NASA CR-112173

DESIGN OF A MINIATURE HYDROGEN FUELED GAS TURBINE ENGINE

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2 February 1973

Prepared under NASA Contract No. NAS1-9752 by

TECH DEVELOPMENT, INC.
Dayton, Ohio

for Langley Research Center

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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SUMMARY

This report covers the completed work performed on NASA Contract No. NAS1-9752 dated February 19, 1970 up to September 20, 1971, on the design, development and delivery of a miniature hydrogen-fueled gas turbine engine. The engine was to be sized to approximate a scaled-down lift engine such as the Teledyne CAE Model 376. As a result, the engine design emerged as a 445N-(100 lb.)-thrust engine flowing 0.86 kg (1.9 lbs.) air/sec. A 4-stage compressor was designed at a 4.0 to 1 pressure ratio for the above conditions. The compressor tip diameter was 9.14 cm (3.60 in.). To improve overall engine performance another compressor with a 4.75 to 1 pressure ratio at the same tip diameter was designed. A matching turbine for each compressor was also designed. The turbine tip diameter was 10.16 cm (4.0 in.). A combustion chamber was designed, built, and tested for this engine. A preliminary design of the mechanical rotating parts also was completed and is discussed in this report. Three exhaust nozzle designs are presented.

INTRODUCTION

Evaluation of a propulsion system on an aircraft is a difficult and expensive task. Scaled-down propulsion simulators have proven to be extremely useful in obtaining aerodynamic interacting characteristics of the aircraft and its engines. The present simulation techniques require the use of externally supplied high pressure air or nitrogen to power either turbine driven compressors simulating fan jet engines, or ejector powered jet engine simulators. These flow simulators fail to simulate both inlet and exit conditions at the same time. A scaled-down gas turbine could do this. Development of scaled-down gas turbine engines has been limited by the inability to proportion the combustion section to the small scale required. The design of the engine described in this report is based on the use of hydrogen as a fuel, a fuel which has a burning rate fast enough to allow small scaled-down combustion systems, which are proportional to the compressor and turbine and the overall length. This report follows an earlier report (ref. 1) describing the development of a small annular hydrogen-fueled combustor.

The present report covers the design of a gas turbine engine with a 9.14 cm-(3.60 in.)-compressor diameter and a turbine diameter of 10.16 cm (4.00 in.). The overall length is 17.46 cm (6.875 in.). (See fig. 1)

The aerodynamics are completely defined for both the compressor and turbine. The results of the burner development and the preliminary mechanical design of the rotating parts are presented herein.

SYMBOLS

a	distance of maximum camber point from leading edge of blade section mean line measured along chord line, cm (in.)
A	blade cross section area, cm^2 ($in.^2$)
AR	aspect ratio (defined in table 1)
A_z	local blade-to-blade stream tube passage area measured in a plane normal to the axial direction, cm^2 ($in.^2$)
b	axial distance between inlet and outlet calculation planes for a blade row, cm (in.) (see fig. 4 and table 1)
c	blade section chord length, cm (in.)
C_D	nozzle discharge coefficient; (actual mass flow)/(ideal mass flow for corresponding nozzle pressure ratio)

C_p	specific heat at constant pressure, Joules/kg°C (Btu/lb°F)
C_T	nozzle thrust coeffieient; (actual thrust for actual mass flow)/(ideal thrust for the same mass flow)
dn	product of bearing bore diameter in millimeters and rpm
d_o	blade throat dimension, cm (in.)
D	diffusion parameter (see equations 1 and 2)
f	natural frequency, hertz
g	gravitational acceleration, 981 cm/sec^2 (32.2 ft/sec^2)
G	modulus of rigidity, kg/cm^2 (lb/in.^{2})
Δh	total enthalpy drop, Joules/kg (Btu/lb)
ΔH	lower heating valve of hydrogen (H_2); 1.1993 x 10^{8}Joules/kg (51,574 Btu/lb)
i	incidence angle, angle between entrance relative flow direction and tangent to blade section mean line at leading edge center, degrees
i_{ss}	suction surface incidence angle, angle between entrance relative flow direction and tangent to blade section suction surface at leading edge, degrees
I_p	polar moment of inertia about the torsion center taken to coincide with the point of maximum thickness along the blade chord, cm^4 (in.^{4})
J	conversion factor, 1.00m N/Joule 778.16 ft lb/Btu
L	blade length, cm (in.)
m	mass, kg (lb)
m_c	empirical factor in deviation angle prediction, equations 7 and 8
n	rotational speed, rpm
N	number of blades in rotor or stator row
P	unit pressure, N/cm^2 (lb/in.^{2})
ΔP	unit pressure differential across orifice plate; also pressure drop across combustor, N/cm^2 (lb/in.^{2})

r	radius measured from compressor rotational axis, cm (in.)
R	velocity relative to turbine bucket, m/sec (ft/sec)
R_X	reaction (fraction of stage ideal enthalpy drop occurring across the turbine rotor)
s_{br}	material unit stress at blade root, kg/cm^2 (lb/in.^{2})
S	blade spacing, cm (in.)
t	blade thickness, cm (in.)
ΔT	temperature differential across burner, °C(°F)
ΔTVR	temperature ratio defined by equation 24
U	pitch wheel speed, m/sec (ft/sec)
V	velocity, m/sec (ft/sec)
w	blade weight, kg (lb)
W	axial projection of blade chord, cm (in.)
W_a	air flow, kg/sec (lb/sec)
W_{ea}	excess air flow, kg/sec (lb/sec)
W_f	fuel flow, kg/sec (lb/sec)
x	chordwise coordinate of blade, cm (in.)
$y_{c.g.}$	distance from axis of rotation to blade center of gravity, cm (in.)
z	blade length coordinate, cm (in.)
Z	Zweifel number defined by equations 26 and 27
α	nozzle leaving air angle measured from tangential, degrees
α_L'	rate of blade twist, deg/cm (deg/in.)
β	meridional plane flow direction angle measured from axial direction, degrees
β_1	bucket relative air angle measured from tangential, degrees
ϕ	turning angle, degrees

ε angle between meridional component of velocity and axial direction, degrees (angles outward from axial direction are positive)

η_c combustion efficiency

$\bar{\omega}_{ps}$ circumferentially-averaged total-pressure loss coefficient due to profile and secondary losses

$\bar{\omega}_{sh}$ circumferentially-averaged total-pressure loss coefficient due to shock wave losses

$\bar{\omega}_t$ combined circumferentially-averaged total-pressure loss coefficient

ρ gas mass per unit volume, kg/m^3 (lb/ft^3); also used for material density in equation 13, kg/cm^3 ($lb/in.^3$)

γ specific heat ratio

θ angular displacement, degrees

σ solidity, ratio of blade section chord length to spacing between blades at trailing edge

T blade setting angle, angle between blade section chord line and axial direction, degrees

δ deviation angle, angle between blade section chord line and axial direction, degrees

Subscripts

a air

adj adjustment

avg average

b bending

br blade root

c.g. center of gravity

ea excess air

f fuel

h hub

in	blade row inlet calculation station
is	isentropic corresponding to stage total-to-static pressure ratio
m	meridional plane
o	blade tip
out	blade row outlet calculation station
ps	profile and secondary
R	rotor
s	static
sh	shock
ss	supersonic; also used for suction surface
S	stator
t	tip
T	total
TB	total at bucket
θ	circumferential
1	nozzle entrance station
2	nozzle exit station
3	bucket entrance station
4	bucket exit station

Superscripts

*	critical (condition associated with Mach number = 1.0)
'	relative to rotating blade row

DISCUSSION

The miniature jet engine design shown in figure 1 has been derived using a computer program to explore the effect on performance of independent variation of system parameters. The analysis indicates that by using a 5-stage compressor an engine with an overall length of 17.46 cm (6.875 in.) and a diameter of 11.43 cm (4.50 in.) can be designed to produce 511N (115 lbs) of thrust at 77,986 rpm. The design considerations explored for the compressor, combustor, and turbine components of the engine are discussed in the following subsections.

BEARING SYSTEM

The bearings selected for this engine were 12-mm bore by 28-mm outside diameter angular contact outer race, AISI 440C stainless steel races with bronze retainers. The design speed of 78,000 rpm resulted in a dn of 936000. The term dn refers to the bore diameter in millimeters times the rotational speed in rpm, a measure of inner race velocity. The overspeed required for 311°K (100°F) wind tunnel operation was 81,000 rpm which results in a dn of 97200. Angular bearings are limited to a dn about 1,500,000 (ref. 2). The axial load on the shaft thrust bearing will have to be limited to about 133N (30 lbs) to obtain 100 hours of bearing life. Bearing axial load can be controlled by proper location of compressor and turbine interstage seals. A study of bearing thrust at intermediate speeds has not yet been made.

DRIVE SHAFT DYNAMIC ANALYSIS

The complete drive shaft and bearings have been analyzed for forced response and critical speeds. The first attempt in the design was to create a shaft system which would always run below its first critical speed. Due to the requirements of the engine design it became impossible to design a shaft with a critical speed above the design speed of 81,000 rpm.

The shaft as shown in figure 1 was input to a critical speed computer program (ref. 3) with no bearing spring mounts. For this case 875,500 N/cm (500,000 lbs/in.) radial bearing spring rate was used in the computer program. The results of this calculation are plotted in figure 2. As can be seen, the shaft runs through several resonance points and critical speeds. The overall requirements of the engine design did not allow much room to change the shaft geometry, therefore it was decided to create a soft shaft mounting system which would allow the shaft to pass through the system critical speed at a low rpm. The energy level of a shaft of this small size would not cause serious problems at a low shaft speed. Therefore the effective bearing spring rate was changed to 17,510 N/cm (10,000 lbs/in.) by mounting the bearings in radial springs. The resonance and critical speeds came down well below the running range of the engine. (See fig. 2). It is expected that the engine will never operate in the 20,000 rpm range, but only pass through on start up and shut down.

ROTOR TEMPERATURES

The calculated temperature distribution in the rotating components was determined with the use of a computer program based on reference 4. The program computes steady-state temperatures in axisymmetric volume elements or nodes. These nodes need not be equal in cross section. The program will take into account contact resistance at the interface between nodes and will also account for material properties that vary from node to node.

Gas temperatures from the cycle analysis were used for the boundary condition temperatures at the design point conditions. The results of the program showing temperatures throughout the rotating system are shown in figure 3.

COMPRESSOR AERODYNAMIC DESIGN

Aerodynamic design of the compressor for the miniature gas turbine engine was based on a somewhat more flexible set of initial conditions than those found in a typical axial-flow compressor design problem. The following subsections review specific requirements encountered in this unusual application, identify the design methods used, describe the design process in some detail and evaluate the recommended configuration. The entire section may be useful in pointing out future small-scale turbomachinery research and development requirements.

Design Point Operating Conditions

During the preliminary phase of the design study supported by NASA Contract NAS 1-9752, a number of important compressor design point operating parameters were not firmly specified. This permitted a significant amount of freedom in investigation of the relationship between aerodynamic, aeromechanical, and manufacturing limits. The following recommended overall configuration and operating parameters are considered to represent a good compromise based on these limits and upon recognition that some experimental data needed to support compressor design in the size range required in this program are not available.

Working fluid	Air
Compressor inlet total pressure	10.131 N/cm^2 (14.696 lbs/in^2)
Compressor inlet total temperature	2.88°K (518.7°R)
Flow rate	8.864 kg/sec (1.905 lbm/sec)
Rotational speed	77,986 rpm
Overall total/total ambient pressure ratio	4.66
Overall total/total ambient adiabatic efficiency (estimated)	0.853
Number of stages	5
Rotor tip diameter (constant throughout)	9.14 cm (3.60 in.)
First rotor inlet hub-to-tip diameter ratio	0.586
Rotor tip speed	373.4 m/sec (1225 ft/sec)
Compressor unit axial length	7.98 cm (3.14 in.)

A 4-stage compressor configuration was also studied. The design of this alternative compressor was continued through the definition of a satisfactory aerodynamic configuration. No detailed meridional plane computations were made and no blading was defined. The "Configuration Selection" subsection discusses the evaluation of the 4-stage alternative and the basis for the eventual decision to recommend a 5-stage axial-flow compressor.

General Design System Considerations

Aerodynamic design of an axial-flow compressor unit ordinarily includes four phases. The first phase involves consideration of design parameter choices which affect the overall dimensions and required rotational speed of the unit. In this preliminary design phase, quantities such as average axial inlet Mach number, hub-to-tip diameter ratio, and approximate blade row aerodynamic loading are varied in order to attain acceptable values for overall unit geometry. Consideration of a reasonable number of combinations of input variables in such a study requires a computer-based evaluation method. For the current design, all configuration selection studies were made using a computer program developed for NASA and described in references 5 and 6. Minor program alterations were necessary to adapt the program to the IBM 360/65 computing system used. This phase of the study is described in the "Configuration Selection" subsection.

In the compressor design process second phase, the meridional plane velocity and property distributions are determined at selected stations in the compressor unit. Principal calculation stations in the present design were located in the axial gaps between blade rows. (See fig. 4.) Inner and outer casing boundary coordinates were specified and the radial equilibrium condition was used in an iterative process with the continuity requirement (conservation of mass) to calculate radial distributions at each calculation station. A detailed description of the assumed flow model and of program input parameter selection is contained in the "Determination of Meridional Plane Velocity and Property Distributions" subsection. A second computer program developed for NASA and reported in reference 7 was used. Program alterations were made to adapt the program to the IBM 360/65 system and to provide added output information for blade selection.

In the third phase of compressor design, appropriate blade section geometries are selected for all blade rows. This procedure requires an inner iteration in which useable combinations of blade section geometric variables (for example, the location and numerical value of blade maximum thickness and the blade camber line shape) and setting angle are determined for estimated section incidence and deviation angle values on several approximate conical stream surfaces for each blade row. The inner iteration is combined with an outer iteration involving the meridional plane calculation program to select for each stream surface a single set of section geometric variables with acceptable estimated losses and blade passage area distributions. The accepted blade sections for each row are then stacked with respect to a designated axis to form a final blade geometry and coordinate values are determined for manufacturing purposes. The primary computer program utilized in the blade specification process was reported in reference 8 with local modifications again required. This phase of the design is the subject of the "Determination of Blade Section and Row Geometries" subsection.

A fourth design step would include prediction of the compressor unit performance for a range of flow rates and engine rotational speeds. No performance map estimates were made during this investigation.

Configuration Selection

This subsection summarizes the analysis of alternate compressor unit options. Alternatives based on four stages were considered first, but design review led to the final selection of a 5-stage compressor. Much of the basic reasoning leading to definition of the configuration is common to both the 4- and 5-stage versions; the selection process is reviewed in a chronological order.

The primary design requirement for the miniature gas turbine engine compressor, differentiating the current design problem from that for typical multistage axial-flow compressors, was the compressor-tip diameter. From the initiation of the study, this value was limited to a maximum of 9.14 cm (3.60 in.). Manufacturing and assembly considerations suggested a constant tip diameter throughout the bladed section of the compressor flow passage. Because of these conditions, a number of secondary design problems existed. These included unanswered aerodynamic questions such as: the possible effects of low Reynolds numbers on component performance, and mechanical or fabrication aspects, such as an inability to utilize desired blade thickness/chord ratios and leading and trailing edge dimensions. These considerations are discussed in presenting the recommended design.

In addition to the fixed compressor rotor tip diameter of 9.14 cm (3.60 in.), the initially proposed engine geometry and cycle specifications prepared for the NAS1-9752 program included a design point flow rate of 0.848 kg/sec (1.87 lbm/sec) at NASA standard sea level inlet conditions and an overall compressor total pressure ratio of 4.0. An allowable compressor bladed passage axial length (from the first rotor leading edge to the trailing edge of the last stator) of approximately 5.8 cm (2.3 in.) was indicated.

As a first step in configuration selection, a 4-stage axial-flow compressor was studied. The resulting requirement for a mean stage pressure ratio greater than 1.4 suggested that supersonic rotor relative Mach numbers would be necessary at some radial locations in some or all of the stages. From both aerodynamic and manufacturing points of view, it appeared that inlet guide vanes would not be desirable; they were, therefore, not considered as a design alternative. Under these conditions, it was realized that to achieve the desired stage pressure ratio levels without exceeding blade element aerodynamic loading limits, the highest feasible rotational speeds should be used. At the same time, bearing selection and shaft design criteria indicated that this rotational speed should not exceed about 85,000 rpm. As a result, all 4-stage configuration selection trials used a rotor tip speed of 396 m/sec (1300 ft/sec) corresponding to 82,760 rpm.

To obtain levels of rotor relative Mach number consistent with the required mean stage pressure ratios, the first row inlet axial Mach number component was maintained at an average level of about 0.6 for all configuration selection studies. For the axial inlet flows assumed, this produced mechanically acceptable hub-to-tip diameter ratios and a range of rotor relative inlet flow angles along the span that was appropriate to the operating requirements of the compressor unit. Each stator in the compressor was assumed in initial trials to return the flow to the axial direction for all radii at the inlet to the following stage. Because no apparent aerodynamic limitations resulted from this assumption, this condition was retained in all configuration trials and for the subsequent meridional plane distribution calculations.

To reach even the most preliminary conclusions regarding configuration acceptability, it is necessary to assume approximate values for individual blade row geometric parameters such as chord length, aspect ratio, number of blades and solidity. Tentative values were selected on the basis of experience, and in the case of the present design, were affected by the unique requirements deriving from small size. Table 1 shows the values used in the 4-stage configuration that was considered most satisfactory. Although higher blade row aspect ratios were investigated, it was decided that the maximum first rotor row aspect ratio should not substantially exceed 2.0 if a requirement for part-span vibration damping devices was to be avoided. Lower aspect ratios were also favored to give the maximum appropriate blade chord lengths (limited by proposed overall compressor unit length), so that fabrication would be feasible, Reynolds number values would be increased and adequate stall-free compressor operating range would be attained. The chord length for the first rotor was set at 0.76 cm (0.30 in.) to obtain the approximate desired aspect ratio level. All other blade row chord lengths were set at 0.64 cm (0.25 in.). This combination of choices led to acceptable overall unit lengths after allowance for a reasonable axial gap between rows.

In reference 9 Benser summarizes NASA data relative to solidity effects on transonic rotor performance and presents a tentative analysis and conclusions on the solidity choice problem. In the present study, the number of blades selected for each row was based on maintenance of a reasonable solidity level in each row with some consideration given to choice of numbers that would not create a pattern of wakes likely to force blade vibration in the following rows. For the rotor rows, solidities were set somewhat higher than in the stators because of higher relative Mach number levels at the tip sections.

In the configuration selection program used, a primary independent variable is the level of blade element aerodynamic loading. The criterion used is the Lieblein diffusion parameter D described in references 10 and 11. Maximum permissible values are assigned for the rotor tip and the stator hub; attainable stage performance is estimated for velocity distributions which do not exceed these values. Closely related to the aerodynamic loading criterion in estimating attainable stage performance is the pattern of axial velocity variation through the individual blade rows in the compressor. When inlet axial velocity components are high as in the present design, a factor in specification of axial velocity ratios is the need to reach an acceptable level of velocity entering the combustion section of the engine. In all configuration studies described here, the axial velocity ratios were established so as to effect a reduction in each stage. The resulting compressor exit values of axial velocity were on the order of 167.6 m/sec (550 ft/sec) ($M \approx 0.40$)

Analysis of possible 4-stage compressor configurations showed that an acceptable unit could be designed for an overall total pressure ratio of about 4.75. The design called for mixed supersonic and subsonic relative velocities along the span of all rotors (transonic stages). A complete list of the independent input variables used for the candidate 4-stage compressor alternative is given in appendix A. Corresponding overall operating and performance parameters for the 4-stage compressor are summarized below:

Working fluid	Air
Compressor inlet total pressure	10.131 N/cm^2 (14.696 lbs/in.^{2})
Compressor inlet total temperature	288.2°K (518.7°R)
Flow rate	0.85 kg/sec (1.87 lbm/sec)
Rotational speed	82,760 rpm
Overall total/total pressure ratio	4.75 (approximate)
Number of stages	4

Table continued on next page.

Rotor tip diameter (constant through unit)	9.14 cm (3.60 in.)
First rotor inlet hub-to-tip diameter ratio	0.591
Rotor tip speed	396 m/sec (1300 ft/sec)
Compressor unit axial length	6.12 cm (2.41 in.)

Parallel studies of the complete engine cycle indicated that the possible increase in design point compressor total pressure ratio from 4.0 to 4.75 would materially aid in achievement of desired engine thrust. It was, therefore, decided to base subsequent configuration studies on this increased pressure ratio. An important factor in evaluating this change should be clearly understood. The configuration selection program uses as input estimated values of rotor and stage efficiency which are believed to be consistent with the other characteristics of the stages under evaluation. Because these efficiencies are estimates and because they affect the calculated pressure ratios, it is incorrect to place any great emphasis on predicted overall efficiency or pressure ratio from the configuration selection program. It will be shown in later subsections that where more realistic evaluation is made of spanwise and stage wise variations in blade section losses, the design point performance calculated does not match these preliminary values.

As mentioned earlier, design reviews of the proposed engine and compressor led to a decision to consider a second compressor configuration alternative. Principal specification changes were a reduced rotational speed and addition of a fifth stage while maintaining a unit overall total pressure ratio on the order of 4.75. Contributing to the decision were advantages which could be realized through lowered compressor and turbine blade stresses and reduced compressor aerodynamic blade loading.

Approximate 5-stage blade row geometric parameters are given in table 1 for comparison with those used in the 4-stage alternative. Appendix A also includes 5-stage independent input variables. It may be noted that values for numerous design variables and limits are common to both 4- and 5-stage compressors. The basis for selection of the variables has been discussed above. The indicated overall operating and performance parameters for the 5-stage compressor are:

Working fluid	Air
Compressor inlet total pressure	10.131 N/cm^2 (14.696 lbs/in.^{2})
Compressor inlet total temperature	288.2°K (518.7°R)
Flow rate	0.863 kg/sec (1.903 lbm/sec)
Rotational speed	77,986 rpm
Overall total/total pressure ratio	4.75 (approximate)
Number of stages	5
Rotor tip diameter (constant through unit)	9.14 cm (3.60 in.)
First rotor inlet hub-to-tip diameter ratio	0.591
Rotor tip speed	373.4 m/sec (1225 ft/sec)
Compressor unit axial length	7.98 cm (3.14 in.)

It should be noted that these values are from the configuration selection program and are not the recommended final compressor design point parameters. The latter are based on the meridional plane program solution and are given in the "Design Point Operating Conditions" subsection. The flow rate increase from the value given previously for the 4-stage compressor resulted from NASA inlet shape analysis described under the "Definition of Compressor Flow Passage Shape" subsection.

An important output of the configuration selection program is dimensional information which permits the determination of a tentative compressor unit meridional plane flow passage. This is essential input to the meridional plane program described in the following section.

Determination of Meridional Plane Velocity and Property Distributions

Computation of design point meridional plane velocity and property distributions was based on a flow model in common current use for design and analysis of axial-flow compressors for aircraft propulsion systems. Background for the model was established in reference 10; a computer program based on application of the model to compressor design is described in reference 7. The model assumes steady, axisymmetric and compressible perfect gas flow along stream surfaces which are traceable through the compressor by computation of stream surface location in designated radial planes. In the computer program of reference 7 the designated radial planes must be located in the axial gaps between blade rows and in the annular passage upstream and downstream from the compressor. Only one calculation plane is permitted in each inter-row axial gap. Figure 4 shows a meridional plane cross-section of the recommended 5-stage compressor configuration flow path and serves as a reference for the location and identification of calculation planes. Although figure 4 was drawn to approximate scale, blade section projections were somewhat distorted.

At each calculation plane, an iterative process using the radial equilibrium equation and the mass-flow continuity condition is the basis for computation of radial distributions of velocities and properties. The radial equilibrium calculation accounts for the effects of stream surface slope and curvature by fitting an approximate curve to computed stream surface locations during the iterative solution process. Cumulative effects of upstream shock losses and combined profile and secondary losses are included in the computation process at each calculation plane.* An approximate additional allowance for end-wall (hub and tip) boundary layers is also included by incorporating effective area or blockage factors in the mass-flow continuity calculations. Specific program utilization and input requirements are discussed in the following subsections.

<u>Definition of compressor flow passage shape.</u>-The meridional plane computer program requires input of flow passage coordinates for five calculation planes located upstream from the first rotor, for one calculation plane in each of the axial gaps between adjacent blade rows and for one station at the exit of the final stator row. In addition, passage area ratios are required for three calculation planes in the annular passage downstream from the bladed section of the compressor unit.

Coordinates for the bladed section of the flow passage were based on values computed during the configuration selection phase

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*The computer program fits an approximate distribution curve to estimated profile and secondary loss parameter values for only three radial locations in each calculation plane. These locations are at 10, 50 and 90 per cent of the actual passage height from the hub. Utilization of the limited number of defining stations reduces the validity of the solution, especially in the end-wall regions.

of the design process. The computer program for configuration selection determines axial distances between calculation planes and corresponding radius values for hub and tip casing coordinates. The reference plane for axial coordinates was the entrance calculation plane for the first rotor blade row. This plane is approximately 0.140 cm (0.055 in.) upstream from the intersection of the leading edge with the hub contour without allowance for a blade root fillet. The axial locations of the remaining calculation planes in the bladed section of the compressor were calculated in the configuration selection program from specified blade row aspect ratios as defined in table 1. The actual location of each blade row with respect to its upstream calculation plane was fixed in the specification process by location of the stacking axis for blade sections. This is discussed in the "Determination of Blade Section and Row Geometries" subsection.

An inlet passage geometry representative of VTOL engine applications was proposed by NASA. NASA's Lewis Research Center staff supplied suggested inlet coordinates and estimated compressor first blade row inlet velocity and property distributions. Appendix B includes tabulated values from the NASA calculations.

One important result of the NASA inlet study was a revised compressor design point flow rate. The original passage coordinates to which the NASA inlet was scaled were based on configuration selection program runs using equal mass-flow blockage factors of 0.99 at hub and tip with a radially constant first rotor inlet veloctiy of 197 m/sec (646 ft/sec). NASA experience suggested that for a rapidly convergent inlet the effective total first blade row inlet blockage factor would be greater than 0.995. It was, therefore, decided to maintain the compressor bladed section coordinates and to use zero blockage for the compressor inlet calculations. For approximately the same mean radius flow conditions in the upstream annulus, this led to a compressor unit flow rate of 0.864 kg/sec (1.905 lbm/sec). This value is basic to the plots of appendix B and to all the calculations reported in the following sections.

Flow passage coordinates were obtained from 4x-scale plot of outer wall casing (shroud) and inner wall (hub) radii against axial position. Plotted values were obtained from NASA inlet section recommendations as in appendix B, from the configuration selection computations for the bladed passage, and from layouts of the transition between the compressor discharge and the combustion section of the engine. Values were read from curves faired through the plotted values and are given in table 2, for the recommended 5-stage configuration. Note that the values do not agree with values tabulated for the first two stations as input to the meridional plane computer program. This is a result of a program requirement that stream surface slope should be 0° at the first and last calculation plane. Note also that two sets of values are given. The first set was read from the flow passage plot and used as meridional plane program input for several design iterations. It became apparent (through computation of $A_z/A_z{}^*$ ratios as described in the "Determination of Blade Section and Row Geometries" section) that unacceptable blade-to blade passage areas were likely to result from this initial flow path contour. Therefore, the hub contour through the first two stages of the compressor was modified as shown in the right-hand column of table 2 so that generally lower axial velocity component levels would be obtained in the flow passages.

Computation of calculation plane velocity distributions.- Organization of the meridional plane program is such that values of blade row aerodynamic limits are independent input variables. Stage and overall total pressure ratios are dependent output values. The magnitude of losses varies with the local velocity distributions determined in the meridional plane program as well as with blade geometry-related variables which come from the blade selection phase of design. Achievement of an acceptable meridional plane solution for the desired overall total pressure ratio is, therefore, a complex process involving iterative use of both meridional plane and blade selection programs and procedures.

In this design study, a total of 12 iterations in the meridional program solution were needed to establish a recommended configuration. In these iterations, the flow passage coordinates were varied only once as indicated in table 2 and a number of other input quantities were held constant. The principal controlled variable was the pattern of rotor tip aerodynamic blade loading distribution through the five stages. The limit used was the diffusion parameter D originally derived for two-dimensional, low-speed plane cascade flows by Lieblein in reference 11. Because the parameter has been utilized in numerous investigations as a design limit and data correlation parameter for annular cascade flows with both stationary and rotating blade rows, several variant-defining equations have resulted, especially through attempts to include effects of rotating reference frame and changes in stream surface radius. As programed in reference 7, the diffusion parameter for rotor blade elements is:

$$D_R = 1 - \frac{V'_{out}}{V'_{in}} + \frac{V'_{\theta\ in} - V'_{\theta\ out}}{2\sigma V'_{in}} \qquad (1)$$

and for stator blade elements is:

$$D_S = 1 - \frac{V_{out}}{V_{in}} + \frac{V_{\theta\ in} - V_{\theta\ out}}{2\sigma V_{in}} \qquad (2)$$

In each case the solidity used is calculated from

$$\sigma = \frac{c}{\frac{2\pi r_{avg}}{N}} \tag{3}$$

In these forms the equations are not consistent with current practice used in compressor data correlation (see refs 12 and 13). The major differences are in the use of $V'_{\theta\,in} - V'_{\theta\,out}$ in the third term of D and in not accounting for stream surface radius change in the third term of either D_R or D_S. The values of D used in data correlation are frequently not clearly defined in reports of experimental work. There are, therefore, probably minor deviations from consistency in reporting results. These factors lead to some difficulty in fixing numerical limits for D_R and D_S. For this reason the basis for calculation used here is clearly defined, even though the definition may be open to question in view of the loss data correlations used.

Although meridional plane program computations were made using seven stream surfaces, the radial distribution of loss was obtained from estimated combined profile and secondary loss parameters computed for only three spanwise locations as mentioned previously. The computer program of reference 7 permits the utilization of different loss correlation tables for each of the three locations. In all cases, however, the tabulated losses must be based on plots of a total-pressure loss coefficient parameter as a function of D where:

$$\text{Total-pressure loss coefficient parameter} = \frac{\bar{\omega}_{ps} \cos\beta_{out}}{2\sigma}$$

Defining equations are given in reference 7. In the current design figures 5 and 6 were used for rotor blade rows and stator blade rows, respectively.* Although these figures were used to prepare the input tables for the recommended configuration, other loss curves were used in early meridional plane program trials. Some additional aspects of the loss correlation selection problem are discussed in the "Evaluation of Recommended Aerodynamic Design" subsection. Shock losses were computed in the meridional plane program for all blade elements which operate with entrance relative Mach numbers above 1.0. The loss coefficient was computed using a

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*The total-pressure loss parameter is defined in a relative sense for each blade row. For rotor rows, the angle β_{out} becomes the relative exit angle β'_{out} and loss coefficient $\bar{\omega}$ is the circumferentially-averaged relative total-pressure loss coefficient $\bar{\omega}_{ps}'$.

model and equation first developed in reference 14. Reference 7 discusses the introduction of the shock loss calculation into the meridional plane program. It should be noted that the three-point profile loss parameter fit was used to estimate the value of the parameter

$$\frac{\bar{\omega}_{ps} \cos \beta_{out}}{2\sigma} \text{ (eq. 4)}$$

for the 0, 10, 30, 50, 70, 90, and 100 percent of flow stream surfaces. For each stream surface, then, the values of $\bar{\omega}_{sh}$ and $\bar{\omega}_{ps}$ were calculated. These values were added to get the total loss coefficient

$$\bar{\omega}_t = \bar{\omega}_{ps} + \bar{\omega}_{sh} \tag{5}$$

The total-pressure loss coefficient $\bar{\omega}_t$ was then used to determine the estimated loss in average relative total pressure for each stream surface.

The meridional plane computer program output for the recommended 5-stage axial-flow compressor configuration is reproduced in appendix D. The numerical output is generally self-explanatory and most quantities are clearly defined in reference 7. A few comments, however, are in order.

The reference 7 program has two available options for input; in this design study, Modification 1 only was employed. This option requires specification of the passage coordinates, and these coordinates are not altered by the program during a design run. The input also requires specification of the variation (gradient not magnitude) of total pressure along the radius in the calculation planes downstream from each rotor. In this design, the total pressure was maintained at a constant value in each of these planes. In each stator exit calculation plane, tangential (whirl) velocity components were required to be zero. Solidity variation was based on the number of blades for each row and a constant aerodynamic chord length along the span of each blade as given in table 1 for the 5-stage configuration.

Mass flow blockage factors for the calculation planes used and identified in figure 4 are given in the computer output of appendix C. In computing the axial velocity in each calculation plane, the effective area of the passage is reduced by changing the input hub and tip wall coordinates to effective values which allow for the fractional area blockage specified. The computed stage and overall total pressure ratios were essentially fixed by setting the allowable rotor tip diffusion parameter D_R. Limiting values for four other variables were established to insure that experienced-based limits of acceptability were not exceeded. The values used are listed as stage input parameters in appendix C. Inspection of the output shows that none of the limits other than D_R was approached in the recommended design configuration.

For each meridional plane program trial, it is necessary to specify the ratio of supersonic to total fluid turning angle as a function of radius for each blade row. Obviously, this variation is not known in the design process until after specific blade section geometries are known. It is this feature of the design process which makes iteration between meridional plane calculations and blade section geometry selection necessary. For the first few iterations on solution of the meridional plane distribution problem, the ratio of supersonic to total turning was set at 0 for all blade sections. This permitted adjustment of maximum rotor tip diffusion parameter for the various stages to reach the desired overall total-pressure ratio. The remaining trials were then devoted to successive improvement of agreement between supersonic to total turning ratios input to the meridional plane program and the values calculated for the blade section geometries determined in the blade selection process. These ratios have an important effect on the magnitude of shock loss for the blade sections having supersonic relative inlet velocities. The variations used in the recommended design meridional plane computer output are shown in figure 7. There was no supersonic turning in any stator row.

Determination of Blade Section and Row Geometries

The blade determination phase of the compressor design process involves specification of rotor and stator row geometries such that the fluid velocity distributions computed in the meridional plane solution will be attained. At the same time, the blade geometries must give acceptable total-pressure losses and blade-to-blade (intrablade) flow passage areas which do not produce choking. To simplify the coordinate determination process, it was decided to use only two blade section profile types. These were the double-circular-arc (DCA) profile and the multiple-circular-arc (MCA) profile, which are described in considerable detail in references 13 and 15. DCA geometry was specified for all stator blade sections and for rotor blade sections at which acceptable shock loss levels could be maintained. MCA section geometries were required for substantial fractions of the blade height in the first three rotors.

The meridional plane velocity and property distribution program determines the flow conditions only in calculation planes that are perpendicular to the axis of the compressor and located in the axial gaps between rows. In this design study, the calculation planes were located in the configuration selection process. For blade specification purposes, it was necessary to locate each blade row within the available axial distance between calculation planes by positioning of the section stacking axis. This was done for the individual rows so that the point of intersection of the leading edge of the meridional plane projection of the blade row and the hub contour would be from 0.051 to 0.188 cm (0.020 to 0.070 in.) downstream from the inlet calculation station for that row.

Table 3 gives the axial location assigned for all blade rows with the reference plane location as given in table 2 and on figure 4 . All stacking axes were assumed to be radial lines (perpendicular to and passing through the compressor rotational axis).

The steps in specification of blade row geometries were as follows:

1. Radial distributions of velocity components and relative flow angle were computed for the calculation planes immediately upstream and downstream from each blade row.

2. For blade section selection and coordinate computation, the flow was assumed to occur along conical surfaces connecting radial stations in the upstream and downstream calculation planes located 0, 10, 30, 50, 70, 90 and 100 percent of the total passage flow from the effective outer passage wall as shown in figure 8 for the first stage.

3. Geometric properties to be used in computing blade section coordinates for each conical blade selection surface were specified. These properties were in some cases fixed on the basis of best aerodynamic characteristics and in other cases on the basis of mechanical or fabrication limitations. Examples of the latter category are the blade section maximum thickness, the leading-and trailing-edge radii, and the section aerodynamic chord length.

4. A trial value of incidence angle measured from a line tangent to the blade section suction surface at the leading edge was selected for each conical selection surface.

5. Using an iterative calculation process, values of fluid deviation angle, blade section camber and blade setting angle were computed.

6. Blade section coordinates were calculated for the unwrapped conical surface.

7. Blade-to-blade channel areas were computed for stream tubes in each blade row to obtain local values of A_z/A_z^* (the critical area ratio for passage choking margin).

In computing the blade section geometries, velocities and fluid properties were adjusted from the calculation planes to radii corresponding to the axial location of the leading and trailing edges of the blades using an assumption of constant angular momentum along a conical surface.

The number of blades used for each blade row was that given in table 1 for the 5-stage configuration. Section geometric property values for the various blade selection surfaces in each blade row are listed in table 4.

For first iterative trials, suction-surface incidence angles were set at 0° for all conical selection surfaces in each row. Values were adjusted in subsequent trials to aid in reaching acceptable A_z/A_z* ratios. This process of adjustment also involved changes in location of maximum thickness and in ratio of supersonic suction surface turning to total turning. Final recommended suction surface incidence angles for the first rotor are plotted in figure 9. For all other blade rows, the suction surface incidence was set at 0° for all blade sections as shown in table 4.

Deviation angles were computed from Carter's rule modified by an experience-based adjustment given as a function of radius. The resulting deviation angle equation was:

$$\delta = \frac{(\Delta\beta - i)\ m_c \sqrt{\frac{1}{\sigma}}}{1 - m_c \sqrt{\frac{1}{\sigma}}} + \delta_{adj} \qquad (6)$$

for double-circular-arc (DCA) profile

$$m_c = 0.219 + 0.0008916\ T + 0.000027085\ T^2 \qquad (7)$$

for multiple-circular-arc (MCA) profile

$$m_c = (0.219 + 0.0008916\ T + 0.000027085\ T^2)(2\ a/c)^B \qquad (8)$$

$$B = 2.175 - 0.035525\ T + 0.00019168\ T^2 \qquad (9)$$

The values of the increment δ_{adj} used for each row are shown in figure 10. Total deviation angles estimated for each blade row are given in figure 11. The values of δ_{adj} used were taken from a correlation first published in reference 13. This correlation was selected because it represents a rather comprehensive analysis of experimental data from several compressor configurations. These deviation angles, as well as the incidence angles, are measured and located in the conical surfaces corresponding to the various stream surfaces, not on plane surfaces parallel to the compressor rotational axis. Values of δ_{adj} and δ are also given in table 4.

Blade-to-blade passage areas A_z/A_z* for each blade row were computed by a method similar to the one described in reference 13. Experimental results reviewed in references 9 and 12 have demonstrated that this ratio should be controlled in order to avoid choking of the blade channels and to insure a reasonable range of operation. Figure 12 shows the minimum A_z/A_z* ratio as a function of passage height for each rotor and stator row. It is believed that in each row acceptable conditions exist. Considerable difficulty was experienced in obtaining adequate A_z/A_z*

margin in the first three rotor rows because of the need to maintain minimum blade-thickness/chord-length ratio and leading-edge radii for fabrication and mechanical reasons. As noted previously, it was necessary to modify the hub contour in the first two stages (see table 2) to reach acceptable A_z/A_z^* levels in these stages.

For blade mechanical design and fabrication, it is desirable to compute coordinates for blade sections cut by planes parallel to the compressor axis. A computer program described by Crouse, Janetzke and Schwirian in reference 8 was used for this purpose. Plane section coordinates, blade setting angles, and section properties were calculated for eight radial locations for each blade row. Figure 13 shows the locations of sections specified for an example rotor geometry. Appendix D contains detailed nomenclature and figures defining the geometrical quantities in the fabrication coordinate results as well as tabulated geometry for all blade rows in the recommended 5-stage compressor configuration. All blade rows have a radial stacking axis and the stacking point for each section is its center of gravity.

Evaluation of Recommended Aerodynamic Design

For convenience, the recommended overall compressor unit configuration and operating parameters for the miniature gas turbine engine are repeated below:

Working fluid	Air
Compressor inlet total pressure	10.131 N/cm² (14.696 lbs/in.)
Compressor inlet total temperature	288.2°K (518.7°R)
Flow rate	0.863 kg/sec (1.905 lbm/sec)
Rotational speed	77,986 rpm
Overall total/total pressure ratio	4.66
Overall total/total adiabatic efficiency (estimated)	0.853
Number of stages	5
Rotor tip diameter (constant throughout)	9.14 cm (3.60 in.)
First rotor inlet hub-to-tip diameter ratio	0.586
Rotor tip speed	373.4 m/sec (1225 ft/sec)
Compressor unit axial length	7.98 cm (3.14 in.)

The estimated unit overall total-pressure ratio is a mass-average value based on calculated total-pressure distribution for the station at the fifth-stage stator exit. It should also be observed that for design point calculations no loss in total pressure was assumed through the engine inlet. The unit's overall adiabatic efficiency was computed in the meridional plane solution program. Its validity depends principally on the profile and secondary loss parameter correlations designated as meridional plane program input on the shock loss estimation model used and on the accuracy of deviation angle estimates. These and other aspects of the compressor design method and results are the subject of this subsection.

Figure 14 compares first rotor inlet meridional velocity components and relative fluid angles from the inlet passage potential flow solution supplied by NASA with the meridional plane distribution program solution obtained for the recommended 5-stage compressor. This comparison is essential because the inlet passage solution does not reflect any effect of the presence of the compressor bladed section and because the meridional plane solution input does not reflect the true shape of the inlet. Agreement between the two estimated distributions is important because of the significance of alignment of the first rotor blade sections with the relative inlet flow.

Examination of first rotor entrance calculation plane values in appendix C, (station number 5, see fig. 4) shows a relative Mach number of about 1.31 at the tip section, decreasing to about 0.90 at the hub. The transition to subsonic relative flow occurs at about 65 percent of the passage height from the tip. The entrance Mach number and relative flow angle distributions are consistent with adequate stage performance as demonstrated by recent experimental investigations at much larger scale [above 76 cm (30-in.) tip diameter] (references 12 and 16). Rotor and stator blade section aerodynamic loading as indicated by diffusion parameter distributions is conservative. Maximum stator entrance Mach number occurs at the hub section and is about 0.69. Full-scale stage experience would indicate that estimated rotor and stage mass-average adiabatic efficiencies of 0.88 and 0.86 are reasonable.

Inspection of first stage blade row section characteristics given in figure 12 shows that minimum A_z/A_z^* ratios are on the order of 1.04 for the rotor and 1.13 for the stator. These ratios together with the low section aerodynamic loadings (D_R and D_S) mentioned previously would help to provide satisfactory stage operating range and compressor starting characteristics in the single-shaft miniature gas turbine engine.

All of the remaining stages, when compared on the basis of similar standards (that is, relative Mach number, section aerodynamic loading and blade-to-blade critical passage area ratios) have similar characteristics. All except stage five exhibit mixed supersonic-subsonic relative rotor flows (transonic stages). There is a tendency toward increased maximum rotor relative flow angle with increasing stage number, and this angle reaches 65° at the fifth rotor tip. Stator diffusion parameters and maximum inlet Mach numbers are low throughout the compressor so that double-circular-arc blade section geometries should provide good performance. The computed distribution of axial Mach number component at the fifth stator exit is shown in figure 15. This distribution is of significance in terms of its influence on combustion chamber performance.

Primary sources of uncertainty in the design point calculations lie in the estimation of blade section total-pressure losses and deviation angles and in the estimation of annulus hub and tip effective area ratios (blockage factors) for each calculation plane. Maximum errors in loss may be expected to occur in the estimate of combined profile and secondary loss parameter for individual blade sections. The extremely small passage and blade section dimensions required in this application have not been duplicated in any known transonic axial-flow compressor prior to this study; there is no satisfactory way to make a reasonable engineering estimate of the deterioration in compressor performance due to low Reynolds number and scale effects.

The smallest multistage axial-flow compressor known to have been built to research standards and to have been tested in an adequate facility was described in references 17, 18, and 19. This 6-stage unit had a tip diameter of 9.4 cm (3.7 in.) and was designed for a pressure ratio of 2.36 at an equivalent flow rate of 0.69 kg/sec (1.52 lbm/sec) in argon. The compressor had subsonic relative Mach numbers in all rows, and as a result, used blade section geometries with considerably greater maximum thicknesses and edge dimensions than were indicated for the present design. In the test program, the pressure ratio was substantially greater than the design values at design flow and rotational speed. The peak efficiency at the design rotational speed was 0.755 as compared to a design value of 0.825. No detailed interstage measurements were made, but analysis of the results led to a conclusion that over-compensation for the effect of Reynolds number on deviation angle and use of low estimated effective area ratios (blockage factor) in design could have contributed to the measured discrepancies in performance. The blade-chord Reynolds numbers in the design of the reference 17 compressor reached a maximum in the first rotor at about 100,000, while stator values remained in the range 60,000 to 70,000. Minimum aerodynamic blade section chord was 1.27 cm (0.50 in.). Passage effective area ratios varied from 0.961 at the first rotor entrance to 0.925 at the sixth stator exit. In the recommended 5-stage configuration, rotor tip blade chord Reynolds numbers were in the range 190,000 (first stage) to 280,000 (fifth stage). Blockage factors were discussed previously.

Some additional effects of Reynolds number as contrasted to geometric scale reduction on plane cascade and multistage axial flow compressor performance were given in references 20-22. It is shwon that for a pure Reynolds number reduction, values less than about 200,000 lead to substantial increases in total-pressure loss parameter and reduction in blade section turning (increased deviation angle).

In selection of deviation angle values, loss parameter correlations, and blockage factors, consideration was given to the limited related data reviewed above. It was decided that there has been an inclination to overcompensate for these effects in numerous cases of transonic compressor design (ref. 23). Furthermore, the very limited data on very small turbomachinery seem to indicate that carefully constructed small-size configurations are not subject to as serious deterioration in performance as anticipated. It was decided, therefore, that no special allowance would be made for the effects of Reynolds number of geometric scale on deviation angle, loss correlations or blockage factors. All of these design method input variables were estimated to have numerical values typical of those used in full-scale transonic compressor design.

In the case of loss parameter correlation curves only, some alternate choices were used in trial meridional plane program solutions. The general results obtained may be of interest in evaluating the final result. The combined profile and secondary loss parameter estimation curves used for the majority of the studies of design alternatives were those shown in figures 5 and 6. These curves are slight modifications of those given in reference 12 for rotors and 13 for stators. The absolute values of the loss parameter and the pattern of increase with diffusion parameter led to reasonable values of blade section, row and overall performance. A second trial set of combined profile and secondary loss correlation curves for rotor sections was taken from figure 33 of reference 13 The shock loss model was not changed for this trial. The trend in results produced by this change in rotor loss correlation alone is typified by an estimated unit overall adiabatic efficiency of 0.950. This value, together with intermediate results, such as rotor and stage efficiency values, appeared to be unrealistic.

A second type of alternate solution was obtained by using loss correlation input tables based on doubling the loss parameter values at a given D level shown in figures 5 and 6. The purpose of this trial was to identify some of the velocity diagram and overall performance changes that would result if a substantial Reynolds number effect were to occur. The results showed a significant reduction in both estimated overall pressure ratio and efficiency (for similar blade section aerodynamic loading). For example, efficiency was reduced by about 10 percent.

These results, while not based on comprehensive studies, show rather conclusively that experiments defining Reynolds number and geometric scale effects are required for accurate design of miniature turbomachinery units. They also show that in all ranges of scale and Reynolds number, the design correlations used for losses and end-wall (blockage factor) effects are extremely important and in need of better definition.

In the meridional plane distribution program, attention should be called again to the method for loss parameter determination in the case of combined profile and secondary losses. The three-point fitting technique does not seem to be consistent with the general quality of the program flow model. Further experiments should be scheduled to provide a more well-defined loss parameter profile at each calculation plane.

Blade-section geometry recommendations might be improved by additional investigation of incidence angle distribution choice and of the estimation of deviation angle. Only a limited number of incidence alternatives were considered in this study. In the deviation angle calculations, experienced-based corrections to Carter's rule such as the δ_{adj} of figure 10 are common in design. Most of these corrections are, however, based on insufficient and wholly empirical information. No valid data are available for adjustment in the case of transonic stages at low Reynolds number.

Some unique geometric requirements were a major influence in blade selection for the recommended axial-flow compressor design. Ordinarily, for the relative Mach number levels computed for the rotor blade rows in the present design, maximum section thickness/chord ratios near the tip would be specified in the range 0.025 to 0.040. Similarly blade section leading-edge and trailing edge radii would be set at the lowest possible levels. In this design case, fabrication capabilities suggested that no blade section minimum thickness should be less than .038 cm (0.015 in.). Both fabrication and maintainability requirements indicated that minimum leading-and trailing-edge radii of .008 cm (0.003 in.) might be specified. To remain within these limits, blade section determination was based on maximum thickness values given in table 4 and on leading-and trailing-edge radii also given in table 4 .

COMPRESSOR BLADE FLUTTER ANALYSIS

The analysis of compressor blading for self-excited aeroelastic instability is generally conducted on two bases:

1. Classical cascade flutter (attached flow) at the design point or other condition of maximum velocity of airflow relative to the blades.

2. Stall flutter (separated flow) of the first few stages, generally assumed to occur at about 70 per cent corrected speed.

The first category has not generally proved to be troublesome in practice; furthermore, the analytical tools to describe the nonsteady aerodynamics are just now becoming available and are not yet widely programed for digital computation. The present analysis was, therefore, confined to the stall flutter regime.

When the flow stalls and unstalls periodically during each cycle of vibratory blade displacement the prediction of aerodynamic reactions, and hence aeroelastic instability, cannot be treated wholly analytically; a semi-empirical method is required. Ideally, an experimentally determined flutter boundary is determined from tests on similar blading, and the analytically predicted incidence, relative airspeed and natural frequency of the blade being analyzed are compared with the boundary over a range of operating conditions.

Stall Flutter Analysis

In the absence of experimentally determined flutter boundaries for radically new type compressor blade sections (that is, the miniature compressor under the present contract) and/or the unavailability of such data for proprietary reasons, the instability boundary to be avoided is usually contracted into a single value of the reduced frequency parameter which must be exceeded for safety. Although the criterion then has the merit of extreme simplicity and reliability, it may suffer in some instances from excessive conservatism. The blade satisfying the criterion may have a very large stability margin and may, therefore, actually be thicker or have a larger chord than is in fact necessary. Be that as it may, in the absence of the experimental data noted above, and without off-design incidences and relative velocities, the single parameter method is all that is possible.

Under these circumstances, the stall flutter criterion is

$$2\pi f_b c/V \geq 0.33 \quad (10)$$

$$2\pi f_t c/V \geq 1.60 \quad (11)$$

in order to avoid dangerous vibration. In these inequalities, c is the blade chord; V is the relative velocity at the tip of a cantilever blade; and f is the natural frequency in hertz with subscripts denoting bending or torsion. Although flutter, if it occurs, appears in the neighborhood of 70 percent speed, the frequency parameter is still calculated at design speed because this is the manner in which the correlation was originally obtained.

Parameter Values

From computer printouts of the predicted aerodynamic conditions at design, it was possible to determine the relative inlet airspeed, V, at the rotor tips.

	V
Rotor #1	428 m/sec (1404 ft/sec)
Rotor #2	921 m/sec (1381 ft/sec)

The stators were not analyzed initially because of the lower airspeeds (circa) 213 m/sec (700 ft/sec) and greater degree of blade fixity.

The chords for the first two rotor blades were taken from a summary of the principal dimensions and checked, for the first rotor, against a computer printout of first rotor and stator blade section properties.

	c
Rotor #1	0.76 cm (0.30 in.)
Rotor #2	0.64 cm (0.25 in.)

The natural frequencies of the rotor blades were not available, although an experimental program to determine the frequencies of over-size models was planned. By scaling the frequencies to prototype dimensions, an excellent estimate of blade frequencies could have been obtained. Initially, therefore, some exceedingly crude estimates of blade natural frequencies were obtained by scaling the frequencies of known blades using only inverse blade length as the parameter. The simplistic nature of this estimate may be appreciated by noting that chord, taper ratio, camber, thickness, twist, stagger, and rotation all have an effect on the frequency.

Nevertheless, as a first cut these frequencies were predicted, including the rotational stiffening.

	f
Rotor #1	3,000 hz (bending)
	12,800 hz (torsion)

	f	
Rotor #2	4,000 hz	(bending)
	18,750 hz	(torsion)

The corresponding frequency parameters could then be computed as:

	$2\pi fc/V$	
Rotor #1	0.34	(bending)
	1.43	(torsion)
Rotor #2	0.38	(bending)
	1.78	(torsion)

Of these values, only the first rotor in torsion appears to be unsafe. (See equations 10 and 11)

Frequency Calculation

The confidence in the results of the previous calculation were very low, stemming from the gross uncertainty in the frequencies. While awaiting better frequency estimates from analysis (computing programs being procured) and from experimental determinations, it was decided to refine the frequency estimate for the first rotor blade in torsion. This was based on a number of considerations.

1. The prediction was just barely unsafe.

2. Transonic stages have tended in the past toward the torsional mode in flutter.

3. Centrifugal stiffening is most effective in bending, tending to keep the frequency high despite poor area taper characteristics.

4. The rearward point of maximum thickness along the chord, and the increasing chord toward the tip, indicated a possibly much lower torsional frequency than had been estimated.

Consequently, taking the blade element structural data from the computer printout, a hand calculation was made of the torsional natural frequency of the first rotor blade.

The Rayleigh method was used assuming a torsional mode shape given by:

$$\theta = \theta_0 \sin(\pi z/2L) \qquad (12)$$

and resulting in a frequency expression of the following form:

$$2\pi f_t = \sqrt{(\pi/6)GI/LJ} \qquad (13)$$

where

$$I = \int_0^L F_c \cos^2(\pi z/2L)\,dz \qquad (14)$$

$$J = \int_0^L I_p \sin^2(\pi z/2L)\,dz \qquad (15)$$

$$F_c = F[1 + (c^2 \alpha_L'/t_{avg})^2/24] \qquad (16)$$

$$F = \int_0^C t^3\,dx \qquad (17)$$

and ρ is material density, c is chord, t is thickness, α_L' is rate of blade twist, z is length coordinate and x is the chordwise coordinate. The length of the blade is L, G is the modulus of rigidity and I_p is the polar moment of inertia about the torsion center taken to coincide with the point of maximum thickness along the chord.

A correction for differential bending had a negligible effect and was omitted from the final calculation. The slopes α_L' were obtained at a number of spanwise stations by numerical integration and the spanwise integrals I and J were obtained graphically.

By the means described above the torsional frequency was predicted to be:

#1 Rotor 6810 hz (torsion)

which is slightly more than half of the first crude estimate of the value. The centrifugal stiffening effect, omitted here, is known to be small for the first torsional mode. This is also compensated by the fact that the Rayleigh method is known to predict frequencies that are slightly too large. Hence, the degree of confidence in the result is quite high.

The first rotor blade as presently designed (TDA 010 TRIAL 1) will probably flutter in torsion. A similar conclusion concerning the second rotor cannot be drawn at present owing to the lack of definitive data. However, the stability margin is likely to be minimal if not negative. Bending stall flutter is probably absent in both rotors, but should be checked.

More accurate frequency parameters should be obtained to finally assess the stability margins of the first rotor in bending and the second rotor in bending and torsion.

The first rotor blade must be redesigned to increase its frequency parameter in torsion; a doubling of the frequency times chord product is required. This may be attained by changing the material to beryllium or by increasing the chord and thickness. Alternatively, the frequency may be raised by adding a tip or part-span shroud.

COMPRESSOR MECHANICAL DESIGN

The last four rotors of the compressor have been designed to be bolted together with tie bolts and are piloted in such a manner as to cause the pilot fits to become tighter as the rotational speed increases. Each rotor is made separately to facilitate manufacturing.

Blade Stresses

The mechanical design of the compressor rotors was facilitated by the use of a disk stress analysis computer program based on an NACA report. (See ref. 24). The stresses shown in figure 16 are for a wheel made of 17-4PH stainless steel, a hardenable stainless, AMS 5643. Using 17-4PH in the H-900 condition of heat treat with a yield strength of 127,540 N/cm^2 (185,000 lbs/in.^{2}) the margins are adequate.

The centrifugal blade stress at the blade root is calculated as follows:

$$s_{br} = \frac{w}{g} \left(\frac{2\pi}{60}\right) n^2 \frac{y_{cg}}{A} \qquad (18)$$

The blade root stresses for each compressor stage are:

	Root Stress	
Stage	N/cm^2	(lbs/in.^{2})
1	34,384	(49,875)
2	26,800	(38,875)
3	22,457	(32,575)
4	17,528	(25,425)
5	14,512	(21,050)

COMBUSTOR

The combustor development program was a continuation of the work done in reference 1. The required ΔT across the burner for the miniature engine was 978°K (1300°F) at a pressure of 48.1 N/cm^2 (4.75 atmospheres). The test burner was designed and built for eventual use in the gas turbine engine.

Test Installation

The air supply for this program was compressed and stored in storage tanks at 2068 N/cm^2 (3000 $lbs/in.^2$). To simulate the heat of compression, the burner used in reference 25 was put in the line in front of the test burner. This pre-burner used hydrogen as a fuel and served to heat the test burner inlet air to approximately 494°K (430°F). Air flow was measured in the air line by use of an orifice plate. Air flow rates have been corrected to include hydrogen burned in heating the inlet air by the following equation:

$$W_f = \frac{\Delta T (C_p) air (W_{air})}{\Delta H} \tag{19}$$

The hydrogen was stored in a truck trailer at 1724 N/cm^2 (2500 $lbs/in.^2$). The burner section was mounted horizontally in a test cell, which was open at both ends for ventilation. Remote controls for operating the test were located in the control room; figure 17 shows the general layout of the test setup.

Instrumentation

Airflow rates were measured by a square-edged orifice installed according to ASME specifications. The ΔP across the orifice plate was read on a mercury "U" tube manometer. Temperatures for the flow calculations and for the combustion chamber inlet were measured with iron-constantan thermocouples and read on a Honeywell multi-channel dial type instrument. Combustor exit air total temperature was measured with Chromel-Alumel ceramic insulated thermocouples on a recording chart type "Honeywell-Brown Electronik" instrument.

Hydrogen flow was measured with a Fisher & Porter flowrator meter. Inlet air total pressure was measured with a three-tube equal-annular area rake and read on standard Bourdon tube-type gages. Combustor exit total pressure was measured at five points around the annular nozzle with total pressure probes.

Calculations

The characteristics of the combustor were calculated as follows and the results are presented in Table 5.

Combustion efficiency η_c was defined as the ratio of actual temperature rise to theoretical temperature rise

$$\eta_c = \frac{\Delta T \text{ (actual)}}{\Delta T \text{ (theoretical)}} \tag{20}$$

$$\text{Where } \Delta T \text{ (theoretical)} = \frac{\Delta H}{(mC_p)_{H_2O} + (mC_p)_{N_2} + (mC_p)_{AIR}} \tag{21}$$

and the values for (m) are obtained from the chemical equation

(22)

$$H_2 + 1/2\ O_2 + 1/2\ (3.76)\ N_2 + W_{ea} \rightarrow H_2O + 1/2(3.76)N_2 + W_{ea}$$

$$(1) + (8) + (26.34) + (92.41)^* \rightarrow (9) + (26.34) + (92.41)$$

*based on air fuel ratio = 126.74

Excess air W_{ea} is calculated as follows:

$$W_{ea} = \frac{W_a \text{ (actual)}}{W_f \text{ (actual)}} - \frac{W_a \text{ (theo)}}{W_f \text{ (theo)}} \tag{23a}$$

$$= \frac{W_a \text{ (actual)}}{W_f \text{ (actual)}} - 34.33 \frac{\text{lbs.-air}}{\text{lbs.-fuel}} = 126.74 - 34.33 \tag{23b}$$

$$= 92.41 \text{ kg(lbs) excess air/kg(lbs) fuel} \tag{23c}$$

Combustor pressure loss $\Delta P/P$ was defined as the drop in total pressure from inlet to exit of the combustor divided by the inlet (to the burner) total pressure. The term ΔTVR is calculated as follows:

(24)

$$\Delta TVR = \frac{\text{(max. local comb. outlet temp.) - (aver. comb. inlet temp.)}}{\text{(aver. comb. outlet temp.) - (aver. comb. inlet temp.)}}$$

Test Procedure

The procedure for operation of the burner test was as follows:

1. Inlet air pressure adjusted to about 0.7 or 1.4 N/cm^2 1 or 2 $lbs/in.^2$).

2. Ignitor turned on.

3. Vernier fuel flow valve opened.

4. When temperature jumped to 589°K (600°F) to 700°K 800°F), air flow valve was gradually opened to full open position; the spark plug was shut off, and at the same time the main fuel valve was opened at a rate sufficient to prevent temperatures over 1367°K (2000°F).

5. The fuel flow, combustor air inlet pressure, and inlet air temperature were adjusted to desired conditions.

6. Data recorded.

7. To shut down, the fuel valve and then the air valve were turned off.

Combustor Results

An annular combustor was designed and built for use in the miniature gas turbine engine. The design was based on that of the combustor reported on in reference 1. Figure 18 shows a cross-sectional view of the liner and housing used in the development program. One major difference in this burner is the height of the turbine nozzle which was 1.778 cm (0.700 in.). The burner reported on in reference 1 had a height of 0.838 cm (0.330 in.).

The difference in turbine nozzle height presented a new temperature distribution problem; radial temperature variations were considerable. Therefore, after discovering the poor radial temperature profile, the development program was concentrated on obtaining an even radial temperature profile at the turbine nozzle.

Combustor test runs 1 through 22 were made with total temperature rakes arranged to determine circumferential temperature distributions. Twelve thermocouples circumferentially spaced on the centerline of the annulus were used on these initial runs. The results indicated greater than 100 percent combustion efficiency. This was caused by measuring temperature on the annulus centerline which was much hotter than the inner and outer extremes of the annulus. Therefore, from run 23 on, a rake assembly containing seven rakes of five thermocouples each was used to obtain a radial temperature profile at seven circumferential locations. Figures 19 thru 23 show the various combustor liners tested. These results are presented in table 5. The combustion efficiency as shown in table 5 is low. This could be due to poor combustion, but it is more likely due to improper temperature sampling of turbine nozzle temperature. It is recommenaed that in future developmental work a greater number of thermocouples be used to establish that all the fuel is burned.

The first real improvement in ΔTVR was made with the changes shown for runs 30, 31, and 32 in fig. 22. A new liner was installed with open area near the fuel nozzle. A deflector was also added in an effort to mechanically mix the hot and cold air streams. Since more than one change had been made between runs 29 and 30, runs 33 and 34 were made with the deflector removed. No real difference was noted in the burner performance in runs 33 and 34. In an attempt to further reduce the value of ΔTVR, run 35 (fig. 23) incorporated a new fuel nozzle with smaller orifices to increase the velocity of the fuel for better mixing. This design was improved by replacing the deflector in run 36 (fig. 23).

Testing was stopped after run 36. This run had the best performance of the program, but as can be seen in table 5 the average exit temperature of 1097°K (1515°F) required for design point performance was not reached; the limiting factor still being the local hot spots. Hot spots cause loss of turbine performance due to off design conditions as well as burning of the nozzle and turbine. Further development work must be done to reduce the ΔTVR factor to near unity to enable the eventual engine to operate successfully.

TURBINE AERODYNAMIC DESIGN

Aerodynamic designs for two turbines for the NASA miniature gas turbine engine are presented. The initial design was for a rotational speed of 82,500 rpm. Later, for reasons presented elsewhere in this report, it was decided to reduce the rotational speed to 78,000 rpm. The turbine was then redesigned to this lower speed while retaining the same inlet flow conditions and power output as the initial design. This resulted in a somewhat higher stage loading for the final design and consequently a lower predicted efficiency.

The required inlet flow conditions and output energy were specified for both turbines by the engine cycle selection and are as follows:

Inlet total temperature, °K (R°)	1217 (2190)
Inlet total pressure, N/cm^2 ($lb/in.^2$)	40.88 (59.30)
Inlet mass flow, kg/sec (lb/sec)	0.86 (1.90)
Output energy, J/(kg) (BTU/lb)	2.08×10^5 (89.50)

The rotational speed was required to be 82,500 rpm for the initial design and 78,000 rpm for the final design. These speeds were as high as possible consistent with the degree of mechanical risk intended for each design.

A maximum tip diameter of 10.16 cm (4.00 in.) was imposed on the turbine in order to keep the overall engine diameter within its objectives. A single-stage turbine was required to meet overall engine length objectives.

Although a specific objective for the efficiency of the turbine was not set, it was desired to have the maximum efficiency consistent with the above requirements so as to maximize the engine's thrust output. Table 6 presents a summary of the significant design point parameters for each turbine.

Design Approach

General Considerations

Stage loading. - The stage loading parameter ($gJ\Delta h/2U^2$) is very important in determining the maximum efficiency potential from any turbine stage. For this design, however, the stage loading parameter has been determined within very narrow limits by the design requirements placed on rotational speed, tip diameter, and output energy. The resulting stage loadings are relatively high for a single-stage turbine, being 0.854 and 0.970 for the initial and final designs, respectively. Because of these high loadings, then we must expect and accept efficiencies which may be rather on the low side. A correlation of turbine efficiency versus stage loading has been made which substantiates this.

Another result to be expected from high stage loading is a relatively large residual swirl in the exhaust flow. This residual swirl velocity is partially responsible for the loss of efficiency and may make it desirable to use straightening vanes in the turbine exhaust stream.

Axial velocities. - Several factors were considered in the choice of the turbine exit axial velocity. First, as the axial velocity increases, the required flow area decreases and the hub diameter may be allowed to increase. This then increases the average wheel speed, lowers the stage loading, and should result in higher efficiency. This also results in shorter buckets and lower bucket centrifugal stresses. The shorter buckets should also make them easier to machine from a solid wheel.

The exit axial velocity cannot be increased indefinitely, however, whithout other sacrifices. With increased axial velocity, the exhaust nozzle losses will probably increase. More important than that, however, is the loss of margin in the turbine to operate effectively at increased pressure ratios in the event that either the turbine or compressor performance is less than predicted. With an exit Mach number of 0.5, the turbine would have enough margin for up to approximately 20 percent decrease in either compressor or turbine efficiency. With an exit Mach number of 0.6, this margin decreases to approximately 12 percent. Based on this, it was decided to keep the exit Mach number under 0.5.

Selection of axial velocities at other stations in the turbine is considerably less critical, since they will vary much less with pressure ratio and will not limit turbine energy output. Generally, velocities should progressively increase through the turbine and result in a smooth flow path geometry.

Root reaction and exit swirl.- For a free vortex design, the designer may choose one additional parameter to define the velocity diagrams. This can be root reaction or exit swirl angle. These are related such that an increase in one results in an increase in the other. Reaction is the fraction of stage ideal enthalpy drop occurring across the rotor and may be expressed in terms of pressures as:

$$R_X = \frac{P_{S3}^{\frac{\gamma - 1}{\gamma}} - P_{S4}^{\frac{\gamma - 1}{\gamma}}}{P_{T1}^{\frac{\gamma - 1}{\gamma}} - P_{S4}^{\frac{\gamma - 1}{\gamma}}} \qquad (25)$$

The significance of reaction is that a positive value indicates a static pressure drop across the turbine rotor and a negative value indicates a pressure rise. Most past experience indicates that a moderately positive root reaction is desirable to insure smooth flow through the rotor. Also, positive reaction tends to lower the rotor inlet Mach numbers and should result in a turbine with a higher efficiency over a broader operating range than one designed with zero or negative root reaction.

Since the requirements for this turbine result in a quite high stage loading, a rather high exit swirl angle must be accepted. The only other alternative would be to design with rather high negative values of root reaction. It was felt that the best compromise would be to design to the minimum root reaction needed to insure a static pressure drop at the turbine rotor root and accept the known losses due to exit swirl.

Nozzle and bucket solidity.- Solidities for nozzles and buckets were selected primarily to give optimum aerodynamic performance. The criteria used was the Zweifel blade loading parameter (1) defined for compressible three-dimensional flow as:

$$Z = \frac{2V_2 \cos \alpha_2}{144(W/S)(P_{T_1} - P_{S_2})(1/\rho_1 V_1 + 1/\rho_2 V_2 \sin \alpha_2)} \tag{26}$$

for nozzles and,

$$Z = \frac{2(R_3 \cos \beta|_3 + R_4 \cos \beta|_4)}{144(W/S)(P_{TB} - P_{S_4})(1/\rho_3 R_3 \sin \beta|_3 + 1/\rho_4 R_4 \sin \beta|_4)} \tag{27}$$

for buckets.

Zweiffel's original paper,reference 26,recommends a value for Z of 0.8 as being optimum for aerodynamic performance. This seems to work quite well for buckets, and the buckets for these turbines have Z equal to 0.8 at all sections.

This was not done for the nozzles, however, since a value of 0.8 seems to result in solidities too low for high pressure ratio nozzles. Also, a radially constant value of Z required a higher nozzle solidity at the tip than at the hub, which is usually difficult to achieve in most designs. For the nozzles, then, the approach was to set Z at about 0.6 at the tip and let the hub and pitch values fall out as they would with a reasonable reduction in axial width from tip to hub. This resulted in hub loading values in the vicinity of 0.4 for the nozzles.

Nozzle and bucket number.- After selection of solidities for the nozzles and buckets, the selection of their number will determine their spacing, axial widths and aspect ratios. Two primary factors governed the choice of nozzle and bucket numbers in these designs. First, the fewer blades in any blade row, the greater the axial width for a given solidity. This increases the overall length of the engine and weight of the turbine rotor. Thus, for minimum length and rotor weight a high number of nozzles and buckets is desired. Second, the more blades there are, the more difficult it becomes to machine them out of a solid wheel, both because of their increased number and because their decreased spacing requires smaller diameter cutters. It was felt that minimum spacing between blades could be 0.254 cm (0.10 in.) for the nozzles and 0.40 cm (0.16 in.) for the buckets. This then effectively determined the maximum number of blades in each row.

Turbine performance is also affected by the selection of blade numbers because of the effects on blade aspect ratios and Reynold's numbers. These two factors tend to oppose each other, however, and their net effect was considered to be small over the range of blade numbers considered practical.

Velocity Diagram and Fluid Property Calculations

The design of this turbine was based on the assumption of "free vortex" flow at the entrance and exit to each blade view. This assumption implies:

1. Radially constant axial velocity, total pressure, and total temperature at each station.

2. Tangential gas velocity varies inversely proportional to radius at each station.

In addition, it was assumed that the working fluid was a perfect gas with the specific heat ratio and gas constant evaluated at the average of the inlet total and exit static temeratures.

A time-sharing computer program was written to solve the continuity and energy equations based on the above assumptions. This program then calculated velocity diagrams and gas properties at hub, pitch and tip radii. A number of loading and performance parameters were also calculated. Appendix E presents this program in detail. It is realized that much more sophisticated methods of turbine analysis are available, which remove many of the restrictions of the free vortex approach; but the time and expense of developing such a computer program was not considered warranted.

Blading Profile Design

After establishing blading numbers, solidities, and velocity diagrams at hub, pitch and tip, the blade profile sections were laid out. For the initial design, these sections were developed on the conical surfaces corresponding to the hub, pitch and tip stream surfaces. For the final design, it was decided that it would be more convenient to develop the sections on cylindrical surfaces whose radii corresponded to the hub, pitch and tip radii at the nozzle and bucket trailing edge stations.

Throat areas for the blading were calculated by applying a flow coefficient to the ideal areas calculated from ideal relative total pressures and downstream static pressures. The flow coefficients used were 0.965 for nozzles and 0.94 for buckets. These are both about 1 percent smaller than would be used for a larger size turbine because of the relatively low Reynolds number for this turbine. These flow coefficients were not applied in addition to the 0.95 flow coefficient on annulus area but represent the net flow coefficients for the blading throat areas.

Physical blade exit angles were set by subtracting a deviation angle from the calculated velocity diagram angle and making the suction surface at the trialing-edge tangent to this angle. The deviation angles used were 1° for the nozzles and 2° for the buckets. Since the nozzle root velocity was supersonic, a small additional deviation angle was added at this section to account for the supersonic expansion downstream of the throat. This amounted to about 0.5°.

Another angle of considerable importance in turbine blading design is the "unguided turning angle." This is defined as the angle between the tangent to the suction surface at the throat and the exit velocity diagram angle. The "unguided turning angle" then is a measure of the turning required of the uncovered portion of the trailing suction surface. For nozzles, this angle was kept under 7°; for buckets, this angle was kept under 10°.

At the bucket root section, the suction surface leading edge was set tangent to the incoming air angle. In the final design, where the sections were developed on cylindrical surfaces, the bucket leading edge of the root section was outside of the actual flowpath. The equivalent leading-edge air angle for this section was obtained by extrapolation of the calculated velocity diagram angles to this radius. Leading-edge angles for all other sections were set by eye and resulted in slightly negative incidence angles relative to the section mean lines.

Turbine Design Details

Figure 24 shows the flowpath details for the initial and final designs respectively. Tables 7 and 8 are the computer printouts for the initial and final designs respectively. These printouts give the details of the velocity diagrams, fluid properties, and various loading and performance parameters.

Figures 25 through 28 show the blading profiles. Tables 9 and 10 list some of the important blade profile parameters. Tables 11 and 12 list coordinates of the turbine blade profiles.

TURBINE MECHANICAL DESIGN

The turbine disk has been designed for minimum weight and stress. It will be of integral construction (that is, buckets investment cast integral with the wheel). The tentative material is MAR-M alloy 246 produced by Martin Marietta. This material was chosen for its high temperature strength characteristics.

The disk stresses were calculated using the equations and methods described in reference 24. The method is essentially a finite difference solution of the equilibrium and compatibility equations for elastic stresses in a symmetrical disk. Account can be taken of point to point variations in disk thickness, temperature, elastic modulus, coefficient of thermal expansion, material density and in Poisson's ratio. The most recent summary of stresses (including thermal effects) are listed in table 13.

The bucket temperature is expected to be 1097°K (1515°F) which is the temperature used for the disk rim temperature. The disk temperature distribution calculations were described in the

"Bearing System" subsection of this report.

The bucket root stress due to centrifugal effects is 43, 430 N/cm^2 (63,000 lbs/in.^{2}). The stress is calculated using equation 18. The airfoil shape produces a relatively stiff bucket, however, vibrational analysis should be done prior to release of the turbine rotor to manufacturing.

EXHAUST NOZZLE

The basic flow parameters were obtained from a computer run of the program described in appendix E. The following conditions were used a basis for the exhaust nozzle design:

Velocity at turbine exit	340 m/sec (117 ft/sec)
Airflow	0.86 kg/sec (1.9 lbs/sec)
Total temperature	1050°K (1890°R)
Static temperature	989°K (1780°R)
Total pressure	19.87 N/cm^2 (28.82 lbs/in.^{2})
Turbine exit area	52.84 cm^2 (8.19 in.^{2})
Ratio of specific heats	1.312

It was desired to keep the total length of the engine as short as possible, preferably within 19.3 cm (7.6 in.). Three types of nozzle configurations were considered: conventional plug, concave base, and short plug. As seen in figure 29, minimum length can be attained only with the concave base on the short plug. The estimates of discharge coefficient C_D and thrust coefficient C_T shown in table 14 were based on information in references 27 and 28.

The concave base appears to afford the best compromise between length and thrust coefficient; however, there is some question regarding the stability of this type of nozzle. Since changing nozzle configurations would be relatively simple and inexpensive, it is recommended that all three types shown in figure 29 be tested.

APPENDIX A

CONFIGURATION SELECTION

PROGRAM INPUT AND OUPUT DATA EXAMPLES

Appendix A includes tables A-1 and A-2 which list independent input variables to the configuration selection program for the candidate 4- and 5-stage axial-flow compressor designs. As an example of the configuration selection program output, the computer output for the 5-stage compressor is also shown on pages 47 to 57.

