ENGINEL

A SINGLE ROTOR TURBOJET ENGINE CYCLE MATCH PERFORMANCE PROGRAM

By

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ENGINEL is a computer program which was developed to generate the design and off-design performance of a single rotor turbojet engine with or without afterburning using a cycle match procedure. It is capable of producing engine performance over a wide range of altitudes and Mach numbers. The flexibility, of operating with a variable geometry turbine, for improved off-design fuel consumption or with a fixed geometry turbine as in conventional turbojets, has been incorporated. In addition, the option of generating engine performance with JP4, liquid hydrogen or methane as a fuel is provided.
This document presents in users format, with a brief description of computational procedures and examples, a Single Rotor Turbojet Engine Cycle Match Performance Program designated ENGINEL, developed by Mr. Arvid L. Keith, Jr., of the NASA Langley Research Center.

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SUMMARY

The computer program ENGINEL was developed to provide engine performance for a single spool turbojet engine with or without afterburning, using a cycle match procedure. ENGINEL will generate, as specified by the user, engine design point performance at sea level static standard day conditions and will both develop and retain the parameters required to generate off design performance. It is then capable of producing engine performance over a wide range of altitudes and Mach numbers as requested by the user.

In the cycle match computational procedure ENGINEL utilizes a non-dimensional compressor map, constant efficiencies for the combustor, turbine, afterburner and a constant thrust coefficient for the convergent-divergent nozzle. A turbine map is not used, instead the cycle match is accomplished by flow matching using a constant turbine flow function, determined in the design point calculation.

ENGINEL has the option, exercised by user request, of generating performance with a variable geometry turbine, for improved off-design fuel consumption, or a fixed geometry turbine as in conventional turbojet engines. In addition, the option of generating engine performance with JP4, liquid hydrogen or methane as a fuel is provided.

Included as Appendix A to this document is a complete FORTRAN IV listing of ENGINEL. Sample problems, with input explanation, showing the various printed output options along with the normal engine control options are provided in Appendix B.

INTRODUCTION

The computer program described in this document provides engine performance for a single spool turbojet engine with and without afterburning. This program, ENGINEL, was developed by Mr. Arvid L. Keith, Jr., of the NASA Langley Research Center (LaRC), to generate the engine performance presented in the Reference 1 document. It was originally programmed by Mrs. Francis T. Meissner, also of NASA (LaRC), for the LaRC-CDC 6400-6600 computer complex using the ICOPS system.

Since its inception, this program has proved to be an exceptionally useful tool. It has been used extensively in the study of Advanced Supersonic Transport type aircraft. During the course of its use, it has been modified by Mr. W. A. Lovell of the Vought Corporation Hampton Technical Center to be operational on the present LaRC-CDC Cyber computer complex using the NOS system. It has also been modified several times by Mr. Lovell to provide the additional engine performance required for engine/aircraft acoustical studies. A complete listing of the program is provided in Appendix A.
The program is capable of four modes of operation based on user selection as follows:

- Fixed geometry turbine with or without afterburning.
- Variable geometry turbine with or without afterburning.

With any of these modes of operation the user may select fullpower operation only or full and part power operation. This is explained in more detail elsewhere in this document and is shown by example in Appendix B.

**SYMBOLS**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
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<tbody>
<tr>
<td>A</td>
<td>area (ft²)</td>
</tr>
<tr>
<td>CPR</td>
<td>operating compressor pressure ratio (PT₂/PT₁)</td>
</tr>
<tr>
<td>CPRD</td>
<td>design compressor pressure ratio (PT₂/PT₁)d</td>
</tr>
<tr>
<td>°K</td>
<td>degrees Kelvin</td>
</tr>
<tr>
<td>M</td>
<td>Mach number</td>
</tr>
<tr>
<td>N</td>
<td>rotational speed, percent of design value</td>
</tr>
<tr>
<td>Ncorr</td>
<td>corrected rotational speed, N/√6, percent</td>
</tr>
<tr>
<td>PT</td>
<td>stagnation or total pressure (1bf/ft²)</td>
</tr>
<tr>
<td>°R</td>
<td>degrees Rankine</td>
</tr>
<tr>
<td>TT4N</td>
<td>design maximum turbine inlet temperature (°R)</td>
</tr>
<tr>
<td>Wcorr</td>
<td>corrected air flow, W√6/δ (lbm/sec)</td>
</tr>
<tr>
<td>ΔdB</td>
<td>change in noise level, decibels</td>
</tr>
<tr>
<td>δ</td>
<td>ratio of local pressure to standard sea-level pressure</td>
</tr>
<tr>
<td>η</td>
<td>efficiency</td>
</tr>
<tr>
<td>θ</td>
<td>ratio of local temperature to standard sea-level temperature</td>
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**Subscripts:**

