SPL/AC 9.373E-02  
A0BLD/AC 0.000E-01  
A0/AC 9.063E-01  
A0BYP/AC 0.000E-01  
A0ENG/AC 9.063E-01

Inlet Total Pressure Recoveries  
PT2/PT0 8.057E-01  
PTL/PT0 1.000E+00  
PT1/PTL 8.127E-01  
PTTH/PT1 1.000E+00  
PT2/PTTH 9.914E-01  
PTx/PTy 1.000E+00

Inlet Drag Breakdown  
AC (ft\*\*2) 1.000E+00

CD D (lbf)  
9.085E-02 9.197E+01  
0.000E-01 0.000E-01  
0.000E-01 0.000E-01  
2.651E-01 2.684E+02  
3.559E-01 3.603E+02  
2.651E-01 2.684E+02  
9.085E-02 9.197E+01

Engine Performance Data  
uninstalled installed  
net thrust (lbf) 0.000E-01 -3.603E+02  
SFC (lbm/hr/lbf) 0.000E-01 -0.000E-01  
W2 (lbm/s) 0.000E-01 3.389E+01  
corrected W2 (lbm/s) 3.861E+01 3.861E+01  
reference recovery 9.445E-01



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277 &ipac  xmach0=1.6,xmth=0.670,  &end
278
279 forebd:  xmachx= 1.600E+00,xmach0= 1.600E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
280 cdpito:  xmach0= 1.600E+00, aoiac= 1.000E+00,xmach1= 6.684E-01,pt1pt0= 8.952E-01,  cda=-2.856E-07,
281 cdpito:  xmach0= 1.600E+00, aoiac= 9.990E-01,xmach1= 6.671E-01,pt1pt0= 8.952E-01,  cda= 1.017E-03,
282 ptrcv:  xmach0= 1.600E+00, aoiac= 9.036E-01,  xmnis= 1.300E+00,pt2pt0= 8.866E-01,thetad= 2.472E+00,
283 xmth= 6.700E-01, athac= 9.025E-01,nishck=-1.000E+00,pthpt0= 8.952E-01,xlipth= 1.000E+00,
284 cdpito:  xmach0= 1.600E+00, aoiac= 9.036E-01,xmach1= 5.611E-01,pt1pt0= 8.952E-01,  cda= 1.054E-01,
285 cdwave:  xmach0= 1.600E+00, cdwav= 1.408E-01,
286 cdllip:  xmach0= 1.600E+00, cdllip= 1.323E-01,
287 clsuc:  xmach0= 1.600E+00, aoiac= 9.036E-01,  cls= 2.665E-02, cdspl= 7.874E-02,thetae= 7.682E+00,
288 :  xmach0= 1.600E+00, aoiac= 9.036E-01,  cdtot= 7.874E-02, cdspl= 7.874E-02, cdref= 2.730E-01,
289 :  xmach0= 1.600E+00,a0enac= 9.036E-01,  w2C= 4.026E+01,  w2= 3.770E+01,
290 :  xmachx= 1.600E+00,a0enac= 9.036E-01,w2ceng= 4.025E+01,
291
292 IPAC  Pitot Inlet Example Case
293
294 Flight Conditions
295
296 Mach number 1.600E+00
297
298 altitude (ft) 3.209E+04
299
300 ambient total
301
302 pressure (lbf/ft**2) 5.706E+02 2.425E+03
303 temperature (R) 4.042E+02 6.112E+02
304 dynamic pressure (lbf/ft**2) 1.023E+03
305
306 Vehicle Effects
307
308 ML/M0 1.000E+00
309 PTL/PT0 1.000E+00
310 AL/A0 1.000E+00
311
312 Inlet Mass Flow Ratios
313
314 A0I/AC 9.036E-01
315 A0SPL/AC 9.643E-02
316 A0BLD/AC 0.000E-01
317 A0/AC 9.036E-01
318 A0BYP/AC 0.000E-01
319 A0ENG/AC 9.036E-01
320
321 Inlet Total Pressure Recoveries
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323 PT2/PT0 8.866E-01
324 PTL/PT0 1.000E+00
325 PT1/PTL 8.952E-01
326 PTH/PT1 1.000E+00
327 PT2/PTH 9.904E-01
328 PTx/PTy 1.000E+00
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332 Inlet Drag Breakdown
333 AC (ft**2) 1.000E+00
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337 CD D (lbf)
338 spillage 7.874E-02 8.052E+01
339 bleed 0.000E-01 0.000E-01
340 bypass 0.000E-01 0.000E-01
341 cow1 2.730E-01 2.792E+02
342 total 3.518E-01 3.597E+02
343 reference 2.730E-01 2.792E+02
344 power setting 7.874E-02 8.052E+01
345
346 Engine Performance Data
347
348 net thrust (lbf) uninstalled installed
349 SFC (lbm/hr/lbf) 0.000E-01 -3.597E+02
350 W2 (lbm/s) 0.000E-01 -0.000E-01
351 corrected W2 (lbm/s) 0.000E-01 3.770E+01
352 4.025E+01 4.026E+01
353 reference recovery 9.624E-01
354
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356 &ipac xmach0=1.4,xmth=0.677, &end
357
358 forebd: xmachx= 1.400E+00,xmach0= 1.400E+00,xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
359 cdpito: xmach0= 1.400E+00, aoiac= 1.000E+00,xmach1= 7.397E-01,ptlpt0= 9.582E-01, cda=-6.867E-07,
360 cdpito: xmach0= 1.400E+00, aoiac= 9.990E-01,xmach1= 7.379E-01,ptlpt0= 9.582E-01, cda= 8.180E-04,
361 ptrcv: xmach0= 1.400E+00, a0ac= 8.670E-01, xmms= 1.300E+00,pt2pt0= 9.488E-01,thetad= 2.472E+00,
362 xnth= 6.770E-01, athac= 9.025E-01,nishck=-1.000E+00,pthpt0= 9.582E-01,xlipth= 1.000E+00,
363 cdpito: xmach0= 1.400E+00, aoiac= 8.670E-01,xmach1= 5.657E-01,ptlpt0= 9.582E-01, cda= 1.273E-01,
364 cdwave: xmach0= 1.400E+00, cdwav= 1.672E-01,
365 cdblip: xmach0= 1.400E+00, cdlip= 1.184E-01,
366 clsuc: xmach0= 1.400E+00, aoiac= 8.670E-01, cls= 3.947E-02, cdspl= 8.779E-02,thetae= 7.682E+00,
367 : xmach0= 1.400E+00, aoiac= 8.670E-01, cdttot= 8.779E-02, cdspl= 8.779E-02, cdref= 2.856E-01,
368 : xmach0= 1.400E+00,a0enac= 8.670E-01, w2c= 4.048E+01, w2= 4.045E+01,

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: xmachx= 1.400E+00,a0enac= 8.670E-01,w2ceng= 4.046E+01,

IPAC Pitot Inlet Example Case

Flight Conditions

Mach number 1.400E+00

altitude (ft) 2.611E+04

ambient total

pressure (lbf/ft\*\*2) 7.481E+02 2.381E+03

temperature (R) 4.256E+02 5.924E+02

dynamic pressure (lbf/ft\*\*2) 1.026E+03

Vehicle Effects

ML/M0 1.000E+00

PTL/PT0 1.000E+00

AL/A0 1.000E+00

Inlet Mass Flow Ratios

A0I/AC 8.670E-01

A0SPL/AC 1.330E-01

A0BLD/AC 0.000E-01

A0/AC 8.670E-01

A0BYP/AC 0.000E-01

A0ENG/AC 8.670E-01

Inlet Total Pressure Recoveries

PT2/PT0 9.488E-01

PTL/PT0 1.000E+00

PT1/PTL 9.582E-01

PTTH/PT1 1.000E+00

PT2/PTTH 9.902E-01

PTx/PTY 1.000E+00

Inlet Drag Breakdown

AC (ft\*\*2) 1.000E+00

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      spillage
      bleed
      bypass
      cowl
      total
      reference
      power setting

      CD          D (lbf)
      8.779E-02   9.011E+01
      0.000E-01   0.000E-01
      0.000E-01   0.000E-01
      2.856E-01   2.931E+02
      3.733E-01   3.832E+02
      2.856E-01   2.931E+02
      8.779E-02   9.011E+01

Engine Performance Data
      installed installed
      net thrust (lbf)      0.000E-01 -3.832E+02
      SFC (lbm/hr/lbf)     0.000E-01 -0.000E-01
      W2 (lbm/s)           0.000E-01 4.045E+01
      corrected W2 (lbm/s) 4.046E+01 4.048E+01

      reference recovery    9.782E-01

&ipac xmach0=1.2, &end

forebd: xmachx= 1.200E+00, xmach0= 1.200E+00, xmlm0= 1.000E+00, ptlpt0= 1.000E+00, ala0= 1.000E+00,
cdpito: xmach0= 1.200E+00, aoiac= 1.000E+00, xmach1= 8.422E-01, ptlpt0= 9.928E-01, cda=-5.840E-06,
cdpito: xmach0= 1.200E+00, aoiac= 9.990E-01, xmach1= 8.389E-01, ptlpt0= 9.928E-01, cda= 5.070E-04,
ptrcv: xmach0= 1.200E+00, aoiac= 8.302E-01, xmms= 1.300E+00, pt2pt0= 9.831E-01, thetad= 2.472E+00,
xpth= 6.770E-01, athac= 9.025E-01, nishck=-1.000E+00, pthpt0= 9.928E-01, xlipth= 1.000E+00,
cdpito: xmach0= 1.200E+00, aoiac= 8.302E-01, xmach1= 5.657E-01, ptlpt0= 9.928E-01, cda= 1.309E-01,
cdwave: xmach0= 1.200E+00, cdwav= 2.160E-01,
cdblip: xmach0= 1.200E+00, cdlip= 9.766E-02,
clsuc: xmach0= 1.200E+00, aoiac= 8.302E-01, cls= 5.322E-02, cdspl= 7.772E-02, thetad= 7.682E+00,
: xmach0= 1.200E+00, aoiac= 8.302E-01, cdtot= 7.772E-02, cdspl= 7.772E-02, cdref= 3.136E-01,
: xmach0= 1.200E+00, aoenac= 8.302E-01, w2c= 4.048E+01, w2= 4.362E+01,
: xmachx= 1.200E+00, aoenac= 8.302E-01, w2ceng= 4.046E+01,

IPAC Pitot Inlet Example Case

Flight Conditions
      Mach number      1.200E+00
      altitude (ft)    1.906E+04
      ambient          total
      pressure (lbf/ft**2) 1.012E+03 2.453E+03

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461	temperature (R)	4.507E+02	5.805E+02
462	dynamic pressure (lbf/ft**2)	1.020E+03	
463			
464	Vehicle Effects		
465	ML/M0	1.000E+00	
466	PTL/PT0	1.000E+00	
467	AL/A0	1.000E+00	
468			
469			
470	Inlet Mass Flow Ratios		
471			
472	A0I/AC	8.302E-01	
473	A0SPL/AC	1.698E-01	
474	A0BLD/AC	0.000E-01	
475	A0/AC	8.302E-01	
476	A0BYP/AC	0.000E-01	
477	A0ENG/AC	8.302E-01	
478			
479	Inlet Total Pressure Recoveries		
480			
481	PT2/PT0	9.831E-01	
482			
483	PTL/PT0	1.000E+00	
484	PT1/PTL	9.928E-01	
485	PTTH/PT1	1.000E+00	
486	PT2/PTTH	9.902E-01	
487			
488	PTx/PTy	1.000E+00	
489			
490	Inlet Drag Breakdown		
491			
492	AC (ft**2)	1.000E+00	
493			
494			
495			
496	spillage	7.772E-02	7.925E+01
497	bleed	0.000E-01	0.000E-01
498	bypass	0.000E-01	0.000E-01
499	cowl	3.136E-01	3.198E+02
500	total	3.914E-01	3.990E+02
501	reference	3.136E-01	3.198E+02
502	power setting	7.772E-02	7.925E+01
503			
504	Engine Performance Data	uninstalled	installed
505	net thrust (lbf)	0.000E-01	-3.990E+02
506			

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507 SFC (lbm/hr/lbf) 0.000E-01 -0.000E-01
508 W2 (lbm/s) 0.000E-01 4.362E+01
509 corrected W2 (lbm/s) 4.046E+01 4.048E+01
510
511 reference recovery 9.915E-01
512
513
514 &ipac xmach0=1.0, &end
515
516 forebd: xmachx= 1.000E+00,xmach0= 1.000E+00, xmlm0= 1.000E+00, ptlpt0= 1.000E+00, ala0= 1.000E+00,
517 ptrcv: xmach0= 1.000E+00, a0ac= 8.115E-01, xmns= 1.300E+00,pt2pt0= 9.902E-01,thetad= 2.472E+00,
518 xpth= 6.770E-01, athac= 9.025E-01,nishck=-1.000E+00,pthpt0= 1.000E+00,xlipth= 1.000E+00,
519 cdpito: xmach0= 1.000E+00, a0iac= 8.115E-01,xmach1= 5.657E-01,ptlpt0= 1.000E+00, cda= 9.982E-02,
520 clsuc: xmach0= 1.000E+00, a0iac= 8.115E-01, cls= 5.017E-02, cdspl= 4.965E-02,thetae= 7.682E+00,
521 : xmach0= 1.000E+00,a0enac= 8.115E-01, cdtot= 4.965E-02, cdspl= 4.965E-02, cdref= 0.000E-01,
522 : xmach0= 1.000E+00,a0enac= 8.115E-01, w2C= 4.048E+01, w2= 4.869E+01,
523 : xmachx= 1.000E+00,a0enac= 8.115E-01,w2ceng= 4.046E+01,
524
525 IPAC Pitot Inlet Example Case
526
527 Flight Conditions
528
529 Mach number 1.000E+00
530
531 altitude (ft) 1.040E+04
532
533 ambient total
534
535 pressure (lb/ft**2) 1.433E+03 2.712E+03
536 temperature (R) 4.816E+02 5.779E+02
537 dynamic pressure (lb/ft**2) 1.003E+03
538
539 Vehicle Effects
540
541 ML/M0 1.000E+00
542 PTL/PT0 1.000E+00
543 AL/A0 1.000E+00
544
545 Inlet Mass Flow Ratios
546
547 A0I/AC 8.115E-01
548 A0SPL/AC 1.885E-01
549 A0BLD/AC 0.000E-01
550 A0/AC 8.115E-01
551 A0BYP/AC 0.000E-01
552 A0ENG/AC 8.115E-01

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Inlet Total Pressure Recoveries

PT2/PT0 9.902E-01  
PTL/PT0 1.000E+00  
PT1/PTL 1.000E+00  
PTTH/PT1 1.000E+00  
PT2/PTTH 9.902E-01  
PTx/PTy 1.000E+00

Inlet Drag Breakdown

AC (ft\*\*2) 1.000E+00

	CD	D (lbf)
spillage	4.965E-02	4.979E+01
bleed	0.000E-01	0.000E-01
bypass	0.000E-01	0.000E-01
cowl	0.000E-01	0.000E-01
total	4.965E-02	4.979E+01
reference	0.000E-01	0.000E-01
power setting	4.965E-02	4.979E+01

Engine Performance Data

net thrust (lbf) 0.000E-01 -4.979E+01  
SFC (lbm/hr/lbf) 0.000E-01 -0.000E-01  
W2 (lbm/s) 0.000E-01 4.869E+01  
corrected W2 (lbm/s) 4.046E+01 4.048E+01  
reference recovery 1.000E+00

&ipac xmach0=0.8, &end

forebd: xmachx= 8.000E-01,xmach0= 8.000E-01, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,  
ptrcv: xmach0= 8.000E-01, a0ac= 8.426E-01, xmns= 1.300E+00,pt2pt0= 9.902E-01,thetad= 2.472E+00,  
xmth= 6.770E-01, athac= 9.025E-01,nishck=-1.000E+00,pthpt0= 1.000E+00,xlipt0= 1.000E+00,  
cdpito: xmach0= 8.000E-01, a0iac= 8.426E-01,xmach1= 5.657E-01,ptlpt0= 1.000E+00, cda= 4.807E-02,  
clsuc: xmach0= 8.000E-01, a0iac= 8.426E-01, cls= 3.470E-02, cdspl= 1.337E-02,thetae= 7.682E+00,  
: xmach0= 8.000E-01, a0enac= 8.426E-01, cdtot= 1.337E-02, cdspl= 1.337E-02, cdref= 0.000E-01,  
: xmach0= 8.000E-01, a0enac= 8.426E-01, w2C= 4.048E+01, w2= 5.756E+01,  
: xmachx= 8.000E-01,a0enac= 8.426E-01,w2ceng= 4.046E+01,

599	IPAC Pitot Inlet Example Case			
600	Flight Conditions			
601	Mach number	8.000E-01		
602	altitude (ft)	0.000E-01		
603		ambient	total	
604	pressure (lb/ft**2)	2.116E+03	3.226E+03	
605	temperature (R)	5.187E+02	5.851E+02	
606	dynamic pressure (lb/ft**2)	9.481E+02		
607	Vehicle Effects			
608	ML/M0	1.000E+00		
609	PTL/PT0	1.000E+00		
610	AL/A0	1.000E+00		
611	Inlet Mass Flow Ratios			
612	A0I/AC	8.426E-01		
613	A0SPL/AC	1.574E-01		
614	A0BLD/AC	0.000E-01		
615	A0/AC	8.426E-01		
616	A0BYP/AC	0.000E-01		
617	A0ENG/AC	8.426E-01		
618	Inlet Total Pressure Recoveries			
619	PT2/PT0	9.902E-01		
620	PTL/PT0	1.000E+00		
621	PT1/PTL	1.000E+00		
622	PTTH/PT1	1.000E+00		
623	PT2/PTTH	9.902E-01		
624	PTx/PTy	1.000E+00		
625	Inlet Drag Breakdown			
626	AC (ft**2)	1.000E+00		
627				
628				
629				
630				
631				
632				
633				
634				
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636				
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644				



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645 spillage 1.337E-02 1.268E+01
646 bleed 0.000E-01 0.000E-01
647 bypass 0.000E-01 0.000E-01
648 cowl 0.000E-01 0.000E-01
649 total 1.337E-02 1.268E+01
650 reference 0.000E-01 0.000E-01
651 power setting 1.337E-02 1.268E+01
652
653 Engine Performance Data
654
655 net thrust (lbf) 0.000E-01 -1.268E+01
656 SFC (lbm/hr/lbf) 0.000E-01 -0.000E-01
657 W2 (lbm/s) 0.000E-01 5.756E+01
658 corrected W2 (lbm/s) 4.046E+01 4.048E+01
659
660 reference recovery 1.000E+00
661
662
663
664 &ipac xmach0=0.6, &end
665
666 forebd: xmachx= 6.000E-01, xmach0= 6.000E-01, xmlm0= 1.000E+00, ptlpt0= 1.000E+00, ala0= 1.000E+00,
667 ptrcv: xmach0= 6.000E-01, a0ac= 9.643E-01, xmns= 1.300E+00, pt2pt0= 9.902E-01, thetad= 2.472E+00,
668 xmtth= 6.770E-01, athac= 9.025E-01, nishck=-1.000E+00, pthpt0= 1.000E+00, xlipth= 1.000E+00,
669 cdpito: xmach0= 6.000E-01, a0iac= 9.643E-01, xmach1= 5.657E-01, ptlpt0= 1.000E+00, cda= 1.934E-03,
670 clsuc: xmach0= 6.000E-01, a0iac= 9.643E-01, cls= 1.543E-03, cdspl= 3.909E-04, thetae= 7.682E+00,
671 : xmach0= 6.000E-01, a0enac= 9.643E-01, cdtot= 3.909E-04, cdspl= 3.909E-04, cdref= 0.000E-01,
672 : xmach0= 6.000E-01, a0enac= 9.643E-01, w2c= 4.048E+01, w2= 4.940E+01,
673 : xmachx= 6.000E-01, a0enac= 9.643E-01, w2ceng= 4.046E+01,
674
675 IPAC Pitot Inlet Example Case
676
677 Flight Conditions
678
679 Mach number 6.000E-01
680
681 altitude (ft) 0.000E-01
682
683 ambient total
684
685 pressure (lbf/ft**2) 2.116E+03 2.699E+03
686 temperature (R) 5.187E+02 5.560E+02
687 dynamic pressure (lbf/ft**2) 5.333E+02
688
689 Vehicle Effects
690

```

691	ML/MO	1.000E+00	
692	PTL/PTO	1.000E+00	
693	AL/AO	1.000E+00	
694			
695	Inlet Mass Flow Ratios		
696			
697	A0I/AC	9.643E-01	
698	A0SPL/AC	3.573E-02	
699	A0BLD/AC	0.000E-01	
700	A0/AC	9.643E-01	
701	A0BYP/AC	0.000E-01	
702	A0ENG/AC	9.643E-01	
703			
704	Inlet Total Pressure Recoveries		
705			
706	PT2/PTO	9.902E-01	
707			
708	PTL/PTO	1.000E+00	
709	PT1/PTL	1.000E+00	
710	PTTH/PT1	1.000E+00	
711	PT2/PTTH	9.902E-01	
712			
713	PTx/PTy	1.000E+00	
714			
715	Inlet Drag Breakdown		
716			
717	AC (ft**2)	1.000E+00	
718			
719			
720			
721	spillage	3.909E-04	2.085E-01
722	bleed	0.000E-01	0.000E-01
723	bypass	0.000E-01	0.000E-01
724	cowl	0.000E-01	0.000E-01
725	total	3.909E-04	2.085E-01
726	reference	0.000E-01	0.000E-01
727	power setting	3.909E-04	2.085E-01
728			
729	Engine Performance Data	uninstalled	installed
730			
731	net thrust (lbf)	0.000E-01	-2.085E-01
732	SFC (lbm/hr/lbf)	0.000E-01	-0.000E-01
733	W2 (lbm/s)	0.000E-01	4.940E+01
734	corrected W2 (lbm/s)	4.046E+01	4.048E+01
735			
736	reference recovery	1.000E+00	

```

737 &ipac  xmach0=0.4,  &end
738
739 forebd:  xmachx= 4.000E-01,xmach0= 4.000E-01, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
740 ptrcv:  xmach0= 4.000E-01,  a0ac= 1.278E+00,  xmns= 1.300E+00,pt2pt0= 9.808E-01,thetad= 2.472E+00,
741 xpth= 6.770E-01,  athac= 9.025E-01,nishck=-1.000E+00,pthpt0= 9.904E-01,xlipth= 1.000E+00,
742 :  xmach0= 4.000E-01,  a0iac= 1.278E+00,  cda= 0.000E-01,
743 :  xmach0= 4.000E-01,  a0iac= 1.278E+00,  cdtot= 0.000E-01,  cdspl= 0.000E-01,  cdref= 0.000E-01,
744 :  xmach0= 4.000E-01,a0enac= 1.278E+00,  w2C= 4.048E+01,  w2= 4.366E+01,
745 :  xmachx= 4.000E-01,a0enac= 1.278E+00,w2ceng= 4.046E+01,
746
747
748 IPAC  Pitot Inlet Example Case
749
750 Flight Conditions
751
752 Mach number 4.000E-01
753
754 altitude (ft) 0.000E-01
755
756 ambient total
757
758 pressure (lbf/ft**2) 2.116E+03 2.363E+03
759 temperature (R) 5.187E+02 5.353E+02
760 dynamic pressure (lbf/ft**2) 2.370E+02
761
762 Vehicle Effects
763
764 ML/MO 1.000E+00
765 PTL/PT0 1.000E+00
766 AL/A0 1.000E+00
767
768 Inlet Mass Flow Ratios
769
770 AOI/AC 1.278E+00
771 AOSPL/AC -2.781E-01
772 AOELD/AC 0.000E-01
773 AO/AC 1.278E+00
774 AOBYE/AC 0.000E-01
775 AOENG/AC 1.278E+00
776
777 Inlet Total Pressure Recoveries
778
779 PT2/PT0 9.808E-01
780
781 PTL/PT0 1.000E+00
782