TABLE A-1.- CONFIGURATION SELECTION PROGRAM INPUT FOR 4-STAGE CANDIDATE COMPRESSOR

Variable	Value Assigned
Working fluid constant pressure specific heat joules/(kg)(°R) [btu/(lbm)(°F)]	1005 (0.240)
Working fluid molecular weight kg/kg mole (lbm/lb mole)	28.97 (28.97)
Working fluid specific heat ratio	1.40
Compressor inlet total temperature °K (°R)	288 (518.7)
Compressor inlet total absolute pressure N/cm² (lbs/in.²)	10.131 (14.696)
Minimum acceptable compressor total pressure ratio	4.75
First rotor inlet tip radius cm (in.)	4.57 (1.80)
First rotor inlet blade tip speed m/sec (ft/sec)	396 (1300)
First rotor inlet hub-to-tip radius ratio	0.591
First rotor inlet tip axial velocity component m/sec (ft/sec)	197 (646)
Number of stream surfaces prescribed for computation	11

Stage Variable	Stage			
	1	2	3	4
Rotor polytropic efficiency	0.86	0.86	0.86	0.86
Stage polytropic efficiency	0.82	0.83	0.83	0.83
Maximum rotor tip diffusion parameter	0.35	0.42	0.45	0.45
Maximum stator hub diffusion parameter	0.60	0.60	0.60	0.60
Maximum stator hub Mach number	0.90	0.90	0.90	0.90
Exit/inlet axial velocity ratio rotor tip	0.930	0.920	0.917	0.912
Exit/inlet axial velocity ratio stator tip	1.040	1.042	1.045	1.047
Tangential velocity stator exit (all radii) m/sec (ft/sec)	0	0	0	0
Rotor inlet mass flow blockage factor tip/hub	0.99/0.99	0.98/0.98	0.97/0.97	0.97/0.97
Rotor exit mass flow blockage factor tip/hub	0.98/0.98	0.97/0.97	0.97/0.97	0.97/0.97
Stator exit mass flow blockage factor tip/hub	0.98/0.98	0.97/0.97	0.97/0.97	0.97/0.97
Rotor tip solidity	1.300	1.040	0.995	0.952
Stator hub solidity	1.700	1.520	1.390	1.305
Rotor blade row aspect ratio	2.000	1.700	1.368	1.117
Stator blade row aspect ratio	1.800	1.500	1.235	1.017
Allowable passage convergence (ramp) angle rotor tip/rotor hub deg/deg	0/40	0/40	0/40	0/40
Allowable passage convergence (ramp) angle stator tip/stator hub deg/deg	0/40	0/40	0/40	0/40

TABLE A-2.- CONFIGURATION SELECTION PROGRAM INPUT FOR 5-STAGE CANDIDATE COMPRESSOR

Variable	Value Assigned
Working fluid constant pressure specific heat joules/(kg)(°K) [btu/(lbm)(°F)]	1005 (0.240)
Working fluid molecular weight kg/kg mole (lbm/lb mole)	28.97 (28.97)
Working fluid specific heat ratio	1.40
Compressor inlet total temperature (°K)	288 (518.7)
Compressor inlet total absolute pressure N/cm² (lb/in.²)	10.131 (14.696)
Minimum acceptable compressor total pressure ratio	4.75
First rotor inlet tip radius cm (in.)	4.57 (1.80)
First rotor inlet blade tip speed m/sec (ft/sec)	373 (1225)
First rotor inlet hub-to-tip radius ratio	0.591
First rotor inlet tip axial velocity component m/sec (ft/sec)	197 (646)
Number of stream surfaces prescribed for computation	11

Stage Variable	Stage				
	1	2	3	4	5
Rotor polytropic efficiency	0.86	0.86	0.86	0.86	0.86
Stage polytropic efficiency	0.82	0.83	0.83	0.83	0.83
Maximum rotor tip diffusion parameter	0.35	0.40	0.39	0.37	0.35
Maximum stator hub diffusion parameter	0.60	0.60	0.60	0.60	0.60
Maximum stator hub Mach number	0.90	0.90	0.90	0.90	0.90
Exit/inlet axial velocity ratio rotor tip	0.930	0.928	0.934	0.940	0.956
Exit/inlet axial velocity ratio stator tip	1.042	1.043	1.037	1.028	1.020
Tangential velocity exit (all radii) m/sec (ft/sec)	0	0	0	0	0
Rotor inlet mass flow blockage factor tip/hub	0.998/0.998	0.98/0.98	0.98/0.98	0.98/0.98	0.98/0.98
Rotor exit mass flow blockage factor tip/hub	0.99/0.99	0.98/0.98	0.98/0.98	0.98/0.98	0.98/0.98
Stator exit mass flow blockage factor tip/hub	0.98/0.98	0.98/0.98	0.98/0.98	0.98/0.98	0.98/0.98
Rotor tip solidity	1.300	1.040	0.995	0.952	0.907
Stator hub solidity	1.600	1.440	1.320	1.220	1.150
Rotor blade row aspect ratio	2.000	1.700	1.368	1.117	0.934
Stator blade row aspect ratio	1.800	1.500	1.235	1.017	0.900
Allowable passage convergence (ramp) angle rotor tip/rotor hub deg/deg	0/40	0/40	0/40	0/40	0/40
Allowable passage convergence (ramp) angle stator tip/stator hub deg/deg	0/40	0/40	0/40	0/40	0/40

COMPRESSOR DESIGN EXAMPLE TD-012

-- PARAMETRIC STUDY OF ADVANCED MULTISTAGE AXIAL-FLOW COMPRESSORS ***--***

*** R O T O R I N L E T I N P U T D A T A ***

NO. RAD. STATIONS	NUMBER STAGES	SP. HEAT (BTU/(LB-R))	MOL. WT. (MOLES)	RATIO OF SP. HEAT	IN. TOT. TEMP. (DEG. R)	IN. TOT. PR. (PSI)	MASS AVG. TOT. PR. RATIO
11	6	0.2400	28.9700	1.4000	518.7000	14.6960	4.7500

TIP RADIUS (INCHES)	TIP WHEEL SPEED (FT/SEC)	HUB TO TIP RADIUS RATIO	AXIAL VEL. (FT/SEC)	TIP BLOCKAGE FACTOR	HUB BLOCKAGE FACTOR
1.8000	1225.0000	0.5910	646.0000	0.9980	0.9980

COEFFICIENTS IN TANGENTIAL VELOCITY EQUATION

B	C	D	E
0.0	0.0	0.0	0.0

****

******** S T A G E   D A T A ********

STAGE NO. 1

*** ROTOR INPUT DATA ***

AXIAL VEL. RATIO	POLYTROPIC EFFICIENCY	SOLIDITY AT TIP	ASPECT RATIO	TIP BLOCKAGE FACTOR	HUB BLOCKAGE FACTOR	MAX ANGLE HUB TAPER (DEGREES)	MAX ANGLE TIP TAPER (DEGREES)
0.9300	0.8600	1.3000	2.0000	0.9900	0.9900	40.000	0.0

COEFFICIENTS IN TANGENTIAL VELOCITY EQUATION

MAX ROTOR DIF. FACTOR	MIN REL. FLOW ANGLE ROTOR HUB (DEGREES)			B	C	D	E
0.3500	0.0			0.0	0.0	0.0	0.0

*** STATOR INPUT DATA ***

AXIAL VELOCITY RATIO	TOTAL POLYTROPIC EFFICIENCY	SOLIDITY AT HUB	ASPECT RATIO	TIP BLOCKAGE FACTOR	HUB BLOCKAGE FACTOR	MAX ANGLE HUB TAPER (DEGREES)	MAX ANGLE TIP TAPER (DEGREES)
1.0520	0.8200	1.6000	1.8000	0.9800	0.9800	40.0000	0.0

COEFFICIENTS IN TANGENTIAL VELOCITY EQUATION

MAX. STATOR DIF. FACTOR	MAX HUB INLET MACH NUMBER			B	C	D	E
0.6000	0.9000			0.0	0.0	0.0	0.0

--**-- S T A G E   O U T P U T   D A T A ***--**--***

MASS FLOW (LB/SEC) = 1.903

OVERALL MASS AVE. PR. RATIO	OVERALL MASS AVE. TEMP. RATIO	OVERALL MASS AVE. EFFECIENCY	MASS AVE. PRESSURE RATIO	MASS AVE. TEMPERATURE RATIO	MASS AVE. EFFICIENCY	ROTOR ASPECT RATIO	STATOR ASPECT RATIO
1.4802	1.1464	0.8098	1.4802	1.1464	0.8098	2.0000	1.8000

ROTOR TIP RAD. 1-G (INCHES)	ROTOR HUB RAD. 1-G (INCHES)	ROTOR TIP RAD. 2-G (INCHES)	ROTOR HUB RAD. 2-G (INCHES)	STATOR TIP RAD. 3-G (INCHES)	STATOR HUB RAD. 3-G (INCHES)	ROTOR PROJ. LENGTH (INCHES)	STATOR PROJ. LENGTH (INCHES)
1.8000	1.0638	1.8000	1.1965	1.8000	1.2439	0.3681	0.3353

ROTOR TIP RAMP ANGLE (DEGREES)	ROTOR HUB RAMP ANGLE (DEGREES)	STATOR TIP RAMP ANGLE (DEGREES)	STATOR HUB RAMP ANGLE (DEGREES)
0.0	19.8301	0.0	8.0400

--**-- ROTOR INLET OUTPUT DATA ***--**--***

STA NO.	RADIUS -E (IN)	WHEEL SPEED (FT/SEC)	AXIAL VEL. (FT/SEC)	TANGENT. VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	REL. VEL. (FT/SEC)	ABS. AIR ANG. (DEG)	REL. AIR ANG. (DEG)	TOTAL TEMP. (DEG R)	TOTAL PRESS. (PSI)	REL. MACH NO.	ABS. MACH NO.	LOSS COEFF
1	1.799	1224.202	646.000	0.0	646.000	1384.189	0.0	62.180	518.700	14.696	1.284	0.599	0.102
2	1.726	1174.314	646.000	0.0	646.000	1340.271	0.0	61.184	518.700	14.696	1.243	0.599	0.107
3	1.652	1124.426	646.000	0.0	646.000	1296.783	0.0	60.122	518.700	14.696	1.203	0.599	0.112
4	1.579	1074.537	646.000	0.0	646.000	1253.771	0.0	58.986	518.700	14.696	1.163	0.599	0.117
5	1.506	1024.649	646.000	0.0	646.000	1211.208	0.0	57.770	518.700	14.696	1.123	0.599	0.123
6	1.432	974.761	646.000	0.0	646.000	1169.390	0.0	56.466	518.700	14.696	1.084	0.599	0.130
7	1.359	924.873	646.000	0.0	646.000	1128.142	0.0	55.067	518.700	14.696	1.046	0.599	0.136
8	1.286	874.984	646.000	0.0	646.000	1087.618	0.0	53.562	518.700	14.696	1.009	0.599	0.144
9	1.212	825.096	646.000	0.0	646.000	1047.902	0.0	51.941	518.700	14.696	0.972	0.599	0.152
10	1.139	775.208	646.000	0.0	646.000	1009.090	0.0	50.195	518.700	14.696	0.936	0.599	0.161
11	1.066	725.320	646.000	0.0	646.000	971.290	0.0	48.310	518.700	14.696	0.901	0.599	0.171

--**-- ROTOR EXIT OUTPUT DATA ***--**--***

STA NO.	RADIUS -E (IN)	WHEEL SPEED (FT/SEC)	AXIAL VEL. (FT/SEC)	TANGENT. VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	REL. VEL. (FT/SEC)	ABS. AIR ANG. (DEG)	REL. AIR ANG. (DEG)	TOTAL TEMP. (DEG R)	TOTAL PRESS. (PSI)	ROTOR DIF. FACTOR	REL. MACH NO.	ABS. MACH NO.	LOSS FUNC
1	1.795	1221.576	600.780	373.487	707.410	1039.322	31.868	54.686	594.655	22.174	0.353	0.902	0.614	0.023
2	1.736	1181.362	600.780	386.201	714.204	996.603	32.734	52.927	594.655	22.174	0.361	0.865	0.620	0.024
3	1.677	1141.148	600.780	399.810	721.655	954.211	33.643	50.979	594.655	22.174	0.369	0.829	0.627	0.025
4	1.618	1100.935	600.780	414.414	729.846	912.275	34.598	48.811	594.655	22.174	0.378	0.793	0.635	0.026
5	1.559	1060.721	600.780	430.125	738.881	870.969	35.601	46.387	594.655	22.174	0.387	0.758	0.643	0.028
6	1.500	1020.507	600.780	447.075	748.874	830.519	36.655	43.666	594.655	22.174	0.397	0.724	0.653	0.029
7	1.440	980.293	600.780	465.415	759.966	791.225	37.764	40.597	594.655	22.174	0.407	0.690	0.663	0.031
8	1.381	940.079	600.780	485.324	772.319	753.485	38.932	37.124	594.655	22.174	0.417	0.658	0.675	0.033
9	1.322	899.865	600.780	507.012	786.129	717.823	40.162	33.181	594.655	22.174	0.427	0.628	0.688	0.034
10	1.263	859.652	600.780	530.730	801.630	684.928	41.457	28.700	594.655	22.174	0.435	0.601	0.703	0.036
11	1.204	819.438	600.780	556.775	819.107	655.689	42.823	23.615	594.655	22.174	0.440	0.576	0.720	0.038

--**-- STATOR EXIT OUTPUT DATA ***--**--***

STA NO.	RADIUS -E (IN)	AXIAL VEL. (FT/SEC)	TANGENT. VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. AIR ANG. (DEG)	LOSS COEFF	STATOR DIF. FACTOR	AXIAL MACH NO.	ABS. MACH NO.	LOSS FUNC
1	1.791	626.012	0.0	626.012	0.0	0.084	0.355	0.539	0.539	0.039
2	1.737	626.013	0.0	626.013	0.0	0.083	0.362	0.539	0.539	0.037
3	1.684	626.013	0.0	626.013	0.0	0.081	0.369	0.539	0.539	0.035
4	1.631	626.013	0.0	626.013	0.0	0.080	0.376	0.539	0.539	0.033
5	1.577	626.013	0.0	626.013	0.0	0.078	0.385	0.539	0.539	0.031
6	1.524	626.013	0.0	626.013	0.0	0.076	0.393	0.539	0.539	0.029
7	1.471	626.013	0.0	626.013	0.0	0.074	0.403	0.539	0.539	0.028
8	1.417	626.013	0.0	626.013	0.0	0.072	0.413	0.539	0.539	0.026
9	1.364	626.013	0.0	626.013	0.0	0.070	0.424	0.539	0.539	0.024
10	1.311	626.013	0.0	626.013	0.0	0.067	0.435	0.539	0.539	0.022
11	1.257	626.013	0.0	626.013	0.0	0.065	0.449	0.539	0.539	0.020

******** S T A G E   D A T A ********

STAGE NO. 2

*** ROTOR INPUT DATA ***

AXIAL VEL. RATIO	POLYTROPIC EFFICIENCY	SOLIDITY AT TIP	ASPECT RATIO	TIP BLOCKAGE FACTOR	HUB BLOCKAGE FACTOR	MAX ANGLE HUB TAPER (DEGREES)	MAX ANGLE TIP TAPER (DEGREES)
0.9280	0.8600	1.0400	1.7000	0.9800	0.9800	40.000	0.0

MAX ROTOR DIF. FACTOR	MIN REL. FLOW ANGLE ROTOR HUB (DEGREES)			COEFFICIENTS IN TANGENTIAL VELOCITY EQUATION B	C	D	E
0.4000	0.0			0.0	0.0	0.0	0.0

*** STATOR INPUT DATA ***

AXIAL VELOCITY RATIO	TOTAL POLYTROPIC EFFICIENCY	SOLIDITY AT HUB	ASPECT RATIO	TIP BLOCKAGE FACTOR	HUB BLOCKAGE FACTOR	MAX ANGLE HUB TAPER (DEGREES)	MAX ANGLE TIP TAPER (DEGREES)
1.0430	0.8300	1.4400	1.5000	0.9800	0.9800	40.0000	0.0

MAX. STATOR DIF. FACTOR	MAX HUB INLET MACH NUMBER			COEFFICIENTS IN TANGENTIAL VELOCITY EQUATION B	C	D	E
0.6000	0.9000			0.0	0.0	0.0	0.0

--**-- S T A G E   O U T P U T   D A T A ***--**--***

MASS FLOW (LB/SEC) = 1.903

OVERALL MASS AVE. PR. RATIO	OVERALL MASS AVE. TEMP. RATIO	OVERALL MASS AVE. EFFICIENCY	MASS AVE. PRESSURE RATIO	MASS AVE. TEMPERATURE RATIO	MASS AVE. EFFICIENCY	ROTOR ASPECT RATIO	STATOR ASPECT RATIO
2.1472	1.3030	0.8052	1.4506	1.1366	0.8208	1.7000	1.5000

ROTOR TIP RAD. 1-G (INCHES)	ROTOR HUB RAD. 1-G (INCHES)	ROTOR TIP RAD. 2-G (INCHES)	ROTOR HUB RAD. 2-G (INCHES)	STATOR TIP RAD. 3-G (INCHES)	STATOR HUB RAD. 3-G (INCHES)	ROTOR PROJ. LENGTH (INCHES)	STATOR PROJ. LENGTH (INCHES)
1.8000	1.2439	1.8000	1.3347	1.8000	1.3799	0.3271	0.3102

ROTOR TIP RAMP ANGLE (DEGREES)	ROTOR HUB RAMP ANGLE (DEGREES)	STATOR TIP RAMP ANGLE (DEGREES)	STATOR HUB RAMP ANGLE (DEGREES)
0.0	15.5222	0.0	8.2753

--**-- ROTOR INLET OUTPUT DATA ***--**--***

STA NO.	RADIUS -E (IN)	WHEEL SPEED (FT/SEC)	AXIAL VEL. (FT/SEC)	TANGENT. VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	REL. VEL. (FT/SEC)	ABS. AIR ANG. (DEG)	REL. AIR ANG. (DEG)	TOTAL TEMP. (DEG R)	TOTAL PRESS. (PSI)	REL. MACH NO.	ABS. MACH NO.	LOSS COEFF
1	1.791	1218.583	626.012	0.0	626.012	1369.975	0.0	62.809	594.655	21.754	1.179	0.539	0.106
2	1.737	1182.300	626.013	0.0	626.013	1337.804	0.0	62.099	594.655	21.754	1.151	0.539	0.109
3	1.684	1146.016	626.013	0.0	626.013	1305.849	0.0	61.354	594.655	21.754	1.124	0.539	0.113
4	1.631	1109.733	626.013	0.0	626.013	1274.125	0.0	60.572	594.655	21.754	1.096	0.539	0.117
5	1.577	1073.450	626.013	0.0	626.013	1242.652	0.0	59.750	594.655	21.754	1.069	0.539	0.121
6	1.524	1037.167	626.013	0.0	626.013	1211.447	0.0	58.886	594.655	21.754	1.042	0.539	0.126
7	1.471	1000.883	626.013	0.0	626.013	1180.532	0.0	57.976	594.655	21.754	1.016	0.539	0.130
8	1.417	964.600	626.013	0.0	626.013	1149.932	0.0	57.017	594.655	21.754	0.990	0.539	0.135
9	1.364	928.316	626.013	0.0	626.013	1119.671	0.0	56.006	594.655	21.754	0.963	0.539	0.141
10	1.311	892.033	626.013	0.0	626.013	1089.777	0.0	54.939	594.655	21.754	0.938	0.539	0.147
11	1.257	855.750	626.013	0.0	626.013	1060.287	0.0	53.813	594.655	21.754	0.912	0.539	0.153

--**-- ROTOR EXIT OUTPUT DATA ***--**--***

STA NO.	RADIUS -E (IN)	WHEEL SPEED (FT/SEC)	AXIAL VEL. (FT/SEC)	TANGENT. VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	REL. VEL. (FT/SEC)	ABS. AIR ANG. (DEG)	REL. AIR ANG. (DEG)	TOTAL TEMP. (DEG R)	TOTAL PRESS. (PSI)	ROTOR DIF. FACTOR	REL. MACH NO.	ABS. MACH NO.	LOSS FUNC
1	1.792	1219.472	580.939	400.118	705.397	1004.406	34.557	54.663	675.886	31.982	0.406	0.813	0.571	0.029
2	1.747	1189.103	580.937	410.337	711.241	971.577	35.235	53.278	675.886	31.982	0.414	0.787	0.576	0.030
3	1.703	1158.732	580.940	421.092	717.502	938.938	35.936	51.777	675.886	31.982	0.422	0.761	0.582	0.032
4	1.658	1128.363	580.940	432.426	724.212	906.542	36.662	50.146	675.886	31.982	0.431	0.736	0.588	0.033
5	1.613	1097.992	580.940	444.386	731.417	874.466	37.414	48.369	675.886	31.982	0.440	0.710	0.594	0.034
6	1.569	1067.623	580.940	457.027	739.165	842.803	38.192	46.426	675.886	31.982	0.450	0.685	0.601	0.036
7	1.524	1037.252	580.937	470.409	747.511	811.665	38.998	44.296	675.886	31.982	0.460	0.660	0.608	0.037
8	1.480	1006.883	580.937	484.597	756.520	781.198	39.834	41.957	675.886	31.982	0.469	0.636	0.616	0.039
9	1.435	976.512	580.940	499.669	766.263	751.579	40.699	39.380	675.886	31.982	0.479	0.612	0.624	0.041
10	1.390	946.143	580.937	515.707	776.815	723.023	41.596	36.536	675.886	31.982	0.489	0.590	0.634	0.043
11	1.346	915.772	580.937	532.810	788.273	695.808	42.526	33.393	675.886	31.982	0.499	0.568	0.644	0.044

--**-- STATOR EXIT OUTPUT DATA ***--**--***

STA NO.	RADIUS -E (IN)	AXIAL VEL. (FT/SEC)	TANGENT. VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. AIR ANG. (DEG)	LOSS COEFF	STATOR DIF. FACTOR	AXIAL MACH NO.	ABS. MACH NO.	LOSS FUNC
1	1.793	605.919	0.0	605.919	0.0	0.067	0.399	0.487	0.487	0.031
2	1.752	605.917	0.0	605.917	0.0	0.066	0.404	0.487	0.487	0.030
3	1.712	605.919	0.0	605.919	0.0	0.065	0.410	0.487	0.487	0.028
4	1.672	605.919	0.0	605.919	0.0	0.064	0.416	0.497	0.487	0.027
5	1.631	605.919	0.0	605.919	0.0	0.063	0.422	0.487	0.487	0.026
6	1.591	605.919	0.0	605.919	0.0	0.062	0.429	0.487	0.487	0.025
7	1.551	605.917	0.0	605.917	0.0	0.060	0.435	0.487	0.487	0.024
8	1.510	605.917	0.0	605.917	0.0	0.059	0.442	0.487	0.487	0.023
9	1.470	605.919	0.0	605.919	0.0	0.058	0.450	0.487	0.487	0.021
10	1.430	605.917	0.0	605.917	0.0	0.056	0.458	0.487	0.487	0.020
11	1.390	605.917	0.0	605.917	0.0	0.055	0.466	0.487	0.487	0.019

******** S T A G E   D A T A ********

STAGE NO. 3

*** ROTOR INPUT DATA ***

AXIAL VEL. RATIO	POLYTROPIC EFFICIENCY	SOLIDITY AT TIP	ASPECT RATIO	TIP BLOCKAGE FACTOR	HUB BLOCKAGE FACTOR	MAX ANGLE HUB TAPER (DEGREES)	MAX ANGLE TIP TAPER (DEGREES)
0.9340	0.8600	0.9950	1.3680	0.9000	0.9800	40.000	0.0

MAX ROTOR DIF. FACTOR	MIN REL. FLOW ANGLE ROTOR HUB (DEGREES)	COEFFICIENTS IN TANGENTIAL VELOCITY EQUATION B	C	D	E
0.3900	0.0	0.0	0.0	0.0	0.0

*** STATOR INPUT DATA ***

AXIAL VELOCITY RATIO	TOTAL POLYTROPIC EFFICIENCY	SOLIDITY AT HUB	ASPECT RATIO	TIP BLOCKAGE FACTOR	HUB BLOCKAGE FACTOR	MAX ANGLE HUB TAPER (DEGREES)	MAX ANGLE TIP TAPER (DEGREES)
1.0370	0.8300	1.3200	1.2350	0.9800	0.9800	40.0000	0.0

MAX. STATOR DIF. FACTOR	MAX HUB INLET MACH NUMBER	COEFFICIENTS IN TANGENTIAL VELOCITY EQUATION B	C	D	E
0.6000	0.9000	0.0	0.0	0.0	0.0

--**-- S T A G E   O U T P U T   D A T A ***--**--***

MASS FLOW (LB/SEC) = 1.903

OVERALL MASS AVE. PR. RATIO	OVERALL MASS AVE. TEMP. RATIO	OVERALL MASS AVE. EFFICIENCY	MASS AVE. PRESSURE RATIO	MASS AVE. TEMPERATURE RATIO	MASS AVE. EFFICIENCY	ROTOR ASPECT RATIO	STATOR ASPECT RATIO
2.9392	1.4518	0.7985	1.3689	1.1141	0.8223	1.3680	1.2350

ROTOR TIP RAD. 1-G (INCHES)	ROTOR HUB RAD. 1-G (INCHES)	ROTOR TIP RAD. 2-G (INCHES)	ROTOR HUB RAD. 2-G (INCHES)	STATOR TIP RAD. 3-G (INCHES)	STATOR HUB RAD. 3-G (INCHES)	ROTOR PROJ. LENGTH (INCHES)	STATOR PROJ. LENGTH (INCHES)
1.8000	1.3759	1.8000	1.4348	1.8000	1.4622	0.3071	0.2957

ROTOR TIP RAMP ANGLE (DEGREES)	ROTOR HUB RAMP ANGLE (DEGREES)	STATOR TIP RAMP ANGLE (DEGREES)	STATOR HUB RAMP ANGLE (DEGREES)
0.0	10.1449	0.0	5.2931

--**-- ROTOR INLET OUTPUT DATA ***--**--***

STA NO.	RADIUS -E (IN)	WHEEL SPEED (FT/SEC)	AXIAL VEL. (FT/SEC)	TANGENT. VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	REL. VEL. (FT/SEC)	ABS. AIR ANG. (DEG)	REL. AIR ANG. (DEG)	TOTAL TEMP. (DEG R)	TOTAL PRESS. (PSI)	REL. MACH NO.	ABS. MACH NO.	LOSS COEFF
1	1.793	1219.938	605.919	0.0	605.919	1362.123	0.0	63.587	675.886	31.555	1.094	0.487	0.098
2	1.752	1192.567	605.917	0.0	605.917	1337.610	0.0	63.065	675.886	31.555	1.074	0.487	0.100
3	1.712	1165.077	605.919	0.0	605.919	1313.217	0.0	62.522	675.886	31.555	1.055	0.487	0.103
4	1.672	1137.646	605.919	0.0	605.919	1288.543	0.0	61.960	675.886	31.555	1.035	0.487	0.106
5	1.631	1110.216	605.919	0.0	605.919	1264.797	0.0	61.376	675.886	31.555	1.016	0.487	0.109
6	1.591	1082.785	605.919	0.0	605.919	1240.790	0.0	60.769	675.886	31.555	0.996	0.487	0.112
7	1.551	1055.355	605.917	0.0	605.917	1216.924	0.0	60.130	675.886	31.555	0.977	0.487	0.115
8	1.510	1027.924	605.917	0.0	605.917	1193.213	0.0	59.482	675.886	31.555	0.958	0.487	0.118
9	1.470	1000.494	605.919	0.0	605.919	1169.667	0.0	58.800	675.886	31.555	0.939	0.487	0.122
10	1.430	973.063	605.917	0.0	605.917	1146.291	0.0	58.090	675.886	31.555	0.921	0.487	0.125
11	1.390	945.633	605.917	0.0	605.917	1123.100	0.0	57.350	675.886	31.555	0.902	0.487	0.129

--**-- ROTOR EXIT OUTPUT DATA ***--**--***

STA NO.	RADIUS -E (IN)	WHEEL SPEED (FT/SEC)	AXIAL VEL. (FT/SEC)	TANGENT. VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	REL. VEL. (FT/SEC)	ABS. AIR ANG. (DEG)	REL. AIR ANG. (DEG)	TOTAL TEMP. (DEG R)	TOTAL PRESS. (PSI)	ROTOR DIF. FACTOR	REL. MACH NO.	ABS. MACH NO.	LOSS FUNC
1	1.793	1220.524	565.928	379.662	681.482	1013.570	33.856	56.058	753.031	43.688	0.395	0.774	0.520	0.027
2	1.758	1196.677	565.927	387.228	685.725	987.664	34.381	55.041	753.031	43.688	0.402	0.754	0.524	0.028
3	1.723	1172.830	565.931	395.101	690.205	961.842	34.921	53.958	753.031	43.688	0.409	0.735	0.527	0.029
4	1.688	1148.983	565.928	403.302	694.929	936.117	35.475	52.804	753.031	43.688	0.416	0.715	0.531	0.030
5	1.653	1125.135	565.928	411.850	699.925	910.523	36.045	51.571	753.031	43.688	0.424	0.696	0.535	0.031
6	1.618	1101.288	565.931	420.768	705.212	885.091	36.631	50.253	753.031	43.688	0.432	0.677	0.539	0.032
7	1.583	1077.441	565.927	430.081	710.804	859.853	37.233	48.840	753.031	43.688	0.440	0.658	0.544	0.033
8	1.548	1053.594	565.927	439.815	716.736	834.863	37.853	47.323	753.031	43.688	0.449	0.639	0.549	0.034
9	1.513	1029.747	565.931	450.001	723.034	810.174	38.490	45.691	753.031	43.688	0.457	0.620	0.554	0.035
10	1.478	1005.899	565.927	460.669	729.719	785.843	39.146	43.933	753.031	43.688	0.466	0.602	0.559	0.037
11	1.443	982.052	565.927	471.855	736.832	761.954	39.820	42.035	753.031	43.688	0.475	0.584	0.565	0.038

--**-- STATOR EXIT OUTPUT DATA ***--**--***

STA NO.	RADIUS -E (IN)	AXIAL VEL. (FT/SEC)	TANGENT. VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. AIR ANG. (DEG)	LOSS COEFF	STATOR DIF. FACTOR	AXIAL MACH NO.	ABS. MACH NO.	LOSS FUNC
1	1.794	586.867	0.0	586.867	0.0	0.067	0.399	0.445	0.445	0.031
2	1.761	586.866	0.0	586.866	0.0	0.066	0.403	0.445	0.445	0.030
3	1.729	586.871	0.0	586.871	0.0	0.065	0.407	0.445	0.445	0.030
4	1.697	586.868	0.0	586.868	0.0	0.065	0.411	0.445	0.445	0.029
5	1.664	586.868	0.0	586.868	0.0	0.064	0.415	0.445	0.445	0.028
6	1.632	586.871	0.0	586.871	0.0	0.063	0.423	0.445	0.445	0.027
7	1.599	586.866	0.0	586.866	0.0	0.062	0.425	0.445	0.445	0.026
8	1.567	586.866	0.0	586.866	0.0	0.061	0.430	0.445	0.445	0.025
9	1.535	586.871	0.0	586.871	0.0	0.060	0.435	0.445	0.445	0.024
10	1.502	586.865	0.0	586.866	0.0	0.059	0.440	0.445	0.445	0.023
11	1.470	586.866	0.0	586.866	0.0	0.058	0.446	0.445	0.445	0.022

******** S T A G E   D A T A ********

STAGE NO. 4

*** ROTOR INPUT DATA ***

AXIAL VEL. RATIO	POLYTROPIC EFFICIENCY	SOLIDITY AT TIP	ASPECT RATIO	TIP BLOCKAGE FACTOR	HUB BLOCKAGE FACTOR	MAX ANGLE HUB TAPER (DEGREES)	MAX ANGLE TIP TAPER (DEGREES)
0.9400	0.8600	0.9520	1.1170	0.9800	0.9800	40.000	0.0

MAX ROTOR DIF. FACTOR	MIN REL. FLOW ANGLE ROTOR HUB (DEGREES)	COEFFICIENTS IN TANGENTIAL VELOCITY EQUATION B	C	D	E
0.3700	0.0	0.0	0.0	0.0	0.0

*** STATOR INPUT DATA ***

AXIAL VELOCITY RATIO	TOTAL POLYTROPIC EFFICIENCY	SOLIDITY AT HUB	ASPECT RATIO	TIP BLOCKAGE FACTOR	HUB BLOCKAGE FACTOR	MAX ANGLE HUB TAPER (DEGREES)	MAX ANGLE TIP TAPER (DEGREES)
1.0280	0.8300	1.2200	1.0170	0.9800	0.9800	40.0000	0.0

MAX. STATOR DIF. FACTOR	MAX HUB INLET MACH NUMBER	COEFFICIENTS IN TANGENTIAL VELOCITY EQUATION B	C	D	E
0.6000	0.9000	0.0	0.0	0.0	0.0

--**-- S T A G E   O U T P U T   D A T A ***--**--***

MASS FLOW (LB/SEC) = 1.903

OVERALL MASS AVE. PR. RATIO	OVERALL MASS AVE. TEMP. RATIO	OVERALL MASS AVE. EFFICIENCY	MASS AVE. PRESSURE RATIO	MASS AVE. TEMPERATURE RATIO	MASS AVE. EFFICIENCY	ROTOR ASPECT RATIO	STATOR ASPECT RATIO
3.8225	1.5892	0.7923	1.3005	1.0947	0.8236	1.1170	1.0170

ROTOR TIP RAD. 1-G (INCHES)	ROTOR HUB RAD. 1-G (INCHES)	ROTOR TIP RAD. 2-G (INCHES)	ROTOR HUB RAD. 2-G (INCHES)	STATOR TIP RAD. 3-G (INCHES)	STATOR HUB RAD. 3-G (INCHES)	ROTOR PROJ. LENGTH (INCHES)	STATOR PROJ. LENGTH (INCHES)
1.8000	1.4622	1.8000	1.4976	1.8000	1.5146	0.3024	0.2974

ROTOR TIP RAMP ANGLE (DEGREES)	ROTOR HUB RAMP ANGLE (DEGREES)	STATOR TIP RAMP ANGLE (DEGREES)	STATOR HUB RAMP ANGLE (DEGREES)
0.0	6.6673	0.0	3.2756

--**-- ROTOR INLET OUTPUT DATA ***--**--***

STA NO.	RADIUS -E (IN)	WHEEL SPEED (FT/SEC)	AXIAL VEL. (FT/SEC)	TANGENT. VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	REL. VEL. (FT/SEC)	ABS. AIR ANG. (DEG)	REL. AIR ANG. (DEG)	TOTAL TEMP. (DEG R)	TOTAL PRESS. (PSI)	REL. MACH NO.	ABS. MACH NO.	LOSS COEFF
1	1.794	1220.826	586.867	0.0	586.867	1354.556	0.0	64.326	753.031	43.195	1.027	0.445	0.089
2	1.761	1198.766	586.866	0.0	586.866	1334.708	0.0	63.915	753.031	43.195	1.012	0.445	0.091
3	1.729	1176.706	586.871	0.0	586.871	1314.933	0.0	63.493	753.031	43.195	0.997	0.445	0.093
4	1.697	1154.646	586.868	0.0	586.868	1295.228	0.0	63.057	753.031	43.195	0.982	0.445	0.095
5	1.664	1132.587	586.868	0.0	586.868	1275.603	0.0	62.608	753.031	43.195	0.967	0.445	0.097
6	1.632	1110.527	586.871	0.0	586.871	1256.058	0.0	62.145	753.031	43.195	0.952	0.445	0.099
7	1.599	1088.467	586.866	0.0	586.866	1236.594	0.0	61.668	753.031	43.195	0.937	0.445	0.101
8	1.567	1066.407	586.866	0.0	586.866	1217.223	0.0	61.175	753.031	43.195	0.923	0.445	0.104
9	1.535	1044.347	586.871	0.0	586.871	1197.947	0.0	60.666	753.031	43.195	0.908	0.445	0.106
10	1.502	1022.287	586.866	0.0	586.866	1178.761	0.0	60.141	753.031	43.195	0.893	0.445	0.109
11	1.470	1000.228	586.866	0.0	586.866	1159.683	0.0	59.598	753.031	43.195	0.879	0.445	0.112

--**-- ROTOR EXIT OUTPUT DATA ***--**--***

STA NO.	RADIUS -E (IN)	WHEEL SPEED (FT/SEC)	AXIAL VEL. (FT/SEC)	TANGENT. VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	REL. VEL. (FT/SEC)	ABS. AIR ANG. (DEG)	REL. AIR ANG. (DEG)	TOTAL TEMP. (DEG R)	TOTAL PRESS. (PSI)	ROTOR DIF. FACTOR	REL. MACH NO.	ABS. MACH NO.	LOSS FUNC
1	1.794	1221.223	551.655	350.630	653.655	1030.657	32.440	57.639	824.317	56.711	0.374	0.749	0.475	0.025
2	1.765	1201.470	551.653	356.394	656.763	1009.194	32.864	56.864	824.317	56.711	0.380	0.733	0.477	0.026
3	1.736	1181.717	551.658	362.352	660.020	987.768	33.299	56.049	824.317	56.711	0.386	0.718	0.480	0.026
4	1.707	1161.963	551.656	368.511	663.419	966.380	33.743	55.191	824.317	56.711	0.392	0.702	0.482	0.027
5	1.678	1142.210	551.656	374.885	666.980	945.046	34.199	54.286	824.317	56.711	0.399	0.687	0.485	0.028
6	1.649	1122.457	551.661	381.482	670.715	923.782	34.664	53.332	824.318	56.711	0.405	0.672	0.488	0.028
7	1.620	1102.704	551.653	388.315	674.618	902.591	35.142	52.325	824.317	56.711	0.412	0.657	0.491	0.029
8	1.591	1082.951	551.656	395.398	678.722	881.505	35.631	51.258	824.317	56.711	0.419	0.641	0.494	0.030
9	1.562	1063.198	551.661	402.745	683.032	860.539	36.132	50.129	824.318	56.711	0.426	0.626	0.497	0.031
10	1.533	1043.444	551.656	410.369	687.551	839.707	36.645	48.931	824.317	56.711	0.434	0.611	0.501	0.032
11	1.504	1023.691	551.656	418.287	692.307	819.046	37.171	47.660	824.317	56.711	0.441	0.597	0.504	0.033

--**-- STATOR EXIT OUTPUT DATA ***--**--***

STA NO.	RADIUS -E (IN)	AXIAL VEL. (FT/SEC)	TANGENT. VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. AIR ANG. (DEG)	LOSS COEFF	STATOR DIF. FACTOR	AXIAL MACH NO.	ABS. MACH NO.	LOSS FUNC
1	1.795	567.101	0.0	567.101	0.0	0.066	0.393	0.410	0.410	0.032
2	1.767	567.099	0.0	567.099	0.0	0.065	0.396	0.410	0.410	0.031
3	1.740	567.104	0.0	567.104	0.0	0.065	0.399	0.410	0.410	0.031
4	1.713	567.101	0.0	567.101	0.0	0.064	0.403	0.410	0.410	0.030
5	1.685	567.101	0.0	567.101	0.0	0.064	0.406	0.410	0.410	0.029
6	1.658	567.107	0.0	567.107	0.0	0.063	0.409	0.410	0.410	0.028
7	1.630	567.099	0.0	567.099	0.0	0.062	0.413	0.410	0.410	0.028
8	1.603	567.101	0.0	567.101	0.0	0.062	0.417	0.410	0.410	0.027
9	1.576	567.107	0.0	567.107	0.0	0.061	0.420	0.410	0.410	0.026
10	1.548	567.101	0.0	567.101	0.0	0.060	0.424	0.410	0.410	0.025
11	1.521	567.101	0.0	567.101	0.0	0.059	0.428	0.410	0.410	0.024

******** S T A G E   D A T A ********

STAGE NO. 5

*** ROTOR INPUT DATA ***

AXIAL VEL. RATIO	POLYTROPIC EFFICIENCY	SOLIDITY AT TIP	ASPECT RATIO	TIP BLOCKAGE FACTOR	HUB BLOCKAGE FACTOR	MAX ANGLE HUB TAPER (DEGREES)	MAX ANGLE TIP TAPER (DEGREES)
0.9560	0.8600	0.9070	0.9340	0.9800	0.9800	40.000	0.0

COEFFICIENTS IN TANGENTIAL VELOCITY EQUATION

MAX ROTOR DIF. FACTOR	MIN REL. FLOW ANGLE ROTOR HUB (DEGREES)	B	C	D	E
0.3500	0.0	0.0	0.0	0.0	0.0

*** STATOR INPUT DATA ***

AXIAL VELOCITY RATIO	TOTAL POLYTROPIC EFFICIENCY	SOLIDITY AT HUB	ASPECT RATIO	TIP BLOCKAGE FACTOR	HUB BLOCKAGE FACTOR	MAX ANGLE HUB TAPER (DEGREES)	MAX ANGLE TIP TAPER (DEGREES)
1.0200	0.8300	1.1500	0.9000	0.9800	0.9800	40.0000	0.0

COEFFICIENTS IN TANGENTIAL VELOCITY EQUATION

MAX. STATOR DIF. FACTOR	MAX HUB INLET MACH NUMBER	B	C	D	E
0.6000	0.9000	0.0	0.0	0.0	0.0

--**-- S T A G E   O U T P U T   D A T A ***--**--***

MASS FLOW (LB/SEC) = 1.903

OVERALL MASS AVE. PR. RATIO	OVERALL MASS AVE. TEMP. RATIO	OVERALL MASS AVE. EFFICIENCY	MASS AVE. PRESSURE RATIO	MASS AVE. TEMPERATURE RATIO	MASS AVE. EFFICIENCY	ROTOR ASPECT RATIO	STATOR ASPECT RATIO
4.7812	1.7165	0.7868	1.2508	1.0801	0.8245	0.9340	0.9000

ROTOR TIP RAD. 1-G (INCHES)	ROTOR HUB RAD. 1-G (INCHES)	ROTOR TIP RAD. 2-G (INCHES)	ROTOR HUB RAD. 2-G (INCHES)	STATOR TIP RAD. 3-G (INCHES)	STATOR HUB RAD. 3-G (INCHES)	ROTOR PROJ. LENGTH (INCHES)	STATOR PROJ. LENGTH (INCHES)
1.8000	1.5146	1.8000	1.5420	1.8000	1.5526	0.3056	0.2867

ROTOR TIP RAMP ANGLE (DEGREES)	ROTOR HUB RAMP ANGLE (DEGREES)	STATOR TIP RAMP ANGLE (DEGREES)	STATOR HUB RAMP ANGLE (DEGREES)
0.0	5.1298	0.0	2.1185

--**-- ROTOR INLET OUTPUT DATA ***--**--***

STA NO.	RADIUS -E (IN)	WHEEL SPEED (FT/SEC)	AXIAL VEL. (FT/SEC)	TANGENT. VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	REL. VEL. (FT/SEC)	ABS. AIR ANG. (DEG)	REL. AIR ANG. (DEG)	TOTAL TEMP. (DEG R)	TOTAL PRESS. (PSI)	REL. MACH NO.	ABS. MACH NO.	LOSS COEFF
1	1.795	1221.417	567.101	0.0	567.101	1346.648	0.0	65.095	824.317	56.175	0.973	0.410	0.081
2	1.767	1202.774	567.099	0.0	567.099	1329.759	0.0	64.756	824.317	56.175	0.961	0.410	0.083
3	1.740	1184.132	567.104	0.0	567.104	1312.924	0.0	64.409	824.317	56.175	0.948	0.410	0.085
4	1.713	1165.489	567.101	0.0	567.101	1296.133	0.0	64.053	824.317	56.175	0.936	0.410	0.086
5	1.685	1146.846	567.101	0.0	567.101	1279.396	0.0	63.688	824.317	56.175	0.924	0.410	0.088
6	1.658	1128.204	567.107	0.0	567.107	1262.715	0.0	63.313	824.318	56.175	0.912	0.410	0.090
7	1.630	1109.561	567.099	0.0	567.099	1246.082	0.0	62.928	824.317	56.175	0.900	0.410	0.091
8	1.603	1090.918	567.101	0.0	567.101	1229.512	0.0	62.533	824.317	56.175	0.888	0.410	0.093
9	1.576	1072.276	567.107	0.0	567.107	1213.005	0.0	62.126	824.318	56.175	0.876	0.410	0.095
10	1.548	1053.633	567.101	0.0	567.101	1196.554	0.0	61.709	824.317	56.175	0.864	0.410	0.097
11	1.521	1034.990	567.101	0.0	567.101	1180.172	0.0	61.280	824.317	56.175	0.853	0.410	0.099

--**-- ROTOR EXIT OUTPUT DATA ***--**--***

STA NO.	RADIUS -E (IN)	WHEEL SPEED (FT/SEC)	AXIAL VEL. (FT/SEC)	TANGENT. VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	REL. VEL. (FT/SEC)	ABS. AIR ANG. (DEG)	REL. AIR ANG. (DEG)	TOTAL TEMP. (DEG R)	TOTAL PRESS. (PSI)	ROTOR DIF. FACTOR	REL. MACH NO.	ABS. MACH NO.	LOSS FUNC
1	1.795	1221.735	542.148	324.566	631.876	1048.253	30.908	58.856	890.332	70.835	0.354	0.730	0.440	0.023
2	1.770	1204.883	542.146	329.105	634.218	1030.003	31.260	58.241	890.332	70.835	0.359	0.718	0.442	0.024
3	1.746	1188.031	542.151	333.774	636.657	1011.771	31.618	57.599	890.332	70.835	0.363	0.705	0.444	0.024
4	1.721	1171.179	542.148	338.576	639.186	993.554	31.985	56.930	890.332	70.835	0.368	0.693	0.446	0.025
5	1.696	1154.327	542.148	343.519	641.818	975.363	32.359	56.231	890.332	70.835	0.374	0.680	0.448	0.025
6	1.671	1137.475	542.154	348.609	644.561	957.204	32.741	55.501	890.333	70.835	0.379	0.668	0.449	0.026
7	1.647	1120.623	542.146	353.851	647.405	939.074	33.132	54.738	890.332	70.835	0.384	0.655	0.452	0.026
8	1.622	1103.771	542.148	359.253	650.375	920.994	33.530	53.938	890.332	70.835	0.390	0.643	0.454	0.027
9	1.597	1086.919	542.154	364.823	653.473	902.968	33.937	53.100	890.333	70.835	0.396	0.630	0.456	0.028
10	1.572	1070.067	542.148	370.569	656.693	884.998	34.353	52.222	890.332	70.835	0.402	0.618	0.458	0.028
11	1.548	1053.215	542.148	376.498	660.057	867.104	34.778	51.300	890.332	70.835	0.408	0.605	0.461	0.029

--**-- STATOR EXIT OUTPUT DATA ***--**--***

STA NO.	RADIUS -E (IN)	AXIAL VEL. (FT/SEC)	TANGENT. VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. AIR ANG. (DEG)	LOSS COEFF	STATOR DIF. FACTOR	AXIAL MACH NO.	ABS. MACH NO.	LOSS FUNC
1	1.795	552.991	0.0	552.991	0.0	0.065	0.383	0.384	0.384	0.033
2	1.772	552.988	0.0	552.988	0.0	0.064	0.385	0.384	0.384	0.032
3	1.748	552.994	0.0	552.994	0.0	0.064	0.388	0.384	0.384	0.031
4	1.724	552.991	0.0	552.991	0.0	0.063	0.390	0.384	0.384	0.031
5	1.700	552.991	0.0	552.991	0.0	0.063	0.393	0.384	0.384	0.030
6	1.677	552.996	0.0	552.996	0.0	0.062	0.396	0.384	0.384	0.029
7	1.653	552.988	0.0	552.988	0.0	0.062	0.398	0.384	0.384	0.029
8	1.629	552.991	0.0	552.991	0.0	0.061	0.401	0.384	0.384	0.028
9	1.605	552.996	0.0	552.996	0.0	0.061	0.404	0.384	0.384	0.027
10	1.582	552.991	0.0	552.991	0.0	0.060	0.407	0.384	0.384	0.027
11	1.558	552.991	0.0	552.991	0.0	0.059	0.410	0.384	0.384	0.026

*** OVERALL PRESSURE RATIO LIMIT HAS BEEN REACHED -- GO TO NEW DATA ***

APPENDIX B

COMPRESSOR INLET GEOMETRY AND VELOCITY DISTRIBUTIONS

Appendix B contains information defining the compressor (engine) inlet shape for the miniature gas turbine engine. This material was furnished by NASA Lewis Research Center staff.

Calculations were made for standard conditions and no inlet area blockage. Total flow rate was 0.864 kg/sec. (1.905 lbm/sec.) The ratio of bellmouth axial depth to diameter at the rotor inlet was set at 0.2, and the bellmouth was designed to give a relatively constant velocity on the shroud (tip) wall in the vicinity of the rotor inlet for the static case (no crossflow). It should be noted that the NASA calculations do not account for effects due to the rotor on the upstream flow.

Coordinates are given in table 2. These coordinates were interpolated from NASA results as replotted for the overall inlet-compressor flow path design. Rotor inlet calculation plane velocity distributions are listed in table B-1. Figure B-1 shows computed shroud and hub surface velocities for potential flow in the inlet as a function of surface distance from the rotor inlet plane.

TABLE B-1. PREDICTED ROTOR INLET PLANE VELOCITY PROFILE FROM NASA INLET BELLMOUTH POTENTIAL FLOW SOLUTION

Radius, cm (in.)	Meridional velocity, m/sec (ft/sec)	Axial velocity component, m/sec (ft/sec)	Meridional plane flow angle, ε, deg
2.700 (1.063)	193.7 (635.4)	177.0 (580.6)	+23.97
2.845 (1.120)	192.2 (630.7)	180.7 (592.7)	+20.00
3.002 (1.182)	190.5 (625.0)	182.8 (599.6)	+16.39
3.160 (1.244)	190.6 (625.3)	185.5 (608.5)	+13.31
3.317 (1.306)	191.8 (629.2)	188.5 (618.5)	+10.61
3.475 (1.368)	193.7 (635.6)	191.7 (629.1)	+ 8.25
3.632 (1.430)	196.2 (643.8)	195.1 (640.1)	+ 6.17
3.790 (1.492)	199.2 (653.4)	198.6 (651.5)	+ 4.37
3.947 (1.554)	202.4 (664.0)	202.1 (663.1)	+ 2.83
4.105 (1.616)	205.8 (675.1)	205.7 (674.9)	+ 1.56
4.262 (1.678)	209.3 (686.6)	209.3 (686.6)	+ 0.58
4.420 (1.740)	212.7 (697.8)	212.7 (697.8)	- 0.08
4.572 (1.800)	214.3 (703.1)	214.3 (703.1)	- 0.47

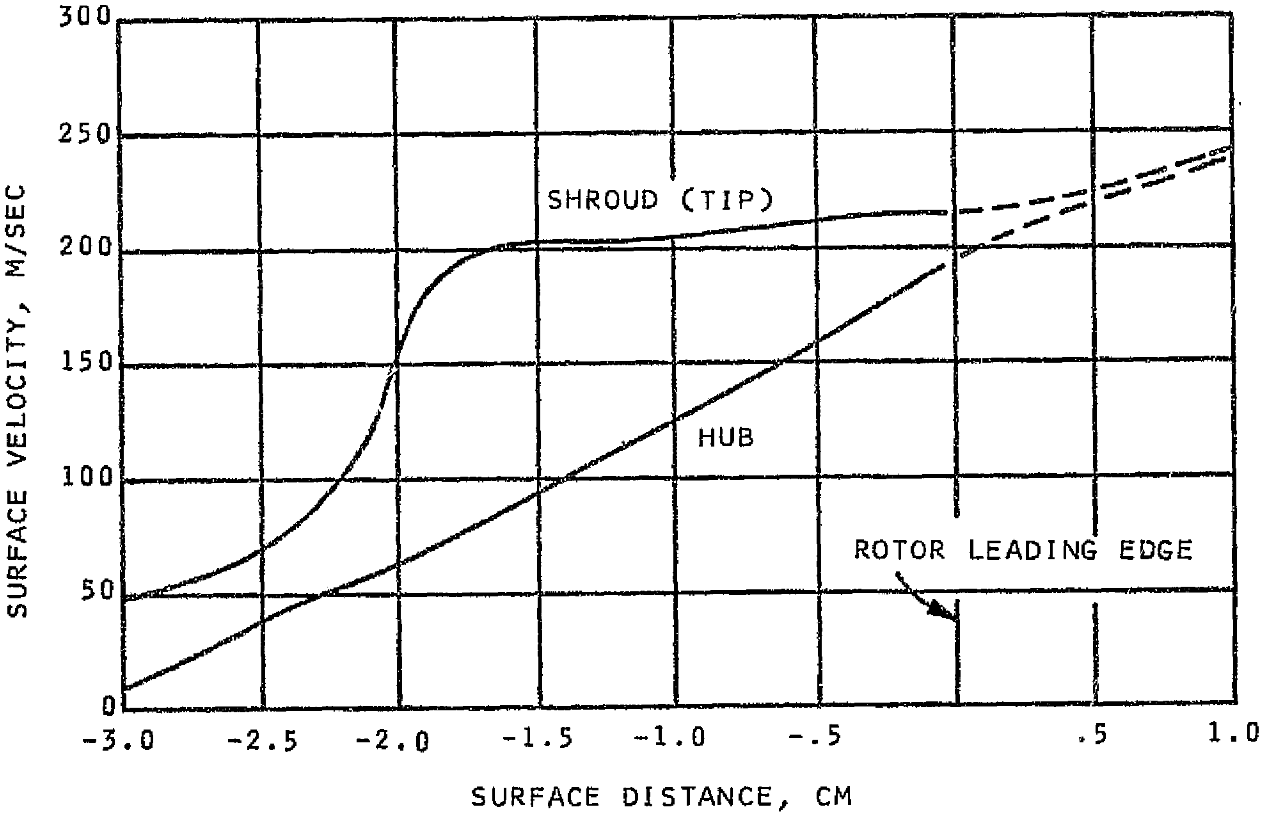

Figure B-1. - Estimated inlet bellmouth surface velocity variation from NASA potential flow solution.

APPENDIX C

MERIDIONAL PLANE COMPUTER PROGRAM OUTPUT

Appendix C presents complete meridional plane velocity and property distribution program output for the recommended 5-stage axial-flow compressor unit.

NASA MINIATURE GTE COMPRESSOR TDA-013

****---*** ADVANCED MULTISTAGE AXIAL-FLOW COMPRESSOR ***---****

-- ANALYSIS AT DESIGN CONDITIONS **--**

----I N P U T D A T A----

THE MACHINE IS TO HAVE NO MORE THAN 5 STAGES

A TOTAL PRESSURE RATIO OF 4.750 IS DESIRED

CALCULATIONS ARE TO BE PERFORMED AT 7 STREAMLINES

THE INLET TOTAL PRESSURE IS 14.7C LBS/SQ IN.

THE INLET MASS FLOW RATE IS 1.90 LB/SEC

THE INLET TOTAL TEMPERATURE IS 518.69 DEG. R

MOLECULAR WEIGHT OF THE FLUID IS 28.97

THE TIP SPEED IS 1225.0 FT./SEC.

AXIAL VELOCITY TOLERANCE IS 0.0100

THE LOADING LIMIT TOLERANCE IS 0.0100

THE EFFICIENCY TOLERANCE IS C.0100

THE CONTINUITY TOLERANCE IS 0.0005

THE FRACTION OF THE TOTAL MASS FLOW BETWEEN THE HUB AND THE J-TH STREAMLINE IS.

0.C 0.100 C.300 C.500 C.70C 0.900 1.000

THE INLET GUIDE VANE LOSS COEFFICIENTS FOR THE 7 STREAMLINES ARE (FROM HUB TO TIP)

0.0 0.0 0.C 0.0 0.0 0.0 0.0

THE INLET GUIDE VANE EXIT TANGENTIAL VELOCITY IS SPECIFIED BY

A = 0.0 B = 0.0 C = 0.0 D = C.0 F = 0.0

THE SPECIFIC HEAT POLYNOMIAL IS IN THE FOLLOWING FORM

CP = 0.23747E 00 + 0.21962E-04*T + -0.87791E-07*T**2 + 0.13991E-09*T**3 + -0.78056E-13*T**4 + 0.15C43E-16*T**5

THE RATIO OF THE AREAS OF THE LAST 3 STATIONS TO THE AREA OF THE LAST STATOR EXIT ARE 1.0819. 1.1829. 1.3429 .

----FLOW PATH DESCRIPTION----

STATION NO.	AXIAL COORDINATE (IN.)	HUB RADIUS (IN.)	HUB BLOCKAGE FACTOR	TIP RADIUS (IN.)	TIP BLOCKAGE FACTOR
1	0.0	0.300	1.000	2.300	1.000
2	0.250	0.399	1.000	2.210	1.000
3	0.400	0.593	1.000	1.920	1.000
4	0.700	0.896	1.000	1.820	1.000
5	1.000	1.055	0.998	1.800	0.998
6	1.368	1.166	0.990	1.800	0.990
7	1.703	1.256	0.980	1.800	0.980
8	2.031	1.335	0.980	1.800	0.980
9	2.341	1.400	0.980	1.800	0.980
10	2.648	1.440	0.980	1.800	0.980
11	2.944	1.470	0.980	1.800	0.980
12	3.246	1.496	0.980	1.800	0.980
13	3.543	1.517	0.980	1.800	0.980
14	3.849	1.538	0.980	1.800	0.980
15	4.136	1.556	0.980	1.800	0.980
16	4.262	0.0	0.980	0.0	0.980
17	4.387	0.0	0.980	0.0	0.980
18	4.636	0.0	0.980	0.0	0.980

.... LOSS DATA SET NUMBER 1 ....

D-FACTOR	AT 10 PERCENT	AT 50 PERCENT	AT 90 PERCENT	(OF BLADE HEIGHT FROM THE GEOMETRIC HUB.)
0.0	0.0121	0.0040	0.0121	
0.100	0.0145	0.0055	0.0145	
0.150	0.0155	0.0061	0.0155	
0.200	0.0165	0.0070	0.0165	
0.250	0.0180	0.0080	0.0180	
0.300	0.0196	0.0090	0.0196	
0.350	0.0220	0.0100	0.0220	
0.400	0.0249	0.0113	0.0249	
0.450	0.0279	0.0140	0.0279	
0.500	0.0310	0.0164	0.0310	
0.550	0.0360	0.0205	0.0360	
0.600	0.0425	0.0257	0.0425	
0.650	0.0507	0.0323	0.0507	
0.700	0.0600	0.0400	0.0600	
0.750	0.0705	0.0480	0.0705	
0.800	0.0823	0.0572	0.0823	
0.850	0.0951	0.0671	0.0951	
0.900	0.1090	0.0779	0.1090	
0.950	0.1235	0.0890	0.1235	
1.000	0.1390	0.1005	0.1390	

.... LOSS DATA SET NUMBER 2 ....

D-FACTOR	AT 10 PERCENT	AT 50 PERCENT	AT 90 PERCENT	(OF BLADE HEIGHT FROM THE GEOMETRIC HUB.)
0.0	0.0060	0.0060	0.0080	
0.100	0.0065	0.0065	0.0085	
0.150	0.0072	0.0069	0.0088	
0.200	0.0075	0.0071	0.0092	
0.250	0.0081	0.0075	0.0100	
0.300	0.0090	0.0082	0.0112	
0.350	0.0099	0.0090	0.0125	
0.400	0.0110	0.0098	0.0140	
0.450	0.0123	0.0110	0.0160	
0.500	0.0140	0.0122	0.0184	
0.550	0.0158	0.0139	0.0218	
0.600	0.0185	0.0157	0.0261	
0.650	0.0220	0.0180	0.0328	
0.700	0.0270	0.0210	0.0450	
0.750	0.0325	0.0240	0.0600	
0.800	0.0390	0.0280	0.0750	
0.850	0.0450	0.0315	0.0920	
0.900	0.0520	0.0355	0.1100	
0.950	0.0590	0.0400	0.1280	
1.000	0.0660	0.0445	0.1480	

ERROR NUMBER 9

THE DESIRED PRESSURE RATIO COULD NOT BE MET (WARNING ONLY)

----STATION NUMBER 1 ----

S.L. NO.	STREAMLINE RADIUS (IN.)	ABS. MACH NUMBER	ABS. VEL. (FT/SEC)	AXIAL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	STREAMLINE SLOPE (DEGS)	STREAMLINE CURVATURE 1/IN.	FLOW ANGLE (DEGREES)
7	2.3000	0.201	224.04	224.04	0.0	0.0	0.0	0.0
6	2.1840	0.201	224.04	224.04	0.0	0.0	0.0	0.0
5	1.9313	0.201	224.04	224.04	0.0	0.0	0.0	0.0
4	1.6401	0.201	224.04	224.04	0.0	0.0	0.0	0.0
3	1.2845	0.201	224.04	224.04	0.0	0.0	0.0	0.0
2	0.7810	0.201	224.04	224.04	0.0	0.0	0.0	0.0
1	0.3000	0.201	224.04	224.04	0.0	0.0	0.0	0.0

S.L. NO.	STREAMLINE RADIUS (IN.)	TOTAL PRES. (LB/SQ IN.)	TOTAL TEMP. (DEGREES)	FRAC PASS. HT FROM TIP
7	2.3000	14.70	518.69	0.000
6	2.1840	14.70	518.69	0.058
5	1.9313	14.70	518.69	0.184
4	1.6401	14.70	518.69	0.330
3	1.2845	14.70	518.69	0.508
2	0.7810	14.70	518.69	0.759
1	0.3000	14.70	518.69	1.000

----STATION NUMBER 2 ----

S.L. NO.	STREAMLINE RADIUS (IN.)	ABS. MACH NUMBER	ABS. VEL. (FT/SEC)	AXIAL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	STREAMLINE SLOPE (DEGS)	STREAMLINE CURVATURE 1/IN.	FLOW ANGLE (DEGREES)
7	2.2100	0.122	135.78	98.44	-93.5213	-43.53	-2.99780	0.0
6	2.0087	0.213	236.97	178.84	-155.4576	-41.00	-0.96192	0.0
5	1.7253	0.296	327.52	275.26	-177.4918	-32.81	1.41755	0.0
4	1.4789	0.324	358.50	336.20	-124.4709	-20.32	3.01872	0.0
3	1.2179	0.314	347.73	347.27	-17.7465	-2.93	2.86087	0.0
2	0.8454	0.246	272.98	256.28	94.0086	20.14	1.20684	0.0
1	0.3900	0.116	128.88	104.35	75.6496	35.94	2.58264	0.0

S.L. NO.	STREAMLINE RADIUS (IN.)	TOTAL PRES. (LB/SQ IN.)	TOTAL TEMP. (DEGREES)	FRAC PASS. HT FROM TIP
7	2.2100	14.70	518.69	0.000
6	2.0087	14.70	518.69	0.111
5	1.7253	14.70	518.69	0.266
4	1.4789	14.70	518.69	0.402
3	1.2179	14.70	518.69	0.545
2	0.8454	14.70	518.69	0.750
1	0.3900	14.70	518.69	1.000

----STATION NUMBER 3 ----

S.L. NO.	STREAMLINE RADIUS (IN.)	ABS. MACH NUMBER	ABS. VEL. (FT/SEC)	AXIAL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	STREAMLINE SLOPE (DEGS)	STREAMLINE CURVATURE 1/IN.	FLOW ANGLE (DEGREES)
7	1.9200	0.453	495.55	374.48	-324.5483	-40.91	3.06882	0.0
6	1.8363	0.450	492.24	429.58	-240.3476	-29.22	2.61378	0.0
5	1.6734	0.419	459.89	447.50	-106.0178	-13.28	0.67770	0.0
4	1.4920	0.373	410.98	410.67	-15.8173	-2.13	-0.82793	0.0
3	1.2641	0.327	361.70	358.38	48.9105	7.85	-1.10138	0.0
2	0.9277	0.277	307.15	279.16	128.1115	24.69	-0.44668	0.0
1	0.5900	0.208	231.26	153.69	172.8102	48.35	-0.40870	0.0

S.L. NO.	STREAMLINE RADIUS (IN.)	TOTAL PRES. (LB/SQ IN.)	TOTAL TEMP. (DEGREES)	FRAC PASS. HT FROM TIP
7	1.9200	14.70	518.69	0.000
6	1.8363	14.70	518.69	0.063
5	1.6734	14.70	518.69	0.185
4	1.4920	14.70	518.69	0.322
3	1.2641	14.70	518.69	0.493
2	0.9277	14.70	518.69	0.746
1	0.5900	14.70	518.69	1.000

----STATION NUMBER 4 ----

S.L. NO.	STREAMLINE RADIUS (IN.)	ABS. MACH NUMBER	ABS. VEL. (FT/SEC)	AXIAL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	STREAMLINE SLOPE (DEGS)	STREAMLINE CURVATURE 1/IN.	FLOW ANGLE (DEGREES)
7	1.8200	0.564	610.63	598.54	-120.8849	-11.42	0.82475	0.0
6	1.7570	0.537	583.48	576.31	-91.2462	-9.00	0.68142	0.0
5	1.6191	0.499	543.67	541.44	-49.1335	-5.18	0.59447	0.0
4	1.4622	0.475	518.72	518.68	-6.6134	-0.72	0.57839	0.0
3	1.2800	0.457	499.66	496.36	57.3393	6.60	0.40973	0.0
2	1.0523	0.438	479.63	447.71	172.0618	21.03	-0.16656	0.0
1	0.8960	0.424	465.43	367.29	285.8784	37.90	-0.79164	0.0

S.L. NO.	STREAMLINE RADIUS (IN.)	TOTAL PRES. (LB/SQ IN.)	TOTAL TEMP. (DEGREES)	FRAC PASS. HT FROM TIP
7	1.8200	14.70	518.69	0.0
6	1.7570	14.70	518.69	0.068
5	1.6191	14.70	518.69	0.217
4	1.4622	14.70	518.69	0.387
3	1.2800	14.70	518.69	0.584
2	1.0523	14.70	518.69	0.831
1	0.8960	14.70	518.69	1.000

----STATION NUMBER 5 ---- (INLET GUIDE VANE EXIT)

S.L. NO.	STREAMLINE RADIUS (IN.)	ABS. MACH NUMBER	ABS. VEL. (FT/SEC)	AXIAL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	STREAMLINE SLOPE (DEG)	STREAMLINE CURVATURE 1/IN.	FLOW ANGLE (DEGREES)
7	1.7988	0.639	685.99	685.50	-25.6925	-2.16	0.17809	0.0
6	1.7414	0.630	677.00	676.84	-14.7795	-1.25	0.16520	0.0
5	1.6190	0.614	661.35	661.19	14.5095	1.27	0.12198	0.0
4	1.4845	0.600	647.34	645.10	53.8104	4.79	0.05136	0.0
3	1.3335	0.589	636.17	627.45	105.0245	9.53	-0.05459	0.0
2	1.1584	0.588	635.24	608.79	181.3786	16.61	-0.26440	0.0
1	1.0570	0.598	645.29	595.75	247.9636	22.60	-0.51530	0.0

S.L. NO.	STREAMLINE RADIUS (IN.)	TOTAL PRES. (LB/SQ IN.)	TOTAL TEMP. (DEGREES)	REL. VEL. (FT/SEC)	WHIRL VEL. (FT/SEC)	RELATIVE MACH NO.	REL. FLOW ANG.(DEG)	WHEEL SPEED (FT/SEC)	FRAC PASS. HT FROM TIP
7	1.7988	14.70	518.69	1403.29	0.0	1.307	60.735	1224.195	0.002
6	1.7414	14.70	518.69	1364.83	0.0	1.270	60.262	1185.090	0.079
5	1.6190	14.70	518.69	1285.07	0.0	1.193	59.026	1101.824	0.243
4	1.4845	14.70	518.69	1199.87	0.0	1.112	57.350	1010.265	0.424
3	1.3335	14.70	518.69	1108.28	0.0	1.026	54.969	907.501	0.626
2	1.1584	14.70	518.69	1012.42	0.0	0.937	51.138	788.333	0.861
1	1.0570	14.70	518.69	966.37	0.0	0.896	48.107	719.356	0.997

ITERATION ON LOADING WAS TAKING PLACE

-- FINAL FLOW PARAMETERS FOR STAGE NUMBER 1 ***--***

*** STAGE INPUT PARAMETERS ***

ROTOR TIP D-FACTOR LIMIT	0.3800
HUB RELATIVE FLOW ANGLE LIMIT AT THE ROTOR EXIT	0.0
STATOR HUB MACH NUMBER LIMIT (IN)	0.8500
STATOR HUB D-FACTOR LIMIT	0.5500
MAXIMUM TIP TANGENTIAL VELOCITY	500.0

---ROTOR---

	PRESSURE PROFILE	RATIO SUPERSONIC TO TOTAL TURNING	SOLIDITY
A	0.0	0.0	0.339302E 01
B	0.100000E 01	0.100000E 01	0.161058E 01
C	0.100000E 01	0.683000E 00	0.0
D	0.0	0.705000E 00	0.0
E	0.0	-0.315500E 00	0.0

---STATOR---

	WHIRL VELOCITY	RATIO SUPERSONIC TO TOTAL TURNING	SOLIDITY
A	0.0	0.0	0.358018E 01
B	0.0	0.100000E 01	0.205602E 01
C	0.0	0.0	0.0
D	0.0	0.0	0.0
E	0.0	0.0	0.0

*** STAGE SCALAR QUANTITIES ***

	ASPECT RATIO	GEOMETRIC HUB RADIUS (IN.)	GEOMETRIC TIP RAD.(IN.)	HUB RAMP ANGLE (DEG)	TIP RAMP ANGLE (DEG)	AXIAL LENGTH (IN.)	MASS FLOW (LB/SEC)	MASS AVE. ADIABATIC EFF.
-ROTOR--	2.024	1.1660	1.8000	16.785	0.0	0.3680	1.9050	0.8824
-STATOR-	1.893	1.2560	1.8000	15.038	0.0	0.3350	1.9050	0.8601

	VEL. RATIO AT THE MEAN	HUB BLOCKAGE FACTOR	TIP BLOCKAGE FACTOR	MASS AVE. PR. RATIO	MASS AVE. TEMP. RATIO	CUMULATIVE MASS AVE. PR. RATIO	CUMULATIVE MASS AVE. TEMP. RATIO	CUMULATIVE MASS AVE. ADIABATIC EFF.
-ROTOR--	0.821	0.9900	0.9900	1.4786	1.1340	1.4786	1.1340	0.8824
-STATOR-	1.161	0.9800	0.9800	1.4648	1.1340	1.4648	1.1340	0.8601

	LOSS DATA SET USED
-ROTOR--	2
-STATOR-	1

****----** R O T O R   E X I T **----****

S.L. NO.	STREAMLINE RADIUS (IN.)	AXIAL VEL. (FT/SEC)	WHIRL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. MACH NUMBER	ABS. FLOW ANGLE (DEG)	REL. FLOW ANGLE (DEG)	PCT PASS. HT FROM TIP
7	1.7948	562.559	375.62	-6.46	676.467	0.5847	33.729	56.370	0.008
6	1.7425	566.724	375.63	3.45	679.915	0.5890	33.536	55.028	0.091
5	1.6339	572.187	382.10	27.20	688.574	0.5989	33.704	51.873	0.262
4	1.5181	574.209	398.44	56.90	701.219	0.6119	34.626	47.727	0.445
3	1.3921	572.822	427.60	93.96	720.968	0.6311	36.377	41.844	0.643
2	1.2516	573.906	465.90	142.54	752.826	0.6622	38.233	33.126	0.865
1	1.1740	575.708	492.27	173.74	777.142	0.6860	39.304	27.025	0.987

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.	LOSS PARAM.
7	1.1472	1.4786	0.8029	0.3797	1221.44	1.302	0.4758	0.1331	0.0283
6	1.1430	1.4786	0.8270	0.3778	1185.84	1.343	0.4873	0.1182	0.0252
5	1.1364	1.4786	0.8670	0.3786	1111.94	1.438	0.5136	0.0947	0.0203
4	1.1321	1.4786	0.8949	0.3855	1033.19	1.558	0.5446	0.0802	0.0173
3	1.1300	1.4786	0.9093	0.3987	947.41	1.717	0.5825	0.0766	0.0166
2	1.1274	1.4786	0.9283	0.4049	851.77	1.942	0.6302	0.0684	0.0147
1	1.1263	1.4786	0.9366	0.4032	799.00	2.097	0.6640	0.0646	0.0137

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
7	595.07	21.73	557.00	17.24	-0.66	-0.00292	1015.8342	0.8781
6	592.84	21.73	554.39	17.18	0.35	0.01845	988.7512	0.8566
5	589.42	21.73	549.97	17.05	2.72	0.04258	927.7986	0.8070
4	587.23	21.73	546.31	16.87	5.66	0.04469	857.8176	0.7486
3	586.14	21.73	542.88	16.61	9.32	0.02695	779.1997	0.6822
2	584.76	21.73	537.59	16.19	13.95	-0.02680	706.1038	0.6212
1	584.18	21.73	533.91	15.86	16.79	-0.08492	675.0613	0.5959

----- S T A T O R   E X I T **-----**

S.L. NO.	STREAMLINE RADIUS (IN.)	AXIAL VEL. (FT/SEC)	WHIRL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. MACH NUMBER	ABS. FLOW ANGLE (DEG)	REL. FLOW ANGLE (DEG)	PCT PASS. HT FROM TIP
7	1.7907	653.314	0.0	-2.84	653.320	0.5634	0.0	61.805	0.017
6	1.7456	654.414	0.0	9.09	654.477	0.5656	0.0	61.149	0.100
5	1.6524	655.164	0.0	35.44	656.121	0.5689	0.0	59.739	0.271
4	1.5541	653.321	0.0	65.58	656.604	0.5704	0.0	58.168	0.452
3	1.4488	646.932	0.0	100.23	654.651	0.5692	0.0	56.418	0.646
2	1.3330	630.289	0.0	139.11	645.457	0.5614	0.0	54.568	0.858
1	1.2692	612.555	0.0	158.77	632.795	0.5500	0.0	53.773	0.976

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.	LOSS PARAM.
7	1.0000	0.9887	0.7783	0.2703	1218.70	1.176	0.6890	0.0548	0.0233
6	1.0000	0.9907	0.8060	0.2659	1188.00	1.209	0.6937	0.0447	0.0185
5	1.0000	0.9936	0.8520	0.2633	1124.58	1.283	0.6994	0.0297	0.0116
4	1.0000	0.9948	0.8821	0.2706	1057.68	1.373	0.7006	0.0235	0.0086
3	1.0000	0.9929	0.8917	0.2916	985.99	1.485	0.6977	0.0303	0.0102
2	1.0000	0.9843	0.8887	0.3321	907.17	1.632	0.6985	0.0615	0.0189
1	1.0000	0.9737	0.8693	0.3693	863.74	1.726	0.7003	0.0976	0.0283

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
7	595.07	21.48	559.56	17.32	-0.25	0.04679	1382.7690	1.1925
6	592.84	21.53	557.21	17.33	0.80	0.02686	1356.3496	1.1722
5	589.42	21.59	553.61	17.33	3.10	-0.00797	1301.9844	1.1288
4	587.23	21.62	551.36	17.33	5.73	-0.04226	1244.9192	1.0815
3	586.14	21.57	550.48	17.32	8.81	-0.08363	1183.5273	1.0290
2	584.76	21.39	550.10	17.27	12.45	-0.12632	1113.3579	0.9683
1	584.18	21.16	550.86	17.22	14.53	-0.13712	1070.7349	0.9306

-- FINAL FLOW PARAMETERS FOR STAGE NUMBER 2 ***--***

*** STAGE INPUT PARAMETERS ***

ROTOR TIP D-FACTOR LIMIT	0.4000
HUB RELATIVE FLOW ANGLE LIMIT AT THE ROTOR EXIT	0.0
STATOR HUB MACH NUMBER LIMIT (IN)	0.8500
STATOR HUB D-FACTOR LIMIT	0.5500
MAXIMUM TIP TANGENTIAL VELOCITY	500.0

	---ROTOR---				---STATOR---		
	PRESSURE PROFILE	RATIO SUPERSONIC TO TOTAL TURNING	SOLIDITY		WHIRL VELOCITY	RATIO SUPERSONIC TO TOTAL TURNING	SOLIDITY
A	0.0	-0.847800E 01	0.370664E 01	A	0.0	0.0	0.469167E 01
B	0.100000E 01	0.100000E 01	0.256788E 01	B	0.0	0.100000E 01	0.316184E 01
C	0.100000E 01	0.943800E 01	0.0	C	0.0	0.0	0.0
D	0.0	-0.673100E 01	0.0	D	0.0	0.0	0.0
E	0.0	0.297200E 01	0.0	E	0.0	0.0	0.0

*** STAGE SCALAR QUANTITIES ***

	ASPECT RATIO	GEOMETRIC HUB RADIUS (IN.)	GEOMETRIC TIP RAD.(IN.)	HUB RAMP ANGLE (DEG)	TIP RAMP ANGLE (DEG)	AXIAL LENGTH (IN.)	MASS FLOW (LB/SEC)	MASS AVE. ADIABATIC EFF.
-ROTOR--	1.659	1.3350	1.8000	13.542	0.0	0.3280	1.9050	0.8920
-STATOR-	1.500	1.4000	1.8000	11.842	0.0	0.3100	1.9050	0.8715

	VEL. RATIO AT THE MEAN	HUB BLOCKAGE FACTOR	TIP BLOCKAGE FACTOR	MASS AVE. PR. RATIO	MASS AVE. TEMP. RATIO	CUMULATIVE MASS AVE. PR. RATIO	CUMULATIVE MASS AVE. TEMP. RATIO	CUMULATIVE MASS AVE. ADIABATIC EFF.
-ROTOR--	0.873	0.9800	0.9800	1.4357	1.1217	2.1030	1.2720	0.8689
-STATOR-	1.139	0.9800	0.9800	1.4244	1.1217	2.0864	1.2720	0.8586

	LOSS DATA SET USED
-ROTOR--	2
-STATOR-	1

----- R O T O R   E X I T **-----**

S.L. NO.	STREAMLINE RADIUS (IN.)	AXIAL VEL. (FT/SEC)	WHIRL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. MACH NUMBER	ABS. FLOW ANGLE (DEG)	REL. FLOW ANGLE (DEG)	PCT PASS. HT FROM TIP
7	1.7919	570.469	383.24	1.91	687.250	0.5574	33.893	55.698	0.017
6	1.7517	575.799	379.01	10.95	685.427	0.5614	33.349	54.691	0.104
5	1.6697	583.452	378.24	30.88	696.014	0.5702	32.918	52.379	0.280
4	1.5847	587.302	388.76	53.49	706.341	0.5811	33.393	49.469	0.463
3	1.4949	586.560	413.31	79.19	721.995	0.5952	34.926	45.582	0.656
2	1.3979	581.408	450.89	109.14	743.810	0.6146	37.315	40.232	0.865
1	1.3459	576.297	476.17	126.41	756.177	0.6270	38.906	36.700	0.977

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.	LOSS PARAM.
7	1.1303	1.4386	0.8375	0.4004	1219.48	1.044	0.4736	0.1102	0.0297
6	1.1265	1.4357	0.8580	0.3946	1192.19	1.069	0.4843	0.0962	0.0260
5	1.1211	1.4315	0.8890	0.3899	1136.35	1.126	0.5076	0.0764	0.0207
4	1.1186	1.4298	0.9048	0.3951	1078.50	1.192	0.5337	0.0684	0.0186
3	1.1191	1.4326	0.9057	0.4125	1017.35	1.271	0.5626	0.0731	0.0201
2	1.1218	1.4450	0.9080	0.4374	951.37	1.370	0.5892	0.0794	0.0221
1	1.1240	1.4608	0.9201	0.4511	915.94	1.430	0.5958	0.0744	0.0209