- d: design
- max: maximum
The engine performance computational procedure described below has been extracted from Reference 1, rewritten, and expanded so as to provide a basic explanation of the methods used in the ENGINEL program.

This computer program utilizes a cycle match procedure to generate the performance of a single rotor turbojet engine. The program computes the design point cycle performance by conducting progressive, step-by-step thermodynamic calculations from the undisturbed free-stream, to the air intake, through each of the engine components and finally through the exhaust nozzle. In the cycle match iteration, a turbine map is not used; instead it is assumed that the work output is available at a constant efficiency (input). The corrected flow parameter, determined from the design point calculation at the turbine inlet, is, therefore, retained and used to define, by flow matching, all possible operating points of a given design cycle. The nondissociated thermodynamic properties of gases from Reference 2 are used in the cycle calculation.

The nondimensionalized compressor map characteristics, shown in Figure 1, are typical of a single rotor supersonic turbojet engine compressor. These are input to the program in its present form, however, may be replaced by another compressor should it be desired. Nondimensionalization is accomplished as defined in the input parameter identification list.

The nondimensionalized compressor map is constructed so that the surge line pressure ratio (TABPT2 versus TABNST - Figure 1a) is defined from the design pressure ratio, PT2T1D (input) and the design surge margin, Y (input). The X value (input) sets the lower limit of pressure ratio for all rotational speed lines (TABNST) relative to the surge pressure ratio of each speed line. With the PT2T1D, Y and X parameters, a design point compressor pressure ratio function (Z) is formed. This Z function is then used to establish the compressor design point shown by the target symbol (on Figures lb and lc).

For the usual case, Y = 1.1, the design surge pressure ratio margin is ten percent greater than the operating pressure ratio and X = 0.1, the lower pressure ratio limit of the map is one tenth of the local surge pressure ratio. The purpose of the X parameter is to allow the intervals of the local
values of pressure ratio (TABZ, 0 to 1.0) to be squeezed together, for maximum accuracy in matching or spread apart, to insure that the matching values (as determined by the compressor map) of pressure ratio and corrected flow can be obtained.

Off-design compressor operating points are established by iteration along constant corrected speed lines until the corrected flow at the turbine inlet is matched with the value determined in the design point calculation. Off-design corrected speed is defined by Mach number, altitude and the engine power level.

Definition of off-design operating points by constant corrected turbine inlet flow was selected as a reasonable simplification to the computational procedure. The alternate method would be to include a map of the turbine work and flow characteristics. Variables which compromise the choice of constant corrected turbine inlet flow as a matching parameter are:

1. Turbine inlet Mach number less than unity.
2. Unknown effective turbine inlet flow area.
3. Variations in the ratio of specific heats and the specific gas constant, due to changes in turbine-inlet temperature and gas constituency, from the design value.

Of the three effects, only item (3) was considered to be significant. Examination of the effects of the specific heat ratio and the specific gas constant when varied from their design values indicated a maximum variation in the corrected compressor inlet flow of less than two percent of the design value, when the turbine inlet temperature is varied from high values at design to very low values at off-design. The variation in compressor corrected inlet flow with Mach number and associated altitude resulting from the selected flow match procedure is shown on Figure 2 for a wide range of conditions.