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783 PT1/PTL 1.000E+00
784 PTH/PT1 9.904E-01
785 PT2/PTH 9.902E-01
786
787 PTx/PTy 1.000E+00
788
789 Inlet Drag Breakdown
790 AC (ft**2) 1.000E+00
791
792
793 CD D (lbf)
794
795 spillage 0.000E-01 0.000E-01
796 bleed 0.000E-01 0.000E-01
797 bypass 0.000E-01 0.000E-01
798 cowl 0.000E-01 0.000E-01
799 total 0.000E-01 0.000E-01
800 reference 0.000E-01 0.000E-01
801 power setting 0.000E-01 0.000E-01
802
803 Engine Performance Data
804
805 net thrust (lbf) 0.000E-01 0.000E-01
806 SFC (lbm/hr/lbf) 0.000E-01 0.000E-01
807 W2 (lbm/s) 0.000E-01 4.366E+01
808 corrected W2 (lbm/s) 4.046E+01 4.048E+01
809
810 reference recovery 1.000E+00
811
812
813 &ipac xmach0=0.2, &end
814
815 forebd: xmachx= 2.000E-01,xmach0= 2.000E-01, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
816 ptrcv: xmach0= 2.000E-01, a0ac= 2.290E+00, xmns= 1.300E+00,pt2pt0= 9.427E-01,thetad= 2.472E+00,
817 xpth= 6.770E-01, athac= 9.025E-01,nishck=-1.000E+00,pthpt0= 9.520E-01,xlipth= 1.000E+00,
818 : xmach0= 2.000E-01, a0iac= 2.290E+00, cda= 0.000E-01,
819 : xmach0= 2.000E-01, a0iac= 2.290E+00, cdtot= 0.000E-01, cdspl= 0.000E-01, cdref= 0.000E-01,
820 : xmach0= 2.000E-01,a0enac= 2.290E+00, w2C= 4.048E+01, w2= 3.910E+01,
821 : xmachx= 2.000E-01,a0enac= 2.290E+00,w2ceng= 4.046E+01,
822
823 IPAC Pitot Inlet Example Case
824
825 Flight Conditions
826
827 Mach number 2.000E-01
828

```

829	altitude	(ft)	0.000E-01		
830					
831			ambient	total	
832	pressure	(lbf/ft**2)	2.116E+03	2.176E+03	
833	temperature	(R)	5.187E+02	5.228E+02	
834	dynamic pressure	(lbf/ft**2)	5.925E+01		
835					
836					
837	Vehicle Effects				
838	ML/M0		1.000E+00		
839	PTL/PT0		1.000E+00		
840	AL/A0		1.000E+00		
841					
842					
843	Inlet Mass Flow Ratios				
844	A0I/AC		2.290E+00		
845	A0SPL/AC		-1.290E+00		
846	A0BLD/AC		0.000E-01		
847	A0/AC		2.290E+00		
848	A0BYP/AC		0.000E-01		
849	A0ENG/AC		2.290E+00		
850					
851					
852	Inlet Total Pressure Recoveries				
853	PT2/PT0		9.427E-01		
854					
855	PTL/PT0		1.000E+00		
856	PT1/PTL		1.000E+00		
857	PTTH/PT1		9.520E-01		
858	PT2/PTTH		9.902E-01		
859					
860	PTx/PTY		1.000E+00		
861					
862					
863	Inlet Drag Breakdown				
864	AC	(ft**2)	1.000E+00		
865					
866					
867					
868					
869	spillage		0.000E-01	0.000E-01	
870	bleed		0.000E-01	0.000E-01	
871	bypass		0.000E-01	0.000E-01	
872	cowl		0.000E-01	0.000E-01	
873	total		0.000E-01	0.000E-01	
874	reference		0.000E-01	0.000E-01	

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875 power setting 0.000E-01 0.000E-01
876
877 Engine Performance Data
878
879 net thrust (lbf) 0.000E-01 0.000E-01
880 SFC (lbm/hr/lbf) 0.000E-01 0.000E-01
881 W2 (lbm/s) 0.000E-01 3.910E+01
882 corrected W2 (lbm/s) 4.046E+01 4.048E+01
883
884 reference recovery 1.000E+00
885
886
887 &ipac xmach0=0.01, &end
888
889 forebd: xmachx= 1.000E-02,xmach0= 1.000E-02, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
890 ptrcv: xmach0= 1.000E-02, a0ac= 4.172E+01, xmns= 1.300E+00,pt2pt0= 8.795E-01,thetad= 2.472E+00,
891 xsth= 6.770E-01, athac= 9.025E-01,nishck=-1.000E+00,pthpt0= 8.882E-01,xlipth= 1.000E+00,
892 : xmach0= 1.000E-02, a0iac= 4.172E+01, cda= 0.000E-01,
893 : xmach0= 1.000E-02, a0iac= 4.172E+01, cdtot= 0.000E-01, cdspl= 0.000E-01, cdref= 0.000E-01,
894 : xmach0= 1.000E-02,a0enac= 4.172E+01, w2c= 4.048E+01, w2= 3.562E+01,
895 : xmachx= 1.000E-02,a0enac= 4.172E+01,w2ceng= 4.046E+01,
896
897 IPAC Pitot Inlet Example Case
898
899 Flight Conditions
900
901 Mach number 1.000E-02
902
903 altitude (ft) 0.000E-01
904
905 ambient total
906
907 pressure (lbf/ft**2) 2.116E+03 2.116E+03
908 temperature (R) 5.187E+02 5.187E+02
909 dynamic pressure (lbf/ft**2) 1.481E-01
910
911 Vehicle Effects
912
913 ML/M0 1.000E+00
914 PTL/PT0 1.000E+00
915 AL/A0 1.000E+00
916
917 Inlet Mass Flow Ratios
918
919 A0I/AC 4.172E+01
920 A0SPL/AC -4.072E+01

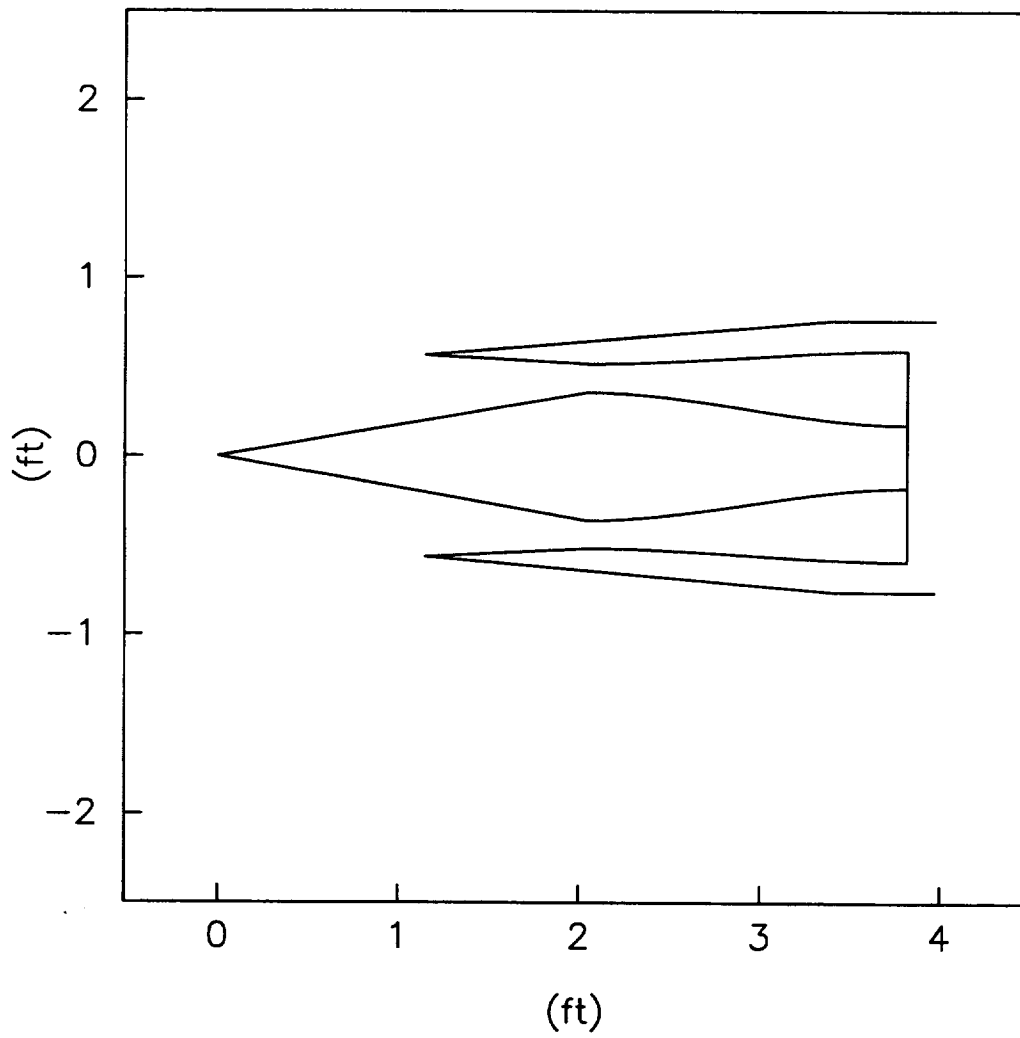
```

921	A0BLD/AC	0.000E-01		
922	A0/AC	4.172E+01		
923	A0BYP/AC	0.000E-01		
924	A0ENG/AC	4.172E+01		
925				
926	Inlet Total Pressure Recoveries			
927				
928	PT2/PT0	8.795E-01		
929				
930	PTL/PT0	1.000E+00		
931	PT1/PTL	1.000E+00		
932	PTTH/PT1	8.882E-01		
933	PT2/PTTH	9.902E-01		
934				
935	PTx/PTY	1.000E+00		
936				
937	Inlet Drag Breakdown			
938				
939	AC (ft**2)	1.000E+00		
940				
941			CD	D (lbf)
942	spillage	0.000E-01	0.000E-01	0.000E-01
943	bleed	0.000E-01	0.000E-01	0.000E-01
944	bypass	0.000E-01	0.000E-01	0.000E-01
945	cowl	0.000E-01	0.000E-01	0.000E-01
946	total	0.000E-01	0.000E-01	0.000E-01
947	reference	0.000E-01	0.000E-01	0.000E-01
948	power setting	0.000E-01	0.000E-01	0.000E-01
949				
950	Engine Performance Data			
951			uninstalled	installed
952				
953	net thrust (lbf)	0.000E-01	0.000E-01	0.000E-01
954	SFC (lbm/hr/lbf)	0.000E-01	0.000E-01	0.000E-01
955	W2 (lbm/s)	0.000E-01	0.000E-01	3.562E+01
956	corrected W2 (lbm/s)	4.046E+01	4.046E+01	4.048E+01
957				
958	reference recovery	1.000E+00		
959				
960				