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
7	672.62	30.91	633.47	25.03	0.19	-0.00089	1012.2874	0.8210
6	667.83	30.91	628.42	24.96	1.09	0.00403	996.3939	0.8113
5	660.78	30.91	620.60	24.79	3.03	0.00120	957.1340	0.7842
4	656.84	30.91	615.45	24.59	5.21	-0.01351	907.4846	0.7466
3	655.96	30.91	612.72	24.33	7.69	-0.02419	845.6860	0.6973
2	655.99	30.91	610.09	23.96	10.63	-0.06297	774.8684	0.6402
1	656.60	30.91	608.90	23.72	12.37	-0.08727	735.8672	0.6086

------ S T A T O R E X I T **------**

S.L. NO.	STREAMLINE RADIUS (IN.)	AXIAL VEL. (FT/SEC)	WHIRL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. MACH NUMBER	ABS. FLOW ANGLE (DEG)	REL. FLOW ANGLE (DEG)	PCT PASS. HT FROM TIP
7	1.7929	649.964	0.0	1.71	649.965	0.5254	0.0	61.956	0.018
6	1.7578	651.103	0.0	10.13	651.182	0.5294	0.0	61.478	0.106
5	1.6862	652.961	0.0	27.98	653.567	0.5334	0.0	60.338	0.284
4	1.6123	653.870	0.0	47.45	655.589	0.5369	0.0	59.142	0.469
3	1.5350	652.633	0.0	68.98	656.268	0.5378	0.0	57.862	0.663
2	1.4528	645.080	0.0	92.79	651.719	0.5339	0.0	56.608	0.868
1	1.4091	626.352	0.0	105.41	645.022	0.5278	0.0	56.075	0.977

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.	LOSS PARAM.
7	1.0000	0.9895	0.8119	0.3006	1220.15	1.132	0.6671	0.0552	0.0244
6	1.0000	0.9915	0.8368	0.2932	1196.26	1.156	0.6745	0.0441	0.0191
5	1.0000	0.9944	0.8743	0.2857	1147.56	1.209	0.6846	0.0284	0.0117
4	1.0000	0.9954	0.8926	0.2887	1097.29	1.269	0.6890	0.0224	0.0088
3	1.0000	0.9938	0.8892	0.3047	1044.62	1.339	0.6867	0.0291	0.0109
2	1.0000	0.9875	0.8753	0.3367	988.68	1.424	0.6788	0.0557	0.0196
1	1.0000	0.9809	0.8709	0.3623	958.98	1.473	0.6718	0.0821	0.0279

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
7	672.62	30.58	637.61	25.34	0.15	-0.00368	1382.4688	1.1176
6	667.83	30.64	632.68	25.34	0.89	-0.02677	1362.0071	1.1053
5	660.78	30.73	625.35	25.32	2.45	-0.06677	1320.6226	1.0779
4	656.84	30.76	621.19	25.29	4.15	-0.10514	1278.1819	1.0467
3	655.96	30.71	620.23	25.23	6.04	-0.15089	1233.6641	1.0110
2	655.99	30.52	620.76	25.14	8.19	-0.20839	1184.1570	0.9700
1	656.60	30.32	622.09	25.08	9.41	-0.23989	1155.7227	0.9457

-- FINAL FLOW PARAMETERS FOR STAGE NUMBER 3 ***--***

*** STAGE INPUT PARAMETERS ***

ROTOR TIP D-FACTOR LIMIT	0.4000
HUB RELATIVE FLOW ANGLE LIMIT AT THE ROTOR EXIT	0.0
STATOR HUB MACH NUMBER LIMIT (IN)	0.8500
STATOR HUB D-FACTOR LIMIT	0.5500
MAXIMUM TIP TANGENTIAL VELOCITY	500.0

	---ROTOR---			---STATOR---		
	PRESSURE PROFILE	RATIO SUPERSONIC TO TOTAL TURNING	SOLIDITY	WHIRL VELOCITY	RATIO SUPERSONIC TO TOTAL TURNING	SOLIDITY
A	0.0	-0.929800E 01	0.471166E 01	0.0	0.0	0.565096E 01
B	0.100000E 01	0.100000E 01	0.373604E 01	0.0	0.100000E 01	0.421739E 01
C	0.100000E 01	0.106080E 02	0.0	0.0	0.0	0.0
D	0.0	-0.775300E 01	0.0	0.0	0.0	0.0
E	0.0	0.335400E 01	0.0	0.0	0.0	0.0

*** STAGE SCALAR QUANTITIES ***

	ASPECT RATIO	GEOMETRIC HUB RADIUS (IN.)	GEOMETRIC TIP RAD.(IN.)	HUB RAMP ANGLE (DEG)	TIP RAMP ANGLE (DEG)	AXIAL LENGTH (IN.)	MASS FLOW (LB/SEC)	MASS AVE. ADIABATIC EFF.
-ROTOR--	1.303	1.4400	1.8000	7.423	0.0	0.3070	1.9050	0.8964
-STATOR-	1.216	1.4700	1.8000	5.787	0.0	0.2960	1.9050	0.8753

	VEL. RATIO AT THE MEAN	HUB BLOCKAGE FACTOR	TIP BLOCKAGE FACTOR	MASS AVE. PR. RATIO	MASS AVE. TEMP. RATIO	CUMULATIVE MASS AVE. PR. RATIO	CUMULATIVE MASS AVE. TEMP. RATIO	CUMULATIVE MASS AVE. ADIABATIC EFF.
-ROTOR--	0.869	0.9800	0.9800	1.3812	1.1071	2.8817	1.4082	0.8622
-STATOR-	1.069	0.9800	0.9800	1.3712	1.1071	2.8609	1.4082	0.8554

	LOSS DATA SET USED
-ROTOR--	2
-STATOR-	1

****-----** R O T O R   E X I T **-----****

S.L. NO.	STREAMLINE RADIUS (IN.)	AXIAL VEL. (FT/SEC)	WHIRL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. MACH NUMBER	ABS. FLOW ANGLE (DEG)	REL. FLOW ANGLE (DEG)	PCT PASS. HT FROM TIP
7	1.7935	564.402	374.86	1.05	677.549	0.5193	33.591	56.282	0.018
6	1.7613	568.743	369.23	6.21	678.112	0.5224	32.990	55.559	0.108
5	1.6962	574.725	365.95	17.39	681.567	0.5291	32.475	53.896	0.288
4	1.6295	577.665	374.21	29.62	688.917	0.5370	32.901	51.790	0.474
3	1.5601	577.074	395.17	42.80	700.716	0.5469	34.329	49.039	0.666
2	1.4867	573.646	426.40	57.01	717.031	0.5596	36.489	45.440	0.870
1	1.4481	571.070	445.91	64.60	727.416	0.5674	37.808	43.194	0.978

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.	LOSS PARAM.
7	1.1124	1.3848	0.8607	0.4002	1220.58	0.998	0.4735	0.0901	0.0250
6	1.1095	1.3820	0.8778	0.3940	1198.64	1.018	0.4815	0.0785	0.0218
5	1.1057	1.3781	0.9014	0.3896	1154.35	1.059	0.4990	0.0637	0.0177
4	1.1045	1.3766	0.9090	0.3965	1108.99	1.105	0.5187	0.0606	0.0170
3	1.1058	1.3789	0.9026	0.4169	1061.75	1.157	0.5402	0.0688	0.0195
2	1.1088	1.3877	0.8962	0.4460	1011.78	1.218	0.5596	0.0796	0.0229
1	1.1107	1.3970	0.8994	0.4627	985.50	1.253	0.5655	0.0813	0.0236

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
7	748.21	42.35	710.34	35.25	0.11	-0.00138	1016.7539	0.7794
6	740.98	42.35	703.02	35.18	0.63	-0.00331	1005.7007	0.7749
5	730.64	42.35	692.27	35.01	1.73	-0.01503	975.8000	0.7575
4	725.49	42.35	686.27	34.82	2.94	-0.03304	935.1323	0.7291
3	725.36	42.35	684.79	34.57	4.24	-0.05231	882.7122	0.6889
2	727.35	42.35	684.87	34.25	5.67	-0.07453	821.5801	0.6412
1	729.28	42.35	685.56	34.06	6.45	-0.09150	788.3167	0.6149

---- S T A T O R   E X I T **----**

S.L. NO.	STREAMLINE RADIUS (IN.)	AXIAL VEL. (FT/SEC)	WHIRL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. MACH NUMBER	ABS. FLOW ANGLE (DEG)	REL. FLOW ANGLE (DEG)	PCT PASS. HT FROM TIP
7	1.7940	603.569	0.0	0.92	603.579	0.4602	0.0	63.694	0.018
6	1.7643	605.157	0.0	5.40	605.181	0.4638	0.0	63.252	0.108
5	1.7045	606.937	0.0	14.90	607.120	0.4687	0.0	62.373	0.289
4	1.6432	607.281	0.0	25.11	607.799	0.4709	0.0	61.476	0.475
3	1.5797	605.115	0.0	36.13	606.193	0.4697	0.0	60.583	0.668
2	1.5127	595.979	0.0	47.78	597.891	0.4623	0.0	59.853	0.871
1	1.4773	586.569	0.0	53.56	589.009	0.4546	0.0	59.636	0.978

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.	LOSS PARAM.
7	1.0000	0.9897	0.8320	0.3637	1220.91	1.087	0.6384	0.0615	0.0283
6	1.0000	0.9919	0.8546	0.3537	1200.74	1.106	0.6454	0.0480	0.0217
5	1.0000	0.9948	0.8860	0.3433	1159.98	1.147	0.6548	0.0301	0.0131
4	1.0000	0.9958	0.8964	0.3454	1118.29	1.191	0.6583	0.0237	0.0100
3	1.0000	0.9943	0.8859	0.3620	1075.06	1.242	0.6554	0.0310	0.0125
2	1.0000	0.9888	0.8639	0.3949	1029.46	1.309	0.6477	0.0589	0.0227
1	1.0000	0.9834	0.8523	0.4201	1005.40	1.333	0.6422	0.0049	0.0318

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
7	748.21	41.91	718.17	36.27	0.09	-0.00075	1361.9553	1.0384
6	740.98	42.01	710.76	36.26	0.51	-0.00987	1344.6245	1.0364
5	730.64	42.13	700.20	36.26	1.41	-0.02250	1309.2578	1.0107
4	725.49	42.17	694.97	36.24	2.37	-0.03195	1272.7683	0.9862
3	725.36	42.11	695.01	36.22	3.42	-0.04186	1234.1887	0.9563
2	727.35	41.87	697.83	36.18	4.58	-0.04978	1190.4880	0.9206
1	729.28	41.65	700.63	36.16	5.22	-0.04898	1165.2295	0.8993

-- FINAL FLOW PARAMETERS FOR STAGE NUMBER 4 ***--***

*** STAGE INPUT PARAMETERS ***

ROTOR TIP D-FACTOR LIMIT	0.3800
HUB RELATIVE FLOW ANGLE LIMIT AT THE ROTOR EXIT	0.0
STATOR HUB MACH NUMBER LIMIT (IN)	0.8500
STATOR HUB D-FACTOR LIMIT	0.5500
MAXIMUM TIP TANGENTIAL VELOCITY	500.0

---ROTOR---

	PRESSURE PROFILE	RATIO SUPERSONIC TO TOTAL TURNING	SOLIDITY
A	0.0	-0.138020E 02	0.539703E 01
B	0.100000E 01	0.100000E 01	0.467823E 01
C	0.100000E 01	0.155020E 02	0.0
D	0.0	-0.118320E 02	0.0
E	0.0	0.557100E 01	0.0

---STATOR---

	WHIRL VELOCITY	RATIO SUPERSONIC TO TOTAL TURNING	SOLIDITY
A	0.0	0.0	0.637140E 01
B	0.0	0.100000E 01	0.513288E 01
C	0.0	0.0	0.0
D	0.0	0.0	0.0
E	0.0	0.0	0.0

*** STAGE SCALAR QUANTITIES ***

	ASPECT RATIO	GEOMETRIC HUB RADIUS (IN.)	GEOMETRIC TIP RAD.(IN.)	HUB RAMP ANGLE (DEG)	TIP RAMP ANGLE (DEG)	AXIAL LENGTH (IN.)	MASS FLOW (LB/SEC)	MASS AVE. ADIABATIC EFF.
-ROTOR--	1.093	1.4960	1.8000	4.921	0.0	0.3020	1.9050	0.9015
-STATOR-	1.024	1.5170	1.8000	4.044	0.0	0.2970	1.9050	0.8826

	VEL. RATIO AT THE MEAN	HUB BLOCKAGE FACTOR	TIP BLOCKAGE FACTOR	MASS AVE. PR. RATIO	MASS AVE. TEMP. RATIO	CUMULATIVE MASS AVE. PR. RATIO	CUMULATIVE MASS AVE. TEMP. RATIO	CUMULATIVE MASS AVE. ADIABATIC EFF.
-ROTOR--	0.887	0.9800	0.9800	1.3058	1.0868	3.7357	1.5305	0.8574
-STATOR-	1.066	0.9800	0.9800	1.2988	1.0869	3.7158	1.5305	0.8532

	LOSS DATA SET USED
-ROTOR--	2
-STATOR-	1

****-----** R O T O R E X I T **-----****

S.L. NO.	STREAMLINE RADIUS (IN.)	AXIAL VEL. (FT/SEC)	WHIRL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. MACH NUMBER	ABS. FLOW ANGLE (DEG)	REL. FLOW ANGLE (DEG)	PCT PASS. HT FROM TIP
7	1.7944	535.382	345.49	0.79	637.180	0.4654	32.835	58.560	0.018
6	1.7666	539.907	336.35	4.14	636.117	0.4675	31.921	58.056	0.110
5	1.7109	544.899	328.52	11.42	636.374	0.4719	31.080	56.893	0.293
4	1.6543	546.723	331.95	19.18	639.905	0.4766	31.249	55.428	0.479
3	1.5958	546.506	345.25	27.50	647.010	0.4822	32.250	53.548	0.672
2	1.5346	542.643	369.05	36.46	657.261	0.4890	34.160	51.155	0.873
1	1.5027	539.112	385.26	41.27	663.906	0.4930	35.471	49.693	0.978

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.	LOSS PARAM.
7	1.0927	1.3098	0.8536	0.3793	1221.20	0.954	0.4498	0.0876	0.0240
6	1.0897	1.3069	0.8745	0.3696	1202.27	0.969	0.4557	0.0739	0.0202
5	1.0862	1.3031	0.9013	0.3614	1164.35	1.002	0.4682	0.0576	0.0157
4	1.0848	1.3018	0.9125	0.3653	1125.81	1.038	0.4815	0.0522	0.0143
3	1.0851	1.3037	0.9145	0.3797	1086.05	1.078	0.4944	0.0535	0.0147
2	1.0872	1.3110	0.9117	0.4043	1044.41	1.123	0.5038	0.0597	0.0167
1	1.0889	1.3182	0.9120	0.4202	1022.66	1.148	0.5049	0.0619	0.0174

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
7	817.54	54.90	784.23	47.36	0.07	-0.00077	1026.4053	0.7496
6	807.47	54.90	774.25	47.30	0.44	0.00144	1020.4636	0.7500
5	793.59	54.90	760.31	47.16	1.20	-0.00168	997.8215	0.7399
4	787.03	54.90	753.35	47.02	2.01	-0.01011	964.1040	0.7181
3	787.10	54.90	752.68	46.86	2.88	-0.02119	920.9846	0.6863
2	790.81	54.90	755.29	46.65	3.84	-0.03706	867.1187	0.6450
1	794.13	54.90	757.90	46.53	4.38	-0.04958	835.8347	0.6207

********* S T A T O R   E X I T *********

S.L. NO.	STREAMLINE RADIUS (IN.)	AXIAL VEL. (FT/SEC)	WHIRL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. MACH NUMBER	ABS. FLOW ANGLE (DEG)	REL. FLOW ANGLE (DEG)	PCT PASS. HT FROM TIP
7	1.7948	570.833	0.0	0.67	570.833	0.4152	0.0	64.951	0.018
6	1.7689	571.671	0.0	4.06	571.686	0.4185	0.0	64.598	0.110
5	1.7170	572.274	0.0	10.89	572.377	0.4227	0.0	63.903	0.293
4	1.6642	571.879	0.0	17.99	572.162	0.4243	0.0	63.198	0.480
3	1.6098	569.805	0.0	25.54	570.377	0.4229	0.0	62.498	0.672
2	1.5529	562.750	0.0	33.61	563.753	0.4168	0.0	61.923	0.873
1	1.5232	555.733	0.0	37.78	557.016	0.4108	0.0	61.749	0.978

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.	LOSS PARAM.
7	1.0000	0.9919	0.8268	0.3645	1221.45	1.042	0.5947	0.0591	0.0283
6	1.0000	0.9937	0.8531	0.3514	1203.87	1.058	0.6028	0.0454	0.0215
5	1.0000	0.9961	0.8873	0.3372	1168.53	1.091	0.6125	0.0280	0.0128
4	1.0000	0.9969	0.9011	0.3360	1132.60	1.127	0.6160	0.0220	0.0097
3	1.0000	0.9959	0.8997	0.3474	1095.58	1.167	0.6146	0.0284	0.0121
2	1.0000	0.9921	0.8841	0.3741	1056.85	1.211	0.6075	0.0526	0.0217
1	1.0000	0.9886	0.8736	0.3954	1036.60	1.236	0.6015	0.0749	0.0303

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
7	817.54	54.45	790.81	48.39	0.07	-0.00009	1348.2500	0.9807
6	807.47	54.55	780.64	48.39	0.41	-0.00532	1332.7126	0.9755
5	793.59	54.68	766.67	48.39	1.09	-0.01120	1301.1853	0.9609
4	787.03	54.73	760.11	48.38	1.80	-0.01403	1268.9158	0.9410
3	787.10	54.67	760.36	48.37	2.57	-0.01504	1235.1575	0.9158
2	790.81	54.47	764.69	48.35	3.42	-0.01193	1197.8113	0.8857
1	794.13	54.27	768.64	48.34	3.89	-0.00659	1176.7813	0.8679

*****--*** FINAL FLOW PARAMETERS FOR STAGE NUMBER 5 ***--***

*** STAGE INPUT PARAMETERS ***

ROTOR TIP D-FACTOR LIMIT	0.3600
HUB RELATIVE FLOW ANGLE LIMIT AT THE ROTOR EXIT	0.C
STATOR HUB MACH NUMBER LIMIT (IN)	C.8500
STATOR HUB D-FACTOR LIMIT	0.5500
MAXIMUM TIP TANGENTIAL VELOCITY	500.0

---ROTOR---

	PRESSURE PROFILE	RATIO SUPERSONIC TO TOTAL TURNING	SOLIDITY
A	G.C	-C.164520E 02	0.598636E 01
B	0.100000E 01	0.100000E C1	0.560550E 01
C	0.100000E 01	C.184520E 02	0.0
D	C.0	-0.143270E 02	0.0
E	C.C	0.667100E 01	C.0

---STATOR---

	WHIRL VELOCITY	RATIO SUPERSONIC TO TOTAL TURNING	SOLIDITY
A	0.0	0.0	0.707681E 01
B	0.0	0.100000E 01	0.611462E 01
C	0.0	0.0	0.0
D	0.0	0.0	0.0
E	0.0	0.0	0.0

*** STAGE SCALAR QUANTITIES ***

	ASPECT RATIO	GEOMETRIC HUB RADIUS (IN.)	GEOMETRIC TIP RAD.(IN.)	HUB RAMP ANGLE (DEG)	TIP RAMP ANGLE (DEG)	AXIAL LENGTH (IN.)	MASS FLOW (LB/SEC)	MASS AVE. ADIABATIC EFF.
-ROTOR--	0.925	1.5380	1.800C	3.926	0.C	0.3060	1.9050	C.9140
-STATOR-	0.913	1.5560	1.8000	3.589	0.0	C.2870	1.9050	0.897C

	VEL. RATIO AT THE MEAN	HUB BLOCKAGE FACTOR	TIP BLOCKAGE FACTOR	MASS AVE. PR. RATIO	MASS AVE. TEMP. RATIO	CUMULATIVE MASS AVE. PR. RATIO	CUMULATIVE MASS AVE. TEMP. RATIO	CUMULATIVE MASS AVE. ADIABATIC EFF.
-ROTOR--	0.905	C.9800	0.980C	1.2587	1.0731	4.6770	1.6424	0.8558
-STATOR-	1.055	0.9800	C.98CC	1.2535	1.0731	4.6579	1.6424	C.8529

	LOSS DATA SET USED
-ROTOR--	2
-STATOR-	1

****-----** R O T O R   E X I T **-----****

S.L. NO.	STREAMLINE RADIUS (IN.)	AXIAL VEL. (FT/SEC)	WHIRL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. MACH NUMBER	ABS. FLOW ANGLE (DEG)	REL. FLOW ANGLE (DEG)	PCT PASS. HT FROM TIP
7	1.7951	516.592	319.13	0.58	607.214	0.4263	31.706	60.215	0.019
6	1.7709	519.903	309.01	3.25	604.814	0.4277	30.725	59.880	0.111
5	1.7223	523.524	300.04	8.77	603.479	0.4309	29.814	59.020	0.296
4	1.6732	525.554	301.69	14.71	606.167	0.4349	29.848	57.866	0.484
3	1.6229	526.955	312.26	21.38	612.898	0.4398	30.629	56.347	0.676
2	1.5707	526.583	331.31	29.21	622.823	0.4459	32.137	54.435	0.875
1	1.5437	525.798	343.78	33.76	629.117	0.4495	33.124	53.297	0.978

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.	LOSS PARAM.
7	1.0779	1.2622	0.8661	0.3587	1221.69	0.909	0.4275	0.0743	0.0203
6	1.0754	1.2599	0.8882	0.3465	1205.18	0.922	0.4318	0.0608	0.0166
5	1.0726	1.2569	0.9148	0.3393	1172.14	0.949	0.4413	0.0458	0.0124
4	1.0715	1.2559	0.9254	0.3412	1138.71	0.978	0.4512	0.0407	0.0111
3	1.0718	1.2572	0.9262	0.3521	1104.44	1.009	0.4607	0.0421	0.0116
2	1.0733	1.2619	0.9214	0.3719	1068.92	1.044	0.4673	0.0481	0.0134
1	1.0745	1.2664	0.9217	0.3841	1050.56	1.064	0.4679	0.0502	0.0141

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
7	881.22	68.73	851.15	60.72	0.06	-0.00028	1039.9453	0.7299
6	868.36	68.73	838.50	60.66	0.36	-0.00047	1036.0598	0.7325
5	851.18	68.73	821.40	60.54	0.96	-0.00435	1017.2141	0.7264
4	843.32	68.73	813.25	60.40	1.60	-0.00964	988.4458	0.7093
3	843.61	68.73	812.87	60.23	2.32	-0.01398	951.6775	0.6830
2	848.81	68.73	817.08	60.01	3.17	-0.01720	906.7573	0.6492
1	853.26	68.73	820.90	59.89	3.67	-0.01925	881.5537	0.6297

------ S T A T O R E X I T **------**

S.L. NO.	STREAMLINE RADIUS (IN.)	AXIAL VEL. (FT/SEC)	WHIRL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. MACH NUMBER	ABS. FLOW ANGLE (DEG)	REL. FLOW ANGLE (DEG)	PCT PASS. HT FROM TIP
7	1.7954	544.790	0.0	-0.08	544.790	0.3811	0.0	65.970	0.019
6	1.7726	545.263	0.0	-0.68	545.264	0.3843	0.0	65.678	0.112
5	1.7269	547.196	0.0	-2.02	547.199	0.3895	0.0	65.034	0.299
4	1.6808	550.999	0.0	-3.28	551.009	0.3942	0.0	64.280	0.489
3	1.6339	556.734	0.0	-4.27	556.751	0.3983	0.0	63.403	0.681
2	1.5858	563.331	0.0	-4.84	563.351	0.4019	0.0	62.436	0.878
1	1.5613	566.715	0.0	-4.97	566.736	0.4034	0.0	61.925	0.978

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.	LOSS PARAM.
7	1.0000	0.9934	0.8406	0.3669	1221.90	0.997	0.5626	0.0569	0.0285
6	1.0000	0.9949	0.8681	0.3526	1296.38	1.011	0.5700	0.0432	0.0214
5	1.0000	0.9969	0.9019	0.3343	1175.28	1.039	0.5787	0.0261	0.0126
4	1.0000	0.9975	0.9150	0.3255	1143.88	1.068	0.5827	0.0203	0.0095
3	1.0000	0.9968	0.9128	0.3245	1111.94	1.100	0.5832	0.0259	0.0118
2	1.0000	0.9943	0.8980	0.3312	1079.24	1.134	0.5801	0.0450	0.0198
1	1.0000	0.9922	0.8902	0.3373	1062.52	1.153	0.5772	0.0607	0.0263

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
7	881.22	68.28	857.02	61.81	-0.01	-0.01965	1337.8472	0.9359
6	868.36	68.39	844.10	61.81	-0.07	-0.11766	1323.8831	0.9330
5	851.18	68.52	826.70	61.75	-0.21	-0.31323	1296.4197	0.9225
4	843.32	68.56	818.48	61.64	-0.34	-0.51468	1269.6721	0.9082
3	843.61	68.51	818.25	61.46	-0.44	-0.73115	1243.5376	0.8897
2	848.81	68.34	822.86	61.18	-0.49	-0.97460	1217.4207	0.8686
1	853.26	68.20	827.01	61.01	-0.50	-1.11129	1204.2163	0.8571

-- OUTLET FLOW PARAMETERS ***--***

STA NO.	AXIAL COORDINATE (IN.)	GEOMETRIC HUB RADIUS (IN.)	GEOMETRIC TIP RADIUS (IN.)	HUB BLOCKAGE FACTOR	TIP BLOCKAGE FACTOR
16	4.262	1.534	1.800	0.980	0.980
17	4.387	1.507	1.800	0.980	0.980
18	4.636	1.463	1.800	0.980	0.980

STATION NUMBER 16

S.L. NO.	STREAMLINE RADIUS IN.	AXIAL VEL. (FT/SEC)	WHIRL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. MACH NUMBER	TOTAL TEMP. (DEG.S R)	TOTAL PRES. (LB/SQ IN.)
7	1.7951	495.927	0.0	-1.65	495.93	0.3461	881.22	68.3
6	1.7704	497.214	0.0	-8.22	497.28	0.3496	868.36	68.4
5	1.7208	500.262	0.0	-22.01	500.75	0.3556	851.18	68.5
4	1.6707	504.452	0.0	-37.71	505.86	0.3610	843.32	68.6
3	1.6197	509.357	0.0	-56.96	512.53	0.3658	843.61	68.5
2	1.5671	512.812	0.0	-81.96	519.32	0.3697	848.81	68.3
1	1.5401	513.079	0.0	-97.55	522.27	0.3709	853.26	68.2

STATION NUMBER 17

S.L. NO.	STREAMLINE RADIUS IN.	AXIAL VEL. (FT/SEC)	WHIRL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. MACH NUMBER	TOTAL TEMP. (DEG.S R)	TOTAL PRES. (LB/SQ IN.)
7	1.7946	468.773	0.0	-1.49	468.78	0.3268	881.22	68.3
6	1.7685	469.805	0.0	-8.72	469.89	0.3300	868.36	68.4
5	1.7159	468.543	0.0	-23.32	469.12	0.3327	851.18	68.5
4	1.6621	463.157	0.0	-38.36	464.74	0.3310	843.32	68.6
3	1.6059	452.361	0.0	-54.01	455.57	0.3243	843.61	68.5
2	1.5457	432.512	0.0	-69.94	438.13	0.3107	848.81	68.3
1	1.5135	417.484	0.0	-77.64	424.64	0.3002	853.26	68.2

STATION NUMBER 18

S.L. NO.	STREAMLINE RADIUS IN.	AXIAL VEL. (FT/SEC)	WHIRL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. MACH NUMBER	TOTAL TEMP. (DEG.S R)	TOTAL PRES. (LB/SQ IN.)
7	1.7939	393.631	0.0	0.0	393.63	0.2736	881.22	68.3
6	1.7634	396.609	0.0	0.0	396.61	0.2777	868.36	68.4
5	1.7022	399.843	0.0	0.0	399.84	0.2828	851.18	68.5
4	1.6398	400.440	0.0	0.0	400.44	0.2845	843.32	68.6
3	1.5751	397.968	0.0	0.0	397.97	0.2826	843.61	68.5
2	1.5066	390.258	0.0	0.0	390.26	0.2763	848.81	68.3
1	1.4705	383.386	0.0	0.0	383.39	0.2706	853.26	68.2

APPENDIX D

AIRFOIL COORDINATES FOR COMPRESSOR BLADE SECTIONS

Appendix D contains blade fabrication data in the form of coordinates and geometric properties of airfoils (blade sections) defined by the intersection of planes, perpendicular to the radial direction, and compressor blades formed by stacking and fairing between design blade elements which lie on conical stream surfaces. Because the computer output in this Appendix resulted from the computer program explained in reference 8, the terminology of that reference is used here. Specifically, in reference 8, the term "blade-element" refers to the trace formed by the intersection of a blade and conical stream surface approximation. The term "blade section" refers to the trace formed by the intersection of a blade and a plane section that is perpendicular to a radius drawn from the machine axis. Note that in other portions of this report, the term "blade section" is used to refer to conical surface intersection traces. The conventional "rotated" coordinate system used to describe the airfoils involves positioning the coordinates so that the abscissa (L-axis) is tangent to the radii of the leading and trailing edges on the pressure side of the blade and the ordinate (H-axis) is tangent to the leading edge radius (see fig. D-1).

A glossary and accompanying illustrations are provided to define the variables used in presenting the blade fabrication data. With the exception of $\mathcal{R}$, the notations used for the variables shown in figures D 1 through D-4 correspond to the Fortran IV words used for these parameters in the computer output. The variable $\mathcal{R}$ is the conical coordinate system radius and the related subscripts i, o, and t are used to specify the blade row inlet, outlet, and transition point values of this variable.

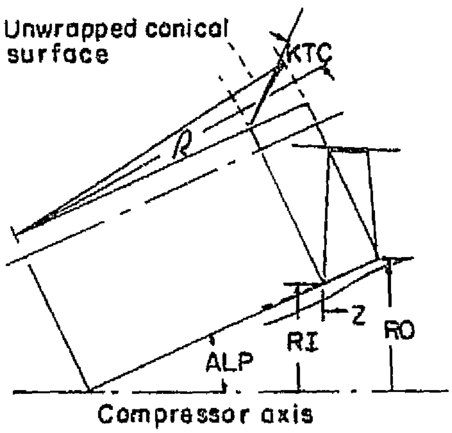

Figure D-3. - Conical coordinate system for blade-element layout (from Reference 8).

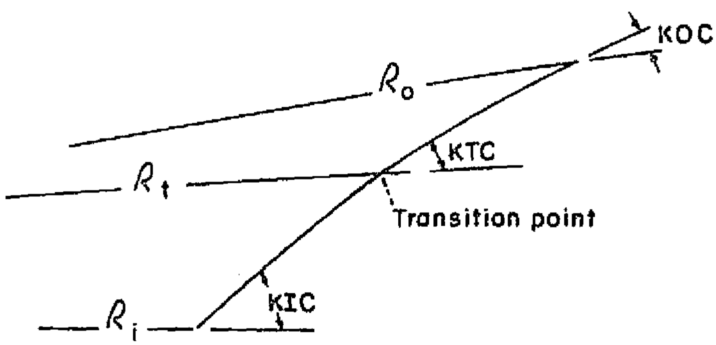

Figure D-4. - Blade-element centerline and surface nomenclature (from Reference 8).

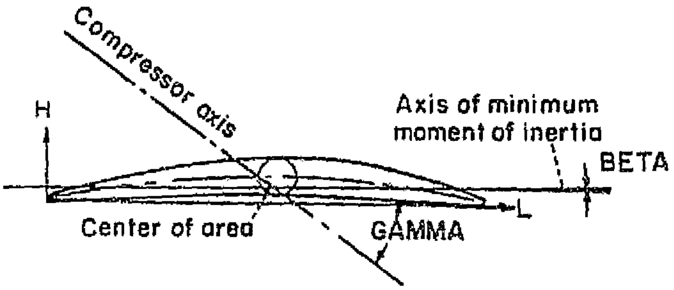

Figure D-1. - Rotated blade section (from Reference 8).

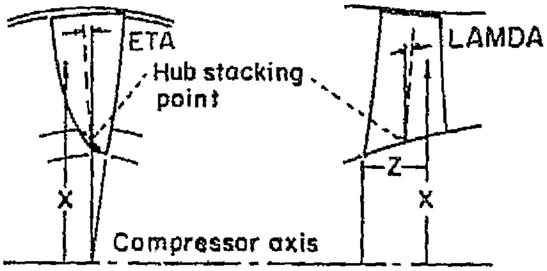

Figure D-2. - Cartesian coordinate system for blade
(from Reference 8).

Glossary of Blade Fabrication Data Variables

NOTE: Same unit length must be used throughout. For this design, inches were used. All angles must be in degrees.

Input for blade coordinate program

ETA — tangential lean angle of stacking line (positive in direction from pressure surface toward suction surface, see Figure D-2)

LAMDA — axial lean angle of stacking line (positive in direction from inlet toward outlet, see Figure D-2)

OP1 — number of specified radial locations for desired blade sections (if OP1 = 0.0, program computes blade sections at radial locations of stacking points for all blade elements)

OP2 — control variable for printing blade-element output

TNLMT — tolerance limit for blade-element stacking iteration

RI — radius from machine axis to leading-edge-center of blade element (see Figure D-3)

RO — radius from machine axis to trailing-edge-center of blade element (see Figure D-3)

TI — blade-element thickness at leading-edge-center

TM — maximum blade-element thickness

TO — blade-element thickness at trailing-edge-center

KIC — blade-element-centerline angle at leading-edge-center

KTC — blade-element-centerline angle at transition point

KOC — blade-element-centerline angle at trailing-edge-center

ZMC — axial distance between hub blade-element leading-edge-center and blade-element maximum thickness location

ZTC — axial distance between hub blade-element leading-edge-center and blade-element transition location

ZOC — axial distance between hub blade-element leading-edge-center and blade-element trailing-edge-center

Stacking iteration parameters

TNORM1	blade-element stacking tolerance
THECG	stacking point circumferential angle coordinate
CRCG	stacking point radius as measured in conical coordinate system

Blade-element angles

ALP	blade-element-cone half angle (see fig. D-3)
KM	local angle at maximum thickness location
KIC	blade-element-centerline angle at leading-edge-center (see figs. D-3 and D-4)
KTC	blade-element-centerline angle at transition point (see figs. D-3 and D-4)
KOC	blade-element-centerline angle at trailing edge center (see figs. D-3 and D-4)
KIP	pressure surface angle at leading edge
KTP	pressure surface angle at transition
KOP	pressure surface angle at trailing edge
KIS	suction surface angle at leading edge
KTS	suction surface angle at transition
KOS	suction surface angle at trailing edge

Blade-element curvatures

CIC	centerline rate of turning for inlet segment
COC	centerline rate of turning for outlet segment
CIP	pressure surface rate of turning for inlet segment
COP	pressure surface rate of turning for outlet segment
CIS	suction surface rate of turning for inlet segment
CAS	suction surface rate of turning for outlet segment

Blade-section coordinates (rotated)

X	X-location of blade-section plane (see fig. D-2)
GAMMA	angle between L-axis and Z-axis (see fig. D-1)
TI	Leading-edge thickness
L(SP)	L-location of hub blade-element stacking point
L-BAR	L-location of blade-section center of area (calculated from L and H coordinates of rotated-blade-section profile)
AREA	blade-section area
IMIN	minimum moment of inertia about an axis through the center of area
ILLCG	moment of inertia about L-axis translated to the center of area
PHLCG	product of inertia associated with the L and H axes translated to the center of area
I(LL)	moment of inertia about the L-axis
PHL	product of inertia associated with the L and H axes
TM	maximum thickness
TO	trailing-edge thickness
H(SP)	H-location of hub blade-element stacking point
H-Bar	H-location of blade-section center of area (calculated from L and H coordinates of rotated-blade-section profile)
BETA	angle between the axis of minimum moment of inertia and the L-axis (see fig. D-4)
IMAX	maximum moment of inertia about an axis through the center of area
IHHCG	moment of inertia about the H-axis translated to the center of area
I(HH)	moment of inertia about the H-axis

L(IC)	L-location of leading-edge-center, centerline
L(MC)	L-location of maximum thickness point, centerline
L(TC)	L-location of transition point, centerline
L(OC)	L-location of trailing-edge-center, centerline
L(IP) L(MP) L(TP) L(OP)	L-location as above, pressure surface
L(IS) L(MS) L(TS) L(OS)	L-locations as above, suction surface
L(CG)	L-location of blade-section center of area (obtained by rotation and translation of the unrotated-blade-section center-of-area coordinate)
H(IC)	H-location of leading-edge-center, centerline
H(MC)	H-location of maximum thickness point, centerline
H(TC)	H-location of transition point, centerline
H(OC)	H-location of trailing-edge-center, centerline
H(IP) H(MP) H(TP) H(OP)	H-locations as above, pressure surface
H(IS) H(MS) H(TS) H(OS)	H-locations as above, suction surface
H(CG)	H-location of blade-section center of area (obtained by rotation and translation of the unrotated-blade-section center-of-area coordinate)
L	L-distance (see fig. D-1)
HP	H-distance to blade-section pressure surface (see fig.D-1)
HS	H-distance to blade-section suction surface (see fig.D-1)

FIRST STAGE ROTOR TDA 015 TRIAL 1

INPUT FOR BLADE COORDINATE PROGRAM

ETA	LAMDA	OP1	OP2	TNLMT
0.0	0.0	8.00000	1.00000	0.00010

ELEMENT	RI	RO	TI	TM	TO	KIC	KTC	KOC	ZMC	ZTC	ZOC
1	1.79771	1.79587	0.00600	0.01500	0.00600	56.69383	55.09062	53.01332	0.11560	0.10697	0.16757
2	1.74165	1.74216	0.00600	0.01540	0.00600	55.33702	53.17501	53.11501	0.11883	0.10590	0.17350
3	1.62271	1.63017	0.00600	0.01620	0.00600	53.90065	49.65875	50.92836	0.12341	0.10129	0.18437
4	1.49218	1.51044	0.00600	0.01710	0.00600	52.05756	45.00659	46.15210	0.12908	0.09513	0.19956
5	1.34532	1.38026	0.00600	0.01810	0.00600	49.76778	39.22347	37.64699	0.13581	0.08627	0.21925
6	1.17449	1.23545	0.00600	0.01930	0.00600	46.44963	32.46554	25.24736	0.14208	0.07349	0.24067
7	1.07549	1.15556	0.00600	0.02000	0.00600	44.05528	28.23166	15.72445	0.14549	0.06493	0.25179

BLADE ELEMENT STACKING PARAMETER--TNORMI = 0.429D-02

THECG

0.7256875D-01 0.7393185D-01 0.7763916D-01 0.8061555D-01 0.8213738D-01 0.8019865D-01 0.7573137D-01

CRCG

-163.6400 592.5979 40.23717 16.48495 8.669173 4.917781 3.692332

BLADE ELEMENT STACKING PARAMETER--TNORMI = 0.641D-04

THECG

0.7255117D-01 0.7392686D-01 0.7767120D-01 0.8066049D-01 0.8199365D-01 0.7961462D-01 0.7454304D-01

CRCG

-163.6400 592.5979 40.23725 16.48523 8.669567 4.918326 3.692949

BLADE ELEMENT ANGLES

ELEMENT	ALP	KM	KIC	KTC	KOC	KIP	KTP	KOP	KIS	KTS	KOS
1	-0.62911	54.78832	56.69383	55.09062	53.01332	55.05974	54.09609	58.86175	58.32731	56.08147	47.18672
2	0.16842	53.16353	55.33702	53.17501	53.11501	53.92616	51.77970	59.02034	56.74193	54.57021	47.21015
3	2.31705	49.99350	53.90065	49.65875	50.92836	52.97853	47.47895	57.02555	54.80461	51.84309	44.81810
4	5.22808	45.37644	52.05756	45.00659	46.15210	51.67617	42.01267	52.44019	52.40565	48.00653	39.85060
5	9.05460	38.63213	49.76778	39.22347	37.64699	50.15069	35.31351	44.16901	49.33947	43.12906	31.13082
6	14.21368	29.44271	46.44963	32.46554	25.24736	47.90873	27.55566	32.06582	44.94650	37.34058	18.47358
7	17.64083	22.70205	44.05528	28.23166	15.72445	46.61150	22.65753	22.75830	41.48335	33.73499	8.77278

BLADE ELEMENT CURVATURES

ELEMENT	CIC	COC	CIP	COP	CIS	CAS
1	0.14667	0.35118	0.08821	-0.80625	0.20524	1.49817
2	0.20814	0.00929	0.20680	-1.11969	0.20870	1.13804
3	0.45174	-0.17025	0.50670	-1.27667	0.31460	0.94187
4	0.85254	-0.13344	1.17215	-1.21132	0.52967	0.94984
5	1.50055	0.16005	2.12245	-0.89816	0.87805	1.21530
6	2.47955	0.63937	3.63607	-0.40045	1.33613	1.66103
7	3.26290	1.03032	4.98212	-0.00835	1.58059	2.03699

BLADE SECTION COORDINATES (ROTATED) AT X = 1.0755

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL			
23.5079	0.0058	0.1607	0.1614	0.3796D-02	0.2245D-06	0.2322D-06	-0.3577D-06	0.2097D-05	0.1322D-04			
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)				
0.0204	0.0062	0.0221	0.0222	-1.223	0.1699D-04	0.1698D-04		0.1159D-03				
L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0029	0.1699	0.0791	0.2825	0.0039	0.1691	0.0794	0.2816	0.0020	0.1710	0.0791	0.2834	0.1607
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0029	0.0265	0.0235	0.0041	0.0002	0.0168	0.0189	0.0001	0.0057	0.0368	0.0288	0.0061	0.0221

L	HP	HS
0.0	0.0029	0.0029
0.0029	-0.0003	0.0060
0.0100	0.0030	0.0087
0.0200	0.0072	0.0122
0.0300	0.0107	0.0156
0.0400	0.0136	0.0187
0.0500	0.0159	0.0216
0.0600	0.0175	0.0243
0.0700	0.0186	0.0268
0.0800	0.0189	0.0290
0.0900	0.0189	0.0311
0.1000	0.0188	0.0328
0.1100	0.0188	0.0343
0.1200	0.0186	0.0354
0.1300	0.0184	0.0363
0.1400	0.0181	0.0369
0.1500	0.0178	0.0372
0.1600	0.0173	0.0372
0.1700	0.0167	0.0369
0.1800	0.0161	0.0362
0.1900	0.0153	0.0352
0.2000	0.0144	0.0339
0.2100	0.0133	0.0322
0.2200	0.0121	0.0301
0.2300	0.0107	0.0276
0.2400	0.0091	0.0246
0.2500	0.0073	0.0212
0.2600	0.0053	0.0174
0.2700	0.0031	0.0129
0.2800	0.0006	0.0079
0.2825	-0.0001	0.0066
0.2856	0.0031	0.0031

BLADE SECTION COORDINATES (ROTATED) AT X = 1.1191

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG		I(LL)	PHL		
26.9332	0.0058	0.1619	0.1626	0.3776D-02	0.1888D-06	0.1962D-06	-0.3569D-06		0.1628D-05	0.1160D-04		
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG			I(HH)			
0.0200	0.0061	0.0195	0.0195	-1.187	0.1742D-04	0.1742D-04			0.1172D-03			
L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0029	0.1730	0.0862	0.2844	0.0038	0.1720	0.0863	0.2835	0.0021	0.1740	0.0862	0.2852	0.1619
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0029	0.0234	0.0221	0.0031	0.0001	0.0135	0.0167	0.0001	0.0057	0.0333	0.0275	0.0060	0.0195

L	HP	HS
0.0	0.0029	0.0029
0.0029	-0.0002	0.0060
0.0100	0.0026	0.0083
0.0200	0.0062	0.0115
0.0300	0.0093	0.0145
0.0400	0.0118	0.0172
0.0500	0.0138	0.0198
0.0600	0.0153	0.0222
0.0700	0.0163	0.0244
0.0800	0.0167	0.0264
0.0900	0.0167	0.0282
0.1000	0.0165	0.0297
0.1100	0.0162	0.0310
0.1200	0.0159	0.0321
0.1300	0.0155	0.0329
0.1400	0.0152	0.0334
0.1500	0.0147	0.0337
0.1600	0.0142	0.0337
0.1700	0.0136	0.0335
0.1800	0.0130	0.0329
0.1900	0.0123	0.0321
0.2000	0.0115	0.0309
0.2100	0.0106	0.0294
0.2200	0.0096	0.0276
0.2300	0.0084	0.0254
0.2400	0.0072	0.0229
0.2500	0.0058	0.0199
0.2600	0.0043	0.0166
0.2700	0.0027	0.0128
0.2800	0.0008	0.0085
0.2844	-0.0001	0.0064
0.2875	0.0031	0.0031

BLADE SECTION COORDINATES (ROTATED) AT X = 1.1556

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
29.6007	0.0059	0.1628	0.1636	0.3758D-02	0.1619D-06	0.1689D-06	-0.3524D-06	0.1301D-05	0.1032D-04
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0197	0.0061	0.0174	0.0174	-1.144	0.1782D-04	0.1781D-04		0.1184D-05	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0029	0.1754	0.0921	0.2863	0.0037	0.1745	0.0920	0.2855	0.0022	0.1763	0.0921	0.2871	0.1628
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0029	0.0207	0.0205	0.0031	0.0001	0.0109	0.0149	0.3001	0.0057	0.0304	0.0261	0.0060	0.0174

L	HP	HS
0.0	0.0029	0.0029
0.0029	-0.0002	0.0060
0.0100	0.0023	0.0081
0.0200	0.0055	0.0109
0.0300	0.0082	0.0136
0.0400	0.0105	0.0161
0.0500	0.0123	0.0184
0.0600	0.0136	0.0205
0.0700	0.0145	0.0225
0.0800	0.0149	0.0242
0.0900	0.0149	0.0258
0.1000	0.0146	0.0272
0.1100	0.0141	0.0284
0.1200	0.0137	0.0294
0.1300	0.0132	0.0301
0.1400	0.0127	0.0306
0.1500	0.0122	0.0309
0.1600	0.0117	0.0309
0.1700	0.0112	0.0307
0.1800	0.0106	0.0302
0.1900	0.0099	0.0295
0.2000	0.0092	0.0285
0.2100	0.0085	0.0272
0.2200	0.0076	0.0256
0.2300	0.0067	0.0237
0.2400	0.0058	0.0215
0.2500	0.0047	0.0189
0.2600	0.0036	0.0160
0.2700	0.0023	0.0127
0.2800	0.0009	0.0089
0.2863	-0.0000	0.0063
0.2894	0.0031	0.0031

BLADE SECTION COORDINATES (ROTATED) AT X =   1.2553

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
35.8718	0.0060	0.1647	0.1651	0.3667D-02	0.1078D-06	0.1137D-06	-0.3286D-06	0.6970D-06	0.7306D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0189	0.0062	0.0125	0.0126	-1.031	0.1836D-04	0.1836D-04		0.1183D-03	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1817	0.1076	0.2914	0.0035	0.1809	0.1076	0.2909	0.0024	0.1824	0.1081	0.2919	0.1647
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0144	0.0161	0.0031	0.0001	0.0050	0.0099	0.0000	0.0059	0.0237	0.0224	0.0061	0.0125

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0001	0.0060
0.0100	0.0017	0.0076
0.0200	0.0039	0.0097
0.0300	0.0058	0.0117
0.0400	0.0075	0.0135
0.0500	0.0088	0.0152
0.0600	0.0097	0.0168
0.0700	0.0104	0.0182
0.0800	0.0107	0.0195
0.0900	0.0107	0.0207
0.1000	0.0103	0.0217
0.1100	0.0098	0.0226
0.1200	0.0091	0.0233
0.1300	0.0083	0.0238
0.1400	0.0075	0.0242
0.1500	0.0068	0.0244
0.1600	0.0062	0.0244
0.1700	0.0056	0.0242
0.1800	0.0050	0.0239
0.1900	0.0045	0.0233
0.2000	0.0040	0.0226
0.2100	0.0035	0.0217
0.2200	0.0030	0.0205
0.2300	0.0025	0.0192
0.2400	0.0021	0.0177
0.2500	0.0017	0.0159
0.2600	0.0013	0.0140
0.2700	0.0009	0.0118
0.2800	0.0005	0.0093
0.2900	0.0001	0.0067
0.2914	0.0000	0.0063
0.2945	0.0031	0.0031

BLADE SECTION COORDINATES (ROTATED) AT X = 1.3915

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
42.6915	0.0060	0.1655	0.1661	0.3560D-02	0.7342D-07	0.7779D-07	-0.2892D-06	0.3271D-06	0.4659D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0179	0.0060	0.0083	0.0084	-0.8698	0.1906D-04	0.1906D-04		0.1172D-03	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1891	0.1291	0.2947	0.0034	0.1885	0.1287	0.2945	0.0026	0.1896	0.1294	0.2950	0.1655
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0089	0.0111	0.0030	0.0000	-0.0000	0.0041	0.0000	0.0060	0.0178	0.0179	0.0060	0.0083

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0000	0.0063
0.0100	0.0010	0.0078
0.0200	0.0023	0.0084
0.0300	0.0035	0.0097
0.0400	0.0044	0.0110
0.0500	0.0052	0.0121
0.0600	0.0057	0.0131
0.0700	0.0061	0.0141
0.0800	0.0062	0.0150
0.0900	0.0062	0.0157
0.1000	0.0060	0.0164
0.1100	0.0055	0.0170
0.1200	0.0048	0.0175
0.1300	0.0040	0.0179
0.1400	0.0032	0.0182
0.1500	0.0023	0.0184
0.1600	0.0016	0.0184
0.1700	0.0009	0.0183
0.1800	0.0004	0.0181
0.1900	-0.0001	0.0178
0.2000	-0.0005	0.0173
0.2100	-0.0008	0.0167
0.2200	-0.0010	0.0159
0.2300	-0.0011	0.0151
0.2400	-0.0012	0.0141
0.2500	-0.0012	0.0129
0.2600	-0.0010	0.0116
0.2700	-0.0008	0.0102
0.2800	-0.0006	0.0086
0.2900	-0.0002	0.0069
0.2947	0.0000	0.0061
0.2978	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.5277

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
48.1941	0.0060	0.1648	0.1654	0.34660-02	0.55660-07	0.58210-07	-0.22350-06	0.16430-06	0.29490-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0169	0.0060	0.0055	0.0055	-0.6560	0.19580-04	0.19570-04		0.11440-03	

L(IC)	L(HC)	L(TC)	L(DC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1959	0.1508	0.2962	0.0032	0.1956	0.1504	0.2961	0.0028	0.1962	0.1511	0.2962	0.1648
H(IC)	H(HC)	H(TC)	H(DC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0053	0.0069	0.0030	0.0000	-0.0031	-0.0005	0.0000	0.0060	0.0138	0.0141	0.0060	0.0055

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0000	0.0060
0.0100	0.0005	0.0067
0.0200	0.0011	0.0075
0.0300	0.0016	0.0084
0.0400	0.0021	0.0091
0.0500	0.0024	0.0099
0.0600	0.0026	0.0105
0.0700	0.0027	0.0111
0.0800	0.0027	0.0117
0.0900	0.0026	0.0122
0.1000	0.0023	0.0126
0.1100	0.0020	0.0130
0.1200	0.0016	0.0134
0.1300	0.0010	0.0137
0.1400	0.0003	0.0139
0.1500	-0.0005	0.0141
0.1600	-0.0012	0.0142
0.1700	-0.0019	0.0142
0.1800	-0.0025	0.0141
0.1900	-0.0029	0.0139
0.2000	-0.0033	0.0136
0.2100	-0.0034	0.0133
0.2200	-0.0035	0.0128
0.2300	-0.0035	0.0122
0.2400	-0.0033	0.0115
0.2500	-0.0030	0.0108
0.2600	-0.0026	0.0099
0.2700	-0.0020	0.0090
0.2800	-0.0014	0.0079
0.2900	-0.0006	0.0068
0.2962	0.0000	0.0060
0.2992	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.6639

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
52.0327	0.0060	0.1629	0.1636	0.3394D-02	0.4656D-07	0.4743D-07	-0.1316D-06	0.1044D-06	0.2143D-05
TH	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0160	0.0060	0.0041	0.0041	-0.3791	0.1994D-04	0.1994D-04		0.1107D-03	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.2020	0.1717	0.2966	0.0031	0.2019	0.1716	0.2966	0.0029	0.2022	0.1719	0.2966	0.1629
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0038	0.0044	0.0030	0.0000	-0.0042	-0.0030	0.0000	0.0060	0.0118	0.0119	0.0060	0.0041

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0000	0.0060
0.0100	0.0001	0.0065
0.0200	0.0003	0.0070
0.0300	0.0004	0.0075
0.0400	0.0005	0.0080
0.0500	0.0005	0.0085
0.0600	0.0005	0.0089
0.0700	0.0004	0.0093
0.0800	0.0003	0.0097
0.0900	0.0001	0.0101
0.1000	-0.0001	0.0104
0.1100	-0.0004	0.0107
0.1200	-0.0007	0.0110
0.1300	-0.0010	0.0112
0.1400	-0.0015	0.0114
0.1500	-0.0019	0.0116
0.1600	-0.0024	0.0117
0.1700	-0.0029	0.0119
0.1800	-0.0035	0.0119
0.1900	-0.0039	0.0119
0.2000	-0.0042	0.0118
0.2100	-0.0043	0.0116
0.2200	-0.0043	0.0113
0.2300	-0.0042	0.0109
0.2400	-0.0040	0.0104
0.2500	-0.0036	0.0098
0.2600	-0.0031	0.0092
0.2700	-0.0024	0.0084
0.2800	-0.0016	0.0076
0.2900	-0.0007	0.0067
0.2966	0.0000	0.0060
0.2996	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.8500

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
56.6431	0.0062	0.1590	0.1598	0.3349D-02	0.4251D-07	0.4273D-07	0.6673D-07	0.1279D-06	0.2765D-05
TH	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0146	0.0060	0.0050	0.0050	0.1877	0.2042D-04	0.2042D-04		0.1059D-03	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0031	0.2113	0.2027	0.2966	0.0031	0.2114	0.2036	0.2964	0.0031	0.2115	0.2034	0.2968	0.1590
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0031	0.0057	0.0053	0.0030	0.0000	-0.0015	-0.0014	0.0000	0.0062	0.0131	0.0131	0.0060	0.0050

L	HP	HS
0.0	0.0031	0.0031
0.0031	0.0000	0.0062
0.0100	-0.0000	0.0066
0.0200	-0.0001	0.0071
0.0300	-0.0001	0.0076
0.0400	-0.0002	0.0081
0.0500	-0.0002	0.0086
0.0600	-0.0003	0.0091
0.0700	-0.0004	0.0095
0.0800	-0.0004	0.0099
0.0900	-0.0005	0.0103
0.1000	-0.0006	0.0106
0.1100	-0.0006	0.0110
0.1200	-0.0007	0.0113
0.1300	-0.0008	0.0116
0.1400	-0.0009	0.0118
0.1500	-0.0009	0.0121
0.1600	-0.0010	0.0123
0.1700	-0.0011	0.0125
0.1800	-0.0012	0.0127
0.1900	-0.0012	0.0129
0.2000	-0.0014	0.0131
0.2100	-0.0015	0.0131
0.2200	-0.0015	0.0130
0.2300	-0.0015	0.0127
0.2400	-0.0014	0.0122
0.2500	-0.0013	0.0116
0.2600	-0.0011	0.0107
0.2700	-0.0009	0.0097
0.2800	-0.0006	0.0085
0.2900	-0.0002	0.0071
0.2966	0.0000	0.0060
0.2996	0.0030	0.0030

FIRST STAGE STATOR   TCA 017   TRIAL 1

INPUT FOR BLADE COORDINATE PROGRAM

ETA	LAMDA	OP1	OP2	TNLMT
0.0	0.0	9.03000	1.00000	0.00010

ELEMENT	RI	RO	TI	TM	TO	KIC	KTC	KOC	ZMC	ZTC	ZOC
1	1.79422	1.79129	0.00600	0.02000	0.00600	26.85025	13.65644	-17.92971	0.11971	0.05902	0.24319
2	1.74289	1.74520	0.00600	0.02000	0.00600	26.55523	14.62054	-14.27392	0.11891	0.06806	0.24253
3	1.63647	1.64984	0.00600	0.02000	0.00600	26.65590	15.79549	-11.55724	0.11803	0.06564	0.24145
4	1.52326	1.54904	0.00600	0.02000	0.00600	27.49964	16.97849	-10.37041	0.11691	0.06343	0.23984
5	1.40040	1.44051	0.00600	0.02000	0.00600	29.18716	18.51204	-9.74766	0.11505	0.06140	0.23707
6	1.26399	1.32057	0.00600	0.02000	0.00600	31.98667	20.26120	-9.48215	0.11245	0.05813	0.23284
7	1.18885	1.25435	0.00600	0.02000	0.00600	32.28955	21.01015	-11.02405	0.11117	0.05585	0.23063

BLADE ELEMENT STACKING PARAMETER--TNORMI = 0.2660-02

THECG
0.1533610D-01   0.1687096D-01   0.1909242D-01   0.2177521D-01   0.2564835D-01   0.3062032D-01   0.3316073D-01

CRCG
-148.8048   183.1162   29.71743   14.37160   8.512643   5.470328   4.468956

BLADE ELEMENT STACKING PARAMETER--TNORMI = 0.3470-04

THECG
0.1524932D-01   0.1681571D-01   0.1904809D-01   0.2175929D-01   0.2557177D-01   0.3061535D-01   0.3309224D-01

CRCG
-148.8049   183.1160   29.71723   14.37133   8.512252   5.469788   4.468422

BLADE ELEMENT ANGLES

ELEMENT	ALP	KN	KIC	KTC	KOC	KIP	KTP	KOP	KIS	KTS	KOS
1	-0.69031	4.46101	26.85025	13.65644	-17.92971	20.38291	10.95634	-11.49278	33.06037	16.24980	-24.12055
2	0.54570	6.14175	26.55523	14.62054	-14.27382	20.08161	11.88301	-7.78555	32.79334	17.25858	-20.52581
3	3.16945	7.54980	26.65590	15.79549	-11.55724	20.22559	12.93947	-5.02543	32.86813	18.55357	-17.86600
4	6.13507	8.56406	27.49964	16.97849	-10.37041	21.14957	14.02430	-3.80457	33.53856	19.83159	-16.71457
5	9.60297	9.71981	29.18716	18.51204	-9.74766	22.95212	15.49292	-3.14687	35.21280	21.42429	-16.12062
6	13.65813	10.80168	31.08667	20.26120	-9.48215	25.02250	17.12070	-2.83493	36.94458	23.28494	-15.89227
7	15.85480	10.63370	32.28955	21.01015	-11.02405	26.45310	17.77219	-4.36169	39.01503	24.11907	-17.43425

BLADE ELEMENT CURVATURES

ELEMENT	CIC	COC	CIP	COP	CIS	CAS
1	3.12294	3.12305	2.26843	2.27344	3.89005	3.88590
2	2.85976	2.85980	1.99364	1.99033	3.64526	3.64874
3	2.68368	2.68374	1.82448	1.79948	3.46851	3.49380
4	2.66054	2.66039	1.82504	1.77017	3.42509	3.47361
5	2.73250	2.73235	1.93433	1.84049	3.46205	3.54497
6	2.84234	2.84236	2.10236	1.94913	3.51764	3.65304
7	3.02564	3.02575	2.33424	2.14003	3.65362	3.87407

BLADE SECTION COORDINATES (ROTATED) AT X = 1.1999

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
10.7673	0.0060	0.1208	0.1210	0.36700-02	0.22920-06	0.22930-06	0.48040-07	0.18030-05	0.92400-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0200	0.0060	0.0206	0.0207	0.2139	0.13100-04	0.13100-04		0.66800-04	

L(TC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1206	0.0630	0.2367	0.0040	0.1205	0.0643	0.2355	0.0020	0.1207	0.0617	0.2379	0.1208
H(TC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0267	0.0208	0.0030	0.0002	0.0167	0.0128	0.0002	0.0058	0.0367	0.0289	0.0058	0.0206

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0001	0.0063
0.0050	0.0005	0.0074
0.0100	0.0018	0.0098
0.0150	0.0031	0.0122
0.0200	0.0044	0.0145
0.0250	0.0056	0.0166
0.0300	0.0067	0.0186
0.0350	0.0078	0.0205
0.0400	0.0088	0.0223
0.0450	0.0097	0.0240
0.0500	0.0106	0.0256
0.0550	0.0114	0.0271
0.0600	0.0122	0.0284
0.0650	0.0129	0.0297
0.0700	0.0135	0.0308
0.0750	0.0141	0.0319
0.0800	0.0146	0.0328
0.0850	0.0151	0.0337
0.0900	0.0155	0.0344
0.0950	0.0158	0.0351
0.1000	0.0161	0.0356
0.1050	0.0164	0.0360
0.1100	0.0166	0.0363
0.1150	0.0167	0.0366
0.1200	0.0167	0.0367
0.1250	0.0167	0.0367
0.1300	0.0167	0.0366
0.1350	0.0166	0.0364
0.1400	0.0164	0.0361
0.1450	0.0161	0.0357
0.1500	0.0158	0.0352
0.1550	0.0155	0.0345
0.1600	0.0151	0.0938
0.1650	0.0146	0.0329
0.1700	0.0140	0.0320
0.1750	0.0134	0.0309
0.1800	0.0127	0.0297
0.1850	0.0119	0.0283
0.1900	0.0111	0.0269
0.1950	0.0102	0.0253
0.2000	0.0092	0.0236
0.2050	0.0082	0.0217
0.2100	0.0071	0.0197
0.2150	0.0059	0.0176
0.2200	0.0046	0.0153
0.2250	0.0033	0.0128
0.2300	0.0019	0.0102
0.2350	0.0004	0.0074
0.2367	-0.0001	0.0064
0.2396	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.2209

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
10.8278	0.0060	0.1212	0.1215	0.3686D-02	0.2239D-06	0.2241D-06	0.4090D-07	0.1733D-05	0.9102D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0200	0.0060	0.0202	0.0202	0.1793	0.1329D-04	0.1329D-04		0.6771D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1211	0.0640	0.2377	0.0040	0.1210	0.0653	0.2366	0.0020	0.1212	0.0627	0.2388	0.1212
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0261	0.0205	0.0030	0.0002	0.0161	0.0124	0.0002	0.0059	0.0361	0.0286	0.0058	0.0202

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0001	0.0064
0.0050	0.0004	0.0073
0.0100	0.0017	0.0097
0.0150	0.0030	0.0121
0.0200	0.0042	0.0143
0.0250	0.0053	0.0163
0.0300	0.0064	0.0183
0.0350	0.0074	0.0202
0.0400	0.0084	0.0219
0.0450	0.0093	0.0236
0.0500	0.0101	0.0251
0.0550	0.0109	0.0266
0.0600	0.0117	0.0279
0.0650	0.0123	0.0292
0.0700	0.0130	0.0303
0.0750	0.0135	0.0313
0.0800	0.0140	0.0323
0.0850	0.0145	0.0331
0.0900	0.0149	0.0338
0.0950	0.0152	0.0344
0.1000	0.0155	0.0350
0.1050	0.0158	0.0354
0.1100	0.0159	0.0357
0.1150	0.0161	0.0360
0.1200	0.0161	0.0361
0.1250	0.0161	0.0361
0.1300	0.0161	0.0360
0.1350	0.0160	0.0358
0.1400	0.0158	0.0355
0.1450	0.0156	0.0352
0.1500	0.0153	0.0347
0.1550	0.0150	0.0340
0.1600	0.0146	0.0333
0.1650	0.0141	0.0325
0.1700	0.0136	0.0316
0.1750	0.0130	0.0305
0.1800	0.0123	0.0294
0.1850	0.0116	0.0281
0.1900	0.0108	0.0267
0.1950	0.0100	0.0251
0.2000	0.0091	0.0235
0.2050	0.0081	0.0217
0.2100	0.0070	0.0198
0.2150	0.0059	0.0177
0.2200	0.0047	0.0155
0.2250	0.0034	0.0131
0.2300	0.0021	0.0106
0.2350	0.0007	0.0079
0.2377	-0.0001	0.0064
0.2407	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.2544

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL			
10.3548	0.0061	0.1217	0.1221	0.3704D-02	0.2170D-06	0.2171D-06	0.3778D-07	0.1653D-05	[illegible]			
TH	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)				
0.0200	0.0060	0.0197	0.0197	0.1630	0.1350D-04	0.1350D-04		0.6869D-04				
L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1216	0.0650	0.2388	0.0040	0.1215	0.0653	0.2377	0.0020	0.1217	0.0637	0.2399	0.1217
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0254	0.0201	0.0030	0.0002	0.0154	0.0119	0.0002	0.0059	0.0354	0.0282	0.0058	0.0197

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0001	0.0064
0.0050	0.0004	0.0073
0.0100	0.0017	0.0096
0.0150	0.0028	0.0119
0.0200	0.0040	0.0140
0.0250	0.0051	0.0161
0.0300	0.0061	0.0180
0.0350	0.0071	0.0198
0.0400	0.0080	0.0215
0.0450	0.0088	0.0231
0.0500	0.0096	0.0246
0.0550	0.0104	0.0260
0.0600	0.0111	0.0273
0.0650	0.0117	0.0285
0.0700	0.0123	0.0296
0.0750	0.0129	0.0307
0.0800	0.0133	0.0316
0.0850	0.0138	0.0324
0.0900	0.0142	0.0331
0.0950	0.0145	0.0337
0.1000	0.0148	0.0342
0.1050	0.0150	0.0347
0.1100	0.0152	0.0350
0.1150	0.0153	0.0352
0.1200	0.0154	0.0353
0.1250	0.0154	0.0354
0.1300	0.0154	0.0353
0.1350	0.0153	0.0351
0.1400	0.0151	0.0349
0.1450	0.0149	0.0345
0.1500	0.0147	0.0340
0.1550	0.0144	0.0335
0.1600	0.0140	0.0328
0.1650	0.0136	0.0320
0.1700	0.0131	0.0311
0.1750	0.0125	0.0301
0.1800	0.0119	0.0290
0.1850	0.0113	0.0278
0.1900	0.0105	0.0264
0.1950	0.0097	0.0250
0.2000	0.0089	0.0234
0.2050	0.0080	0.0217
0.2100	0.0070	0.0198
0.2150	0.0059	0.0178
0.2200	0.0048	0.0157
0.2250	0.0036	0.0135
0.2300	0.0023	0.0110
0.2350	0.0010	0.0085
0.2388	-0.0001	0.0064
0.2418	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.3367

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG		I(LL)	PHL		
10.6285	0.0061	0.1228	0.1230	0.37340-02	0.19900-06	0.19900-06	0.16500-07		0.14740-05	0.85030-05		
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG			I(HH)			
0.0200	0.0060	0.0184	0.0185	0.69400-01	0.13820-04	0.13820-04			0.79310-04			
L(IC)	L(HC)	L(TC)	L(DC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0031	0.1228	0.0671	0.2416	0.0040	0.1227	0.0683	0.2406	0.0021	0.1229	0.0659	0.2427	0.1228
H(IC)	H(HC)	H(TC)	H(DC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0031	0.0237	0.0192	0.0030	0.0002	0.0137	0.0109	0.0002	0.0060	0.0337	0.0275	0.0058	0.0184

L	HP	HS
0.0	0.0031	0.0031
0.0031	-0.0001	0.0064
0.0050	0.0004	0.0072
0.0100	0.0015	0.0094
0.0150	0.0026	0.0116
0.0200	0.0036	0.0136
0.0250	0.0046	0.0155
0.0300	0.0055	0.0174
0.0350	0.0064	0.0191
0.0400	0.0072	0.0207
0.0450	0.0080	0.0222
0.0500	0.0087	0.0237
0.0550	0.0094	0.0250
0.0600	0.0100	0.0262
0.0650	0.0106	0.0274
0.0700	0.0111	0.0284
0.0750	0.0116	0.0293
0.0800	0.0120	0.0302
0.0850	0.0124	0.0310
0.0900	0.0127	0.0316
0.0950	0.0130	0.0322
0.1000	0.0132	0.0327
0.1050	0.0134	0.0331
0.1100	0.0136	0.0334
0.1150	0.0137	0.0336
0.1200	0.0137	0.0337
0.1250	0.0137	0.0337
0.1300	0.0137	0.0337
0.1350	0.0136	0.0335
0.1400	0.0135	0.0332
0.1450	0.0133	0.0329
0.1500	0.0131	0.0325
0.1550	0.0128	0.0319
0.1600	0.0124	0.0313
0.1650	0.0121	0.0306
0.1700	0.0116	0.0298
0.1750	0.0112	0.0289
0.1800	0.0106	0.0278
0.1850	0.0101	0.0267
0.1900	0.0094	0.0255
0.1950	0.0088	0.0242
0.2000	0.0080	0.0227
0.2050	0.0073	0.0212
0.2100	0.0064	0.0195
0.2150	0.0055	0.0179
0.2200	0.0046	0.0159
0.2250	0.0036	0.0139
0.2300	0.0026	0.0118
0.2350	0.0015	0.0095
0.2400	0.0003	0.0071
0.2416	-0.0001	0.0063
0.2446	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.4525

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL			
0.4498	0.0062	0.1239	0.1243	0.3785D-02	0.1969D-06	0.1969D-06	-0.2893D-08	0.1420D-05	0.8457D-05			
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)				
0.0200	0.0060	0.0180	0.0180	-0.1167D-01	0.1440D-04	0.1440D-04		0.7291D-04				
L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0031	0.1239	0.0688	0.2444	0.0040	0.1239	0.0700	0.2434	0.0022	0.1240	0.0676	0.2454	0.1239
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0031	0.0231	0.0190	0.0030	0.0001	0.0131	0.0105	0.0002	0.0060	0.0331	0.0274	0.0058	0.0180

L	HP	HS
0.0	0.0031	0.0031
0.0031	-0.0000	0.0064
0.0050	0.0003	0.0072
0.0100	0.0014	0.0093
0.0150	0.0024	0.0114
0.0200	0.0034	0.0134
0.0250	0.0043	0.0153
0.0300	0.0052	0.0171
0.0350	0.0060	0.0188
0.0400	0.0068	0.0203
0.0450	0.0075	0.0219
0.0500	0.0082	0.0232
0.0550	0.0089	0.0245
0.0600	0.0095	0.0257
0.0650	0.0100	0.0268
0.0700	0.0105	0.0278
0.0750	0.0110	0.0288
0.0800	0.0114	0.0296
0.0850	0.0118	0.0303
0.0900	0.0121	0.0310
0.0950	0.0124	0.0316
0.1000	0.0126	0.0320
0.1050	0.0128	0.0324
0.1100	0.0129	0.0327
0.1150	0.0130	0.0330
0.1200	0.0131	0.0331
0.1250	0.0131	0.0331
0.1300	0.0131	0.0331
0.1350	0.0130	0.0329
0.1400	0.0129	0.0327
0.1450	0.0127	0.0324
0.1500	0.0125	0.0320
0.1550	0.0123	0.0315
0.1600	0.0120	0.0309
0.1650	0.0116	0.0302
0.1700	0.0112	0.0295
0.1750	0.0108	0.0286
0.1800	0.0103	0.0276
0.1850	0.0098	0.0266
0.1900	0.0092	0.0254
0.1950	0.0086	0.0242
0.2000	0.0079	0.0229
0.2050	0.0072	0.0214
0.2100	0.0065	0.0199
0.2150	0.0057	0.0192
0.2200	0.0048	0.0165
0.2250	0.0039	0.0146
0.2300	0.0030	0.0126
0.2350	0.0020	0.0105
0.2400	0.0009	0.0083
0.2444	-0.0001	0.0063
0.2474	0.0010	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.5684

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
0.3202	0.0062	0.1246	0.1247	0.3804D-02	0.1947D-06	0.1947D-06	0.7291D-08	0.1410D-05	0.8489D-05

TN	TO	H(SP)	H-BAR	BETA	IMAX	I-HCG	I(HH)
0.0200	0.0060	0.0179	0.0179	0.2902D-01	0.1459D-04	0.1459D-04	0.7377D-04

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0031	0.1246	0.0703	0.2461	0.0041	0.1246	0.0716	0.2451	0.0022	0.1246	0.0691	0.2470	0.1246

H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0031	0.0229	0.0190	0.0030	0.0001	0.0129	0.0105	0.0002	0.0061	0.0329	0.0275	0.0058	0.0179

L	HP	HS
0.0	0.0031	0.0031
0.0031	-0.0000	0.0065
0.0050	0.0003	0.0072
0.0100	0.0013	0.0093
0.0150	0.0023	0.0114
0.0200	0.0033	0.0133
0.0250	0.0042	0.0152
0.0300	0.0051	0.0170
0.0350	0.0059	0.0187
0.0400	0.0067	0.0202
0.0450	0.0074	0.0217
0.0500	0.0081	0.0231
0.0550	0.0087	0.0244
0.0600	0.0093	0.0256
0.0650	0.0098	0.0267
0.0700	0.0103	0.0277
0.0750	0.0108	0.0286
0.0800	0.0112	0.0294
0.0850	0.0116	0.0302
0.0900	0.0119	0.0308
0.0950	0.0122	0.0314
0.1000	0.0124	0.0319
0.1050	0.0126	0.0323
0.1100	0.0128	0.0326
0.1150	0.0129	0.0328
0.1200	0.0129	0.0329
0.1250	0.0129	0.0329
0.1300	0.0129	0.0329
0.1350	0.0129	0.0328
0.1400	0.0127	0.0326
0.1450	0.0126	0.0323
0.1500	0.0124	0.0319
0.1550	0.0121	0.0314
0.1600	0.0119	0.0308
0.1650	0.0115	0.0302
0.1700	0.0112	0.0294
0.1750	0.0107	0.0286
0.1800	0.0103	0.0277
0.1850	0.0098	0.0266
0.1900	0.0092	0.0255
0.1950	0.0086	0.0243
0.2000	0.0080	0.0230
0.2050	0.0073	0.0216
0.2100	0.0066	0.0201
0.2150	0.0058	0.0186
0.2200	0.0050	0.0169
0.2250	0.0041	0.0151
0.2300	0.0032	0.0132
0.2350	0.0022	0.0111
0.2400	0.0012	0.0090
0.2450	0.0002	0.0068
0.2461	-0.0000	0.0063
0.2491	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.6842

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
7.3104	0.0063	0.1249	0.1250	0.38220-02	0.20110-06	0.20110-06	0.48780-08	0.14720-05	0.87170-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IMHCG		I(MM)	
0.0200	0.0060	0.0182	0.0182	0.19170-01	0.14780-04	0.14780-04		0.74510-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0031	0.1250	0.0726	0.2470	0.0041	0.1250	0.0738	0.2460	0.0022	0.1250	0.0713	0.2479	0.1249
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0031	0.0234	0.0197	0.0030	0.0002	0.0134	0.0111	0.0002	0.0061	0.0334	0.0284	0.0058	0.0182

L	HP	HS
0.0	0.0031	0.0031
0.0031	-0.0000	0.0065
0.0050	0.0003	0.0073
0.0100	0.0014	0.0093
0.0150	0.0024	0.0115
0.0200	0.0034	0.0135
0.0250	0.0043	0.0154
0.0300	0.0052	0.0172
0.0350	0.0061	0.0189
0.0400	0.0069	0.0205
0.0450	0.0076	0.0220
0.0500	0.0084	0.0234
0.0550	0.0090	0.0247
0.0600	0.0096	0.0259
0.0650	0.0102	0.0271
0.0700	0.0107	0.0281
0.0750	0.0112	0.0290
0.0800	0.0116	0.0299
0.0850	0.0120	0.0306
0.0900	0.0123	0.0313
0.0950	0.0126	0.0319
0.1000	0.0129	0.0323
0.1050	0.0131	0.0327
0.1100	0.0132	0.0330
0.1150	0.0134	0.0333
0.1200	0.0134	0.0334
0.1250	0.0134	0.0334
0.1300	0.0134	0.0334
0.1350	0.0133	0.0333
0.1400	0.0132	0.0330
0.1450	0.0131	0.0327
0.1500	0.0129	0.0323
0.1550	0.0126	0.0319
0.1600	0.0123	0.0313
0.1650	0.0120	0.0306
0.1700	0.0116	0.0299
0.1750	0.0112	0.0291
0.1800	0.0107	0.0281
0.1850	0.0102	0.0271
0.1900	0.0096	0.0260
0.1950	0.0090	0.0248
0.2000	0.0084	0.0235
0.2050	0.0077	0.0221
0.2100	0.0069	0.0206
0.2150	0.0061	0.0190
0.2200	0.0053	0.0173
0.2250	0.0044	0.0155
0.2300	0.0035	0.0136
0.2350	0.0025	0.0116
0.2400	0.0015	0.0094
0.2450	0.0004	0.0072
0.2470	-0.0001	0.0063
0.2500	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.8000

GAMMA	TT	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
4.1389	0.0063	0.1249	0.1250	0.38540-02	0.25270-06	0.25270-06	0.18260-07	0.19940-05	0.13260-04
TH	TD	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0200	0.0060	0.0212	0.0213	0.70790-01	0.15030-04	0.15030-04		0.75240-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0032	0.1251	0.0739	0.2470	0.0043	0.1251	0.0754	0.2459	0.0020	0.1250	0.0725	0.2482	0.1249
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0032	0.0275	0.0233	0.0030	0.0002	0.0175	0.0146	0.0002	0.0061	0.0375	0.0320	0.0058	0.0212