Control for the fixed geometry turbine mode of operation is accomplished by giving values to two and solving for the third of the following parameters:

1. Compressor physical rotational speed.
2. Turbine inlet temperature.
3. Exhaust nozzle throat area.

Maximum power at all off-design conditions is determined by setting the compressor rotational speed at 100 percent of design, turbine inlet temperature at the design value and computing the required nozzle throat area. Partial power is defined by a schedule of the ratio of nozzle throat area (Figure 3) as a function of compressor rotational speed. This manner of engine control requires the computer program to iterate to satisfy flow...
matching, at both the turbine inlet and nozzle throat by varying turbine inlet temperature.

Control for the variable geometry turbine mode of operation is initially the same as for the fixed geometry turbine in that the maximum power point is computed in the same manner. On completion of this solution, the computational procedure differs in that the compressor map operating point is retained in the computer memory. Part power operating points are produced by reducing the turbine inlet temperature to provide lower than maximum power, while maintaining the compressor map operating point constant. The turbine inlet area is then reduced to match the design corrected turbine inlet flow and the exhaust nozzle throat area required, to pass the internal flow, is calculated. The program recognizes a maximum variation in turbine area by the value assigned to the variable geometry turbine control parameter (A4A4DN). To solve for this limit, iteration of turbine inlet temperature and area is conducted until the limiting A4A4DN input value is obtained.

The inlet total pressure recovery schedule as a function of Mach number, presently input to the program is shown on Figure 4. This schedule is considered typical of fully variable internal-external compression inlets, however, it may be replaced with any other suitable schedule if so desired.

The exhaust nozzle, incorporated in the program, is a fully variable convergent-divergent nozzle, that operates in the fully expanded mode for all operating conditions. The nozzle schedule for controlling part-power engine operation (Figure 3) is typical of turbojet engines designed for supersonic speeds.

Current FAA regulations require jet engines and aircraft to meet specific noise requirements. Advanced turbojet engines, while operating at maximum power do not meet these regulations without the aid of jet noise suppression. The performance characteristics of an advanced jet suppressor have been extracted from Reference 3 and incorporated in the program. These characteristics are shown graphically on Figure 5, with jet suppressor effectiveness (dB) as a function of exhaust jet velocity (ft/sec).

A complete listing of the ENGINEL computer program is provided in Appendix A. Provided in Appendix B are several sample problems with the required input data and examples of the three printed output formats.

DISCUSSION

The ENGINEL computer program provides the performance of single rotor turbojet engines, as defined by the user selection of sea level static design component performance. It requires a storage capacity of approximately 60,000 octal words and computation times as follows:
Time to compile \( \approx 5.26 \) seconds

Run time for a design point \( \approx .13 \) seconds

Run time per data point \( \approx .03 \) seconds

With this program engine performance can be generated for wide ranges of Mach number, altitude and engine power setting with and without afterburning.

Incorporated in the program are the nondissociated thermodynamic properties of gases from Reference 2, which will provide the combustion characteristics with air of Methane (CH₄), Hydrogen (H₂), and simulate those of JP fuel (CH₂). Computation of engine performance with any of these three fuels can be accomplished by input of the appropriate control parameter (IFUEL). The thermodynamic properties of air are also taken from Reference 2, therefore, the temperature tables for air are also applicable to the fuels used, requiring the input of only one temperature table.

All of the input to the program is by the namelist method and all of the parameters shown in the following list must be input for every design or off design point computed. The namelist method of input, however, provides the flexibility of only changing those parameters which are required to generate the desired engine performance. These parameters are normally Mach number, altitude, and the program controls which determine the number of afterburning and/or dry part power operating points. This is explained in the examples shown in Appendix B.

As shown in Appendix B the user may select any combination of internal component design values, such as overall compressor pressure ratio, compressor efficiency, turbine inlet temperature, turbine polytropic efficiency, airflow rate, etc. The program will then dimensionalize the nondimensional compressor map, determine the turbine flow function to be used as a matching parameter when computing off-design performance. It will also establish a nondimensional exhaust nozzle throat area to be used as a reference when computing all of the afterburning and part power data points requested.

Output from the program may be obtained in several forms as listed below and explained later under the output options control coding.