Appendix III

Mach 2.4 Axisymmetric Inlet

Example Case





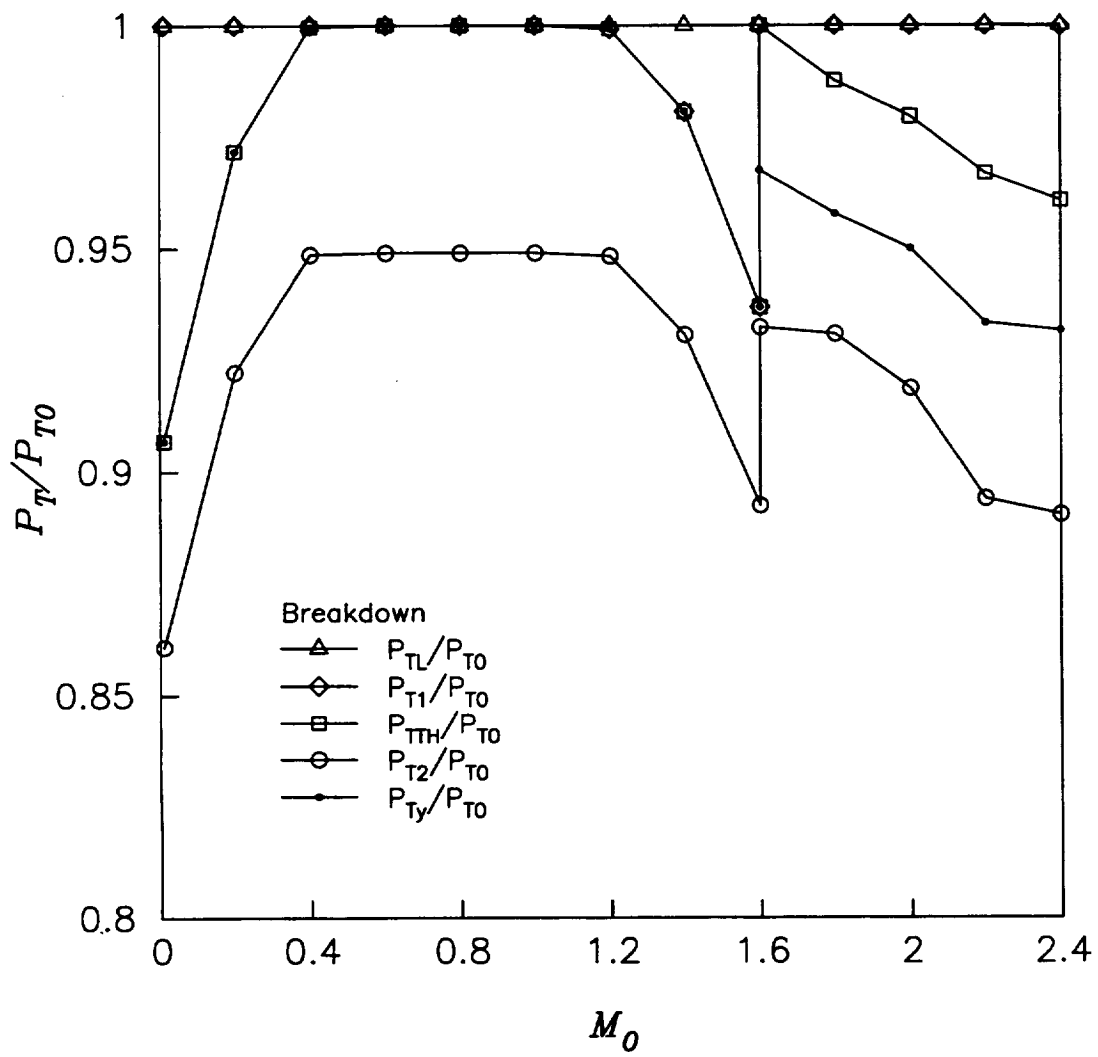


Figure III.1 Total Pressure Recoveries

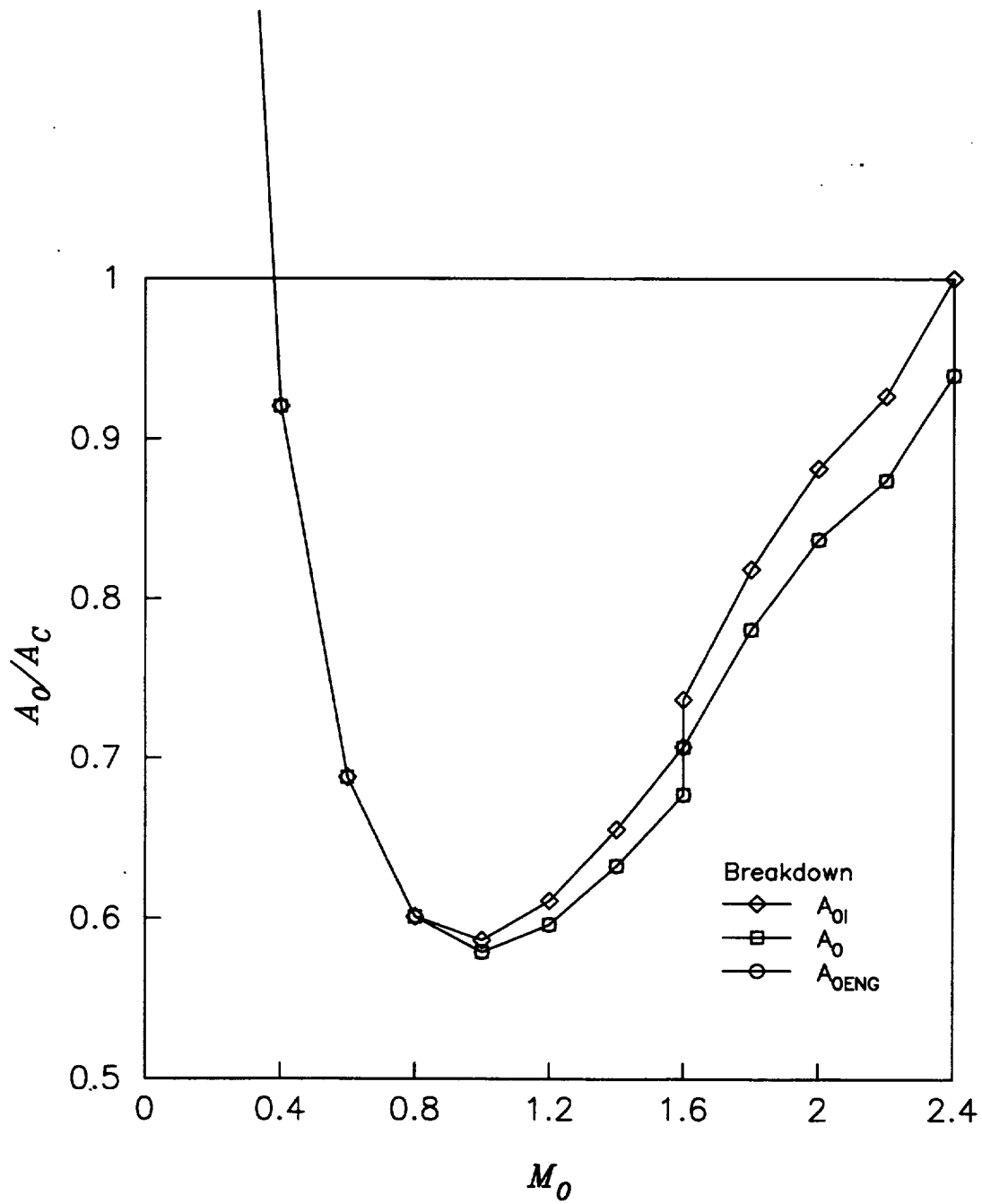


Figure III.2

Mass Flow Ratios

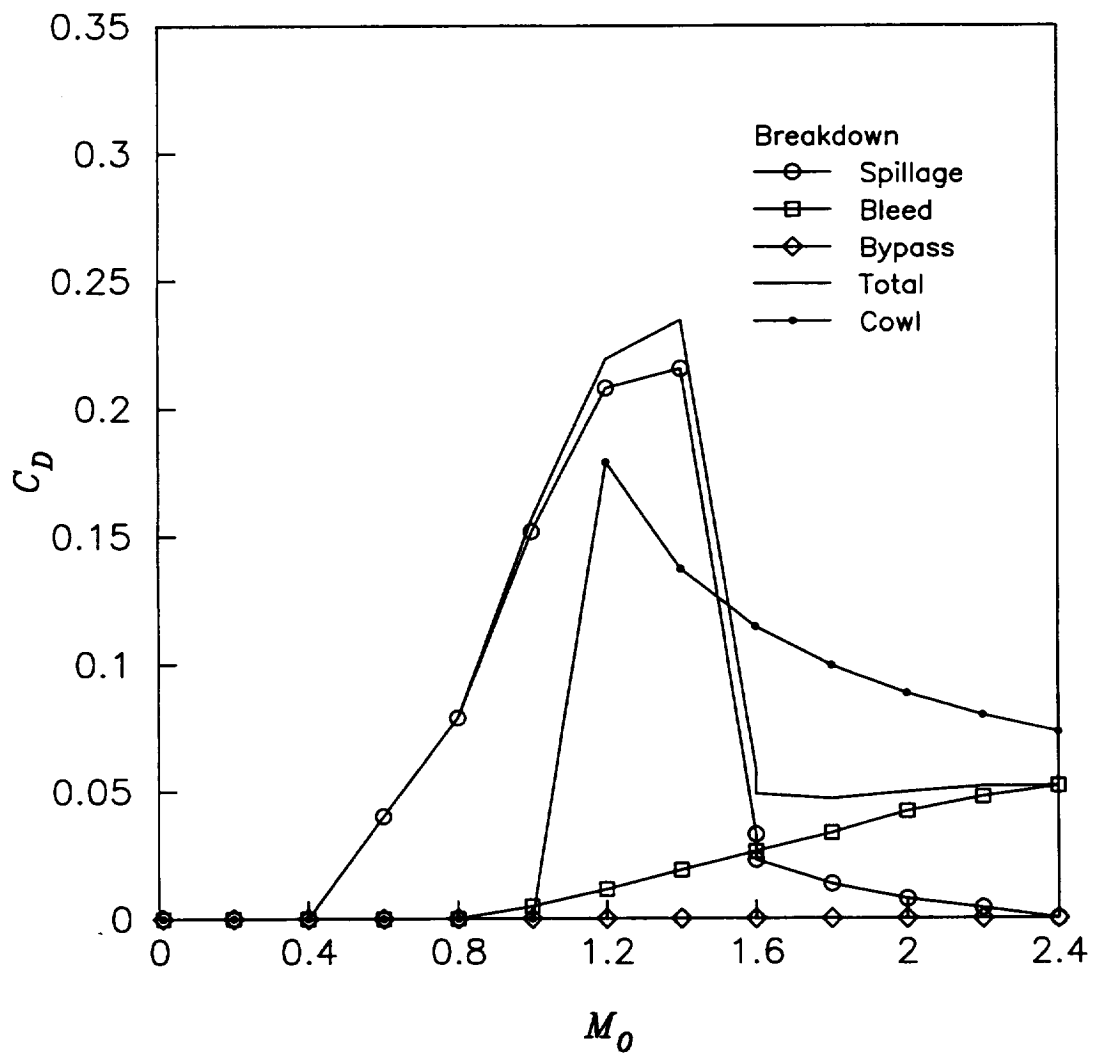


Figure III.3 Drag Coefficients

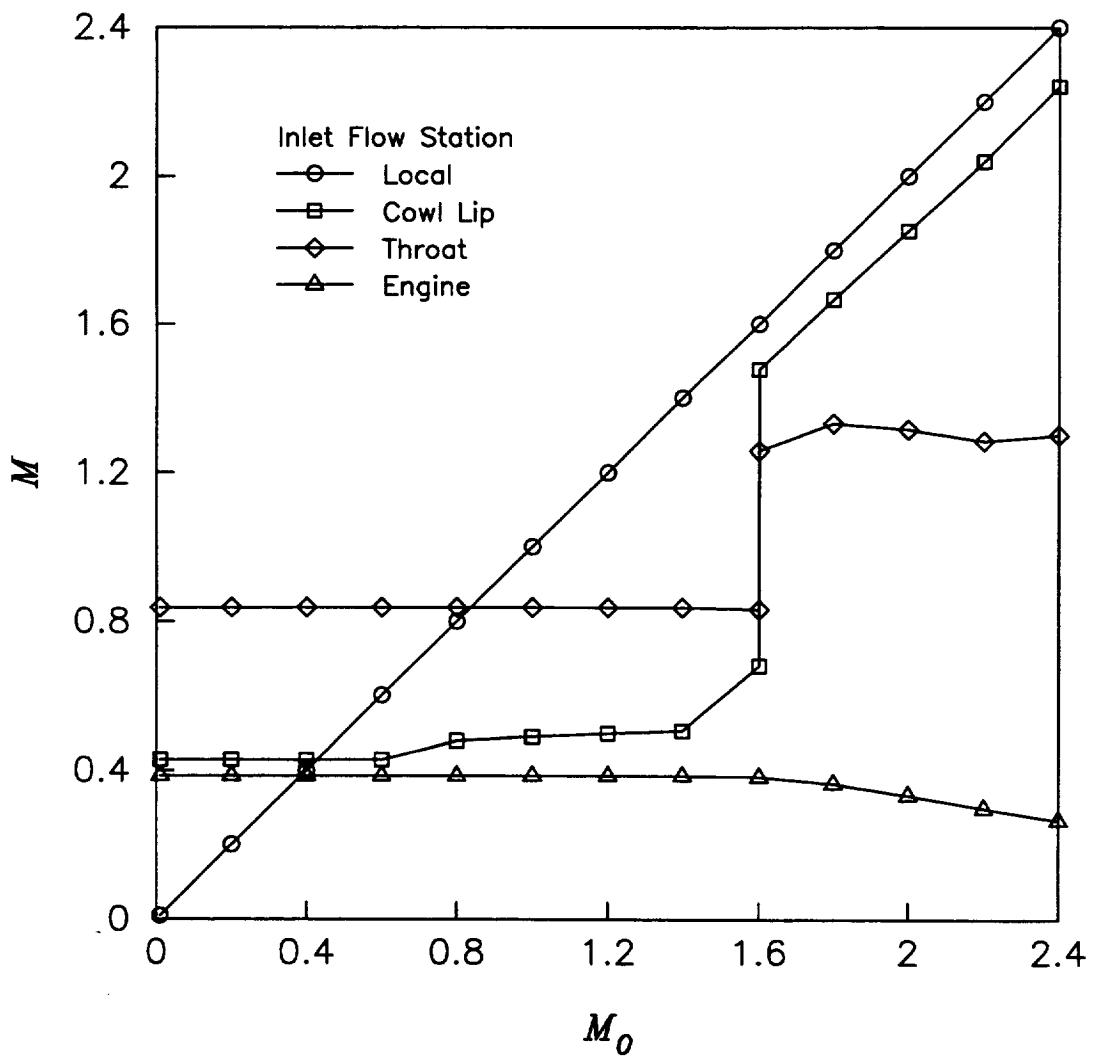


Figure III.4 Mach Numbers

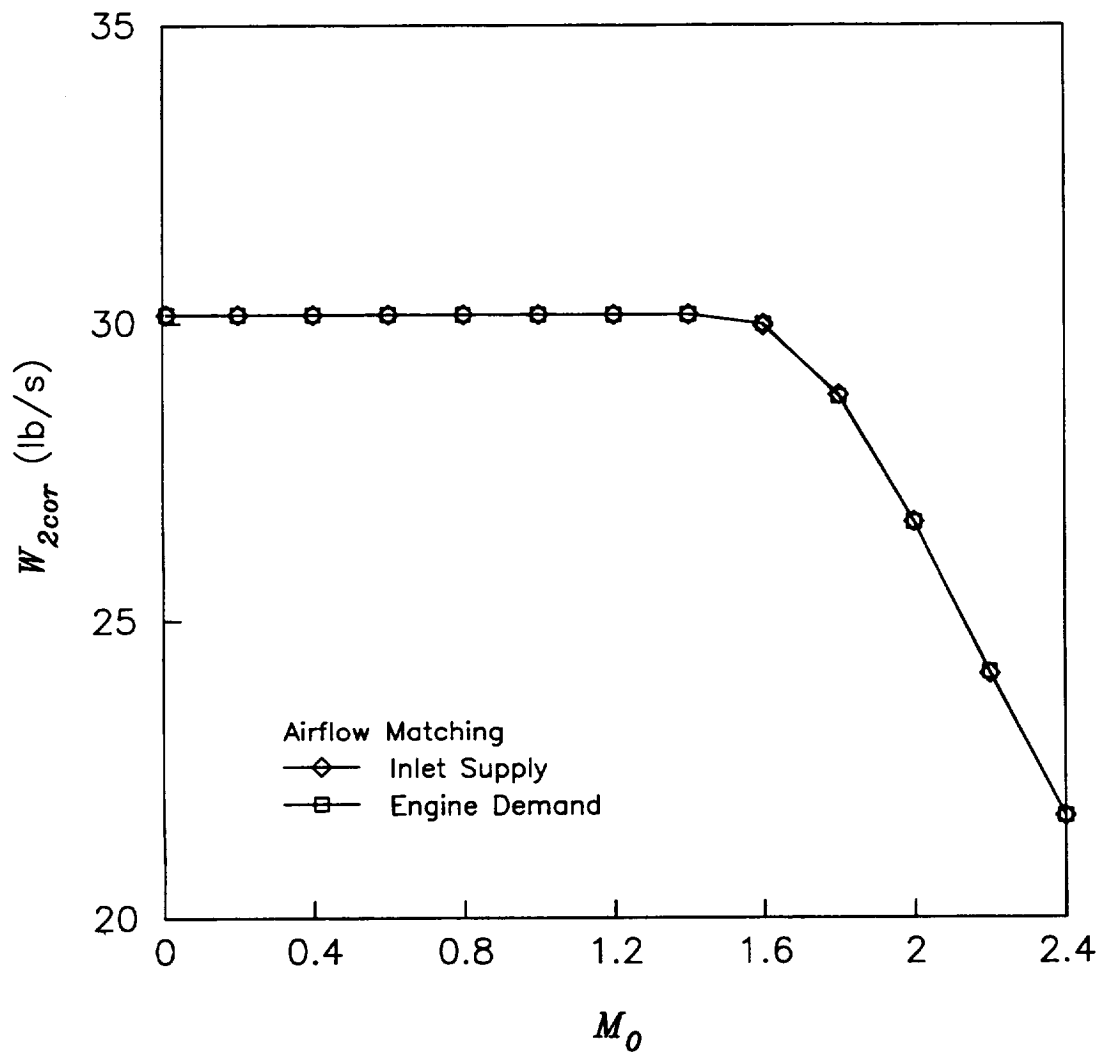


Figure III.5 Corrected Airflows

```

1 &ipac
2 title='Axisymmetric Inlet Example Case',
3 echo=1,figure=1,npts=10,20,iout=1,1,1,1,
4 xmach0=2.4,alt=-1000,
5 idim=3,ac=1.0,ar=1,
6 ramps=1,theta=10,
7 xcowl=0.0,ycowl=1.0,
8 rclip=0.0,thetac=3.0,
9 cowls=2,cowlth=5,-5,cowlx1=4,1,
10 a2ac=1.00,xlidd2=1.5,hubtip=0.3,
11 nishck=-1,xmth=-1.30,xmns=1.35,
12 athac=-1,
13 w2cor=-1,
14 bleed=-1,pblpt0=-1,
15 &end
16
17 forebd: xmachx= 2.400E+00,xmach0= 2.400E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
18 cdaxi: xmach0= 2.400E+00, aoiac= 9.999E-01,xmach1= 2.241E+00,ptlpt0= 9.997E-01, cda= 3.023E-06,
19 cdaxi: xmach0= 2.400E+00, aoiac= 9.989E-01,xmach1= 5.360E-01,ptlpt0= 6.095E-01, cda= 8.542E-03,
20 ptrcv: xmach0= 2.400E+00, a0ac= 9.400E-01, xmns= 1.350E+00,pt2pt0= 8.903E-01,thetad= 4.057E+00,
21 xmth= 1.300E+00, athac= 4.341E-01,nishck= 1.000E+00,pthpt0= 9.606E-01,xlipt0= 9.118E-01,
22 cdaxi: xmach0= 2.400E+00, aoiac= 9.999E-01,xmach1= 2.241E+00,ptlpt0= 9.997E-01, cda= 3.023E-06,
23 cdwave: xmach0= 2.400E+00, cdwav= 7.306E-02,
24 cdbld: xmach0= 2.400E+00, aoiac= 9.999E-01, bleed= 6.000E-02, cdbld= 5.186E-02,ptblpe= 1.465E+00,
25 : xmach0= 2.400E+00, aoiac= 9.999E-01, bleed= 6.000E-02, cdbld= 5.186E-02,
26 : xmach0= 2.400E+00, aoiac= 9.999E-01, cdtot= 5.186E-02, cdspl= 3.023E-06, cdref= 7.306E-02,
27 : xmach0= 2.400E+00, a0enac= 9.399E-01, w2c= 2.170E+01, w2= 2.574E+01,
28 : xmachx= 2.400E+00,a0enac= 9.399E-01,w2ceng= 2.170E+01,
29
30 IPAC Axisymmetric Inlet Example Case
31
32 Flight Conditions
33
34 Mach number 2.400E+00
35
36 altitude (ft) 4.974E+04
37
38 ambient total
39
40 pressure (lbf/ft**2) 2.452E+02 3.585E+03
41 temperature (R) 3.900E+02 8.392E+02
42 dynamic pressure (lbf/ft**2) 9.888E+02
43
44 Vehicle Effects
45
46 ML/MO 1.000E+00

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47	PTL/PT0	1.000E+00	
48	AL/A0	1.000E+00	
49			
50	Inlet Mass Flow Ratios		
51			
52	A0I/AC	9.999E-01	
53	A0SPL/AC	8.440E-05	
54	A0BLD/AC	6.000E-02	
55	A0/AC	9.399E-01	
56	A0BYP/AC	0.000E-01	
57	A0ENG/AC	9.399E-01	
58			
59	Inlet Total Pressure Recoveries		
60			
61	PT2/PT0	8.903E-01	
62			
63	PTL/PT0	1.000E+00	
64	PT1/PTL	9.997E-01	
65	PTTH/PT1	9.609E-01	
66	PT2/PTTH	9.268E-01	
67			
68	PTx/PTY	9.697E-01	
69			
70	Inlet Drag Breakdown		
71			
72	AC (ft**2)	1.000E+00	
73			
74		CD	D (lbf)
75			
76	spillage	3.023E-06	2.990E-03
77	bleed	5.186E-02	5.128E+01
78	bypass	0.000E-01	0.000E-01
79	cowl	7.306E-02	7.224E+01
80	total	1.249E-01	1.235E+02
81	reference	7.306E-02	7.224E+01
82	power setting	5.186E-02	5.128E+01
83			
84	Engine Performance Data	uninstalled	installed
85			
86	net thrust (lbf)	0.000E-01	-1.235E+02
87	SFC (lbm/hr/lbf)	0.000E-01	-0.000E-01
88	W2 (lbm/s)	0.000E-01	2.574E+01
89	corrected W2 (lbm/s)	2.170E+01	2.170E+01
90			
91	reference recovery	8.819E-01	
92			

Inlet Flow Properties	free stream	inlet local	cowl lip	throat	engine face
station	0	L	1	TH	2
flow area (ft**2)	9.999E-01	9.999E-01	8.706E-01	4.341E-01	1.000E+00
Mach number	2.400E+00	2.400E+00	2.241E+00	1.300E+00	2.651E-01
pressure (lbf/ft**2)	2.452E+02	2.452E+02	3.145E+02	1.243E+03	3.040E+03
temperature (R)	3.900E+02	3.900E+02	4.187E+02	6.273E+02	8.276E+02
density (slg/ft**3)	3.664E-04	3.664E-04	4.377E-04	1.155E-03	2.140E-03
velocity (ft/s)	2.323E+03	2.323E+03	2.248E+03	1.596E+03	3.738E+02
total pressure (lbf/ft**2)	3.585E+03	3.585E+03	3.585E+03	3.444E+03	3.192E+03
total temperature (R)	8.392E+02	8.392E+02	8.392E+02	8.392E+02	8.392E+02
weight flow (lbm/s)	2.739E+01	2.739E+01	2.739E+01	2.574E+01	2.574E+01
corrected weight flow (lbm/s)	2.055E+01	2.055E+01	2.056E+01	2.011E+01	2.170E+01
Geometry Data for Axisymmetric Inlet					
inlet capture, AC (ft**2)	1.000E+00				
wrap angle (degrees)	3.600E+02				
radius (ft)	5.642E-01				
engine face, A2 (ft**2)	1.000E+00				
diameter (ft)	1.183E+00				
H/T	3.000E-01				
Figure Data for Inlet Geometry					
internal cowl surface (ft)	X	Y			
	1.147E+00	5.642E-01			
	2.040E+00	5.173E-01			
	2.040E+00	5.173E-01			
	2.134E+00	5.179E-01			
	2.227E+00	5.196E-01			
	2.321E+00	5.223E-01			
	2.414E+00	5.258E-01			



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		X	Y	
	external cowl surface (ft)			
		2.507E+00	5.300E-01	
		2.601E+00	5.348E-01	
		2.694E+00	5.401E-01	
		2.788E+00	5.457E-01	
		2.881E+00	5.515E-01	
		2.974E+00	5.573E-01	
		3.068E+00	5.631E-01	
		3.161E+00	5.687E-01	
		3.254E+00	5.739E-01	
		3.348E+00	5.787E-01	
		3.441E+00	5.830E-01	
		3.535E+00	5.865E-01	
		3.628E+00	5.891E-01	
		3.721E+00	5.908E-01	
		3.815E+00	5.914E-01	
		1.147E+00	5.642E-01	
		3.403E+00	7.616E-01	
		3.967E+00	7.616E-01	
	centerbody surface (ft)			
		0.000E-01	0.000E-01	
		2.040E+00	3.598E-01	
		2.040E+00	3.598E-01	
		2.134E+00	3.583E-01	
		2.227E+00	3.542E-01	
		2.321E+00	3.476E-01	
		2.414E+00	3.389E-01	
		2.507E+00	3.286E-01	
		2.601E+00	3.167E-01	
		2.694E+00	3.038E-01	
		2.788E+00	2.900E-01	
		2.881E+00	2.758E-01	
		2.974E+00	2.614E-01	
		3.068E+00	2.472E-01	
		3.161E+00	2.334E-01	
		3.254E+00	2.205E-01	
		3.348E+00	2.087E-01	
		3.441E+00	1.983E-01	
		3.535E+00	1.896E-01	
		3.628E+00	1.831E-01	
		3.721E+00	1.789E-01	
		3.815E+00	1.774E-01	

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3.815E+00 1.774E-01

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&ipac
  xmach0=2.2,figure=0,iout=1,1,0,0,
  xnth=-1.3,xlipth=-1,
  xtrans=0.45,xmns=1.37,
&end
forebd: xmachx= 2.200E+00,xmach0= 2.200E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
cdaxi: xmach0= 2.200E+00, aoiac= 9.268E-01,xmach1= 2.039E+00,ptipt0= 9.999E-01, cda= 4.079E-03,
cdaxi: xmach0= 2.200E+00, aoiac= 9.259E-01,xmach1= 5.708E-01,ptipt0= 7.024E-01, cda= 1.631E-03,
ptrcv: xmach0= 2.200E+00, a0ac= 8.743E-01, xmns= 1.370E+00,pt2pt0= 8.939E-01,thetad= 3.789E+00,
      xnth= 1.284E+00, athac= 4.780E-01,nishck= 1.000E+00,pthpt0= 9.668E-01,xlipth= 7.176E-01,
cdaxi: xmach0= 2.200E+00, aoiac= 9.268E-01,xmach1= 2.039E+00,ptlpt0= 9.999E-01, cda= 4.079E-03,
cdwave: xmach0= 2.200E+00, cdwav= 7.992E-02,
cdbld: xmach0= 2.200E+00, aoiac= 9.268E-01, bleed= 5.250E-02, cdbld= 4.766E-02,ptblpe= 1.225E+00,
      : xmach0= 2.200E+00, aoiac= 9.268E-01, bleed= 5.250E-02, cdbld= 4.766E-02,
      : xmach0= 2.200E+00, aoiac= 9.268E-01, cdtot= 5.174E-02, cdspl= 4.079E-03, cdref= 7.992E-02,
      : xmach0= 2.200E+00,a0enac= 8.743E-01, w2C= 2.410E+01, w2= 2.627E+01,
      : xmachx= 2.200E+00,a0enac= 8.743E-01,w2ceng= 2.413E+01,
```

IPAC Axisymmetric Inlet Example Case

Flight Conditions

Mach number	2.200E+00		
altitude (ft)	4.601E+04	ambient	total
pressure (lbf/ft**2)	2.934E+02	2.934E+02	3.138E+03
temperature (R)	3.900E+02	3.900E+02	7.675E+02
dynamic pressure (lbf/ft**2)	9.942E+02		

Vehicle Effects

ML/M0	1.000E+00
PTL/PT0	1.000E+00
AL/A0	1.000E+00

Inlet Mass Flow Ratios

A0I/AC	9.268E-01
A0SPL/AC	7.319E-02

231	A0BLD/AC	5.250E-02	
232	A0/AC	8.743E-01	
233	A0BYP/AC	0.000E-01	
234	A0ENG/AC	8.743E-01	
235			
236	Inlet Total Pressure Recoveries		
237			
238	PT2/PT0	8.939E-01	
239	PTL/PT0	1.000E+00	
240	PT1/PTL	9.999E-01	
241	PTTH/PT1	9.670E-01	
242	PT2/PTTH	9.245E-01	
243			
244			
245	PTx/PTy	9.653E-01	
246			
247	Inlet Drag Breakdown		
248			
249	AC (ft**2)	1.000E+00	
250			
251		CD	D (lbf)
252	spillage	4.079E-03	4.055E+00
253	bleed	4.766E-02	4.739E+01
254	bypass	0.000E-01	0.000E-01
255	cowl	7.992E-02	7.946E+01
256	total	1.317E-01	1.309E+02
257	reference	7.992E-02	7.946E+01
258	power setting	5.174E-02	5.144E+01
259			
260	Engine Performance Data		
261		uninstalled	installed
262	net thrust (lbf)	0.000E-01	-1.309E+02
263	SFC (lbm/hr/lbf)	0.000E-01	-0.000E-01
264	W2 (lbm/s)	0.000E-01	2.627E+01
265	corrected W2 (lbm/s)	2.413E+01	2.410E+01
266			
267	reference recovery	9.041E-01	
268			
269			
270			
271	&ipac		
272	xmach0=2.0,figure=0,		
273	xtrans=0.61,xmns=1.35,		
274	thetac= 1.5,		
275	&end		
276			

```

forebd: xmachx= 2.000E+00,xmach0= 2.000E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
cdaxi: xmach0= 2.000E+00, aoiac= 8.816E-01,xmach1= 1.853E+00,ptlpt0= 9.999E-01, cda= 7.564E-03,
278 cdaxi: xmach0= 2.000E+00, aoiac= 8.807E-01,xmach1= 6.086E-01,pt1pt0= 7.889E-01, cda= 9.161E-04,
279 ptrcv: xmach0= 2.000E+00, a0ac= 8.366E-01, xmns= 1.350E+00,pt2pt0= 9.187E-01,thetad= 3.383E+00,
280 xmth= 1.315E+00, athac= 5.429E-01,nishck= 1.000E+00,pthpt0= 9.796E-01,xlipth= 6.263E-01,
281 cdaxi: xmach0= 2.000E+00, aoiac= 8.816E-01,xmach1= 1.853E+00,pt1pt0= 9.999E-01, cda= 7.564E-03,
282 cdwav= xmach0= 2.000E+00, cdwav= 8.844E-02,
283 cdbld: xmach0= 2.000E+00, aoiac= 8.816E-01, bleed= 4.500E-02, cdbld= 4.195E-02,ptblpe= 1.093E+00,
284 : xmach0= 2.000E+00, aoiac= 8.816E-01, bleed= 4.500E-02, cdbld= 4.195E-02,
285 : xmach0= 2.000E+00, aoiac= 8.816E-01, bleed= 4.500E-02, cdbld= 4.195E-02,
286 : xmach0= 2.000E+00, aoiac= 8.816E-01, cdtot= 4.951E-02, cdspl= 7.564E-03, cdref= 8.844E-02,
287 : xmach0= 2.000E+00,a0enac= 8.366E-01, w2c= 2.665E+01, w2= 2.786E+01,
288 : xmachx= 2.000E+00,a0enac= 8.366E-01,w2ceng= 2.664E+01,
289

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IPAC Axisymmetric Inlet Example Case

Flight Conditions

Mach number	2.000E+00	ambient	total
altitude (ft)	4.189E+04		
pressure (lbf/ft**2)	3.578E+02	3.578E+02	2.800E+03
temperature (R)	3.900E+02	3.900E+02	7.019E+02
dynamic pressure (lbf/ft**2)	1.002E+03	1.002E+03	

Vehicle Effects

ML/M0	1.000E+00
PTL/PT0	1.000E+00
AL/A0	1.000E+00

Inlet Mass Flow Ratios

A0I/AC	8.816E-01
A0SPL/AC	1.184E-01
A0BLD/AC	4.500E-02
A0/AC	8.366E-01
A0BYP/AC	0.000E-01
A0ENG/AC	8.366E-01

Inlet Total Pressure Recoveries

PT2/PT0	9.187E-01
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323 PTL/PT0 1.000E+00
324 PTL/PTL 9.999E-01
325 PTH/PT1 9.796E-01
326 PT2/PTH 9.379E-01
327
328 PTx/PTY 9.697E-01
329
330 Inlet Drag Breakdown
331 AC (ft**2) 1.000E+00
332
333 CD D (lbf)
334
335 spillage 7.564E-03 7.578E+00
336 bleed 4.195E-02 4.202E+01
337 bypass 0.000E-01 0.000E-01
338 cowl 8.844E-02 8.860E+01
339 total 1.380E-01 1.382E+02
340 reference 8.844E-02 8.860E+01
341 power setting 4.951E-02 4.960E+01
342
343
344 Engine Performance Data uninstalled installed
345
346 net thrust (lbf) 0.000E-01 -1.382E+02
347 SFC (lbm/hr/lbf) 0.000E-01 -0.000E-01
348 W2 (lbm/s) 0.000E-01 2.786E+01
349 corrected W2 (lbm/s) 2.664E+01 2.665E+01
350
351 reference recovery 9.250E-01
352
353
354 &ipac
355 xmach0=1.8,figure=0,
356 xtrans=0.87,xmns=1.35,
357 thetac= 0.0,
358 &end
359
360 forebd: xmachx= 1.800E+00,xmach0= 1.800E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
361 cdaxi: xmach0= 1.800E+00, a0iac= 8.182E-01,xmach1= 1.666E+00,ptlpt0= 1.666E+00, cda= 1.342E-02,
362 cdaxi: xmach0= 1.800E+00, a0iac= 8.174E-01,xmach1= 6.631E-01,ptlpt0= 8.697E-01, cda=-2.811E-05,
363 ptrcv: xmach0= 1.800E+00, a0ac= 7.807E-01, xmns= 1.350E+00,pt2pt0= 9.309E-01,thetad= 3.060E+00,
364 xmrh= 1.331E+00, athac= 5.933E-01,nishck= 1.000E+00,pthpt0= 9.876E-01,xlipth= 5.039E-01,
365 cdaxi: xmach0= 1.800E+00, a0iac= 8.182E-01,xmach1= 1.666E+00,ptlpt0= 1.000E+00, cda= 1.342E-02,
366 cdwave: xmach0= 1.800E+00, cdwav= 9.942E-02,
367 cdbld: xmach0= 1.800E+00, a0iac= 8.182E-01, bleed= 3.750E-02, cdbld= 3.344E-02,ptblpe= 1.082E+00,
368 : xmach0= 1.800E+00, a0iac= 8.182E-01, bleed= 3.750E-02, cdbld= 3.344E-02,

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369 : xmach0= 1.800E+00, a0iac= 8.182E-01, cdtot= 4.686E-02, cdspl= 1.342E-02, cdref= 9.942E-02,  
 370 : xmach0= 1.800E+00, a0enac= 7.807E-01, w2c= 2.879E+01, w2= 2.919E+01,  
 371 : xmachx= 1.800E+00, a0enac= 7.807E-01, w2ceng= 2.876E+01,

372 IPAC Axisymmetric Inlet Example Case

373 Flight Conditions

374 Mach number 1.800E+00  
 375 altitude (ft) 3.729E+04  
 376 ambient total  
 377 pressure (lbf/ft\*\*2) 4.464E+02 2.565E+03  
 378 temperature (R) 3.900E+02 6.427E+02  
 379 dynamic pressure (lbf/ft\*\*2) 1.012E+03

380 Vehicle Effects

381 ML/M0 1.000E+00  
 382 PTL/PT0 1.000E+00  
 383 AL/A0 1.000E+00

384 Inlet Mass Flow Ratios

385 A0I/AC 8.182E-01  
 386 A0SPL/AC 1.818E-01  
 387 A0BLD/AC 3.750E-02  
 388 A0/AC 7.807E-01  
 389 A0BYP/AC 0.000E-01  
 390 A0ENG/AC 7.807E-01

391 Inlet Total Pressure Recoveries

392 PT2/PT0 9.309E-01  
 393 PTL/PT0 1.000E+00  
 394 PT1/PTL 1.000E+00  
 395 PTH/PT1 9.876E-01  
 396 PT2/PTTH 9.426E-01  
 397 PTX/PTY 9.697E-01

398 Inlet Drag Breakdown

399

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415 AC (ft**2) 1.000E+00
416
417 CD D (lbf)
418 spillage 1.342E-02 1.358E+01
419 bleed 3.344E-02 3.386E+01
420 bypass 0.000E-01 0.000E-01
421 cowl 9.942E-02 1.007E+02
422 total 1.463E-01 1.481E+02
423 reference 9.942E-02 1.007E+02
424 power setting 4.686E-02 4.744E+01
425
426 Engine Performance Data
427 net thrust (lbf) 0.000E-01 -1.481E+02
428 SFC (lbm/hr/lbf) 0.000E-01 -0.000E-01
429 W2 (lbm/s) 0.000E-01 2.919E+01
430 corrected W2 (lbm/s) 2.876E+01 2.879E+01
431
432 reference recovery 9.445E-01
433
434
435
436
437
438 &ipac
439 xmach0=1.6,figure=0,
440 xtrans=1.2,xmns=1.36,
441 thetac=0.0,
442 &end
443
444 forebd: xmachx= 1.600E+00,xmach0= 1.600E+00,xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
445 cdaxi: xmach0= 1.600E+00, aoiac= 7.367E-01,xmach1= 1.477E+00,ptlpt0= 1.000E+00, cda= 2.276E-02,
446 cdaxi: xmach0= 1.600E+00, aoiac= 7.360E-01,xmach1= 7.419E-01,ptlpt0= 9.369E-01, cda= 4.604E-03,
447 *** error *** in program segment ptring (errflg=1)
448 ptrcv: xmach0= 1.600E+00, aoiac= 7.067E-01, xmns= 1.360E+00,pt2pt0= 9.324E-01,thetad= 3.060E+00,
449 xnth= 1.258E+00, athac= 5.933E-01,nishck= 0.000E-01,pthpt0= 1.000E+00,xlipth= 0.000E-01,
450 cdaxi: xmach0= 1.600E+00, aoiac= 7.367E-01,xmach1= 1.477E+00,ptlpt0= 1.000E+00, cda= 2.276E-02,
451 cdwave: xmach0= 1.600E+00, cdwav= 1.144E-01,
452 cdbld: xmach0= 1.600E+00, aoiac= 7.367E-01, bleed= 3.000E-02, cdbld= 2.609E-02,ptblpe= 1.037E+00,
453 : xmach0= 1.600E+00, aoiac= 7.367E-01, bleed= 3.000E-02, cdbld= 2.609E-02,
454 : xmach0= 1.600E+00, aoiac= 7.367E-01, cdtot= 4.885E-02, cdspl= 2.276E-02, cdref= 1.144E-01,
455 : xmach0= 1.600E+00, aoiac= 7.067E-01, w2c= 2.995E+01, w2= 2.949E+01,
456 : xmachx= 1.600E+00, aoiac= 7.067E-01, w2ceng= 2.998E+01,
457
458 IPAC Axisymmetric Inlet Example Case
459 Flight Conditions
460