L	HP	HS
0.0	0.0032	0.0032
0.0032	-0.0001	0.0067
0.0050	0.0004	0.0075
0.0100	0.0017	0.0099
0.0150	0.0031	0.0123
0.0200	0.0043	0.0147
0.0250	0.0056	0.0169
0.0300	0.0067	0.0190
0.0350	0.0079	0.0209
0.0400	0.0089	0.0228
0.0450	0.0099	0.0245
0.0500	0.0108	0.0261
0.0550	0.0117	0.0276
0.0600	0.0125	0.0290
0.0650	0.0132	0.0302
0.0700	0.0139	0.0314
0.0750	0.0145	0.0325
0.0800	0.0151	0.0334
0.0850	0.0156	0.0343
0.0900	0.0160	0.0350
0.0950	0.0164	0.0357
0.1000	0.0168	0.0363
0.1050	0.0170	0.0367
0.1100	0.0172	0.0371
0.1150	0.0174	0.0373
0.1200	0.0175	0.0375
0.1250	0.0175	0.0375
0.1300	0.0175	0.0375
0.1350	0.0174	0.0373
0.1400	0.0173	0.0371
0.1450	0.0171	0.0368
0.1500	0.0168	0.0363
0.1550	0.0165	0.0358
0.1600	0.0161	0.0351
0.1650	0.0157	0.0344
0.1700	0.0152	0.0336
0.1750	0.0147	0.0326
0.1800	0.0141	0.0316
0.1850	0.0134	0.0304
0.1900	0.0127	0.0291
0.1950	0.0119	0.0278
0.2000	0.0110	0.0263
0.2050	0.0101	0.0247
0.2100	0.0091	0.0230
0.2150	0.0081	0.0212
0.2200	0.0070	0.0192
0.2250	0.0058	0.0171
0.2300	0.0046	0.0149
0.2350	0.0033	0.0126
0.2400	0.0019	0.0101
0.2450	0.0005	0.0075
0.2470	-0.0001	0.0064
0.2500	0.0030	0.0030

SECOND STAGE ROTOR   TOA 013   TRIAL 1

INPUT FOR BLADE COORDINATE PROGRAM

ETA	LAMDA	OP1	OP2	TNLMT
0.0	0.0	8.00000	1.00000	0.00010

ELEMENT	RI	RO	TI	TM	TO	KIC	KTC	KOC	ZMC	ZTC	ZOC
1	1.79107	1.79155	0.00600	0.01510	0.00600	57.40324	54.39508	51.63688	0.08098	0.11117	0.13870
2	1.74735	1.74995	0.00600	0.01550	0.00600	56.15332	53.92462	51.86047	0.08135	0.10976	0.14140
3	1.65719	1.66499	0.00600	0.01640	0.00600	54.22431	52.17586	50.47458	0.08188	0.10637	0.14769
4	1.56211	1.57677	0.00600	0.01730	0.00600	52.12855	49.06357	46.64851	0.08263	0.10247	0.15722
5	1.45987	1.48380	0.00600	0.01820	0.00600	49.89918	44.47362	40.17464	0.08391	0.09714	0.17027
6	1.34721	1.38370	0.00600	0.01930	0.00600	47.68186	39.42934	31.63407	0.08678	0.08942	0.18428
7	1.28500	1.33004	0.00600	0.01990	0.00600	46.49703	36.43483	25.18911	0.08981	0.08445	0.19260

BLADE ELEMENT STACKING PARAMETER--TNORM1 = 0.360D-02

THECG

0.5908471D-01   0.5953697D-01   0.6062790D-01   0.6125842D-01   0.6125339D-01   0.6110789D-01   0.6055029D-01

CRCG

517.6186   95.11731   31.49697   16.90411   10.57338   7.025738   5.737323

BLADE ELEMENT STACKING PARAMETER--TNORM1 = 0.542D-04

THECG

0.5907964D-01   0.5954428D-01   0.6068259D-01   0.6136175D+01   0.6142480D-01   0.6121840D-01   0.6049332D-01

CRCG

517.6186   95.11735   31.49707   16.90438   10.57396   7.026590   5.738361

BLADE ELEMENT ANGLES

ELEMENT	ALP	KH	KIC	KTC	KOC	KIP	KTP	KOP	KIS	KTS	KOS
1	0.19828	55.18939	57.40324	54.39508	51.63688	53.82796	55.67742	60.30945	60.96844	53.11636	43.06302
2	1.05341	54.48978	56.15332	53.92462	51.86047	52.34890	55.21645	59.77048	59.94960	52.63556	44.01015
3	3.02317	52.63894	54.22431	52.17586	50.47458	49.90675	53.43608	57.47722	58.53342	50.91819	43.50656
4	5.32715	49.64180	52.12855	49.06357	46.64851	47.22990	50.20170	53.03717	57.00942	47.92971	40.29534
5	8.00004	45.18144	49.89918	44.47362	40.17464	44.37125	45.30266	46.27013	55.38819	43.65052	34.12933
6	11.20048	39.65812	47.68186	39.42934	31.63407	41.51980	39.60527	37.98818	53.76367	39.25570	25.36259
7	13.16224	35.84305	46.49703	36.43483	25.18911	40.10344	36.06397	31.84426	52.77656	36.79874	18.65267

BLADE ELEMENT CURVATURES

ELEMENT	CIC	COC	CIP	COP	CIS	CAS
1	0.26475	1.05185	-0.16296	-1.76873	0.68956	3.79542
2	0.20303	0.68679	-0.26141	-1.51528	0.66507	2.84842
3	0.20105	0.44842	-0.34655	-1.06461	0.74595	1.94282
4	0.32992	0.51431	-0.32022	-0.60412	0.97440	1.61701
5	0.65581	0.75101	-0.11292	-0.16943	1.41083	1.65209
6	1.14410	1.14407	0.26701	0.23870	1.99209	2.01901
7	1.51543	1.51530	0.61344	0.57373	2.37643	2.41331

BLADE SECTION COORDINATES (ROTATED) AT X = 1.2850

GAMMA	TE	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
34.5485	0.0060	0.1233	0.1235	0.3700D-02	0.1480D-06	0.1486D-06	0.8897D-07	0.9405D-06	0.6776D-05
TH	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0201	0.0062	0.0146	0.0146	0.3776	0.1365D-04	0.1365D-04		0.7013D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1223	0.1123	0.2415	0.0035	0.1222	0.1123	0.2406	0.0025	0.1224	0.1126	0.2423	0.1233
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0185	0.0180	0.0031	0.0000	0.0086	0.0084	0.0001	0.0059	0.0285	0.0281	0.0061	0.0146

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0000	0.0061
0.0050	0.0002	0.0068
0.0100	0.0008	0.0085
0.0150	0.0014	0.0101
0.0200	0.0020	0.0117
0.0250	0.0025	0.0132
0.0300	0.0031	0.0146
0.0350	0.0036	0.0160
0.0400	0.0040	0.0173
0.0450	0.0045	0.0185
0.0500	0.0049	0.0196
0.0550	0.0054	0.0207
0.0600	0.0058	0.0217
0.0650	0.0061	0.0227
0.0700	0.0065	0.0235
0.0750	0.0068	0.0243
0.0800	0.0071	0.0251
0.0850	0.0074	0.0257
0.0900	0.0076	0.0263
0.0950	0.0079	0.0269
0.1000	0.0081	0.0273
0.1050	0.0082	0.0277
0.1100	0.0084	0.0280
0.1150	0.0085	0.0282
0.1200	0.0086	0.0284
0.1250	0.0086	0.0285
0.1300	0.0087	0.0285
0.1350	0.0087	0.0285
0.1400	0.0086	0.0283
0.1450	0.0086	0.0281
0.1500	0.0085	0.0278
0.1550	0.0083	0.0274
0.1600	0.0082	0.0270
0.1650	0.0080	0.0264
0.1700	0.0077	0.0258
0.1750	0.0075	0.0251
0.1800	0.0072	0.0243
0.1850	0.0068	0.0234
0.1900	0.0064	0.0225
0.1950	0.0060	0.0214
0.2000	0.0056	0.0202
0.2050	0.0051	0.0190
0.2100	0.0045	0.0176
0.2150	0.0039	0.0161
0.2200	0.0033	0.0146
0.2250	0.0026	0.0129
0.2300	0.0018	0.0111
0.2350	0.0011	0.0092
0.2400	0.0002	0.0071
0.2415	-0.0000	0.0065
0.2446	0.0031	0.0031

BLADE SECTION COORDINATES (ROTATED) AT X = 1.3067

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
36.1155	0.0059	0.1236	0.1238	0.3670D-02	0.1340D-06	0.1344D-06	0.7433D-07	0.8006D-06	0.6193D-05
TH	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0199	0.0062	0.0134	0.0135	0.3162	0.1360D-04	0.1360D-04		0.6980D-04	

L(IC)	L(HC)	L(TC)	L(OC)	L(IP)	L(HP)	L(TP)	L(OP)	L(IS)	L(HS)	L(TS)	L(OS)	L(CG)
0.0030	0.1226	0.1163	0.2421	0.0035	0.1225	0.1160	0.2414	0.0025	0.1228	0.1165	0.2429	0.1236
H(IC)	H(HC)	H(TC)	H(OC)	H(IP)	H(HP)	H(TP)	H(OP)	H(IS)	H(HS)	H(TS)	H(OS)	H(CG)
0.0030	0.0170	0.0169	0.0031	0.0000	0.0072	0.0071	0.0001	0.0059	0.0268	0.0267	0.0061	0.0134

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0000	0.0060
0.0050	0.0002	0.0067
0.0100	0.0007	0.0083
0.0150	0.0012	0.0098
0.0200	0.0016	0.0113
0.0250	0.0021	0.0126
0.0300	0.0025	0.0140
0.0350	0.0030	0.0152
0.0400	0.0034	0.0164
0.0450	0.0037	0.0176
0.0500	0.0041	0.0186
0.0550	0.0045	0.0196
0.0600	0.0048	0.0206
0.0650	0.0051	0.0215
0.0700	0.0054	0.0223
0.0750	0.0057	0.0230
0.0800	0.0059	0.0237
0.0850	0.0062	0.0243
0.0900	0.0064	0.0249
0.0950	0.0066	0.0254
0.1000	0.0067	0.0258
0.1050	0.0069	0.0261
0.1100	0.0070	0.0264
0.1150	0.0071	0.0266
0.1200	0.0072	0.0268
0.1250	0.0072	0.0269
0.1300	0.0072	0.0269
0.1350	0.0072	0.0268
0.1400	0.0072	0.0267
0.1450	0.0071	0.0265
0.1500	0.0071	0.0262
0.1550	0.0069	0.0259
0.1600	0.0068	0.0254
0.1650	0.0066	0.0249
0.1700	0.0065	0.0244
0.1750	0.0062	0.0237
0.1800	0.0060	0.0230
0.1850	0.0057	0.0222
0.1900	0.0054	0.0213
0.1950	0.0050	0.0203
0.2000	0.0047	0.0192
0.2050	0.0042	0.0180
0.2100	0.0038	0.0168
0.2150	0.0033	0.0154
0.2200	0.0028	0.0140
0.2250	0.0022	0.0125
0.2300	0.0016	0.0108
0.2350	0.0010	0.0091
0.2400	0.0003	0.0072
0.2421	-0.0000	0.0064
0.2452	0.0031	0.0031

BLADE SECTION COORDINATES (ROTATED) AT X = 1.3300

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
37.7116	0.0059	0.1239	0.1240	0.3641D-02	0.1210D-06	0.1213D-06	0.5957D-07	0.6719D-06	0.5614D-05
TH	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0197	0.0061	0.0123	0.0123	0.2532	0.1360D-04	0.1360D-04		0.6963D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1228	0.1206	0.2428	0.0034	0.1227	0.1202	0.2422	0.0025	0.1230	0.1209	0.2435	0.1239
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0154	0.0155	0.0031	0.0000	0.0057	0.0057	0.0001	0.0059	0.0252	0.0251	0.0060	0.0123

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0000	0.0060
0.0050	0.0002	0.0066
0.0100	0.0006	0.0081
0.0150	0.0009	0.0095
0.0200	0.0013	0.0108
0.0250	0.0017	0.0121
0.0300	0.0020	0.0133
0.0350	0.0024	0.0145
0.0400	0.0027	0.0156
0.0450	0.0030	0.0167
0.0500	0.0033	0.0176
0.0550	0.0036	0.0186
0.0600	0.0038	0.0194
0.0650	0.0041	0.0202
0.0700	0.0043	0.0210
0.0750	0.0045	0.0217
0.0800	0.0047	0.0223
0.0850	0.0049	0.0229
0.0900	0.0051	0.0234
0.0950	0.0052	0.0238
0.1000	0.0054	0.0242
0.1050	0.0055	0.0245
0.1100	0.0056	0.0248
0.1150	0.0057	0.0250
0.1200	0.0057	0.0251
0.1250	0.0057	0.0252
0.1300	0.0058	0.0252
0.1350	0.0058	0.0251
0.1400	0.0058	0.0250
0.1450	0.0057	0.0248
0.1500	0.0056	0.0246
0.1550	0.0056	0.0243
0.1600	-0.0055	0.0239
0.1650	0.0053	0.0234
0.1700	0.0052	0.0229
0.1750	0.0050	0.0223
0.1800	0.0048	0.0216
0.1850	0.0046	0.0209
0.1900	0.0043	0.0201
0.1950	0.0041	0.0192
0.2000	0.0038	0.0182
0.2050	0.0034	0.0171
0.2100	0.0031	0.0160
0.2150	0.0027	0.0148
0.2200	0.0023	0.0135
0.2250	0.0018	0.0121
0.2300	0.0014	0.0106
0.2350	0.0009	0.0090
0.2400	0.0003	0.0073
0.2420	-0.0000	0.0063
0.2459	0.0031	0.0031

BLADE SECTION COORDINATES (ROTATED) AT X = 1.4054

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
42.1233	0.0059	0.1248	0.1251	0.3543D-02	0.9170D-07	0.9174D-07	0.2402D-07	0.3965D-06	0.4133D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0189	0.0062	0.0092	0.0093	0.1022	0.1355D-04	0.1355D-04		0.6896D-04	

L(IC)	L(HC)	L(TC)	L(OC)	L(IP)	L(HP)	L(TP)	L(OP)	L(IS)	L(HS)	L(TS)	L(OS)	L(CG)
0.0030	0.1247	0.1341	0.2448	0.0033	0.1246	0.1337	0.2443	0.0026	0.1249	0.1345	0.2453	0.1248
H(IC)	H(HC)	H(TC)	H(OC)	H(IP)	H(HP)	H(TP)	H(OP)	H(IS)	H(HS)	H(TS)	H(OS)	H(CG)
0.0030	0.0114	0.0115	0.0031	0.0000	0.0021	0.0021	0.0000	0.0059	0.0208	0.0208	0.0061	0.0092

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0060
0.0050	0.0001	0.0065
0.0100	0.0002	0.0076
0.0150	0.0003	0.0087
0.0200	0.0005	0.0097
0.0250	0.0006	0.0107
0.0300	0.0007	0.0117
0.0350	0.0009	0.0126
0.0400	0.0010	0.0134
0.0450	0.0011	0.0142
0.0500	0.0012	0.0150
0.0550	0.0013	0.0157
0.0600	0.0014	0.0164
0.0650	0.0015	0.0170
0.0700	0.0016	0.0176
0.0750	0.0016	0.0181
0.0800	0.0017	0.0186
0.0850	0.0018	0.0190
0.0900	0.0018	0.0194
0.0950	0.0019	0.0198
0.1000	0.0019	0.0201
0.1050	0.0020	0.0203
0.1100	0.0020	0.0205
0.1150	0.0021	0.0207
0.1200	0.0021	0.0208
0.1250	0.0021	0.0208
0.1300	0.0021	0.0208
0.1350	0.0021	0.0208
0.1400	0.0021	0.0207
0.1450	0.0021	0.0205
0.1500	0.0021	0.0203
0.1550	0.0020	0.0201
0.1600	0.0020	0.0198
0.1650	0.0020	0.0194
0.1700	0.0019	0.0190
0.1750	0.0018	0.0186
0.1800	0.0018	0.0180
0.1850	0.0017	0.0175
0.1900	0.0016	0.0168
0.1950	0.0015	0.0162
0.2000	0.0014	0.0154
0.2050	0.0013	0.0146
0.2100	0.0012	0.0138
0.2150	0.0010	0.0129
0.2200	0.0009	0.0119
0.2250	0.0007	0.0109
0.2300	0.0006	0.0098
0.2350	0.0004	0.0087
0.2400	0.0002	0.0075
0.2448	0.0000	0.0063
0.2479	0.0031	0.0031

BLADE SECTION COORDINATES (ROTATED) AT X = 1.5041

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
47.0538	0.0060	0.1261	0.1261	0.3412D-02	0.7091D-07	0.7094D-07	0.1978D-07	J.2227D-06	0.2889D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0179	0.0061	0.0067	0.0067	0.8618D-01	0.1322D-04	0.1322D-04		0.6747D-04	

L(IC)	L(HC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(HS)	L(TS)	L(OS)	L(CG)
0.0030	0.1298	0.1523	0.2462	0.0032	0.1297	0.1519	0.2460	0.0028	0.1299	0.1526	0.2465	0.1261
H(IC)	H(HC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(HS)	H(TS)	H(OS)	H(CG)
0.0030	0.0080	0.0079	0.0030	0.0000	-0.0010	-0.0010	0.0000	0.0060	0.0168	0.0165	0.0061	0.0067

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0060
0.0050	-0.0000	0.0063
0.0100	-0.0001	0.0071
0.0150	-0.0002	0.0079
0.0200	-0.0002	0.0087
0.0250	-0.0003	0.0094
0.0300	-0.0004	0.0101
0.0350	-0.0004	0.0107
0.0400	-0.0005	0.0113
0.0450	-0.0005	0.0119
0.0500	-0.0006	0.0125
0.0550	-0.0006	0.0130
0.0600	-0.0007	0.0135
0.0650	-0.0007	0.0139
0.0700	-0.0007	0.0144
0.0750	-0.0008	0.0147
0.0800	-0.0008	0.0151
0.0850	-0.0008	0.0154
0.0900	-0.0009	0.0157
0.0950	-0.0009	0.0160
0.1000	-0.0009	0.0162
0.1050	-0.0009	0.0164
0.1100	-0.0009	0.0166
0.1150	-0.0010	0.0167
0.1200	-0.0010	0.0168
0.1250	-0.0010	0.0168
0.1300	-0.0010	0.0168
0.1350	-0.0010	0.0168
0.1400	-0.0010	0.0168
0.1450	-0.0010	0.0167
0.1500	-0.0010	0.0166
0.1550	-0.0010	0.0165
0.1600	-0.0010	0.0163
0.1650	-0.0009	0.0160
0.1700	-0.0009	0.0158
0.1750	-0.0009	0.0155
0.1800	-0.0009	0.0151
0.1850	-0.0008	0.0147
0.1900	-0.0008	0.0142
0.1950	-0.0007	0.0137
0.2000	-0.0007	0.0132
0.2050	-0.0006	0.0126
0.2100	-0.0006	0.0120
0.2150	-0.0005	0.0113
0.2200	-0.0004	0.0106
0.2250	-0.0004	0.0098
0.2300	-0.0003	0.0090
0.2350	-0.0002	0.0082
0.2400	-0.0001	0.0073
0.2450	-0.0000	0.0064
0.2462	0.0000	0.0061
0.2493	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.6027

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
51.0508	0.0060	0.1276	0.1276	0.3298D-02	0.5930D-07	0.5930D-07	0.9673D-08	0.1383D-06	0.2069D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0170	0.0060	0.0049	0.0049	0.4275D-01	0.1302D-04	0.1302D-04		0.6672D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1365	0.1704	0.2469	0.0031	0.1364	0.1701	0.2467	0.0029	0.1366	0.1706	0.2470	0.1276
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0056	0.0054	0.0030	0.0000	-0.0029	-0.0029	0.0000	0.0060	0.0140	0.0134	0.0060	0.0049

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0060
0.0050	-0.0001	0.0062
0.0100	-0.0003	0.0068
0.0150	-0.0005	0.0074
0.0200	-0.0007	0.0079
0.0250	-0.0008	0.0084
0.0300	-0.0010	0.0089
0.0350	-0.0012	0.0094
0.0400	-0.0013	0.0099
0.0450	-0.0015	0.0103
0.0500	-0.0016	0.0107
0.0550	-0.0018	0.0111
0.0600	-0.0019	0.0114
0.0650	-0.0020	0.0117
0.0700	-0.0021	0.0121
0.0750	-0.0022	0.0123
0.0800	-0.0023	0.0126
0.0850	-0.0024	0.0128
0.0900	-0.0025	0.0131
0.0950	-0.0026	0.0133
0.1000	-0.0027	0.0134
0.1050	-0.0027	0.0136
0.1100	-0.0028	0.0137
0.1150	-0.0028	0.0138
0.1200	-0.0029	0.0139
0.1250	-0.0029	0.0140
0.1300	-0.0029	0.0140
0.1350	-0.0029	0.0140
0.1400	-0.0030	0.0140
0.1450	-0.0030	0.0140
0.1500	-0.0030	0.0139
0.1550	-0.0029	0.0138
0.1600	-0.0029	0.0137
0.1650	-0.0029	0.0136
0.1700	-0.0029	0.0135
0.1750	-0.0028	0.0133
0.1800	-0.0027	0.0131
0.1850	-0.0027	0.0128
0.1900	-0.0025	0.0125
0.1950	-0.0024	0.0121
0.2000	-0.0023	0.0118
0.2050	-0.0021	0.0113
0.2100	-0.0019	0.0108
0.2150	-0.0017	0.0103
0.2200	-0.0015	0.0098
0.2250	-0.0013	0.0092
0.2300	-0.0010	0.0085
0.2350	-0.0007	0.0078
0.2400	-0.0004	0.0071
0.2450	-0.0001	0.0063
0.2469	0.0000	0.0060
0.2499	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.7014

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
53.6753	0.0060	0.1290	0.1290	0.3167D-02	0.5087D-07	0.5088D-07	0.1100D-07	0.1090D-06	0.1762D-05
TH	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0160	0.0060	0.0043	0.0043	0.4953D-01	0.1278D-04	0.1278D-04		0.6550D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1429	0.1870	0.2469	0.0031	0.1428	0.1868	0.2468	0.0029	0.1429	0.1871	0.2471	0.1290
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0047	0.0045	0.0030	0.0000	-0.0033	-0.0031	0.0000	0.0060	0.0127	0.0119	0.0060	0.0043

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0060
0.0050	-0.0001	0.0062
0.0100	-0.0003	0.0067
0.0150	-0.0005	0.0071
0.0200	-0.0007	0.0076
0.0250	-0.0009	0.0080
0.0300	-0.0011	0.0084
0.0350	-0.0013	0.0088
0.0400	-0.0014	0.0091
0.0450	-0.0016	0.0095
0.0500	-0.0018	0.0098
0.0550	-0.0019	0.0101
0.0600	-0.0020	0.0104
0.0650	-0.0022	0.0107
0.0700	-0.0023	0.0109
0.0750	-0.0024	0.0112
0.0800	-0.0025	0.0114
0.0850	-0.0026	0.0116
0.0900	-0.0027	0.0118
0.0950	-0.0028	0.0120
0.1000	-0.0029	0.0121
0.1050	-0.0030	0.0122
0.1100	-0.0031	0.0123
0.1150	-0.0031	0.0124
0.1200	-0.0032	0.0125
0.1250	-0.0032	0.0126
0.1300	-0.0032	0.0126
0.1350	-0.0033	0.0127
0.1400	-0.0033	0.0127
0.1450	-0.0033	0.0127
0.1500	-0.0033	0.0126
0.1550	-0.0033	0.0126
0.1600	-0.0033	0.0125
0.1650	-0.0033	0.0125
0.1700	-0.0032	0.0124
0.1750	-0.0032	0.0123
0.1800	-0.0031	0.0122
0.1850	-0.0031	0.0120
0.1900	-0.0030	0.0118
0.1950	-0.0029	0.0116
0.2000	-0.0028	0.0113
0.2050	-0.0026	0.0110
0.2100	-0.0024	0.0106
0.2150	-0.0022	0.0102
0.2200	-0.0019	0.0097
0.2250	-0.0017	0.0091
0.2300	-0.0013	0.0085
0.2350	-0.0010	0.0078
0.2400	-0.0006	0.0071
0.2450	-0.0002	0.0063
0.2469	0.0000	0.0060
0.2499	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.8500

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN		ILLCG	PHLCG	I(LL)	PHL		
56.3845	0.0060	0.1311	0.1312	0.2977D-02	0.4246D-07		0.4255D-07	0.3349D-07	0.1282D-06	0.2130D-05		
TM	TO	H(SP)	H-BAR	BETA	IMAX		IHHCG		I(HH)			
0.0145	0.0062	0.0053	0.0054	0.1543	0.1248D-04		0.1248D-04		0.6377D-04			
L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1528	0.2106	0.2467	0.0032	0.1528	0.2105	0.2463	0.0029	0.1529	0.2110	0.2471	0.1311
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0060	0.0051	0.0031	0.0000	-0.0012	-0.0015	0.0000	0.0060	0.0134	0.0119	0.0062	0.0053

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0060
0.0050	-0.0000	0.0062
0.0100	-0.0001	0.0067
0.0150	-0.0001	0.0072
0.0200	-0.0002	0.0077
0.0250	-0.0002	0.0081
0.0300	-0.0003	0.0086
0.0350	-0.0003	0.0090
0.0400	-0.0004	0.0094
0.0450	-0.0004	0.0097
0.0500	-0.0005	0.0101
0.0550	-0.0005	0.0104
0.0600	-0.0006	0.0107
0.0650	-0.0006	0.0110
0.0700	-0.0006	0.0113
0.0750	-0.0007	0.0116
0.0800	-0.0007	0.0118
0.0850	-0.0008	0.0121
0.0900	-0.0008	0.0123
0.0950	-0.0008	0.0125
0.1000	-0.0009	0.0126
0.1050	-0.0009	0.0128
0.1100	-0.0010	0.0129
0.1150	-0.0010	0.0130
0.1200	-0.0010	0.0131
0.1250	-0.0011	0.0132
0.1300	-0.0011	0.0133
0.1350	-0.0011	0.0133
0.1400	-0.0011	0.0134
0.1450	-0.0012	0.0134
0.1500	-0.0012	0.0134
0.1550	-0.0012	0.0133
0.1600	-0.0013	0.0133
0.1650	-0.0013	0.0132
0.1700	-0.0013	0.0132
0.1750	-0.0013	0.0131
0.1800	-0.0013	0.0130
0.1850	-0.0013	0.0128
0.1900	-0.0014	0.0127
0.1950	-0.0014	0.0126
0.2000	-0.0015	0.0125
0.2050	-0.0015	0.0122
0.2100	-0.0015	0.0120
0.2150	-0.0014	0.0116
0.2200	-0.0013	0.0111
0.2250	-0.0012	0.0105
0.2300	-0.0010	0.0098
0.2350	-0.0007	0.0089
0.2400	-0.0004	0.0079
0.2450	-0.0001	0.0068
0.2467	0.0001	0.0063
0.2498	0.0031	0.0031

SECOND STAGE STATOR   TDA 013   TRIAL 1

INPUT FOR BLADE COORDINATE PROGRAM

ETA	LANDA	OP1	OP2	TNLMT
0.0	0.0	8.00000	1.00000	0.00010

ELEMENT	RI	RO	TI	TM	TO	KIC	KTC	KOC	ZMC	ZTC	ZOC
1	1.79199	1.79277	0.00600	0.01500	0.00600	29.41312	13.75952	-18.86491	0.11907	0.07554	0.24294
2	1.75253	1.75710	0.00600	0.01500	0.00600	28.83672	14.72484	-15.03947	0.11824	0.07447	0.24216
3	1.67157	1.68439	0.00600	0.01500	0.00600	28.37373	15.71224	-12.20247	0.11754	0.07181	0.24120
4	1.58784	1.60918	0.00600	0.01500	0.00600	28.81639	16.62886	-10.99615	0.11674	0.06989	0.24008
5	1.49951	1.53033	0.00600	0.01500	0.00600	30.31614	17.83850	-10.43846	0.11541	0.06894	0.23832
6	1.40449	1.44619	0.00600	0.01500	0.00600	32.70374	19.31727	-10.63083	0.11350	0.06815	0.23560
7	1.35356	1.40143	0.00600	0.01500	0.00600	34.24772	19.88286	-12.28780	0.11265	0.06737	0.23467

BLADE ELEMENT STACKING PARAMETER--TNORM1 = 0.258D-02

THECG

0.1688264D-01   0.1817978D-01   0.1972948D-01   0.2163560D-01   0.2454007D-01   0.2848001D-01   0.3038619D-01

CRCG

558.2586   89.09737   31.61251   18.05225   11.80936   8.181975   6.888783

BLADE ELEMENT STACKING PARAMETER--TNORM1 = 0.252D-04

THECG

0.1679488D-01   0.1811980D-01   0.1966415D-01   0.2159719D-01   0.2453744D-01   0.2845374D-01   0.3028944D-01

CRCG

558.2584   89.09716   31.61228   18.05197   11.80900   8.181577   6.888431

BLADE ELEMENT ANGLES

ELEMENT	ALP	KM	KIC	KTC	KOC	KIP	KTP	KOP	KIS	KTS	KOS
1	0.18396	5.27402	29.41312	13.75952	-18.86491	25.30204	12.27617	-14.75071	33.38189	15.19165	-22.83691
2	1.12845	6.89803	28.83672	14.72484	-15.03947	24.71307	13.21471	-10.89276	32.82994	16.18720	-19.05515
3	3.04246	8.08456	28.37373	15.71224	-12.20247	24.26377	14.11440	-8.02389	32.36336	17.26298	-16.25858
4	5.07950	8.91018	28.81839	16.62886	-10.99615	24.74117	14.97500	-6.79753	32.77894	18.23470	-15.07416
5	7.36871	9.93808	30.31614	17.83850	-10.43846	26.28640	16.17789	-6.22415	34.22872	19.44963	-14.52937
6	10.02877	11.03530	32.70074	19.31727	-10.63083	28.73587	17.67239	-6.40419	36.54444	20.90999	-14.72687
7	11.52951	10.97901	34.24772	19.88286	-12.28780	30.33348	18.23289	-8.06331	38.03464	21.47671	-16.37297

BLADE ELEMENT CURVATURES

ELEMENT	CIC	COC	CIP	COP	CIS	CAS
1	3.35259	3.35234	2.83640	2.83552	3.82365	3.82401
2	3.06289	3.06257	2.53318	2.52791	3.55071	3.55492
3	2.84259	2.84251	2.30962	2.29415	3.33680	3.35083
4	2.79145	2.79124	2.26594	2.23803	3.27966	3.30483
5	2.85461	2.85446	2.34364	2.30149	3.32867	3.36690
6	3.02644	3.02658	2.53750	2.47900	3.47806	3.53147
7	3.23854	3.23828	2.76983	2.70048	3.66889	3.73096

BLADE SECTION COORDINATES (ROTATED) AT X = 1.3536

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
10.9997	0.0060	0.1227	0.1229	0.2953D-02	0.1969D-06	0.1820D-06	0.4627D-07	0.1590D-05	0.7957D-05
TA	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0150	0.0060	0.0217	0.0218	0.2307	0.1168D-04	0.1168D-04		0.5629D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1226	0.0758	0.2415	0.0042	0.1226	0.0769	0.2403	0.0019	0.1226	0.0747	0.2427	0.1227
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0288	0.0246	0.0030	0.0002	0.0213	0.0179	0.0003	0.0058	0.0363	0.0313	0.0057	0.0217

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0002	0.0064
0.0050	0.0005	0.0073
0.0100	0.0022	0.0098
0.0150	0.0039	0.0121
0.0200	0.0054	0.0143
0.0250	0.0069	0.0164
0.0300	0.0083	0.0183
0.0350	0.0096	0.0202
0.0400	0.0109	0.0220
0.0450	0.0121	0.0236
0.0500	0.0132	0.0251
0.0550	0.0142	0.0266
0.0600	0.0152	0.0279
0.0650	0.0161	0.0291
0.0700	0.0169	0.0303
0.0750	0.0177	0.0313
0.0800	0.0184	0.0323
0.0850	0.0190	0.0331
0.0900	0.0195	0.0338
0.0950	0.0200	0.0345
0.1000	0.0204	0.0350
0.1050	0.0207	0.0355
0.1100	0.0209	0.0358
0.1150	0.0211	0.0361
0.1200	0.0212	0.0362
0.1250	0.0213	0.0363
0.1300	0.0213	0.0362
0.1350	0.0211	0.0361
0.1400	0.0210	0.0358
0.1450	0.0207	0.0355
0.1500	0.0204	0.0350
0.1550	0.0200	0.0345
0.1600	0.0195	0.0338
0.1650	0.0189	0.0331
0.1700	0.0183	0.0322
0.1750	0.0176	0.0312
0.1800	0.0168	0.0301
0.1850	0.0159	0.0289
0.1900	0.0149	0.0276
0.1950	0.0139	0.0261
0.2000	0.0128	0.0246
0.2050	0.0115	0.0229
0.2100	0.0102	0.0211
0.2150	0.0088	0.0191
0.2200	0.0073	0.0171
0.2250	0.0057	0.0148
0.2300	0.0041	0.0125
0.2350	0.0023	0.0099
0.2400	0.0004	0.0077
0.2415	-0.0002	0.0064
0.2445	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.3768

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
10.9279	0.0061	0.1229	0.1232	0.2956D-02	0.1780D-06	0.1782D-05	0.4456D-07	0.1506D-05	0.7761D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IMHCG		I(HH)	
0.0150	0.0060	0.0212	0.0212	0.2210	0.1173D-04	0.1173D-04		0.5656D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1229	0.0760	0.2421	0.0041	0.1228	0.0770	0.2409	0.0019	0.1229	0.0750	0.2433	0.1229
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0280	0.0259	0.0330	0.0002	0.0205	0.0177	0.0303	0.0058	0.0354	0.0306	0.0057	0.0212

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0002	0.0064
0.0050	0.0005	0.0073
0.0100	0.0021	0.0096
0.0150	0.0037	0.0119
0.0200	0.0052	0.0140
0.0250	0.0066	0.0160
0.0300	0.0079	0.0180
0.0350	0.0092	0.0198
0.0400	0.0104	0.0215
0.0450	0.0116	0.0231
0.0500	0.0126	0.0246
0.0550	0.0136	0.0260
0.0600	0.0146	0.0273
0.0650	0.0154	0.0285
0.0700	0.0162	0.0296
0.0750	0.0170	0.0306
0.0800	0.0176	0.0315
0.0850	0.0182	0.0323
0.0900	0.0187	0.0331
0.0950	0.0192	0.0337
0.1000	0.0196	0.0342
0.1050	0.0199	0.0347
0.1100	0.0201	0.0350
0.1150	0.0203	0.0353
0.1200	0.0204	0.0354
0.1250	0.0205	0.0355
0.1300	0.0205	0.0354
0.1350	0.0204	0.0353
0.1400	0.0202	0.0350
0.1450	0.0199	0.0347
0.1500	0.0196	0.0343
0.1550	0.0192	0.0337
0.1600	0.0188	0.0331
0.1650	0.0182	0.0324
0.1700	0.0176	0.0315
0.1750	0.0170	0.0306
0.1800	0.0162	0.0295
0.1850	0.0154	0.0284
0.1900	0.0144	0.0271
0.1950	0.0134	0.0257
0.2000	0.0124	0.0242
0.2050	0.0112	0.0226
0.2100	0.0099	0.0208
0.2150	0.0086	0.0189
0.2200	0.0072	0.0169
0.2250	0.0057	0.0148
0.2300	0.0041	0.0125
0.2350	0.0024	0.0101
0.2400	0.0006	0.0079
0.2421	-0.0002	0.0064
0.2451	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.4914

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
19.9356	0.0061	0.1231	0.1235	0.2961D-02	0.1687D-06	0.1688D-06	0.3961D-07	0.1415D-05	0.7544D-05

TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG	I(HH)
0.0150	0.0060	0.0209	0.0205	0.1938	0.1182D-04	0.1182D-04	0.5700D-04

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1231	0.0763	0.2427	0.0041	0.1231	0.0773	0.2415	0.0020	0.1232	0.0753	0.2439	0.1231
H(IC)	**H(MC)**	**H(TC)**	**H(OC)**	**H(IP)**	**H(MP)**	**H(TP)**	**H(OP)**	**H(IS)**	**H(MS)**	**H(TS)**	**H(OS)**	**H(CG)**
0.0030	0.0270	0.0231	0.0030	0.0002	0.0195	0.0164	0.0002	0.0059	0.0345	0.0298	0.0057	0.0205

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0001	0.0064
0.0050	0.0005	0.0072
0.0100	0.0020	0.0095
0.0150	0.0035	0.0117
0.0200	0.0049	0.0137
0.0250	0.0063	0.0157
0.0300	0.0076	0.0175
0.0350	0.0088	0.0193
0.0400	0.0099	0.0209
0.0450	0.0110	0.0225
0.0500	0.0120	0.0239
0.0550	0.0130	0.0253
0.0600	0.0139	0.0266
0.0650	0.0147	0.0277
0.0700	0.0155	0.0288
0.0750	0.0162	0.0298
0.0800	0.0168	0.0307
0.0850	0.0173	0.0315
0.0900	0.0178	0.0322
0.0950	0.0183	0.0328
0.1000	0.0186	0.0333
0.1050	0.0190	0.0337
0.1100	0.0192	0.0341
0.1150	0.0194	0.0343
0.1200	0.0195	0.0345
0.1250	0.0195	0.0345
0.1300	0.0195	0.0345
0.1350	0.0194	0.0344
0.1400	0.0193	0.0341
0.1450	0.0191	0.0338
0.1500	0.0188	0.0334
0.1550	0.0184	0.0329
0.1600	0.0180	0.0323
0.1650	0.0175	0.0316
0.1700	0.0169	0.0308
0.1750	0.0163	0.0299
0.1800	0.0156	0.0289
0.1850	0.0148	0.0278
0.1900	0.0139	0.0265
0.1950	0.0130	0.0252
0.2000	0.0119	0.0238
0.2050	0.0108	0.0222
0.2100	0.0097	0.0205
0.2150	0.0084	0.0187
0.2200	0.0071	0.0168
0.2250	0.0056	0.0147
0.2300	0.0041	0.0126
0.2350	0.0025	0.0102
0.2400	0.0008	0.0077
0.2427	-0.0002	0.0064
0.2457	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.4615

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
10.6259	0.0061	0.1238	0.1249	0.29760-02	0.15000-06	0.15900-06	0.33360-05	0.12260-05	0.70330-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0150	0.0060	0.0190	0.0190	0.16390-02	0.12030-04	0.12030-04		0.58020-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0031	0.1238	0.0764	0.2442	0.0041	0.1238	0.0773	0.2431	0.0020	0.1239	0.0755	0.2453	0.1238
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0031	0.0250	0.0216	0.0030	0.0002	0.0175	0.0149	0.0002	0.0059	0.0325	0.0293	0.0058	0.0190

L	HP	HS
0.0	0.0031	0.0031
0.0031	-0.0001	0.0064
0.0050	0.0004	0.0072
0.0100	0.0019	0.0093
0.0150	0.0032	0.0113
0.0200	0.0045	0.0132
0.0250	0.0057	0.0151
0.0300	0.0069	0.0168
0.0350	0.0080	0.0184
0.0400	0.0090	0.0200
0.0450	0.0100	0.0214
0.0500	0.0109	0.0228
0.0550	0.0118	0.0241
0.0600	0.0126	0.0252
0.0650	0.0133	0.0263
0.0700	0.0140	0.0273
0.0750	0.0146	0.0282
0.0800	0.0152	0.0290
0.0850	0.0157	0.0298
0.0900	0.0161	0.0304
0.0950	0.0165	0.0310
0.1000	0.0168	0.0314
0.1050	0.0171	0.0318
0.1100	0.0173	0.0321
0.1150	0.0174	0.0323
0.1200	0.0175	0.0325
0.1250	0.0175	0.0325
0.1300	0.0175	0.0325
0.1350	0.0174	0.0323
0.1400	0.0172	0.0321
0.1450	0.0170	0.0318
0.1500	0.0168	0.0314
0.1550	0.0164	0.0309
0.1600	0.0160	0.0304
0.1650	0.0156	0.0297
0.1700	0.0151	0.0290
0.1750	0.0145	0.0281
0.1800	0.0139	0.0272
0.1850	0.0132	0.0262
0.1900	0.0124	0.0250
0.1950	0.0116	0.0238
0.2000	0.0107	0.0225
0.2050	0.0097	0.0211
0.2100	0.0087	0.0196
0.2150	0.0076	0.0180
0.2200	0.0065	0.0162
0.2250	0.0052	0.0144
0.2300	0.0039	0.0125
0.2350	0.0026	0.0106
0.2400	0.0011	0.0082
0.2442	-0.0001	0.0063
0.2472	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.5461

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
9.5571	0.0061	0.1243	0.1245	0.2980D-02	0.1401D-06	0.1401D-06	0.7621D-08	0.1152D-05	0.6844D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0150	0.0060	0.0184	0.0184	0.3656D-01	0.1208D-04	0.1208D-04		0.5829D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0031	0.1244	0.0764	0.2456	0.0041	0.1244	0.0773	0.2445	0.0021	0.1244	0.0755	0.2465	0.1243
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0031	0.0241	0.0209	0.0030	0.0002	0.0166	0.0141	0.0002	0.0060	0.0316	0.0276	0.0059	0.0184

L	HP	HS
0.0	0.0031	0.0031
0.0031	-0.0001	0.0064
0.0050	0.0004	0.0071
0.0100	0.0018	0.0091
0.0150	0.0030	0.0111
0.0200	0.0043	0.0130
0.0250	0.0054	0.0148
0.0300	0.0066	0.0165
0.0350	0.0076	0.0180
0.0400	0.0086	0.0195
0.0450	0.0095	0.0209
0.0500	0.0104	0.0223
0.0550	0.0112	0.0235
0.0600	0.0120	0.0246
0.0650	0.0127	0.0257
0.0700	0.0133	0.0266
0.0750	0.0139	0.0275
0.0800	0.0144	0.0283
0.0850	0.0149	0.0290
0.0900	0.0153	0.0296
0.0950	0.0157	0.0307
0.1000	0.0160	0.0306
0.1050	0.0162	0.0310
0.1100	0.0164	0.0313
0.1150	0.0165	0.0315
0.1200	0.0166	0.0316
0.1250	0.0166	0.0316
0.1300	0.0166	0.0316
0.1350	0.0165	0.0315
0.1400	0.0164	0.0313
0.1450	0.0162	0.0310
0.1500	0.0159	0.0306
0.1550	0.0156	0.0301
0.1600	0.0152	0.0296
0.1650	0.0148	0.0290
0.1700	0.0143	0.0282
0.1750	0.0138	0.0274
0.1800	0.0132	0.0266
0.1850	0.0126	0.0256
0.1900	0.0118	0.0245
0.1950	0.0111	0.0234
0.2000	0.0102	0.0221
0.2050	0.0094	0.0208
0.2100	0.0084	0.0193
0.2150	0.0074	0.0178
0.2200	0.0063	0.0162
0.2250	0.0052	0.0145
0.2300	0.0040	0.0126
0.2350	0.0027	0.0107
0.2400	0.0014	0.0087
0.2450	0.0000	0.0065
0.2456	-0.0001	0.0063
0.2486	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.6309

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
8.6431	0.0061	0.1246	0.1248	0.2992D-02	0.1407D-06	0.1407D-06	0.2900D-08	0.1155D-05	0.6879D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0150	0.0060	0.0184	0.0184	0.1377D-01	0.1221D-04	0.1221D-04		0.5883D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0031	0.1248	0.0773	0.2464	0.0041	0.1248	0.0782	0.2454	0.0021	0.1248	0.0764	0.2474	0.1246
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0031	0.0241	0.0210	0.0030	0.0002	0.0166	0.0142	0.0002	0.0060	0.0316	0.0277	0.0059	0.0184

L	HP	HS
0.0	0.0031	0.0031
0.0031	-0.0001	0.0064
0.0050	0.0004	0.0071
0.0100	0.0017	0.0091
0.0150	0.0030	0.0111
0.0200	0.0043	0.0130
0.0250	0.0054	0.0148
0.0300	0.0065	0.0165
0.0350	0.0076	0.0181
0.0400	0.0086	0.0196
0.0450	0.0095	0.0210
0.0500	0.0104	0.0223
0.0550	0.0112	0.0235
0.0600	0.0120	0.0246
0.0650	0.0127	0.0257
0.0700	0.0133	0.0266
0.0750	0.0139	0.0275
0.0800	0.0144	0.0283
0.0850	0.0149	0.0290
0.0900	0.0153	0.0296
0.0950	0.0157	0.0302
0.1000	0.0160	0.0306
0.1050	0.0162	0.0310
0.1100	0.0164	0.0313
0.1150	0.0165	0.0315
0.1200	0.0166	0.0316
0.1250	0.0166	0.0316
0.1300	0.0166	0.0316
0.1350	0.0165	0.0315
0.1400	0.0164	0.0313
0.1450	0.0162	0.0310
0.1500	0.0159	0.0306
0.1550	0.0156	0.0301
0.1600	0.0152	0.0296
0.1650	0.0148	0.0290
0.1700	0.0144	0.0283
0.1750	0.0138	0.0275
0.1800	0.0132	0.0266
0.1850	0.0126	0.0256
0.1900	0.0119	0.0246
0.1950	0.0111	0.0234
0.2000	0.0103	0.0222
0.2050	0.0094	0.0209
0.2100	0.0085	0.0195
0.2150	0.0075	0.0180
0.2200	0.0064	0.0164
0.2250	0.0053	0.0147
0.2300	0.0042	0.0129
0.2350	0.0029	0.0110
0.2400	0.0016	0.0090
0.2450	0.0003	0.0069
0.2464	-0.0001	0.0063
0.2494	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.7154

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL			
7.8841	0.0062	0.1248	0.1250	0.3003D-02	0.1496D-06	0.1496D-06	0.1580D-10	0.1237D-05	0.7143D-05			
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)				
0.0150	0.0060	0.0190	0.0190	0.7432D-04	0.1233D-04	0.1233D-04		0.5925D-04				
L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CS)
0.0031	0.1250	0.0797	0.2470	0.0041	0.1250	0.0806	0.2459	0.0020	0.1250	0.0788	0.2480	0.1248
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CS)
0.0031	0.0250	0.0220	0.0030	0.0002	0.0175	0.0152	0.0002	0.0060	0.0325	0.0289	0.0058	0.0190

L	HP	HS
0.0	0.0031	0.0031
0.0031	-0.0001	0.0064
0.0050	0.0004	0.0072
0.0100	0.0018	0.0093
0.0150	0.0032	0.0113
0.0200	0.0045	0.0133
0.0250	0.0057	0.0151
0.0300	0.0069	0.0169
0.0350	0.0080	0.0185
0.0400	0.0090	0.0200
0.0450	0.0100	0.0215
0.0500	0.0109	0.0228
0.0550	0.0118	0.0241
0.0600	0.0126	0.0253
0.0650	0.0133	0.0264
0.0700	0.0140	0.0273
0.0750	0.0146	0.0282
0.0800	0.0152	0.0291
0.0850	0.0156	0.0298
0.0900	0.0161	0.0304
0.0950	0.0165	0.0310
0.1000	0.0168	0.0314
0.1050	0.0170	0.0318
0.1100	0.0172	0.0321
0.1150	0.0174	0.0323
0.1200	0.0175	0.0324
0.1250	0.0175	0.0325
0.1300	0.0175	0.0324
0.1350	0.0174	0.0323
0.1400	0.0172	0.0321
0.1450	0.0170	0.0318
0.1500	0.0167	0.0314
0.1550	0.0164	0.0310
0.1600	0.0160	0.0304
0.1650	0.0156	0.0298
0.1700	0.0151	0.0290
0.1750	0.0146	0.0282
0.1800	0.0139	0.0273
0.1850	0.0133	0.0263
0.1900	0.0125	0.0253
0.1950	0.0117	0.0241
0.2000	0.0109	0.0228
0.2050	0.0100	0.0215
0.2100	0.0090	0.0200
0.2150	0.0080	0.0185
0.2200	0.0069	0.0168
0.2250	0.0057	0.0151
0.2300	0.0045	0.0133
0.2350	0.0032	0.0113
0.2400	0.0019	0.0093
0.2450	0.0005	0.0071
0.2470	-0.0001	0.0063
0.2500	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.8009

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
4.9096	0.0062	0.1249	0.1250	0.3033D-02	0.2016D-06	0.2016D-06	0.8703D-09	0.1710D-05	0.8467D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0150	0.0060	0.0223	0.0223	0.4029D-01	0.1258D-04	0.1258D-04		0.6000D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0031	0.1251	0.0811	0.2471	0.0044	0.1251	0.0822	0.2459	0.0019	0.1251	0.0801	0.2484	0.1249
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0031	0.0295	0.0262	0.0030	0.0003	0.0220	0.0193	0.0003	0.0060	0.0370	0.0330	0.0057	0.0223

L	HP	HS
0.0	0.0031	0.0031
0.0031	-0.0002	0.0066
0.0050	0.0005	0.0075
0.0100	0.0022	0.0098
0.0150	0.0039	0.0123
0.0200	0.0056	0.0146
0.0250	0.0071	0.0167
0.0300	0.0086	0.0188
0.0350	0.0100	0.0207
0.0400	0.0113	0.0225
0.0450	0.0125	0.0242
0.0500	0.0137	0.0258
0.0550	0.0148	0.0273
0.0600	0.0158	0.0286
0.0650	0.0167	0.0299
0.0700	0.0176	0.0310
0.0750	0.0183	0.0321
0.0800	0.0190	0.0330
0.0850	0.0197	0.0339
0.0900	0.0202	0.0346
0.0950	0.0207	0.0352
0.1000	0.0211	0.0358
0.1050	0.0214	0.0362
0.1100	0.0217	0.0366
0.1150	0.0219	0.0368
0.1200	0.0220	0.0370
0.1250	0.0220	0.0370
0.1300	0.0220	0.0370
0.1350	0.0219	0.0368
0.1400	0.0217	0.0366
0.1450	0.0214	0.0363
0.1500	0.0211	0.0358
0.1550	0.0207	0.0353
0.1600	0.0203	0.0347
0.1650	0.0197	0.0339
0.1700	0.0191	0.0331
0.1750	0.0184	0.0322
0.1800	0.0176	0.0311
0.1850	0.0168	0.0300
0.1900	0.0159	0.0287
0.1950	0.0149	0.0274
0.2000	0.0138	0.0259
0.2050	0.0127	0.0244
0.2100	0.0115	0.0227
0.2150	0.0102	0.0209
0.2200	0.0088	0.0190
0.2250	0.0073	0.0169
0.2300	0.0057	0.0148
0.2350	0.0041	0.0125
0.2400	0.0024	0.0101
0.2450	0.0006	0.0075
0.2471	-0.0002	0.0064
0.2501	0.0030	0.0030

THIRD STAGE ROTOR   TDA 013   TRIAL 1

INPUT FOR BLADE COORDINATE PROGRAM

ETA	LAMDA	OP1	OP2	TNLMT
0.0	0.0	8.00000	1.00000	0.00010

ELEMENT	RI	RO	TI	TM	TO	KIC	KTC	KOC	ZMC	ZTC	ZOC
1	1.79305	1.79333	0.00600	0.01510	0.00600	57.80185	54.64604	52.03183	0.08009	0.11570	0.13708
2	1.75872	1.76031	0.00600	0.01550	0.00600	56.83131	54.46247	52.49231	0.07978	0.11444	0.13889
3	1.68887	1.69354	0.00600	0.01640	0.00600	55.19461	53.27566	51.90291	0.07939	0.11193	0.14368
4	1.61665	1.62517	0.00600	0.01740	0.00600	53.43480	50.64553	49.00618	0.07992	0.10959	0.15176
5	1.54086	1.55423	0.00600	0.01830	0.00600	51.60610	46.70112	43.82327	0.08032	0.10655	0.16305
6	1.46004	1.47942	0.00600	0.01940	0.00600	49.89467	42.37804	37.48985	0.08310	0.10190	0.17527
7	1.41698	1.44021	0.00600	0.01990	0.00600	49.13332	39.63453	32.49073	0.08580	0.09692	0.18311

BLADE ELEMENT STACKING PARAMETER--TNORMI = 0.297D-02

THECG

0.5950072D-01	0.5983905D-01	0.6050432D-01	0.6070042D-01	0.6023360D-01	0.5998884D-01	0.5960792D-01

CRCG

877.8983	153.7094	52.06144	28.91766	18.93425	13.36974	11.34691

BLADE ELEMENT STACKING PARAMETER--TNORMI = 0.457D-04

THECG

0.5951751D-01	0.5985340D-01	0.6053869D-01	0.6076600D-01	0.6033690D-01	0.6017528D-01	0.5971915D-01

CRCG

877.8983	153.7095	52.06151	28.91784	18.93460	13.37040	11.34772

BLADE ELEMENT ANGLES

ELEMENT	ALP	KH	KIC	KTC	KOC	KIP	KTP	KOP	KIS	KTS	KOS
1	0.11703	55.59015	57.80185	54.64604	52.03183	54.22439	56.17266	62.44516	61.36919	53.12374	41.76016
2	0.65589	55.16499	56.83131	54.46247	52.49231	53.01634	56.07009	61.79988	60.63799	52.95836	43.26926
3	1.86162	53.82444	55.19461	53.27566	51.90291	50.84603	55.01610	59.75368	59.53540	51.53840	44.09224
4	3.21329	51.38380	53.43480	50.64553	49.00618	48.46834	52.43168	55.94258	58.38520	48.86530	42.10312
5	4.68775	47.86494	51.60610	46.70112	43.82327	45.97291	48.45213	50.03841	57.20645	44.96044	37.65311
6	6.30969	43.69182	49.89467	42.37804	37.48985	43.63403	43.70402	43.86810	56.09005	41.06595	31.17812
7	7.23013	40.81242	49.13332	39.63453	32.49073	42.65049	40.55346	39.10884	55.52291	38.72882	25.96777

BLADE ELEMENT CURVATURES

ELEMENT	CIC	COC	CIP	COP	CIS	CAS
1	0.26463	1.27410	-0.16357	-3.05816	0.68991	5.46678
2	0.20384	0.83689	-0.26297	-2.43201	0.66819	4.03409
3	0.17478	0.45819	-0.37996	-1.57896	0.72706	2.46944
4	0.27279	0.43700	-0.38793	-0.93517	0.92849	1.79243
5	0.52357	0.62357	-0.26527	-0.34407	1.30079	1.57337
6	0.88608	0.88595	-0.00829	-0.02984	1.75676	1.77728
7	1.18687	1.18689	0.26388	0.24139	2.07612	2.09753

BLADE SECTION COORDINATES (ROTATED) AT X = 1.4170

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
40.0059	0.0060	0.1249	0.1249	0.3752D-02	0.1207D-06	0.1208D-06	0.3880D-07	0.6066D-06	0.5370D-05

TH	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG	I(HH)
0.0200	0.0062	0.0113	0.0114	0.1579	0.1420D-04	0.1420D-04	0.7270D-04

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1240	0.1387	0.2452	0.0034	0.1240	0.1384	0.2446	0.0026	0.1240	0.1392	0.2458	0.1249

H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0142	0.0140	0.0031	0.0000	0.0042	0.0042	0.0001	0.0060	0.0242	0.0240	0.0062	0.0113

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0061
0.0050	0.0001	0.0067
0.0100	0.0004	0.0080
0.0150	0.0007	0.0094
0.0200	0.0010	0.0107
0.0250	0.0013	0.0119
0.0300	0.0015	0.0131
0.0350	0.0018	0.0142
0.0400	0.0020	0.0152
0.0450	0.0022	0.0162
0.0500	0.0024	0.0171
0.0550	0.0027	0.0180
0.0600	0.0028	0.0188
0.0650	0.0030	0.0196
0.0700	0.0032	0.0203
0.0750	0.0034	0.0209
0.0800	0.0035	0.0215
0.0850	0.0036	0.0221
0.0900	0.0038	0.0225
0.0950	0.0039	0.0229
0.1000	0.0040	0.0233
0.1050	0.0041	0.0236
0.1100	0.0041	0.0238
0.1150	0.0042	0.0240
0.1200	0.0042	0.0241
0.1250	0.0043	0.0242
0.1300	0.0043	0.0242
0.1350	0.0043	0.0241
0.1400	0.0042	0.0240
0.1450	0.0042	0.0238
0.1500	0.0042	0.0236
0.1550	0.0041	0.0233
0.1600	0.0040	0.0229
0.1650	0.0039	0.0225
0.1700	0.0038	0.0220
0.1750	0.0037	0.0214
0.1800	0.0035	0.0208
0.1850	0.0034	0.0201
0.1900	0.0032	0.0194
0.1950	0.0030	0.0186
0.2000	0.0028	0.0177
0.2050	0.0026	0.0167
0.2100	0.0023	0.0157
0.2150	0.0020	0.0146
0.2200	0.0018	0.0134
0.2250	0.0014	0.0122
0.2300	0.0011	0.0108
0.2350	0.0008	0.0095
0.2400	0.0004	0.0080
0.2450	0.0000	0.0064
0.2452	0.0000	0.0064
0.2483	0.0031	0.0031

BLADE SECTION COORDINATES (ROTATED) AT X = 1.4282

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
40.8707	0.0060	0.1249	0.1249	0.3729D-02	0.1144D-06	0.1144D-06	0.3295D-07	0.5459D-06	0.5041D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0199	0.0061	0.0107	0.0108	0.1348	0.1412D-04	0.1412D-04		0.7226D-04	

L(TC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1241	0.1411	0.2454	0.0034	0.1240	0.1406	0.2449	0.0026	0.1241	0.1415	0.2459	0.1249
H(TC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0134	0.0133	0.0031	0.0000	0.0035	0.0035	0.0000	0.0060	0.0233	0.0231	0.0061	0.0107

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0061
0.0050	0.0001	0.0066
0.0100	0.0003	0.0079
0.0150	0.0006	0.0092
0.0200	0.0008	0.0104
0.0250	0.0010	0.0116
0.0300	0.0012	0.0127
0.0350	0.0014	0.0138
0.0400	0.0016	0.0148
0.0450	0.0018	0.0157
0.0500	0.0020	0.0166
0.0550	0.0022	0.0174
0.0600	0.0023	0.0182
0.0650	0.0025	0.0189
0.0700	0.0026	0.0196
0.0750	0.0028	0.0202
0.0800	0.0029	0.0208
0.0850	0.0030	0.0213
0.0900	0.0031	0.0217
0.0950	0.0032	0.0221
0.1000	0.0033	0.0225
0.1050	0.0033	0.0227
0.1100	0.0034	0.0230
0.1150	0.0034	0.0231
0.1200	0.0035	0.0232
0.1250	0.0035	0.0233
0.1300	0.0035	0.0233
0.1350	0.0035	0.0232
0.1400	0.0035	0.0231
0.1450	0.0035	0.0229
0.1500	0.0034	0.0227
0.1550	0.0034	0.0224
0.1600	0.0033	0.0221
0.1650	0.0032	0.0217
0.1700	0.0031	0.0212
0.1750	0.0030	0.0206
0.1800	0.0029	0.0201
0.1850	0.0028	0.0194
0.1900	0.0026	0.0187
0.1950	0.0025	0.0179
0.2000	0.0023	0.0171
0.2050	0.0021	0.0161
0.2100	0.0019	0.0152
0.2150	0.0017	0.0141
0.2200	0.0014	0.0130
0.2250	0.0012	0.0118
0.2300	0.0009	0.0106
0.2350	0.0006	0.0093
0.2400	0.0003	0.0079
0.2450	0.0000	0.0064
0.2454	0.0000	0.0063
0.2485	0.0031	0.0031

BLADE SECTION COORDINATES (ROTATED) AT X = 1.4402

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
41.7654	0.0060	0.1249	0.1249	0.3706D-02	0.1082D-06	0.1082D-06	0.2852D-07	0.4873D-06	0.4709D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0198	0.0061	0.0101	0.0101	0.1172	0.1406D-04	0.1406D-04		0.7185D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(NP)	L(TP)	L(OP)	L(IS)	L(NS)	L(TS)	L(OS)	L(CG)
0.0030	0.1241	0.1436	0.2456	0.0034	0.1240	0.1432	0.2451	0.0026	0.1241	0.1440	0.2461	0.1249
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(NP)	H(TP)	H(OP)	H(IS)	H(NS)	H(TS)	H(OS)	H(CG)
0.0030	0.0125	0.0124	0.0031	0.0000	0.0027	0.0027	0.0000	0.0059	0.0224	0.0221	0.0061	0.0101

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0060
0.0050	0.0001	0.0066
0.0100	0.0003	0.0078
0.0150	0.0004	0.0090
0.0200	0.0006	0.0102
0.0250	0.0008	0.0113
0.0300	0.0009	0.0124
0.0350	0.0011	0.0134
0.0400	0.0013	0.0143
0.0450	0.0014	0.0152
0.0500	0.0015	0.0160
0.0550	0.0017	0.0168
0.0600	0.0018	0.0176
0.0650	0.0019	0.0183
0.0700	0.0020	0.0189
0.0750	0.0021	0.0195
0.0800	0.0022	0.0200
0.0850	0.0023	0.0205
0.0900	0.0024	0.0209
0.0950	0.0025	0.0213
0.1000	0.0025	0.0216
0.1050	0.0026	0.0218
0.1100	0.0026	0.0221
0.1150	0.0027	0.0222
0.1200	0.0027	0.0223
0.1250	0.0027	0.0224
0.1300	0.0027	0.0224
0.1350	0.0027	0.0223
0.1400	0.0027	0.0222
0.1450	0.0027	0.0220
0.1500	0.0026	0.0218
0.1550	0.0026	0.0215
0.1600	0.0026	0.0212
0.1650	0.0025	0.0208
0.1700	0.0024	0.0204
0.1750	0.0023	0.0198
0.1800	0.0023	0.0193
0.1850	0.0022	0.0187
0.1900	0.0020	0.0180
0.1950	0.0019	0.0172
0.2000	0.0018	0.0164
0.2050	0.0016	0.0156
0.2100	0.0015	0.0147
0.2150	0.0013	0.0137
0.2200	0.0011	0.0126
0.2250	0.0009	0.0115
0.2300	0.0007	0.0103
0.2350	0.0005	0.0091
0.2400	0.0003	0.0078
0.2450	0.0000	0.0064
0.2456	0.0000	0.0062
0.2487	0.0031	0.0031

BLADE SECTION COORDINATES (ROTATED) AT X = 1.5026

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
45.6210	0.0060	0.1252	0.1252	0.35750-02	0.85090-07	0.85100-07	0.14020-07	0.29380-06	0.34350-05

TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG	I(HH)
0.0189	0.0062	0.0076	0.0076	0.58940-01	0.13720-04	0.13720-04	0.69800-04

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1251	0.1565	0.2462	0.0032	0.1251	0.1561	0.2458	0.0027	0.1252	0.1569	0.2465	0.1252

H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0092	0.0089	0.0031	0.0000	-0.0002	-0.0002	0.0000	0.0060	0.0186	0.0179	0.0062	0.0076

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0060
0.0050	0.0000	0.0064
0.0100	-0.0000	0.0074
0.0150	-0.0000	0.0083
0.0200	-0.0001	0.0092
0.0250	-0.0001	0.0101
0.0300	-0.0001	0.0109
0.0350	-0.0001	0.0117
0.0400	-0.0001	0.0124
0.0450	-0.0001	0.0131
0.0500	-0.0001	0.0138
0.0550	-0.0002	0.0144
0.0600	-0.0002	0.0150
0.0650	-0.0002	0.0155
0.0700	-0.0002	0.0160
0.0750	-0.0002	0.0164
0.0800	-0.0002	0.0168
0.0850	-0.0002	0.0172
0.0900	-0.0002	0.0175
0.0950	-0.0002	0.0178
0.1000	-0.0002	0.0181
0.1050	-0.0002	0.0183
0.1100	-0.0002	0.0184
0.1150	-0.0002	0.0185
0.1200	-0.0002	0.0186
0.1250	-0.0002	0.0186
0.1300	-0.0002	0.0186
0.1350	-0.0002	0.0186
0.1400	-0.0002	0.0185
0.1450	-0.0002	0.0184
0.1500	-0.0002	0.0182
0.1550	-0.0002	0.0180
0.1600	-0.0002	0.0177
0.1650	-0.0002	0.0174
0.1700	-0.0002	0.0171
0.1750	-0.0001	0.0167
0.1800	-0.0001	0.0163
0.1850	-0.0001	0.0158
0.1900	-0.0001	0.0153
0.1950	-0.0001	0.0147
0.2000	-0.0001	0.0141
0.2050	-0.0001	0.0134
0.2100	-0.0001	0.0127
0.2150	-0.0000	0.0120
0.2200	-0.0000	0.0112
0.2250	-0.0000	0.0103
0.2300	-0.0000	0.0095
0.2350	-0.0000	0.0085
0.2400	0.0000	0.0075
0.2450	0.0000	0.0065
0.2462	0.0000	0.0063
0.2493	0.0031	0.0031

BLADE SECTION COORDINATES (ROTATED) AT X = 1.5770

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL			
49.5809	0.0060	0.1265	0.1265	0.3448D-02	0.6986D-07	0.6986D-07	0.5727D-08	0.1808D-06	0.2480D-05			
TH	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)				
0.0180	0.0060	0.0057	0.0057	0.2456D-01	0.1343D-04	0.1343D-04		0.6862D-04				
L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1302	0.1721	0.2468	0.0031	0.1301	0.1718	0.2466	0.0028	0.1303	0.1724	0.2470	0.1265
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0066	0.0062	0.0030	0.0000	-0.0024	-0.0022	0.0000	0.0060	0.0155	0.0145	0.0060	0.0057

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0060
0.0050	-0.0001	0.0063
0.0100	-0.0002	0.0070
0.0150	-0.0004	0.0077
0.0200	-0.0005	0.0084
0.0250	-0.0007	0.0090
0.0300	-0.0008	0.0096
0.0350	-0.0010	0.0102
0.0400	-0.0011	0.0108
0.0450	-0.0012	0.0113
0.0500	-0.0013	0.0118
0.0550	-0.0015	0.0122
0.0600	-0.0016	0.0127
0.0650	-0.0017	0.0131
0.0700	-0.0018	0.0134
0.0750	-0.0018	0.0138
0.0800	-0.0019	0.0141
0.0850	-0.0020	0.0144
0.0900	-0.0021	0.0146
0.0950	-0.0021	0.0148
0.1000	-0.0022	0.0150
0.1050	-0.0022	0.0152
0.1100	-0.0023	0.0153
0.1150	-0.0023	0.0154
0.1200	-0.0023	0.0155
0.1250	-0.0024	0.0155
0.1300	-0.0024	0.0155
0.1350	-0.0024	0.0155
0.1400	-0.0024	0.0155
0.1450	-0.0024	0.0154
0.1500	-0.0024	0.0153
0.1550	-0.0024	0.0152
0.1600	-0.0023	0.0150
0.1650	-0.0023	0.0148
0.1700	-0.0023	0.0146
0.1750	-0.0022	0.0143
0.1800	-0.0021	0.0140
0.1850	-0.0021	0.0137
0.1900	-0.0020	0.0133
0.1950	-0.0019	0.0129
0.2000	-0.0017	0.0124
0.2050	-0.0016	0.0119
0.2100	-0.0015	0.0114
0.2150	-0.0013	0.0108
0.2200	-0.0011	0.0102
0.2250	-0.0010	0.0095
0.2300	-0.0008	0.0088
0.2350	-0.0005	0.0080
0.2400	-0.0003	0.0072
0.2450	-0.0001	0.0064
0.2468	0.0000	0.0061
0.2498	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.6513

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
52.7424	0.0060	0.1280	0.1280	0.3318D-02	0.5940D-07	0.5940D-07	0.2269D-08	0.1247D-06	0.1887D-05

TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG	I(HH)
0.0170	0.0060	0.0044	0.0044	0.9909D-02	0.1318D-04	0.1318D-04	0.6759D-04

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1365	0.1871	0.2469	0.0031	0.1364	0.1869	0.2468	0.0029	0.1365	0.1872	0.2470	0.1280

H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0049	0.0045	0.0030	0.0000	-0.0036	-0.0032	0.0000	0.0060	0.0134	0.0122	0.0060	0.0044

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0060
0.0050	-0.0001	0.0062
0.0100	-0.0003	0.0068
0.0150	-0.0006	0.0073
0.0200	-0.0008	0.0078
0.0250	-0.0010	0.0083
0.0300	-0.0012	0.0087
0.0350	-0.0014	0.0092
0.0400	-0.0016	0.0096
0.0450	-0.0018	0.0100
0.0500	-0.0020	0.0104
0.0550	-0.0021	0.0107
0.0600	-0.0023	0.0110
0.0650	-0.0024	0.0113
0.0700	-0.0026	0.0116
0.0750	-0.0027	0.0119
0.0800	-0.0028	0.0121
0.0850	-0.0029	0.0124
0.0900	-0.0030	0.0126
0.0950	-0.0031	0.0127
0.1000	-0.0032	0.0129
0.1050	-0.0033	0.0130
0.1100	-0.0034	0.0131
0.1150	-0.0034	0.0132
0.1200	-0.0035	0.0133
0.1250	-0.0035	0.0133
0.1300	-0.0035	0.0134
0.1350	-0.0036	0.0134
0.1400	-0.0036	0.0134
0.1450	-0.0036	0.0133
0.1500	-0.0036	0.0133
0.1550	-0.0036	0.0132
0.1600	-0.0035	0.0131
0.1650	-0.0035	0.0130
0.1700	-0.0034	0.0128
0.1750	-0.0034	0.0127
0.1800	-0.0033	0.0125
0.1850	-0.0032	0.0123
0.1900	-0.0032	0.0121
0.1950	-0.0030	0.0118
0.2000	-0.0029	0.0115
0.2050	-0.0027	0.0111
0.2100	-0.0025	0.0107
0.2150	-0.0023	0.0102
0.2200	-0.0020	0.0097
0.2250	-0.0017	0.0091
0.2300	-0.0013	0.0085
0.2350	-0.0010	0.0078
0.2400	-0.0006	0.0071
0.2450	-0.0002	0.0063
0.2469	0.0000	0.0060
0.2499	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.7257

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
54.7031	0.0060	0.1295	0.1295	0.31790-02	0.51080-07	0.51090-07	0.84830-08	0.10680-06	0.17320-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0159	0.0060	0.0042	0.0042	0.37800-01	0.12910-04	0.12910-04		0.66220-04	

L(IC)	L(HC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(HS)	L(TS)	L(OS)	L(CG)
0.0030	0.1426	0.2003	0.2468	0.0031	0.1426	0.2001	0.2467	0.0029	0.1427	0.2005	0.2469	0.1295
H(IC)	H(HC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(HS)	H(TS)	H(OS)	H(CG)
0.0030	0.0046	0.0042	0.0030	0.0000	-0.0034	-0.0030	0.0000	0.0060	0.0125	0.0113	0.0060	0.0042

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0060
0.0050	-0.0001	0.0062
0.0100	-0.0003	0.0067
0.0150	-0.0005	0.0071
0.0200	-0.0007	0.0075
0.0250	-0.0009	0.0080
0.0300	-0.0011	0.0083
0.0350	-0.0013	0.0087
0.0400	-0.0015	0.0091
0.0450	-0.0016	0.0094
0.0500	-0.0018	0.0097
0.0550	-0.0020	0.0100
0.0600	-0.0021	0.0103
0.0650	-0.0022	0.0106
0.0700	-0.0024	0.0108
0.0750	-0.0025	0.0111
0.0800	-0.0026	0.0113
0.0850	-0.0027	0.0115
0.0900	-0.0028	0.0117
0.0950	-0.0029	0.0118
0.1000	-0.0030	0.0120
0.1050	-0.0031	0.0121
0.1100	-0.0032	0.0122
0.1150	-0.0032	0.0123
0.1200	-0.0033	0.0124
0.1250	-0.0033	0.0124
0.1300	-0.0034	0.0125
0.1350	-0.0034	0.0125
0.1400	-0.0034	0.0125
0.1450	-0.0034	0.0125
0.1500	-0.0034	0.0125
0.1550	-0.0034	0.0124
0.1600	-0.0034	0.0124
0.1650	-0.0034	0.0123
0.1700	-0.0033	0.0122
0.1750	-0.0033	0.0121
0.1800	-0.0033	0.0120
0.1850	-0.0032	0.0118
0.1900	-0.0031	0.0117
0.1950	-0.0031	0.0115
0.2000	-0.0030	0.0113
0.2050	-0.0029	0.0111
0.2100	-0.0027	0.0108
0.2150	-0.0025	0.0104
0.2200	-0.0022	0.0099
0.2250	-0.0019	0.0093
0.2300	-0.0014	0.0087
0.2350	-0.0012	0.0080
0.2400	-0.0007	0.0072
0.2450	-0.0002	0.0064
0.2468	0.0000	0.0060
0.2498	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.8500

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
56.6042	0.0060	0.1319	0.1320	0.29740-02	0.42170-07	0.42270-07	0.35480-07	0.13100-06	0.21800-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0144	0.0064	0.0054	0.0055	0.1619	0.12600-04	0.12600-04		0.64460-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1541	0.2202	0.2466	0.0032	0.1542	0.2199	0.2460	0.0028	0.1542	0.2205	0.2471	0.1319
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0061	0.0050	0.0032	0.0000	-0.0010	-0.0015	0.0000	0.0060	0.0134	0.0114	0.0064	0.0054

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0060
0.0050	-0.0000	0.0062
0.0100	-0.0000	0.0067
0.0150	-0.0001	0.0072
0.0200	-0.0001	0.0077
0.0250	-0.0001	0.0081
0.0300	-0.0002	0.0086
0.0350	-0.0002	0.0090
0.0400	-0.0003	0.0094
0.0450	-0.0003	0.0098
0.0500	-0.0003	0.0101
0.0550	-0.0004	0.0105
0.0600	-0.0004	0.0108
0.0650	-0.0004	0.0111
0.0700	-0.0005	0.0114
0.0750	-0.0005	0.0116
0.0800	-0.0005	0.0119
0.0850	-0.0006	0.0121
0.0900	-0.0006	0.0123
0.0950	-0.0007	0.0125
0.1000	-0.0007	0.0127
0.1050	-0.0007	0.0128
0.1100	-0.0008	0.0130
0.1150	-0.0008	0.0131
0.1200	-0.0008	0.0132
0.1250	-0.0009	0.0133
0.1300	-0.0009	0.0133
0.1350	-0.0009	0.0134
0.1400	-0.0010	0.0134
0.1450	-0.0010	0.0134
0.1500	-0.0010	0.0134
0.1550	-0.0010	0.0134
0.1600	-0.0011	0.0134
0.1650	-0.0011	0.0133
0.1700	-0.0011	0.0132
0.1750	-0.0012	0.0131
0.1800	-0.0012	0.0130
0.1850	-0.0012	0.0129
0.1900	-0.0012	0.0127
0.1950	-0.0013	0.0126
0.2000	-0.0013	0.0124
0.2050	-0.0014	0.0123
0.2100	-0.0015	0.0121
0.2150	-0.0014	0.0119
0.2200	-0.0014	0.0115
0.2250	-0.0014	0.0110
0.2300	-0.0012	0.0104
0.2350	-0.0009	0.0095
0.2400	0.0005	0.0084
0.2450	0.0000	0.0070
0.2466	0.0002	0.0066
0.2498	0.0032	0.0032

THIRD STAGE STATOR TDA 013 TRIAL 1

INPUT FOR BLADE COORDINATE PROGRAM

ETA	LAMDA	OP1	OP2	TNLMT
0.0	0.0	8.00000	1.00000	0.00010

ELEMENT	RI	RO	TI	TM	TO	KIC	KTC	KOC	ZMC	ZTC	ZOC
1	1.79355	1.79395	0.00600	0.01500	0.00600	29.34397	13.20974	-19.10126	0.11919	0.07778	0.24305
2	1.76154	1.76407	0.00600	0.01500	0.00600	28.71264	14.15553	-15.24591	0.11838	0.07689	0.24232
3	1.69695	1.70370	0.00600	0.01500	0.00600	28.17272	15.07484	-12.36032	0.11781	0.07466	0.24161
4	1.63080	1.64193	0.00600	0.01500	0.00600	28.58821	15.86409	-11.24875	0.11726	0.07339	0.24098
5	1.56197	1.57783	0.00600	0.01500	0.00600	30.01567	16.89135	-10.72188	0.11636	0.07334	0.24005
6	1.48920	1.51017	0.00600	0.01500	0.00600	32.19996	18.05811	-10.96432	0.11519	0.07365	0.23892
7	1.45090	1.47450	0.00600	0.01500	0.00600	33.57477	18.38507	-12.65321	0.11489	0.07350	0.23880

BLADE ELEMENT STACKING PARAMETER--TNORM1 = 0.219D-02

THECG

0.1673253D-01	0.1791578D-01	0.1921856D-01	0.2078782D-01	0.2320872D-01	0.2630541D-01	0.2761271D-01

CRCG

1089.927	168.8463	60.88316	35.46506	23.81055	17.14925	14.86951

BLADE ELEMENT STACKING PARAMETER--TNORM1 = 0.120D-04

THECG

0.1664428D-01	0.1784778D-01	0.1914662D-01	0.2073027D-01	0.2316979D-01	0.2624262D-01	0.2749495D-01

CRCG

1089.927	168.8461	60.88295	35.46484	23.81031	17.14903	14.86935

BLADE ELEMENT ANGLES

ELEMENT	ALP	KM	KIC	KTC	KOC	KIP	KTP	KOP	KIS	KTS	KOS
1	0.09429	5.12141	29.34397	13.20974	-19.10126	25.23407	11.80375	-14.98942	33.31119	14.56994	-23.07054
2	0.59819	6.73452	28.71264	14.15553	-15.24591	24.58238	12.72751	-11.10413	32.71197	15.53834	-19.25655
3	1.60029	7.90518	28.17272	15.07484	-12.36032	24.03995	13.57474	-8.19315	32.18429	16.53088	-16.40535
4	2.64441	8.66963	28.58821	15.86409	-11.24875	24.46811	14.32973	-7.07026	32.58968	17.35405	-15.30690
5	3.78002	9.64655	30.01567	16.89135	-10.72188	25.91881	15.37744	-6.53812	33.99234	18.36045	-14.79274
6	5.01600	10.61818	32.19996	18.05811	-10.96432	28.13532	16.58815	-6.78183	36.13900	19.48203	-15.01728
7	5.64407	10.46248	33.57477	18.38507	-12.65021	29.53858	16.92310	-8.47884	37.47816	19.79816	-16.68392