1. Long form printed output contains state point data at each engine location defined in Figure 6 as well as the overall engine performance.
2. Long form printed output and card deck for use in LaRC airplane mission analysis computer program.
3. Short form printed output - contains overall engine performance and key data for acoustic analysis only.
4. Short form printed output and card deck for use in LaRC airplane missions analysis computer program.
5. Printed output at a specified thrust level, providing performance data specifically for use in acoustic analysis. Data for acoustic analysis is also written on tape 8 which may be saved for use at a later time.

The input required to operate the program, the variable name, control options, and iteration intervals used, along with explanation where necessary, are contained in the following list. The numbers included in the parameter in the following list refer to engine station locations as shown in Figure 6.

Input Parameter Identification

I. Single Value Inputs

A. Design Installation and Flight Variable

ALT - Geometric altitude (ft) - must equal 0 for the design case.
CV - Exhaust nozzle internal gross thrust coefficient (decimal value)
DTEMP - Desired increment from standard day temperature (°C) - used in subroutine AT65SP (atmosphere).

1. If DTEMP is input with standard atmospheric pressures (PBTAB), the calculated performance will be for a simple hot day; i.e., pressure variation with altitude is the same as standard day (pressure altitude) while the ambient temperature is for a standard day +DTEMP atmosphere.

2. If DTEMP is input with the correct PBTAB for that specific atmosphere - the calculated performance will be for the correct hydrostatic equilibrium day.

EMACH - Flight Mach number - must equal 0 for the design case.
ENN - Compressor design rotational speed ratio - equals 1.0 for compressor-map used in the program.
ETA2D - Compressor design adiabatic efficiency (decimal value).
ETA4 - Combustion efficiency (decimal value).
ETA5 - Turbine polytropic efficiency (decimal value).
ETA6 - Afterburner combustion efficiency (decimal value).
HPExT - Power extraction from the turbine (horsepower, HP).
PT2T1D - Compressor design total pressure ratio.
PT4T2D - Combustor design total pressure ratio, (decimal value).

PT65AD - Design afterburner total pressure ratio (constant, decimal value) - If PT65AD < 1.0, the data produced will be for an engine equipped with an afterburner. If PT65AD = 1.0, there is no afterburner pressure loss, therefore, a non-afterburning case will provide data the same as if the engine did not have an afterburner.

PT8PT6 - Exhaust nozzle to afterburner total pressure ratio, (decimal value).

TT4N - Design maximum turbine inlet temperature, (°R).

TT6MAX - Maximum afterburner temperature, (°R).

W1D - Design sea level static air flow rate, (lbfm/sec) - must be the same as the parameter WIDE.

WB - Bleed flow rate from compressor discharge, (lbfm/sec) - air bleed quantity is fixed for all operating conditions.

WCOW1 - Turbine cooling flow factor (decimal value), such that the cooling flow ratio WC/W1 = WCOW1 (TT4-2160°R).

NOTE: Turbine cooling flow is returned to the cycle downstream of the turbine. The associated pressure loss is fixed in the program.

WIDE - Design sea level static air flow rate, (lbfm/sec), must be the same as the parameter WID.

X - Factor for lower limit of the compressor pressure ratio - Equals 0.1 for the compressor used in the program.

XMNSLU - Flight Mach number at which the compressor rotational speed is held constant at 100%.

Y - Compressor surge margin at design - Equals PT2T1S/PT2T1D, Equals 1.1 for the compressor used in the program.

B. Standard Constants

AJ - Mechanical equivalent of heat (778.156 ft-lbf/Btu).

G - Acceleration due to gravity (32.174 ft/sec²).

GAMO - Ratio of specific heats for air (1.4) - assumed constant for all operating conditions.
PSLS - Atmospheric pressure at sea level static, standard day conditions (2116.2381 lbf/ft²).
RO - Gas constant for air (53.33 ft-lbf/lbm-°R).
TSLs - Atmospheric temperature at sea level static, standard day conditions (518.67°R).