```

461	Mach number	1.600E+00		
462				
463	altitude (ft)	3.209E+04		
464				
465		ambient	total	
466				
467	pressure (lbf/ft**2)	5.706E+02	2.425E+03	
468	temperature (R)	4.042E+02	6.112E+02	
469	dynamic pressure (lbf/ft**2)	1.023E+03		
470				
471	Vehicle Effects			
472				
473	ML/M0	1.000E+00		
474	PTL/PT0	1.000E+00		
475	AL/A0	1.000E+00		
476				
477	Inlet Mass Flow Ratios			
478				
479	A0I/AC	7.367E-01		
480	A0SPL/AC	2.633E-01		
481	A0BLD/AC	3.000E-02		
482	A0/AC	7.067E-01		
483	A0BYP/AC	0.000E-01		
484	A0ENG/AC	7.067E-01		
485				
486	Inlet Total Pressure Recoveries			
487				
488	PT2/PT0	9.324E-01		
489				
490	PTL/PT0	1.000E+00		
491	PTI/PTL	1.000E+00		
492	PTTH/PT1	1.000E+00		
493	PT2/PTTH	9.324E-01		
494				
495	PTx/PTy	9.676E-01		
496				
497	Inlet Drag Breakdown			
498				
499	AC (ft**2)	1.000E+00		
500				
501		CD	D (lbf)	
502				
503	spillage	2.276E-02	2.328E+01	
504	bleed	2.609E-02	2.667E+01	
505	bypass	0.000E-01	0.000E-01	
506	cowl	1.144E-01	1.170E+02	



```

507 total 1.632E-01 1.669E+02
508 reference 1.144E-01 1.170E+02
509 power setting 4.885E-02 4.995E+01
510
511 Engine Performance Data  uninstalled installed
512
513 net thrust (lbf) 0.000E-01 -1.669E+02
514 SFC (lbm/hr/lbf) 0.000E-01 -0.000E-01
515 W2 (lbm/s) 0.000E-01 2.949E+01
516 corrected W2 (lbm/s) 2.998E+01 2.995E+01
517
518 reference recovery 9.624E-01
519
520
521 &ipac
522 xmach0=1.6,figure=0,
523 xtrans=1.2,
524 thetac=0.0,
525 xnth=0.832,
526 &end
527
528 forebd: xmachx= 1.600E+00,xmach0= 1.600E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
529 cdaxi: xmach0= 1.600E+00, a0iac= 5.000E-01,xmach1= 4.061E-01,ptlpt0= 9.369E-01, cda= 3.588E-01,
530 ptrcv: xmach0= 1.600E+00, a0ac= 6.772E-01, xmns= 1.360E+00,pt2pt0= 8.924E-01,thetad= 3.060E+00,
531 xnth= 8.320E-01, athac= 5.933E-01,nishck=-1.000E+00,pthpt0= 9.369E-01,xlipth=-1.000E+00,
532 cdaxi: xmach0= 1.600E+00, a0iac= 7.072E-01,xmach1= 6.790E-01,ptlpt0= 9.369E-01, cda= 4.048E-02,
533 cdwave: xmach0= 1.600E+00, cdwav= 1.144E-01,
534 clsuc: xmach0= 1.600E+00, a0iac= 7.072E-01, cls= 7.686E-03, cdspl= 3.280E-02,thetae= 3.811E+00,
535 cdbld: xmach0= 1.600E+00, a0iac= 7.072E-01, bleed= 3.000E-02, cdbld= 2.609E-02,ptblpe= 1.037E+00,
536 : xmach0= 1.600E+00, a0iac= 7.072E-01, bleed= 3.000E-02, cdbld= 2.609E-02,
537 : xmach0= 1.600E+00, a0iac= 7.072E-01, cdtot= 5.888E-02, cdspl= 3.280E-02, cdref= 1.144E-01,
538 : xmach0= 1.600E+00,a0enac= 6.772E-01, w2c= 2.998E+01, w2= 2.826E+01,
539 : xmachx= 1.600E+00,a0enac= 6.772E-01,w2ceng= 2.998E+01,
540
541 IPAC Axisymmetric Inlet Example Case
542
543 Flight Conditions
544 Mach number 1.600E+00
545 altitude (ft) 3.209E+04
546
547 ambient total
548 pressure (lbf/ft**2) 5.706E+02 2.425E+03
549 temperature (R) 4.042E+02 6.112E+02
550
551
552

```

553	dynamic pressure	(lbf/ft**2)	1.023E+03
554			
555	Vehicle Effects		
556			
557	ML/MO		1.000E+00
558	PTL/PTO		1.000E+00
559	AL/AO		1.000E+00
560			
561	Inlet Mass Flow Ratios		
562			
563	A0I/AC		7.072E-01
564	A0SPL/AC		2.928E-01
565	A0BLD/AC		3.000E-02
566	A0/AC		6.772E-01
567	A0BYP/AC		0.000E-01
568	A0ENG/AC		6.772E-01
569			
570	Inlet Total Pressure Recoveries		
571			
572	PT2/PTO		8.924E-01
573			
574	PTL/PTO		1.000E+00
575	PT1/PTL		9.369E-01
576	PTTH/PT1		1.000E+00
577	PT2/PTTH		9.525E-01
578			
579	PTx/PTY		1.000E+00
580			
581	Inlet Drag Breakdown		
582			
583	AC	(ft**2)	1.000E+00
584			
585			
586			
587	spillage		3.280E-02
588	bleed		2.609E-02
589	bypass		0.000E-01
590	cowl		1.144E-01
591	total		1.733E-01
592	reference		1.144E-01
593	power setting		5.888E-02
594			
595	Engine Performance Data		uninstalled installed
596			
597	net thrust	(lbf)	0.000E-01 -1.772E+02
598	SFC	(lbm/hr/lbf)	0.000E-01 -0.000E-01

```

599          W2 (lbm/s)      0.000E-01  2.826E+01
600  corrected W2 (lbm/s)  2.998E+01  2.998E+01
601
602  reference recovery      9.624E-01
603
604
605  &ipac
606  xmach0=1.4,figure=0,
607  xtrans=0.5,
608  thetac=0.0,
609  xmth=0.837,
610  &end
611
612  forebd: xmachx= 1.400E+00,xmach0= 1.400E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
613  cdaxi: xmach0= 1.400E+00, aoiac= 5.000E-01,xmach1= 3.580E-01,ptlpt0= 9.807E-01, cda= 4.593E-01,
614  ptrcv: xmach0= 1.400E+00, a0ac= 6.331E-01, xmns= 1.360E+00,pt2pt0= 9.307E-01,thetad= 3.060E+00,
615  xmth= 8.370E-01, athac= 5.933E-01,nishck=-1.000E+00,pthpt0= 9.807E-01,xlipth=-1.000E+00,
616  cdaxi: xmach0= 1.400E+00, aoiac= 6.556E-01,xmach1= 5.051E-01,ptlpt0= 9.807E-01, cda= 2.239E-01,
617  cdwave: xmach0= 1.400E+00, cdwav= 1.369E-01,
618  clsuc: xmach0= 1.400E+00, aoiac= 6.556E-01, cls= 8.257E-03, cdspl= 2.156E-01,thetae= 3.811E+00,
619  *** error *** in program segment cdbld (errflg=2)
620  cdbld: xmach0= 1.400E+00, aoiac= 6.556E-01, bleed= 2.250E-02, cdbld= 1.884E-02,ptblpe= 1.001E+00,
621  : xmach0= 1.400E+00, aoiac= 6.556E-01, bleed= 2.250E-02, cdbld= 1.884E-02,
622  : xmach0= 1.400E+00, aoiac= 6.556E-01, cdtot= 2.344E-01, cdspl= 2.156E-01, cdref= 1.369E-01,
623  : xmach0= 1.400E+00,a0enac= 6.331E-01, w2c= 3.014E+01, w2= 2.954E+01,
624  : xmachx= 1.400E+00,a0enac= 6.331E-01,w2ceng= 3.014E+01,
625
626  IPAC Axisymmetric Inlet Example Case
627
628  Flight Conditions
629
630  Mach number      1.400E+00
631
632  altitude (ft)   2.611E+04
633
634  ambient          total
635
636  pressure (lbf/ft**2)  7.481E+02  2.381E+03
637  temperature (R)      4.256E+02  5.924E+02
638  dynamic pressure (lbf/ft**2)  1.026E+03
639
640  Vehicle Effects
641
642  ML/M0            1.000E+00
643  PTL/PT0          1.000E+00
644  AL/A0            1.000E+00

```

645	Inlet Mass Flow Ratios			
646				
647				
648	A0I/AC	6.556E-01		
649	A0SPL/AC	3.444E-01		
650	A0BLD/AC	2.250E-02		
651	A0/AC	6.331E-01		
652	A0BYP/AC	0.000E-01		
653	A0ENG/AC	6.331E-01		
654				
655	Inlet Total Pressure Recoveries			
656				
657	PT2/PT0	9.307E-01		
658				
659	PTL/PT0	1.000E+00		
660	PT1/PTL	9.807E-01		
661	PTTH/PT1	1.000E+00		
662	PT2/PTTH	9.490E-01		
663				
664	PTx/PTy	1.000E+00		
665				
666	Inlet Drag Breakdown			
667				
668	AC (ft**2)	1.000E+00		
669				
670				
671				
672	spillage	2.156E-01	D (lbf)	2.213E+02
673	bleed	1.884E-02		1.934E+01
674	bypass	0.000E-01		0.000E-01
675	cowl	1.369E-01		1.406E+02
676	total	3.714E-01		3.812E+02
677	reference	1.369E-01		1.406E+02
678	power setting	2.344E-01		2.407E+02
679				
680	Engine Performance Data			
681		uninstalled	installed	
682	net thrust (lbf)	0.000E-01	-3.812E+02	
683	SFC (lbm/hr/lbf)	0.000E-01	-0.000E-01	
684	W2 (lbm/s)	0.000E-01	2.954E+01	
685	corrected W2 (lbm/s)	3.014E+01	3.014E+01	
686				
687	reference recovery	9.782E-01		
688				
689				
690	&ipac			

```

691 xmach0=1.2,figure=0,
692 xtrans=0.5,
693 thetac=0.0,
694 &end
695
696 forebd: xmachx= 1.200E+00,xmach0= 1.200E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
697 cdaxi: xmach0= 1.200E+00, a0iac= 5.000E-01,xmach1= 3.845E-01,ptipt0= 9.992E-01, cda= 3.719E-01,
698 ptrcv: xmach0= 1.200E+00, a0ac= 5.962E-01, xmns= 1.360E+00,pt2pt0= 9.483E-01,thetad= 3.060E+00,
699 xmth= 8.370E-01, athac= 5.933E-01,nishck=-1.000E+00,pthpt0= 9.992E-01,xlipth=-1.000E+00,
700 cdaxi: xmach0= 1.200E+00, a0iac= 6.112E-01,xmach1= 4.981E-01,ptipt0= 9.992E-01, cda= 2.157E-01,
701 cdwave: xmach0= 1.200E+00, cdwav= 1.789E-01,
702 clsuc: xmach0= 1.200E+00, a0iac= 6.112E-01, cls= 7.676E-03, cdspl= 2.080E-01,thetae= 3.811E+00,
703 *** error *** in program segment cdbld (errflg=2)
704 cdbld: xmach0= 1.200E+00, a0iac= 6.112E-01, bleed= 1.500E-02, cdbld= 1.131E-02,ptblpe= 1.001E+00,
705 : xmach0= 1.200E+00, a0iac= 6.112E-01, bleed= 1.500E-02, cdbld= 1.131E-02,
706 : xmach0= 1.200E+00, a0iac= 6.112E-01, cdtot= 2.193E-01, cdspl= 2.080E-01, cdref= 1.789E-01,
707 : xmach0= 1.200E+00,a0enac= 5.962E-01, w2c= 3.014E+01, w2= 3.132E+01,
708 : xmachx= 1.200E+00,a0enac= 5.962E-01,w2ceng= 3.014E+01,
709
710 IPAC Axisymmetric Inlet Example Case
711
712 Flight Conditions
713
714 Mach number 1.200E+00
715
716 altitude (ft) 1.906E+04
717
718 ambient total
719
720 pressure (lbf/ft**2) 1.012E+03 2.453E+03
721 temperature (R) 4.507E+02 5.805E+02
722 dynamic pressure (lbf/ft**2) 1.020E+03
723
724 Vehicle Effects
725
726 ML/M0 1.000E+00
727 PTL/PT0 1.000E+00
728 AL/A0 1.000E+00
729
730 Inlet Mass Flow Ratios
731
732 A0I/AC 6.112E-01
733 A0SPL/AC 3.888E-01
734 A0BLD/AC 1.500E-02
735 A0/AC 5.962E-01
736 A0BYP/AC 0.000E-01

```

```

737 AOENG/AC 5.962E-01
738
739 Inlet Total Pressure Recoveries
740
741 PT2/PT0 9.483E-01
742
743 PTL/PT0 1.000E+00
744 PT1/PTL 9.992E-01
745 PTH/PT1 1.000E+00
746 PT2/PTH 9.490E-01
747
748 PTx/PTy 1.000E+00
749
750 Inlet Drag Breakdown
751 AC (ft**2) 1.000E+00
752
753
754
755
756 spillage CD D (lbf)
757 bleed 2.080E-01 2.121E+02
758 bypass 1.131E-02 1.153E+01
759 cowl 0.000E-01 0.000E-01
760 total 1.789E-01 1.824E+02
761 reference 3.982E-01 4.060E+02
762 power setting 1.789E-01 1.824E+02
763 2.193E-01 2.236E+02
764 Engine Performance Data uninstalled installed
765
766 net thrust (lbf) 0.000E-01 -4.060E+02
767 SFC (lbm/hr/lbf) 0.000E-01 -0.000E-01
768 W2 (lbm/s) 0.000E-01 3.132E+01
769 corrected W2 (lbm/s) 3.014E+01 3.014E+01
770
771 reference recovery 9.915E-01
772
773
774 &ipac
775 xmach0=1.0,figure=0,
776 xtrans=0.5,
777 thetac=0.0,
778 &end
779
780 forebd: xmachx= 1.000E+00,xmach0= 1.000E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
781 ptrcv: xmach0= 1.000E+00, a0ac= 5.791E-01, xmns= 1.360E+00,pt2pt0= 9.490E-01,thetad= 3.060E+00,
782 xmth= 8.370E-01, athac= 5.933E-01,nishck=-1.000E+00,pthpt0= 1.000E+00,xlipth=-1.000E+00,

```

```

783 cdaxi: xmach0= 1.000E+00, a0iac= 5.866E-01, xmach1= 4.898E-01, ptlpt0= 1.000E+00, cda= 1.518E-01,
784 clsuc: xmach0= 1.000E+00, a0iac= 5.866E-01, cls= 0.000E-01, cdspl= 1.518E-01, thetae= 3.811E+00,
785 *** error *** in program segment cdbld (errflg=2)
786 cdbld: xmach0= 1.000E+00, a0iac= 5.866E-01, bleed= 7.500E-03, cdbld= 4.803E-03, ptblpe= 1.001E+00,
787 : xmach0= 1.000E+00, a0iac= 5.866E-01, bleed= 7.500E-03, cdbld= 4.803E-03,
788 : xmach0= 1.000E+00, a0iac= 5.866E-01, bleed= 7.500E-03, cdbld= 4.803E-03,
789 : xmach0= 1.000E+00, a0enac= 5.791E-01, cdttot= 1.567E-01, cdspl= 1.518E-01, cdref= 0.000E-01,
790 : xmachx= 1.000E+00, a0enac= 5.791E-01, w2c= 3.014E+01, w2= 3.474E+01,
791 :

```

IPAC Axisymmetric Inlet Example Case

Flight Conditions

```

795 Mach number          1.000E+00
796 altitude (ft)      1.040E+04
797
798 ambient             2.712E+03
799 total               5.779E+02
800
801 pressure (lbf/ft**2) 1.433E+03
802 temperature (R)      4.816E+02
803 dynamic pressure (lbf/ft**2) 1.003E+03
804

```

Vehicle Effects

```

805 ML/M0                1.000E+00
806 PTL/PT0              1.000E+00
807 AL/A0                1.000E+00

```

Inlet Mass Flow Ratios

```

813 A0I/AC               5.866E-01
814 A0SPL/AC            4.134E-01
815 A0BLD/AC            7.500E-03
816 A0/AC               5.791E-01
817 A0BYP/AC           0.000E-01
818 A0ENG/AC            5.791E-01

```

Inlet Total Pressure Recoveries

```

821 PT2/PT0             9.490E-01
822
823 PTL/PT0             1.000E+00
824 PTH/PTH             1.000E+00
825 PTH/PTH             1.000E+00
826 PT2/PT2             9.490E-01

```

```

829
830 PTX/PTY 1.000E+00
831
832 Inlet Drag Breakdown
833
834 AC (ft**2) 1.000E+00
835
836
837
838 spillage CD D (lbf)
839 bleed 1.518E-01 1.523E+02
840 bypass 4.803E-03 4.818E+00
841 cow1 0.000E-01 0.000E-01
842 total 0.000E-01 0.000E-01
843 reference 1.567E-01 1.571E+02
844 power setting 0.000E-01 0.000E-01
845 1.567E-01 1.571E+02
846
847 Engine Performance Data
848 net thrust (lbf) 0.000E-01 1.571E+02
849 SFC (lbm/hr/lbf) 0.000E-01 -0.000E-01
850 W2 (lbm/s) 0.000E-01 3.474E+01
851 corrected W2 (lbm/s) 3.014E+01 3.014E+01
852
853 reference recovery 1.000E+00
854
855
856 &ipac
857 xmach0=0.8,figure=0,
858 xtrans=0.5,
859 thetac=0.0,
860 &end
861
862 forebd: xmachx= 8.000E-01,xmach0= 8.000E-01, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
863 ptrcv: xmach0= 8.000E-01, a0ac= 6.012E-01, xmns= 1.360E+00,pt2pt0= 9.490E-01,thetad= 3.060E+00,
864 xnth= 8.370E-01, athac= 5.933E-01,nishck=-1.000E+00,pthpt0= 1.000E+00,xlipth=-1.000E+00,
865 cdaxi: xmach0= 8.000E-01, a0iac= 6.012E-01,xmach1= 4.788E-01,ptlpt0= 1.000E+00, cda= 8.446E-02,
866 clsuc: xmach0= 8.000E-01, a0iac= 6.012E-01, cls= 5.559E-03, cdspl= 7.890E-02,thetae= 3.811E+00,
867 *** error *** in program segment cdbld (errflg=2)
868 cdbld: xmach0= 8.000E-01, a0iac= 6.012E-01, bleed= 2.310E-09, cdbld= 1.109E-09,ptblpe= 1.001E+00,
869 : xmach0= 8.000E-01, a0iac= 6.012E-01, bleed= 2.310E-09, cdbld= 1.109E-09,
870 : xmach0= 8.000E-01, a0iac= 6.012E-01, cdtot= 7.890E-02, cdspl= 7.890E-02, cdref= 0.000E-01,
871 : xmach0= 8.000E-01,a0enac= 6.012E-01, w2c= 3.014E+01, w2= 4.107E+01,
872 : xmachx= 8.000E-01,a0enac= 6.012E-01,w2ceng= 3.014E+01,
873
874 IPAC Axisymmetric Inlet Example Case

```



875	Flight Conditions			
876				
877	Mach number	8.000E-01		
878				
879	altitude (ft)	0.000E-01	ambient	total
880				
881				
882				
883				
884	pressure (lbf/ft**2)	2.116E+03	3.226E+03	
885	temperature (R)	5.187E+02	5.851E+02	
886	dynamic pressure (lbf/ft**2)	9.481E+02		
887				
888	Vehicle Effects			
889				
890	ML/M0	1.000E+00		
891	PTL/PT0	1.000E+00		
892	AL/A0	1.000E+00		
893				
894	Inlet Mass Flow Ratios			
895				
896	A0I/AC	6.012E-01		
897	A0SPL/AC	3.988E-01		
898	A0BLD/AC	2.310E-09		
899	A0/AC	6.012E-01		
900	A0BYP/AC	0.000E-01		
901	A0ENG/AC	6.012E-01		
902				
903	Inlet Total Pressure Recoveries			
904				
905	PT2/PT0	9.490E-01		
906				
907	PTL/PT0	1.000E+00		
908	PT1/PTL	1.000E+00		
909	PTTH/PT1	1.000E+00		
910	PT2/PTTH	9.490E-01		
911				
912	PTx/PTy	1.000E+00		
913				
914	Inlet Drag Breakdown			
915				
916	AC (ft**2)	1.000E+00		
917				
918			CD	D (lbf)
919	spillage	7.890E-02		7.480E+01
920				

```

921 bleed 1.109E-09 1.052E-06
922 bypass 0.000E-01 0.000E-01
923 cowl 0.000E-01 0.000E-01
924 total 7.890E-02 7.480E+01
925 reference 0.000E-01 0.000E-01
926 power setting 7.890E-02 7.480E+01
927
928 Engine Performance Data
929
930 net thrust (lbf)
931 SFC (lbm/hr/lbf) 0.000E-01 -7.480E+01
932 W2 (lbm/s) 0.000E-01 -0.000E-01
933 corrected W2 (lbm/s) 0.000E-01 4.107E+01
934 3.014E+01 3.014E+01
935
936 reference recovery 1.000E+00
937
938 &ipac
939 xmach0=0.6, figure=0,
940 xtrans=0.0,
941 thetac=0.0,
942 &end
943
944 forebd: xmachx= 6.000E-01,xmach0= 6.000E-01, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
945 ptrcv: xmach0= 6.000E-01, a0ac= 6.880E-01, xmns= 1.360E+00,pt2pt0= 9.490E-01, thetad= 3.060E+00,
946 xnth= 8.370E-01, athac= 5.933E-01,nishck=-1.000E+00,pthpt0= 1.000E+00,xlipth=-1.000E+00,
947 cdaxi: xmach0= 6.000E-01, a0iac= 6.880E-01,xmach1= 4.284E-01,pt1pt0= 1.000E+00, cda= 4.333E-02,
948 clsuc: xmach0= 6.000E-01, a0iac= 6.880E-01, c1s= 3.203E-03, cdspl= 4.013E-02, thetai= 3.811E+00,
949 : xmach0= 6.000E-01, a0enac= 6.880E-01, cdtot= 4.013E-02, cdspl= 4.013E-02, cdref= 0.000E-01,
950 : xmach0= 6.000E-01,a0enac= 6.880E-01, w2c= 3.014E+01,
951 : xmachx= 6.000E-01,a0enac= 6.880E-01,w2ceng= 3.014E+01,
952
953 IPAC Axisymmetric Inlet Example Case
954
955 Flight Conditions
956
957 Mach number 6.000E-01
958
959 altitude (ft) 0.000E-01
960
961 ambient total
962
963 pressure (lbf/ft**2) 2.116E+03 2.699E+03
964 temperature (R) 5.187E+02 5.560E+02
965 dynamic pressure (lbf/ft**2) 5.333E+02
966