BLADE ELEMENT CURVATURES

ELEMENT	CIC	COC	CIP	COP	CIS	CAS
1	3.36249	3.36270	2.84704	2.84682	3.83273	3.83336
2	3.06736	3.06770	2.53609	2.53407	3.55651	3.55902
3	2.83911	2.83890	2.29984	2.29217	3.33910	3.34575
4	2.79243	2.79209	2.25497	2.24195	3.29150	3.30281
5	2.85278	2.85263	2.32301	2.30410	3.34394	3.36097
6	3.01481	3.01484	2.49799	2.47317	3.49178	3.51442
7	3.21729	3.21724	2.71441	2.68612	3.67862	3.70405

BLADE SECTION COORDINATES (ROTATED) AT X = 1.4509

GAMMA	TT	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
10.2803	0.0061	0.1244	0.1246	0.3007D-02	0.1870D-06	0.1871D-06	0.2646D-07	0.1589D-05	0.8116D-05

TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG	I(HH)
0.0150	0.0060	0.0215	0.0216	0.1251	0.1230D-04	0.1230D-04	0.5900D-04

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1244	0.0818	0.2457	0.0042	0.1244	0.0827	0.2445	0.0019	0.1244	0.0808	0.2470	0.1244

H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0285	0.0253	0.0030	0.0002	0.0210	0.0184	0.0003	0.0058	0.0360	0.0321	0.0057	0.0215

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0002	0.0064
0.0050	0.0005	0.0073
0.0100	0.0022	0.0098
0.0150	0.0038	0.0121
0.0200	0.0053	0.0142
0.0250	0.0068	0.0163
0.0300	0.0082	0.0183
0.0350	0.0095	0.0201
0.0400	0.0107	0.0218
0.0450	0.0119	0.0235
0.0500	0.0130	0.0250
0.0550	0.0140	0.0264
0.0600	0.0150	0.0277
0.0650	0.0158	0.0289
0.0700	0.0167	0.0301
0.0750	0.0174	0.0311
0.0800	0.0181	0.0320
0.0850	0.0187	0.0328
0.0900	0.0192	0.0336
0.0950	0.0197	0.0342
0.1000	0.0201	0.0347
0.1050	0.0204	0.0352
0.1100	0.0206	0.0355
0.1150	0.0208	0.0358
0.1200	0.0209	0.0359
0.1250	0.0210	0.0360
0.1300	0.0210	0.0360
0.1350	0.0209	0.0358
0.1400	0.0207	0.0356
0.1450	0.0205	0.0353
0.1500	0.0202	0.0349
0.1550	0.0198	0.0344
0.1600	0.0194	0.0338
0.1650	0.0189	0.0330
0.1700	0.0183	0.0322
0.1750	0.0176	0.0313
0.1800	0.0169	0.0303
0.1850	0.0161	0.0292
0.1900	0.0152	0.0280
0.1950	0.0142	0.0266
0.2000	0.0132	0.0252
0.2050	0.0120	0.0236
0.2100	0.0108	0.0220
0.2150	0.0096	0.0202
0.2200	0.0082	0.0183
0.2250	0.0067	0.0162
0.2300	0.0052	0.0141
0.2350	0.0036	0.0118
0.2400	0.0019	0.0093
0.2450	0.0001	0.0068
0.2457	-0.0002	0.0064
0.2487	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.4624

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
10.3440	0.0061	0.1244	0.1246	0.3005D-02	0.1812D-06	0.1812D-06	0.2618D-07	0.1534D-05	0.7973D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0150	0.0060	0.0212	0.0212	0.1239	0.1229D-04	0.1229D-04		0.5897D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(HP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1244	0.0818	0.2458	0.0042	0.1244	0.0827	0.2446	0.0019	0.1244	0.0808	0.2470	0.1244
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(HP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0280	0.0248	0.0030	0.0002	0.0205	0.0179	0.0002	0.0058	0.0355	0.0317	0.0057	0.0212

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0002	0.0064
0.0050	0.0005	0.0073
0.0100	0.0021	0.0097
0.0150	0.0037	0.0119
0.0200	0.0052	0.0141
0.0250	0.0066	0.0161
0.0300	0.0080	0.0180
0.0350	0.0092	0.0198
0.0400	0.0104	0.0215
0.0450	0.0116	0.0231
0.0500	0.0127	0.0246
0.0550	0.0137	0.0260
0.0600	0.0146	0.0273
0.0650	0.0154	0.0285
0.0700	0.0162	0.0296
0.0750	0.0170	0.0306
0.0800	0.0176	0.0315
0.0850	0.0182	0.0324
0.0900	0.0187	0.0331
0.0950	0.0192	0.0337
0.1000	0.0196	0.0342
0.1050	0.0199	0.0347
0.1100	0.0201	0.0350
0.1150	0.0203	0.0353
0.1200	0.0204	0.0354
0.1250	0.0205	0.0355
0.1300	0.0205	0.0355
0.1350	0.0204	0.0353
0.1400	0.0202	0.0351
0.1450	0.0200	0.0348
0.1500	0.0197	0.0344
0.1550	0.0193	0.0339
0.1600	0.0189	0.0333
0.1650	0.0184	0.0326
0.1700	0.0178	0.0318
0.1750	0.0172	0.0309
0.1800	0.0165	0.0299
0.1850	0.0157	0.0288
0.1900	0.0148	0.0276
0.1950	0.0139	0.0263
0.2000	0.0128	0.0249
0.2050	0.0118	0.0233
0.2100	0.0106	0.0217
0.2150	0.0093	0.0199
0.2200	0.0080	0.0180
0.2250	0.0066	0.0161
0.2300	0.0051	0.0139
0.2350	0.0035	0.0117
0.2400	0.0019	0.0093
0.2450	0.0001	0.0068
0.2458	-0.0002	0.0064
0.2488	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.4745

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
10.3998	0.0061	0.1244	0.1247	0.3002D-02	0.1745D-06	0.1746D-06	0.2867D-07	0.1475D-05	0.7819D-05

TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG	I(HH)
0.0150	0.0060	0.0208	0.0208	0.1358	0.1227D-04	0.1227D-04	0.5894D-04

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1244	0.0818	0.2459	0.0042	0.1244	0.0827	0.2447	0.0019	0.1244	0.0808	0.2470	0.1244

H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0274	0.0243	0.0030	0.0002	0.0199	0.0174	0.0002	0.0058	0.0349	0.0312	0.0058	0.0208

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0002	0.0064
0.0050	0.0005	0.0073
0.0100	0.0021	0.0096
0.0150	0.0036	0.0118
0.0200	0.0050	0.0139
0.0250	0.0064	0.0159
0.0300	0.0077	0.0178
0.0350	0.0090	0.0195
0.0400	0.0101	0.0212
0.0450	0.0112	0.0228
0.0500	0.0123	0.0242
0.0550	0.0133	0.0256
0.0600	0.0142	0.0269
0.0650	0.0150	0.0281
0.0700	0.0158	0.0291
0.0750	0.0165	0.0301
0.0800	0.0171	0.0310
0.0850	0.0177	0.0318
0.0900	0.0182	0.0325
0.0950	0.0186	0.0331
0.1000	0.0190	0.0337
0.1050	0.0193	0.0341
0.1100	0.0196	0.0344
0.1150	0.0198	0.0347
0.1200	0.0199	0.0348
0.1250	0.0199	0.0349
0.1300	0.0199	0.0349
0.1350	0.0198	0.0348
0.1400	0.0197	0.0346
0.1450	0.0195	0.0343
0.1500	0.0192	0.0339
0.1550	0.0188	0.0334
0.1600	0.0184	0.0328
0.1650	0.0179	0.0321
0.1700	0.0174	0.0313
0.1750	0.0167	0.0304
0.1800	0.0160	0.0295
0.1850	0.0153	0.0284
0.1900	0.0144	0.0272
0.1950	0.0135	0.0259
0.2000	0.0125	0.0245
0.2050	0.0115	0.0230
0.2100	0.0103	0.0214
0.2150	0.0091	0.0197
0.2200	0.0078	0.0179
0.2250	0.0065	0.0159
0.2300	0.0050	0.0138
0.2350	0.0035	0.0116
0.2400	0.0018	0.0093
0.2450	0.0001	0.0068
0.2459	-0.0002	0.0064
0.2489	0.0030	0.0037

BLADE SECTION COORDINATES (ROTATED) AT X = 1.5300

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
10.1737	0.0061	0.1246	0.1249	0.2997D-02	0.1513D-06	0.1513D-06	0.9175D-08	0.1258D-05	0.7199D-05
TM	TD	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0150	0.0060	0.0192	0.0192	0.4344D-01	0.1225D-04	0.1225D-04		0.5897D-04	

L(TC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1247	0.0812	0.2464	0.0041	0.1247	0.0821	0.2453	0.0020	0.1247	0.0803	0.2475	0.1246
H(TC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0252	0.0224	0.0030	0.0002	0.0177	0.0155	0.0002	0.0059	0.0327	0.0293	0.0058	0.0192

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0001	0.0063
0.0050	0.0005	0.0072
0.0100	0.0019	0.0093
0.0150	0.0032	0.0114
0.0200	0.0045	0.0133
0.0250	0.0058	0.0152
0.0300	0.0070	0.0169
0.0350	0.0081	0.0186
0.0400	0.0091	0.0201
0.0450	0.0101	0.0216
0.0500	0.0110	0.0229
0.0550	0.0119	0.0242
0.0600	0.0127	0.0254
0.0650	0.0134	0.0265
0.0700	0.0141	0.0275
0.0750	0.0147	0.0284
0.0800	0.0153	0.0292
0.0850	0.0158	0.0299
0.0900	0.0163	0.0306
0.0950	0.0166	0.0312
0.1000	0.0170	0.0316
0.1050	0.0172	0.0320
0.1100	0.0175	0.0323
0.1150	0.0176	0.0325
0.1200	0.0177	0.0327
0.1250	0.0177	0.0327
0.1300	0.0177	0.0327
0.1350	0.0176	0.0326
0.1400	0.0175	0.0324
0.1450	0.0173	0.0321
0.1500	0.0170	0.0317
0.1550	0.0167	0.0312
0.1600	0.0163	0.0307
0.1650	0.0159	0.0300
0.1700	0.0154	0.0293
0.1750	0.0148	0.0285
0.1800	0.0142	0.0276
0.1850	0.0135	0.0266
0.1900	0.0127	0.0255
0.1950	0.0119	0.0243
0.2000	0.0111	0.0230
0.2050	0.0101	0.0216
0.2100	0.0091	0.0202
0.2150	0.0081	0.0186
0.2200	0.0069	0.0169
0.2250	0.0057	0.0151
0.2300	0.0045	0.0132
0.2350	0.0032	0.0113
0.2400	0.0018	0.0091
0.2450	0.0003	0.0069
0.2464	-0.0001	0.0063
0.2494	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.5975

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
9.2101	0.0061	0.1247	0.1250	0.2997D-02	0.1426D-06	0.1426D-06	0.3545D-08	0.1175D-05	0.6955D-05

TM	TD	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)
0.0150	0.0060	0.0185	0.0186	0.1676D-01	0.1226D-04	0.1226D-04		0.5906D-04

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1249	0.0803	0.2467	0.0041	0.1249	0.0811	0.2457	0.0020	0.1249	0.0794	0.2477	0.1247

H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0243	0.0215	0.0030	0.0002	0.0168	0.0147	0.0002	0.0059	0.0318	0.0284	0.0059	0.0195

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0001	0.0063
0.0050	0.0004	0.0071
0.0100	0.0018	0.0092
0.0150	0.0031	0.0112
0.0200	0.0043	0.0131
0.0250	0.0055	0.0149
0.0300	0.0066	0.0166
0.0350	0.0077	0.0182
0.0400	0.0087	0.0197
0.0450	0.0096	0.0211
0.0500	0.0105	0.0224
0.0550	0.0113	0.0236
0.0600	0.0121	0.0248
0.0650	0.0128	0.0258
0.0700	0.0134	0.0268
0.0750	0.0140	0.0277
0.0800	0.0146	0.0285
0.0850	0.0150	0.0292
0.0900	0.0155	0.0298
0.0950	0.0158	0.0303
0.1000	0.0161	0.0308
0.1050	0.0164	0.0312
0.1100	0.0166	0.0315
0.1150	0.0167	0.0317
0.1200	0.0168	0.0318
0.1250	0.0168	0.0318
0.1300	0.0168	0.0318
0.1350	0.0167	0.0317
0.1400	0.0166	0.0315
0.1450	0.0164	0.0312
0.1500	0.0161	0.0308
0.1550	0.0158	0.0304
0.1600	0.0155	0.0298
0.1650	0.0150	0.0292
0.1700	0.0146	0.0285
0.1750	0.0140	0.0277
0.1800	0.0134	0.0268
0.1850	0.0128	0.0259
0.1900	0.0121	0.0248
0.1950	0.0113	0.0237
0.2000	0.0105	0.0224
0.2050	0.0096	0.0211
0.2100	0.0087	0.0197
0.2150	0.0077	0.0182
0.2200	0.0066	0.0166
0.2250	0.0055	0.0149
0.2300	0.0043	0.0131
0.2350	0.0031	0.0111
0.2400	0.0017	0.0091
0.2450	0.0004	0.0071
0.2467	-0.0001	0.0063
0.2497	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.6650

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL			
8.3884	0.0061	0.1248	0.1250	0.2999D-02	0.1420D-06	0.1420D-06	0.7456D-09	0.1169D-05	0.6943D-05			
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)				
0.0150	0.0060	0.0185	0.0185	0.3521D-02	0.1229D-04	0.1229D-04		0.5917D-04				
L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1250	0.0805	0.2469	0.0041	0.1250	0.0813	0.2459	0.0020	0.1250	0.0796	0.2479	0.1248
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0243	0.0215	0.0030	0.0002	0.0168	0.0146	0.0002	0.0059	0.0318	0.0283	0.0058	0.0185

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0001	0.0063
0.0050	0.0004	0.0071
0.0100	0.0018	0.0092
0.0150	0.0031	0.0112
0.0200	0.0043	0.0131
0.0250	0.0055	0.0149
0.0300	0.0066	0.0165
0.0350	0.0077	0.0181
0.0400	0.0086	0.0196
0.0450	0.0096	0.0210
0.0500	0.0105	0.0224
0.0550	0.0113	0.0236
0.0600	0.0120	0.0247
0.0650	0.0127	0.0258
0.0700	0.0134	0.0267
0.0750	0.0140	0.0276
0.0800	0.0145	0.0284
0.0850	0.0150	0.0291
0.0900	0.0154	0.0297
0.0950	0.0158	0.0303
0.1000	0.0161	0.0307
0.1050	0.0163	0.0311
0.1100	0.0165	0.0314
0.1150	0.0166	0.0316
0.1200	0.0167	0.0317
0.1250	0.0168	0.0318
0.1300	0.0167	0.0317
0.1350	0.0166	0.0316
0.1400	0.0165	0.0314
0.1450	0.0163	0.0311
0.1500	0.0161	0.0307
0.1550	0.0157	0.0303
0.1600	0.0154	0.0297
0.1650	0.0150	0.0291
0.1700	0.0145	0.0284
0.1750	0.0140	0.0276
0.1800	0.0134	0.0267
0.1850	0.0127	0.0258
0.1900	0.0120	0.0247
0.1950	0.0113	0.0236
0.2000	0.0104	0.0224
0.2050	0.0096	0.0211
0.2100	0.0086	0.0197
0.2150	0.0076	0.0182
0.2200	0.0066	0.0166
0.2250	0.0055	0.0149
0.2300	0.0043	0.0131
0.2350	0.0031	0.0112
0.2400	0.0018	0.0092
0.2450	0.0004	0.0071
0.2469	-0.0001	0.0063
0.2499	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.7325

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
7.6696	0.0061	0.1249	0.1251	0.3005D-02	0.1510D-06	0.1510D-06	-0.1595D-08	0.1252D-05	0.7193D-05

TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG	I(HH)
0.0150	0.0060	0.0191	0.0191	-0.7066D-02	0.1235D-04	0.1235D-04	0.5935D-04

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CS)
0.0031	0.1250	0.0823	0.2471	0.0041	0.1250	0.0831	0.2460	0.0020	0.1250	0.0814	0.2481	0.1249

H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CS)
0.0031	0.0251	0.0225	0.0030	0.0002	0.0176	0.0156	0.0002	0.0059	0.0326	0.0294	0.0058	0.0191

L	HP	HS
0.0	0.0031	0.0031
0.0031	-0.0001	0.0064
0.0050	0.0004	0.0072
0.0100	0.0019	0.0093
0.0150	0.0032	0.0114
0.0200	0.0045	0.0133
0.0250	0.0058	0.0152
0.0300	0.0070	0.0169
0.0350	0.0081	0.0186
0.0400	0.0091	0.0201
0.0450	0.0101	0.0216
0.0500	0.0110	0.0230
0.0550	0.0119	0.0242
0.0600	0.0127	0.0254
0.0650	0.0134	0.0265
0.0700	0.0141	0.0275
0.0750	0.0147	0.0284
0.0800	0.0153	0.0292
0.0850	0.0158	0.0299
0.0900	0.0162	0.0306
0.0950	0.0166	0.0311
0.1000	0.0169	0.0316
0.1050	0.0172	0.0320
0.1100	0.0174	0.0323
0.1150	0.0175	0.0325
0.1200	0.0176	0.0326
0.1250	0.0176	0.0326
0.1300	0.0176	0.0326
0.1350	0.0175	0.0325
0.1400	0.0174	0.0323
0.1450	0.0172	0.0320
0.1500	0.0169	0.0316
0.1550	0.0166	0.0311
0.1600	0.0162	0.0305
0.1650	0.0157	0.0299
0.1700	0.0152	0.0292
0.1750	0.0147	0.0284
0.1800	0.0141	0.0275
0.1850	0.0134	0.0265
0.1900	0.0127	0.0254
0.1950	0.0119	0.0242
0.2000	0.0110	0.0230
0.2050	0.0101	0.0216
0.2100	0.0091	0.0201
0.2150	0.0081	0.0186
0.2200	0.0070	0.0170
0.2250	0.0058	0.0152
0.2300	0.0046	0.0134
0.2350	0.0033	0.0114
0.2400	0.0019	0.0094
0.2450	0.0005	0.0072
0.2471	-0.0001	0.0063
0.2501	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.8300

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
4.7761	0.0062	0.1250	0.1251	0.3034D-02	0.2030D-06	0.2030D-06	0.4395D-08	0.1727D-05	0.9510D-05

TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG	I(HH)
0.0150	0.0060	0.0224	0.0224	0.2034D-01	0.1259D-04	0.1259D-04	0.6005D-04

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0031	0.1251	0.0833	0.2471	0.0043	0.1251	0.0843	0.2459	0.0018	0.1251	0.0823	0.2484	0.1250

H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0031	0.0297	0.0266	0.0030	0.0003	0.0222	0.0197	0.0003	0.0059	0.0372	0.0336	0.0057	0.0224

L	HP	HS
0.0	0.0031	0.0031
0.0031	-0.0002	0.0065
0.0050	0.0005	0.0074
0.0100	0.0023	0.0099
0.0150	0.0040	0.0124
0.0200	0.0057	0.0147
0.0250	0.0072	0.0168
0.0300	0.0087	0.0189
0.0350	0.0101	0.0208
0.0400	0.0114	0.0226
0.0450	0.0127	0.0243
0.0500	0.0138	0.0259
0.0550	0.0149	0.0274
0.0600	0.0159	0.0288
0.0650	0.0168	0.0300
0.0700	0.0177	0.0312
0.0750	0.0185	0.0322
0.0800	0.0192	0.0332
0.0850	0.0198	0.0340
0.0900	0.0203	0.0347
0.0950	0.0208	0.0354
0.1000	0.0212	0.0359
0.1050	0.0216	0.0364
0.1100	0.0218	0.0367
0.1150	0.0220	0.0370
0.1200	0.0221	0.0371
0.1250	0.0222	0.0372
0.1300	0.0221	0.0371
0.1350	0.0220	0.0370
0.1400	0.0218	0.0367
0.1450	0.0216	0.0364
0.1500	0.0213	0.0359
0.1550	0.0209	0.0354
0.1600	0.0204	0.0348
0.1650	0.0198	0.0340
0.1700	0.0192	0.0332
0.1750	0.0185	0.0323
0.1800	0.0178	0.0312
0.1850	0.0169	0.0301
0.1900	0.0160	0.0288
0.1950	0.0150	0.0275
0.2000	0.0139	0.0263
0.2050	0.0128	0.0244
0.2100	0.0115	0.0228
0.2150	0.0102	0.0210
0.2200	0.0088	0.0190
0.2250	0.0073	0.0170
0.2300	0.0058	0.0148
0.2350	0.0041	0.0125
0.2400	0.0024	0.0101
0.2450	0.0006	0.0075
0.2471	-0.0002	0.0064
0.2501	0.0030	0.0030

FOURTH STAGE ROTOR   TDA 013   TRIAL 1

INPUT FOR BLADE COORDINATE PROGRAM

ETA	LAMDA	OP1	OP2	TNLMT
0.0	0.0	8.00000	1.00000	0.00010

ELEMENT	RI	RO	TI	TM	TO	KIC	KTC	KOC	ZMC	ZTC	ZOC
1	1.79411	1.79431	0.00600	0.01510	0.00600	59.06125	55.00982	54.56485	0.06481	0.11969	0.13362
2	1.76498	1.76598	0.00600	0.01550	0.00600	58.25804	55.65104	55.31500	0.06554	0.11791	0.13371
3	1.70623	1.70911	0.00600	0.01650	0.00600	56.88974	55.65155	55.43325	0.06731	0.11521	0.13590
4	1.64613	1.65133	0.00600	0.01740	0.00600	55.58059	53.68471	53.22476	0.06998	0.11364	0.14200
5	1.58372	1.59179	0.00600	0.01840	0.00600	54.25706	50.43173	49.17241	0.07339	0.11205	0.15103
6	1.51782	1.52950	0.00600	0.01940	0.00600	53.11800	46.96819	44.31691	0.07680	0.10931	0.16063
7	1.48296	1.49705	0.00600	0.01990	0.00600	52.58758	44.31573	40.18176	0.07913	0.10769	0.16780

BLADE ELEMENT STACKING PARAMETER--TNORM1 = 0.217D-02

THECG

0.5748175D-01   0.5821433D-01   0.5959156D-01   0.6059138D-01   0.6123356D-01   0.6187453D-01   0.6179699D-01

CRCG

1198.712   236.0680   80.59832   45.05247   29.75568   21.00700   17.80365

BLADE ELEMENT STACKING PARAMETER--TNORM1 = 0.316D-04

THECG

0.5746024D-01   0.5820643D-01   0.5961822D-01   0.6065340D-01   0.6133164D-01   0.6201894D-01   0.6195991D-01

CRCG

1198.712   236.0680   80.59836   45.05259   29.75591   21.00738   17.80424

BLADE ELEMENT ANGLES

ELEMENT	ALP	KM	KIC	KTC	KOC	KIP	KTP	KOP	KIS	KTS	KOS
1	0.08576	56.81296	59.06125	55.00982	54.56485	54.78624	58.43759	58.84673	63.32160	51.59380	50.29327
2	0.42850	56.78654	58.25804	55.65104	55.31500	53.79766	59.09172	59.78491	62.70832	52.21815	50.85108
3	1.21403	56.16149	56.88974	55.65155	55.43325	51.96384	59.09882	60.38676	61.80765	52.21003	50.47552
4	2.09722	54.40271	55.58059	53.68471	53.22476	50.23750	56.93897	58.61513	60.91304	50.43708	47.84032
5	3.05858	51.71478	54.25706	50.43173	49.17241	48.44862	53.36016	55.04839	60.04201	47.51528	43.32031
6	4.15887	48.71753	53.11800	46.96819	44.31691	46.84527	49.45972	50.67837	59.34413	44.49527	38.00265
7	4.79981	46.38442	52.58758	44.31573	40.18176	46.08516	46.48385	46.78589	59.01977	42.17107	33.64881

BLADE ELEMENT CURVATURES

ELEMENT	CIC	COC	CIP	COP	CIS	CAS
1	0.32139	0.32147	-0.29001	-0.29528	0.92775	0.93633
2	0.21041	0.21034	-0.42749	-0.43321	0.84481	0.85297
3	0.10413	0.10417	-0.59985	-0.61316	0.80584	0.82510
4	0.16842	0.16844	-0.59531	-0.61250	0.92858	0.94751
5	0.36342	0.36341	-0.46723	-0.48660	1.18553	1.20461
6	0.62864	0.62867	-0.26812	-0.28912	1.50845	1.52905
7	0.88528	0.88521	-0.04289	-0.06483	1.78797	1.80906

BLADE SECTION COORDINATES (ROTATED) AT X = 1.4830

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
45.9513	0.0061	0.1253	0.1252	0.3760D-02	0.1050D-06	0.1050D-06	0.1362D-07	0.4073D-06	0.4234D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0200	0.0062	0.0089	0.0090	0.5491D-01	0.1431D-04	0.1431D-04		0.7323D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1245	0.1633	0.2463	0.0033	0.1245	0.1628	0.2459	0.0028	0.1246	0.1639	0.2467	0.1253
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0110	0.0102	0.0031	0.0000	0.0010	0.0009	0.0000	0.0061	0.0210	0.0196	0.0061	0.0089

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0061
0.0050	0.0000	0.0066
0.0100	0.0001	0.0077
0.0150	0.0002	0.0088
0.0200	0.0002	0.0099
0.0250	0.0003	0.0109
0.0300	0.0004	0.0119
0.0350	0.0004	0.0128
0.0400	0.0005	0.0137
0.0450	0.0005	0.0145
0.0500	0.0006	0.0153
0.0550	0.0006	0.0160
0.0600	0.0007	0.0166
0.0650	0.0007	0.0173
0.0700	0.0008	0.0178
0.0750	0.0008	0.0184
0.0800	0.0008	0.0189
0.0850	0.0009	0.0193
0.0900	0.0009	0.0197
0.0950	0.0009	0.0200
0.1000	0.0010	0.0203
0.1050	0.0010	0.0205
0.1100	0.0010	0.0207
0.1150	0.0010	0.0208
0.1200	0.0010	0.0209
0.1250	0.0010	0.0210
0.1300	0.0010	0.0210
0.1350	0.0010	0.0209
0.1400	0.0010	0.0208
0.1450	0.0010	0.0206
0.1500	0.0010	0.0204
0.1550	0.0010	0.0202
0.1600	0.0010	0.0198
0.1650	0.0009	0.0195
0.1700	0.0009	0.0191
0.1750	0.0009	0.0186
0.1800	0.0008	0.0181
0.1850	0.0008	0.0175
0.1900	0.0007	0.0169
0.1950	0.0007	0.0162
0.2000	0.0006	0.0155
0.2050	0.0006	0.0148
0.2100	0.0005	0.0139
0.2150	0.0005	0.0130
0.2200	0.0004	0.0121
0.2250	0.0003	0.0111
0.2300	0.0003	0.0101
0.2350	0.0002	0.0090
0.2400	0.0001	0.0078
0.2450	0.0000	0.0066
0.2463	0.0000	0.0063
0.2494	0.0031	0.0031

BLADE SECTION COORDINATES (ROTATED) AT X = 1.4898

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
46.4739	0.0060	0.1252	0.1252	0.3742D-02	0.1018D-06	0.1018D-06	0.1074D-07	0.3780D-06	0.4036D-05

TH	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG	I(HH)
0.0199	0.0061	0.0086	0.0086	0.4351D-01	0.1425D-04	0.1425D-04	0.7288D-04

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(HP)	L(TP)	L(OP)	L(IS)	L(HS)	L(TS)	L(OS)	L(CG)
0.0030	0.1246	0.1648	0.2464	0.0033	0.1245	0.1643	0.2460	0.0027	0.1246	0.1654	0.2468	0.1252

H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(HP)	H(TP)	H(OP)	H(IS)	H(HS)	H(TS)	H(OS)	H(CG)
0.0030	0.0105	0.0097	0.0031	0.0000	0.0006	0.0005	0.0000	0.0060	0.0204	0.0190	0.0061	0.0086

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0061
0.0050	0.0000	0.0065
0.0100	0.0001	0.0076
0.0150	0.0001	0.0087
0.0200	0.0001	0.0097
0.0250	0.0001	0.0107
0.0300	0.0002	0.0116
0.0350	0.0002	0.0125
0.0400	0.0002	0.0134
0.0450	0.0003	0.0142
0.0500	0.0003	0.0149
0.0550	0.0003	0.0156
0.0600	0.0004	0.0163
0.0650	0.0004	0.0169
0.0700	0.0004	0.0174
0.0750	0.0004	0.0179
0.0800	0.0005	0.0184
0.0850	0.0005	0.0188
0.0900	0.0005	0.0192
0.0950	0.0005	0.0195
0.1000	0.0005	0.0198
0.1050	0.0006	0.0200
0.1100	0.0006	0.0202
0.1150	0.0006	0.0203
0.1200	0.0006	0.0204
0.1250	0.0006	0.0204
0.1300	0.0006	0.0204
0.1350	0.0006	0.0204
0.1400	0.0006	0.0202
0.1450	0.0006	0.0201
0.1500	0.0006	0.0199
0.1550	0.0006	0.0196
0.1600	0.0005	0.0193
0.1650	0.0005	0.0190
0.1700	0.0005	0.0186
0.1750	0.0005	0.0181
0.1800	0.0005	0.0176
0.1850	0.0004	0.0171
0.1900	0.0004	0.0165
0.1950	0.0004	0.0158
0.2000	0.0003	0.0152
0.2050	0.0003	0.0144
0.2100	0.0003	0.0136
0.2150	0.0003	0.0128
0.2200	0.0002	0.0118
0.2250	0.0002	0.0109
0.2300	0.0001	0.0099
0.2350	0.0001	0.0088
0.2400	0.0001	0.0077
0.2450	0.0000	0.0065
0.2464	0.0000	0.0062
0.2495	0.0031	0.0031

BLADE SECTION COORDINATES (ROTATED) AT X = 1.4970

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
47.0154	0.0060	0.1252	0.1252	0.3724D-02	0.9848D-07	0.9848D-07	0.9216D-08	0.3487D-06	0.3831D-05
TH	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0198	0.0061	0.0082	0.0082	0.3745D-01	0.1420D-04	0.1420D-04		0.7257D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1246	0.1666	0.2465	0.0033	0.1246	0.1660	0.2462	0.0027	0.1246	0.1671	0.2469	0.1252
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0100	0.0092	0.0030	0.0000	0.0001	0.0001	0.0000	0.0060	0.0198	0.0183	0.0061	0.0082

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0061
0.0050	0.0000	0.0065
0.0100	0.0000	0.0076
0.0150	0.0000	0.0086
0.0200	0.0000	0.0096
0.0250	0.0000	0.0105
0.0300	0.0000	0.0114
0.0350	0.0000	0.0123
0.0400	0.0000	0.0131
0.0450	0.0000	0.0138
0.0500	0.0000	0.0146
0.0550	0.0000	0.0152
0.0600	0.0000	0.0159
0.0650	0.0000	0.0164
0.0700	0.0000	0.0170
0.0750	0.0001	0.0175
0.0800	0.0001	0.0179
0.0850	0.0001	0.0183
0.0900	0.0001	0.0186
0.0950	0.0001	0.0190
0.1000	0.0001	0.0192
0.1050	0.0001	0.0194
0.1100	0.0001	0.0196
0.1150	0.0001	0.0197
0.1200	0.0001	0.0198
0.1250	0.0001	0.0198
0.1300	0.0001	0.0198
0.1350	0.0001	0.0198
0.1400	0.0001	0.0197
0.1450	0.0001	0.0195
0.1500	0.0001	0.0193
0.1550	0.0001	0.0191
0.1600	0.0001	0.0188
0.1650	0.0001	0.0185
0.1700	0.0001	0.0181
0.1750	0.0001	0.0176
0.1800	0.0001	0.0172
0.1850	0.0001	0.0166
0.1900	0.0001	0.0161
0.1950	0.0001	0.0154
0.2000	0.0000	0.0148
0.2050	0.0000	0.0141
0.2100	0.0000	0.0133
0.2150	0.0000	0.0125
0.2200	0.0000	0.0116
0.2250	0.0000	0.0107
0.2300	0.0000	0.0097
0.2350	0.0000	0.0087
0.2400	0.0000	0.0076
0.2450	0.0000	0.0065
0.2465	0.0000	0.0062
0.2496	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.5519

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
50.1660	0.0060	0.1252	0.1251	0.3589D-02	0.8058D-07	0.8058D-07	-0.2640D-08	0.2117D-06	0.2712D-05

TH	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)
0.0190	0.0060	0.0060	0.0060	-0.1104D-01	0.1378D-04	0.1378D-04		0.6998D-04

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1248	0.1787	0.2468	0.0032	0.1247	0.1783	0.2466	0.0028	0.1248	0.1790	0.2470	0.1252

H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0071	0.0063	0.0030	0.0000	-0.0024	-0.0020	0.0000	0.0060	0.0166	0.0145	0.0060	0.0060

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0060
0.0050	-0.0001	0.0064
0.0100	-0.0002	0.0072
0.0150	-0.0004	0.0080
0.0200	-0.0006	0.0088
0.0250	-0.0008	0.0095
0.0300	-0.0009	0.0102
0.0350	-0.0011	0.0108
0.0400	-0.0012	0.0115
0.0450	-0.0013	0.0120
0.0500	-0.0014	0.0126
0.0550	-0.0016	0.0131
0.0600	-0.0017	0.0136
0.0650	-0.0018	0.0140
0.0700	-0.0019	0.0144
0.0750	-0.0019	0.0148
0.0800	-0.0020	0.0151
0.0850	-0.0021	0.0154
0.0900	-0.0021	0.0157
0.0950	-0.0022	0.0159
0.1000	-0.0022	0.0161
0.1050	-0.0023	0.0163
0.1100	-0.0023	0.0164
0.1150	-0.0023	0.0165
0.1200	-0.0024	0.0165
0.1250	-0.0024	0.0166
0.1300	-0.0024	0.0165
0.1350	-0.0024	0.0165
0.1400	-0.0023	0.0164
0.1450	-0.0023	0.0163
0.1500	-0.0023	0.0161
0.1550	-0.0023	0.0159
0.1600	-0.0022	0.0157
0.1650	-0.0022	0.0154
0.1700	-0.0021	0.0151
0.1750	-0.0020	0.0148
0.1800	-0.0019	0.0144
0.1850	-0.0019	0.0140
0.1900	-0.0018	0.0136
0.1950	-0.0017	0.0131
0.2000	-0.0015	0.0126
0.2050	-0.0014	0.0121
0.2100	-0.0013	0.0115
0.2150	-0.0011	0.0109
0.2200	-0.0010	0.0102
0.2250	-0.0008	0.0095
0.2300	-0.0006	0.0088
0.2350	-0.0005	0.0080
0.2400	-0.0003	0.0072
0.2450	-0.0001	0.0064
0.2468	0.0000	0.0061
0.2498	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.6139

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
53.1048	0.0060	0.1251	0.1251	0.3426D-02	0.6685D-07	0.6685D-07	-0.7938D-08	0.1385D-06	0.1953D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0180	0.0060	0.0046	0.0046	-0.3437D-01	0.1330D-04	0.1330D-04		0.6695D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1249	0.1919	0.2470	0.0031	0.1248	0.1916	0.2469	0.0029	0.1249	0.1921	0.2471	0.1251
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0051	0.0045	0.0030	0.0000	-0.0038	-0.0028	0.0000	0.0060	0.0141	0.0116	0.0060	0.0046

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0060
0.0050	-0.0001	0.0063
0.0100	-0.0004	0.0069
0.0150	-0.0007	0.0075
0.0200	-0.0010	0.0081
0.0250	-0.0012	0.0087
0.0300	-0.0015	0.0092
0.0350	-0.0017	0.0097
0.0400	-0.0019	0.0102
0.0450	-0.0021	0.0107
0.0500	-0.0023	0.0111
0.0550	-0.0025	0.0115
0.0600	-0.0027	0.0118
0.0650	-0.0028	0.0122
0.0700	-0.0030	0.0125
0.0750	-0.0031	0.0128
0.0800	-0.0033	0.0130
0.0850	-0.0034	0.0133
0.0900	-0.0035	0.0135
0.0950	-0.0036	0.0136
0.1000	-0.0036	0.0138
0.1050	-0.0037	0.0139
0.1100	-0.0038	0.0140
0.1150	-0.0038	0.0141
0.1200	-0.0038	0.0141
0.1250	-0.0038	0.0141
0.1300	-0.0038	0.0141
0.1350	-0.0038	0.0140
0.1400	-0.0038	0.0140
0.1450	-0.0038	0.0139
0.1500	-0.0037	0.0137
0.1550	-0.0037	0.0136
0.1600	-0.0036	0.0134
0.1650	-0.0035	0.0132
0.1700	-0.0034	0.0130
0.1750	-0.0033	0.0127
0.1800	-0.0031	0.0124
0.1850	-0.0030	0.0121
0.1900	-0.0028	0.0118
0.1950	-0.0027	0.0114
0.2000	-0.0025	0.0110
0.2050	-0.0023	0.0106
0.2100	-0.0021	0.0101
0.2150	-0.0018	0.0097
0.2200	-0.0016	0.0092
0.2250	-0.0013	0.0086
0.2300	-0.0011	0.0081
0.2350	-0.0008	0.0075
0.2400	-0.0005	0.0069
0.2450	-0.0001	0.0063
0.2470	0.0000	0.0060
0.2500	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.6760

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
55.4491	0.0060	0.1251	0.1251	0.3269D-02	0.5671D-07	0.5671D-07	-0.6568D-08	0.1009D-06	0.1497D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0170	0.0060	0.0037	0.0037	-0.2946D-01	0.1283D-04	0.1283D-04		0.6398D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1249	0.2047	0.2470	0.0030	0.1249	0.2045	0.2470	0.0030	0.1250	0.2048	0.2471	0.1251
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0039	0.0035	0.0030	0.0000	-0.0046	-0.0027	0.0000	0.0060	0.0124	0.0096	0.0060	0.0037

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0060
0.0050	-0.0001	0.0062
0.0100	-0.0005	0.0067
0.0150	-0.0008	0.0072
0.0200	-0.0012	0.0077
0.0250	-0.0015	0.0081
0.0300	-0.0018	0.0086
0.0350	-0.0020	0.0090
0.0400	-0.0023	0.0093
0.0450	-0.0026	0.0097
0.0500	-0.0028	0.0100
0.0550	-0.0030	0.0103
0.0600	-0.0032	0.0106
0.0650	-0.0034	0.0109
0.0700	-0.0036	0.0112
0.0750	-0.0038	0.0114
0.0800	-0.0039	0.0116
0.0850	-0.0040	0.0118
0.0900	-0.0042	0.0119
0.0950	-0.0043	0.0121
0.1000	-0.0044	0.0122
0.1050	-0.0044	0.0123
0.1100	-0.0045	0.0123
0.1150	-0.0045	0.0124
0.1200	-0.0046	0.0124
0.1250	-0.0046	0.0124
0.1300	-0.0046	0.0124
0.1350	-0.0046	0.0124
0.1400	-0.0045	0.0123
0.1450	-0.0045	0.0122
0.1500	-0.0044	0.0121
0.1550	-0.0043	0.0120
0.1600	-0.0042	0.0119
0.1650	-0.0041	0.0117
0.1700	-0.0040	0.0115
0.1750	-0.0039	0.0113
0.1800	-0.0037	0.0111
0.1850	-0.0035	0.0108
0.1900	-0.0033	0.0106
0.1950	-0.0031	0.0103
0.2000	-0.0029	0.0100
0.2050	-0.0027	0.0096
0.2100	-0.0024	0.0093
0.2150	-0.0021	0.0089
0.2200	-0.0019	0.0085
0.2250	-0.0016	0.0081
0.2300	-0.0012	0.0076
0.2350	-0.0009	0.0072
0.2400	-0.0005	0.0067
0.2450	-0.0002	0.0062
0.2470	0.0000	0.0060
0.2500	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.7380

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL			
56.6055	0.0060	0.1250	0.1250	0.3097D-02	0.4766D-07	0.4766D-07	-0.1703D-08	0.9249D-07	0.1471D-05			
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)				
0.0159	0.0060	0.0038	0.0038	-0.7956D-02	0.1231D-04	0.1231D-04		0.6072D-04				
L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1250	0.2154	0.2470	0.0031	0.1250	0.2152	0.2469	0.0029	0.1250	0.2154	0.2470	0.1250
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0041	0.0035	0.0030	0.0000	-0.0039	-0.0018	0.0000	0.0060	0.0121	0.0087	0.0060	0.0038

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0060
0.0050	-0.0001	0.0062
0.0100	-0.0004	0.0067
0.0150	-0.0007	0.0072
0.0200	-0.0010	0.0076
0.0250	-0.0012	0.0080
0.0300	-0.0015	0.0084
0.0350	-0.0017	0.0088
0.0400	-0.0020	0.0091
0.0450	-0.0022	0.0095
0.0500	-0.0024	0.0098
0.0550	-0.0026	0.0101
0.0600	-0.0028	0.0104
0.0650	-0.0029	0.0106
0.0700	-0.0031	0.0108
0.0750	-0.0032	0.0111
0.0800	-0.0033	0.0112
0.0850	-0.0034	0.0114
0.0900	-0.0035	0.0116
0.0950	-0.0036	0.0117
0.1000	-0.0037	0.0118
0.1050	-0.0038	0.0119
0.1100	-0.0038	0.0120
0.1150	-0.0039	0.0120
0.1200	-0.0039	0.0120
0.1250	-0.0039	0.0121
0.1300	-0.0039	0.0120
0.1350	-0.0039	0.0120
0.1400	-0.0038	0.0120
0.1450	-0.0038	0.0119
0.1500	-0.0037	0.0118
0.1550	-0.0037	0.0117
0.1600	-0.0036	0.0116
0.1650	-0.0035	0.0114
0.1700	-0.0034	0.0112
0.1750	-0.0032	0.0110
0.1800	-0.0031	0.0108
0.1850	-0.0029	0.0106
0.1900	-0.0028	0.0104
0.1950	-0.0026	0.0101
0.2000	-0.0024	0.0098
0.2050	-0.0022	0.0095
0.2100	-0.0020	0.0091
0.2150	-0.0018	0.0088
0.2200	-0.0015	0.0084
0.2250	-0.0013	0.0080
0.2300	-0.0010	0.0076
0.2350	-0.0007	0.0071
0.2400	-0.0004	0.0067
0.2450	-0.0001	0.0062
0.2470	0.0000	0.0060
0.2500	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.8500

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
56.8011	0.0060	0.1248	0.1249	0.2834D-02	0.3899D-07	0.3900D-07	0.7898D-08	0.1403D-06	0.2124D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0143	0.0061	0.0060	0.0060	0.3939D-01	0.1153D-04	0.1153D-04		0.5572D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1249	0.2304	0.2468	0.0032	0.1249	0.2296	0.2465	0.0028	0.1249	0.2303	0.2470	0.1248
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0071	0.0044	0.0030	0.0000	-0.0001	0.0001	0.0000	0.0060	0.0142	0.0082	0.0061	0.0060

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0060
0.0050	0.0000	0.0063
0.0100	-0.0000	0.0069
0.0150	-0.0000	0.0076
0.0200	-0.0000	0.0081
0.0250	-0.0001	0.0087
0.0300	-0.0001	0.0092
0.0350	-0.0001	0.0097
0.0400	-0.0001	0.0102
0.0450	-0.0001	0.0107
0.0500	-0.0001	0.0111
0.0550	-0.0001	0.0115
0.0600	-0.0001	0.0119
0.0650	-0.0001	0.0122
0.0700	-0.0001	0.0125
0.0750	-0.0001	0.0128
0.0800	-0.0001	0.0131
0.0850	-0.0001	0.0133
0.0900	-0.0001	0.0135
0.0950	-0.0001	0.0137
0.1000	-0.0001	0.0139
0.1050	-0.0001	0.0140
0.1100	-0.0001	0.0141
0.1150	-0.0001	0.0142
0.1200	-0.0001	0.0142
0.1250	-0.0001	0.0142
0.1300	-0.0001	0.0142
0.1350	-0.0001	0.0142
0.1400	-0.0001	0.0141
0.1450	-0.0001	0.0140
0.1500	-0.0000	0.0139
0.1550	-0.0000	0.0138
0.1600	-0.0000	0.0136
0.1650	-0.0000	0.0134
0.1700	0.0000	0.0132
0.1750	0.0000	0.0129
0.1800	0.0000	0.0126
0.1850	0.0000	0.0123
0.1900	0.0000	0.0120
0.1950	0.0001	0.0116
0.2000	0.0001	0.0112
0.2050	0.0001	0.0108
0.2100	0.0001	0.0103
0.2150	0.0001	0.0098
0.2200	0.0001	0.0093
0.2250	0.0001	0.0088
0.2300	0.0001	0.0082
0.2350	0.0000	0.0076
0.2400	0.0000	0.0070
0.2450	0.0000	0.0063
0.2468	0.0000	0.0061
0.2498	0.0030	0.0030

FOURTH STAGE STATOR -TDA 013 TRIAL 1

INPUT FOR BLADE COORDINATE PROGRAM

ETA	LAMDA	OP1	OP2	TNLMT
0.0	0.0	8.00000	1.00000	0.00010

ELEMENT	RI	RO	TI	TM	TO	KIC	KTC	KOC	ZHC	ZTC	ZOC
1	1.79446	1.79474	0.00600	0.01500	0.00600	28.60080	12.52849	-19.14986	0.11945	0.07890	0.24316
2	1.76682	1.76873	0.00600	0.01500	0.00600	27.67434	13.42704	-15.10704	0.11874	0.07768	0.24251
3	1.71145	1.71646	0.00600	0.01500	0.00600	26.81306	14.20054	-12.19628	0.11831	0.07517	0.24195
4	1.65519	1.66329	0.00600	0.01500	0.00600	26.97414	14.84354	-11.03742	0.11792	0.07391	0.24150
5	1.59715	1.60850	0.00600	0.01500	0.00600	27.97256	15.64845	-10.44036	0.11729	0.07383	0.24087
6	1.53639	1.55117	0.00600	0.01500	0.00600	29.89693	16.59985	-10.68272	0.11642	0.07471	0.24011
7	1.50465	1.52121	0.00600	0.01500	0.00600	31.24263	16.82074	-12.41355	0.11623	0.07505	0.24013

BLADE ELEMENT STACKING PARAMETER--TNORM1 = 0.202D-02

THECG

0.1610247D-01 0.1706374D-01 0.1797789D-01 0.1917177D-01 0.2099347D-01 0.2350016D-01 0.2454091D-01

CRCG

1558.481 224.4570 82.78856 49.49574 34.05072 25.12455 21.98781

BLADE ELEMENT STACKING PARAMETER--TNORM1 = 0.896D-05

THECG

0.1601693D-01 0.1699780D-01 0.1790837D-01 0.1911416D-01 0.2094727D-01 0.2343532D-01 0.2442911D-01

CRCG

1558.481 224.4569 82.78838 49.49554 34.05050 25.12436 21.98768

BLADE ELEMENT ANGLES

ELEMENT	ALP	KM	KIC	KTC	KOC	KIP	KTP	KOP	KIS	KTS	KOS
1	0.06598	4.72609	28.60080	12.52849	-19.14986	24.48487	11.14894	-15.03355	32.57571	13.86090	-23.12533
2	0.45125	6.28306	27.67434	13.42704	-15.10704	23.53603	12.01379	-10.95900	31.68473	14.79668	-19.12701
3	1.18624	7.30876	26.81306	14.20054	-12.19628	22.66610	12.70248	-8.02409	30.84266	15.65618	-15.25247
4	1.92100	7.96860	26.97414	14.84354	-11.03742	22.83420	13.30781	-6.85515	30.99992	16.33680	-15.10437
5	2.69783	8.76652	27.97256	15.64845	-10.44036	23.84665	14.12518	-6.25359	31.98373	17.12913	-14.51063
6	3.52241	9.60743	29.89693	16.59985	-10.68272	25.79441	15.13298	-6.49901	33.87945	18.02346	-14.74393
7	3.94502	9.41401	31.24263	16.82074	-12.41355	27.16314	15.37666	-8.24192	35.19430	18.21936	-16.45439

BLADE ELEMENT CURVATURES

ELEMENT	CIC	COC	CIP	COP	CIS	CAS
1	3.31786	3.31770	2.79914	2.79897	3.79174	3.79162
2	2.98959	2.98984	2.45373	2.45186	3.48412	3.48633
3	2.73673	2.73702	2.19071	2.18552	3.24448	3.24981
4	2.66942	2.66948	2.12326	2.11406	3.17834	3.18695
5	2.69665	2.69664	2.15480	2.14158	3.20122	3.21336
6	2.84237	2.84260	2.31059	2.29357	3.33553	3.35154
7	3.04786	3.04791	2.52838	2.50910	3.52671	3.54433

BLADE SECTION COORDINATES (ROTATED) AT X = 1.0546

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
5.9718	0.0059	0.1235	0.1236	0.3131D-02	0.6309D-06	0.6310D-06	0.4127D-07	0.5189D-05	0.1481D-04
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0150	0.0055	0.0375	0.0381	0.1862	0.1333D-04	0.1333D-04		0.6118D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CS)
0.0030	0.1222	0.0881	0.2448	0.0052	0.1222	0.0898	0.2426	0.0008	0.1221	0.0864	0.2470	0.1235
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CS)
0.0030	0.0518	0.0472	0.0028	0.0010	0.0444	0.0406	0.0011	0.0050	0.0594	0.0545	0.0044	0.0375

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0007	0.0069
0.0050	0.0008	0.0088
0.0100	0.0045	0.0132
0.0150	0.0079	0.0174
0.0200	0.0112	0.0214
0.0250	0.0144	0.0251
0.0300	0.0173	0.0286
0.0350	0.0201	0.0319
0.0400	0.0228	0.0350
0.0450	0.0252	0.0378
0.0500	0.0276	0.0405
0.0550	0.0297	0.0430
0.0600	0.0317	0.0453
0.0650	0.0336	0.0474
0.0700	0.0353	0.0493
0.0750	0.0369	0.0511
0.0800	0.0383	0.0527
0.0850	0.0396	0.0541
0.0900	0.0407	0.0553
0.0950	0.0417	0.0564
0.1000	0.0425	0.0573
0.1050	0.0432	0.0581
0.1100	0.0437	0.0586
0.1150	0.0441	0.0591
0.1200	0.0443	0.0593
0.1250	0.0444	0.0594
0.1300	0.0444	0.0593
0.1350	0.0442	0.0591
0.1400	0.0439	0.0587
0.1450	0.0434	0.0581
0.1500	0.0428	0.0574
0.1550	0.0420	0.0565
0.1600	0.0410	0.0554
0.1650	0.0399	0.0542
0.1700	0.0387	0.0527
0.1750	0.0373	0.0511
0.1800	0.0357	0.0493
0.1850	0.0340	0.0473
0.1900	0.0321	0.0452
0.1950	0.0300	0.0428
0.2000	0.0277	0.0402
0.2050	0.0253	0.0374
0.2100	0.0227	0.0344
0.2150	0.0199	0.0312
0.2200	0.0170	0.0277
0.2250	0.0138	0.0240
0.2300	0.0105	0.0200
0.2350	0.0069	0.0158
0.2400	0.0031	0.0113
0.2448	-0.0007	0.0066
0.2476	0.0028	0.0028

PLADE SECTION COORDINATES (ROTATED) AT X = 1.5127

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
9.2916	0.0060	0.1246	0.1248	0.3004D-02	0.1659D-06	0.1660D-06	0.2184D-07	0.1393D-05	0.7602D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	I-HCG		I(HH)	
0.0150	0.0060	0.0202	0.0202	0.1030	0.1231D-04	0.1231D-04		0.5913D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CS)
0.0030	0.1247	0.0824	0.2464	0.0041	0.1247	0.0833	0.2452	0.0019	0.1246	0.0815	0.2475	0.1246
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CS)
0.0030	0.0266	0.0237	0.0030	0.0002	0.0191	0.0168	0.0002	0.0058	0.0341	0.0306	0.0058	0.0202

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0001	0.0063
0.0050	0.0005	0.0072
0.0100	0.0020	0.0095
0.0150	0.0035	0.0116
0.0200	0.0048	0.0137
0.0250	0.0062	0.0156
0.0300	0.0074	0.0174
0.0350	0.0086	0.0192
0.0400	0.0097	0.0208
0.0450	0.0108	0.0223
0.0500	0.0118	0.0237
0.0550	0.0127	0.0251
0.0600	0.0136	0.0263
0.0650	0.0144	0.0275
0.0700	0.0151	0.0285
0.0750	0.0158	0.0295
0.0800	0.0164	0.0303
0.0850	0.0170	0.0311
0.0900	0.0175	0.0318
0.0950	0.0179	0.0324
0.1000	0.0182	0.0329
0.1050	0.0185	0.0333
0.1100	0.0188	0.0337
0.1150	0.0190	0.0339
0.1200	0.0191	0.0340
0.1250	0.0191	0.0341
0.1300	0.0191	0.0341
0.1350	0.0190	0.0340
0.1400	0.0189	0.0337
0.1450	0.0187	0.0334
0.1500	0.0184	0.0331
0.1550	0.0180	0.0326
0.1600	0.0176	0.0320
0.1650	0.0172	0.0313
0.1700	0.0166	0.0306
0.1750	0.0160	0.0297
0.1800	0.0154	0.0288
0.1850	0.0146	0.0277
0.1900	0.0138	0.0266
0.1950	0.0130	0.0254
0.2000	0.0120	0.0240
0.2050	0.0110	0.0226
0.2100	0.0099	0.0210
0.2150	0.0088	0.0194
0.2200	0.0076	0.0176
0.2250	0.0063	0.0157
0.2300	0.0049	0.0137
0.2350	0.0034	0.0116
0.2400	0.0019	0.0094
0.2450	0.0003	0.0070
0.2464	-0.0002	0.0063
0.2494	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.5212

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL	
9.3510	0.0060	0.1246	0.1249	0.3002D-02	0.1606D-06	0.1606D-06	0.2418D-07	0.1345D-05	0.7470D-05	
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)		
0.0150	0.0060	0.0199	0.0199	0.1142	0.1229D-04	0.1229D-04		0.5909D-04		
L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1247	0.0823	0.2464	0.0041	0.1247	0.0832	0.2453	0.0019	0.1247	0.0814	0.2475	0.1246
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0261	0.0232	0.0030	0.0002	0.0186	0.0163	0.0002	0.0058	0.0336	0.0301	0.0358	0.0199

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0001	0.0063
0.0050	0.0005	0.0072
0.0100	0.0019	0.0094
0.0150	0.0034	0.0115
0.0200	0.0047	0.0135
0.0250	0.0060	0.0154
0.0300	0.0072	0.0172
0.0350	0.0084	0.0189
0.0400	0.0095	0.0205
0.0450	0.0105	0.0220
0.0500	0.0115	0.0234
0.0550	0.0124	0.0247
0.0600	0.0132	0.0259
0.0650	0.0140	0.0271
0.0700	0.0147	0.0281
0.0750	0.0154	0.0290
0.0800	0.0160	0.0299
0.0850	0.0165	0.0307
0.0900	0.0170	0.0313
0.0950	0.0174	0.0319
0.1000	0.0178	0.0324
0.1050	0.0181	0.0328
0.1100	0.0183	0.0332
0.1150	0.0185	0.0334
0.1200	0.0186	0.0336
0.1250	0.0186	0.0336
0.1300	0.0186	0.0336
0.1350	0.0185	0.0335
0.1400	0.0184	0.0333
0.1450	0.0182	0.0330
0.1500	0.0179	0.0326
0.1550	0.0176	0.0321
0.1600	0.0172	0.0316
0.1650	0.0168	0.0309
0.1700	0.0163	0.0302
0.1750	0.0157	0.0294
0.1800	0.0150	0.0284
0.1850	0.0143	0.0274
0.1900	0.0135	0.0263
0.1950	0.0127	0.0251
0.2000	0.0118	0.0237
0.2050	0.0108	0.0223
0.2100	0.0097	0.0208
0.2150	0.0086	0.0192
0.2200	0.0074	0.0174
0.2250	0.0061	0.0156
0.2300	0.0048	0.0136
0.2350	0.0034	0.0115
0.2400	0.0019	0.0093
0.2450	0.0003	0.0070
0.2464	-0.0001	0.0063
0.2494	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.5732

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
9.1952	0.0061	0.1247	0.1250	0.29940-02	0.13860-06	0.13860-06	0.57750-08	0.11380-05	0.68430-05

TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG	I(HH)
0.0150	0.0060	0.0182	0.0183	0.32070-01	0.12240-04	0.12240-04	0.58990-04

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1248	0.0812	0.2467	0.0040	0.1249	0.0820	0.2457	0.0020	0.1248	0.0803	0.2477	0.1247

H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0239	0.0213	0.0030	0.0002	0.0164	0.0144	0.0002	0.0059	0.0314	0.0281	0.0059	0.0182

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0001	0.0063
0.0050	0.0004	0.0071
0.0100	0.0018	0.0091
0.0150	0.0030	0.0111
0.0200	0.0042	0.0129
0.0250	0.0054	0.0147
0.0300	0.0064	0.0164
0.0350	0.0075	0.0179
0.0400	0.0084	0.0194
0.0450	0.0094	0.0208
0.0500	0.0102	0.0221
0.0550	0.0110	0.0233
0.0600	0.0118	0.0244
0.0650	0.0125	0.0255
0.0700	0.0131	0.0264
0.0750	0.0137	0.0273
0.0800	0.0142	0.0281
0.0850	0.0147	0.0288
0.0900	0.0151	0.0294
0.0950	0.0154	0.0299
0.1000	0.0157	0.0304
0.1050	0.0160	0.0308
0.1100	0.0162	0.0310
0.1150	0.0163	0.0313
0.1200	0.0164	0.0314
0.1250	0.0164	0.0314
0.1300	0.0164	0.0314
0.1350	0.0163	0.0313
0.1400	0.0162	0.0311
0.1450	0.0160	0.0308
0.1500	0.0158	0.0304
0.1550	0.0155	0.0300
0.1600	0.0151	0.0295
0.1650	0.0147	0.0289
0.1700	0.0142	0.0282
0.1750	0.0137	0.0274
0.1800	0.0131	0.0265
0.1850	0.0125	0.0256
0.1900	0.0118	0.0245
0.1950	0.0111	0.0234
0.2000	0.0103	0.0222
0.2050	0.0094	0.0209
0.2100	0.0085	0.0195
0.2150	0.0075	0.0180
0.2200	0.0065	0.0164
0.2250	0.0054	0.0147
0.2300	0.0042	0.0129
0.2350	0.0030	0.0111
0.2400	0.0017	0.0091
0.2450	0.0004	0.0070
0.2467	-0.0001	0.0063
0.2497	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.6277

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
0.3959	0.0061	0.1248	0.1250	0.2993D-02	0.1324D-06	0.1324D-06	0.1684D-08	0.1079D-05	0.6656D-05

TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG	I(HH)
0.0150	0.0060	0.0178	0.0178	0.7969D-02	0.1224D-04	0.1224D-04	0.5930D-04

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1249	0.0802	0.2469	0.0040	0.1249	0.0810	0.2459	0.0021	0.1249	0.0793	0.2479	0.1248

H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0233	0.0206	0.0030	0.0002	0.0158	0.0137	0.0002	0.0059	0.0308	0.0274	0.0058	0.0178

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0001	0.0063
0.0050	0.0004	0.0071
0.0100	0.0017	0.0091
0.0150	0.0029	0.0110
0.0200	0.0041	0.0128
0.0250	0.0052	0.0145
0.0300	0.0062	0.0161
0.0350	0.0072	0.0176
0.0400	0.0081	0.0191
0.0450	0.0090	0.0204
0.0500	0.0098	0.0217
0.0550	0.0106	0.0229
0.0600	0.0113	0.0240
0.0650	0.0120	0.0250
0.0700	0.0126	0.0259
0.0750	0.0131	0.0268
0.0800	0.0136	0.0275
0.0850	0.0141	0.0282
0.0900	0.0145	0.0288
0.0950	0.0148	0.0293
0.1000	0.0151	0.0298
0.1050	0.0153	0.0301
0.1100	0.0155	0.0304
0.1150	0.0157	0.0306
0.1200	0.0157	0.0307
0.1250	0.0158	0.0308
0.1300	0.0157	0.0307
0.1350	0.0157	0.0306
0.1400	0.0155	0.0304
0.1450	0.0153	0.0301
0.1500	0.0151	0.0298
0.1550	0.0148	0.0293
0.1600	0.0145	0.0288
0.1650	0.0141	0.0282
0.1700	0.0136	0.0275
0.1750	0.0131	0.0268
0.1800	0.0126	0.0259
0.1850	0.0120	0.0250
0.1900	0.0113	0.0240
0.1950	0.0106	0.0229
0.2000	0.0098	0.0217
0.2050	0.0090	0.0205
0.2100	0.0081	0.0191
0.2150	0.0072	0.0177
0.2200	0.0062	0.0161
0.2250	0.0051	0.0145
0.2300	0.0040	0.0128
0.2350	0.0029	0.0109
0.2400	0.0017	0.0090
0.2450	0.0004	0.0070
0.2469	-0.0001	0.0062
0.2499	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.6951

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
7.7142	0.0061	0.1248	0.1250	0.2995D-02	0.1336D-06	.1736D-06	-0.4968D-09	0.1999D-05	0.6691D-05
TM	TP	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0150	0.0060	0.0178	0.0179	-0.2348D-02	0.1226D-04	0.1226D-04		0.5907D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CS)
0.0030	0.1250	0.0805	0.2470	0.0040	0.1250	0.0813	0.2460	0.0021	0.1250	0.0797	0.2479	0.1248
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CS)
0.0030	0.0234	0.0207	0.0030	0.0002	0.0159	0.0139	0.0002	0.0059	0.0309	0.0276	0.0058	0.0178

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0001	0.0063
0.0050	0.0004	0.0071
0.0100	0.0017	0.0091
0.0150	0.0029	0.0110
0.0200	0.0041	0.0128
0.0250	0.0052	0.0145
0.0300	0.0063	0.0162
0.0350	0.0073	0.0177
0.0400	0.0082	0.0192
0.0450	0.0091	0.0205
0.0500	0.0099	0.0218
0.0550	0.0107	0.0230
0.0600	0.0114	0.0241
0.0650	0.0121	0.0251
0.0700	0.0127	0.0260
0.0750	0.0132	0.0269
0.0800	0.0137	0.0276
0.0850	0.0142	0.0283
0.0900	0.0146	0.0289
0.0950	0.0149	0.0294
0.1000	0.0152	0.0299
0.1050	0.0155	0.0302
0.1100	0.0156	0.0305
0.1150	0.0158	0.0307
0.1200	0.0159	0.0308
0.1250	0.0159	0.0309
0.1300	0.0159	0.0308
0.1350	0.0158	0.0307
0.1400	0.0156	0.0305
0.1450	0.0155	0.0302
0.1500	0.0152	0.0299
0.1550	0.0149	0.0294
0.1600	0.0146	0.0289
0.1650	0.0142	0.0283
0.1700	0.0137	0.0276
0.1750	0.0132	0.0269
0.1800	0.0127	0.0260
0.1850	0.0121	0.0251
0.1900	0.0114	0.0241
0.1950	0.0107	0.0230
0.2000	0.0099	0.0218
0.2050	0.0091	0.0205
0.2100	0.0082	0.0192
0.2150	0.0072	0.0177
0.2200	0.0062	0.0162
0.2250	0.0052	0.0145
0.2300	0.0041	0.0128
0.2350	0.0029	0.0110
0.2400	0.0017	0.0091
0.2450	0.0004	0.0071
0.2470	-0.0001	0.0062
0.2500	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.7426

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
7.1355	0.0061	0.1249	0.1250	0.3001D-02	0.1436D-06	0.1436D-06	-0.2604D-08	0.1184D-05	0.6983D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0150	0.0060	0.0186	0.0186	-0.1226D-01	0.1231D-04	0.1231D-04		0.5923D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CS)
0.0030	0.1250	0.0826	0.2471	0.0041	0.1250	0.0834	0.2460	0.0020	0.1250	0.0817	0.2481	0.1249
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0244	0.0219	0.0030	0.0002	0.0169	0.0153	0.0002	0.0059	0.0319	0.0288	0.0058	0.0186

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0001	0.0063
0.0050	0.0004	0.0071
0.0100	0.0018	0.0092
0.0150	0.0031	0.0112
0.0200	0.0044	0.0131
0.0250	0.0056	0.0149
0.0300	0.0067	0.0166
0.0350	0.0077	0.0182
0.0400	0.0087	0.0198
0.0450	0.0097	0.0212
0.0500	0.0106	0.0225
0.0550	0.0114	0.0237
0.0600	0.0122	0.0249
0.0650	0.0129	0.0259
0.0700	0.0135	0.0269
0.0750	0.0141	0.0278
0.0800	0.0147	0.0286
0.0850	0.0151	0.0293
0.0900	0.0156	0.0299
0.0950	0.0159	0.0304
0.1000	0.0162	0.0309
0.1050	0.0165	0.0313
0.1100	0.0167	0.0315
0.1150	0.0168	0.0317
0.1200	0.0169	0.0319
0.1250	0.0169	0.0319
0.1300	0.0169	0.0319
0.1350	0.0168	0.0317
0.1400	0.0167	0.0315
0.1450	0.0165	0.0312
0.1500	0.0162	0.0309
0.1550	0.0159	0.0304
0.1600	0.0155	0.0299
0.1650	0.0151	0.0292
0.1700	0.0146	0.0285
0.1750	0.0141	0.0277
0.1800	0.0135	0.0269
0.1850	0.0128	0.0259
0.1900	0.0121	0.0248
0.1950	0.0114	0.0237
0.2000	0.0105	0.0225
0.2050	0.0097	0.0211
0.2100	0.0087	0.0197
0.2150	0.0077	0.0182
0.2200	0.0067	0.0166
0.2250	0.0055	0.0149
0.2300	0.0044	0.0131
0.2350	0.0031	0.0112
0.2400	0.0018	0.0093
0.2450	0.0005	0.0072
0.2471	-0.0001	0.0063
0.2501	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.8000

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL			
4.3974	0.0061	0.1249	0.1250	0.3031D-02	0.1987D-06	0.1987D-06	0.3056D-08	0.1691D-05	0.8411D-05			
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)				
0.0150	0.0060	0.0221	0.0222	0.1417D-01	0.1256D-04	0.1256D-04		0.5995D-04				
L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0031	0.1250	0.0843	0.2471	0.0043	0.1250	0.0952	0.2458	0.0018	0.1250	0.0833	0.2483	0.1249
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0031	0.0293	0.0265	0.0030	0.0003	0.0218	0.0195	0.0003	0.0059	0.0368	0.0334	0.0057	0.0221

L	HP	HS
0.0	0.0031	0.0031
0.0031	-0.0002	0.0065
0.0050	0.0005	0.0074
0.0100	0.0023	0.0099
0.0150	0.0040	0.0123
0.0200	0.0056	0.0146
0.0250	0.0071	0.0167
0.0300	0.0086	0.0188
0.0350	0.0100	0.0207
0.0400	0.0113	0.0225
0.0450	0.0125	0.0242
0.0500	0.0136	0.0257
0.0550	0.0147	0.0272
0.0600	0.0157	0.0285
0.0650	0.0166	0.0298
0.0700	0.0174	0.0309
0.0750	0.0182	0.0319
0.0800	0.0189	0.0329
0.0850	0.0195	0.0337
0.0900	0.0201	0.0344
0.0950	0.0205	0.0351
0.1000	0.0209	0.0356
0.1050	0.0212	0.0361
0.1100	0.0215	0.0364
0.1150	0.0217	0.0366
0.1200	0.0218	0.0368
0.1250	0.0218	0.0368
0.1300	0.0218	0.0368
0.1350	0.0217	0.0366
0.1400	0.0215	0.0364
0.1450	0.0213	0.0361
0.1500	0.0209	0.0356
0.1550	0.0205	0.0351
0.1600	0.0201	0.0345
0.1650	0.0195	0.0337
0.1700	0.0189	0.0329
0.1750	0.0182	0.0320
0.1800	0.0175	0.0310
0.1850	0.0167	0.0298
0.1900	0.0157	0.0286
0.1950	0.0148	0.0272
0.2000	0.0137	0.0258
0.2050	0.0126	0.0242
0.2100	0.0113	0.0226
0.2150	0.0100	0.0208
0.2200	0.0087	0.0189
0.2250	0.0072	0.0168
0.2300	0.0057	0.0147
0.2350	0.0041	0.0124
0.2400	0.0024	0.0100
0.2450	0.0006	0.0075
0.2471	-0.0002	0.0064
0.2501	0.0030	0.0030

FIFTH STAGE ROTOR   TOA 013   TRIAL 1

INPUT FOR BLADE COORDINATE PROGRAM

ETA	LANDA	OP1	OP2	TNLMT
0.0	0.0	8.00000	1.00000	0.00010

ELEMENT	RI	RO	TI	TM	TO	KIC	KTC	KOC	ZMC	ZTC	ZOC
1	1.79488	1.79503	0.00600	0.01510	0.00600	60.28184	56.82515	56.68711	0.06215	0.12243	0.12757
2	1.76951	1.77031	0.00600	0.01560	0.00600	59.59997	57.70611	57.60474	0.06266	0.12050	0.12714
3	1.71857	1.72079	0.00600	0.01650	0.00600	58.47200	58.11604	58.08456	0.06397	0.11782	0.12830
4	1.66675	1.67068	0.00600	0.01740	0.00600	57.34792	56.35299	56.21389	0.06631	0.11703	0.13364
5	1.61332	1.61936	0.00600	0.01840	0.00600	56.18737	53.20063	52.58140	0.06943	0.11672	0.14199
6	1.55742	1.56616	0.00600	0.01940	0.00600	55.16607	49.85208	48.33571	0.07256	0.11539	0.15083
7	1.52814	1.53871	0.00600	0.01990	0.00600	54.63611	47.14507	44.60479	0.07481	0.11477	0.15775

BLADE ELEMENT STACKING PARAMETER--TNORM1 = 0.186D-02

THECG

0.5837283D-01	0.5909180D-01	0.6043048D-01	0.6137045D-01	0.6196924D-01	0.6256130D-01	0.6246501D-01

CRCG

1526.549	281.2879	99.39987	56.76898	38.03061	26.99563	22.93366

BLADE ELEMENT STACKING PARAMETER--TNORM1 = 0.316D-04

THECG

0.5834874D-01	0.5908287D-01	0.6045060D-01	0.6143106D-01	0.6205684D-01	0.6269249D-01	0.6261561D-01

CRCG

1526.549	281.2879	99.39990	56.76908	38.03080	26.99593	22.93413

BLADE ELEMENT ANGLES

ELEMENT	ALP	KM	KIC	KTC	KOC	KIP	KTP	KOP	KIS	KTS	KOS
1	0.06737	58.48454	60.28184	56.82515	56.68711	56.00591	60.77255	60.95449	64.54594	52.88867	52.42413
2	0.36052	58.60236	59.59997	57.70611	57.60474	55.09239	61.75491	62.12686	64.10051	53.66364	53.08343
3	0.99130	58.27829	58.47200	58.11604	58.08456	53.54461	62.24180	63.03095	63.39510	53.99408	53.11846
4	1.68443	56.78094	57.34792	56.35299	56.21389	52.00241	60.38542	61.60746	62.68776	52.32500	50.81776
5	2.43579	54.38446	56.18737	53.20063	52.58140	50.37489	57.01392	58.46210	61.98338	49.39827	46.71746
6	3.31636	51.75097	55.16607	49.85208	48.33571	48.88627	53.34045	54.70151	61.40967	46.38396	42.00638
7	3.83336	49.62073	54.63611	47.14507	44.60479	48.12316	50.35785	51.21311	61.09201	43.96049	38.05403

BLADE ELEMENT CURVATURES

ELEMENT	CIC	COC	CIP	COP	CIS	CAS
1	0.25704	0.25696	-0.35471	-0.33808	0.86474	0.86183
2	0.14269	0.14255	-0.50196	-0.52185	0.78492	0.81328
3	0.02771	0.02770	-0.67639	-0.69226	0.73092	0.76802
4	0.08110	0.08110	-0.68286	-0.71025	0.84332	0.87551
5	0.25785	0.25780	-0.57344	-0.60142	1.08313	1.11078
6	0.48821	0.48817	-0.41011	-0.43762	1.37333	1.40042
7	0.71648	0.71653	-0.21460	-0.24130	1.62682	1.65306

BLADE SECTION COORDINATES (ROTATED) AT X = 1.5281

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
49.3114	0.0061	0.1252	0.1252	0.37600-02	0.99280-07	0.99280-07	0.29110-08	0.32850-06	0.36790-05
TH	TD	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0200	0.0062	0.0078	0.0078	0.11730-01	0.14320-04	0.14320-04		0.73270-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1246	0.1830	0.2465	0.0032	0.1246	0.1825	0.2461	0.0028	0.1247	0.1836	0.2468	0.1252
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0094	0.0079	0.0031	0.0000	-0.0005	-0.0005	0.0000	0.0061	0.0194	0.0164	0.0062	0.0078

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0061
0.0050	-0.0000	0.0065
0.0100	-0.0001	0.0075
0.0150	-0.0001	0.0085
0.0200	-0.0001	0.0095
0.0250	-0.0002	0.0104
0.0300	-0.0002	0.0113
0.0350	-0.0002	0.0121
0.0400	-0.0003	0.0129
0.0450	-0.0003	0.0136
0.0500	-0.0003	0.0143
0.0550	-0.0003	0.0150
0.0600	-0.0004	0.0156
0.0650	-0.0004	0.0162
0.0700	-0.0004	0.0167
0.0750	-0.0004	0.0171
0.0800	-0.0004	0.0176
0.0850	-0.0005	0.0180
0.0900	-0.0005	0.0183
0.0950	-0.0005	0.0186
0.1000	-0.0005	0.0188
0.1050	-0.0005	0.0190
0.1100	-0.0005	0.0192
0.1150	-0.0005	0.0193
0.1200	-0.0005	0.0194
0.1250	-0.0005	0.0194
0.1300	-0.0005	0.0194
0.1350	-0.0005	0.0193
0.1400	-0.0005	0.0192
0.1450	-0.0005	0.0191
0.1500	-0.0005	0.0189
0.1550	-0.0005	0.0187
0.1600	-0.0005	0.0184
0.1650	-0.0005	0.0180
0.1700	-0.0005	0.0177
0.1750	-0.0005	0.0172
0.1800	-0.0005	0.0168
0.1850	-0.0005	0.0163
0.1900	-0.0004	0.0157
0.1950	-0.0004	0.0151
0.2000	-0.0004	0.0145
0.2050	-0.0004	0.0138
0.2100	-0.0003	0.0130
0.2150	-0.0003	0.0123
0.2200	-0.0003	0.0114
0.2250	-0.0002	0.0105
0.2300	-0.0002	0.0096
0.2350	-0.0001	0.0086
0.2400	-0.0001	0.0076
0.2450	0.0000	0.0066
0.2465	0.0000	0.0062
0.2495	0.0031	0.0031

BLADE SECTION COORDINATES (ROTATED) AT X = 1.5333

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
49.7463	0.0061	0.1252	0.1252	0.3743D-02	0.9684D-07	0.9684D-07	0.6974D-09	0.3079D-06	0.3520D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0199	0.0061	0.0075	0.0075	0.2821D-02	0.1426D-04	0.1426D-04		0.7294D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1247	0.1844	0.2466	0.0032	0.1246	0.1839	0.2463	0.0028	0.1247	0.1850	0.2469	0.1252
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0091	0.0076	0.0031	0.0000	-0.0009	-0.0007	0.0000	0.0061	0.0190	0.0159	0.0061	0.0075

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0061
0.0050	-0.0000	0.0065
0.0100	-0.0001	0.0075
0.0150	-0.0002	0.0084
0.0200	-0.0002	0.0094
0.0250	-0.0003	0.0103
0.0300	-0.0003	0.0111
0.0350	-0.0004	0.0119
0.0400	-0.0004	0.0127
0.0450	-0.0005	0.0134
0.0500	-0.0005	0.0141
0.0550	-0.0006	0.0147
0.0600	-0.0006	0.0153
0.0650	-0.0006	0.0158
0.0700	-0.0007	0.0163
0.0750	-0.0007	0.0168
0.0800	-0.0007	0.0172
0.0850	-0.0008	0.0176
0.0900	-0.0008	0.0179
0.0950	-0.0008	0.0182
0.1000	-0.0008	0.0184
0.1050	-0.0008	0.0186
0.1100	-0.0008	0.0188
0.1150	-0.0009	0.0189
0.1200	-0.0009	0.0190
0.1250	-0.0009	0.0190
0.1300	-0.0009	0.0190
0.1350	-0.0009	0.0189
0.1400	-0.0009	0.0188
0.1450	-0.0009	0.0187
0.1500	-0.0009	0.0185
0.1550	-0.0009	0.0182
0.1600	-0.0008	0.0179
0.1650	-0.0008	0.0176
0.1700	-0.0008	0.0173
0.1750	-0.0008	0.0169
0.1800	-0.0008	0.0164
0.1850	-0.0007	0.0159
0.1900	-0.0007	0.0154
0.1950	-0.0007	0.0148
0.2000	-0.0006	0.0142
0.2050	-0.0006	0.0135
0.2100	-0.0005	0.0128
0.2150	-0.0005	0.0120
0.2200	-0.0004	0.0112
0.2250	-0.0003	0.0104
0.2300	-0.0003	0.0095
0.2350	-0.0002	0.0085
0.2400	-0.0001	0.0075
0.2450	-0.0000	0.0065
0.2466	0.0000	0.0062
0.2496	0.0031	0.0031

BLADE SECTION COORDINATES (ROTATED) AT X = 1.5387

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
50.1922	0.0060	0.1252	0.1252	0.3728D-02	0.9441D-07	0.9441D-07	-0.5532D-09	0.2870D-06	0.3355D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0198	0.0061	0.0072	0.0072	-0.2245D-02	0.1421D-04	0.1421D-04		0.7267D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1247	0.1859	0.2466	0.0032	0.1246	0.1854	0.2464	0.0028	0.1247	0.1865	0.2469	0.1252
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0086	0.0072	0.0030	0.0000	-0.0012	-0.0010	0.0000	0.0060	0.0185	0.0154	0.0061	0.0072

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0061
0.0050	-0.0000	0.0064
0.0100	-0.0001	0.0074
0.0150	-0.0002	0.0084
0.0200	-0.0003	0.0093
0.0250	-0.0004	0.0101
0.0300	-0.0005	0.0109
0.0350	-0.0006	0.0117
0.0400	-0.0006	0.0124
0.0450	-0.0007	0.0131
0.0500	-0.0008	0.0138
0.0550	-0.0008	0.0144
0.0600	-0.0009	0.0149
0.0650	-0.0009	0.0155
0.0700	-0.0010	0.0160
0.0750	-0.0010	0.0164
0.0800	-0.0011	0.0168
0.0850	-0.0011	0.0172
0.0900	-0.0011	0.0175
0.0950	-0.0012	0.0177
0.1000	-0.0012	0.0180
0.1050	-0.0012	0.0182
0.1100	-0.0012	0.0183
0.1150	-0.0012	0.0184
0.1200	-0.0012	0.0185
0.1250	-0.0012	0.0185
0.1300	-0.0013	0.0185
0.1350	-0.0013	0.0184
0.1400	-0.0012	0.0183
0.1450	-0.0012	0.0182
0.1500	-0.0012	0.0180
0.1550	-0.0012	0.0178
0.1600	-0.0012	0.0175
0.1650	-0.0012	0.0172
0.1700	-0.0011	0.0169
0.1750	-0.0011	0.0165
0.1800	-0.0011	0.0160
0.1850	-0.0010	0.0155
0.1900	-0.0010	0.0150
0.1950	-0.0009	0.0145
0.2000	-0.0009	0.0139
0.2050	-0.0008	0.0132
0.2100	-0.0007	0.0125
0.2150	-0.0007	0.0118
0.2200	-0.0006	0.0110
0.2250	-0.0005	0.0102
0.2300	-0.0004	0.0093
0.2350	-0.0003	0.0084
0.2400	-0.0002	0.0075
0.2450	-0.0000	0.0065
0.2466	0.0000	0.0061
0.2497	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.5867

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG		I(LL)	PHL		
53.0814	0.0060	0.1252	0.1251	0.3586D-02	0.7859D-07	0.7859D-07	-0.6304D-08		0.1782D-06	0.2359D-05		
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG			I(HH)			
0.0189	0.0061	0.0053	0.0053	-0.2637D-01	0.1377D-04	0.1377D-04			0.6992D-04			
L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1248	0.1980	0.2468	0.0031	0.1248	0.1976	0.2466	0.0029	0.1248	0.1983	0.2469	0.1252
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0061	0.0049	0.0030	0.0000	-0.0034	-0.0023	0.0000	0.0060	0.0155	0.0121	0.0060	0.0053

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0060
0.0050	-0.0001	0.0063
0.0100	-0.0004	0.0071
0.0150	-0.0006	0.0078
0.0200	-0.0008	0.0085
0.0250	-0.0011	0.0092
0.0300	-0.0013	0.0098
0.0350	-0.0015	0.0104
0.0400	-0.0017	0.0109
0.0450	-0.0019	0.0115
0.0500	-0.0021	0.0120
0.0550	-0.0022	0.0124
0.0600	-0.0024	0.0129
0.0650	-0.0025	0.0133
0.0700	-0.0027	0.0136
0.0750	-0.0028	0.0140
0.0800	-0.0029	0.0143
0.0850	-0.0030	0.0145
0.0900	-0.0031	0.0148
0.0950	-0.0032	0.0150
0.1000	-0.0032	0.0151
0.1050	-0.0033	0.0153
0.1100	-0.0033	0.0154
0.1150	-0.0034	0.0155
0.1200	-0.0034	0.0155
0.1250	-0.0034	0.0155
0.1300	-0.0034	0.0155
0.1350	-0.0034	0.0155
0.1400	-0.0034	0.0154
0.1450	-0.0033	0.0153
0.1500	-0.0033	0.0151
0.1550	-0.0032	0.0149
0.1600	-0.0032	0.0147
0.1650	-0.0031	0.0145
0.1700	-0.0030	0.0142
0.1750	-0.0029	0.0139
0.1800	-0.0028	0.0136
0.1850	-0.0027	0.0132
0.1900	-0.0025	0.0128
0.1950	-0.0024	0.0124
0.2000	-0.0022	0.0119
0.2050	-0.0020	0.0114
0.2100	-0.0018	0.0109
0.2150	-0.0016	0.0103
0.2200	-0.0014	0.0098
0.2250	-0.0012	0.0091
0.2300	-0.0009	0.0085
0.2350	-0.0007	0.0078
0.2400	-0.0004	0.0071
0.2450	-0.0001	0.0063
0.2468	0.0000	0.0061
0.2498	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.6400

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
55.7117	0.0060	0.1251	0.1251	0.3421D-02	0.6593D-07	0.6593D-07	-0.1047D-07	0.1197D-06	0.168[illegible]D-05
TH	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0179	0.0060	0.0040	0.0040	-0.4537D-01	0.1328D-04	0.1328D-04		0.6683D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1249	0.2105	0.2470	0.0031	0.1248	0.2103	0.2469	0.0029	0.1249	0.2107	0.2470	0.1251
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0043	0.0036	0.0030	0.0000	-0.0046	-0.0025	0.0000	0.0060	0.0133	0.0096	0.0060	0.0040

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0060
0.0050	-0.0001	0.0062
0.0100	-0.0005	0.0068
0.0150	-0.0008	0.0074
0.0200	-0.0012	0.0079
0.0250	-0.0015	0.0084
0.0300	-0.0018	0.0089
0.0350	-0.0021	0.0094
0.0400	-0.0023	0.0098
0.0450	-0.0026	0.0102
0.0500	-0.0028	0.0106
0.0550	[illegible]	0.0109
0.0600	-0.0033	0.0113
0.0650	-0.0034	0.0116
0.0700	-0.0036	0.0119
0.0750	-0.0038	0.0121
0.0800	-0.0039	0.0123
0.0850	-0.0041	0.0125
0.0900	-0.0042	0.0127
0.0950	-0.0043	0.0129
0.1000	-0.0044	0.0130
0.1050	-0.0045	0.0131
0.1100	-0.0045	0.0132
0.1150	-0.0046	0.0132
0.1200	-0.0046	0.0133
0.1250	-0.0046	0.0133
0.1300	-0.0046	0.0133
0.1350	-0.0046	0.0132
0.1400	-0.0046	0.0131
0.1450	-0.0046	0.0131
0.1500	-0.0045	0.0129
0.1550	-0.0044	0.0128
0.1600	-0.0043	0.0126
0.1650	-0.0042	0.0124
0.1700	-0.0041	0.0122
0.1750	-0.0040	0.0120
0.1800	-0.0038	0.0117
0.1850	-0.0036	0.0115
0.1900	-0.0034	0.0111
0.1950	-0.0032	0.0108
0.2000	-0.0030	0.0105
0.2050	-0.0028	0.0101
0.2100	-0.0025	0.0097
0.2150	-0.0022	0.0093
0.2200	-0.0019	0.0088
0.2250	-0.0016	0.0083
0.2300	-0.0013	0.0079
0.2350	-0.0009	0.0073
0.2400	-0.0006	0.0068
0.2450	-0.0002	0.0062
0.2470	0.0000	0.0060
0.2500	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.6934

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
37.7409	0.0060	0.1250	0.1250	0.3263D-02	0.5621D-07	0.5621D-07	-0.6733D-08	0.8979D-07	0.1302D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0170	0.0060	0.0032	0.0032	-0.3026D-01	0.1281D-04	0.1281D-04		0.6382D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1249	0.2224	0.2470	0.0030	0.1249	0.2222	0.2470	0.0030	0.1249	0.2224	0.2470	0.1250
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0033	0.0031	0.0030	0.0000	-0.0052	-0.0019	0.0000	0.0060	0.0118	0.0081	0.0060	0.0032

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0060
0.0050	-0.0002	0.0062
0.0100	-0.0006	0.0067
0.0150	-0.0009	0.0071
0.0200	-0.0013	0.0075
0.0250	-0.0017	0.0079
0.0300	-0.0020	0.0083
0.0350	-0.0023	0.0087
0.0400	-0.0026	0.0090
0.0450	-0.0029	0.0093
0.0500	-0.0032	0.0096
0.0550	-0.0034	0.0099
0.0600	-0.0037	0.0102
0.0650	-0.0039	0.0104
0.0700	-0.0041	0.0106
0.0750	-0.0043	0.0108
0.0800	-0.0044	0.0110
0.0850	-0.0046	0.0112
0.0900	-0.0047	0.0113
0.0950	-0.0048	0.0114
0.1000	-0.0049	0.0115
0.1050	-0.0050	0.0116
0.1100	-0.0051	0.0117
0.1150	-0.0051	0.0117
0.1200	-0.0052	0.0118
0.1250	-0.0052	0.0118
0.1300	-0.0052	0.0118
0.1350	-0.0052	0.0117
0.1400	-0.0051	0.0117
0.1450	-0.0051	0.0116
0.1500	-0.0050	0.0115
0.1550	-0.0049	0.0114
0.1600	-0.0048	0.0113
0.1650	-0.0047	0.0111
0.1700	-0.0045	0.0109
0.1750	-0.0044	0.0108
0.1800	-0.0042	0.0105
0.1850	-0.0040	0.0103
0.1900	-0.0038	0.0101
0.1950	-0.0035	0.0098
0.2000	-0.0033	0.0095
0.2050	-0.0030	0.0092
0.2100	-0.0027	0.0089
0.2150	-0.0024	0.0086
0.2200	-0.0021	0.0082
0.2250	-0.0018	0.0079
0.2300	-0.0014	0.0075
0.2350	-0.0010	0.0071
0.2400	-0.0006	0.0066
0.2450	-0.0002	0.0062
0.2470	0.0000	0.0060
0.2500	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.7467

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
58.5501	0.0060	0.1250	0.1250	0.3110D-02	0.4819D-07	0.4819D-07	-0.2169D-09	0.8476D-07	0.1333D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0160	0.0060	0.0034	0.0034	-0.1011D-02	0.1234D-04	0.1234D-04		0.6092D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1249	0.2316	0.2469	0.0030	0.1249	0.2315	0.2469	0.0030	0.1249	0.2316	0.2470	0.1250
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0036	0.0032	0.0030	0.0000	-0.0044	-0.0010	0.0000	0.0060	0.0116	0.0073	0.0060	0.0034

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0060
0.0050	-0.0001	0.0062
0.0100	-0.0005	0.0066
0.0150	-0.0008	0.0071
0.0200	-0.0011	0.0075
0.0250	-0.0014	0.0078
0.0300	-0.0017	0.0082
0.0350	-0.0020	0.0086
0.0400	-0.0023	0.0089
0.0450	-0.0025	0.0092
0.0500	-0.0027	0.0095
0.0550	-0.0030	0.0098
0.0600	-0.0032	0.0100
0.0650	-0.0033	0.0102
0.0700	-0.0035	0.0105
0.0750	-0.0037	0.0107
0.0800	-0.0038	0.0108
0.0850	-0.0040	0.0110
0.0900	-0.0041	0.0111
0.0950	-0.0042	0.0113
0.1000	-0.0043	0.0114
0.1050	-0.0043	0.0114
0.1100	-0.0044	0.0115
0.1150	-0.0044	0.0116
0.1200	-0.0044	0.0116
0.1250	-0.0044	0.0116
0.1300	-0.0044	0.0116
0.1350	-0.0044	0.0116
0.1400	-0.0044	0.0115
0.1450	-0.0043	0.0114
0.1500	-0.0043	0.0114
0.1550	-0.0042	0.0113
0.1600	-0.0041	0.0111
0.1650	-0.0040	0.0110
0.1700	-0.0038	0.0108
0.1750	-0.0037	0.0107
0.1800	-0.0035	0.0105
0.1850	-0.0034	0.0102
0.1900	-0.0032	0.0100
0.1950	-0.0030	0.0098
0.2000	-0.0027	0.0095
0.2050	-0.0025	0.0092
0.2100	-0.0023	0.0089
0.2150	-0.0020	0.0086
0.2200	-0.0017	0.0082
0.2250	-0.0014	0.0078
0.2300	-0.0011	0.0075
0.2350	-0.0008	0.0071
0.2400	-0.0005	0.0066
0.2450	-0.0001	0.0062
0.2469	0.0000	0.0060
0.2499	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.8500

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
58.1075	0.0060	0.1248	0.1248	0.2780D-02	0.3658D-07	0.3659D-07	0.1497D-07	0.1342D-06	0.2072D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0140	0.0062	0.0059	0.0059	0.7568D-01	0.1137D-04	0.1137D-04		0.5470D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1249	0.2446	0.2466	0.0032	0.1249	0.2433	0.2462	0.0028	0.1249	0.2442	0.2469	0.1248
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0070	0.0038	0.0031	0.0000	-0.0000	0.0000	0.0000	0.0060	0.0140	0.0065	0.0062	0.0059

L	HP	HS
0.0	0.0030	0.0030
0.0030	0.0000	0.0060
0.0050	0.0000	0.0063
0.0100	-0.0000	0.0069
0.0150	-0.0000	0.0075
0.0200	-0.0000	0.0081
0.0250	-0.0001	0.0086
0.0300	-0.0001	0.0091
0.0350	-0.0001	0.0096
0.0400	-0.0001	0.0101
0.0450	-0.0001	0.0105
0.0500	-0.0001	0.0109
0.0550	-0.0001	0.0113
0.0600	-0.0001	0.0117
0.0650	-0.0001	0.0120
0.0700	-0.0001	0.0123
0.0750	-0.0001	0.0126
0.0800	-0.0001	0.0128
0.0850	-0.0001	0.0131
0.0900	-0.0001	0.0133
0.0950	-0.0001	0.0135
0.1000	-0.0001	0.0136
0.1050	-0.0001	0.0137
0.1100	-0.0000	0.0138
0.1150	-0.0000	0.0139
0.1200	-0.0000	0.0140
0.1250	-0.0000	0.0140
0.1300	0.0000	0.0140
0.1350	0.0000	0.0140
0.1400	0.0000	0.0139
0.1450	0.0001	0.0138
0.1500	0.0001	0.0137
0.1550	0.0001	0.0136
0.1600	0.0001	0.0134
0.1650	0.0001	0.0132
0.1700	0.0001	0.0130
0.1750	0.0002	0.0128
0.1800	0.0002	0.0125
0.1850	0.0002	0.0122
0.1900	0.0002	0.0119
0.1950	0.0002	0.0115
0.2000	0.0002	0.0111
0.2050	0.0002	0.0107
0.2100	0.0002	0.0103
0.2150	0.0002	0.0098
0.2200	0.0002	0.0093
0.2250	0.0002	0.0088
0.2300	0.0001	0.0062
0.2350	0.0001	0.0077
0.2400	0.0001	0.0071
0.2450	0.0000	0.0064
0.2466	0.0000	0.0062
0.2497	0.0031	0.0031

FIFTH STAGE STATOR TDA 013 TRIAL 1

INPUT FOR BLADE COORDINATE PROGRAM

ETA	LAMDA	DP1	DP2	TNLHT
0.0	0.0	8.00000	1.00000	0.00010

ELEMENT	RI	RO	TI	TM	TO	KIC	KTC	KOC	ZMC	ZTC	ZOC
1	1.79516	1.79542	0.00600	0.01500	0.00600	27.53934	11.81396	-19.03475	0.11976	0.07948	0.24325
2	1.77101	1.77250	0.00600	0.01500	0.00600	26.53067	12.67378	-14.99825	0.11909	0.07818	0.24268
3	1.72269	1.72658	0.00600	0.01500	0.00600	25.59240	13.38795	-12.06367	0.11871	0.07573	0.24219
4	1.67380	1.68020	0.00600	0.01500	0.00600	25.60732	13.94992	-10.82813	0.11839	0.07453	0.24181
5	1.62373	1.63300	0.00600	0.01500	0.00600	26.36644	14.60014	-10.26357	0.11792	0.07448	0.24134
6	1.57188	1.58459	0.00600	0.01500	0.00600	27.86004	15.32577	-10.47625	0.11728	0.07530	0.24078
7	1.54509	1.55984	0.00600	0.01500	0.00600	28.79939	15.39065	-12.08430	0.11725	0.07541	0.24088

BLADE ELEMENT STACKING PARAMETER--TNORM1 = 0.191D-02

THECG

0.1527506D-01 0.1612562D-01 0.1688763D-01 0.1786464D-01 0.1930466D-01 0.2120542D-01 0.2177787D-01

CRCG

1679.631 288.5739 107.3873 63.38217 42.42301 29.93774 25.39833

BLADE ELEMENT STACKING PARAMETER--TNORM1 = 0.905D-05

THECG

0.1519424D-01 0.1606281D-01 0.1682252D-01 0.1780956D-01 0.1925731D-01 0.2113701D-01 0.2165832D-01

CRCG

1679.631 288.5738 107.3871 63.38199 42.42282 29.93757 25.39820

BLADE ELEMENT ANGLES

ELEMENT	ALP	KM	KIC	KTC	KOC	KIP	KTP	KOP	KIS	KTS	KOS
1	0.06124	4.25314	27.53934	11.81396	-19.03475	23.41548	10.44227	-14.91005	31.52514	13.13984	-23.02150
2	0.35178	5.76666	26.53067	12.67378	-14.99825	22.38214	11.26565	-10.84360	30.55444	14.03965	-19.02812
3	0.92019	6.76488	25.59240	13.38795	-12.06367	21.43363	11.89633	-7.88618	29.63727	14.83873	-16.12685
4	1.51610	7.38919	25.60732	13.94992	-10.82813	21.45284	12.42092	-6.64369	29.65165	15.43832	-14.90460
5	2.19968	8.05142	26.36644	14.60014	-10.26357	22.22391	13.08024	-6.07152	30.39873	16.07944	-14.34404
6	3.02166	8.69234	27.86004	15.32577	-10.47625	23.73701	13.85296	-6.28509	31.86865	16.75745	-14.55101
7	3.50406	8.35788	28.79939	15.39065	-12.08430	24.69681	13.92612	-7.90131	32.78107	16.81166	-16.14387

BLADE ELEMENT CURVATURES

ELEMENT	CIC	COC	CIP	COP	CIS	CAS
1	3.24135	3.24159	2.71782	2.71792	3.72079	3.72118
2	2.90704	2.90687	2.36579	2.36441	3.40779	3.40874
3	2.64620	2.64619	2.09442	2.09042	3.16064	3.16432
4	2.56354	2.56329	2.01059	2.00312	3.08032	3.08676
5	2.57649	2.57660	2.02696	2.01623	3.08995	3.10006
6	2.69222	2.69226	2.15071	2.13622	3.19656	3.20995
7	2.86356	2.86373	2.33238	2.31550	3.35585	3.37161

BLADE SECTION COORDINATES (ROTATED) AT X = 1.5451

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
0.1417	0.0060	0.1247	0.1248	0.2998D-02	0.1547D-06	0.1547D-06	0.1950D-07	0.1290D-05	0.7302D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0150	0.0060	0.0194	0.0195	0.9228D-01	0.1226D-04	0.1226D-04		0.5898D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1247	0.0820	0.2464	0.0041	0.1247	0.0829	0.2453	0.0020	0.1246	0.0811	0.2475	0.1247
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0256	0.0227	0.0030	0.0002	0.0181	0.0158	0.0002	0.0059	0.0331	0.0295	0.0058	0.0194

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0001	0.0063
0.0050	0.0005	0.0072
0.0100	0.0019	0.0093
0.0150	0.0033	0.0114
0.0200	0.0046	0.0134
0.0250	0.0058	0.0152
0.0300	0.0070	0.0170
0.0350	0.0081	0.0187
0.0400	0.0092	0.0202
0.0450	0.0102	0.0217
0.0500	0.0111	0.0231
0.0550	0.0120	0.0244
0.0600	0.0128	0.0256
0.0650	0.0136	0.0267
0.0700	0.0143	0.0277
0.0750	0.0149	0.0286
0.0800	0.0155	0.0294
0.0850	0.0160	0.0302
0.0900	0.0165	0.0308
0.0950	0.0169	0.0314
0.1000	0.0172	0.0319
0.1050	0.0175	0.0323
0.1100	0.0178	0.0326
0.1150	0.0179	0.0329
0.1200	0.0180	0.0330
0.1250	0.0181	0.0331
0.1300	0.0180	0.0330
0.1350	0.0180	0.0329
0.1400	0.0178	0.0327
0.1450	0.0176	0.0324
0.1500	0.0174	0.0320
0.1550	0.0171	0.0316
0.1600	0.0167	0.0310
0.1650	0.0162	0.0304
0.1700	0.0157	0.0297
0.1750	0.0152	0.0288
0.1800	0.0145	0.0279
0.1850	0.0138	0.0269
0.1900	0.0131	0.0258
0.1950	0.0123	0.0246
0.2000	0.0114	0.0233
0.2050	0.0104	0.0219
0.2100	0.0094	0.0204
0.2150	0.0083	0.0188
0.2200	0.0071	0.0171
0.2250	0.0059	0.0153
0.2300	0.0046	0.0134
0.2350	0.0032	0.0114
0.2400	0.0018	0.0092
0.2450	0.0003	0.0069
0.2464	-0.0001	0.0063
0.2494	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.5523

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
8.2513	0.0060	0.1246	0.1248	0.2996D-02	0.1509D-06	0.1509D-06	0.1921D-07	0.1254D-05	0.7195D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0150	0.0060	0.0192	0.0192	0.9101D-01	0.1225D-04	0.1225D-04		0.5895D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1247	0.0820	0.2464	0.0041	0.1247	0.0929	0.2453	0.0020	0.1247	0.0811	0.2475	0.1246
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CS)
0.0030	0.0252	0.0224	0.0030	0.0002	0.0177	0.0155	0.0002	0.0059	0.0327	0.0293	0.0058	0.0192

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0001	0.0063
0.0050	0.0005	0.0072
0.0100	0.0019	0.0093
0.0150	0.0032	0.0113
0.0200	0.0045	0.0133
0.0250	0.0057	0.0151
0.0300	0.0069	0.0168
0.0350	0.0080	0.0185
0.0400	0.0090	0.0200
0.0450	0.0100	0.0215
0.0500	0.0109	0.0228
0.0550	0.0118	0.0241
0.0600	0.0126	0.0253
0.0650	0.0133	0.0264
0.0700	0.0140	0.0274
0.0750	0.0146	0.0283
0.0800	0.0152	0.0291
0.0850	0.0157	0.0298
0.0900	0.0162	0.0305
0.0950	0.0166	0.0311
0.1000	0.0169	0.0315
0.1050	0.0172	0.0319
0.1100	0.0174	0.0323
0.1150	0.0175	0.0325
0.1200	0.0176	0.0326
0.1250	0.0177	0.0327
0.1300	0.0177	0.0327
0.1350	0.0176	0.0325
0.1400	0.0175	0.0323
0.1450	0.0173	0.0321
0.1500	0.0170	0.0317
0.1550	0.0167	0.0312
0.1600	0.0163	0.0307
0.1650	0.0159	0.0300
0.1700	0.0154	0.0293
0.1750	0.0148	0.0285
0.1800	0.0142	0.0276
0.1850	0.0135	0.0266
0.1900	0.0128	0.0255
0.1950	0.0120	0.0243
0.2000	0.0111	0.0231
0.2050	0.0102	0.0217
0.2100	0.0092	0.0202
0.2150	0.0081	0.0186
0.2200	0.0070	0.0169
0.2250	0.0058	0.0152
0.2300	0.0045	0.0133
0.2350	0.0032	0.0113
0.2400	0.0018	0.0092
0.2450	0.0003	0.0069
0.2464	-0.0001	0.0063
0.2494	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.5598

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
8.3558	0.0060	0.1246	0.1248	0.2995D-02	0.1465D-06	0.1466D-06	0.2158D-07	0.1214D-05	0.7081D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0150	0.0060	0.0189	0.0189	0.1023	0.1224D-04	0.1224D-04		0.5892D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1247	0.0820	0.2464	0.0040	0.1247	0.0828	0.2454	0.0020	0.1247	0.0811	0.2475	0.1246
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0248	0.0220	0.0030	0.0002	0.0173	0.0151	0.0002	0.0059	0.0323	0.0289	0.0058	0.0189

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0001	0.0063
0.0050	0.0004	0.0071
0.0100	0.0018	0.0092
0.0150	0.0031	0.0112
0.0200	0.0044	0.0131
0.0250	0.0056	0.0149
0.0300	0.0067	0.0166
0.0350	0.0078	0.0182
0.0400	0.0088	0.0199
0.0450	0.0097	0.0212
0.0500	0.0106	0.0225
0.0550	0.0115	0.0238
0.0600	0.0123	0.0249
0.0650	0.0130	0.0260
0.0700	0.0136	0.0270
0.0750	0.0143	0.0279
0.0800	0.0148	0.0287
0.0850	0.0153	0.0294
0.0900	0.0158	0.0301
0.0950	0.0161	0.0307
0.1000	0.0165	0.0311
0.1050	0.0167	0.0315
0.1100	0.0170	0.0318
0.1150	0.0171	0.0321
0.1200	0.0172	0.0322
0.1250	0.0173	0.0323
0.1300	0.0172	0.0322
0.1350	0.0172	0.0321
0.1400	0.0171	0.0319
0.1450	0.0169	0.0317
0.1500	0.0166	0.0313
0.1550	0.0163	0.0308
0.1600	0.0160	0.0303
0.1650	0.0155	0.0297
0.1700	0.0151	0.0290
0.1750	0.0145	0.0282
0.1800	0.0139	0.0273
0.1850	0.0133	0.0263
0.1900	0.0125	0.0252
0.1950	0.0117	0.0241
0.2000	0.0109	0.0228
0.2050	0.0100	0.0215
0.2100	0.0090	0.0200
0.2150	0.0080	0.0185
0.2200	0.0069	0.0168
0.2250	0.0057	0.0150
0.2300	0.0044	0.0132
0.2350	0.0031	0.0112
0.2400	0.0017	0.0091
0.2450	0.0003	0.0069
0.2464	-0.0001	0.0063
0.2494	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.6019

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
9.3670	0.0060	0.1249	0.1249	0.2989D-02	0.1287D-06	0.1287D-06	0.5198D-08	0.1044D-05	0.6541D-05

TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG	I(HH)
0.0150	0.0060	0.0175	0.0175	0.2467D-01	0.1220D-04	0.1220D-04	0.5987D-04

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1249	0.0812	0.2467	0.0040	0.1249	0.0820	0.2458	0.0021	0.1249	0.0804	0.2477	0.1248

H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0229	0.0203	0.0030	0.0002	0.0154	0.0134	0.0007	0.0059	0.0304	0.0272	0.0058	0.0175

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0001	0.0063
0.0050	0.0004	0.0070
0.0100	0.0016	0.0090
0.0150	0.0028	0.0109
0.0200	0.0039	0.0126
0.0250	0.0050	0.0143
0.0300	0.0060	0.0159
0.0350	0.0070	0.0174
0.0400	0.0079	0.0188
0.0450	0.0088	0.0202
0.0500	0.0096	0.0214
0.0550	0.0103	0.0226
0.0600	0.0110	0.0237
0.0650	0.0116	0.0247
0.0700	0.0122	0.0256
0.0750	0.0128	0.0264
0.0800	0.0133	0.0272
0.0850	0.0137	0.0278
0.0900	0.0141	0.0284
0.0950	0.0144	0.0289
0.1000	0.0147	0.0294
0.1050	0.0149	0.0297
0.1100	0.0151	0.0300
0.1150	0.0153	0.0302
0.1200	0.0153	0.0303
0.1250	0.0154	0.0304
0.1300	0.0153	0.0303
0.1350	0.0153	0.0302
0.1400	0.0151	0.0300
0.1450	0.0150	0.0298
0.1500	0.0147	0.0294
0.1550	0.0145	0.0290
0.1600	0.0141	0.0285
0.1650	0.0137	0.0279
0.1700	0.0133	0.0272
0.1750	0.0128	0.0265
0.1800	0.0123	0.0256
0.1850	0.0117	0.0247
0.1900	0.0110	0.0237
0.1950	0.0103	0.0226
0.2000	0.0096	0.0215
0.2050	0.0088	0.0202
0.2100	0.0079	0.0189
0.2150	0.0070	0.0175
0.2200	0.0060	0.0159
0.2250	0.0050	0.0143
0.2300	0.0039	0.0126
0.2350	0.0028	0.0108
0.2400	0.0016	0.0089
0.2450	0.0004	0.0069
0.2467	-0.0001	0.0062
0.2497	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.6514

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
7.7327	0.0060	0.1248	0.1250	0.2989D-02	0.1243D-06	0.1243D-06	0.9593D-09	0.1002D-05	0.4403D-[illegible]

TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG	I(HH)
0.0150	0.0060	0.0171	0.0171	0.4546D-02	0.1220D-04	0.1220D-04	0.5898D-04

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1249	0.0804	0.2468	0.0040	0.1249	0.0812	0.2459	0.0021	0.1249	0.0796	0.2478	0.1248

H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0224	0.0198	0.0030	0.0001	0.0149	0.0130	0.0001	0.0059	0.0299	0.0267	0.0059	0.0171

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0001	0.0063
0.0050	0.0004	0.0070
0.0100	0.0016	0.0089
0.0150	0.0027	0.0108
0.0200	0.0038	0.0125
0.0250	0.0049	0.0142
0.0300	0.0059	0.0157
0.0350	0.0068	0.0172
0.0400	0.0077	0.0186
0.0450	0.0085	0.0199
0.0500	0.0093	0.0211
0.0550	0.0100	0.0223
0.0600	0.0107	0.0233
0.0650	0.0113	0.0243
0.0700	0.0119	0.0252
0.0750	0.0124	0.0260
0.0800	0.0129	0.0267
0.0850	0.0133	0.0274
0.0900	0.0137	0.0280
0.0950	0.0140	0.0285
0.1000	0.0143	0.0289
0.1050	0.0145	0.0293
0.1100	0.0147	0.0295
0.1150	0.0148	0.0297
0.1200	0.0148	0.0298
0.1250	0.0149	0.0299
0.1300	0.0148	0.0298
0.1350	0.0148	0.0297
0.1400	0.0146	0.0295
0.1450	0.0145	0.0293
0.1500	0.0143	0.0289
0.1550	0.0140	0.0285
0.1600	0.0137	0.0280
0.1650	0.0133	0.0274
0.1700	0.0129	0.0268
0.1750	0.0124	0.0260
0.1800	0.0119	0.0252
0.1850	0.0113	0.0243
0.1900	0.0107	0.0233
0.1950	0.0100	0.0223
0.2000	0.0093	0.0211
0.2050	0.0085	0.0199
0.2100	0.0077	0.0186
0.2150	0.0068	0.0172
0.2200	0.0058	0.0157
0.2250	0.0048	0.0142
0.2300	0.0038	0.0125
0.2350	0.0027	0.0107
0.2400	0.0016	0.0089
0.2450	0.0004	0.0070
0.2468	-0.0001	0.0062
0.2498	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.7010

GAMMA	TI	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
7.1339	0.0061	0.1248	0.1250	0.2991D-02	0.1266D-06	0.1266D-06	-0.1047D-08	0.1023D-05	0.6473D-05
TM	**TO**	**H(SP)**	**H-BAR**	**BETA**	**IMAX**	**IHHCG**		**I(HH)**	
0.0150	0.0060	0.0173	0.0173	-0.4958D-02	0.1222D-04	0.1222D-04		0.5895D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0030	0.1250	0.0808	0.2469	0.0040	0.1250	0.0815	0.2460	0.0021	0.1250	0.0803	0.2479	0.1248

H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0030	0.0226	0.0201	0.0030	0.0001	0.0151	0.0132	0.0002	0.0059	0.0301	0.0270	0.0058	0.0173

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0001	0.0063
0.0050	0.0004	0.0070
0.0100	0.0016	0.0090
0.0150	0.0028	0.0108
0.0200	0.0039	0.0126
0.0250	0.0050	0.0143
0.0300	0.0060	0.0159
0.0350	0.0069	0.0173
0.0400	0.0078	0.0188
0.0450	0.0087	0.0201
0.0500	0.0094	0.0213
0.0550	0.0102	0.0225
0.0600	0.0109	0.0235
0.0650	0.0115	0.0245
0.0700	0.0121	0.0254
0.0750	0.0126	0.0262
0.0800	0.0131	0.0270
0.0850	0.0135	0.0276
0.0900	0.0139	0.0282
0.0950	0.0142	0.0287
0.1000	0.0145	0.0292
0.1050	0.0147	0.0295
0.1100	0.0149	0.0298
0.1150	0.0150	0.0300
0.1200	0.0151	0.0301
0.1250	0.0151	0.0301
0.1300	0.0151	0.0301
0.1350	0.0150	0.0300
0.1400	0.0149	0.0298
0.1450	0.0147	0.0295
0.1500	0.0145	0.0291
0.1550	0.0142	0.0287
0.1600	0.0139	0.0282
0.1650	0.0135	0.0276
0.1700	0.0131	0.0270
0.1750	0.0126	0.0262
0.1800	0.0120	0.0254
0.1850	0.0115	0.0245
0.1900	0.0108	0.0235
0.1950	0.0101	0.0224
0.2000	0.0094	0.0213
0.2050	0.0086	0.0200
0.2100	0.0078	0.0187
0.2150	0.0069	0.0173
0.2200	0.0059	0.0158
0.2250	0.0049	0.0142
0.2300	0.0039	0.0126
0.2350	0.0028	0.0108
0.2400	0.0016	0.0090
0.2450	0.0004	0.0070
0.2469	-0.0001	0.0062
0.2499	0.0030	0.0030

BLADE SECTION COORDINATES (ROTATED) AT X = 1.7505

GAMMA	TT	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL
5.5740	0.0361	0.1248	0.1250	0.2997D-02	0.1370D-06	0.1370D-06	-0.2854D-09	0.1122D-05	0.6789D-05
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)	
0.0150	0.0060	0.0181	0.0181	-0.1347D-01	0.1228D-04	0.1228D-04		0.5909D-04	

L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CS)
0.0030	0.1250	0.0827	0.2470	0.0040	0.1250	0.0835	0.2460	0.0020	0.1250	0.0819	0.2480	0.1248
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CS)
0.0030	0.0237	0.0213	0.0030	0.0002	0.0162	0.0144	0.0002	0.0059	0.0312	0.0293	0.0058	0.0191

L	HP	HS
0.0	0.0030	0.0030
0.0030	-0.0001	0.0063
0.0050	0.0004	0.0071
0.0100	0.0017	0.0091
0.0150	0.0030	0.0111
0.0200	0.0042	0.0129
0.0250	0.0053	0.0147
0.0300	0.0064	0.0164
0.0350	0.0074	0.0179
0.0400	0.0084	0.0194
0.0450	0.0093	0.0208
0.0500	0.0102	0.0221
0.0550	0.0110	0.0233
0.0600	0.0117	0.0244
0.0650	0.0124	0.0254
0.0700	0.0130	0.0263
0.0750	0.0136	0.0272
0.0800	0.0141	0.0280
0.0850	0.0145	0.0287
0.0900	0.0149	0.0293
0.0950	0.0153	0.0298
0.1000	0.0156	0.0302
0.1050	0.0158	0.0306
0.1100	0.0160	0.0309
0.1150	0.0161	0.0311
0.1200	0.0162	0.0312
0.1250	0.0162	0.0312
0.1300	0.0162	0.0312
0.1350	0.0161	0.0311
0.1400	0.0160	0.0309
0.1450	0.0158	0.0306
0.1500	0.0156	0.0302
0.1550	0.0153	0.0298
0.1600	0.0149	0.0292
0.1650	0.0145	0.0286
0.1700	0.0140	0.0279
0.1750	0.0135	0.0272
0.1800	0.0129	0.0263
0.1850	0.0123	0.0254
0.1900	0.0116	0.0243
0.1950	0.0109	0.0232
0.2000	0.0101	0.0220
0.2050	0.0093	0.0207
0.2100	0.0084	0.0193
0.2150	0.0074	0.0179
0.2200	0.0064	0.0163
0.2250	0.0053	0.0147
0.2300	0.0042	0.0129
0.2350	0.0030	0.0111
0.2400	0.0017	0.0091
0.2450	0.0004	0.0071
0.2470	-0.0001	0.0062
0.2500	0.0030	0.0033

BLADE SECTION COORDINATES (ROTATED) AT X = 1.0000

GAMMA	TT	L(SP)	L-BAR	AREA	IMIN	ILLCG	PHLCG	I(LL)	PHL			
3.9405	0.0061	0.1249	0.1250	0.3026D-02	0.1906D-06	0.1906D-06	0.1924D-09	0.1617D-05	0.8216D-05			
TM	TO	H(SP)	H-BAR	BETA	IMAX	IHHCG		I(HH)				
0.0150	0.0060	0.0217	0.0217	0.8949D-02	0.1251D-04	0.1251D-04		0.5990D-04				
L(IC)	L(MC)	L(TC)	L(OC)	L(IP)	L(MP)	L(TP)	L(OP)	L(IS)	L(MS)	L(TS)	L(OS)	L(CG)
0.0031	0.1250	0.0946	0.2470	0.0043	0.1250	0.0855	0.2458	0.0018	0.1250	0.0836	0.2482	0.1249
H(IC)	H(MC)	H(TC)	H(OC)	H(IP)	H(MP)	H(TP)	H(OP)	H(IS)	H(MS)	H(TS)	H(OS)	H(CG)
0.0031	0.0287	0.0260	0.0030	0.0002	0.0212	0.0190	0.0003	0.0059	0.0362	0.0329	0.0057	0.0217

L	HP	HS
0.0	0.0031	0.0031
0.0031	-0.0002	0.0064
0.0050	0.0005	0.0074
0.0100	0.0022	0.0098
0.0150	0.0039	0.0122
0.0200	0.0055	0.0144
0.0250	0.0069	0.0165
0.0300	0.0084	0.0185
0.0350	0.0097	0.0204
0.0400	0.0109	0.0221
0.0450	0.0121	0.0238
0.0500	0.0132	0.0253
0.0550	0.0143	0.0267
0.0600	0.0152	0.0280
0.0650	0.0161	0.0293
0.0700	0.0169	0.0304
0.0750	0.0177	0.0314
0.0800	0.0183	0.0323
0.0850	0.0189	0.0331
0.0900	0.0195	0.0338
0.0950	0.0199	0.0345
0.1000	0.0203	0.0350
0.1050	0.0206	0.0354
0.1100	0.0209	0.0358
0.1150	0.0210	0.0360
0.1200	0.0211	0.0361
0.1250	0.0212	0.0362
0.1300	0.0211	0.0361
0.1350	0.0210	0.0360
0.1400	0.0209	0.0358
0.1450	0.0206	0.0354
0.1500	0.0203	0.0350
0.1550	0.0199	0.0345
0.1600	0.0195	0.0339
0.1650	0.0189	0.0331
0.1700	0.0184	0.0323
0.1750	0.0177	0.0314
0.1800	0.0169	0.0304
0.1850	0.0161	0.0293
0.1900	0.0153	0.0281
0.1950	0.0143	0.0268
0.2000	0.0133	0.0253
0.2050	0.0122	0.0238
0.2100	0.0110	0.0222
0.2150	0.0097	0.0204
0.2200	0.0084	0.0185
0.2250	0.0070	0.0166
0.2300	0.0055	0.0145
0.2350	0.0039	0.0122
0.2400	0.0023	0.0099
0.2450	0.0005	0.0074
0.2470	-0.0002	0.0064
0.2500	0.0030	0.0030

APPENDIX E

TIME-SHARING COMPUTER PROGRAM FOR THE DESIGN OF FREE VORTEX TURBINES

SUMMARY

Appendix E describes a time sharing computer program named "TURBINE" which was written to aid in the design calculations for free vortex, axial flow turbines. Any gas for which the specific heat ratio and gas constant are known may be used for the working fluid. The program will analyze any number of stages or spools.

NOMENCLATURE*FOR COMPUTER PROGRAM "TURBINE"

ALP	flow angle measured from tangential, deg
BETA1	bucket entrance angle, deg
BETA2	bucket exit angle, deg
CF	flow coefficient applied to annulus area at all stations in a stage.
DELBET	bucket turning angle, deg
DP	inner stage total pressure loss, fraction.
DW	inner stage flow loss, fraction.
D(I,J)	diameter at station I, streamline J, in.
EFB	bucket efficiency at pitch line.
EFF	stage total to total efficiency.
EFN	nozzle efficiency at pitch line.
ESD	stage energy or enthalpy drop, Btu/lb
ETAT	overall total to total efficiency.
ETAS	overall total to static efficiency.
ETAA	overall total to axial total efficiency.
FAX BUC	axial air load on buckets, lbs
FAX NOZ	axial air load on nozzles, lbs
FTAN BUC	tangential air load on buckets, lbs
FTAN NOZ	tangential air load on nozzles, lbs

* This nomenclature is used in the program input and output but does not apply to the program listing.

GAMA	specific heat ratio, stage average.
I	station number, (see fig E-1)
J	streamline number, 1 = hub, 2 = pitch, 3 = tip.
LOAD	loading coefficient, $(0.50)(32.17)(778.26)(ESD)/(U2)^2$.
MF	stage exit axial Mach number.
MR1	bucket inlet relative Mach number.
MR2	bucket exit relative Mach number.
NDO-NOZ	summation of effective nozzle throat dimensions on indicated streamline, in.
NDO-BUC	summation of effective bucket throat dimensions on indicated streamline, in.
NS	number of stages.
PAX	turbine exit total pressure assuming recovery of axial component of leaving velocity, psia.
PEX	turbine exit total pressure assuming full recovery of leaving velocity, psia.
PSEX	turbine exit static pressure at pitch line, psia.
PI	stage inlet total pressure, psia.
PO	turbine inlet total pressure, psia.
PS	static pressure, psia.
P4	stage exit total pressure, psia.
PTB	total pressure relative to bucket leading edge, psia.
RCUO	radius times tangential velocity at turbine inlet, (ft/sec)(in.).
RG	gas constant of working fluid, ft/°R.
RPM	stage rotational speed, rpm.
RX	reaction, (root value in input data).
R1	gas velocity relative to bucket leading edge, ft/sec

R2	gas velocity relative to bucket trailing edge, ft/sec
TEX	turbine exit total temperature, °R.
TF	test factor or vector diagram efficiency; applied to vector diagram energy to get actual stage output energy.
TI	stage inlet total temperature, °R.
TO	turbine inlet total temperature, °R.
TS	static temperature, °R.
TTB	total temperature relative to bucket leading edge, °R.
T4	stage exit total temperature, °R.
U1	bucket leading edge velocity, ft/sec
U2	bucket trailing edge velocity, ft/sec
V	gas velocity, ft/sec
VU	tangential component of V, ft/sec
VZ	axial component of V, ft/sec
WD	stage mass flow rate, lbs/sec
WO	turbine inlet mass flow rate, lbs/sec
ZWEIN	nozzle Zweifel loading parameter.
ZWEIB	bucket Zweifel loading parameter.

GENERAL DESCRIPTION

"TURBINE" performs a simple, straight forward design calculation of the velocity diagrams in a multistage axial flow turbine. Also calculated are the pressures and temperatures throughout the turbine and a number of other useful design parameters. Input to the program consists of turbine inlet gas conditions, required energy extraction, thermodynamic properties of the working fluid, turbine flow path dimensions from preliminary design calculations, and certain optional items which are left to the discretion of the designer.

Basic assumptions in the calculation are that free vortex flow exists in the space between each blade row and that a constant average value of specific heat ratio may be assumed for each stage. Continuity, angular momentum, and energy relationships are satisfied at the leading edge and trailing edge of each blade row.

This program was conceived as a useful, time-saving design tool and is simple enough to be used in preliminary design studies where a large number of turbine configurations may be examined at low cost. It may also be used as a detail design tool in cases where the assumption of free vortex flow is adequate or the use of more sophisticated design procedures is not warranted. The program has the flexibility of being able to handle any number of stages and any working fluid that may be assumed to have a fixed gas constant and a constant specific heat ratio through each stage. Also the rpm may differ for each stage, permitting the analysis of multi-spool turbines.

The program was not intended to be used in the off-design mode or to predict turbine efficiency, although stage and overall efficiencies are calculated using blade row efficiencies and other loss factors supplied by the designer. Detail design of blade sections is beyond the capability of this program although it does calculate most of the needed parameters such as inlet and exit flow angles. Zweifel loading parameters, air loads, and blade throat areas.

TURBINE is written in the Fortran language for the G. E. Mark II time-sharing system. The program listing is given in appendix E-A.

THEORY

Figure E-1 defines the stations at which calculations are made for each stage. An outline of the calculation logic appears in figure E-2. After reading in the general and stage input data, the first calculation step is to initialize the stage inlet conditions. For the frist stage, the inlet conditions are set equal to the given turbine inlet conditions. For subsequent stages, the inlet conditions are set equal to the exit conditions of the previous stage unless DW or DP have non-zero values. In this case, the flow and total pressure will be reduced by the fractional amount equal to DW and DP respectively. Thus, DW and DP may be used to account for inner stage leakage and total pressure losses.

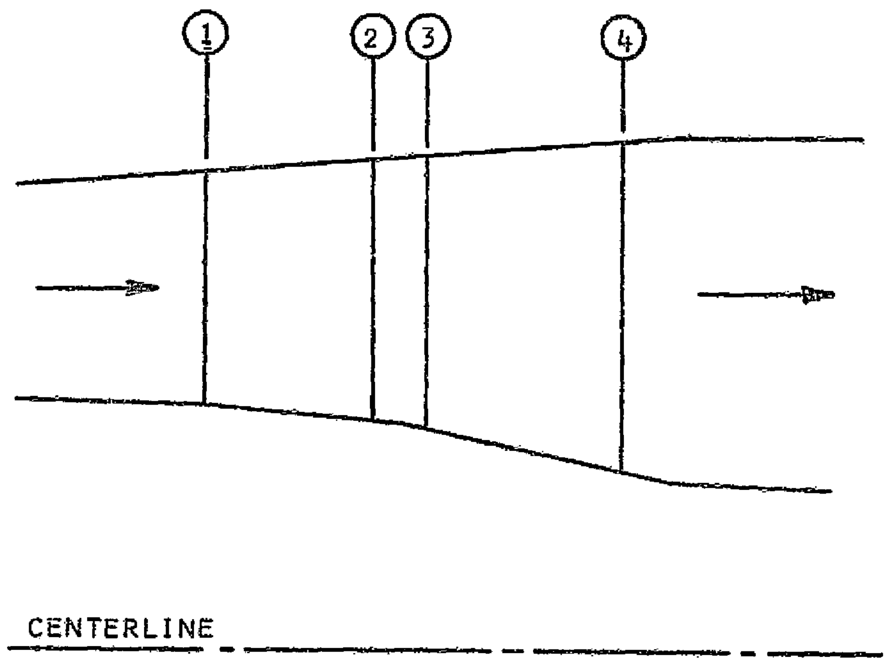

Figure E-1. - Definition of calculation stations.

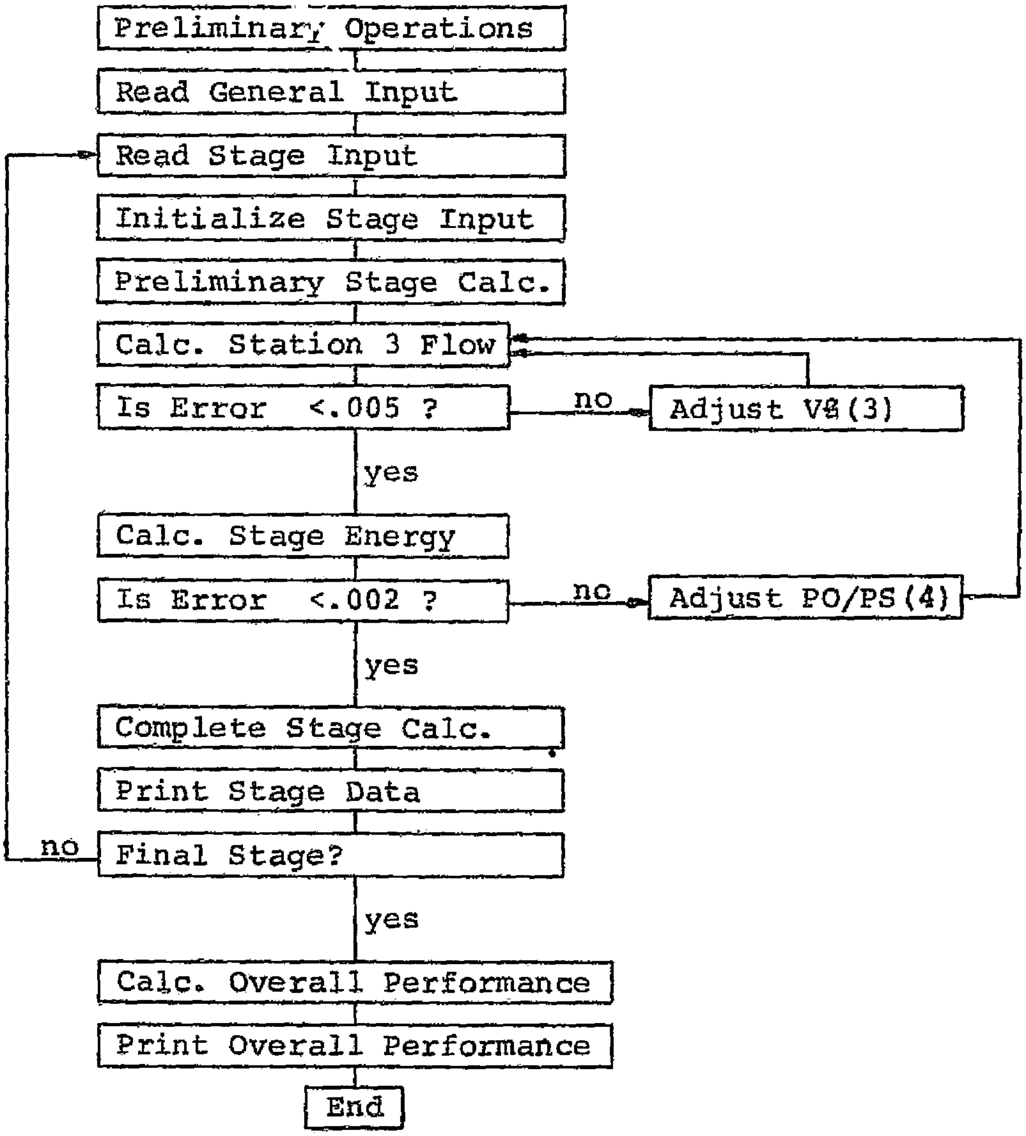

Figure E-2. - Program logic diagram

Next, the program makes preliminary calculations for various constants, annulus areas, pitch line diameters, wheel speeds, and initial estimates of stage pressure ratio and axial velocity at station 3.

Using this first estimate of stage pressure ratio and an approximate equation relating the nozzle pitch line pressure ratio to the bucket root reaction, the pitch line static pressure at station 3 is calculated. A free vortex flow field is then assumed at station 3 and the mass flow computed based on the first estimate of axial velocity at this station. This axial velocity is then adjusted and the mass flow recomputed until continuity is satisfied at station 3. The calculation then shifts to station 4, at the bucket exit, where continuity is satisfied and the stage energy output calculated. This energy output is then compared to the required value, and, if they are not equal, an adjustment is made to the stage pressure ratio. The iteration then continues until both continuity and stage energy requirements are satisfied.

After the iterations on continuity and energy are converged the program completes the calculation of the remaining stage parameters, including the velocity vectors at stations 1 and 2, bucket relative conditions, loading parameters, blade loads, efficiency, etc. Output for the stage is then printed. If another stage follows, the program returns, reads in new stage data, and proceeds as before.

After the final stage, the program calculates overall temperature and pressure ratios and an average specific heat ratio. Overall aerodynamic efficiencies are then calculated from these quantities; three efficiencies are calculated. The first is based on full recovery of the leaving velocity and is usually called the "impact efficiency" or the "total to toal efficiency;" it is this efficiency which is also calculated for each stage. The second efficiency in the output is the "total to static efficiency" which charges the turbine with all the leaving velocity as a loss. The third efficiency calculated assumes recovery of the axial component of leaving velocity and charges the turbine with the swirl component as a loss.

PROGRAM INPUT

Input data for TURBINE is in a separate data file which must be set up and named prior to running the main program. Input to TURBINE then consists of only the name of the data file and is input when the program asks for it after the RUN command is given. The name of the data file is arbitrary and several input data files may be stored at the same time.

Input must be stored in the data files according to the following format:

Line 1 PO, TO, WO, NS, RG, RCUO

Line 2 D(1,3), D(2,3), D(3,3), D(4,3)

Line 3 D(1,1), D(2,1), D(3,1), D(4,1)

Line 4 ESD, TF, EFN, EFB, EFF, MF

Line 5 RX, RPM, GAMA, CF, DW, DP

Each line of data must be preceded by a line number as in any Fortran program. The first line contains general data and is input only once. Lines 2 through 5 contain stage data and must be repeated for each stage. The input values of EFF and MF serve only initial estimates and will be recalculated by the program. The value of RX is satisfied only approximately by the program and the exact values calculated are printed out for each stage. A sample input data file is shown in appendix E-B.

PROGRAM OUTPUT

A sample printout is given in the appendix E-C and is largely self explanatory. The first block of data gives the static presure, static temperature, and velocity vector information at hub, pitch, and tip diameters for station 1. The effective annulus area is also given for this station. This same output is then repeated for stations 2, 3, and 4. The next two blocks of data primarily give gas conditions and velocity vector information relative to the bucket on hub, pitch, and tip streamlines. Also given are several loading parameters and nozzle and bucket throat dimensions.

The next two lines of data give the stage input data plus the stage inlet and outlet temperatures and pressures. Note that the input estimates of efficiency and axial Mach number have been replaced with the calculated values. The next line of data under BLADE LOADS, gives the total aerodynamic loads on the nozzle and buckets in the axial and tangential directions. These loads are the total due to momentum changes and static pressure differences.

The foregoing output is repeated for each stage. Following the output for the last stage is a block of output entitled "OVERALL PERFORMANCE" giving the turbine inlet conditions, overall temperature and pressure ratios; the three overall efficiencies and the average specific heat ratio for the turbine.

APPENDIX E-A

COMPUTER "TURBINE" PROGRAM LISTING

```
        FILENAME IDF
        REAL D(4,3),A(4),U3(3),U4(3),VA(4),V(4,3),
   &    VU(4,3),R1(3),R2(3),RCU(4),T(4),P(4),TS(4,3),
   &    PS(4,3),TTR(3),PTB(3),RHØ(4,3),PHIS3(3),
   &    DTN(3),ALP(4,3),BETA1(3),BETA2(3)
         REAL MR1(3),MR2(3),DBET(3),NDØ(3),BDØ(3)
        REAL LØAD(3),MF,RAX(3),ZN(3),ZR(3)
         ALPHA ANV
        PRINT,"NAME OF TURBINE";INPUT,ANV
        PRINT,"NAME ØF INPUT DATA FILE";INPUT,IDF
        K=1
        END=0
        SUMG=0
     10 FØRMAT (V)
        READ (IDF,10)LN,PO,TO,WO,NS,RG,RCUO
     20 READ (IDF,10)LN,(D(I,3),I=1,4)
        READ (IDF,10)LN,(D(I,1),I=1,4)
        READ (IDF,10)LN,ESD,TF,EFN,EFB,EFF,MF
        READ (IDF,10)LN,RX,RPM,G,CF,DW,DP
        IF (K-1)30,30,40
     30 T(1)=TO;P(1)=PO;WD=WO;RCU(1)=RCUO
        GØ TØ 50
     40 T(1)=T(4);P(1)=P(4)*(1-DP)
        WD=WD*(1-DW);RCU(1)=RCU(4)
        GØ TØ 50
C
C       PRELIMINARY STAGE CALCULATIØNS
C
     50 G1=(G-1)/G
        G2=1/G1
        CP=G2*RG/778.26
        C1=2*32.17405*778.26*CP
        C2=32.17405*G*RG
        PI=3.14159
        DØ 60 I=1,4
        D(I,2)=(D(I,1)+D(I,3))/2
        A(I)=CF*PI*(D(I,3)↑2-D(I,1)↑2)/4
     60 CØNTINUE
        UP=PI*RPM/720
        DØ 70 J=1,3
        U3(J)=UP*D(3,J);U4(J)=UP*D(4,J)
     70 CØNTINUE
        SPR=((1+(G-1)/2*MF↑2)/(1-ESD/EFF/CP/T(1)))↑G2
        VA(3)=MF*(C2*(T(1)-ESD/CP))↑.5
        TSØ=.15
C
C       CØNTINUITY AND ENERGY BALANCE ITERATIØNS
C
     80 PS(4,2)=P(1)/SPR;PHIS4=(PS(4,2)/P(1))↑G1
     90 PHIS3(2)=1-(1-PHIS4)*(1-RX)*(TSØ+(D(3,1)/D(3,2))↑2)/(TSØ+1)
```

```
      DTN(2)=EFN*T(1)*(1-PHIS3(2))
      V(3,2)=(C1*DTN(2))↑.5
      VU(3,2)=(V(3,2)↑2-VA(3)↑2)↑.5
      DØ 100 J=1,3,2
      VU(3,J)=VU(3,2)*D(3,2)/D(3,J)
       V(3,J)=(VU(3,J)↑2+VA(3)↑2)↑.5
      DTN(J)=V(3,J)↑2/C1
      PHIS3(J)=PHIS3(2)*(T(1)-DTN(J))/(T(1)-DTN(2))
  100CØNTINUE
      DØ 110 J=1,3
      TS(3,J)=T(1)-DTN(J)
      PS(3,J)=P(1)*PHIS3(J)↑G2
      RHØ(3,J)=144*PS(3,J)/RG/TS(3,J)
  110CØNTINUE
      RHØA=.2*(RHØ(3,1)+RHØ(3,3))+.6*RHØ(3,2)
      WC=RHØA*VA(3)*A(3)/144
      ERR=(WC-WD)/WD
      IF (ABS(ERR).LT..005)GØ TØ 120
      VA(3)=VA(3)*WD/WC
      TSØ=(VA(3)/VU(3,1))↑2
      GØ TØ 90
  120R1(2)=(VA(3)↑2+(VU(3,2)-U3(2))↑2)↑.5
      TTB(2)=TS(3,2)+R1(2)↑2/C1
      PTB(2)=PS(3,2)*(TTB(2)/TS(3,2))↑G2
      PHIB=(PS(4,2)/PTB(2))↑G1
      DTB=EFB*TTB(2)*(1-PHIB)
      R2(2)=(C1*DTB)↑.5
      TS(4,2)=TTB(2)-DTB
      RHØ(4,2)=144*PS(4,2)/RG/TS(4,2)
      VA(4)=WD*144/RHØ(4,2)/A(4)
      RU2=(R2(2)↑2-VA(4)↑2)↑.5
      VU(4,2)=RU2-U4(2)
      ESC=TF*(D(3,2)*VU(3,2)+D(4,2)*VU(4,2))*RPM*PI*CP/360/C1
      ERR=(ESC-ESD)/ESD
      IF (ABS(ERR).LT..002) GØ TØ 130
      SPR=(1-(1-SPR↑(-G1))*ESD/ESC)↑(-G2)
      GØ TØ 80
C
C     STAGE CØMPLETIØN
C
  130V(4,2)=(VU(4,2)↑2+VA(4)↑2)↑.5
      T(4)=TS(4,2)+V(4,2)↑2/C1
      P(4)=PS(4,2)*(T(4)/TS(4,2))↑G2
      DØ 140 J=1,3,2
      VU(4,J)=VU(4,2)*D(4,2)/D(4,J)
      V(4,J)=(VU(4,J)↑2+VA(4)↑2)↑.5
      TS(4,J)=T(4)-V(4,J)↑2/C1
      PS(4,J)=P(4)*(TS(4,J)/T(4))↑G2
      RHØ(4,J)=144*PS(4,J)/RG/TS(4,J)
      R1(J)=(VA(3)↑2+(VU(3,J)-U3(J))↑2)↑.5
```

```
      TTB(J)=TS(3,J)+R1(J)↑2/C1
      PTB(J)=PS(3,J)*(TTB(J)/TS(3,J))↑G2
      R2(J)=(VA(4)↑2+(VU(4,J)+U4(J))↑2)↑.5
  140CØNTINUE
      T(4)=T(1)-ESD/CP
      RCU(4)=D(4,2)*VU(4,2)/2
      MF=VA(4)/(C2*TS(4,2))↑.5
       EFF=(1-T(4)/T(1))/(1-(P(4)/P(1))↑G1)
      RCU(3)=D(3,2)*VU(3,2)/2;RCU(2)=RCU(3)
      P(3)=PS(3,2)*(T(1)/TS(3,2))↑G2
      P(2)=P(3);T(2)=T(1)
C
C     CØNTINUITY AT STATIØNS 1 AND 2
C
      DØ 160 I=1,2
      VA(I)=VA(3)
      DØ 150 J=1,3
      VU(I,J)=2*RCU(I)/D(I,J)
  150CØNTINUE
      DØ 155 J=1,3
      V(I,J)=(VA(I)↑2+VU(I,J)↑2)↑.5
      TS(I,J)=T(I)-V(I,J)↑2/C1
      PS(I,J)=P(I)*(TS(I,J)/T(I))↑G2
      RHØ(I,J)=144*PS(I,J)/TS(I,J)/RG
  155CØNTINUE
      RHØA=.2*(RHØ(I,1)+RHØ(I,3))+.6*RHØ(I,2)
      WC=RHØA*VA(I)*A(I)/144
      ERR=(WC-WD)/WD
      IF (ABS(ERR).LT..005) GØ TØ 160
      VA(I)=VA(I)*WD/WC
      GØ TØ 150
  160CØNTINUE
      GØ TØ 200
C
C       PRINT STATEMENTS
  799PRINT,"STAGE NUMBER ",K
      PRINT 900
      PRINT,"          DIAMETER     PS        TS         V         VU
     &         VZ       ALP"
      PRINT,"              (IN)      (PSIA)      (R)      (FPS)     (FPS)
     &(FPS)    (DEG)"
      PRINT 900
      DØ 800 I=1,4
      PRINT,"   STATIØN",I
       PRINT 910,(D(I,J),PS(I,J),TS(I,J),V(I,J),VU(I,J),VA(I),ALP(I,J)
     &,J=1,3)
      PRINT 900
      PRINT," ","EFFECTIVE AREA =",A(I)
  800PRINT 900
      PRINT,"SL  BETA1  BETA2   TTB    PTB     R1     R2     U1
```

```
     &U2"
      DØ 810 J=1,3
  810PRINT 920,J,BETA1(J),BETA2(J),TTB(J),PTB(J),R1(J),R2(J),
     &U3(J),U4(J)
      PRINT 900
      PRINT,"SL  MR1   MR2  LØAD    RX  DELBET NDØ-NZ NDØ-BK ZWIEN
     &ZWIEB"
      DØ 820 J=1,3
  820PRINT 930,J,MR1(J),MR2(J),LØAD(J),RAX(J),DBET(J),NDØ(J),
 &    BDØ(J),ZN(J),ZB(J)
      PRINT 900
      PRINT,"     EFF      EFN      EFB      TF      CF      DW
     &      DP      MF"
      PRINT 940,EFF,EFN,EFB,TF,CF,DW,DP,MF
      PRINT 900
      PRINT,"     ESD      RPM      WD      T1      T4      P1
     &      P4      GAMA"
      PRINT 950,ESD,RPM,WD,T(1),T(4),P(1),P(4),G
      PRINT 900
      PRINT,"BLADE LØADS"
      PRINT,"      FAX NØZ    FTAN NØZ    FAX BUC    FTAN BUC"
      PRINT960,FZN,FTN,FZB,FTB
      PRINT 900
      EØD=EØD+ESD;SUMG=SUMG+ESD*G;K=K+1
      IF(K-NS)20,20,500
  900FØRMAT(1H )
  910FØRMAT(1H F14.3,F10.2,4F9.1,F9.2)
  920FØRMAT(1H I2,2F7.2,F7.1,F8.2,4F7.1)
  930FØRMAT(1H I2,4F6.3,F7.2,2F7.3,2F6.3)
  940FØRMAT(1H F7.3,7F8.3)
  950FØRMAT(1H F9.2,F8.0,F9.3,2F8.1,2F8.2,F8.4)
  960FØRMAT(1H F12.2,3F11.2)
  970FØRMAT(1H F12.2,F9.1,F10.3,F9.3,F10.1)
  980FØRMAT(1H F11.3,3F9.3)
  990FØRMAT(1H F10.3,2F8.3,F11.4)
C
C     AUXILIARY CALCULATIØNS
C
  200DØ 210 J=1,3
      DØ 205 I=1,4
      IF(VU(I,J))17,201,17
   17CØNTINUE
      ALP(I,J)=180/PI*ATAN(VA(I)/VU(I,J))
      GØ TØ 205
  201ALP(I,J)=90.00
      GØ TØ 205
  205CØNTINUE
      BETA1(J)=180/PI*ATAN(VA(3)/(VU(3,J)-U3(J)))
      IF(BETA1(J))206,207,207
  206BETA1(J)=180+BETA1(J)
```

```
1038  207CØNTINUE
1040     BETA2(J)=180/PI*ATAN(VA(4)/(VU(4,J)+U4(J)))
1045     MR1(J)=R1(J)/(C2*TS(3,J))↑.5
1050     MR2(J)=R2(J)/(C2*TS(4,J))↑.5
1055     LØAD(J)=C1*ESD/4/CP/(U4(J))↑2
1060     RAX(J)=1-(1-(PS(3,J)/P(1))↑G1)/(1-(PS(4,J)/P(1))↑G1)
1065     DBET(J)=180-BETA1(J)-BETA2(J)
1070     ZN(J)=2*(VU(1,J)+VU(2,J))/(P(1)-PS(2,J))/(1/RHØ(1,J)/VA(1)
1071  &  +1/RHØ(2,J)/VA(2))/144/32.17405
1075     ZB(J)=2*(VU(3,J)+VU(4,J))/(PTB(J)-PS(4,J))/(1/RHØ(3,J)/VA(3)
1076  &  +1/RHØ(4,J)/VA(4))/144/32.17405
1080     NDØ(J)=PI*D(2,J)*EFN↑.5*SIN(PI*ALP(2,J)/180)
1085     BDØ(J)=PI*D(4,J)*EFB↑.5*SIN(PI*BETA2(J)/180)
1090  210CØNTINUE
1100     FTN=WD*(RCU(1)+RCU(2))*4/(D(1,2)+D(2,2))/32.17405
1105     FTB=WD*ESD*778.26/(U3(2)+U4(2))*2
1110     FZN=(PS(1,2)-PS(2,2))*A(2)+WD*(VA(1)-VA(2))/32.17405
1115     FZB=(PS(3,2)-PS(4,2))*A(4)+WD*(VA(3)-VA(4))/32.17405
1199     GØ TØ 799
1200C
1205C    ØVERALL PERFØRMANCE
1210C
1215  500AVGG=SUMG/EØD
1220     TOTX=TO/T(4)
1225     POPX=PO/P(4)
1230     POPSX=PO/PS(4,2)
1235     POPAX=POPSX/(1+(G-1)/2*MF↑2)↑G2
1240     G3=(AVGG-1)/AVGG
1245     ETAT=(1-1/TOTX)/(1-(POPX)↑(-G3))
1250     ETAS=(1-1/TOTX)/(1-(POPSX)↑(-G3))
1255     ETAA=(1-1/TOTX)/(1-(POPAX)↑(-G3))
1500     PRINT,"ØVERALL PERFØRMANCE"
1505     PRINT 900
1510     PRINT,"          PO        TO        WO          RG         RCUO"
1515     PRINT970,PO,TO,WO,RG,RCUO
1520     PRINT 900
1525     PRINT,"      TO/TEX    PO/PEX    PO/PSEX   PO/PAX"
1535     PRINT980,TOTX,POPX,POPSX,POPAX
1540     PRINT 900
1545     PRINT,"        ETAT      ETAS      ETAA     AVG GAMA"
1550     PRINT990,ETAT,ETAS,ETAA,AVGG
1560      STØP;END
```

APPENDIX E-B

SAMPLE INPUT DATA FILE

```
NASA778      11/16/72


110 258 610 .53 2 53.3 0
120 1.750 1.750 1.750 1.750
130 1.570 1.570 1.560 1.510
140 35 .893 .95 .85 .8 .2
150 .176 85000 1.412 .95 0 0
160 1.750 1.750 1.750 1.750
170 1.500 1.330 1.320 1.192
180 23.25 .873 .95 .85 .8 .5
190 .12 85000 1.412 .95 0 0
```

APPENDIX E-C

SAMPLE PROGRAM PRINTOUT

```
ØLD TURBINE3

READY
RUN

TURBINE3    11:21EST    11/16/72

NAME ØF TURBINE? 778 PERFØRMANCE PRINTØUT

NAME ØF INPUT DATA FILE?NASA778

STAGE NUMBER            1

      DIAMETER    PS      TS       V       VU       VZ      ALP
        (IN)    (PSIA)    (R)    (FPS)   (FPS)    (FPS)    (DEG)

  STATIØN           1
         1.570  255.20   608.1   151.0     0.      151.0    90.00
         1.660  255.20   608.1   151.0     0.      151.0    90.00
         1.750  255.20   608.1   151.0     0.      151.0    90.00

 EFFECTIVE AREA =    4.4588589E-01

  STATIØN           2
         1.570   85.97   450.0  1371.5   1337.4   303.9    12.80
         1.660   96.94   466.0  1300.9   1264.9   303.9    13.51
         1.750  107.01   479.7  1237.7   1199.8   303.9    14.22

 EFFECTIVE AREA =    4.4588589E-01

  STATIØN           3
         1.560   85.17   448.8  1376.7   1346.0   289.2    12.13
         1.655   96.88   465.9  1301.3   1268.7   289.2    12.84
         1.750  107.58   480.4  1234.2   1199.8   289.2    13.55

 EFFECTIVE AREA =    4.6923966E-01

  STATIØN           4
         1.510   62.08   424.0   486.9    360.2   327.5    42.28
         1.630   62.87   425.5   467.6    333.7   327.5    44.47
         1.750   63.50   426.8   451.5    310.8   327.5    46.50
```

EFFECTIVE AREA = 5.8377025E-01

SL	BETA1	BETA2	TTB	PTB	R1	R2	U1	U2
1	20.65	19.59	506.0	128.50	820.1	976.8	578.6	560.0
2	23.82	19.24	509.5	131.64	715.9	993.8	613.8	604.5
3	27.70	18.84	513.3	135.02	622.1	1014.2	649.0	649.0

SL	MR1	MR2	LØAD	RX	DELBET	NDØ-NZ	NDØ-BK	ZWIEN	ZWIEB
1	0.787	0.964	1.397	0.188	139.76	1.065	1.467	0.275	0.767
2	0.674	0.979	1.199	0.264	136.93	1.188	1.556	0.290	0.729
3	0.577	0.998	1.040	0.329	133.46	1.316	1.637	0.304	0.685

EFF	EFN	EFB	TF	CF	DW	DP	MF
0.792	0.950	0.850	0.893	0.950	0.	0.	0.323

ESD	RPM	WD	TI	T4	PI	P4	GAMA
35.00	85000.	0.530	610.0	460.9	258.00	72.79	1.4120

BLADE LØADS

FAX NØZ	FTAN NØZ	FAX BUC	FTAN BUC
68.05	20.84	19.23	23.70

STAGE NUMBER 2

	DIAMETER (IN)	PS (PSIA)	TS (R)	V (FPS)	VU (FPS)	VZ (FPS)	ALP (DEG)
STATIØN 1							
	1.500	62.42	440.7	487.5	362.6	325.8	41.94
	1.625	63.23	442.3	467.1	334.7	325.8	44.23
	1.750	63.87	443.6	450.3	310.8	325.8	46.35

EFFECTIVE AREA = 6.0622869E-01

STATIØN 2							
	1.330	25.66	344.3	1170.5	1123.3	328.9	16.32
	1.540	33.32	371.6	1024.4	970.1	328.9	18.73
	1.750	39.20	389.7	914.9	853.7	328.9	21.07

EFFECTIVE AREA = 9.6519070E-01

STATIØN 3							
	1.320	25.32	343.0	1177.1	1131.8	323.2	15.94
	1.535	33.25	371.4	1025.6	973.3	323.2	18.37
	1.750	39.31	390.0	912.9	853.7	323.2	20.74

EFFECTIVE AREA = 9.8496310E-01

STATIØN 4							
	1.192	20.43	332.7	448.8	253.4	370.4	55.63
	1.471	20.83	334.5	423.5	205.3	370.4	61.00
	1.750	21.05	335.6	408.7	172.6	370.4	65.02

EFFECTIVE AREA = 1.2248700E+00

SL	BETA1	BETA2	TTB	PTB	R1	R2	U1	U2
1	26.72	28.04	387.0	38.28	719.0	788.0	489.6	442.1
2	38.66	26.26	394.2	40.78	517.4	837.3	569.3	545.6
3	57.66	24.27	402.4	43.78	382.6	901.3	649.0	649.0

SL	MR1	MR2	LØAD	RX	DELBET	NDØ-NZ	NDØ-BK	ZWIEN	ZWIEB
1	0.789	0.878	1.489	0.144	125.24	1.144	1.623	0.588	1.054
2	0.546	0.930	0.978	0.332	115.08	1.514	1.885	0.696	0.884
3	0.394	1.000	0.691	0.458	98.07	1.926	2.083	0.784	0.714

EFF	EFN	EFB	TF	CF	DW	DP	MF
0.784	0.950	0.850	0.873	0.950	0.	0.	0.412

ESD	RPM	WD	TI	T4	PI	P4	GAMA
23.25	85000.	0.530	460.9	361.8	72.79	24.27	1.4120

BLADE LØADS

FAX NØZ	FTAN NØZ	FAX BUC	FTAN BUC
28.82	21.21	14.44	17.20

ØVERALL PERFØRMANCE

PO	TO	WO	RG	RCUO
258.00	610.0	0.530	53.300	0.

TO/TEX	PO/PEX	PO/PSEX	PO/PAX
1.686	10.631	12.388	11.014

ETAT	ETAS	ETAA	AVG GAMA
0.816	0.782	0.808	1.4120

PRØGRAM STØP AT 1560

USED .75 UNITS

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*Computer Programs for Axial-flow Compressor Design. Identifying Numbers: M69-10345 and LEW-10765

*Computer Program for Designing Compressor Blades. Identifying Numbers: M70-10057 and LEW-11059

The above programs and their supporting documents are available to domestic (U.S.A.) users by purchase from:

Computer Software Management and Information Center
Barrow Hall
University of Georgia
Athens, Georgia 30601

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TABLE 1.- CONFIGURATION SELECTION PROGRAM BLADE ROW GEOMETRY

Stage	Number of Rotor Blades	Rotor Chord Length cm (in.)	Rotor Tip Solidity	Rotor Aspect Ratio	Number of Stator Blades	Stator Chord Length cm (in.)	Stator Hub Solidity	Stator Aspect Ratio
Four-Stage Configuration								
1	49	0.76 (.30)	1.300	2.000	57	0.64 (.25)	1.700	1.800
2	47	.64 (.25)	1.040	1.700	55	.64 (.25)	1.520	1.500
3	45	.64 (.25)	0.995	1.368	53	.64 (.25)	1.090	1.235
4	43	.64 (.25)	0.952	1.117	51	.64 (.25)	1.305	1.017
Five-Stage Configuration								
1	49	0.76 (.30)	1.300	2.000	53	0.64 (.25)	1.60	1.800
2	47	.64 (.25)	1.040	1.700	51	.64 (.25)	1.44	1.500
3	45	.64 (.25)	0.995	1.368	49	.64 (.25)	1.32	1.235
4	43	.64 (.25)	0.952	1.117	47	.64 (.25)	1.22	1.017
5	41	.64 (.25)	0.907	0.934	45	.64 (.25)	1.15	0.900
		Note 1		Note 2		Note 3	Note 4	Note 5

Note 1 Chord length is constant along blade span.

2 Rotor aspect ratio is defined in the configuration selection program as

$$AR_R = \frac{(r_{t,in} - r_{h,in})_R}{b_R}. \quad \text{(See fig. 4.)}$$

3 Chord length is constant along blade span.

4 Stator hub solidity estimated from equation $\sigma = \frac{cN}{2\pi r_{h,out}}$

where $r_{h,out}$ is first approximation of stator hub radius at stator outlet station; $r_{h,out}$ = 3.38, 3.67, 3.85, 3.98 cm (1.332, 1.443, 1.517, 1.566 in.) for 4-stage compressor and 3.35, 3.58, 3.76, 3.89, 3.96 cm (1.32, 1.41, 1.48, 1.53, 1.56 in.) for 5-stage compressor.