```

967	Vehicle Effects			
968		ML/M0	1.000E+00	
969		PTL/PT0	1.000E+00	
970		AL/A0	1.000E+00	
971				
972				
973	Inlet Mass Flow Ratios			
974		A0I/AC	6.880E-01	
975		A0SPL/AC	3.120E-01	
976		A0BLD/AC	0.000E-01	
977		A0/AC	6.880E-01	
978		A0BYP/AC	0.000E-01	
979		A0ENG/AC	6.880E-01	
980				
981				
982	Inlet Total Pressure Recoveries			
983		PT2/PT0	9.490E-01	
984				
985		PTL/PT0	1.000E+00	
986		PT1/PTL	1.000E+00	
987		PTTH/PT1	1.000E+00	
988		PT2/PTTH	9.490E-01	
989				
990		PTx/PTy	1.000E+00	
991				
992				
993	Inlet Drag Breakdown			
994		AC (ft**2)	1.000E+00	
995				
996				
997				
998				
999				
1000		spillage	4.013E-02	2.140E+01
1001		bleed	0.000E-01	0.000E-01
1002		bypass	0.000E-01	0.000E-01
1003		cowl	0.000E-01	0.000E-01
1004		total	4.013E-02	2.140E+01
1005		reference	0.000E-01	0.000E-01
1006		power setting	4.013E-02	2.140E+01
1007	Engine Performance Data		uninstalled	installed
1008		net thrust (lbf)	0.000E-01	-2.140E+01
1009		SFC (lbm/hr/lbf)	0.000E-01	-0.000E-01
1010		W2 (lbm/s)	0.000E-01	3.525E+01
1011		corrected W2 (lbm/s)	3.014E+01	3.014E+01
1012				

```

1013 reference recovery 1.000E+00
1014
1015
1016
1017 &ipac
1018   xmach0=0.4, figure=0,
1019   xtrans=0.0,
1020   thetac=0.0,
1021   &end
1022
1023   forebd: xmachx= 4.000E-01, xmach0= 4.000E-01, xmlm0= 1.000E+00, ptlpt0= 1.000E+00, ala0= 1.000E+00,
1024   ptrcv: xmach0= 4.000E-01, a0ac= 9.204E-01, xms= 1.360E+00, pt2pt0= 9.486E-01, thetad= 3.060E+00,
1025   xmh= 8.370E-01, athac= 5.933E-01, nishck=-1.000E+00, pthpt0= 9.996E-01, xlipth=-1.000E+00,
1026   cdaxi: xmach0= 4.000E-01, a0iac= 9.204E-01, xmach1= 4.281E-01, ptlpt0= 1.000E+00, cda= 0.000E-01,
1027   : xmach0= 4.000E-01, a0iac= 9.204E-01, cdtot= 0.000E-01, cdspl= 0.000E-01, cdref= 0.000E-01,
1028   : xmach0= 4.000E-01, a0enac= 9.204E-01, w2c= 3.014E+01, w2= 3.144E+01,
1029   : xmachx= 4.000E-01, a0enac= 9.204E-01, w2ceng= 3.014E+01,
1030
1031 IPAC Axisymmetric Inlet Example Case
1032
1033 Flight Conditions
1034
1035 Mach number 4.000E-01
1036
1037 altitude (ft) 0.000E-01
1038
1039 ambient total
1040
1041 pressure (lb/ft**2) 2.116E+03 2.363E+03
1042 temperature (R) 5.187E+02 5.353E+02
1043 dynamic pressure (lb/ft**2) 2.370E+02
1044
1045 Vehicle Effects
1046
1047 ML/M0 1.000E+00
1048 PTL/PT0 1.000E+00
1049 AL/A0 1.000E+00
1050
1051 Inlet Mass Flow Ratios
1052
1053 A0I/AC 9.204E-01
1054 A0SPL/AC 7.962E-02
1055 A0BLD/AC 0.000E-01
1056 A0/AC 9.204E-01
1057 A0BYP/AC 0.000E-01
1058 A0ENG/AC 9.204E-01

```

```

1059
1060 Inlet Total Pressure Recoveries
1061
1062 PT2/PT0 9.486E-01
1063
1064 PTL/PT0 1.000E+00
1065 PT1/PTL 1.000E+00
1066 PTH/PT1 9.996E-01
1067 PT2/PTH 9.490E-01
1068
1069 PTx/PTy 1.000E+00
1070
1071 Inlet Drag Breakdown
1072
1073 AC (ft**2) 1.000E+00
1074
1075 CD D (lbf)
1076
1077 spillage 0.000E-01 0.000E-01
1078 bleed 0.000E-01 0.000E-01
1079 bypass 0.000E-01 0.000E-01
1080 cowl 0.000E-01 0.000E-01
1081 total 0.000E-01 0.000E-01
1082 reference 0.000E-01 0.000E-01
1083 power setting 0.000E-01 0.000E-01
1084
1085 Engine Performance Data
1086
1087 net thrust (lbf) 0.000E-01 0.000E-01
1088 SFC (lbm/hr/lbf) 0.000E-01 0.000E-01
1089 W2 (lbm/s) 0.000E-01 3.144E+01
1090 corrected W2 (lbm/s) 3.014E+01 3.014E+01
1091
1092 reference recovery 1.000E+00
1093
1094
1095 &ipac
1096 xmach0=0.2,figure=0,
1097 xtrans=0.0,
1098 thetac=0.0,
1099 &end
1100
1101 forebd: xmachx= 2.000E-01,xmach0= 2.000E-01, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
1102 ptrcv: xmach0= 2.000E-01, a0ac= 1.668E+00, xmns= 1.360E+00,pt2pt0= 9.223E-01,thetad= 3.060E+00,
1103 xmth= 8.370E-01, athac= 5.933E-01,nishck=-1.000E+00,pthpt0= 9.718E-01,xlipth=-1.000E+00,
1104 : xmach0= 2.000E-01, a0iac= 1.668E+00, cda= 0.000E-01,

```

: xmach0= 2.000E-01, a0iac= 1.668E+00, cdtot= 0.000E-01, cdspl= 0.000E-01, cdref= 0.000E-01,  
 : xmach0= 2.000E-01, a0enac= 1.668E+00, w2c= 3.014E+01, w2= 2.848E+01,  
 : xmachx= 2.000E-01, a0enac= 1.668E+00, w2ceng= 3.014E+01,

IPAC Axisymmetric Inlet Example Case

Flight Conditions

1113	Mach number	2.000E-01		
1115	altitude (ft)	0.000E-01	ambient	total
1119	pressure (lbf/ft**2)	2.116E+03	2.176E+03	
1120	temperature (R)	5.187E+02	5.228E+02	
1121	dynamic pressure (lbf/ft**2)	5.925E+01		

Vehicle Effects

1124	ML/M0	1.000E+00
1125	PTL/PT0	1.000E+00
1126	AL/A0	1.000E+00

Inlet Mass Flow Ratios

1131	A0I/AC	1.668E+00
1132	A0SPL/AC	-6.676E-01
1133	A0BLD/AC	0.000E-01
1134	A0/AC	1.668E+00
1135	A0BYP/AC	0.000E-01
1136	A0ENG/AC	1.668E+00

Inlet Total Pressure Recoveries

1138	PT2/PT0	9.223E-01
1142	PTL/PT0	1.000E+00
1143	PT1/PTL	1.000E+00
1144	PTTH/PT1	9.718E-01
1145	PT2/PTTH	9.490E-01
1147	PTx/PTy	1.000E+00

Inlet Drag Breakdown

1148

1149

1150

```

1151 AC (ft**2) 1.000E+00
1152
1153 CD D (lbf)
1154 0.000E-01 0.000E-01
1155 spillage 0.000E-01 0.000E-01
1156 bleed 0.000E-01 0.000E-01
1157 bypass 0.000E-01 0.000E-01
1158 cowl 0.000E-01 0.000E-01
1159 total 0.000E-01 0.000E-01
1160 reference 0.000E-01 0.000E-01
1161 power setting 0.000E-01 0.000E-01
1162
1163 Engine Performance Data
1164 net thrust (lbf) 0.000E-01 0.000E-01
1165 SFC (lbm/hr/lbf) 0.000E-01 0.000E-01
1166 W2 (lbm/s) 0.000E-01 0.000E-01
1167 corrected W2 (lbm/s) 3.014E+01 3.014E+01
1168
1169 reference recovery 1.000E+00
1170
1171
1172
1173 &ipac
1174 xmach0=0.01,figure=0,
1175 xtrans=0.0,
1176 thetac=0.0,
1177 &end
1178
1179 forebd: xmachx= 1.000E-02,xmach0= 1.000E-02, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
1180 ptrcv: xmach0= 1.000E-02, a0ac= 3.039E+01, xmns= 1.360E+00,pt2pt0= 8.607E-01,thetad= 3.060E+00,
1181 xnth= 8.370E-01, athac= 5.933E-01,nishck=-1.000E+00,pthpt0= 9.069E-01,xlipth=-1.000E+00,
1182 : xmach0= 1.000E-02, a0iac= 3.039E+01, cda= 0.000E-01,
1183 : xmach0= 1.000E-02, a0iac= 3.039E+01, cdtot= 0.000E-01, cdspl= 0.000E-01, cdref= 0.000E-01,
1184 : xmach0= 1.000E-02,a0enac= 3.039E+01, w2C= 3.014E+01, w2= 2.595E+01,
1185 : xmachx= 1.000E-02,a0enac= 3.039E+01,w2ceng= 3.014E+01,
1186
1187 IPAC Axisymmetric Inlet Example Case
1188
1189 Flight Conditions
1190
1191 Mach number 1.000E-02
1192
1193 altitude (ft) 0.000E-01
1194
1195 ambient total
1196

```

1197	pressure	(lbf/ft**2)	2.116E+03	2.116E+03
1198	temperature	(R)	5.187E+02	5.187E+02
1199	dynamic pressure	(lbf/ft**2)	1.481E-01	
1200				
1201	Vehicle Effects			
1202				
1203	ML/M0		1.000E+00	
1204	PTL/PT0		1.000E+00	
1205	AL/A0		1.000E+00	
1206				
1207	Inlet Mass Flow Ratios			
1208				
1209	A0I/AC		3.039E+01	
1210	A0SPL/AC		-2.939E+01	
1211	A0BLD/AC		0.000E-01	
1212	A0/AC		3.039E+01	
1213	A0BYP/AC		0.000E-01	
1214	A0ENG/AC		3.039E+01	
1215				
1216	Inlet Total Pressure Recoveries			
1217				
1218	PT2/PT0		8.607E-01	
1219				
1220	PTL/PT0		1.000E+00	
1221	PT1/PTL		1.000E+00	
1222	PTTH/PT1		9.069E-01	
1223	PT2/PTTH		9.490E-01	
1224				
1225	PTx/PTY		1.000E+00	
1226				
1227	Inlet Drag Breakdown			
1228				
1229	AC	(ft**2)	1.000E+00	
1230				
1231				
1232				
1233	spillage		0.000E-01	0.000E-01
1234	bleed		0.000E-01	0.000E-01
1235	bypass		0.000E-01	0.000E-01
1236	cowl		0.000E-01	0.000E-01
1237	total		0.000E-01	0.000E-01
1238	reference		0.000E-01	0.000E-01
1239	power setting		0.000E-01	0.000E-01
1240				
1241	Engine Performance Data		uninstalled	installed
1242				

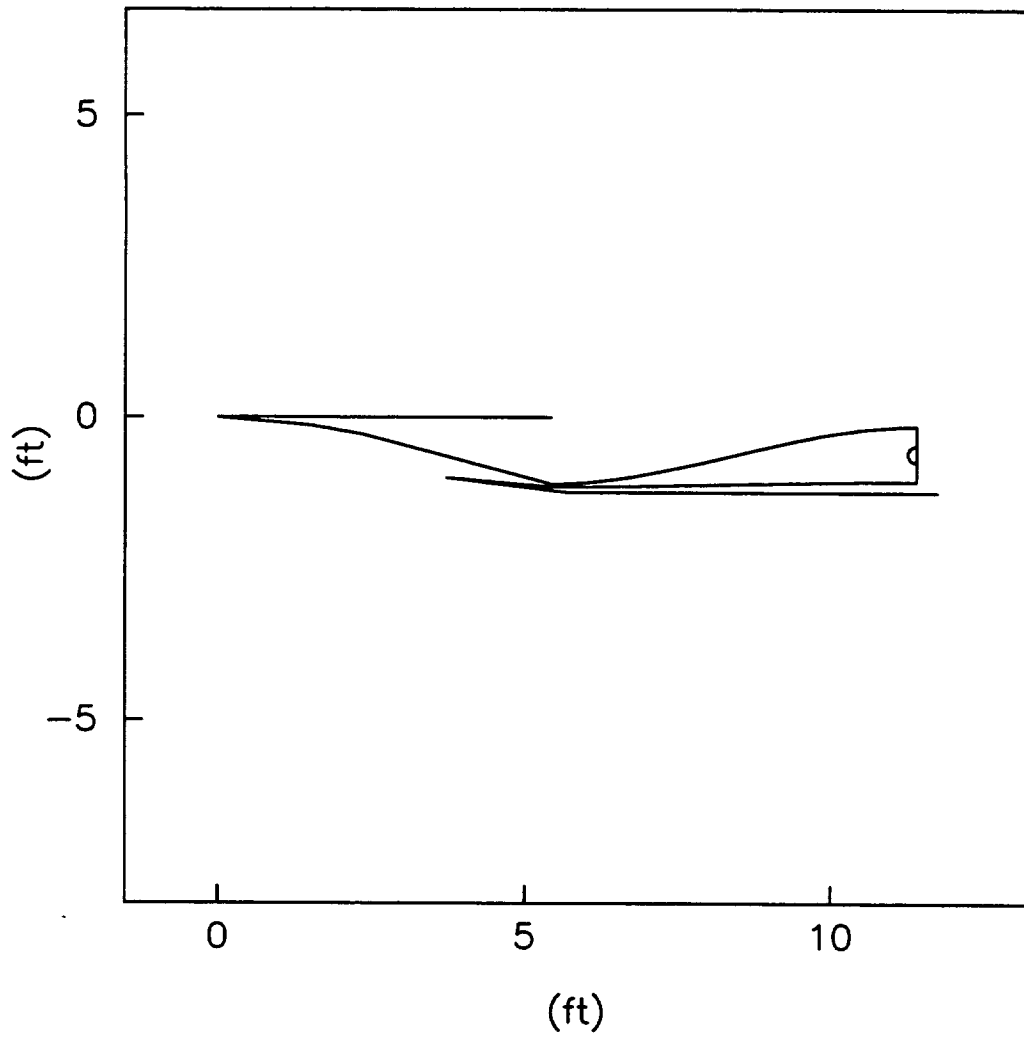


1243	net thrust	(lbf)	0.000E-01	0.000E-01
1244	SFC	(lbm/hr/lbf)	0.000E-01	0.000E-01
1245	W2	(lbm/s)	0.000E-01	2.595E+01
1246	corrected W2	(lbm/s)	3.014E+01	3.014E+01
1247				
1248	reference recovery		1.000E+00	
1249				
1250				