5 Stator aspect ratio is defined in the configuration selection program as

$$AR_S = \frac{(r_{t,in} - r_{h,in})_S}{b_S}. \quad \text{(See fig. 4.)}$$

TABLE 2. COMPRESSOR INLET AND PASSAGE COORDINATES FOR MINIATURE GAS TURBINE ENGINE (see fig. 4)

Axial[a] coordinate, cm (in.)	Shroud (tip) radius, cm (in.)	Initial[b] hub radius, cm (in.)	Final[b] hub radius, cm (in.)
-1.829 (- .720)	6.350 (2.500)	0.0 (0.0)	0.0 (0.0)
-1.829 (- .720)	5.588 (2.200)	.508 (.200)	.508 (.200)
-1.778 (- .700)	5.156 (2.030)	.889 (.350)	.889 (.350)
-1.524 (- .600)	4.877 (1.920)	1.499 (.590)	1.499 (.590)
-1.270 (- .500)	4.750 (1.870)	1.842 (.725)	1.842 (.725)
-1.016 (- .400)	4.674 (1.840)	2.083 (.820)	2.083 (.820)
- .762 (- .300)	4.623 (1.820)	2.276 (.896)	2.276 (.896)
- .508 (- .200)	4.597 (1.810)	2.436 (.959)	2.436 (.959)
- .254 (- .100)	4.572 (1.800)	2.581 (1.016)	2.581 (1.016)
0.0 (0.0)	4.572 (1.800)	2.680 (1.055)	2.680 (1.055)
0.935 (0.368)	4.572 (1.800)	3.018 (1.188)	2.962 (1.166)
1.786 (0.703)	4.572 (1.800)	3.254 (1.281)	3.190 (1.256)
2.619 (1.031)	4.572 (1.800)	3.429 (1.350)	3.391 (1.335)
3.406 (1.341)	4.572 (1.800)	3.556 (1.400)	3.556 (1.400)
4.186 (1.648)	4.572 (1.800)	3.658 (1.440)	3.658 (1.440)
4.938 (1.944)	4.572 (1.800)	3.734 (1.470)	3.734 (1.470)
5.705 (2.246)	4.572 (1.800)	3.800 (1.496)	3.800 (1.496)
6.459 (2.543)	4.572 (1.800)	3.853 (1.517)	3.853 (1.517)
7.236 (2.849)	4.572 (1.800)	3.907 (1.538)	3.907 (1.538)
7.965 (3.136)	4.572 (1.800)	3.952 (1.556)	3.952 (1.556)

[a]To obtain corresponding axial coordinates in Appendix C program output, add 1.0 to these values. Only positive values are permitted in the meridional plane program coordinate input.

[b]The two sets of hub radius values given are discussed in the subsection Definition of Compressor Flow Passage Shape. The final hub radius values are those for the recommended design and these should be used in preparation of fabrication drawings.

TABLE 3.- AXIAL LOCATIONS OF BLADE ROW STACKING AXES

Blade row	Axial distance from first rotor inlet calculation plane (station 5) cm	(in.)
First stage rotor	0.497	(0.1955)
First stage stator	1.353	(0.5327)
Second stage rotor	2.193	(0.8633)
Second stage stator	3.004	(1.1826)
Third stage rotor	3.788	(1.4912)
Third stage stator	4.553	(1.7925)
Fourth stage rotor	5.314	(2.0923)
Fourth stage stator	6.074	(2.3914)
Fifth stage rotor	6.841	(2.6931)
Fifth stage stator	7.594	(2.9898)

TABLE 4.- BLADE SECTION GEOMETRIC PROPERTIES WITH ASSIGNED INCIDENCE ANGLES AND ESTIMATED DEVIATION ANGLES FOR CONICAL APPROXIMATE STREAM SURFACES

	Radius to leading edge center, cm(in.)	Radius to trailing edge center, cm(in.)	Maximum thickness, cm(in.)	Location of maximum thickness as fraction of chord	Location of maximum camber as fraction of chord	Chord length, cm(in.)	Solidity	i_{ss}, deg	δ_{adj}, deg	δ, deg
	4.5662 (1.7977)	4.5616 (1.7959)	0.0381 (0.0150)	0.700	0.586	0.76 (0.30)	1.3020	2.00	1.32	3.73
	4.4237 (1.7416)	4.4252 (1.7422)	.0391 (.0154)	.690	.430	.76 (.30)	1.3430	2.32	0.80	2.96
	4.1217 (1.6227)	4.1407 (1.6302)	.0411 (.0162)	.674	.365	.76 (.30)	1.4384	2.97	0.10	2.03
First rotor	3.7902 (1.4922)	3.8364 (1.5104)	.0434 (.0171)	.655	.350	.76 (.30)	1.5583	3.70	0.30	2.58
	3.4171 (1.3453)	3.5060 (1.3803)	.0460 (.0181)	.635	.347	.76 (.30)	1.7166	4.51	1.59	4.87
	2.9832 (1.1745)	3.1382 (1.2355)	.0490 (.0193)	.612	.340	.76 (.30)	1.9415	5.45	3.15	7.73
	2.7318 (1.0755)	2.[illegible]352 (1.1556)	.0508 (.0200)	.601	.411	.76 (.30)	2.0972	5.99	5.31	10.93
	4.5573 (1.7942)	4.5499 (1.7913)	.0508 (.0200)	.500	.500	.64 (.25)	1.1760	0.00	8.70	17.93
	4.4270 (1.7429)	4.4328 (1.7452)	.0508 (.0200)	.500	.500	.64 (.25)	1.2088	.00	5.90	14.27
	4.1567 (1.6365)	4.1905 (1.6498)	.0508 (.0200)	.500	.500	.64 (.25)	1.2831	.00	3.89	11.56
First stator	3.8692 (1.5233)	3.9345 (1.5490)	.0508 (.0200)	.500	.500	.64 (.25)	1.3724	.00	2.98	10.37
	3.5570 (1.4004)	3.6589 (1.4405)	.0508 (.0200)	.500	.500	.64 (.25)	1.4842	.00	2.39	9.75
	3.2106 (1.2640)	3.3543 (1.3206)	.0508 (.0200)	.500	.500	.64 (.25)	1.6314	.00	2.12	9.48
	3.0198 (1.1889)	3.1859 (1.2543)	.0508 (.0200)	.500	.500	.64 (.25)	1.7258	.00	3.39	11.02
	4.5494 (1.7911)	4.5507 (1.7916)	.0384 (.0151)	.598	.552	.64 (.25)	1.0440	.00	1.29	4.88
	4.4384 (1.7474)	4.4447 (1.7499)	.0394 (.0155)	.586	.555	.64 (.25)	1.0695	.00	0.71	4.00
	4.2093 (1.6572)	4.2291 (1.6650)	.0417 (.0164)	.564	.545	.64 (.25)	1.1258	.00	0.02	3.03
Second rotor	3.9677 (1.5621)	4.0051 (1.5768)	.0439 (.0173)	.539	.532	.64 (.25)	1.1916	.00	0.39	3.84
	3.7081 (1.4599)	3.7689 (1.4838)	.0462 (.0182)	.514	.512	.64 (.25)	1.2706	.00	1.69	6.17
	3.4219 (1.3472)	3.5146 (1.3837)	.0490 (.0193)	.500	.500	.64 (.25)	1.3696	.00	3.14	8.91
	3.2639 (1.2850)	3.3782 (1.3300)	.0505 (.0199)	.500	.500	.64 (.25)	1.4303	.00	5.00	11.87
	4.5517 (1.7920)	4.5537 (1.7928)	.0381 (.0150)	.500	.500	.64 (.25)	1.1320	.00	8.68	18.86
	4.4508 (1.7523)	4.4630 (1.7571)	.0381 (.0150)	.500	.500	.64 (.25)	1.1563	.00	5.80	15.04
	4.2459 (1.6716)	4.2784 (1.6844)	.0381 (.0150)	.500	.500	.64 (.25)	1.2092	.00	3.79	12.20
Second stator	4.0330 (1.5878)	4.0874 (1.6092)	.0381 (.0150)	.500	.500	.64 (.25)	1.2693	.00	2.90	11.00
	3.8087 (1.4995)	3.8870 (1.5303)	.0381 (.0150)	.500	.500	.64 (.25)	1.3393	.00	2.32	10.44
	3.5674 (1.4045)	3.6733 (1.4462)	.0381 (.0150)	.500	.500	.64 (.25)	1.4235	.00	2.20	10.63
	3.4381 (1.3536)	3.5596 (1.4014)	.0381 (.0150)	.500	.500	.64 (.25)	1.4729	.00	3.39	12.29
	4.5542 (1.7930)	4.5550 (1.7933)	.0384 (.0151)	.060	.541	.64 (.25)	0.9980	.00	1.29	4.84
	4.4671 (1.7587)	4.4713 (1.7603)	.0394 (.0155)	.058	.544	.64 (.25)	1.0171	.00	0.70	3.87
	4.2898 (1.6889)	4.3015 (1.6935)	.0417 (.0164)	.056	.537	.64 (.25)	1.0582	.00	0.01	2.77
Third rotor	4.1062 (1.6166)	4.1280 (1.6252)	.0442 (.0174)	.054	.522	.64 (.25)	1.1041	.00	0.41	3.49
	3.9139 (1.5409)	3.9477 (1.5542)	.0465 (.0183)	.051	.510	.64 (.25)	1.1564	.00	1.75	5.77
	3.7084 (1.4600)	3.7577 (1.4794)	.0493 (.0194)	.050	.500	.64 (.25)	1.2176	.00	3.20	8.30
	3.5992 (1.4170)	3.6581 (1.4402)	.0505 (.0199)	.050	.500	.64 (.25)	1.2527	.00	5.00	11.07
	4.5555 (1.7935)	4.5568 (1.7940)	.0381 (.0150)	.500	.500	.64 (.25)	1.0870	.00	8.68	19.10
	4.4742 (1.7615)	4.4808 (1.7641)	.0381 (.0150)	.500	.500	.64 (.25)	1.1061	.00	5.79	15.25
	4.3104 (1.6970)	4.3274 (1.7037)	.0381 (.0150)	.500	.500	.64 (.25)	1.1467	.00	3.74	12.36
Third stator	4.1422 (1.6308)	4.1704 (1.6419)	.0381 (.0150)	.500	.500	.64 (.25)	1.1915	.00	2.90	11.25
	3.9675 (1.5620)	4.0076 (1.5778)	.0381 (.0150)	.500	.500	.64 (.25)	1.2420	.00	2.31	10.72
	3.7826 (1.4892)	3.8359 (1.5102)	.0381 (.0150)	.500	.500	.64 (.25)	1.3001	.00	2.20	10.96
	3.6853 (1.4509)	3.7452 (1.4745)	.0381 (.0150)	.500	.500	.64 (.25)	1.3330	.00	3.39	12.65
	4.5770 (1.7941)	4.5575 (1.7943)	.0384 (.0151)	.500	.500	.64 (.25)	0.9540	.00	1.29	4.38
	4.4831 (1.7650)	4.5856 (1.7660)	.0394 (.0155)	.500	.500	.64 (.25)	0.9695	.00	0.70	3.31
	4.3337 (1.7062)	4.3411 (1.7091)	.0419 (.0165)	.500	.500	.64 (.25)	1.0023	.00	0.01	2.04
Fourth rotor	4.1811 (1.6461)	4.1943 (1.6513)	.0442 (.0174)	.500	.500	.64 (.25)	1.0382	.00	0.47	2.76
	4.0226 (1.5837)	4.0432 (1.5918)	.0467 (.0184)	.500	.500	.64 (.25)	1.0780	.00	1.79	6.88
	3.8552 (1.5178)	3.8849 (1.5295)	.0493 (.0194)	.500	.500	.64 (.25)	1.1234	.00	3.20	7.27
	3.7668 (1.4830)	3.8026 (1.4971)	.0505 (.0199)	.500	.500	.64 (.25)	1.1488	.00	5.00	10.05
	4.5580 (1.7945)	4.5585 (1.7947)	.0381 (.0150)	.500	.500	.64 (.25)	1.0420	.00	8.68	19.15
	4.4877 (1.7668)	4.4925 (1.7687)	.0381 (.0150)	.500	.500	.64 (.25)	1.0578	.00	5.72	15.11
	4.3470 (1.7114)	4.3599 (1.7165)	.0381 (.0150)	.500	.500	.64 (.25)	1.0910	.00	3.72	12.20
Fourth stator	4.2042 (1.6552)	4.2248 (1.6633)	.0381 (.0150)	.500	.500	.64 (.25)	1.1270	.00	2.88	11.04
	4.0569 (1.5972)	4.0856 (1.6085)	.0381 (.0150)	.500	.500	.64 (.25)	1.1667	.00	2.30	10.46
	3.9025 (1.5364)	3.9400 (1.5512)	.0381 (.0150)	.500	.500	.64 (.25)	1.2113	.00	2.20	10.68
	3.8217 (1.5046)	3.8638 (1.5212)	.0381 (.0150)	.500	.500	.64 (.25)	1.2360	.00	3.39	12.41
	4.5590 (1.7949)	4.5593 (1.7950)	.0384 (.0151)	.500	.500	.64 (.25)	0.9090	.00	1.28	3.97
	4.4945 (1.7695)	4.4966 (1.7703)	.0396 (.0156)	.500	.500	.64 (.25)	0.9219	.00	0.70	2.81
	4.3652 (1.7186)	4.3708 (1.7208)	.0419 (.0165)	.500	.500	.64 (.25)	0.9488	.00	0.01	1.47
Fifth rotor	4.2337 (1.6668)	4.2436 (1.6707)	.0442 (.0174)	.500	.500	.64 (.25)	0.9778	.00	0.49	2.18
	4.0970 (1.6133)	4.1133 (1.6194)	.0467 (.0184)	.500	.500	.64 (.25)	1.0095	.00	1.81	4.28
	3.9558 (1.5574)	3.9781 (1.5662)	.0493 (.0194)	.500	.500	.64 (.25)	1.0447	.00	3.21	6.60
	3.8814 (1.5281)	3.9085 (1.5387)	.0505 (.0199)	.500	.500	.64 (.25)	1.0640	.00	5.00	9.35
	4.5598 (1.7952)	4.5603 (1.7954)	.0381 (.0150)	.500	.500	.64 (.25)	0.9970	.00	8.62	19.03
	4.4983 (1.7710)	4.5022 (1.7725)	.0351 (.0350)	.500	.500	.64 (.25)	1.0102	.00	5.70	15.00
	4.3757 (1.7227)	4.3856 (1.7266)	.0381 (.0150)	.500	.500	.64 (.25)	1.0378	.00	3.70	12.06
Fifth stator	4.2515 (1.6738)	4.2677 (1.6802)	.0381 (.0150)	.500	.500	.64 (.25)	1.0673	.00	2.82	10.83
	4.1242 (1.6237)	4.1478 (1.6330)	.0381 (.0150)	.500	.600	.64 (.25)	1.0992	.00	2.30	10.26
	3.9926 (1.5719)	4.0249 (1.5846)	.0381 (.0150)	.500	.500	.64 (.25)	1.1341	.00	2.24	10.48
	3.9246 (1.5451)	3.9619 (1.5598)	.0381 (.0150)	.500	.500	.64 (.25)	1.1529	.00	3.39	12.08

TABLE 5.- COMBUSTOR CHARACTERISTICS

Run	Inlet Press. Atm.	Inlet Air Flow*		Air/Fuel Ratio	Inlet Temp. °F	Avg. Exit Temp. °F	Theoret. Temp. °F	Combustion Efficiency Percent	ΔTVR	$\Delta P/P_T$	Inlet Velocity		Reference Velocity	
		kg/sec	lbs/sec								m/sec	ft/sec	m/sec	ft/sec
23	4.587	0.833	(1.837)	154	433	1331	1647	73.9	2.06	N.A.	149.0	(489)	45.4	(149)
24	4.964	.869	(1.916)	166	427	1161	1586	63.3	2.20	N.A.	142.6	(468)	43.6	(143)
25	4.860	.871	(1.921)	209	406	1024	1347	65.6	2.05	N.A.	142.6	(468)	44.5	(146)
26	4.513	.851	(1.877)	236	427	1096	1260	80.3	2.31	N.A.	153.6	(504)	47.2	(155)
27	4.923	.910	(2.007)	237	417	1109	1245	83.6	2.36	N.A.	149.0	(489)	44.8	(147)
28	4.573	.806	(1.777)	195	412	1171	1406	76.2	1.92	N.A.	141.4	(464)	42.7	(140)
29	5.259	.885	(1.952)	189	428	1167	1451	72.1	2.03	N.A.	137.2	(450)	41.5	(136)
30	4.547	.892	(1.967)	303	398	887	1067	72.9	1.64	N.A.	154.8	(508)	48.2	(158)
31	4.840	.858	(1.892)	184	426	1209	1466	75.2	1.77	N.A.	144.2	(473)	43.3	(142)
32	5.060	.886	(1.953)	173	415	1302	1508	81.1	1.51	N.A.	140.8	(462)	40.5	(133)
33	4.945	.883	(1.946)	174	407	1288	1498	81.0	1.63	N.A.	142.0	(466)	43.3	(142)
34	4.938	.867	(1.911)	168	416	1296	1537	78.4	1.66	0.83	141.4	(464)	43.0	(141)
35	4.934	.878	(1.936)	167	420	1221	1563	70.0	1.88	0.97	143.9	(472)	43.0	(141)
36	5.368	.830	(1.830)	134	268	1324	1652	76.3	1.52	0.167	136.9	(449)	30.2	(99)

*Includes hydrogen added and burned to heat to desired temperature.

TABLE 6.- TURBINE DESIGN PARAMETERS
(see figure 4)

	Initial	Final
Inlet Total Temperature, °K(°R)	1217(2190)	1217(2190)
Inlet Total Pressure, N/cm^2 $(lbs/in.^2)$	40.88(59.30)	40.88(59.30)
Inlet Gas Flow, kg/sec(lbs/sec)	0.86(1.90)	0.86(1.90)
Output Energy, J/kg(Btu/lb)	$208.2x10^3$(89.50)	$208.2x10^3$(89.50)
Output Power, horsepower	240	240
Exhaust Static Pressure, N/cm^2 $(16/in.^2)$	16.70(24.23)	15.88(23.03)
Exhaust Total Pressure, N/cm^2 $(16/in.^2)$	19.89(28.85)	19.49(28.27)
Rotational Speed, rpm	82,500	78,000
Exit Axial Mach Number	0.487	0.498
Tip Diameter, cm(in.)	10.16(4.00)	10.16(4.00)
Inlet Radius Ratio	0.655	0.655
Exit Radius Ratio	0.590	0.577
Total to Static Pressure Ratio	2.45	2.58
Total to Total Pressure Ratio	2.06	2.10
Pitch Wheel Speed, U, m/sec(ft/sec)	349(1145)	327(1074)
Stage Velocity Ratio, U/V_{is}	0.457	0.419
Stage Loading Parameter, $gJ\Delta h/U^2$	0.854	0.970
Estimated Adiabatic Efficiency	0.850	0.807
Root Reaction	0.102	0.129
Mean Swirl Angle, deg	21	28

TABLE 7.- COMPUTER PRINT-OUT FOR INITIAL TURBINE DESIGN*

DIAMETER (IN)	PS (PSIA)	TS (R)	V (FPS)	VU (FPS)	VZ (FPS)	ALP (DEG)
STATIØN	1					
2.620	56.71	2166.8	587.1	0.	587.1	90.00
3.310	56.71	2166.8	587.1	0.	587.1	90.00
4.000	56.71	2166.8	587.1	0.	587.1	90.00

EFFECTIVE AREA = 6.8163235E+00

DIAMETER (IN)	PS (PSIA)	TS (R)	V (FPS)	VU (FPS)	VZ (FPS)	ALP (DEG)
STATIØN	2					
2.500	26.35	1815.1	2362.3	2222.3	801.0	19.82
3.250	35.67	1950.6	1887.8	1709.5	801.0	25.11
4.000	41.08	2017.3	1603.4	1389.0	801.0	29.97

EFFECTIVE AREA = 7.2747444E+00

DIAMETER (IN)	PS (PSIA)	TS (R)	V (FPS)	VU (FPS)	VZ (FPS)	ALP (DEG)
STATIØN	3					
2.500	26.35	1815.1	2362.3	2222.3	801.0	19.82
3.250	35.67	1950.6	1887.8	1709.5	801.0	25.11
4.000	41.08	2017.3	1603.4	1389.0	801.0	29.97

EFFECTIVE AREA = 7.2747444E+00

DIAMETER (IN)	PS (PSIA)	TS (R)	V (FPS)	VU (FPS)	VZ (FPS)	ALP (DEG)
STATIØN	4					
2.360	23.78	1783.1	1116.6	511.4	992.7	62.74
3.180	24.23	1791.0	1062.7	379.5	992.7	69.08
4.000	24.43	1794.5	1037.5	301.7	992.7	73.09

EFFECTIVE AREA = 7.7824095E+00

SL	BETA1	BETA2	TTB	PTB	R1	R2	U1	U2
1	31.20	36.11	1975.7	37.64	1546.1	1684.5	899.9	849.5
2	56.03	33.07	2013.2	40.74	965.8	1819.0	1169.9	1144.7
3	93.64	29.68	2060.6	44.92	802.6	2004.6	1439.9	1439.9

SL	MR1	MR2	LØAD	RX	DELBET	NDØ-NZ	NDØ-BK	ZWIEN	ZWIEB
1	0.753	0.828	1.553	0.102	112.69	2.609	4.259	0.504	1.381
2	0.454	0.892	0.855	0.406	90.89	4.245	5.314	0.613	1.002
3	0.371	0.982	0.540	0.560	56.68	6.151	6.065	0.682	0.689

EFF	EFN	EFB	TF	CF	DW	DP	MF
0.873	0.960	0.950	0.922	0.950	0.	0.	0.467

ESD	RPM	WD	TI	T4	PI	P4	GAMA
89.50	82500.	1.900	2190.0	1888.9	59.30	28.85	1.3120

BLADE LØADS

FAX NØZ	FTAN NØZ	FAX BUC	FTAN BUC
140.45	100.03	77.67	114.35

ØVERALL PERFØRMANCE

PO	TO	WO	RG	RCUO
59.30	2190.0	1.900	55.010	0.

TO/TEX	PO/PEX	PO/PSEX	PO/PAX
1.159	2.055	2.447	2.101

ETAT	ETAS	ETAA	AVG GAMA
0.873	0.717	0.850	1.3120

*For definition of symbols see NOMENCLATURE FOR COMPUTER PROGRAM "TURBINE" in Appendix E.

TABLE 8.- COMPUTER PRINT-OUT FOR FINAL TURBINE DESIGN*

DIAMETER (IN)	PS (PSIA)	TS (R)	V (FPS)	VU (FPS)	VZ (FPS)	ALP (DEG)
STATIØN 1						
2.620	56.71	2166.9	587.0	0.	587.0	90.00
3.310	56.71	2166.9	587.0	0.	587.0	90.00
4.000	56.71	2166.9	587.0	0.	587.0	90.00
EFFECTIVE AREA = 6.8163235E+00						
STATIØN 2						
2.460	25.46	1800.5	2407.8	2273.9	791.9	19.20
3.230	35.33	1946.4	1904.3	1731.8	791.9	24.57
4.000	41.00	2016.5	1607.1	1398.4	791.9	29.52
EFFECTIVE AREA = 7.4227760E+00						
STATIØN 3						
2.460	25.46	1800.5	2407.8	2273.9	791.9	19.20
3.230	35.33	1946.4	1904.3	1731.8	791.9	24.57
4.000	41.00	2016.5	1607.1	1398.4	791.9	29.52
EFFECTIVE AREA = 7.4227760E+00						
STATIØN 4						
2.311	22.11	1753.8	1254.0	742.6	1010.5	53.69
3.155	23.03	1771.0	1147.6	543.9	1010.5	61.71
4.000	23.44	1778.5	1097.8	429.1	1010.5	66.99
EFFECTIVE AREA = 7.9531826E+00						

SL	BETA1	BETA2	TTB	PTB	R1	R2	U1	U2
1	28.86	33.46	1981.3	38.07	1640.5	1832.9	837.2	786.5
2	51.38	31.99	2015.4	40.90	1013.5	1907.5	1099.3	1073.9
3	87.32	29.44	2058.7	44.73	792.8	2055.9	1361.4	1361.4

SL	MR1	MR2	LØAD	RX	DELBET	ND0-NZ	ND0-BK	ZWIEN	ZWIEB
1	0.802	0.908	1.811	0.129	117.68	2.490	3.901	0.492	1.272
2	0.477	0.941	0.972	0.425	96.63	4.134	5.119	0.606	0.988
3	0.366	1.012	0.605	0.576	63.24	6.067	6.020	0.679	0.707

EFF	EFN	EFR	TF	CF	DW	DP	MF
0.851	0.960	0.950	0.900	0.950	0.	0.	0.498

ESD	RPM	WD	TI	T4	PI	P4	GAMA
89.50	78000.	1.900	2190.0	1888.9	59.30	28.27	1.3120

BLADE LØADS

FAX NØZ	FTAN NØZ	FAX BUC	FTAN BUC
146.59	101.02	84.90	121.79

ØVERALL PERFØRMANCE

PO	TO	WO	RG	RCUO
59.30	2190.0	1.900	55.010	0.

TO/TEX	PO/PEX	PO/PSEX	PO/PAX
1.159	2.097	2.575	2.194

ETAT	ETAS	ETAA	AVG GAMA
0.851	0.683	0.807	1.3120

*For definition of symbols see NOMENCLATURE FOR COMPUTER PROGRAM "TURBINE" in Appendix E.

TABLE 9.- NOZZLE DESIGN PARAMETERS

	Hub	Pitch	Tip
Initial Design: (24 nozzles)			
Diameter, cm(in.)	6.35(2.50)	8.26(3.25)	10.16(4.00)
W, cm(in.)	1.016(0.400)	1.232(0.485)	1.473(0.580)
α, deg	19.82	25.11	29.97
d_o, cm(in.)	0.265(0.104)	0.448(0.176)	0.652(0.257)
Z	0.422	0.538	0.615
Unguided turning, deg	1.7	6.8	3.9
Final Design: (24 nozzles)			
Diameter, cm(in.)	6.25(2.46)	8.20(3.23)	10.16(4.00)
W, cm(in.)	1.016(0.400)	1.245(0.490)	1.473(0.580)
α, deg	19.20	24.57	29.52
d_o, cm(in.)	0.254(0.100)	0.431(0.170)	0.632(0.249)
Z	0.396	0.523	0.614
Unguided turning, deg	5.4	5.0	5.2

TABLE 10.- BUCKET DESIGN PARAMETERS

	Hub	Pitch	Tip
Initial Design: (27 buckets)			
Diameter, cm(in.)	5.99(2.36)	8.08(3.18)	10.16(4.00)
W, cm(in.)	1.240(.488)	1.189(.468)	1.019(.401)
β_1, deg	31.2	56.0	93.6
β_2, deg	36.11	33.07	29.68
d_o, cm(in.)	0.409(.161)	0.513(.202)	0.587(.231)
Z	0.800	0.800	0.800
Unguided turning, deg	9.5	8.6	9.1
Final Design: (24 buckets)			
Diameter, cm(in.)	5.87(2.31)	8.00(3.15)	10.16(4.00)
W, cm(in.)	1.262(.497)	1.280(.504)	1.173(.462)
β_1, deg	26.0	48.6	87.3
β_2, deg	33.46	31.99	29.44
d_o, cm(in.)	0.417(.164)	0.546(.215)	0.645(.254)
Z	0.800	0.800	0.800
Unguided turning, deg	9.0	8.0	6.6

TABLE 11.- TURBINE BLADE SECTIONS

4-Stage Engine (Initial Design)

Buckets

Chord Station		Lower Ordinate		Upper Ordinate	
cm	(in.)	cm	(in.)	cm	(in.)
Root Section					
0.015	(0.006)	0.015	(0.006)	Center of L.E. radius	
.023	(.009)	-	-	0.058	(0.023)
.074	(.029)	.056	(.022)	.142	(.056)
.124	(.049)	.107	(.042)	.221	(.087)
.175	(.069)	.150	(.059)	.297	(.117)
.226	(.089)	.188	(.074)	.363	(.143)
.277	(.109)	.218	(.086)	.417	(.164)
.328	(.129)	.246	(.097)	.462	(.182)
.378	(.149)	.269	(.106)	.500	(.197)
.429	(.169)	.287	(.113)	.528	(.208)
.480	(.189)	.302	(.119)	.551	(.217)
.531	(.209)	.312	(.123)	.564	(.222)
.582	(.229)	.317	(.125)	.571	(.225)
.632	(.249)	.317	(.125)	.571	(.225)
.683	(.269)	.315	(.124)	.564	(.222)
.734	(.289)	.307	(.121)	.549	(.216)
.785	(.309)	.297	(.117)	.528	(.208)
.836	(.329)	.282	(.111)	.498	(.196)
.886	(.349)	.262	(.103)	.460	(.181)
.937	(.369)	.236	(.093)	.411	(.162)
.988	(.389)	.208	(.082)	.358	(.141)
1.039	(.409)	.173	(.068)	.295	(.116)
1.090	(.429)	.132	(.052)	.229	(.090)
1.140	(.449)	.086	(.034)	.163	(.064)
1.191	(.469)	.030	(.012)	.089	(.035)
1.227	(.483)	.015	(.006)	Center of T.E. radius	
1.242	(.489)	Total chord length			
	L.E. radius = 0.015cm (0.006 in.)				
	T.E. radius = 0.015cm (0.006 in.)				
Pitch Section					
0.015	(0.006)	0.648	(0.255)	Center of L.E. radius	
.020	(.008)	.632	(.249)	.678	(0.267)
.071	(.028)	.645	(.254)	.724	(.285)
.122	(.048)	.658	(.259)	.757	(.298)
.173	(.068)	.665	(.262)	.785	(.309)
.224	(.088)	.671	(.264)	.805	(.317)
.274	(.108)	.673	(.265)	.820	(.323)
.325	(.128)	.673	(.265)	.828	(.326)
.376	(.148)	.668	(.263)	.831	(.327)
.427	(.168)	.660	(.260)	.825	(.325)
.478	(.188)	.648	(.255)	.815	(.321)
.528	(.208)	.630	(.248)	.800	(.315)
.579	(.228)	.607	(.239)	.777	(.306)
.630	(.248)	.579	(.228)	.747	(.294)
.681	(.268)	.546	(.215)	.709	(.279)
.732	(.288)	.508	(.200)	.663	(.261)
.782	(.308)	.465	(.183)	.607	(.239)
.833	(.328)	.417	(.164)	.549	(.216)
.884	(.348)	.381	(.150)	.483	(.190)
.935	(.368)	.305	(.120)	.411	(.162)
.986	(.388)	.244	(.096)	.338	(.133)
1.036	(.408)	.178	(.070)	.259	(.102)
1.087	(.428)	.109	(.043)	.180	(.071)
1.138	(.448)	.038	(.015)	.097	(.038)
1.173	(.462)	.015	(.006)	Center of T.E. radius	
1.188	(.468)	Total chord length			
	L.E. radius = 0.015cm (0.006 in.)				
	T.E. radius = 0.015cm (0.006 in.)				
Tip Section					
0.020	(0.008)	1.021	(0.402)	Center of L.E. radius	
.061	(.024)	.991	(.390)	1.046	(0.412)
.112	(.044)	.973	(.383)	1.049	(.413)
.163	(.064)	.950	(.374)	1.049	(.413)
.213	(.084)	.927	(.365)	1.041	(.410)
.264	(.104)	.899	(.354)	1.026	(.404)
.315	(.124)	.866	(.341)	1.006	(.396)
.366	(.144)	.828	(.326)	.980	(.386)
.417	(.164)	.785	(.309)	.945	(.372)
.467	(.184)	.739	(.291)	.902	(.355)
.518	(.204)	.686	(.270)	.848	(.334)
.569	(.224)	.630	(.248)	.787	(.310)
.620	(.244)	.566	(.223)	.714	(.281)
.671	(.264)	.498	(.196)	.635	(.250)
.721	(.284)	.427	(.168)	.549	(.216)
.772	(.304)	.353	(.139)	.462	(.182)
.823	(.324)	.274	(.108)	.371	(.146)
.874	(.344)	.198	(.078)	.284	(.112)
.925	(.364)	.119	(.047)	.196	(.077)
.975	(.384)	.041	(.016)	.107	(.042)
1.001	(.394)	.015	(.006)	Center of T.E. radius	
1.026	(.404)	Total chord length			
	L.E. radius = 0.020cm (0.008 in.)				
	T.E. radius = 0.015cm (0.006 in.)				

Nozzles

Chord Station		Lower Ordinate		Upper Ordinate	
cm	(in.)	cm	(in.)	cm	(in.)
Root Section					
0.069	(0.027)	0.922	(0.363)	Center of L.E. radius	
.079	(.031)	.848	(.334)	1.013	(0.399)
.130	(.051)	.833	(.328)	1.036	(.408)
.180	(.071)	.818	(.322)	1.057	(.416)
.231	(.091)	.798	(.314)	1.069	(.421)
.282	(.111)	.777	(.306)	1.077	(.424)
.333	(.131)	.752	(.296)	1.077	(.424)
.384	(.151)	.726	(.286)	1.072	(.422)
.434	(.171)	.696	(.274)	1.062	(.418)
.485	(.191)	.663	(.261)	1.046	(.412)
.536	(.211)	.625	(.246)	1.019	(.401)
.587	(.231)	.582	(.229)	.983	(.387)
.638	(.251)	.536	(.211)	.935	(.368)
.688	(.271)	.483	(.190)	.864	(.340)
.739	(.291)	.422	(.166)	.749	(.295)
.790	(.311)	.353	(.139)	.602	(.237)
.841	(.331)	.274	(.108)	.455	(.179)
.892	(.351)	.180	(.071)	.305	(.120)
.942	(.371)	.074	(.029)	.157	(.062)
.983	(.387)	.010	(.004)	Center of T.E. radius	
.993	(.391)	Total chord length			
	L.E. radius = 0.071cm (0.028 in.)				
	T.E. radius = 0.010cm (0.004 in.)				
Pitch Section					
0.071	(0.028)	1.003	(0.395)	Center of L.E. radius	
.066	(.026)	.930	(.366)	1.090	(0.429)
.117	(.046)	.914	(.360)	1.118	(.440)
.168	(.066)	.899	(.354)	1.138	(.448)
.218	(.086)	.884	(.348)	1.153	(.454)
.269	(.106)	.869	(.342)	1.163	(.458)
.320	(.126)	.851	(.335)	1.168	(.460)
.371	(.146)	.833	(.328)	1.166	(.459)
.422	(.166)	.813	(.320)	1.161	(.457)
.472	(.186)	.790	(.311)	1.148	(.452)
.523	(.206)	.767	(.307)	1.130	(.445)
.574	(.226)	.742	(.292)	1.107	(.436)
.625	(.246)	.714	(.281)	1.077	(.424)
.676	(.266)	.683	(.269)	1.039	(.409)
.726	(.286)	.650	(.256)	.991	(.390)
.777	(.306)	.615	(.242)	.932	(.367)
.828	(.326)	.571	(.225)	.859	(.338)
.879	(.346)	.526	(.207)	.772	(.304)
.930	(.366)	.472	(.186)	.676	(.266)
.980	(.386)	.411	(.162)	.569	(.224)
1.031	(.406)	.343	(.135)	.460	(.181)
1.082	(.426)	.264	(.104)	.348	(.137)
1.133	(.446)	.173	(.068)	.236	(.093)
1.184	(.466)	.069	(.027)	.122	(.048)
1.224	(.482)	.010	(.004)	Center of T.E. radius	
1.234	(.486)	Total chord length			
	L.E. radius = 0.071cm (0.028 in.)				
	T.E. radius = 0.010cm (0.004 in.)				
Tip Section					
0.071	(0.028)	1.173	(0.462)	Center of L.E. radius	
.053	(.021)	1.102	(.434)	1.260	(0.496)
.104	(.041)	1.085	(.427)	1.280	(.504)
.155	(.061)	1.067	(.420)	1.303	(.513)
.206	(.081)	1.049	(.413)	1.321	(.520)
.257	(.101)	1.031	(.406)	1.331	(.524)
.307	(.121)	1.011	(.398)	1.339	(.527)
.358	(.141)	.991	(.390)	1.341	(.528)
.460	(.181)	.945	(.372)	1.331	(.524)
.511	(.201)	.922	(.363)	1.318	(.519)
.561	(.221)	.894	(.352)	1.300	(.512)
.612	(.241)	.869	(.342)	1.275	(.502)
.663	(.261)	.838	(.330)	1.245	(.490)
.714	(.281)	.808	(.318)	1.207	(.475)
.765	(.301)	.775	(.305)	1.161	(.457)
.815	(.321)	.739	(.291)	1.105	(.435)
.866	(.341)	.704	(.277)	1.041	(.410)
.917	(.361)	.663	(.261)	.968	(.381)
.968	(.381)	.620	(.244)	.886	(.349)
1.019	(.401)	.574	(.226)	.800	(.315)
1.069	(.421)	.526	(.207)	.714	(.281)
1.120	(.441)	.472	(.186)	.625	(.246)
1.171	(.461)	.414	(.163)	.538	(.212)
1.222	(.481)	.353	(.139)	.450	(.177)
1.273	(.501)	.284	(.112)	.363	(.143)
1.323	(.521)	.213	(.084)	.277	(.109)
1.374	(.541)	.135	(.053)	.188	(.074)
1.425	(.561)	.053	(.021)	.102	(.040)
1.466	(.577)	.010	(.004)	Center of T.E. radius	
1.476	(.581)	Total chord length			
	L.E. radius = 0.071cm (0.028 in.)				
	T.E. radius = 0.010cm (0.004 in.)				

TABLE 12.- TURBINE BLADE SECTIONS

5-Stage Engine (Final Design)

Buckets

Chord Station		Lower Ordinate		Upper Ordinate	
cm	(in.)	cm	(in.)	cm	(in.)
Root Section					
0.015	(0.006)	0.015	(0.006)	Center of L.E. radius	
.051	(.020)	.036	(.014)	0.124	(0.049)
.102	(.040)	.104	(.041)	.229	(.090)
.152	(.060)	.163	(.064)	.328	(.129)
.203	(.080)	.213	(.084)	.417	(.164)
.254	(.100)	.259	(.102)	.493	(.194)
.305	(.120)	.300	(.118)	.559	(.220)
.356	(.140)	.333	(.131)	.615	(.242)
.406	(.160)	.361	(.142)	.660	(.260)
.457	(.180)	.384	(.151)	.693	(.273)
.508	(.200)	.404	(.159)	.721	(.284)
.559	(.220)	.417	(.164)	.739	(.291)
.610	(.240)	.427	(.168)	.749	(.295)
.660	(.260)	.432	(.170)	.752	(.296)
.711	(.280)	.434	(.171)	.747	(.294)
.762	(.300)	.432	(.170)	.734	(.289)
.813	(.320)	.424	(.167)	.714	(.281)
.864	(.340)	.411	(.162)	.683	(.269)
.914	(.360)	.396	(.156)	.638	(.251)
.965	(.380)	.376	(.148)	.582	(.229)
1.016	(.400)	.348	(.137)	.518	(.204)
1.067	(.420)	.315	(.124)	.449	(.177)
1.118	(.440)	.272	(.107)	.378	(.149)
1.168	(.460)	.221	(.087)	.302	(.119)
1.219	(.480)	.157	(.062)	.221	(.087)
1.247	(.491)	.147	(.058)	Center of T.L. radius	
1.262	(.497)	Total chord length			
		L.L. radius = 0.015cm (0.006 in.)			
		T.E. radius = 0.015cm (0.006 in.)			
Pitch Section					
0.015	(0.006)	0.594	(0.234)	Center of L.L. radius	
.051	(.020)	.589	(.232)	0.665	(0.262)
.102	(.040)	.610	(.240)	.716	(.282)
.152	(.060)	.627	(.247)	.762	(.300)
.203	(.080)	.640	(.252)	.798	(.314)
.254	(.100)	.653	(.257)	.838	(.326)
.305	(.120)	.660	(.260)	.851	(.335)
.356	(.140)	.663	(.261)	.866	(.341)
.406	(.160)	.665	(.262)	.876	(.345)
.457	(.180)	.663	(.261)	.881	(.347)
.508	(.200)	.655	(.258)	.879	(.346)
.559	(.220)	.645	(.254)	.871	(.343)
.610	(.240)	.630	(.248)	.858	(.338)
.660	(.260)	.612	(.241)	.838	(.330)
.711	(.280)	.589	(.232)	.808	(.318)
.762	(.300)	.559	(.220)	.772	(.304)
.813	(.320)	.526	(.207)	.724	(.285)
.864	(.340)	.488	(.192)	.665	(.262)
.914	(.360)	.442	(.174)	.599	(.236)
.965	(.380)	.391	(.154)	.528	(.208)
1.016	(.400)	.335	(.132)	.452	(.178)
1.067	(.420)	.274	(.108)	.371	(.146)
1.118	(.440)	.208	(.082)	.289	(.114)
1.168	(.460)	.135	(.053)	.208	(.082)
1.219	(.480)	.056	(.022)	.122	(.048)
1.262	(.497)	.015	(.006)	Center of T.E. radius	
1.278	(.503)	Total chord length			
		L.E. radius = 0.015cm (0.006 in.)			
		T.E. radius = 0.015cm (0.006 in.)			
Tip Section					
0.020	(0.008)	1.201	(0.473)	Center of L.E. radius	
.020	(.008)	1.176	(.463)	1.229	(0.484)
.051	(.020)	1.166	(.459)	1.247	(.491)
.102	(.040)	1.148	(.452)	1.260	(.496)
.152	(.060)	1.135	(.447)	1.265	(.498)
.203	(.080)	1.118	(.440)	1.265	(.498)
.254	(.100)	1.097	(.432)	1.255	(.494)
.305	(.120)	1.074	(.423)	1.240	(.488)
.356	(.140)	1.049	(.413)	1.217	(.479)
.406	(.160)	1.016	(.400)	1.184	(.466)
.457	(.180)	.975	(.384)	1.143	(.450)
.508	(.200)	.930	(.366)	1.095	(.431)
.559	(.220)	.876	(.345)	1.036	(.408)
.610	(.240)	.818	(.322)	.973	(.383)
.660	(.260)	.754	(.297)	.902	(.355)
.711	(.280)	.686	(.270)	.828	(.326)
.762	(.300)	.615	(.242)	.747	(.294)
.813	(.320)	.536	(.211)	.663	(.261)
.864	(.340)	.457	(.180)	.574	(.226)
.914	(.360)	.378	(.149)	.485	(.191)
.965	(.380)	.297	(.117)	.396	(.156)
1.016	(.400)	.216	(.085)	.302	(.119)
1.067	(.420)	.132	(.052)	.211	(.083)
1.118	(.440)	.048	(.019)	.117	(.046)
1.158	(.456)	.015	(.006)	Center of T.E. radius	
1.173	(.462)	Total chord length			
		L.E. radius = 0.020cm (0.008 in.)			
		T.E. radius = 0.015cm (0.006 in.)			

Nozzles

Chord Station		Lower Ordinate		Upper Ordinate	
cm	(in.)	cm	(in.)	cm	(in.)
Root Section					
0.071	(0.028)	0.904	(0.356)	Center of L.E. radius	
.035	(.012)	.848	(.334)	0.963	(0.379)
.051	(.020)	.836	(.329)	.978	(.385)
.102	(.040)	.818	(.322)	1.003	(.395)
.152	(.060)	.805	(.317)	1.026	(.404)
.203	(.080)	.792	(.312)	1.041	(.410)
.254	(.100)	.777	(.306)	1.049	(.413)
.305	(.120)	.759	(.299)	1.054	(.415)
.356	(.140)	.739	(.291)	1.052	(.414)
.406	(.160)	.716	(.282	1.044	(.411)
.457	(.180)	.693	(.273)	1.031	(.406)
.508	(.200)	.665	(.262)	1.011	(.398)
.559	(.220)	.632	(.249)	.983	(.387)
.610	(.240)	.597	(.235)	.945	(.372)
.660	(.260)	.556	(.219)	.897	(.353)
.711	(.280)	.508	(.200)	.825	(.325)
.762	(.300)	.455	(.179)	.726	(.286)
.813	(.320)	.389	(.153)	.610	(.240)
.864	(.340)	.315	(.124)	.478	(.188)
.914	(.360)	.221	(.087)	.328	(.129)
.965	(.380)	.102	(.040)	.173	(.068)
1.006	(.396)	.010	(.004)	Center of T.E. radius	
1.016	(.400)	Total chord length			
		L.E. radius = 0.071cm (0.028 in.)			
		T.E. radius = 0.010cm (0.004 in.)			
Pitch Section					
0.071	(0.028)	1.057	(0.416)	Center of L.E. radius	
.025	(.010)	1.003	(.395)	1.112	(0.438)
.051	(.020)	.988	(.389)	1.135	(.447)
.076	(.030)	.980	(.386)	1.153	(.454)
.127	(.050)	.963	(.379)	1.178	(.464)
.178	(.070)	.950	(.374)	1.198	(.472)
.229	(.090)	.932	(.367)	1.211	(.477)
.279	(.110)	.914	(.360)	1.221	(.481)
.330	(.130)	.897	(.353)	1.224	(.482)
.381	(.150)	.676	(.345)	1.221	(.481)
.432	(.170)	.853	(.336)	1.216	(.479)
.483	(.190)	.831	(.327)	1.206	(.475)
.533	(.210)	.805	(.317)	1.186	(.467)
.584	(.230)	.777	(.306)	1.160	(.457)
.635	(.250)	.744	(.293)	1.130	(.445)
.686	(.270)	.711	(.280)	1.089	(.429)
.737	(.290)	.673	(.265)	1.041	(.410)
.787	(.310)	.630	(.248)	.980	(.386)
.838	(.330)	.584	(.230)	.904	(.356)
.889	(.350)	.533	(.210)	.812	(.320)
.940	(.370)	.470	(.185)	.711	(.280)
.991	(.390)	.417	(.164)	.596	(.235)
1.041	(.410)	.348	(.137)	.482	(.190)
1.092	(.430)	.267	(.105)	.360	(.142)
1.143	(.450)	.178	(.070)	.246	(.097)
1.194	(.470)	.076	(.030)	.132	(.052)
1.234	(.486)	.010	(.004)	Center of T.E. radius	
1.245	(.490)	Total chord lenoth			
		L.E. radius = 0.071cm (0.028 in.)			
		T.E. radius = 0.010cm (0.004 in.)			
Tip Section					
0.071	(0.026)	1.168	(0.460)	Center of L.E. radius	
.038	(.015)	1.107	(.436)	1.237	(0.487)
.051	(.020)	1.100	(.433)	1.247	(.491)
.102	(.040)	1.079	(.425)	1.275	(.502)
.152	(.060)	1.062	(.418)	1.295	(.510)
.203	(.080)	1.044	(.411)	1.311	(.516)
.254	(.100)	1.026	(.404)	1.026	(.521)
.305	(.120)	1.006	(.396)	1.331	(.524)
.356	(.140)	.986	(.388)	1.336	(.526)
.406	(.160)	.963	(.379)	1.333	(.525)
.457	(.180)	.940	(.370)	1.326	(.522)
.508	(.200)	.917	(.361)	1.316	(.518)
.559	(.220)	.892	(.351)	1.290	(.511)
.610	(.240)	.866	(.341)	1.278	(.503)
.660	(.260)	.838	(.330)	1.247	(.491)
.711	(.280)	.810	(.319)	1.214	(.478)
.762	(.300)	.777	(.306)	1.173	(.462)
.813	(.320)	.744	(.293)	1.128	(.444)
.864	(.340)	.706	(.278)	1.069	(.421)
.914	(.360)	.668	(.263)	1.003	(.395)
.965	(.380)	.625	(.246)	.930	(.366)
1.016	(.400)	.582	(.229)	.848	(.334)
1.067	(.420)	.533	(.210)	.765	(.301)
1.118	(.400)	.483	(.190)	.673	(.265)
1.168	(.460)	.424	(.167)	.577	(.227)
1.219	(.480)	.361	(.142)	.483	(.190)
1.270	(.500)	.297	(.117)	.389	(.153)
1.321	(.520)	.226	(.089)	.295	(.116)
1.372	(.540)	.147	(.058)	.201	(.079)
1.422	(.560)	.064	(.025)	.107	(.042)
1.463	(.576)	.010	(.004)	Center of T.E. radius	
1.473	(.580)	Total chord length			
		L.E. radius = 0.071cm (0.028 in.)			
		T.E. radius = 0.010cm (0.004 in.)			

TABLE 13

ROTATING DISK STRESS
TURBINE WHEEL
77986 R P M

RADIUS INCH	THICK INCH	RHØ ---	PØIS RAT.	MØDULUS ELASTIC	CØEF. ØF THER. EX	DELTA TEMP.	S-RAD PSI	S-TAN PSI
.060	.500	.305	.330	24800000.	.0000083	1113.	57890.	57890.
.072	.500	.305	.330	24800000.	.0000083	1113.	57850.	57874.
.084	.500	.305	.330	24800000.	.0000083	1113.	57806.	57852.
.096	.500	.305	.330	24800000.	.0000083	1113.	57756.	57826.
.120	.500	.305	.330	24800000.	.0000083	1113.	57639.	57759.
.187	.500	.305	.330	24800000.	.0000083	1113.	57167.	57483.
.250	.500	.305	.330	24800000.	.0000083	1113.	56553.	57116.
.312	.500	.305	.330	24800000.	.0000083	1113.	55782.	56653.
.375	.414	.305	.330	24800000.	.0000083	1099.	65956.	63105.
.500	.421	.305	.330	25000000.	.0000083	1061.	62674.	70642.
.593	.390	.305	.330	25000000.	.0000083	1058.	66014.	70874.
.656	.250	.305	.330	24500000.	.0000084	1185.	98457.	52741.
.718	.250	.305	.330	24200000.	.0000085	1217.	92143.	47779.
.781	.275	.305	.330	24100000.	.0000085	1251.	78063.	39535.
.843	.296	.305	.330	23900000.	.0000086	1282.	67255.	32333.
.906	.312	.305	.330	23800000.	.0000086	1313.	58560.	24824.
.968	.343	.305	.330	23600000.	.0000087	1343.	48267.	16566.
1.031	.375	.305	.330	23400000.	.0000088	1371.	39045.	7279.
1.093	.406	.305	.330	23400000.	.0000087	1397.	31039.	2940.
1.356	.437	.305	.330	23200000.	.0000088	1422.	7966.	-4880.
1.218	.484	.305	.330	23000000.	.0000088	1445.	18193.	-9709.

NØ. ØF BUCKETS 24
WEIGHT ØF BUCKETS 0.01
RADIAL DISTANCE TØ C.G. 1.625

TABLE 14.- EXHAUST NOZZLE PARAMETERS

	Plug Nozzle	Concave Base Nozzle	Short Plug Nozzle
Inner exit diameter, cm(in.)	4.83(1.90)	4.75(1.87)	5.16(2.03)
Outer exit diameter, cm(in.)	7.01(2.76)	7.01(2.76)	7.29(2.87)
Exit area, $cm^2 (in.^2)$	20.45(3.17)	20.84(3.23)	20.84(3.23)
Discharge coefficient, C_D	0.96	0.94	0.94
Thrust coefficient, C_T	0.97	0.96	0.90
Thrust, N(lbs)	495.1(111.3)	489.7(110.1)	459.0(103.2)

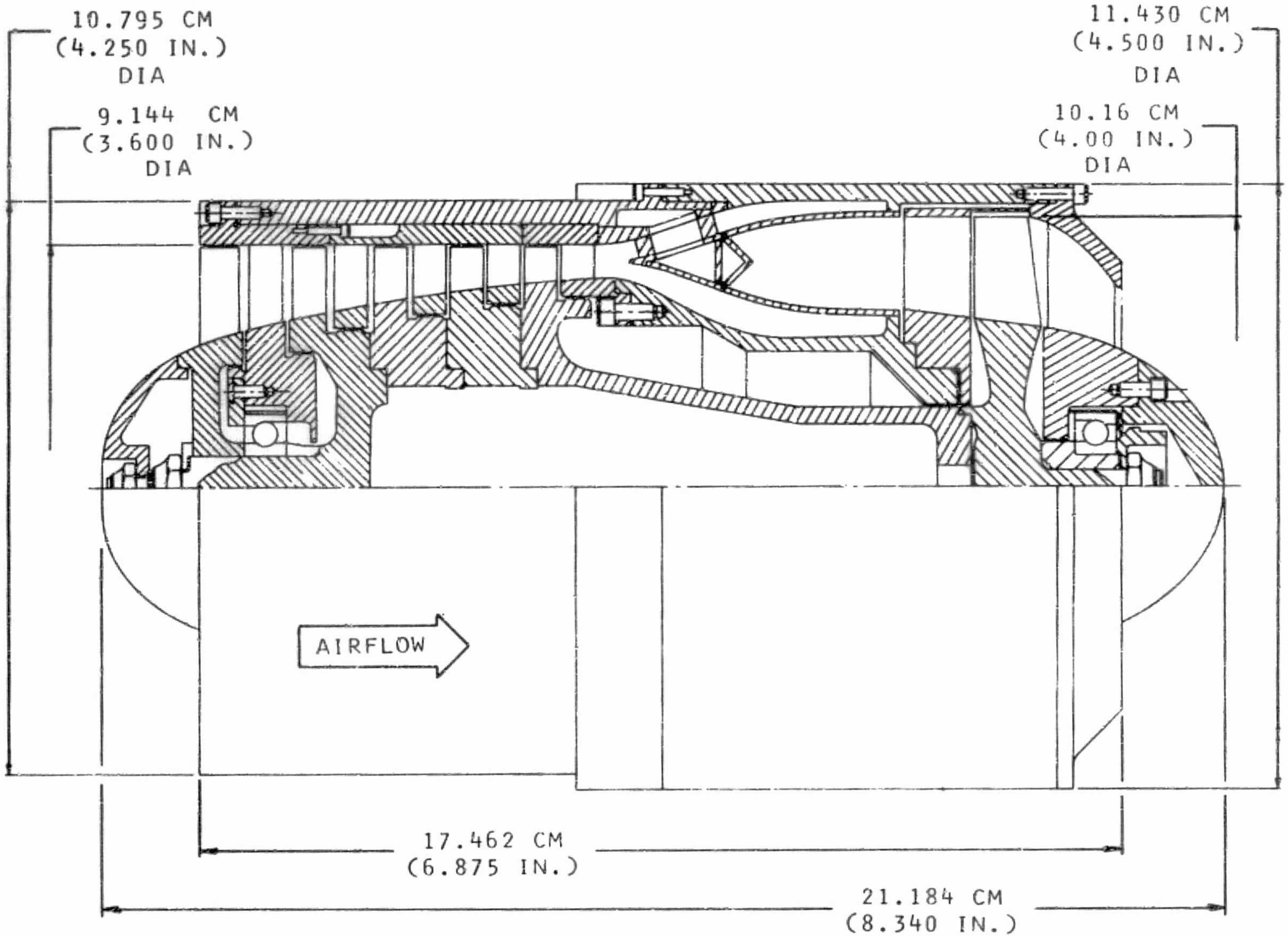


Figure 1. - Miniature gas turbine engine assembly.

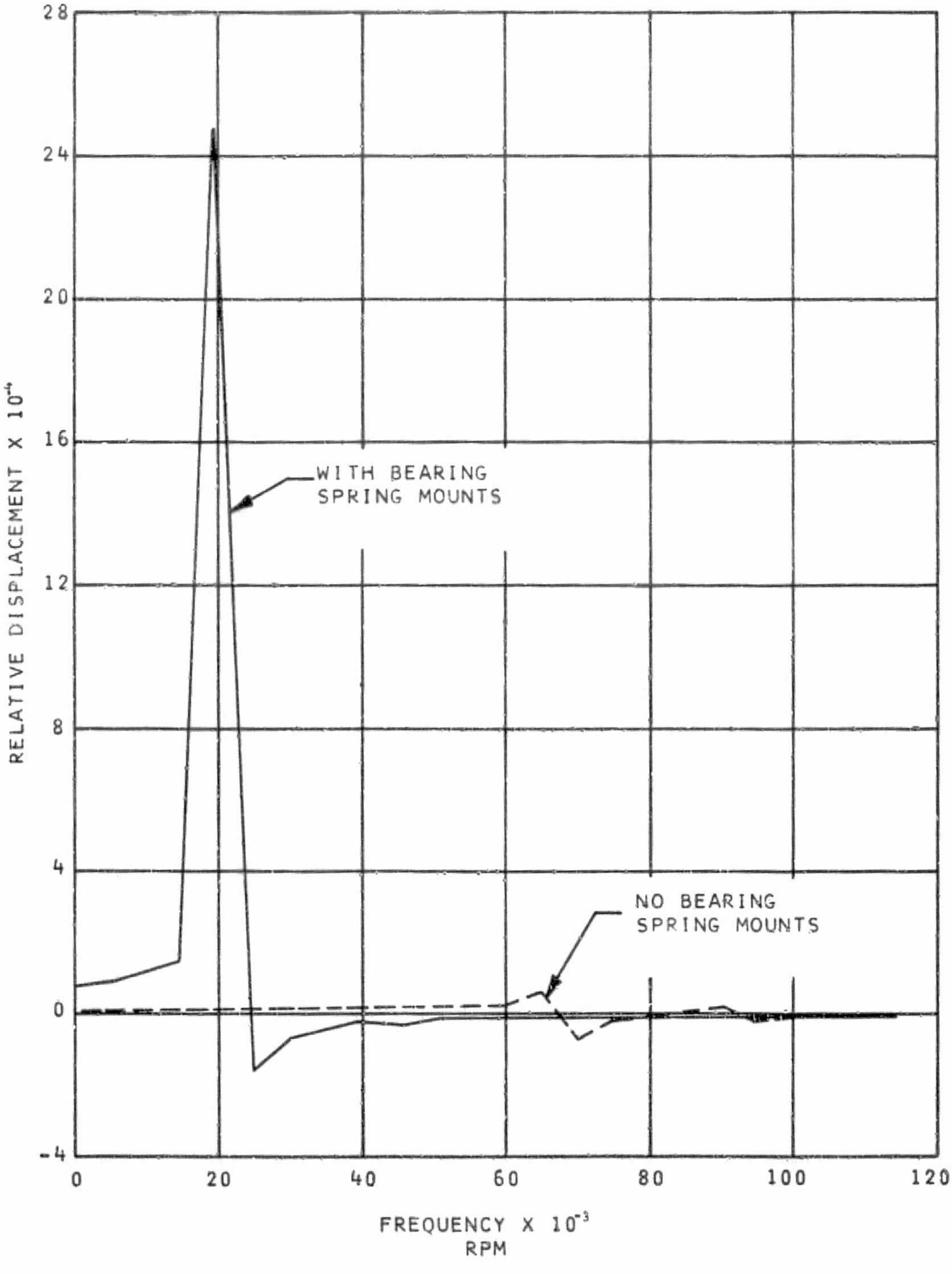


Figure 2. - Shaft deflection at turbine wheel with and without bearing radial spring mounts.

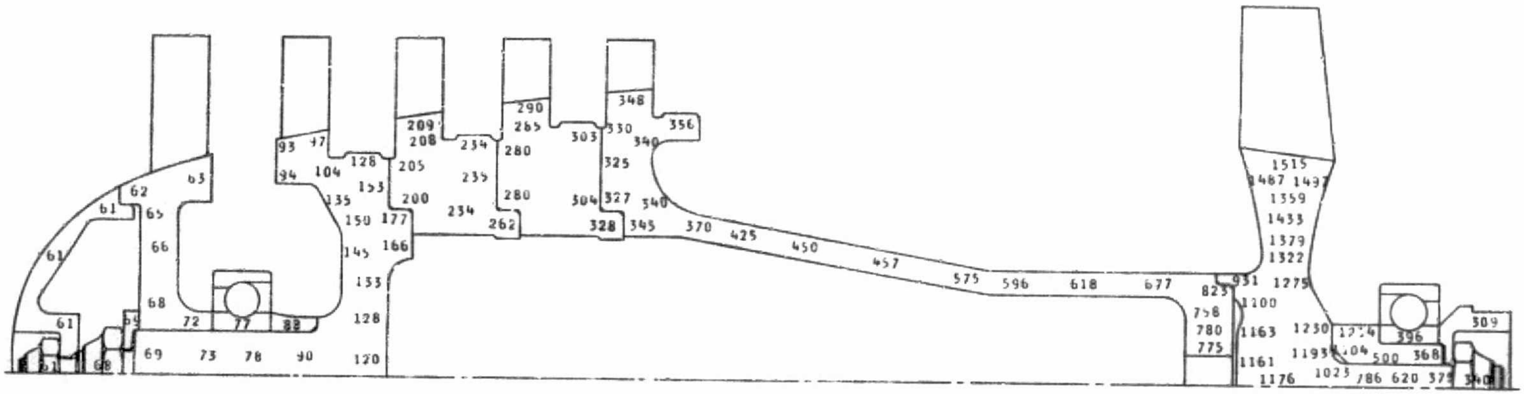


Figure 3. - Temperature distribution of rotating parts at design conditions.

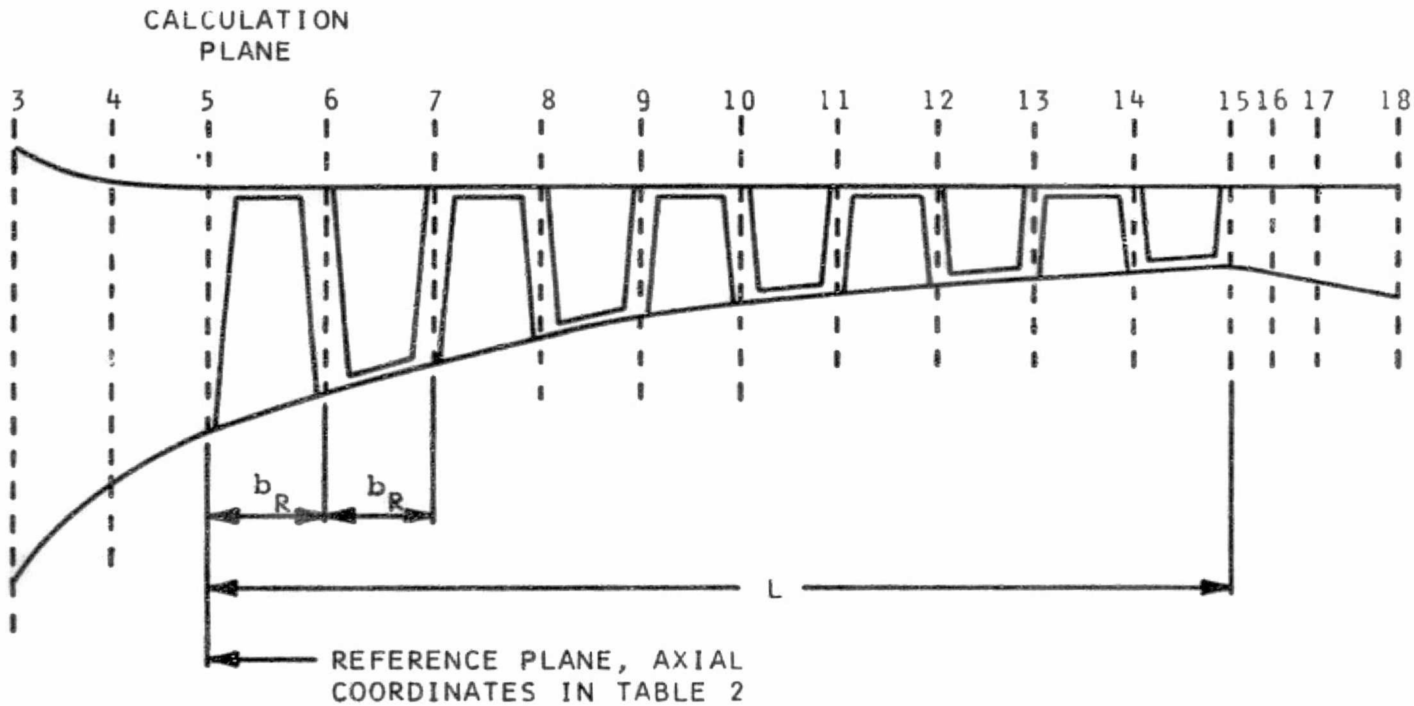


Figure 4. - Meridional plane section of flow passage for 5-stage axial-flow compressor unit showing calculation planes and axial reference plane location. (Blade profiles are distorted and should not be scaled.)

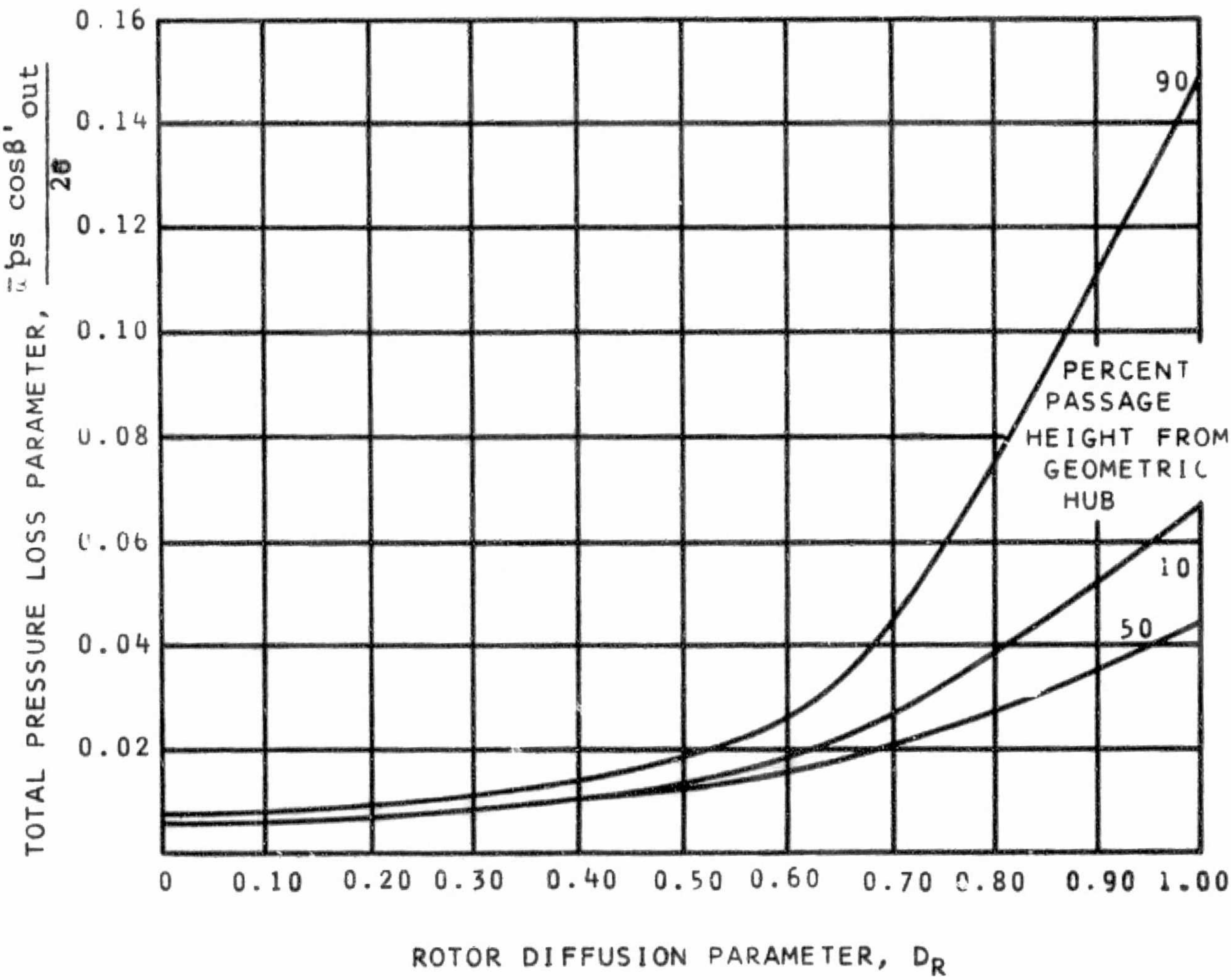


Figure 5. - Rotor blade section loss correlation used for recommended 5-stage compressor unit.

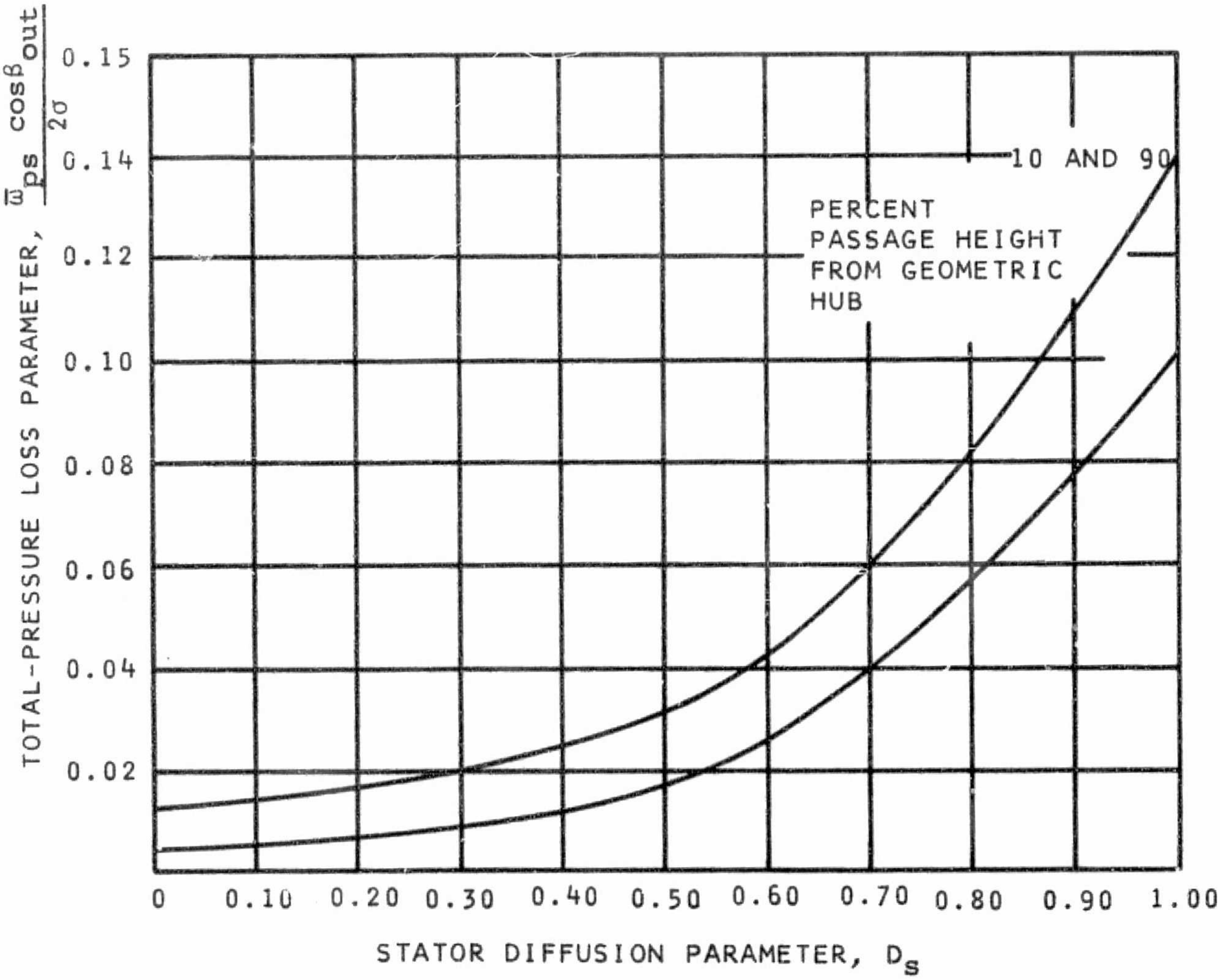


Figure 6. - Stator blade section loss correlation used for recommended 5-stage compressor unit (see ref. 13).

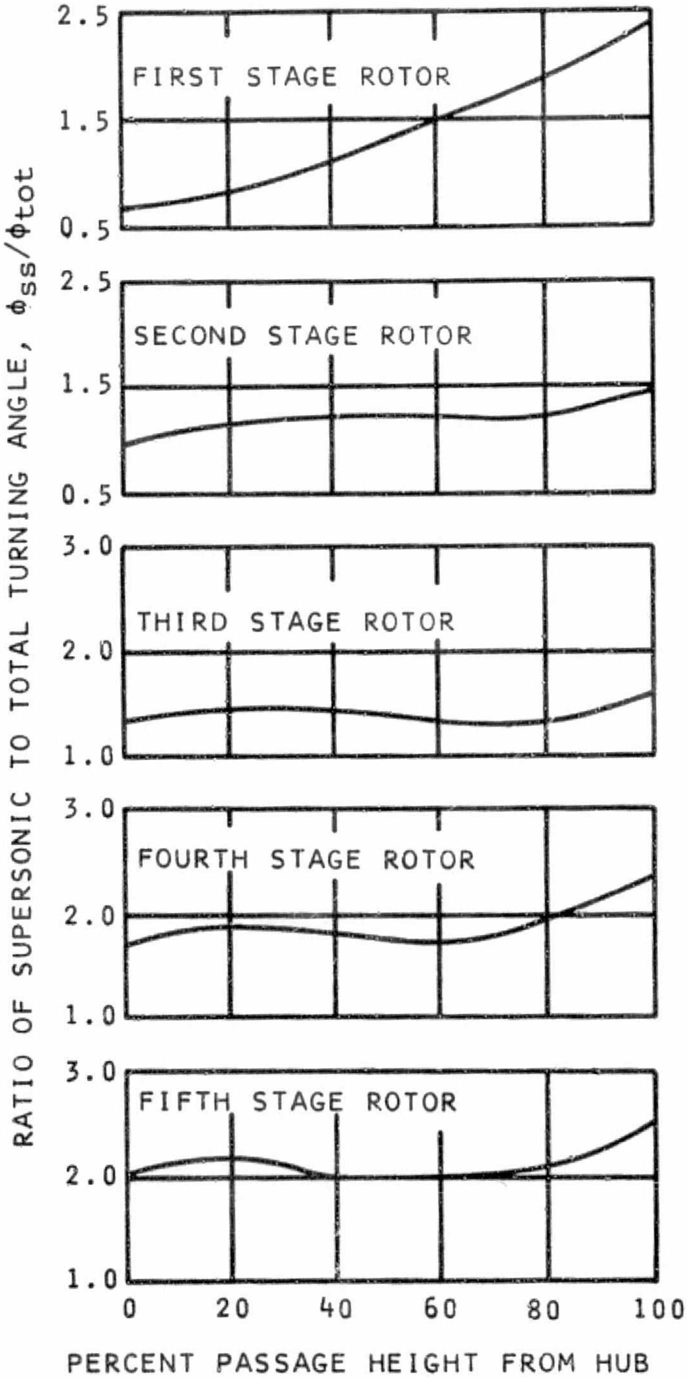


Figure 7. - Radial variation of ratio of supersonic to total turning angle.

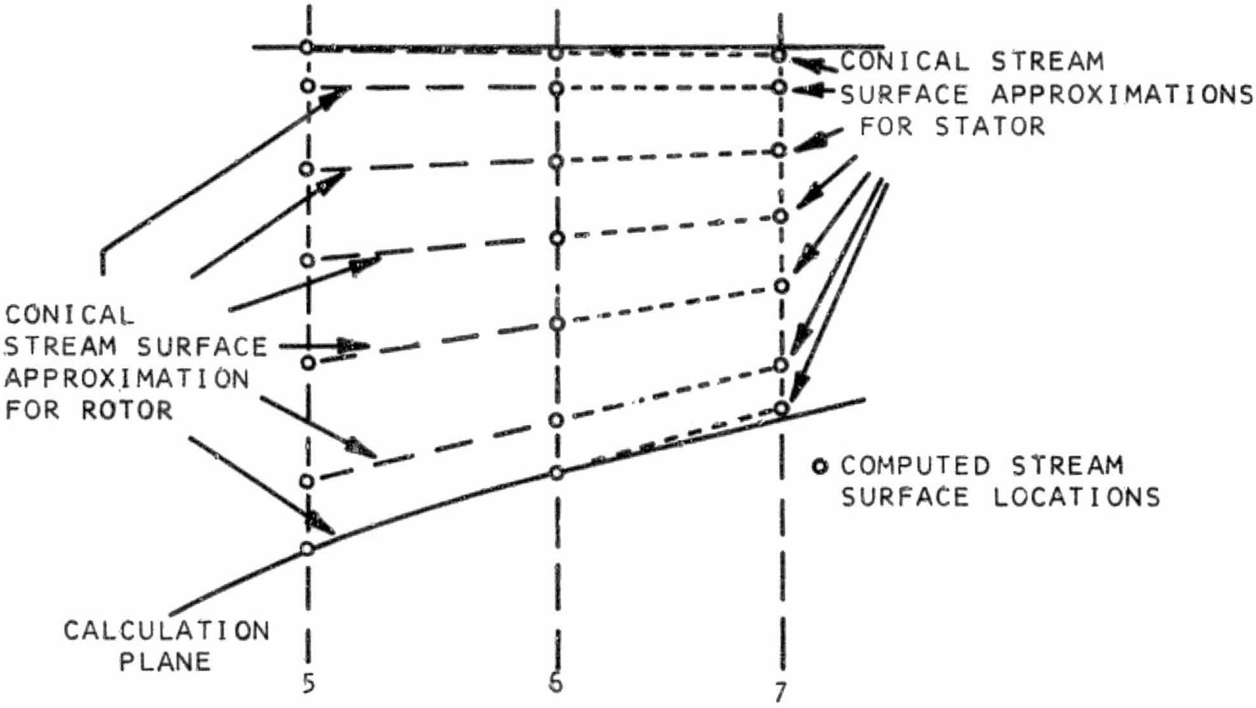


Figure 8. - Stream surface approximations for typical compressor stage as used in blade selection process.

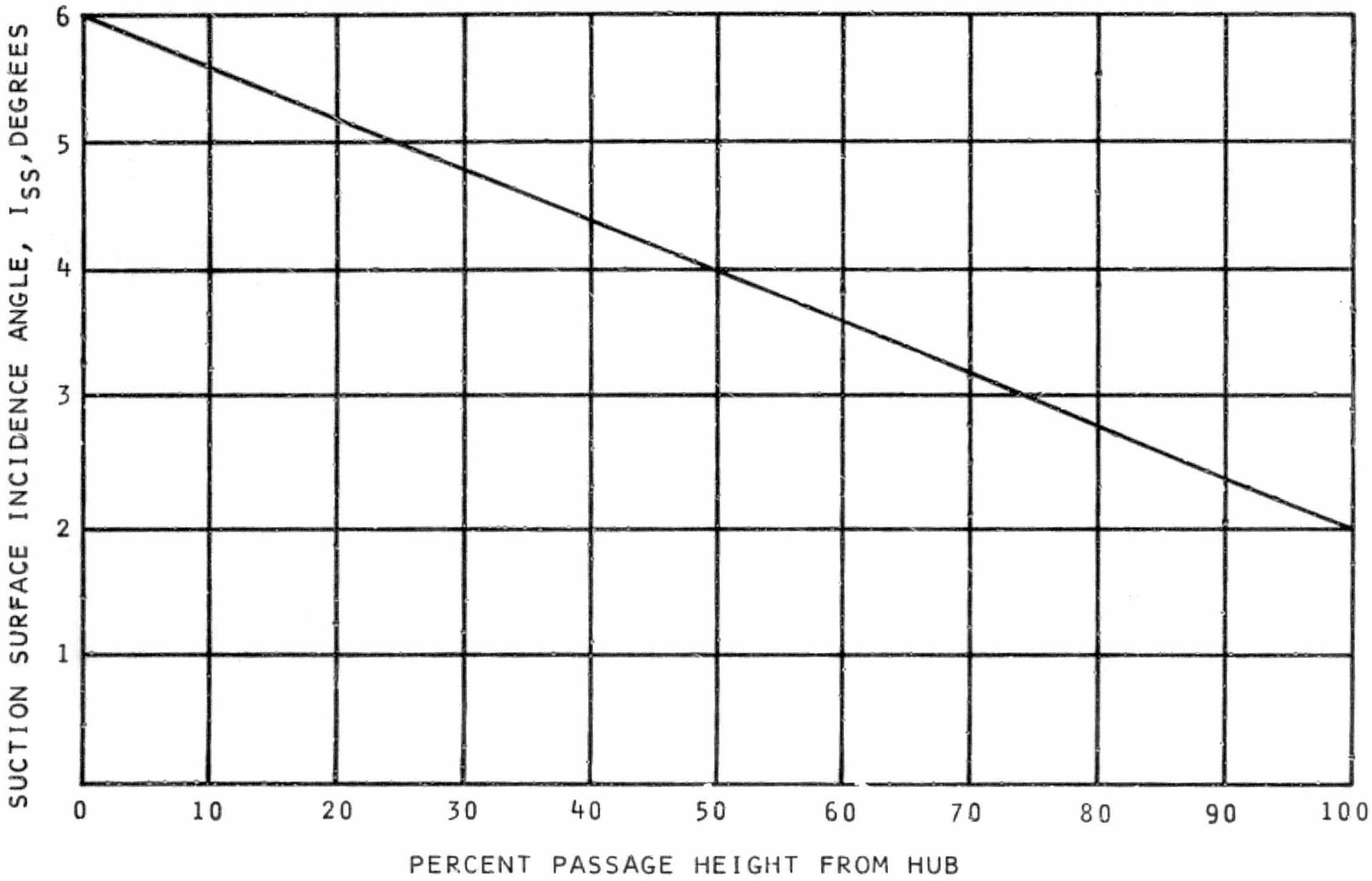
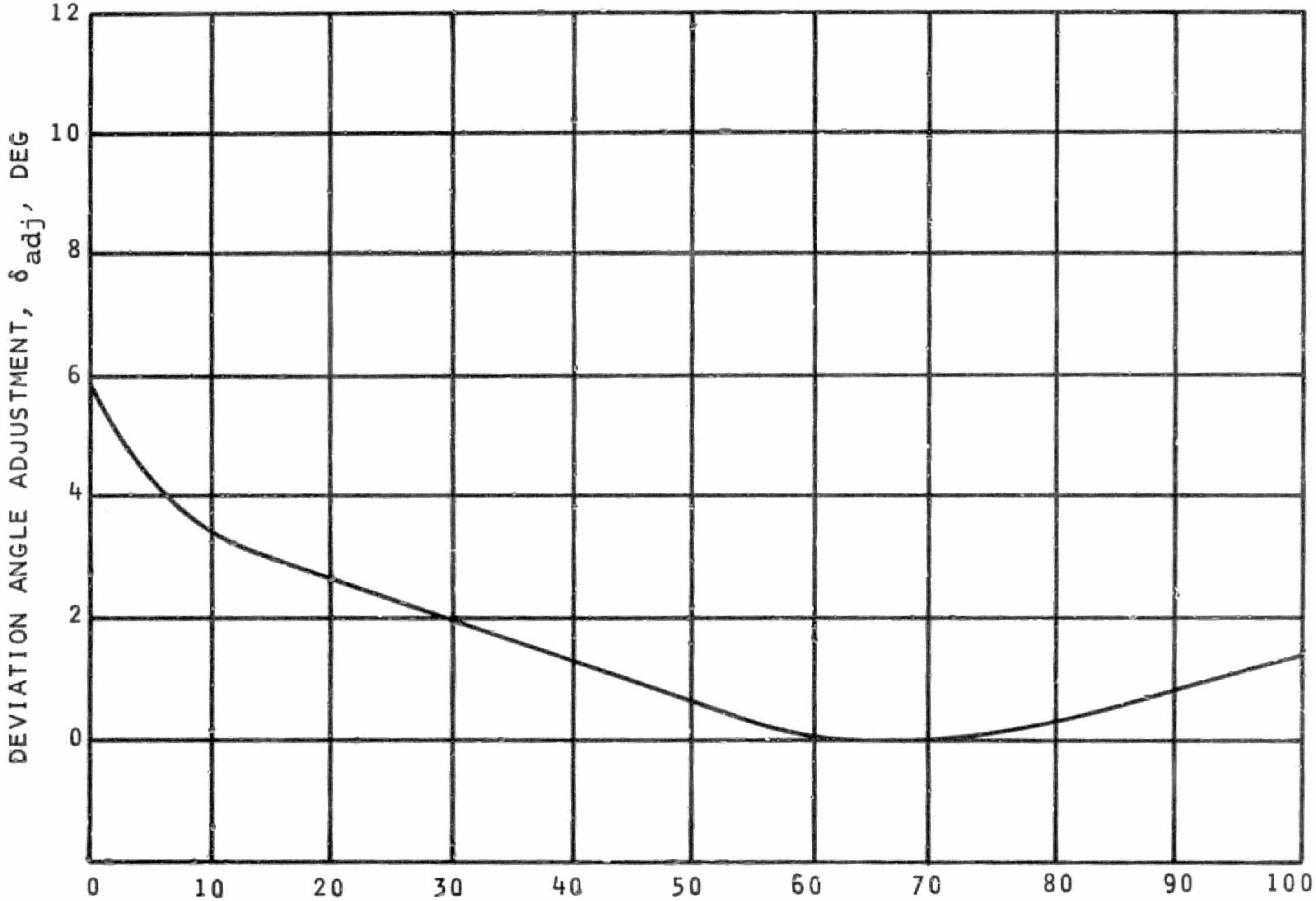
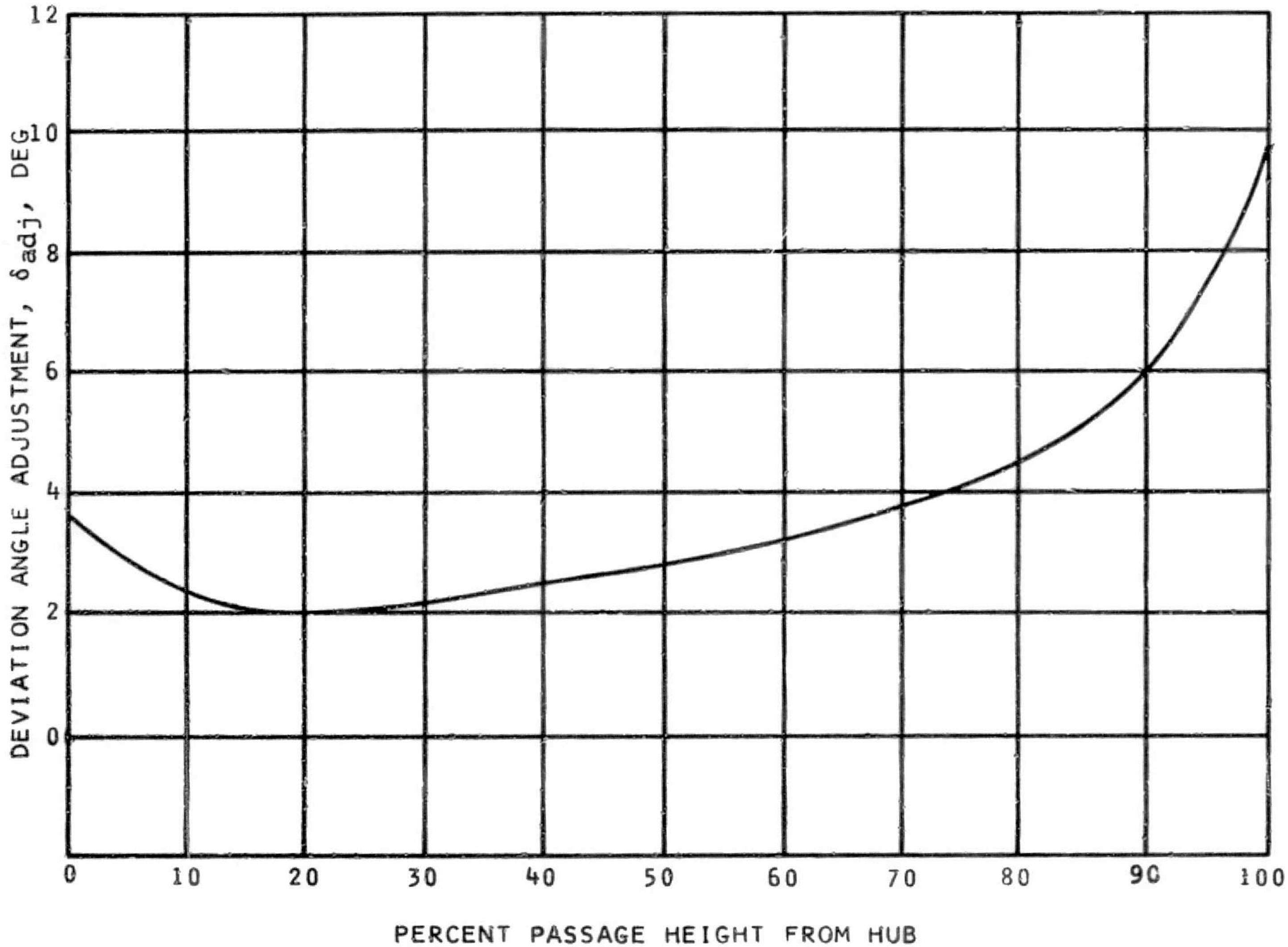


Figure 9. - First-stage rotor suction surface incidence angle variation.



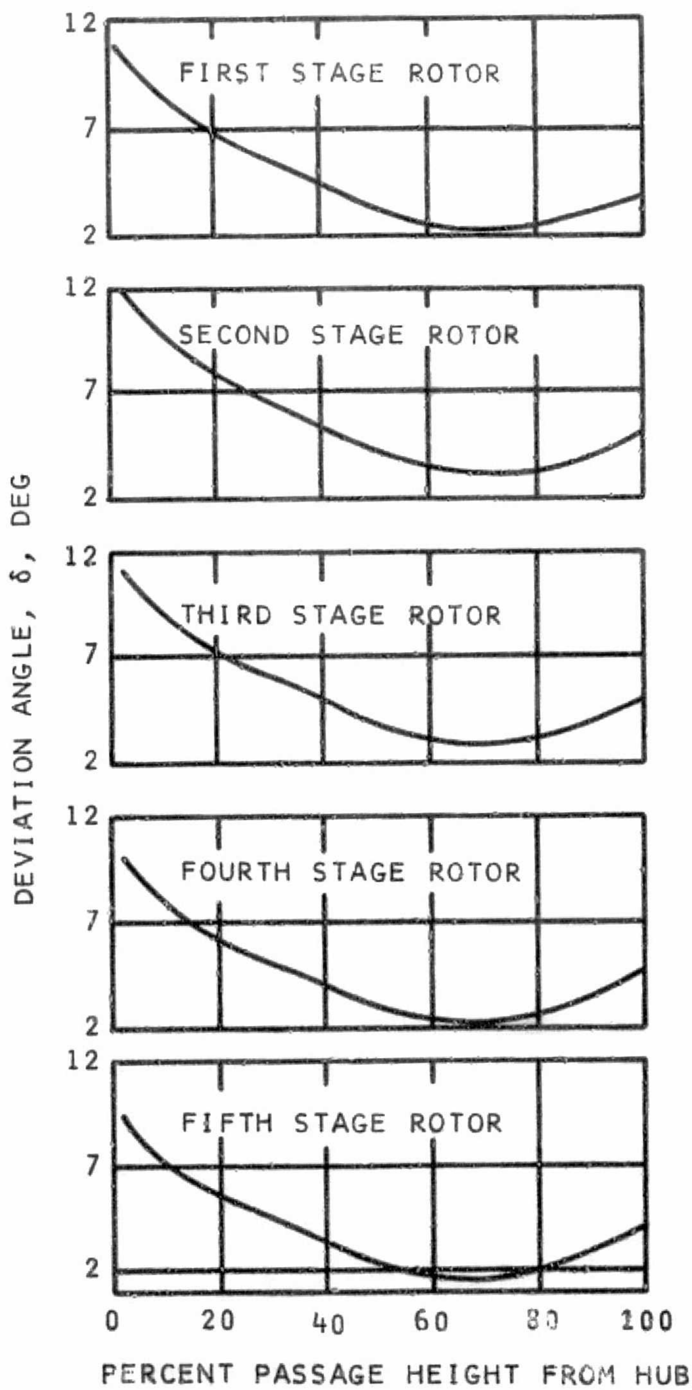
(a) Rotor blade row

Figure 10. - Empirical adjustment used in computation of deviation angles. (see ref. 13)



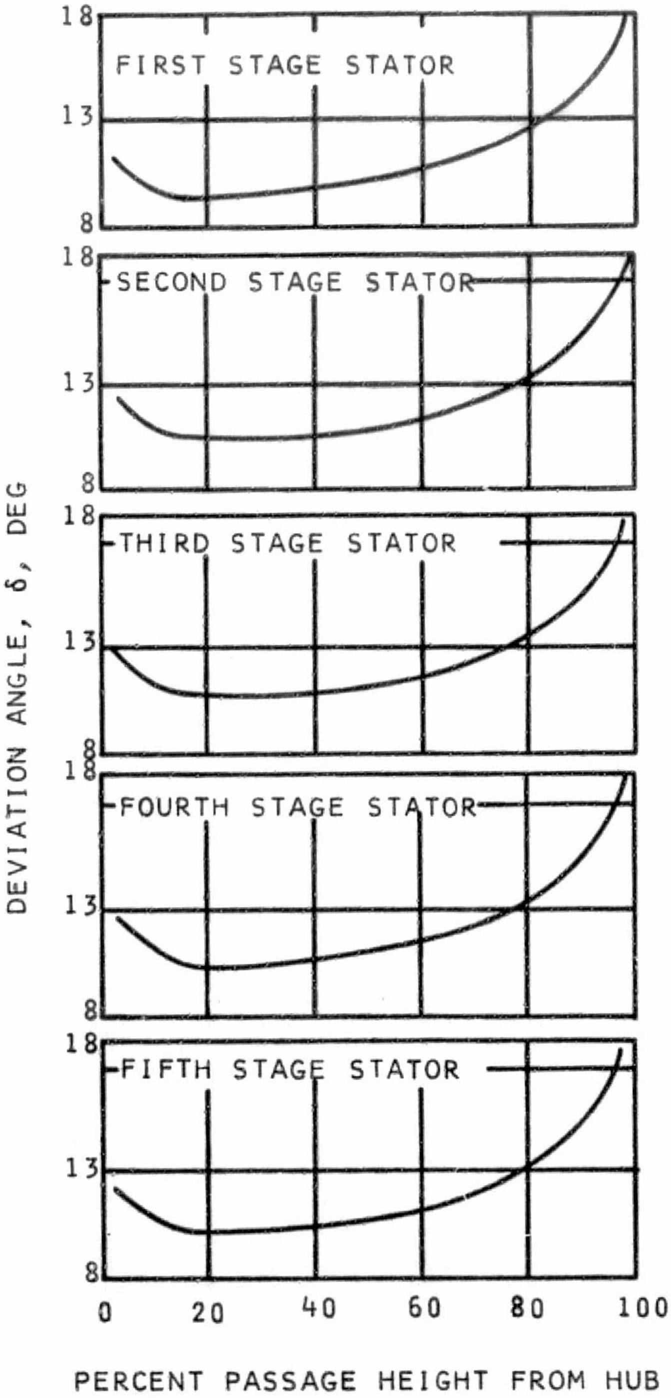
(b) Stator blade row

Figure 10. - Concluded.



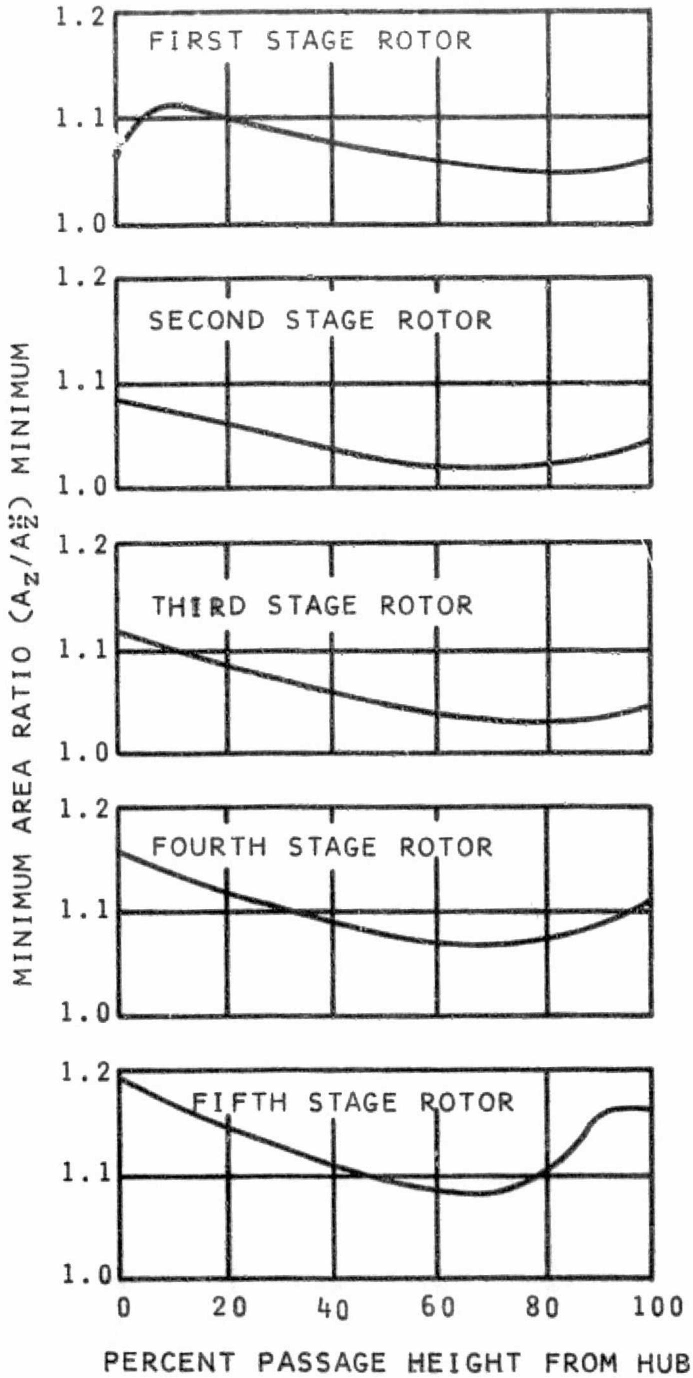
(a) Rotor blade rows

Figure 11. - Distribution of computed deviation angles.



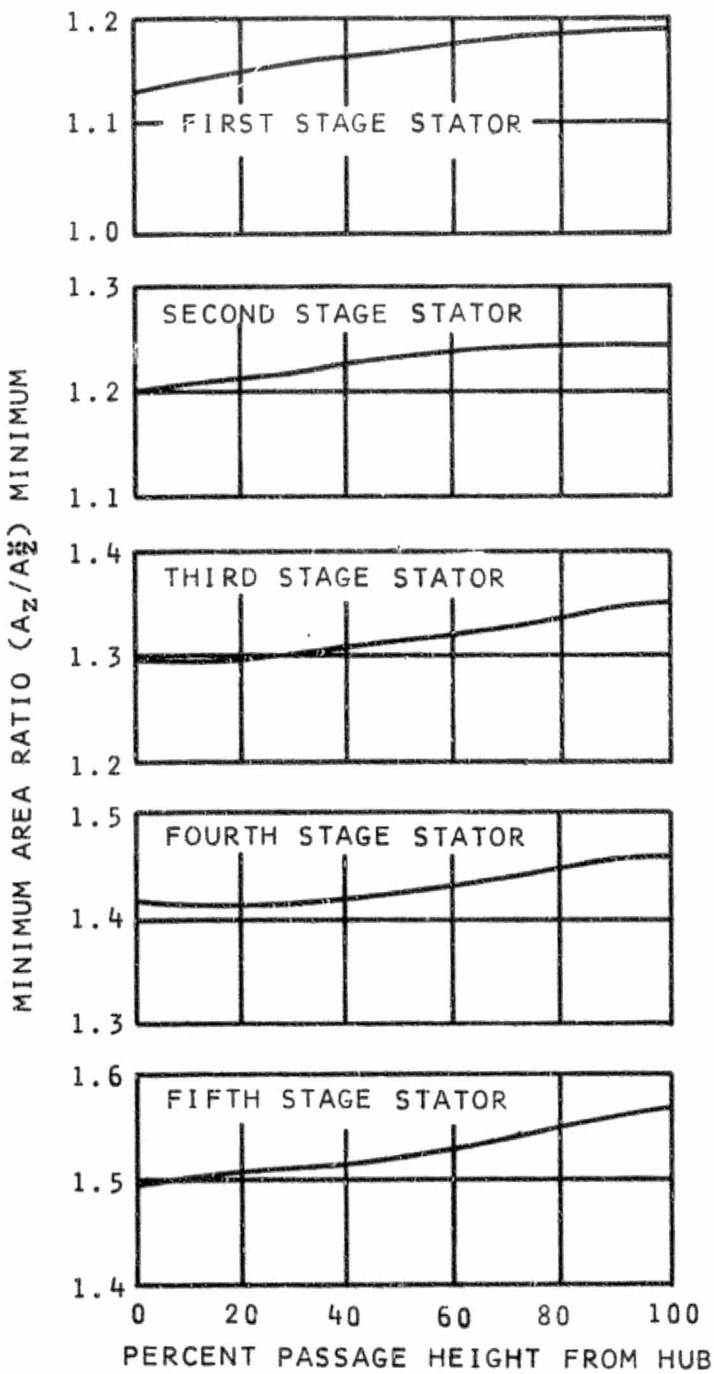
(b) Stator blade rows

Figure 11. - Concluded.



(a) Rotor blade-to-blade stream tubes

Figure 12. - Computed critical area ratios.



(b) Stator blade-to-blade stream tubes

Figure 12. - Concluded.

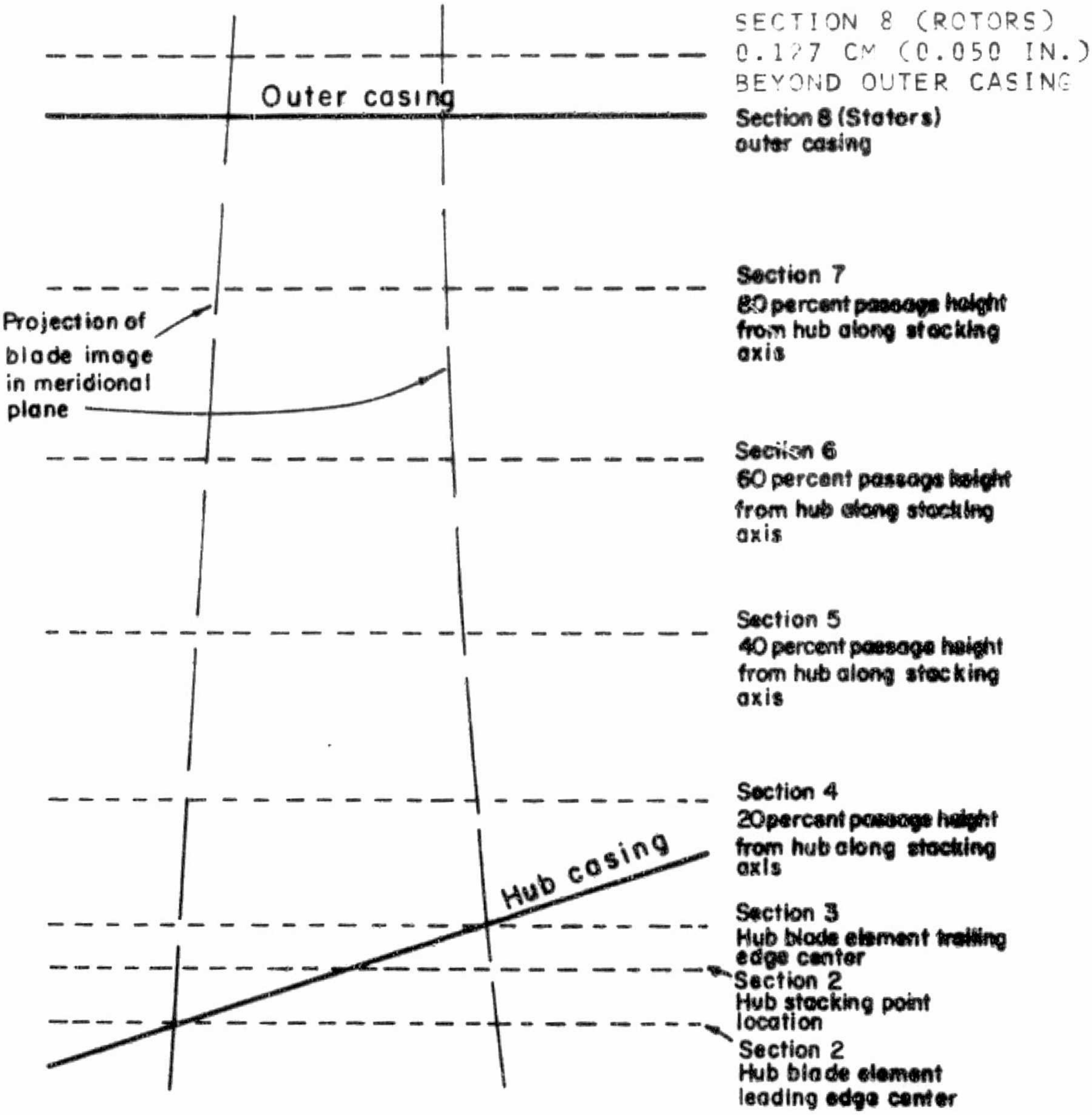


Figure 13. - Location of planes used in specification of blade manufacturing coordinates.

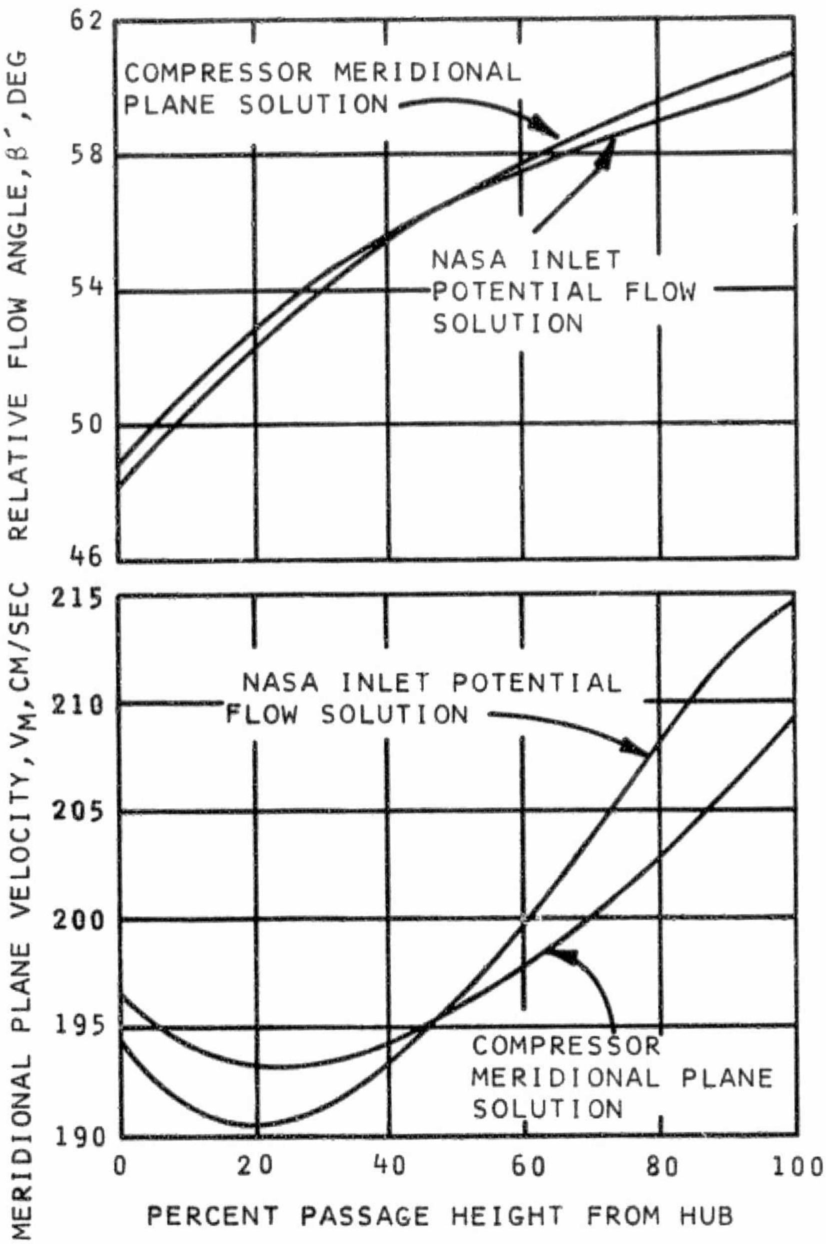


Figure 14. - First blade row inlet calculation plane velocity distributions from NASA inlet bellmouth potential flow solution and meridional plane program.

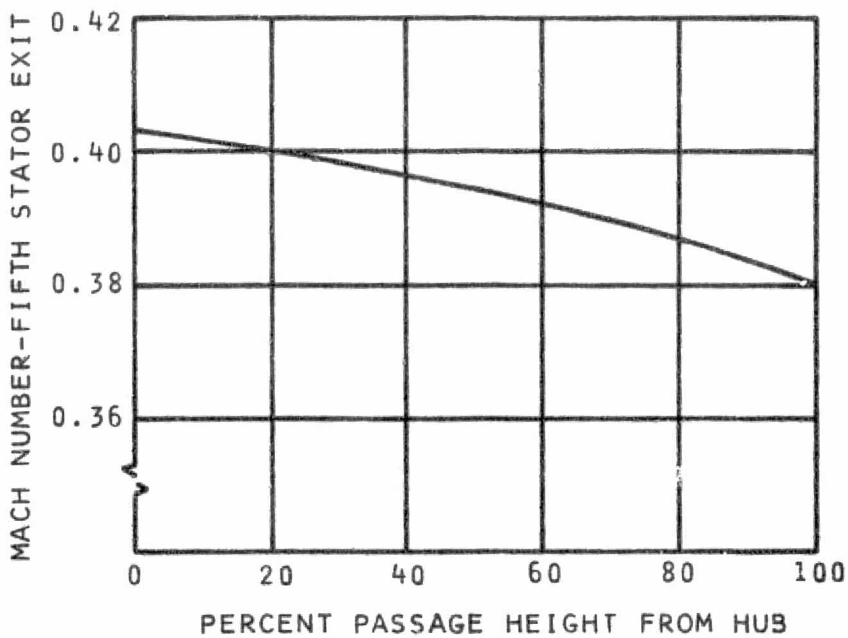


Figure 15. - Computed Mach number distribution at exit calculation plane, fifth stator.

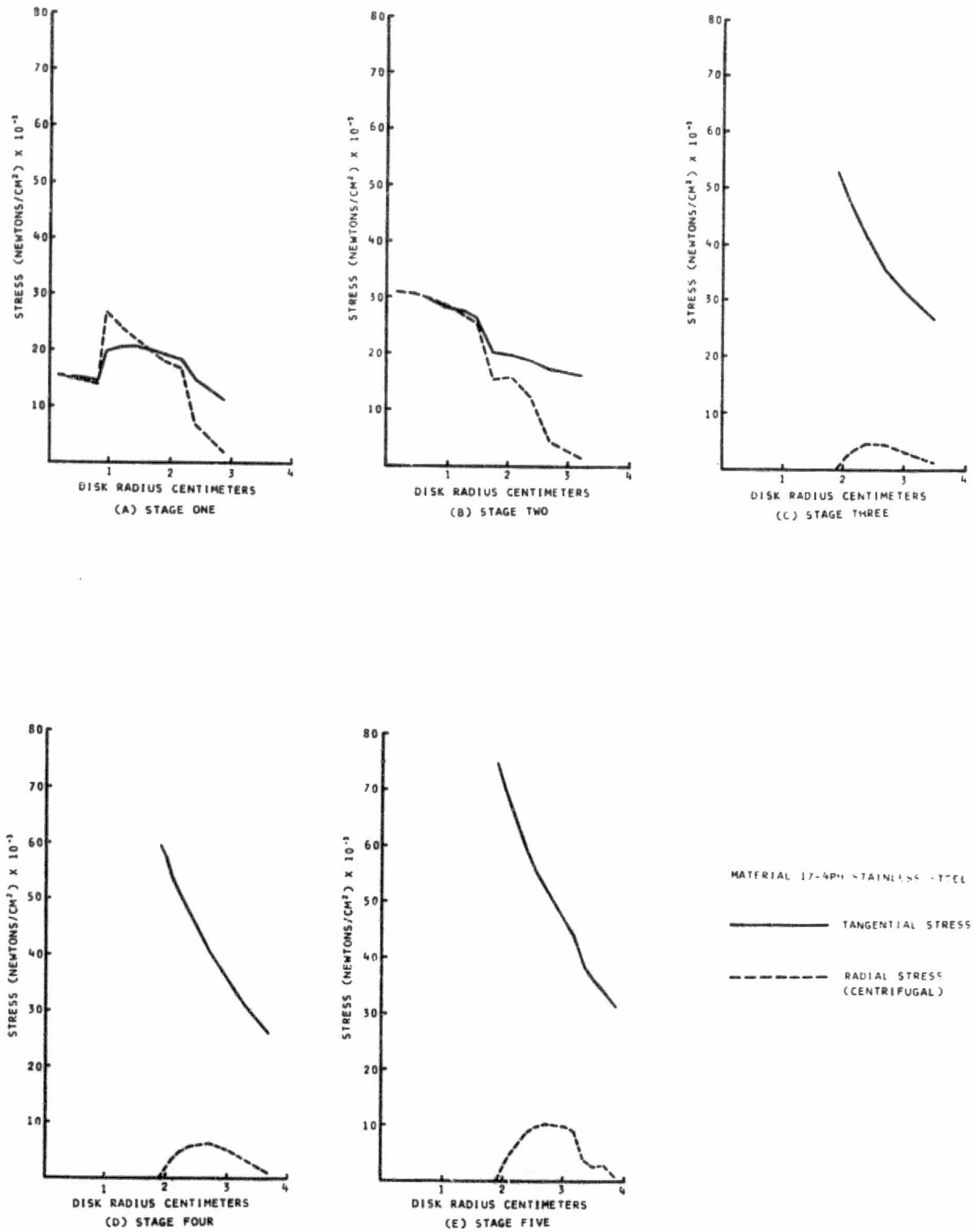


Figure 16. - Compressor disk stress at 78,000 rpm.

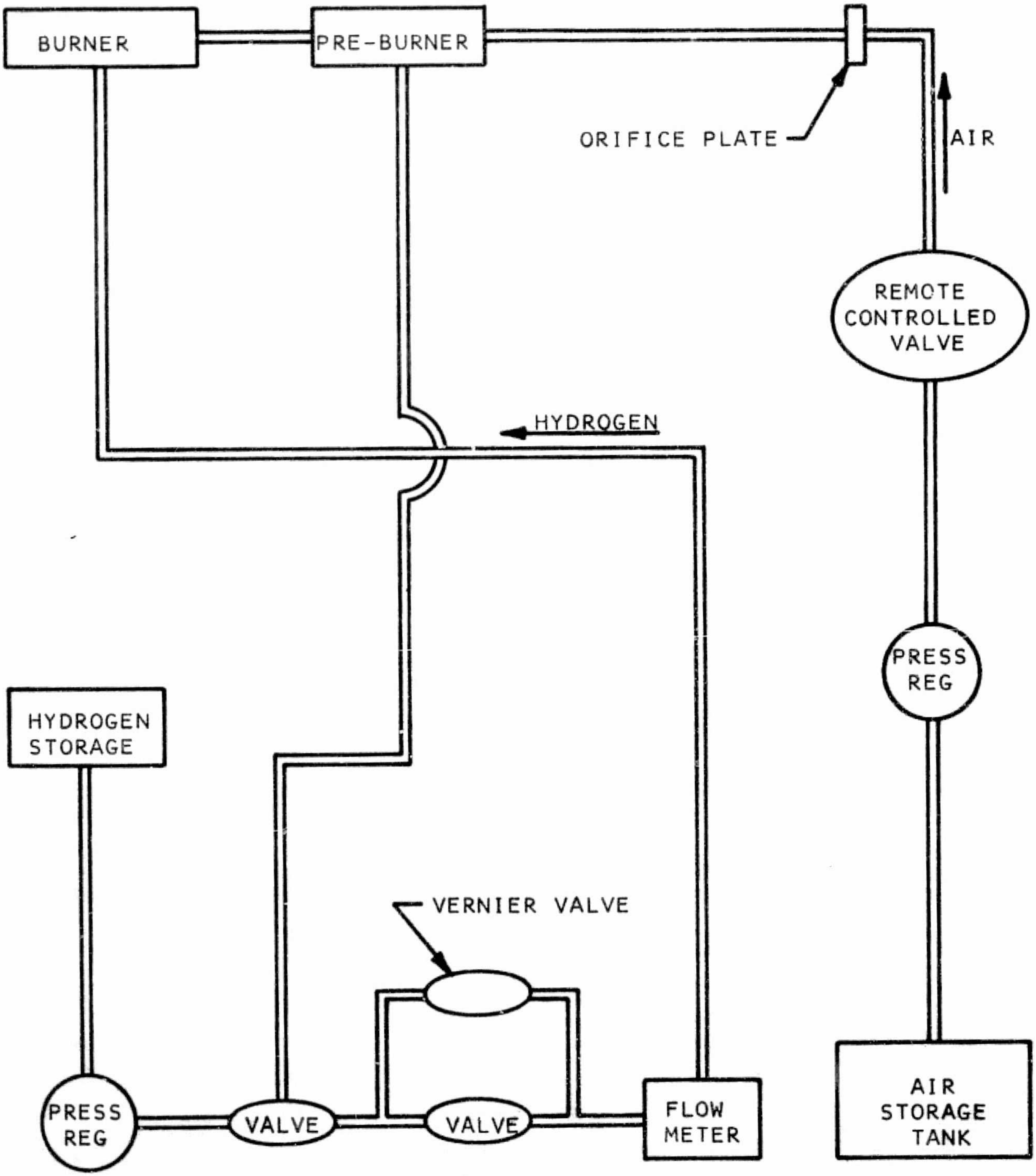


Figure 17. - Combustor development test set-up

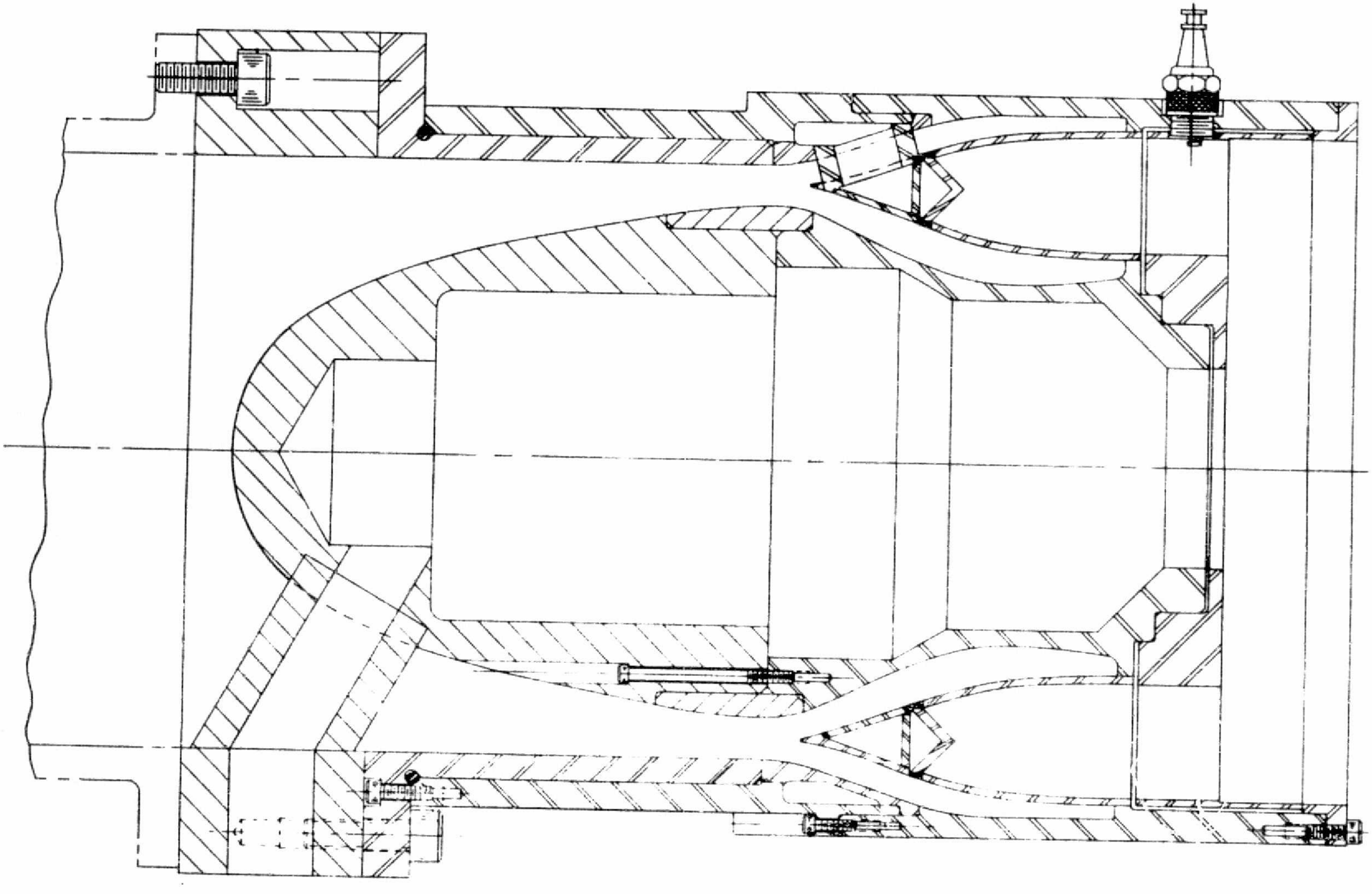
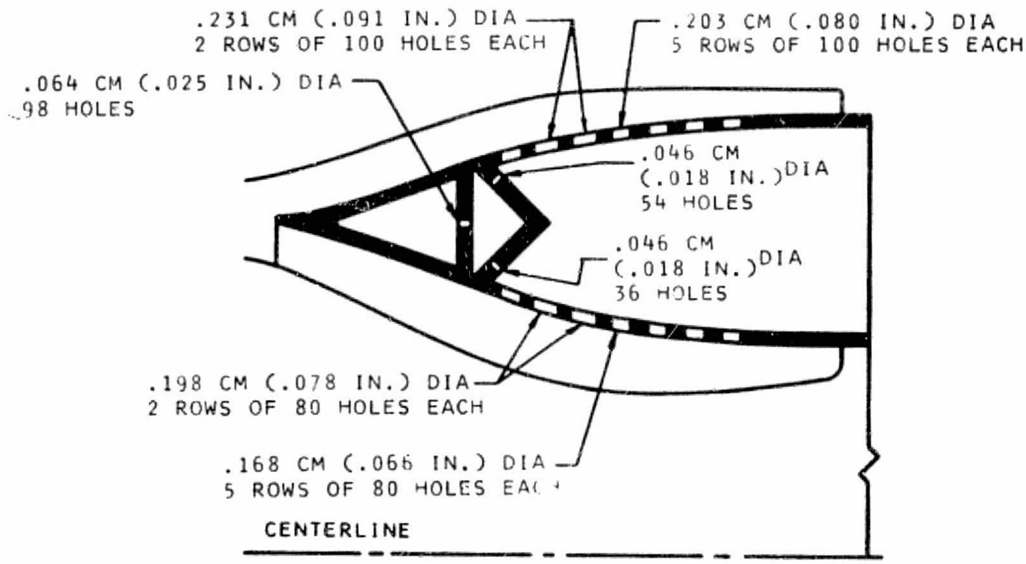
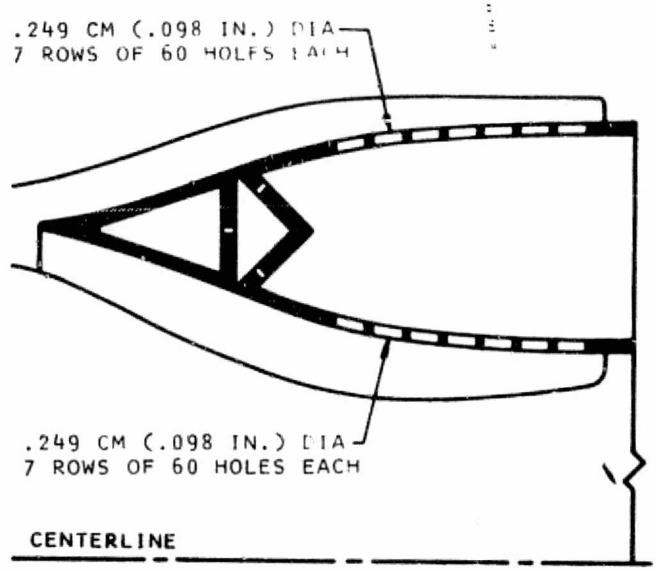


Figure 18. - Combustion chamber assembly.



RUN 23

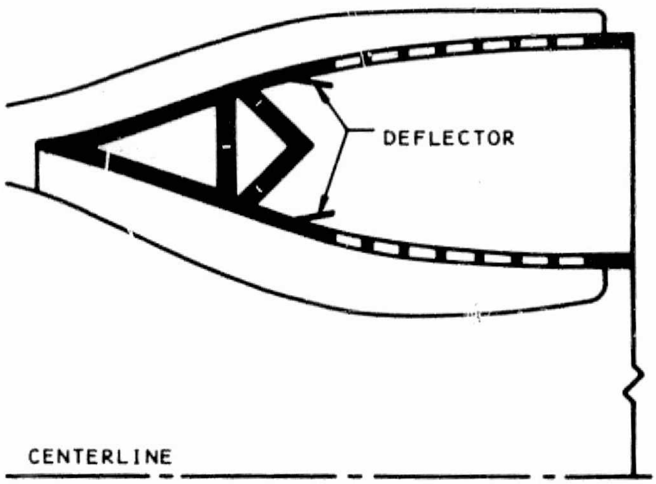
ΔTVR 2.06



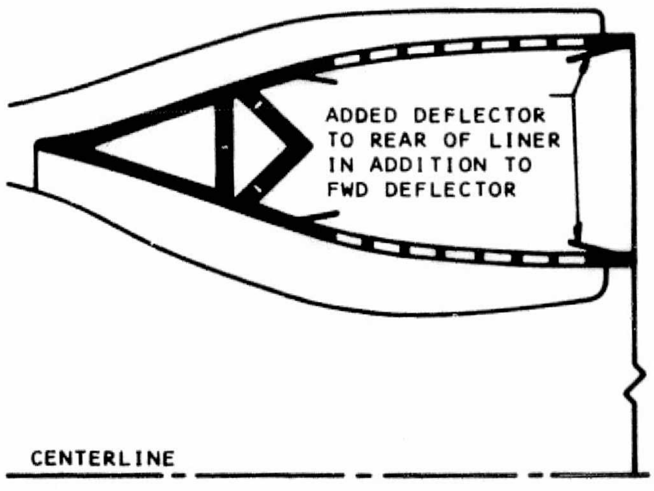
RUN 24

ΔTVR 2.20

Figure 19. - Combustion liner configurations.

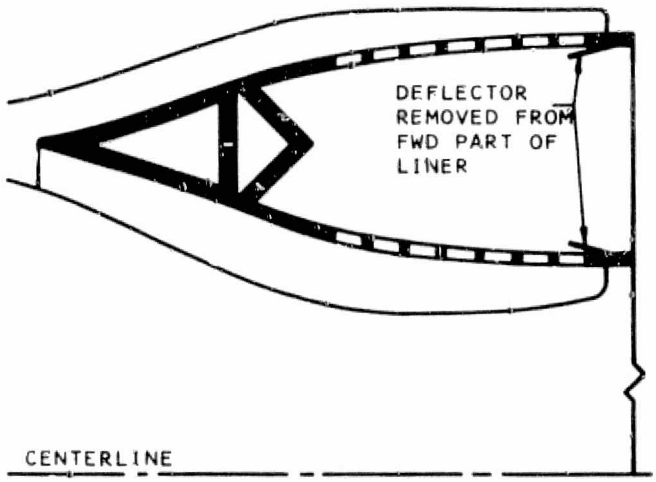


RUN	25	26
ΔTVR	2.06	2.31



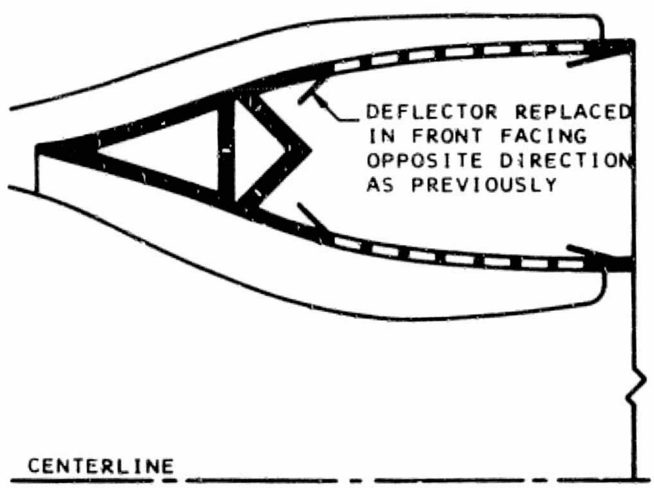
RUN	27
ΔTVR	2.36

Figure 20. - Combustion liner configurations.



RUN 28

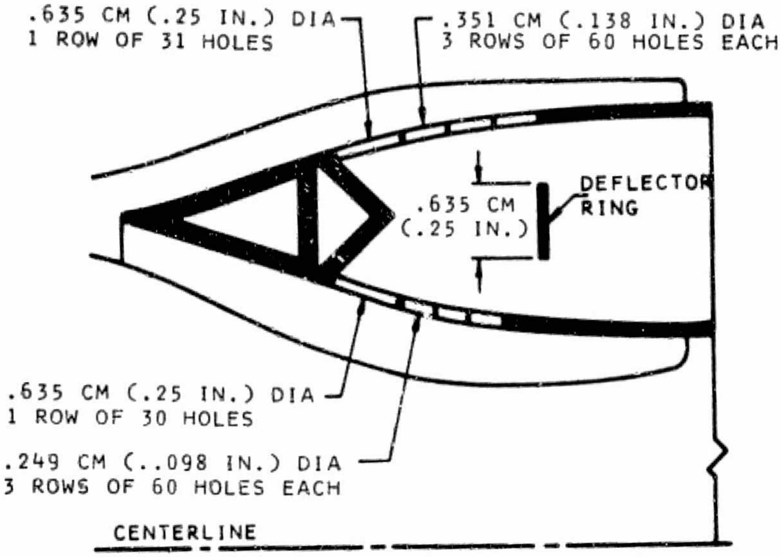
ΔTVR 1.92



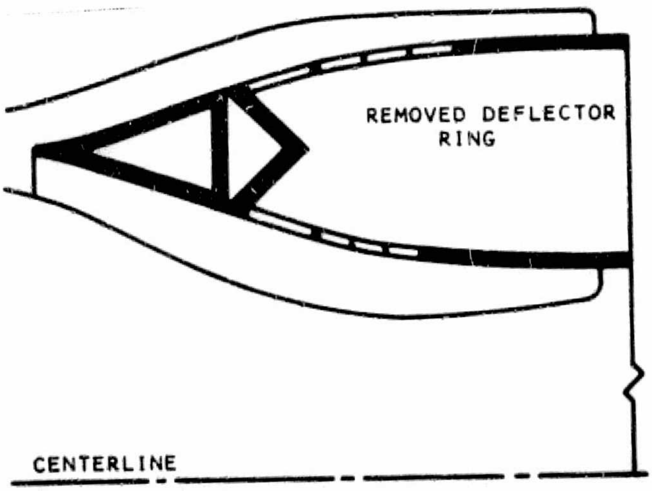
RUN 29

ΔTVR 2.03

Figure 21. - Combustion liner configurations.

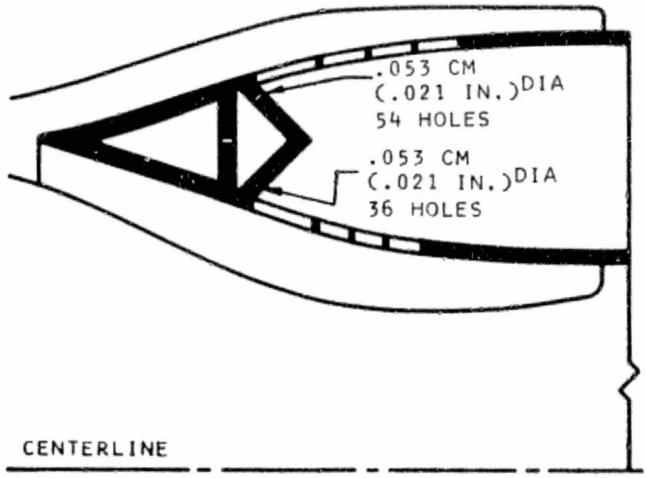


RUN	30	31	32
ΔTVR	1.64	1.77	1.51



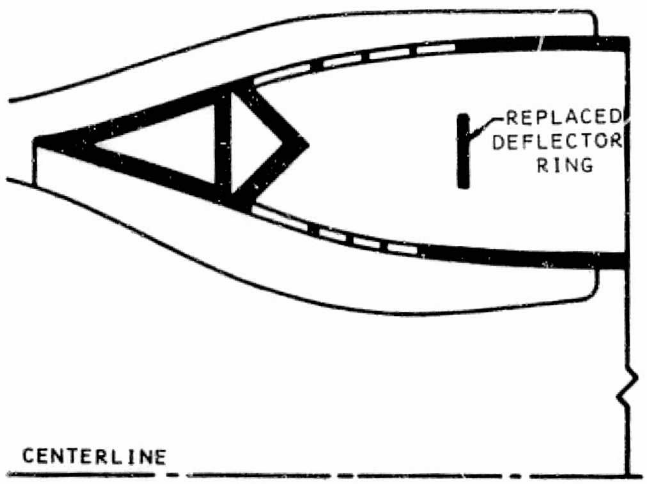
RUN	33	34
ΔTVR	1.63	1.66

Figure 22. - Combustion liner configurations.



RUN 35

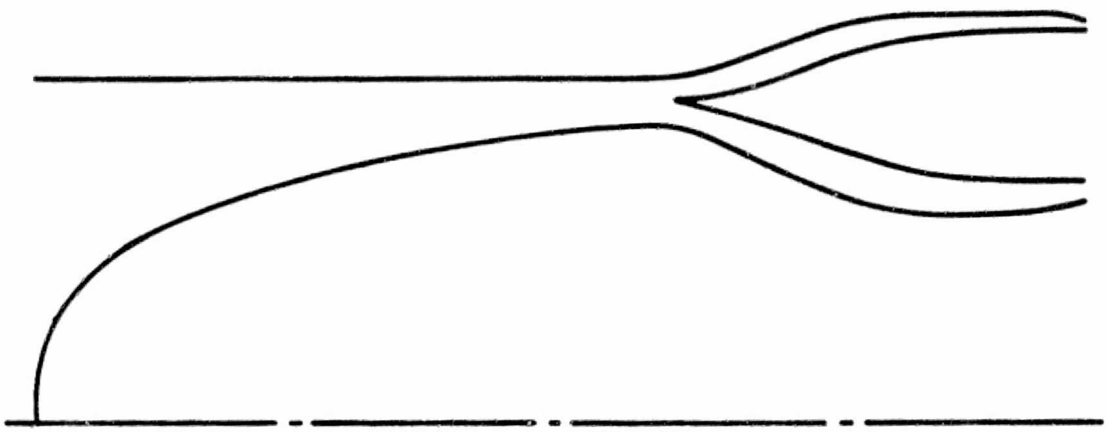
ΔTVR 1.88



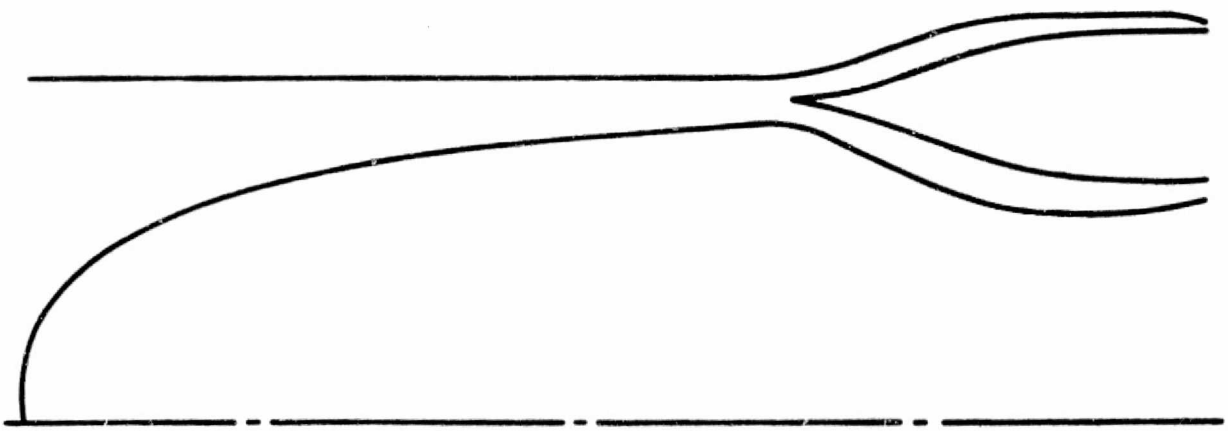
RUN 36

ΔTVR 1.52

Figure 23. - Combustion liner configurations.



(a) 4-stage



(b) 5-stage

Figure 24. - Flow path compressor and combustor.

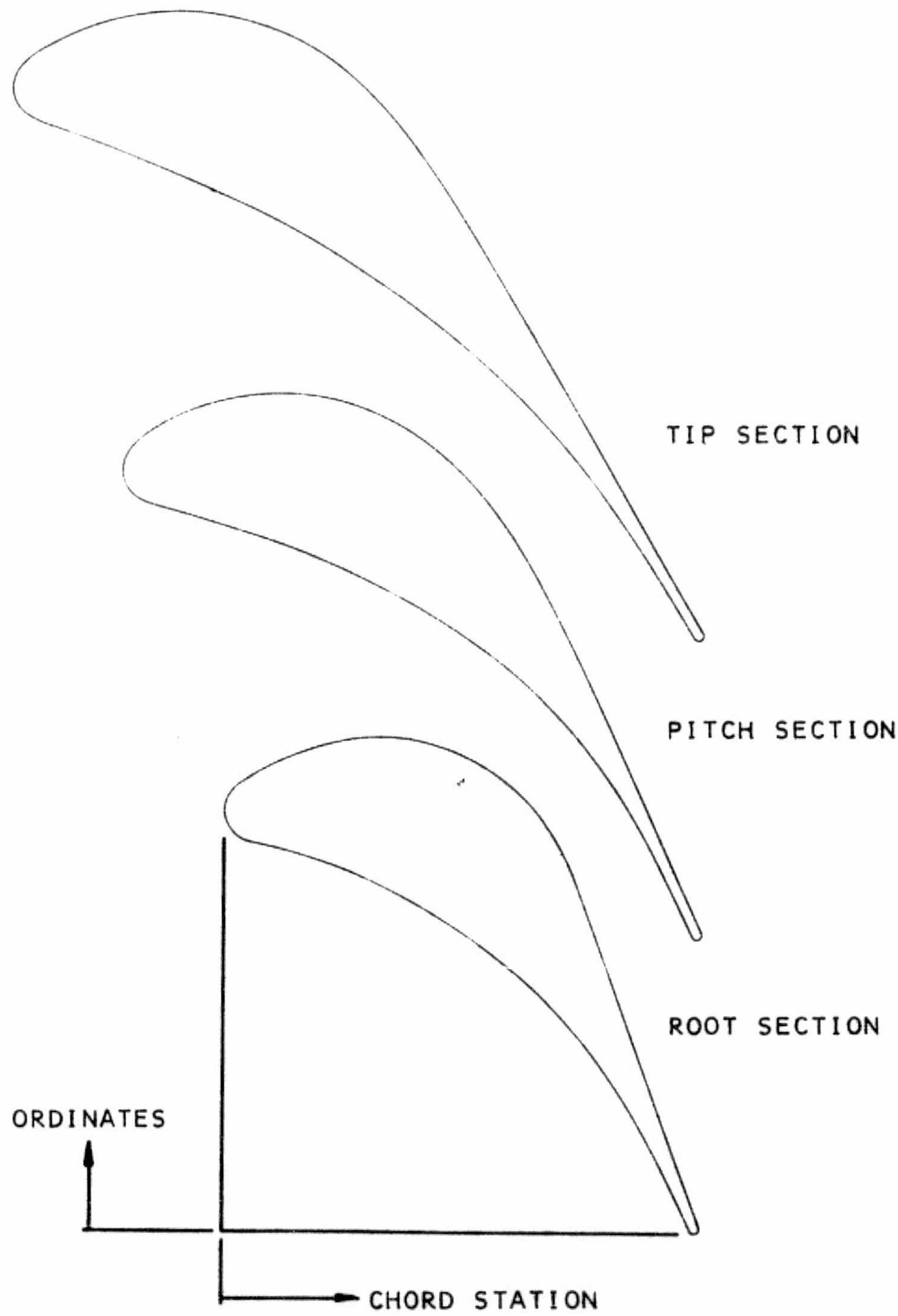


Figure 25. - Turbine nozzle contours for initial engine design.

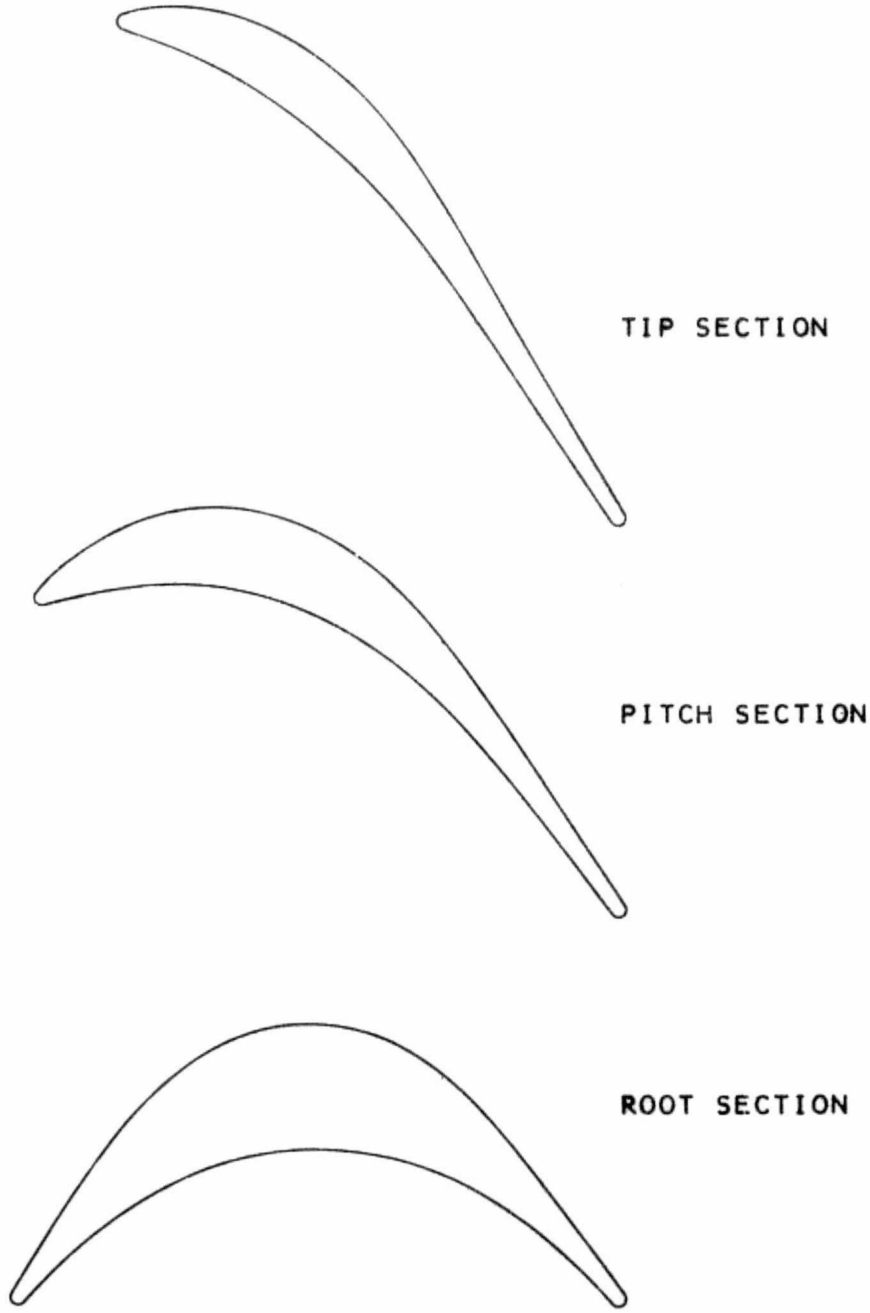


Figure 26. - Turbine bucket contours for initial engine design.

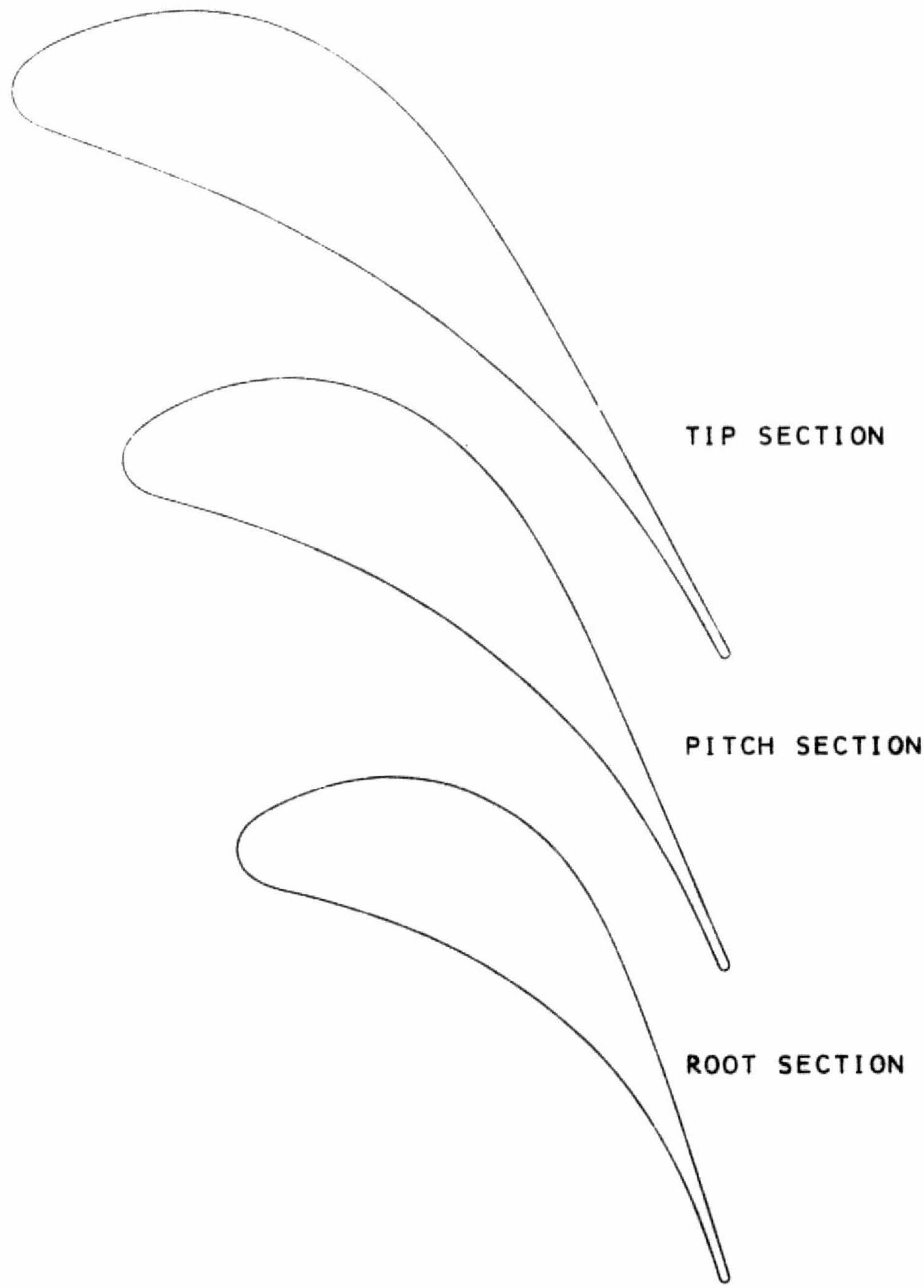


Figure 27. - Turbine nozzle contours for final engine design.

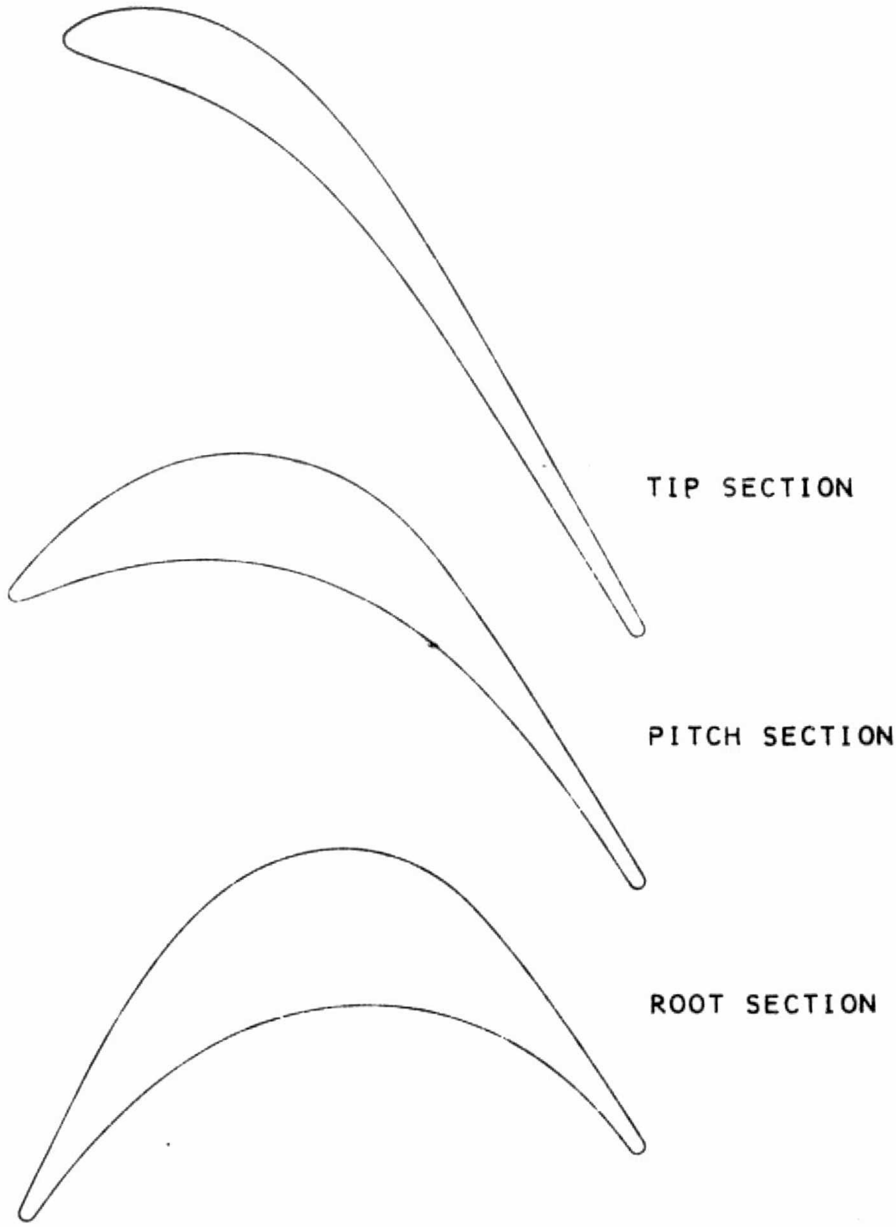


Figure 28. - Turbine bucket contours for final engine design.

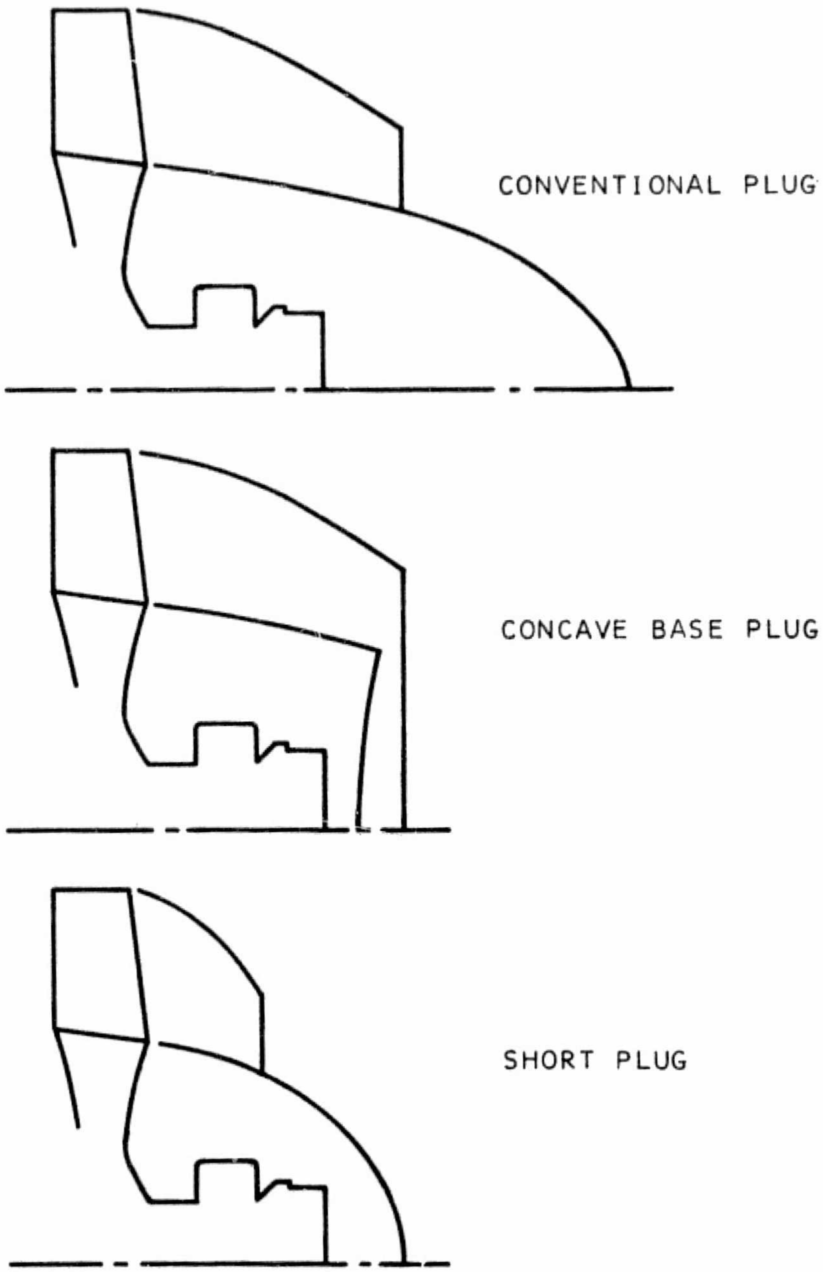


Figure 29. - Nozzle configurations.