Appendix IV

Mach 5.0 Two-Dimensional Inlet

Example Case



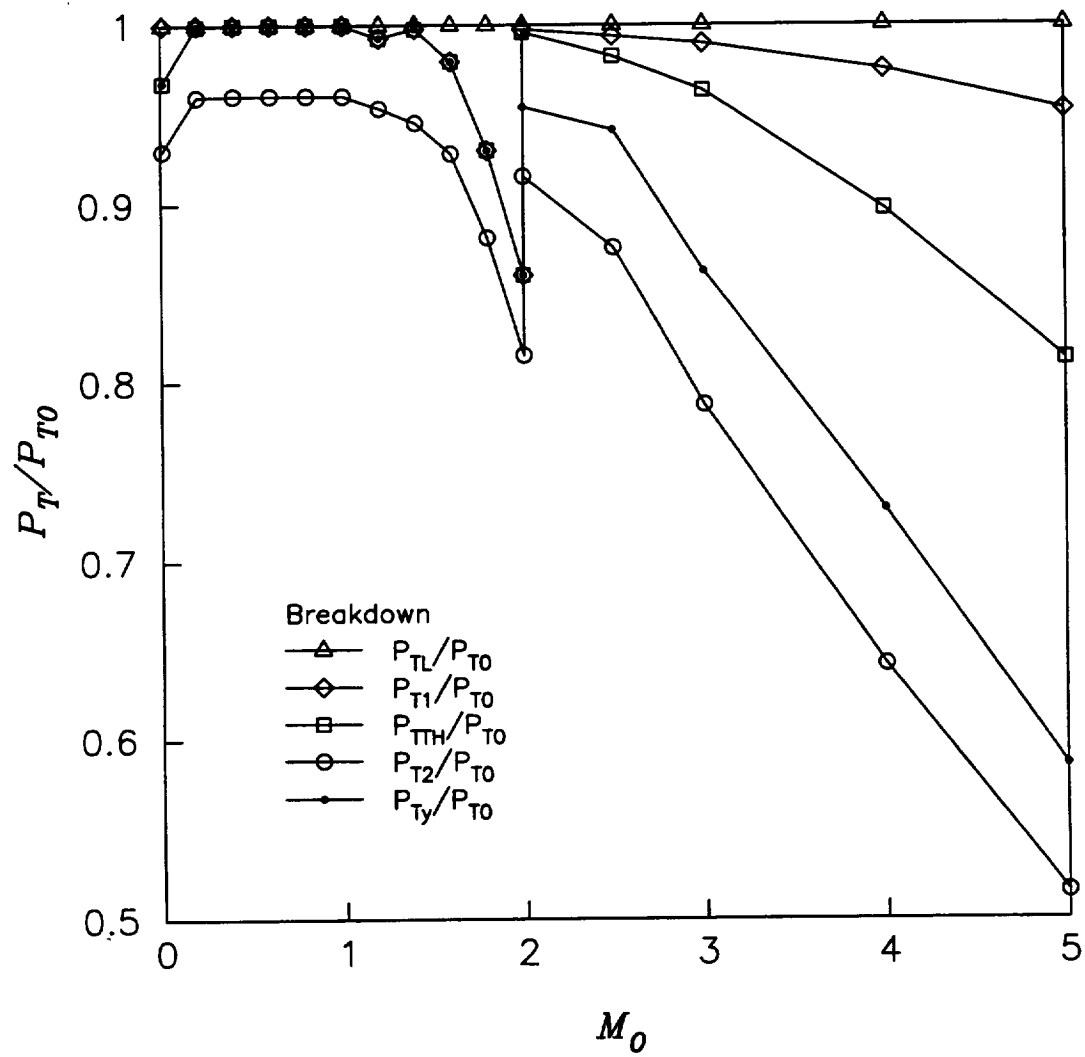


Figure IV.1 Total Pressure Recoveries

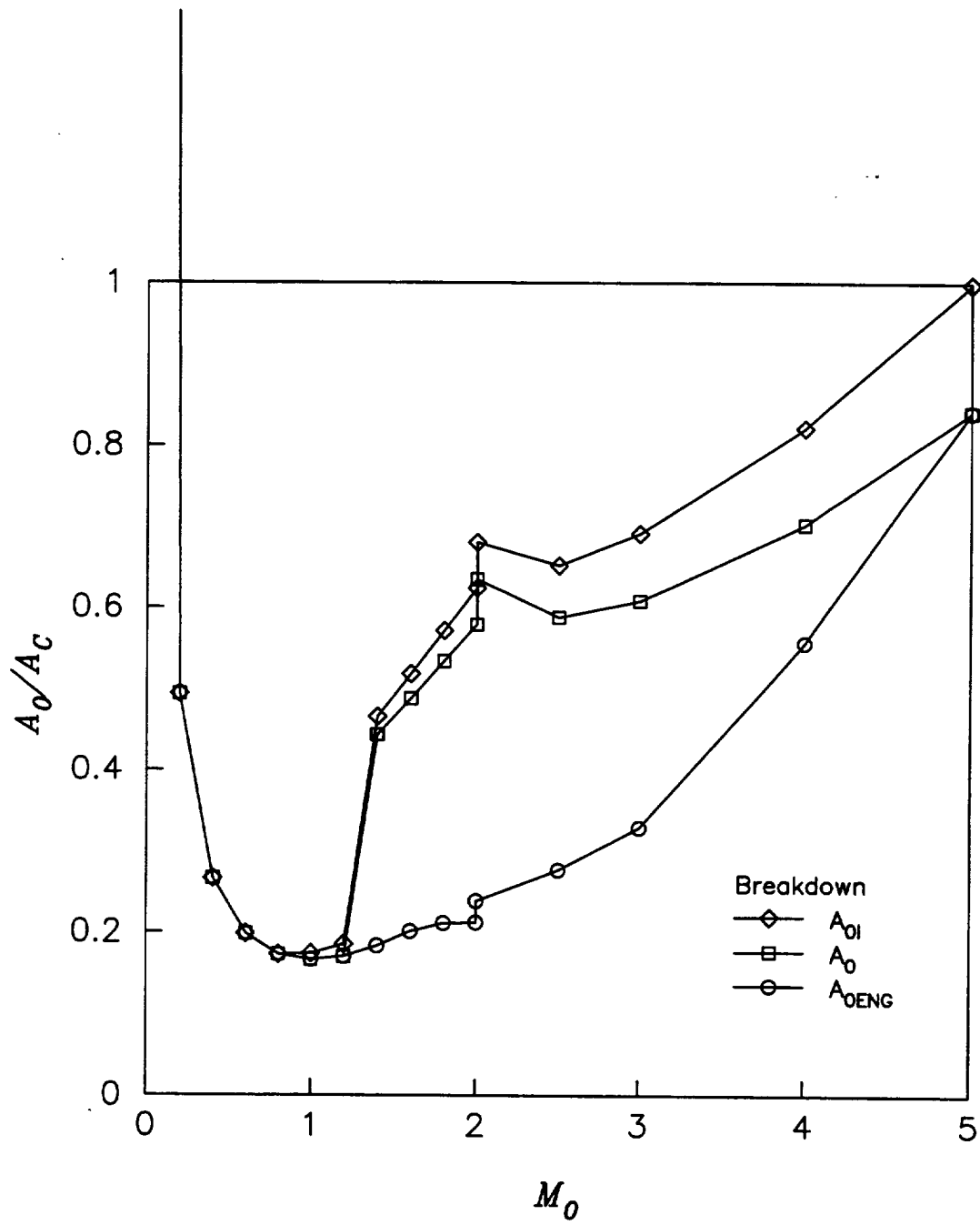


Figure IV.2 Mass Flow Ratios

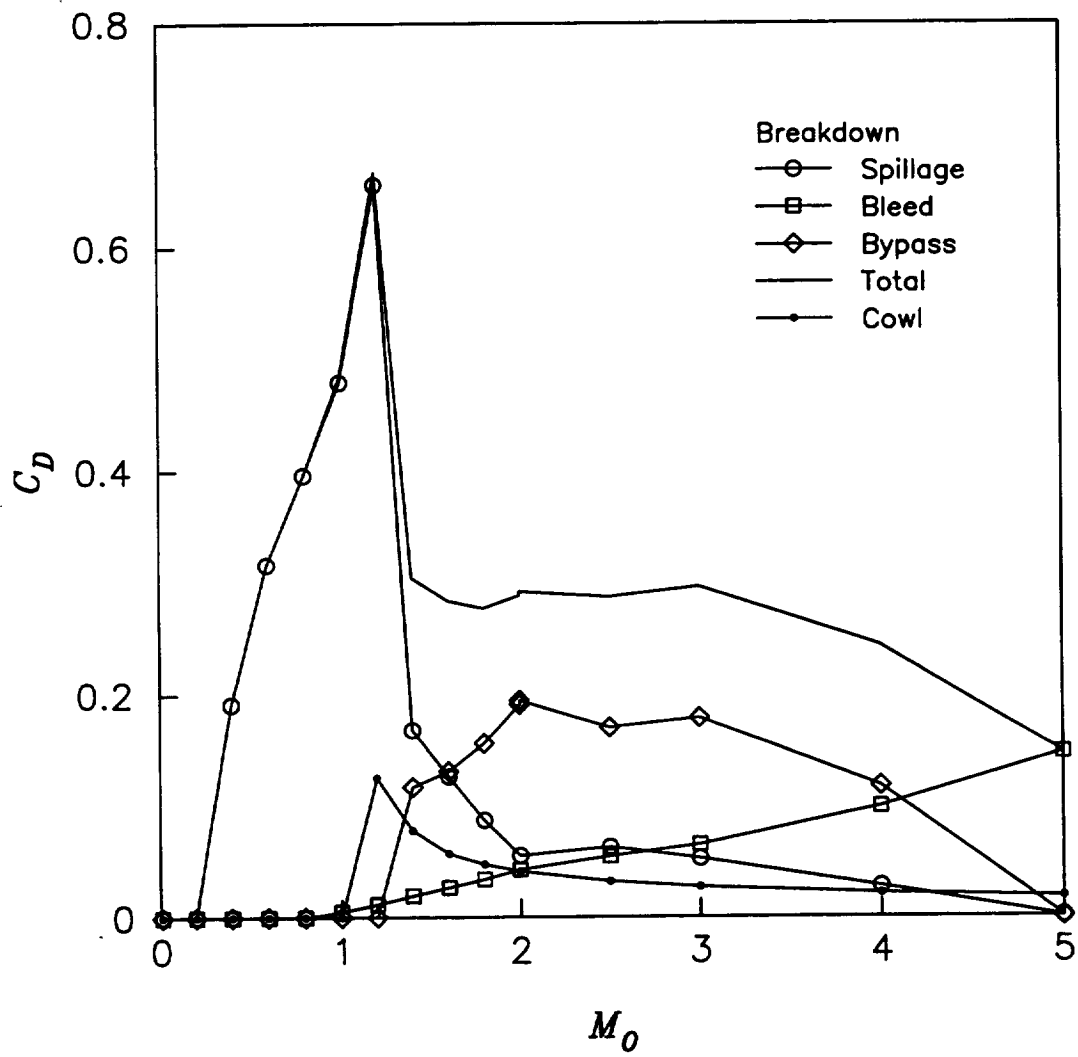


Figure IV.3 Drag Coefficients

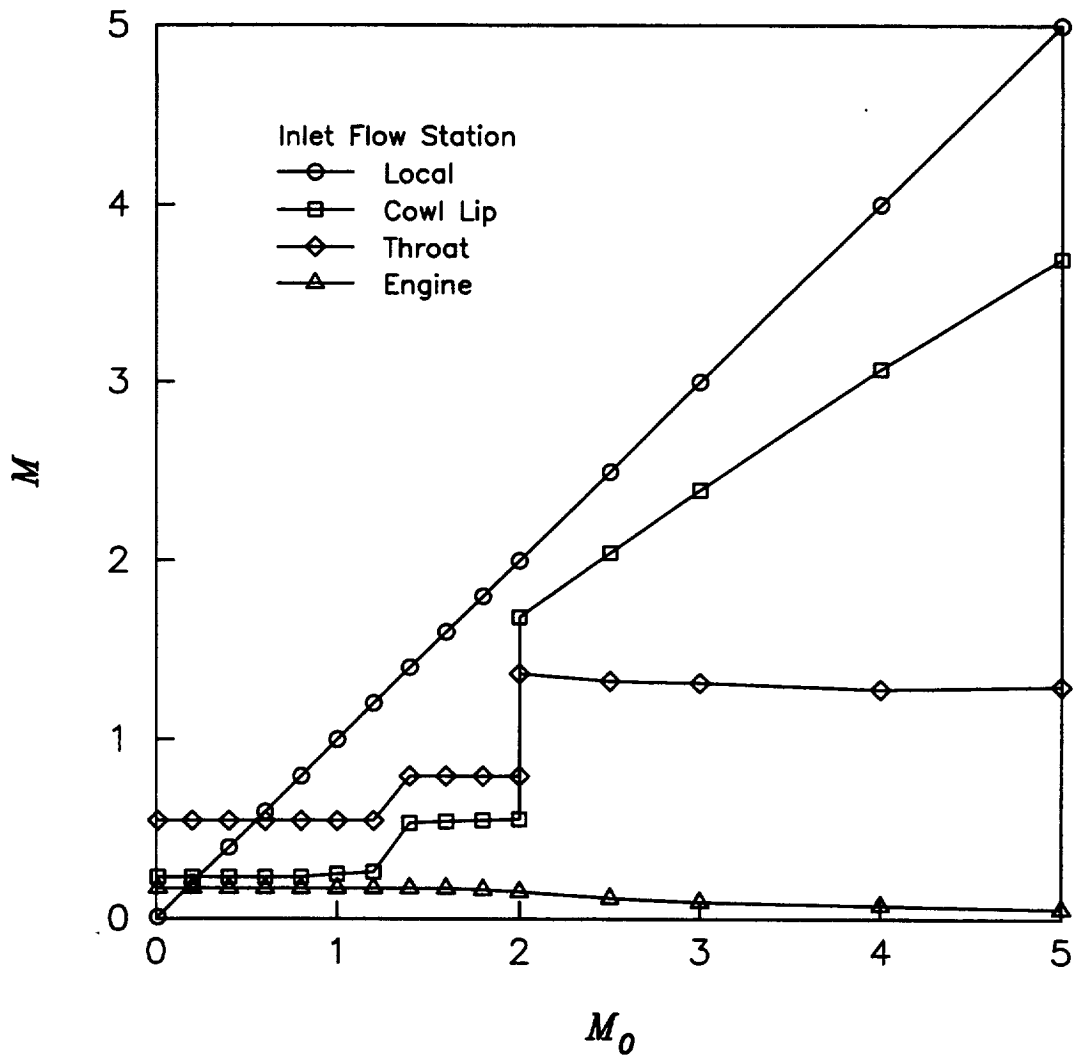


Figure IV.4 Mach Numbers

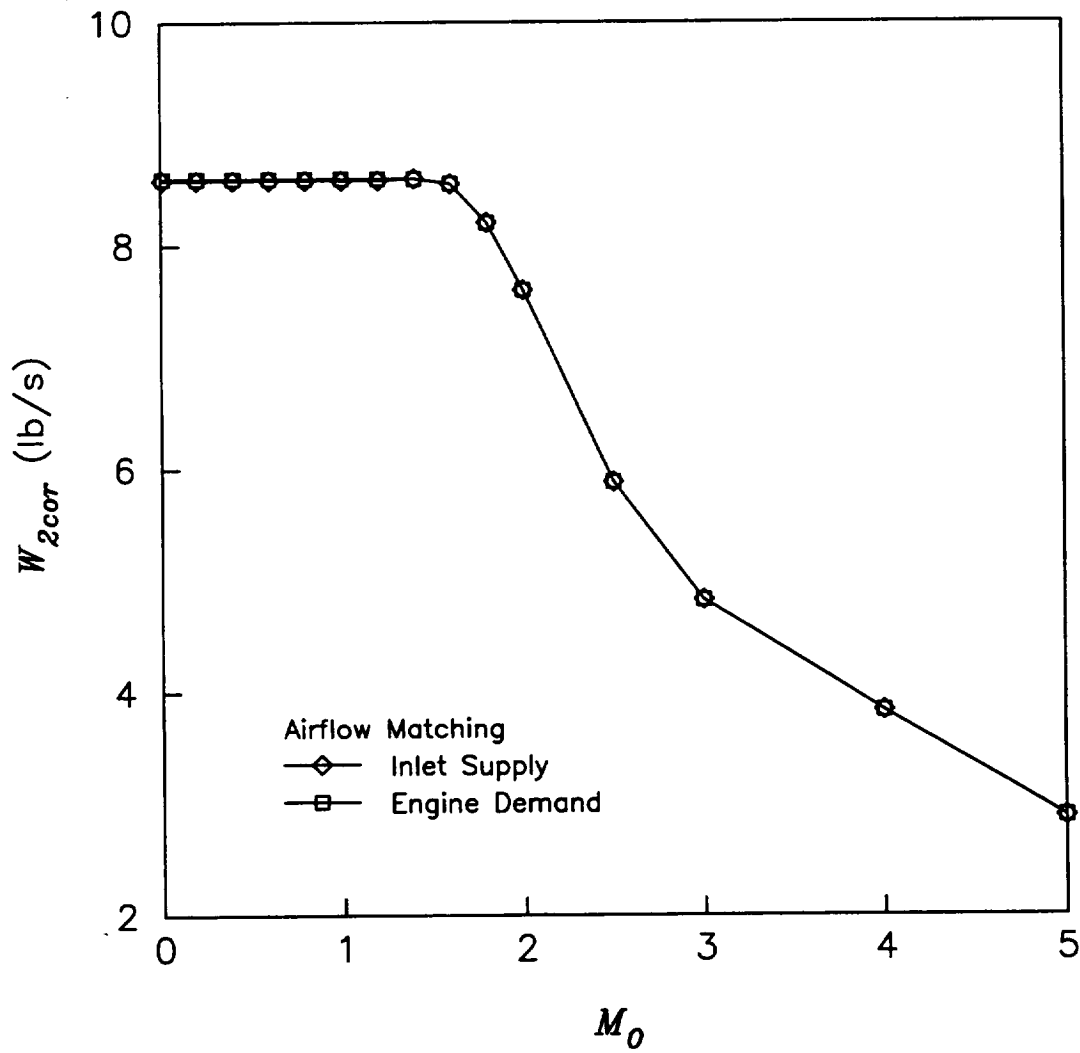


Figure IV.5 Corrected Airflows

```

1 &ipac
2 title='2-D Inlet Example Case',
3 echo=1,figure=1,npts=10,20,iout=1,1,1,1,
4 xmach0=5.0,alt=-1000,igas=1,
5 idim=2,ac=1.0,ar=1,
6 ramps=3,theta=5,5,5,rleng=0,0,0,
7 xcowl=0,ycowl=1,
8 rclip=0.0,thetac=-5,
9 cowl=2,cowlth=7,-7,cowlxl=2,6,
10 a2ac=0.6,xladd=6.5,hubtip=0.3,cloff=0.6,
11 xmth=-1.3,xmns=2.0,nishck=-1,
12 athac=-1,
13 w2cor=-1,
14 bleed=-1,pblpt0=-1,
15 &end
16
17 forebd: xmachx= 5.000E+00,xmach0= 5.000E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
18 cd2d: xmach0= 5.000E+00, aoiac= 9.985E-01,xmach1= 3.694E+00,ptipt0= 9.528E-01, cda= 2.723E-04,
19 cd2d: xmach0= 5.000E+00, aoiac= 9.975E-01,xmach1= 4.436E-01,ptipt0= 1.716E-01, cda= 1.604E-03,
20 ptrcv: xmach0= 5.000E+00, aoiac= 8.425E-01, xmns= 2.000E+00,pt2pt0= 5.151E-01,thetad= 3.393E+00,
21 xmth= 1.296E+00, athac= 4.411E-02,nishck= 5.000E+00,pthpt0= 8.132E-01,xlipth= 1.569E+00,
22 cd2d: xmach0= 5.000E+00, aoiac= 9.985E-01,xmach1= 3.694E+00,ptipt0= 9.528E-01, cda= 2.723E-04,
23 cdwave: xmach0= 5.000E+00, cdwav= 1.746E-02,
24 cdbld: xmach0= 5.000E+00, aoiac= 9.985E-01, bleed= 1.575E-01, cdbld= 1.477E-01,ptblpe= 2.408E+01,
25 : xmach0= 5.000E+00, aoiac= 9.985E-01, bleed= 1.575E-01, cdbld= 1.477E-01,
26 : xmach0= 5.000E+00, aoiac= 9.985E-01, cdtot= 1.480E-01, cdspl= 2.723E-04, cdref= 1.746E-02,
27 calimp: xmachx= 5.000E+00, gama= 1.400E+00,pratio= 9.074E-01,trato= 1.066E+00,aratio= 1.117E+00,
28 : xmach0= 5.000E+00,aoenac= 8.410E-01, w2c= 2.888E+00, w2= 1.100E+01,
29 : xmachx= 5.000E+00,aoenac= 8.410E-01,w2ceng= 2.888E+00,
30
31 IPAC 2-D Inlet Example Case
32
33 Flight Conditions
34
35 Mach number 5.000E+00
36
37 altitude (ft) 8.047E+04
38
39 ambient total
40
41 pressure (lbf/ft**2) 5.677E+01 3.310E+04
42 temperature (R) 3.979E+02 2.240E+03
43 dynamic pressure (lbf/ft**2) 9.935E+02
44
45 Vehicle Effects
46

```



47	ML/M0	1.000E+00	
48	PTL/PT0	1.000E+00	
49	AL/A0	1.000E+00	
50			
51	Inlet Mass Flow Ratios		
52			
53	A0I/AC	9.985E-01	
54	A0SPL/AC	1.457E-03	
55	A0BLD/AC	1.575E-01	
56	A0/AC	8.410E-01	
57	A0BYP/AC	0.000E-01	
58	A0ENG/AC	8.410E-01	
59			
60	Inlet Total Pressure Recoveries		
61			
62	PT2/PT0	5.151E-01	
63			
64	PTL/PT0	1.000E+00	
65	PT1/PTL	9.528E-01	
66	PTTH/PT1	8.535E-01	
67	PT2/PTTH	6.335E-01	
68			
69	PTx/PTy	7.209E-01	
70			
71	Inlet Drag Breakdown		
72			
73	AC (ft**2)	1.000E+00	
74			
75			
76			
77	spillage	2.723E-04	2.706E-01
78	bleed	1.477E-01	1.467E+02
79	bypass	0.000E-01	0.000E-01
80	cowl	1.746E-02	1.734E+01
81	total	1.654E-01	1.643E+02
82	reference	1.746E-02	1.734E+01
83	power setting	1.480E-01	1.470E+02
84	Engine Performance Data		
85		uninstalled	installed
86			
87	net thrust (lbf)	0.000E-01	-1.643E+02
88	SFC (lbm/hr/lbf)	0.000E-01	-0.000E-01
89	W2 (lbm/s)	0.000E-01	1.100E+01
90	corrected W2 (lbm/s)	2.888E+00	2.888E+00
91			
92	reference recovery	5.126E-01	

93	Inlet Flow Properties				
94	station	0	L	TH	
95	flow area (ft**2)	9.985E-01	9.985E-01	3.406E-01 4.411E-02 6.000E-01	
96	Mach number	5.000E+00	5.000E+00	3.694E+00 1.296E+00 5.546E-02	
97	pressure (lbf/ft**2)	5.677E+01	5.677E+01	2.858E+02 8.868E+03 1.544E+04	
98	temperature (R)	3.979E+02	3.979E+02	6.403E+02 1.788E+03 2.386E+03	
99	density (slg/ft**3)	8.313E-05	8.313E-05	2.601E-04 2.891E-03 3.770E-03	
100	velocity (ft/s)	4.889E+03	4.889E+03	4.582E+03 2.685E+03 1.328E+02	
101	total pressure (lbf/ft**2)	3.310E+04	3.310E+04	3.154E+04 2.692E+04 1.705E+04	
102	total temperature (R)	2.240E+03	2.240E+03	2.240E+03 2.240E+03 2.240E+03	
103	weight flow (lbm/s)	1.308E+01	1.308E+01	1.306E+01 1.100E+01 1.100E+01	
104	corrected weight flow (lbm/s)	1.737E+00	1.737E+00	1.820E+00 1.796E+00 2.835E+00	
105	Geometry Data for 2-D Inlet				
106	inlet capture, AC (ft**2)	1.000E+00			
107	width (ft)	1.000E+00			
108	height (ft)	1.000E+00			
109	engine face, A2 (ft**2)	6.000E-01			
110	diameter (ft)	9.162E-01			
111	H/T	3.000E-01			
112	Figure Data for Inlet Geometry				
113	internal cowl surface (ft)	X	Y		
114		3.715E+00	1.000E+00		
115		5.424E+00	1.150E+00		
116		5.424E+00	1.150E+00		
117		5.738E+00	1.149E+00		
118		6.051E+00	1.147E+00		
119		6.365E+00	1.143E+00		

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external cowl surface (ft)

X	Y
6.678E+00	1.139E+00
6.992E+00	1.134E+00
7.305E+00	1.128E+00
7.619E+00	1.121E+00
7.932E+00	1.115E+00
8.245E+00	1.107E+00
8.559E+00	1.100E+00
8.872E+00	1.093E+00
9.186E+00	1.086E+00
9.499E+00	1.080E+00
9.813E+00	1.074E+00
1.013E+01	1.069E+00
1.044E+01	1.064E+00
1.075E+01	1.061E+00
1.107E+01	1.059E+00
1.138E+01	1.058E+00

2-D ramp surface (ft)

X	Y
3.715E+00	1.000E+00
5.715E+00	1.246E+00
1.172E+01	1.246E+00

X	Y
0.000E-01	0.000E-01
1.494E+00	1.307E-01
2.350E+00	2.816E-01
5.424E+00	1.105E+00
5.424E+00	1.105E+00
5.738E+00	1.098E+00
6.051E+00	1.076E+00
6.365E+00	1.041E+00
6.678E+00	9.953E-01
6.992E+00	9.404E-01
7.305E+00	8.779E-01
7.619E+00	8.094E-01
7.932E+00	7.368E-01
8.245E+00	6.617E-01
8.559E+00	5.857E-01
8.872E+00	5.105E-01
9.186E+00	4.379E-01
9.499E+00	3.695E-01
9.813E+00	3.069E-01
1.013E+01	2.520E-01
1.044E+01	2.064E-01

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engine face spinner (ft)

1.075E+01 1.717E-01  
1.107E+01 1.496E-01  
1.138E+01 1.419E-01  
  
1.138E+01 -4.626E-01  
1.136E+01 -4.647E-01  
1.133E+01 -4.709E-01  
1.131E+01 -4.810E-01  
1.129E+01 -4.947E-01  
1.127E+01 -5.117E-01  
1.126E+01 -5.313E-01  
1.125E+01 -5.530E-01  
1.124E+01 -5.761E-01  
1.124E+01 -6.000E-01  
1.124E+01 -6.239E-01  
1.125E+01 -6.470E-01  
1.126E+01 -6.687E-01  
1.127E+01 -6.883E-01  
1.129E+01 -7.053E-01  
1.131E+01 -7.190E-01  
1.133E+01 -7.291E-01  
1.136E+01 -7.353E-01  
1.138E+01 -7.374E-01

Y

X

&ipac  
xmach0=4.0,figure=0,iout=1,1,0,0,  
xmth=-1.3,xlipth=-1,  
bypass=-1,pppt2=-1,  
theta=5,5,4.4,  
xmms=1.8,  
&end  
  
forebd: xmachx= 4.000E+00,xmach0= 4.000E+00,ptlpt0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,  
cd2d: xmach0= 4.000E+00, aoiac= 8.215E-01,xmach1= 3.072E+00,ptlpt0= 9.753E-01, cda= 2.687E-02,  
cd2d: xmach0= 4.000E+00, aoiac= 8.207E-01,xmach1= 4.705E-01,ptlpt0= 3.010E-01, cda= 2.791E-02,  
ptrcv: xmach0= 4.000E+00, aoiac= 7.015E-01, xmms= 1.800E+00,pt2pt0= 6.427E-01,thetad= 3.069E+00,  
xmth= 1.279E+00, athac= 7.709E-02,nishck= 4.000E+00,ptlpt0= 8.978E-01,xlipth= 1.494E+00,  
cd2d: xmach0= 4.000E+00, aoiac= 8.215E-01,xmach1= 3.072E+00,ptlpt0= 9.753E-01, cda= 2.687E-02,  
cdwave: xmach0= 4.000E+00, cdwav= 2.061E-02,  
cdbl: xmach0= 4.000E+00, aoiac= 8.215E-01, bleed= 1.200E-01, cdbld= 9.915E-02,ptblpe= 8.449E+00,  
: xmach0= 4.000E+00, aoiac= 8.215E-01, bleed= 1.200E-01, cdbld= 9.915E-02,  
: xmach0= 4.000E+00, aoiac= 8.215E-01, cdtot= 1.260E-01, cdspl= 2.687E-02, cdref= 2.061E-02,  
calimp: xmachx= 4.000E+00, gama= 1.400E+00,pratio= 9.659E-01,tratio= 1.032E+00,aratio= 1.040E+00,

231 cdbyp: xmach0= 4.000E+00, a0iac= 8.215E-01, bypass= 1.450E-01, cdbyrp= 1.178E-01, ptbpps= 3.248E+01,  
 232 : xmach0= 4.000E+00, a0iac= 8.215E-01, cdtot= 2.644E-01, pt2pt0= 6.427E-01,  
 233 : xmach0= 4.000E+00, a0enac= 5.566E-01, w2c= 3.839E+00, w2= 9.122E+00,  
 234 : xmachx= 4.000E+00, a0enac= 5.566E-01, w2ceng= 3.839E+00,  
 235

236 IPAC 2-D Inlet Example Case

237 Flight Conditions

238 Mach number 4.000E+00  
 239 altitude (ft) 7.125E+04

ambient total

240 pressure (lbf/ft\*\*2) 8.839E+01 1.389E+04  
 241 temperature (R) 3.929E+02 1.598E+03  
 242 dynamic pressure (lbf/ft\*\*2) 9.899E+02

243 Vehicle Effects

244 ML/M0 1.000E+00  
 245 PTL/PT0 1.000E+00  
 246 AL/A0 1.000E+00

247 Inlet Mass Flow Ratios

248 A0I/AC 8.215E-01  
 249 A0SPL/AC 1.785E-01  
 250 A0BLD/AC 1.200E-01  
 251 A0/AC 7.015E-01  
 252 A0BYP/AC 1.450E-01  
 253 A0ENG/AC 5.566E-01

254 Inlet Total Pressure Recoveries

255 PT2/PT0 6.427E-01  
 256 PTL/PT0 1.000E+00  
 257 PT1/PTL 9.753E-01  
 258 PTH/PT1 9.205E-01  
 259 PT2/PTH 7.159E-01  
 260 PTx/PTy 8.127E-01

261 Inlet Drag Breakdown

262

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277 AC (ft**2) 1.000E+00
278
279
280 CD D (lbf)
281
282 spillage 2.687E-02 2.660E+01
283 bleed 9.915E-02 9.815E+01
284 bypass 1.178E-01 1.166E+02
285 cowl 2.061E-02 2.040E+01
286 total 2.644E-01 2.618E+02
287 reference 2.061E-02 2.040E+01
288 power setting 2.438E-01 2.414E+02
289
290 Engine Performance Data
291
292 net thrust (lbf) 0.000E-01 -2.618E+02
293 SFC (lbm/hr/lbf) 0.000E-01 -0.000E-01
294 W2 (lbm/s) 0.000E-01 9.122E+00
295 corrected W2 (lbm/s) 3.839E+00 3.839E+00
296
297 reference recovery 6.695E-01
298
299
300 &ipac
301 xmach0=3.0,figure=0,
302 theta=5,5,2.9,
303 xmns=1.6,
304 &end
305
306 forebd: xmachx= 3.000E+00,xmach0= 3.000E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
307 cd2d: xmach0= 3.000E+00, aoiac= 6.905E-01,xmach1= 2.399E+00,ptipt0= 9.897E-01, cda= 5.196E-02,
308 cd2d: xmach0= 3.000E+00, aoiac= 6.898E-01,xmach1= 5.225E-01,ptlpt0= 5.351E-01, cda= 5.271E-02,
309 ptrcv: xmach0= 3.000E+00, aoiac= 6.080E-01, xmns= 1.600E+00,pt2pt0= 7.876E-01,thetad= 2.483E+00,
310 xmth= 1.314E+00, athac= 1.598E-01,nishck= 3.000E+00,pthpt0= 9.637E-01,xlipth= 1.377E+00,
311 cd2d: xmach0= 3.000E+00, aoiac= 6.905E-01,xmach1= 2.399E+00,ptlpt0= 9.897E-01, cda= 5.196E-02,
312 cdwave: xmach0= 3.000E+00, cdwav= 2.632E-02,
313 cdbld: xmach0= 3.000E+00, aoiac= 6.905E-01, bleed= 8.250E-02, cdbld= 6.451E-02, ptblpe= 2.782E+00,
314 : xmach0= 3.000E+00, aoiac= 6.905E-01, bleed= 8.250E-02, cdbld= 6.451E-02,
315 : xmach0= 3.000E+00, aoiac= 6.905E-01, cdtot= 1.165E-01, cdspl= 5.196E-02, cdref= 2.632E-02,
316 calimp: xmachx= 3.000E+00, gama= 1.400E+00,pratio= 9.936E-01, tratio= 1.009E+00, aratio= 1.007E+00,
317 cdbyp: xmach0= 3.000E+00, aoiac= 6.905E-01, bypass= 2.794E-01, cdbyp= 1.792E-01, ptbpe= 1.019E+01,
318 : xmach0= 3.000E+00, aoiac= 6.905E-01, cdtot= 3.220E-01, pt2pt0= 7.876E-01,
319 : xmach0= 3.000E+00, aoenac= 3.286E-01, w2C= 4.834E+00, w2= 7.172E+00,
320 : xmachx= 3.000E+00, aoenac= 3.286E-01, w2ceng= 4.834E+00,
321
322 IPAC 2-D Inlet Example Case

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323	Flight Conditions			
324				
325	Mach number	3.000E+00		
326				
327	altitude (ft)	5.922E+04		
328				
329		ambient	total	
330				
331	pressure (lb/ft**2)	1.563E+02	5.780E+03	
332	temperature (R)	3.900E+02	1.082E+03	
333	dynamic pressure (lb/ft**2)	9.849E+02		
334				
335	Vehicle Effects			
336				
337				
338	ML/M0	1.000E+00		
339	PTL/PT0	1.000E+00		
340	AL/A0	1.000E+00		
341				
342	Inlet Mass Flow Ratios			
343				
344	A0I/AC	6.905E-01		
345	A0SPL/AC	3.095E-01		
346	A0BLD/AC	8.250E-02		
347	A0/AC	6.080E-01		
348	A0BYP/AC	2.794E-01		
349	A0ENG/AC	3.286E-01		
350				
351	Inlet Total Pressure Recoveries			
352				
353	PT2/PT0	7.876E-01		
354				
355	PTL/PT0	1.000E+00		
356	PT1/PTL	9.897E-01		
357	PTTH/PT1	9.737E-01		
358	PT2/PTTH	8.172E-01		
359				
360	PTx/PTy	8.952E-01		
361				
362	Inlet Drag Breakdown			
363				
364	AC (ft**2)	1.000E+00		
365				
366		CD	D (lbf)	
367	spillage	5.196E-02	5.118E+01	
368				

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369 bleed 6.451E-02 6.353E+01
370 bypass 1.792E-01 1.765E+02
371 cowl 2.632E-02 2.593E+01
372 total 3.220E-01 3.172E+02
373 reference 2.632E-02 2.593E+01
374 power setting 2.957E-01 2.913E+02
375
376 Engine Performance Data  uninstalled installed
377
378 net thrust (lbf) 0.000E-01 -3.172E+02
379 SFC (lbm/hr/lbf) 0.000E-01 -0.000E-01
380 W2 (lbm/s) 0.000E-01 7.172E+00
381 corrected W2 (lbm/s) 4.834E+00 4.834E+00
382
383 reference recovery 8.088E-01
384
385
386
387 &ipac
388 xmach0=2.5,figure=0,
389 theta=5,4.9,1.5,
390 xmns=1.4,
391 &end
392 forebd: xmachx= 2.500E+00,xmach0= 2.500E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
393 cd2d: xmach0= 2.500E+00, aoiac= 6.516E-01,xmach1= 2.045E+00,pt1pt0= 9.939E-01, cda= 6.234E-02,
394 cd2d: xmach0= 2.500E+00, aoiac= 6.509E-01,xmach1= 5.689E-01,pt1pt0= 6.954E-01, cda= 6.293E-02,
395 ptrcv: xmach0= 2.500E+00, a0ac= 5.878E-01, xmns= 1.400E+00,pt2pt0= 8.761E-01,thetad= 2.029E+00,
396 xmth= 1.324E+00, athac= 2.443E-01,nishck= 3.000E+00,pthpt0= 9.827E-01,xlipth= 1.407E+00,
397 cd2d: xmach0= 2.500E+00, aoiac= 6.516E-01,xmach1= 2.045E+00,pt1pt0= 9.939E-01, cda= 6.234E-02,
398 cdwave: xmach0= 2.500E+00, cdwav= 3.144E-02,
399 cdbld: xmach0= 2.500E+00, aoiac= 6.516E-01, bleed= 6.375E-02, cdbld= 5.382E-02,ptblpe= 1.619E+00,
400 : xmach0= 2.500E+00, aoiac= 6.516E-01, bleed= 6.375E-02, cdbld= 5.382E-02,
401 : xmach0= 2.500E+00, aoiac= 6.516E-01, cdtot= 1.162E-01, cdspl= 6.234E-02, cdref= 3.144E-02,
402 calimp: xmachx= 2.500E+00, gama= 1.400E+00,pratio= 9.985E-01,atratio= 1.003E+00,aratio= 1.002E+00,
403 cdbyp: xmach0= 2.500E+00, aoiac= 6.516E-01,bypass= 3.120E-01, cdbyp= 1.704E-01,ptbype= 5.668E+00,
404 : xmach0= 2.500E+00, aoiac= 6.516E-01, cdtot= 3.180E-01,pt2pt0= 8.761E-01,
405 : xmach0= 2.500E+00,a0enac= 2.759E-01, w2c= 5.884E+00, w2= 7.237E+00,
406 : xmachx= 2.500E+00,a0enac= 2.759E-01,w2ceng= 5.884E+00,
407
408 IPAC 2-D Inlet Example Case
409
410 Flight Conditions
411
412 Mach number 2.500E+00
413
414 altitude (ft) 5.149E+04

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		ambient	total
415			
416			
417			
418	pressure (lbf/ft**2)	2.255E+02	3.859E+03
419	temperature (R)	3.900E+02	8.744E+02
420	dynamic pressure (lbf/ft**2)	9.866E+02	
421			
422	Vehicle Effects		
423		1.000E+00	
424	ML/M0	1.000E+00	
425	PTL/PT0	1.000E+00	
426	AL/A0		
427			
428	Inlet Mass Flow Ratios		
429			
430	A0I/AC	6.516E-01	
431	A0SPL/AC	3.484E-01	
432	A0BLD/AC	6.375E-02	
433	A0/AC	5.878E-01	
434	A0BYP/AC	3.120E-01	
435	A0ENG/AC	2.759E-01	
436			
437	Inlet Total Pressure Recoveries		
438			
439	PT2/PT0	8.761E-01	
440			
441	PTL/PT0	1.000E+00	
442	PT1/PTL	9.939E-01	
443	PTTH/PT1	9.887E-01	
444	PT2/PTTH	8.915E-01	
445			
446	PTx/PTY	9.582E-01	
447			
448	Inlet Drag Breakdown		
449			
450	AC (ft**2)	1.000E+00	
451			
452			
453			
454	spillage	6.234E-02	6.150E+01
455	bleed	5.382E-02	5.310E+01
456	bypass	1.704E-01	1.681E+02
457	cowl	3.144E-02	3.102E+01
458	total	3.180E-01	3.137E+02
459	reference	3.144E-02	3.102E+01
460	power setting	2.866E-01	2.827E+02

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461 Engine Performance Data
462
463
464 net thrust (lbf) 0.000E-01 -3.137E+02
465 SFC (lbm/hr/lbf) 0.000E-01 -0.000E-01
466 W2 (lbm/s) 0.000E-01 7.237E+00
467 corrected W2 (lbm/s) 5.884E+00 5.884E+00
468
469 reference recovery 8.703E-01
470
471
472 &ipac
473 xmach0=2.0,figure=0,igas=0,
474 theta=5,2.5,1.5,
475 &end
476
477 forebd: xmachx= 2.000E+00,xmach0= 2.000E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
478 cd2d: xmach0= 2.000E+00, aoiac= 6.796E-01,xmach1= 1.684E+00,ptipt0= 9.976E-01, cda= 5.461E-02,
479 cd2d: xmach0= 2.000E+00, aoiac= 6.789E-01,xmach1= 6.436E-01,ptlpt0= 8.604E-01, cda= 5.503E-02,
480 ptrcv: xmach0= 2.000E+00, aoiac= 6.346E-01, xmns= 1.400E+00,pt2pt0= 9.158E-01,thetad= 1.312E+00,
481 xpth= 1.365E+00, athac= 4.140E-01,nishck= 2.000E+00,pthpt0= 9.960E-01,xliph= 1.139E+00,
482 cd2d: xmach0= 2.000E+00, aoiac= 6.796E-01,xmach1= 1.684E+00,ptlpt0= 9.976E-01, cda= 5.461E-02,
483 cdwave: xmach0= 2.000E+00, cdwav= 4.051E-02,
484 cdbld: xmach0= 2.000E+00, aoiac= 6.796E-01, bleed= 4.500E-02, cdbld= 4.195E-02,ptblpe= 1.093E+00,
485 : xmach0= 2.000E+00, aoiac= 6.796E-01, bleed= 4.500E-02, cdbld= 4.195E-02,
486 : xmach0= 2.000E+00, aoiac= 6.796E-01, cdtot= 9.656E-02, cdbld= 4.195E-02,
487 cdbyp: xmach0= 2.000E+00, aoiac= 6.796E-01,bypass= 3.968E-01, cdbyp= 1.948E-01,ptbype= 2.847E+00,
488 : xmach0= 2.000E+00, aoiac= 6.796E-01, cdtot= 3.318E-01,pt2pt0= 9.158E-01,
489 : xmach0= 2.000E+00, aoenac= 2.378E-01, w2c= 7.602E+00,
490 : xmachx= 2.000E+00, aoenac= 2.378E-01, w2ceng= 7.602E+00,
491
492 IPAC 2-D Inlet Example Case
493
494 Flight Conditions
495
496 Mach number 2.000E+00
497
498 altitude (ft) 4.189E+04
499
500 ambient total
501
502 pressure (lbf/ft**2) 3.578E+02 2.800E+03
503 temperature (R) 3.900E+02 7.019E+02
504 dynamic pressure (lbf/ft**2) 1.002E+03
505
506 Vehicle Effects

```

507				
508	ML/MO	1.000E+00		
509	PTL/PTO	1.000E+00		
510	AL/AO	1.000E+00		
511				
512	Inlet Mass Flow Ratios			
513				
514	A0I/AC	6.796E-01		
515	A0SPL/AC	3.204E-01		
516	A0BLD/AC	4.500E-02		
517	A0/AC	6.346E-01		
518	A0BYP/AC	3.968E-01		
519	A0ENG/AC	2.378E-01		
520				
521	Inlet Total Pressure Recoveries			
522				
523	PT2/PTO	9.158E-01		
524				
525	PTL/PTO	1.000E+00		
526	PT1/PTL	9.976E-01		
527	PTTH/PT1	9.984E-01		
528	PT2/PTTH	9.194E-01		
529				
530	PTx/PTy	9.582E-01		
531				
532	Inlet Drag Breakdown			
533				
534	AC (ft**2)	1.000E+00		
535				
536				
537				
538	spillage	5.461E-02	5.471E+01	
539	bleed	4.195E-02	4.202E+01	
540	bypass	1.948E-01	1.951E+02	
541	cowl	4.051E-02	4.058E+01	
542	total	3.318E-01	3.324E+02	
543	reference	4.051E-02	4.058E+01	
544	power setting	2.913E-01	2.919E+02	
545				
546	Engine Performance Data	uninstalled	installed	
547				
548	net thrust (lbf)	0.000E-01	-3.324E+02	
549	SFC (lbm/hr/lbf)	0.000E-01	-0.000E-01	
550	W2 (lbm/s)	0.000E-01	7.920E+00	
551	corrected W2 (lbm/s)	7.602E+00	7.602E+00	
552				

```

553 reference recovery          9.250E-01
554
555
556 &ipac
557   xmach0=2.0,figure=0,
558   theta=5,2.5,1.5,
559   xmh=0.80,xmns=0,
560   &end
561
562   forebd: xmachx= 2.000E+00,xmach0= 2.000E+00, xmlm0= 1.000E+00, ptlpt0= 1.000E+00, ala0= 1.000E+00,
563   cd2d: xmach0= 2.000E+00, a0iac= 5.000E-01,xmach1= 4.128E-01,ptlpt0= 8.604E-01, cda= 1.806E-01,
564   ptrcv: xmach0= 2.000E+00, a0ac= 5.790E-01, xmns= 0.000E-01,pt2pt0= 8.153E-01,thetad= 1.312E+00,
565   xmh= 8.000E-01, athac= 4.140E-01,nishck=-1.000E+00,pthpt0= 8.604E-01,xlipth=-1.000E+00,
566   cd2d: xmach0= 2.000E+00, a0iac= 6.240E-01,xmach1= 5.587E-01,ptlpt0= 8.604E-01, cda= 9.095E-02,
567   cdwave: xmach0= 2.000E+00, cdwav= 4.051E-02,
568   clsuc: xmach0= 2.000E+00, a0iac= 6.240E-01, cls= 3.637E-02, cdspl= 5.458E-02,thetae= 5.412E+00,
569   cdbld: xmach0= 2.000E+00, a0iac= 6.240E-01, bleed= 4.500E-02, cdbld= 4.195E-02,ptblpe= 1.093E+00,
570   : xmach0= 2.000E+00, a0iac= 6.240E-01, bleed= 4.500E-02, cdbld= 4.195E-02,
571   : xmach0= 2.000E+00, a0iac= 6.240E-01, cdtot= 9.653E-02, cdspl= 5.458E-02, cdref= 4.051E-02,
572   cdbyp: xmach0= 2.000E+00, a0iac= 6.240E-01,bypass= 3.673E-01, cdbyp= 1.912E-01,ptbyp= 2.593E+00,
573   : xmach0= 2.000E+00, a0enac= 2.117E-01, cdtot= 3.283E-01,pt2pt0= 8.153E-01,
574   : xmach0= 2.000E+00, a0enac= 2.117E-01, w2c= 7.602E+00, w2= 7.050E+00,
575   : xmachx= 2.000E+00,a0enac= 2.117E-01,w2ceng= 7.602E+00,
576
577 IPAC 2-D Inlet Example Case
578
579 Flight Conditions
580
581   Mach number          2.000E+00
582
583   altitude (ft)       4.189E+04
584
585   ambient              total
586
587   pressure (lbf/ft**2) 3.578E+02  2.800E+03
588   temperature (R)      3.900E+02  7.019E+02
589   dynamic pressure (lbf/ft**2) 1.002E+03
590
591 Vehicle Effects
592
593   ML/M0                1.000E+00
594   PTL/PT0              1.000E+00
595   AL/A0                 1.000E+00
596
597 Inlet Mass Flow Ratios
598

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A0I/AC  
A0SPL/AC  
A0BLD/AC  
A0/AC  
A0BYP/AC  
A0ENG/AC

Inlet Total Pressure Recoveries

PT2/PT0  
PTL/PT0  
PT1/PTL  
PTTH/PT1  
PT2/PTTH  
PTx/PTy

Inlet Drag Breakdown

AC (ft\*\*2)

CD D (lbf)  
spillage  
bleed  
bypass  
Cowl  
total  
reference  
power setting

Engine Performance Data

net thrust (lbf)  
SFC (lbm/hr/lbf)  
W2 (lbm/s)  
corrected W2 (lbm/s)  
reference recovery

&ipac xmach0=1.8,figure=0, &end

forebd: xmachx= 1.800E+00,xmach0= 1.800E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,  
cd2d: xmach0= 1.800E+00, a0iac= 5.000E-01,xmach1= 4.580E-01,ptlpt0= 9.303E-01, cda= 1.795E-01,

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645 ptrcv: xmach0= 1.800E+00, a0ac= 5.339E-01, xmns= 0.000E-01, pt2pt0= 8.816E-01, thetad= 1.312E+00,
646      xsth= 8.000E-01, athac= 4.140E-01, nishck=-1.000E+00, pthpt0= 9.303E-01, xlipth=-1.000E+00,
647 cd2d: xmach0= 1.800E+00, a0iac= 5.714E-01, xmach1= 5.527E-01, pt1pt0= 9.303E-01, cda= 1.253E-01,
648 cdwave: xmach0= 1.800E+00, cdwav= 4.670E-02,
649 clsuc: xmach0= 1.800E+00, a0iac= 5.714E-01, cls= 3.838E-02, cdspl= 8.688E-02, thetae= 5.412E+00,
650 cdbld: xmach0= 1.800E+00, a0iac= 5.714E-01, bleed= 3.750E-02, cdbld= 3.344E-02, ptblpe= 1.082E+00,
651      : xmach0= 1.800E+00, a0iac= 5.714E-01, bleed= 3.750E-02, cdbld= 3.344E-02,
652      : xmach0= 1.800E+00, a0iac= 5.714E-01, cdtot= 1.203E-01, cdspl= 8.688E-02, cdref= 4.670E-02,
653      : xmach0= 1.800E+00, a0iac= 5.714E-01, bypass= 3.231E-01, cdbyp= 1.561E-01, ptbtp0= 2.238E+00,
654      : xmach0= 1.800E+00, a0enac= 2.108E-01, cdtot= 3.232E-01, pt2pt0= 8.816E-01,
655      : xmach0= 1.800E+00, a0enac= 2.108E-01, w2c= 8.206E+00, w2= 7.880E+00,
656      : xmachx= 1.800E+00, a0enac= 2.108E-01, w2ceng= 8.206E+00,
657

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IPAC 2-D Inlet Example Case

Flight Conditions

Mach number 1.800E+00

altitude (ft) 3.729E+04

ambient total

pressure (lbf/ft\*\*2) 4.464E+02 2.565E+03

temperature (R) 3.900E+02 6.427E+02

dynamic pressure (lbf/ft\*\*2) 1.012E+03

Vehicle Effects

ML/M0 1.000E+00

PTL/PT0 1.000E+00

AL/A0 1.000E+00

Inlet Mass Flow Ratios

A0I/AC 5.714E-01

A0SPL/AC 4.286E-01

A0BLD/AC 3.750E-02

A0/AC 5.339E-01

A0BYP/AC 3.231E-01

A0ENG/AC 2.108E-01

Inlet Total Pressure Recoveries

PT2/PT0 8.816E-01

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PTL/PTO 1.000E+00  
PTL/PTL 9.303E-01  
PTTH/PT1 1.000E+00  
PT2/PTTH 9.476E-01  
  
PTx/PTy 1.000E+00

Inlet Drag Breakdown  
AC (ft\*\*2) 1.000E+00

	CD	D (lbf)
spillage	8.688E-02	8.796E+01
bleed	3.344E-02	3.386E+01
bypass	1.561E-01	1.581E+02
cowl	4.670E-02	4.728E+01
total	3.232E-01	3.272E+02
reference	4.670E-02	4.728E+01
power setting	2.765E-01	2.799E+02

Engine Performance Data  
uninstalled installed  
  
net thrust (lbf) 0.000E-01 -3.272E+02  
SFC (lbm/hr/lbf) 0.000E-01 -0.000E-01  
W2 (lbm/s) 0.000E-01 7.880E+00  
corrected W2 (lbm/s) 8.206E+00 8.206E+00  
  
reference recovery 9.445E-01

&ipac xmach0=1.6,figure=0, &end

forebd: xmachx= 1.600E+00,xmach0= 1.600E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,  
cd2d: xmach0= 1.600E+00, a0iac= 5.000E-01,xmach1= 5.173E-01,pt1pt0= 9.798E-01, cda= 1.812E-01,  
ptrcv: xmach0= 1.600E+00, a0ac= 4.885E-01, xmns= 0.000E-01,pt2pt0= 9.285E-01,thetad= 1.312E+00,  
xmth= 8.000E-01, athac= 4.140E-01,nishck=-1.000E+00,pthpt0= 9.798E-01,xlipth=-1.000E+00,  
cd2d: xmach0= 1.600E+00, a0iac= 5.185E-01,xmach1= 5.458E-01,pt1pt0= 9.798E-01, cda= 1.665E-01,  
cdwave: xmach0= 1.600E+00, cdwav= 5.652E-02,  
clsuc: xmach0= 1.600E+00, a0iac= 5.185E-01, cls= 4.035E-02, cdspl= 1.262E-01,thetae= 5.412E+00,  
cdbld: xmach0= 1.600E+00, a0iac= 5.185E-01, bleed= 3.000E-02, cdbld= 2.609E-02,ptblpe= 1.037E+00,  
: xmach0= 1.600E+00, a0iac= 5.185E-01, bleed= 3.000E-02, cdbld= 2.609E-02,  
: xmach0= 1.600E+00, a0iac= 5.185E-01, cdtot= 1.523E-01, cdspl= 1.262E-01, cdref= 5.652E-02,  
cdbyp: xmach0= 1.600E+00, a0iac= 5.185E-01,bypass= 2.875E-01, cdbyp= 1.310E-01,ptbppe= 1.888E+00,  
: xmach0= 1.600E+00, a0iac= 5.185E-01, cdtot= 3.397E-01,pt2pt0= 9.285E-01,  
: xmach0= 1.600E+00,a0enac= 2.010E-01, w2c= 8.389E+00,

737 : xmachx= 1.600E+00, a0enac= 2.010E-01, w2ceng= 8.555E+00,

738 IPAC 2-D Inlet Example Case

740 Flight Conditions

741 Mach number 1.600E+00

742 altitude (ft) 3.209E+04

743 ambient total

744 pressure (lbf/ft\*\*2) 5.706E+02 2.425E+03

745 temperature (R) 4.042E+02 6.112E+02

746 dynamic pressure (lbf/ft\*\*2) 1.023E+03

747 Vehicle Effects

748 ML/M0 1.000E+00

749 PTL/PT0 1.000E+00

750 AL/A0 1.000E+00

751 Inlet Mass Flow Ratios

752 A0I/AC 5.185E-01

753 A0SPL/AC 4.815E-01

754 A0BLD/AC 3.000E-02

755 A0/AC 4.885E-01

756 A0BYP/AC 2.875E-01

757 A0ENG/AC 2.010E-01

758 Inlet Total Pressure Recoveries

759 PT2/PT0 9.285E-01

760 PTL/PT0 1.000E+00

761 PTL/PTL 9.798E-01

762 PTH/PT1 1.000E+00

763 PT2/PTTH 9.476E-01

764 PTx/PTy 1.000E+00

765 Inlet Drag Breakdown

766 AC (ft\*\*2) 1.000E+00

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783
784
785 spillage
786 bleed
787 bypass
788 cowl
789 total
790 reference
791 power setting
792
793 Engine Performance Data
794
795 net thrust (lbf)
796 SFC (lbm/hr/lbf)
797 W2 (lbm/s)
798 corrected W2 (lbm/s)
799
800 reference recovery
801
802
803 &ipac xmach0=1.4,figure=0, &end
804
805 forebd: xmachx= 1.400E+00, xmach0= 1.400E+00, xmlm0= 1.000E+00, ptlpt0= 1.000E+00, ala0= 1.000E+00,
806 cd2d: xmach0= 1.400E+00, aoiac= 5.000E-01, xmach1= 6.001E-01, pt1pt0= 9.979E-01, cda= 1.899E-01,
807 ptrcv: xmach0= 1.400E+00, aoiac= 4.437E-01, xmns= 0.000E-01, pt2pt0= 9.456E-01, thetad= 1.312E+00,
808 xmth= 8.000E-01, athac= 4.140E-01, nishck=-1.000E+00, pthpt0= 9.979E-01, xlipth=-1.000E+00,
809 cd2d: xmach0= 1.400E+00, aoiac= 4.662E-01, xmach1= 5.376E-01, pt1pt0= 9.979E-01, cda= 2.102E-01,
810 cdwave: xmach0= 1.400E+00, cdwav= 7.750E-02,
811 clsuc: xmach0= 1.400E+00, aoiac= 4.662E-01, cls= 4.214E-02, cdspl= 1.680E-01, thetae= 5.412E+00,
812 *** error *** in program segment cdbld (errflg=2)
813 cdbld: xmach0= 1.400E+00, aoiac= 4.662E-01, bleed= 2.250E-02, cdbld= 1.884E-02, ptblpe= 1.001E+00,
814 : xmach0= 1.400E+00, aoiac= 4.662E-01, bleed= 2.250E-02, cdbld= 1.884E-02,
815 : xmach0= 1.400E+00, aoiac= 4.662E-01, cdtot= 1.869E-01, cdspl= 1.680E-01, cdref= 7.750E-02,
816 *** error *** in program segment cdbyp (errflg=2)
817 cdbyp: xmach0= 1.400E+00, aoiac= 4.662E-01, bypass= 2.601E-01, cdbyp= 1.168E-01, ptbppe= 1.553E+00,
818 : xmach0= 1.400E+00, aoiac= 4.662E-01, cdtot= 3.812E-01, pt2pt0= 9.456E-01,
819 : xmach0= 1.400E+00, aoenac= 1.836E-01, w2C= 8.601E+00, w2= 8.565E+00,
820 : xmachx= 1.400E+00, aoenac= 1.836E-01, w2ceng= 8.601E+00,
821
822 IPAC 2-D Inlet Example Case
823
824 Flight Conditions
825
826 Mach number 1.400E+00
827
828 altitude (ft) 2.611E+04

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		ambient	total
829			
830			
831			
832	pressure (lb/ft**2)	7.481E+02	2.381E+03
833	temperature (R)	4.256E+02	5.924E+02
834	dynamic pressure (lb/ft**2)	1.026E+03	
835			
836	Vehicle Effects		
837			
838	ML/M0	1.000E+00	
839	PTL/PT0	1.000E+00	
840	AL/A0	1.000E+00	
841			
842	Inlet Mass Flow Ratios		
843			
844	A0I/AC	4.662E-01	
845	A0SPL/AC	5.338E-01	
846	A0BLD/AC	2.250E-02	
847	A0/AC	4.437E-01	
848	A0BYP/AC	2.601E-01	
849	A0ENG/AC	1.836E-01	
850			
851	Inlet Total Pressure Recoveries		
852			
853	PT2/PT0	9.456E-01	
854			
855	PTL/PT0	1.000E+00	
856	PT1/PTL	9.979E-01	
857	PTTH/PT1	1.000E+00	
858	PT2/PTTH	9.476E-01	
859			
860	PTx/PTy	1.000E+00	
861			
862	Inlet Drag Breakdown		
863			
864	AC (ft**2)	1.000E+00	
865			
866			
867			
868	spillage	CD	D (lbf)
869	bleed	1.680E-01	1.725E+02
870	bypass	1.884E-02	1.934E+01
871	cowl	1.168E-01	1.199E+02
872	total	7.750E-02	7.955E+01
873	reference	3.812E-01	3.912E+02
874	power setting	7.750E-02	7.955E+01
		3.037E-01	3.117E+02

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875 Engine Performance Data                               uninstalled installed
876
877 net thrust (lbf)                                     0.000E-01 -3.912E+02
878 SFC (lbm/hr/lbf)                                    0.000E-01 -0.000E-01
879 W2 (lbm/s)                                           0.000E-01 8.565E+00
880 corrected W2 (lbm/s)                                8.601E+00 8.601E+00
881
882 reference recovery                                   9.782E-01
883
884
885
886
887 &ipac
888   xmach0=1.2,figure=0,
889   theta=5,5.0,2.0,
890   xmth=0.550,
891   bypass=0.0,
892   &end
893 forebd: xmachx= 1.200E+00,xmach0= 1.200E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
894 *** error *** in program segment cd2d (errflg=2)
895 cd2d: xmach0= 1.200E+00, aoiac= 5.000E-01,xmach1=-1.000E+00,pt1pt0= 9.928E-01, cda= 2.102E-01,
896 ptrcv: xmach0= 1.200E+00, a0ac= 1.708E-01, xmns= 0.000E-01,pt2pt0= 9.538E-01,thetad= 2.204E+00,
897 xmth= 5.500E-01, athac= 2.096E-01,nishck=-1.000E+00,pthpt0= 9.928E-01,xlipth=-1.000E+00,
898 cd2d: xmach0= 1.200E+00, aoiac= 1.858E-01,xmach1= 2.614E-01,pt1pt0= 9.928E-01, cda= 7.740E-01,
899 cdwave: xmach0= 1.200E+00, cdwav= 1.251E-01,
900 clsuc: xmach0= 1.200E+00, aoiac= 1.858E-01, cls= 1.180E-01, cdspl= 6.560E-01,thetae= 5.412E+00,
901 *** error *** in program segment cdbld (errflg=2)
902 cdbld: xmach0= 1.200E+00, aoiac= 1.858E-01, bleed= 1.500E-02, cdbld= 1.131E-02,ptblpe= 1.001E+00,
903 : xmach0= 1.200E+00, aoiac= 1.858E-01, bleed= 1.500E-02, cdbld= 1.131E-02,
904 : xmach0= 1.200E+00, aoiac= 1.858E-01, cdtot= 6.673E-01, cdspl= 6.560E-01, cdref= 1.251E-01,
905 : xmach0= 1.200E+00,a0enac= 1.708E-01, w2C= 8.585E+00, w2= 8.975E+00,
906 : xmachx= 1.200E+00,a0enac= 1.708E-01,w2ceng= 8.601E+00,
907
908 IPAC 2-D Inlet Example Case
909
910 Flight Conditions
911
912 Mach number                                           1.200E+00
913
914 altitude (ft)                                         1.906E+04
915
916 ambient total
917
918 pressure (lbf/ft**2)                                  1.012E+03 2.453E+03
919 temperature (R)                                       4.507E+02 5.805E+02
920 dynamic pressure (lbf/ft**2)                          1.020E+03

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921	Vehicle Effects			
922			1.000E+00	
923			1.000E+00	
924	ML/M0		1.000E+00	
925	PTL/PT0			
926	AL/A0			
927				
928	Inlet Mass Flow Ratios			
929				
930	A0I/AC		1.858E-01	
931	A0SPL/AC		8.142E-01	
932	A0BLD/AC		1.500E-02	
933	A0/AC		1.708E-01	
934	A0BYP/AC		0.000E-01	
935	A0ENG/AC		1.708E-01	
936				
937	Inlet Total Pressure Recoveries			
938				
939	PT2/PT0		9.538E-01	
940				
941	PTL/PT0		1.000E+00	
942	PT1/PTL		9.928E-01	
943	PTTH/PT1		1.000E+00	
944	PT2/PTTH		9.608E-01	
945				
946	PTx/PTY		1.000E+00	
947				
948	Inlet Drag Breakdown			
949				
950	AC (ft**2)		1.000E+00	
951				
952				
953				
954	spillage		6.560E-01	6.689E+02
955	bleed		1.131E-02	1.153E+01
956	bypass		0.000E-01	0.000E-01
957	cowl		1.251E-01	1.275E+02
958	total		7.924E-01	8.079E+02
959	reference		1.251E-01	1.275E+02
960	power setting		6.673E-01	6.804E+02
961				
962	Engine Performance Data		uninstalled	installed
963				
964	net thrust (lbf)		0.000E-01	-8.079E+02
965	SFC (lbm/hr/lbf)		0.000E-01	-0.000E-01
966	W2 (lbm/s)		0.000E-01	8.975E+00

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967 corrected W2 (lbm/s) 8.601E+00 8.585E+00
968
969 reference recovery 9.915E-01
970
971
972 &ipac xmach0=1.0,figure=0, &end
973
974 forebd: xmachx= 1.000E+00,xmach0= 1.000E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
975 ptrcv: xmach0= 1.000E+00, a0ac= 1.670E-01, xmns= 0.000E-01,pt2pt0= 9.608E-01,thetad= 2.204E+00,
976 xpth= 5.500E-01, athac= 2.096E-01,nishck=-1.000E+00,pthpt0= 1.000E+00,xlipth=-1.000E+00,
977 cd2d: xmach0= 1.000E+00, a0iac= 1.745E-01,xmach1= 2.503E-01,ptlpt0= 1.000E+00, cda= 5.619E-01,
978 clsuc: xmach0= 1.000E+00, a0iac= 1.745E-01, cls= 8.218E-02, cdspl= 4.797E-01,thetae= 5.412E+00,
979 *** error *** in program segment cdbld (errflg=2)
980 cdbld: xmach0= 1.000E+00, a0iac= 1.745E-01, bleed= 7.500E-03, cdbld= 4.803E-03,ptblpe= 1.001E+00,
981 : xmach0= 1.000E+00, a0iac= 1.745E-01, bleed= 7.500E-03, cdbld= 4.803E-03,
982 : xmach0= 1.000E+00, a0iac= 1.745E-01, cdtot= 4.845E-01, cdspl= 4.797E-01, cdref= 0.000E-01,
983 : xmach0= 1.000E+00,a0enac= 1.670E-01, w2c= 8.585E+00, w2= 1.002E+01,
984 : xmachx= 1.000E+00,a0enac= 1.670E-01,w2ceng= 8.601E+00,
985
986
987
988 IPAC 2-D Inlet Example Case
989
990 Flight Conditions
991
992 Mach number 1.000E+00
993
994 altitude (ft) 1.040E+04
995
996 ambient total
997
998 pressure (lbf/ft**2) 1.433E+03 2.712E+03
999 temperature (R) 4.816E+02 5.779E+02
1000 dynamic pressure (lbf/ft**2) 1.003E+03
1001
1002 Vehicle Effects
1003
1004 ML/M0 1.000E+00
1005 PTL/PT0 1.000E+00
1006 AL/A0 1.000E+00
1007
1008 Inlet Mass Flow Ratios
1009
1010 A0I/AC 1.745E-01
1011 A0SPL/AC 8.255E-01
1012 A0BLD/AC 7.500E-03
1013 A0/AC 1.670E-01
1014 A0BYP/AC 0.000E-01

```

1013 A0ENG/AC 1.670E-01  
1014  
1015 Inlet Total Pressure Recoveries  
1016  
1017 PT2/PT0 9.608E-01  
1018  
1019 PTL/PT0 1.000E+00  
1020 PT1/PTL 1.000E+00  
1021 PTTH/PT1 1.000E+00  
1022 PT2/PTTH 9.608E-01  
1023  
1024 PTx/PTy 1.000E+00  
1025  
1026  
1027 Inlet Drag Breakdown  
1028 AC (ft\*\*2) 1.000E+00  
1029  
1030  
1031 CD D (lbf)  
1032 spillage 4.797E-01 4.811E+02  
1033 bleed 4.803E-03 4.818E+00  
1034 bypass 0.000E-01 0.000E-01  
1035 cowl 0.000E-01 0.000E-01  
1036 total 4.845E-01 4.859E+02  
1037 reference 0.000E-01 0.000E-01  
1038 power setting 4.845E-01 4.859E+02  
1039  
1040 Engine Performance Data  
1041  
1042 net thrust (lbf) 0.000E-01 -4.859E+02  
1043 SFC (lbm/hr/lbf) 0.000E-01 -0.000E-01  
1044 W2 (lbm/s) 0.000E-01 1.002E+01  
1045 corrected W2 (lbm/s) 8.601E+00 8.585E+00  
1046  
1047 reference recovery 1.000E+00  
1048  
1049  
1050 sipac xmach0=0.8,figure=0, send  
1051  
1052 forebd: xmachx= 8.000E-01,xmach0= 8.000E-01, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,  
1053 ptrcv: xmach0= 8.000E-01, a0ac= 1.734E-01, xmms= 0.000E-01,pt2pt0= 9.608E-01,thetad= 2.204E+00,  
1054 xmtH= 5.500E-01, athac= 2.096E-01,nishck=-1.000E+00,pthpt0= 1.000E+00,xlipth=-1.000E+00,  
1055 cd2d: xmach0= 8.000E-01, a0iac= 1.734E-01,xmach1= 2.331E-01,pt1pt0= 1.000E+00, cda= 4.913E-01,  
1056 clsuc: xmach0= 8.000E-01, a0iac= 1.734E-01, cls= 9.522E-02, cdspl= 3.961E-01,thetae= 5.412E+00,  
1057 \*\*\* error \*\*\* in program segment cdbld (errflg=2)  
1058 cdbld: xmach0= 8.000E-01, a0iac= 1.734E-01, bleed= 2.310E-09, cdbld= 1.109E-09, ptblpe= 1.001E+00,

1059 : xmach0= 8.000E-01, aoiac= 1.734E-01, bleed= 2.310E-09, cdbld= 1.109E-09, cdspl= 3.961E-01, cdref= 0.000E-01,  
 1060 : xmach0= 8.000E-01, aoiac= 1.734E-01, cdtot= 3.961E-01, cdspl= 3.961E-01, cdref= 0.000E-01,  
 1061 : xmach0= 8.000E-01, aoenac= 1.734E-01, w2c= 8.585E+00, w2= 1.184E+01,  
 1062 : xmachx= 8.000E-01, aoenac= 1.734E-01, w2ceng= 8.601E+00,

IPAC 2-D Inlet Example Case

Flight Conditions

Mach number 8.000E-01

altitude (ft) 0.000E-01

ambient total

pressure (lbf/ft\*\*2) 2.116E+03 3.226E+03

temperature (R) 5.187E+02 5.851E+02

dynamic pressure (lbf/ft\*\*2) 9.481E+02

Vehicle Effects

ML/M0 1.000E+00

PTL/PT0 1.000E+00

AL/A0 1.000E+00

Inlet Mass Flow Ratios

A0I/AC 1.734E-01

A0SPL/AC 8.266E-01

A0BLD/AC 2.310E-09

A0/AC 1.734E-01

A0BYP/AC 0.000E-01

A0ENG/AC 1.734E-01

Inlet Total Pressure Recoveries

PT2/PT0 9.608E-01

PTL/PT0 1.000E+00

PT1/PTL 1.000E+00

PTTH/PT1 1.000E+00

PT2/PTTH 9.608E-01

PTx/PTY 1.000E+00

Inlet Drag Breakdown

```

1105 AC (ft**2) 1.000E+00
1106
1107
1108 CD D (lbf)
1109
1110 spillage 3.961E-01 3.755E+02
1111 bleed 1.109E-09 1.052E-06
1112 bypass 0.000E-01 0.000E-01
1113 cowl 0.000E-01 0.000E-01
1114 total 3.961E-01 3.755E+02
1115 reference 0.000E-01 0.000E-01
1116 power setting 3.961E-01 3.755E+02
1117
1118 Engine Performance Data
1119
1120 net thrust (lbf) 0.000E-01 -3.755E+02
1121 SFC (lbm/hr/lbf) 0.000E-01 -0.000E-01
1122 W2 (lbm/s) 0.000E-01 1.184E+01
1123 corrected W2 (lbm/s) 8.601E+00 8.585E+00
1124
1125 reference recovery 1.000E+00
1126
1127
1128 &ipac xmach0=0.6,figure=0, &end
1129
1130 forebd: xmachx= 6.000E-01,xmach0= 6.000E-01, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
1131 ptrcv: xmach0= 6.000E-01, a0ac= 1.984E-01, xmns= 0.000E-01,pt2pt0= 9.608E-01,thetad= 2.204E+00,
1132 xpth= 5.500E-01, athac= 2.096E-01,nishck=-1.000E+00,pthpt0= 1.000E+00,xlipth=-1.000E+00,
1133 cd2d: xmach0= 6.000E-01, a0iac= 1.984E-01,xmach1= 2.331E-01,ptlpt0= 1.000E+00, cda= 3.932E-01,
1134 clsuc: xmach0= 6.000E-01, a0iac= 1.984E-01, cls= 7.733E-02, cdspl= 3.159E-01,thetae= 5.412E+00,
1135 : xmach0= 6.000E-01,a0enac= 1.984E-01, cdtot= 3.159E-01, cdspl= 3.159E-01, cdref= 0.000E-01,
1136 : xmach0= 6.000E-01,a0enac= 1.984E-01, w2c= 8.585E+00, w2= 1.017E+01,
1137 : xmachx= 6.000E-01,a0enac= 1.984E-01,w2ceng= 8.601E+00,
1138
1139 IPAC 2-D Inlet Example Case
1140
1141 Flight Conditions
1142
1143 Mach number 6.000E-01
1144
1145 altitude (ft) 0.000E-01
1146
1147 ambient total
1148
1149 pressure (lbf/ft**2) 2.116E+03 2.699E+03
1150 temperature (R) 5.187E+02 5.560E+02

```



1151	dynamic pressure (lbf/ft**2)	5.333E+02		
1152				
1153	Vehicle Effects			
1154	ML/M0	1.000E+00		
1155	PTL/PT0	1.000E+00		
1156	AL/A0	1.000E+00		
1157				
1158	Inlet Mass Flow Ratios			
1159				
1160	A0I/AC	1.984E-01		
1161	A0SPL/AC	8.016E-01		
1162	A0BLD/AC	0.000E-01		
1163	A0/AC	1.984E-01		
1164	A0BYP/AC	0.000E-01		
1165	A0ENG/AC	1.984E-01		
1166				
1167	Inlet Total Pressure Recoveries			
1168				
1169	PT2/PT0	9.608E-01		
1170				
1171	PTL/PT0	1.000E+00		
1172	PT1/PTL	1.000E+00		
1173	PTTH/PT1	1.000E+00		
1174	PT2/PTTH	9.608E-01		
1175				
1176	PTx/PTY	1.000E+00		
1177				
1178	Inlet Drag Breakdown			
1179				
1180	AC (ft**2)	1.000E+00		
1181				
1182				
1183				
1184				
1185	spillage	3.159E-01	1.685E+02	
1186	bleed	0.000E-01	0.000E-01	
1187	bypass	0.000E-01	0.000E-01	
1188	cowl	0.000E-01	0.000E-01	
1189	total	3.159E-01	1.685E+02	
1190	reference	0.000E-01	0.000E-01	
1191	power setting	3.159E-01	1.685E+02	
1192				
1193	Engine Performance Data	uninstalled	installed	
1194				
1195	net thrust (lbf)	0.000E-01	-1.685E+02	
1196	SFC (lbm/hr/lbf)	0.000E-01	-0.000E-01	

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1197      W2 (lbm/s)      0.000E-01  1.017E+01
1198      corrected W2 (lbm/s)  8.601E+00  8.585E+00
1199
1200      reference recovery  1.000E+00
1201
1202
1203      &ipac  xmach0=0.4,figure=0, &end
1204
1205      forebd: xmachx= 4.000E-01,xmach0= 4.000E-01, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
1206      ptrcv: xmach0= 4.000E-01, a0ac= 2.655E-01, xms= 0.000E-01,pt2pt0= 9.608E-01,thetad= 2.204E+00,
1207      xpth= 5.500E-01, athac= 2.096E-01,nishck=-1.000E+00,pthpt0= 1.000E+00,xlipth=-1.000E+00,
1208      cd2d: xmach0= 4.000E-01, a0iac= 2.655E-01,xmach1= 2.331E-01,ptlpt0= 1.000E+00, cda= 2.407E-01,
1209      clsuc: xmach0= 4.000E-01, a0iac= 2.655E-01, cls= 4.936E-02, cdspl1= 1.914E-01,thetae= 5.412E+00,
1210      : xmach0= 4.000E-01, a0iac= 2.655E-01, cdtot= 1.914E-01, cdspl1= 1.914E-01, cdref= 0.000E-01,
1211      : xmach0= 4.000E-01,a0enac= 2.655E-01, w2c= 8.585E+00, w2= 9.069E+00,
1212      : xmachx= 4.000E-01,a0enac= 2.655E-01,w2ceng= 8.601E+00,
1213
1214      IPAC  2-D Inlet Example Case
1215
1216      Flight Conditions
1217
1218      Mach number      4.000E-01
1219
1220      altitude (ft)    0.000E-01
1221
1222      ambient          total
1223
1224      pressure (lbf/ft**2)  2.116E+03  2.363E+03
1225      temperature (R)      5.187E+02  5.353E+02
1226      dynamic pressure (lbf/ft**2)  2.370E+02
1227
1228      Vehicle Effects
1229
1230      ML/M0            1.000E+00
1231      PTL/PT0          1.000E+00
1232      AL/A0            1.000E+00
1233
1234      Inlet Mass Flow Ratios
1235
1236      AOI/AC           2.655E-01
1237      AOSPL/AC         7.345E-01
1238      AOBLD/AC         0.000E-01
1239      AO/AC            2.655E-01
1240      AOBYP/AC         0.000E-01
1241      AOENG/AC         2.655E-01
1242

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```

1243 Inlet Total Pressure Recoveries
1244
1245 PT2/PT0 9.608E-01
1246
1247 PTL/PT0 1.000E+00
1248 PTL/PTL 1.000E+00
1249 PTH/PT1 1.000E+00
1250 PT2/PTTH 9.608E-01
1251
1252 PTx/PTy 1.000E+00
1253
1254 Inlet Drag Breakdown
1255 AC (ft**2) 1.000E+00
1256
1257 CD D (lbf)
1258
1259 spillage 1.914E-01 4.536E+01
1260 bleed 0.000E-01 0.000E-01
1261 bypass 0.000E-01 0.000E-01
1262 cowl 0.000E-01 0.000E-01
1263 total 1.914E-01 4.536E+01
1264 reference 0.000E-01 0.000E-01
1265 power setting 1.914E-01 4.536E+01
1266
1267 Engine Performance Data
1268
1269 net thrust (lbf) 0.000E-01 -4.536E+01
1270 SFC (lbm/hr/lbf) 0.000E-01 -0.000E-01
1271 W2 (lbm/s) 0.000E-01 9.069E+00
1272 corrected W2 (lbm/s) 8.601E+00 8.585E+00
1273
1274 reference recovery 1.000E+00
1275
1276
1277
1278 &ipac xmach0=0.2,figure=0, &end
1279
1280 forebd: xmachx= 2.000E-01,xmach0= 2.000E-01, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
1281 ptrcv: xmach0= 2.000E-01, a0ac= 4.945E-01, xms= 0.000E-01,pt2pt0= 9.601E-01,thetad= 2.204E+00,
1282 xnth= 5.500E-01, athac= 2.096E-01,nishck=-1.000E+00,pthpt0= 9.993E-01,xlipth=-1.000E+00,
1283 cd2d: xmach0= 2.000E-01, a0iac= 4.945E-01,xmach1= 2.329E-01,ptlpt0= 1.000E+00, cda= 0.000E-01,
1284 : xmach0= 2.000E-01, a0iac= 4.945E-01, cdtot= 0.000E-01, cdspl= 0.000E-01, cdref= 0.000E-01,
1285 : xmach0= 2.000E-01,a0enac= 4.945E-01, w2c= 8.585E+00, w2= 8.445E+00,
1286 : xmachx= 2.000E-01,a0enac= 4.945E-01,w2ceng= 8.601E+00,
1287
1288 IPAC 2-D Inlet Example Case

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1289	Flight Conditions			
1290				
1291	Mach number	2.000E-01		
1292				
1293	altitude (ft)	0.000E-01	ambient	total
1294				
1295	pressure (lbF/ft**2)	2.116E+03	2.116E+03	2.176E+03
1296	temperature (R)	5.187E+02	5.187E+02	5.228E+02
1297	dynamic pressure (lbF/ft**2)	5.925E+01	5.925E+01	
1298				
1299	Vehicle Effects			
1300				
1301	ML/M0	1.000E+00		
1302	PTL/PT0	1.000E+00		
1303	AL/A0	1.000E+00		
1304				
1305	Inlet Mass Flow Ratios			
1306				
1307	A0I/AC	4.945E-01		
1308	A0SPL/AC	5.055E-01		
1309	A0BLD/AC	0.000E-01		
1310	A0/AC	4.945E-01		
1311	A0BYP/AC	0.000E-01		
1312	A0ENG/AC	4.945E-01		
1313				
1314	Inlet Total Pressure Recoveries			
1315				
1316				
1317	PT2/PT0	9.601E-01		
1318				
1319	PTL/PT0	1.000E+00		
1320	PT1/PTL	1.000E+00		
1321	PTTH/PT1	9.993E-01		
1322	PT2/PTTH	9.608E-01		
1323				
1324	PTx/PTY	1.000E+00		
1325				
1326				
1327				
1328	Inlet Drag Breakdown			
1329				
1330	AC (ft**2)	1.000E+00		
1331			CD	D (lbF)
1332				
1333	spillage	0.000E-01	0.000E-01	0.000E-01
1334				

```

1335      bleed      0.000E-01  0.000E-01
1336      bypass     0.000E-01  0.000E-01
1337      cowl       0.000E-01  0.000E-01
1338      total      0.000E-01  0.000E-01
1339      reference  0.000E-01  0.000E-01
1340      power setting 0.000E-01  0.000E-01
1341
1342      Engine Performance Data      0.000E-01  0.000E-01
1343      net thrust (lbf)             0.000E-01  0.000E-01
1344      SFC (lbm/hr/lbf)             0.000E-01  0.000E-01
1345      W2 (lbm/s)                   0.000E-01  8.445E+00
1346      corrected W2 (lbm/s)         8.601E+00  8.585E+00
1347
1348      reference recovery             1.000E+00
1349
1350      &ipac  xmach0=0.01,figure=0, &end
1351
1352      forebd:  xmachx= 1.000E-02,xmach0= 1.000E-02, xmlm0= 1.000E+00,ptlpt0= 1.000E+00, ala0= 1.000E+00,
1353      ptrcv:  xmach0= 1.000E-02, a0ac= 9.355E+00, xmns= 0.000E-01,pt2pt0= 9.300E-01,thetad= 2.204E+00,
1354      xmth= 5.500E-01, athac= 2.096E-01,nishck=-1.000E+00,pthpt0= 9.680E-01,xlipth=-1.000E+00,
1355      :  xmach0= 1.000E-02, a0iac= 9.355E+00, cda= 0.000E-01,
1356      :  xmach0= 1.000E-02, a0iac= 9.355E+00, cdtot= 0.000E-01, cdspl= 0.000E-01, cdref= 0.000E-01,
1357      :  xmach0= 1.000E-02,a0enac= 9.355E+00, w2C= 8.585E+00, w2= 7.988E+00,
1358      :  xmachx= 1.000E-02,a0enac= 9.355E+00,w2ceng= 8.601E+00,
1359
1360      IPAC  2-D Inlet Example Case
1361
1362      Flight Conditions
1363      Mach number             1.000E-02
1364      altitude (ft)          0.000E-01
1365
1366      ambient                total
1367      pressure (lbf/ft**2)    2.116E+03  2.116E+03
1368      temperature (R)         5.187E+02  5.187E+02
1369      dynamic pressure (lbf/ft**2) 1.481E-01
1370
1371      Vehicle Effects
1372      ML/MO                   1.000E+00
1373      PTL/PTO                 1.000E+00
1374      AL/AO                   1.000E+00
1375
1376
1377
1378
1379
1380

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1381					
1382	Inlet Mass Flow Ratios				
1383					
1384	A0I/AC	9.355E+00			
1385	A0SPL/AC	-8.355E+00			
1386	A0BLD/AC	0.000E-01			
1387	A0/AC	9.355E+00			
1388	A0BYP/AC	0.000E-01			
1389	A0ENG/AC	9.355E+00			
1390					
1391	Inlet Total Pressure Recoveries				
1392					
1393	PT2/PT0	9.300E-01			
1394					
1395	PTL/PT0	1.000E+00			
1396	PT1/PTL	1.000E+00			
1397	PTTH/PT1	9.680E-01			
1398	PT2/PTTH	9.608E-01			
1399					
1400	PTx/PTy	1.000E+00			
1401					
1402	Inlet Drag Breakdown				
1403					
1404	AC (ft**2)	1.000E+00			
1405					
1406			CD	D (lbf)	
1407					
1408	spillage	0.000E-01	0.000E-01	0.000E-01	
1409	bleed	0.000E-01	0.000E-01	0.000E-01	
1410	bypass	0.000E-01	0.000E-01	0.000E-01	
1411	cowl	0.000E-01	0.000E-01	0.000E-01	
1412	total	0.000E-01	0.000E-01	0.000E-01	
1413	reference	0.000E-01	0.000E-01	0.000E-01	
1414	power setting	0.000E-01	0.000E-01	0.000E-01	
1415					
1416	Engine Performance Data		uninstalled	installed	
1417					
1418	net thrust (lbf)	0.000E-01	0.000E-01	0.000E-01	
1419	SFC (lbm/hr/lbf)	0.000E-01	0.000E-01	0.000E-01	
1420	W2 (lbm/s)	0.000E-01	0.000E-01	7.988E+00	
1421	corrected W2 (lbm/s)	8.601E+00	8.601E+00	8.585E+00	
1422					
1423	reference recovery	1.000E+00			
1424					
1425					



# REPORT DOCUMENTATION PAGE

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<b>13. ABSTRACT</b> ( <i>Maximum 200 words</i> )  A series of analyses have been developed which permit the calculation of the performance of common inlet designs. The methods presented are useful for determining the inlet weight flows, total pressure recovery, and aerodynamic drag coefficients for given inlet geometric designs. Limited geometric input data is required to use this inlet performance prediction methodology. The analyses presented here may also be used to perform inlet preliminary design studies. The calculated inlet performance parameters may be used in subsequent engine cycle analyses or installed engine performance calculations for existing uninstalled engine data.			
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