C. Iteration Intervals and Miscellaneous

AVAL - Interval used in the partial power routine to define the desired accuracy of matching the nozzle throat area ratio with the scheduled nozzle throat ratio (decimal value, .005 = interval used).
ICASE - Case number - program has no provision for automatic indexing.
NLIM - Maximum number of iterations in the Iteration Subroutine (ITL).

T5VAL - Iterative constant for turbine outlet total temperature (decimal value, .001 = constant used).
T7VAL - Iterative constant for nozzle throat static temperature (decimal value, .01 = constant used).
T8VAL - Iterative constant for nozzle exit static temperature (decimal value, .001 = constant used).
VAL - Interval used to determine nozzle throat total to static pressure ratio (choke) when the nozzle exhaust Mach number is supersonic (decimal value, .025 = interval used).

II. Tabular Inputs

NOTE: The numbers in parenthesis following the variable name are the number of values that must be contained in the variable array.

A. Atmospheric Pressure

PBTAB (8) - Atmospheric pressure for a standard hydrostatic equilibrium day from the U.S. Standard Atmosphere 1962 - with DTEMP = 0°C and the PBTAB table input to the program, atmospheric pressures and temperatures as a function of altitude will be generated for a standard hydrostatic equilibrium day. Should DTEMP ≠ 0 be input, then to produce data for a non-standard hydrostatic equilibrium day a new PBTAB table derived from the U.S. Standard Atmosphere 1962 and corresponding to the input DTEMP will have to replace the current PBTAB table. Should the PBTAB table not be replaced the atmospheric data generated will be for a simple non-standard day, where the temperatures will be non-standard and the pressures will be for a standard day.
B. Air Inlet Total Pressure Recovery - Figure 4

TABM (19) - Mach number.

TABPT1 (19) - Inlet pressure recovery.

C. Compressor Map - Figure 1

TABETA (99) - Adiabatic efficiency ratioed to the surge value of adiabatic efficiency at each compressor rotational speed (N).

TABNST (9) - Corrected Compressor rotational speed (N/√N) ratioed to design corrected speed.

TABPT2 (9) - Surge line pressure ratio - surge pressure ratio at each speed (N) is ratioed to the surge pressure ratio at design speed (100% N).

TABW1 (99) - Corrected air flow ratio - corrected air flow (NaV/√N) is ratioed to the surge corrected air flow at each rotational speed (N).

TABZ (11) - Interval of pressure ratio along a corrected speed line.

D. Air Thermodynamic Tables - Reference 2

TABH (78) - Enthaply of dry air (H, Btu/lbm).

TABPHI (78) - Constant pressure entropy of air (φ, Btu/lbm °R).

TABTEM (78) - Temperature (°R, from 0 to 5000).

E. Part Power Speed/Nozzle Throat Area Control - Figure 3

TABA7 (12) - Nozzle throat area ratio.

TABN (12) - Engine rotational speed ratio.

F. Exhaust Nozzle Sound Suppressor - Figure 5

TABDLDB (17) - Sound level suppression (dB).

TABVJ (17) - Exhaust nozzle jet velocity (ft/sec).

III. Program Operating Controls

A. Design and Operating Code - IDES

IDES = 0 Used to calculate the design values of the turbine flow function.
and the nozzle area ratio \( \frac{A_7}{A_{7D}} \), which are then used in the matching process for that particular engine design at off-design operating conditions. IDES must be input as 0 before normal operating cases are computed.

IDES = 1 Following an engine design case (IDES = 0), IDES = 1 must be input to fix the design matching parameters which are used in subsequent normal operation. Then IDES = 1 must be maintained for all normal operation with variable inputs of Mach number, power setting, altitude, etc., for an engine design determined previously with IDES = 0.

B. Power Setting Codes - IPC, ZTHRUST and IDDBS

IDDBS = 0 Provides engine performance without suppression.

IDDBS = 1 Estimates the available jet suppression (dB) based on the computed exhaust jet velocity and the tables TABDIDB and TABVJ. It also reduces the computed gross thrust by 0.5% for each dB of estimated available suppression. However, when the exhaust jet velocity is equal to or less than 1000 ft/sec no jet suppression is available and no thrust loss is assessed.

IPC = 1 Provides power points from maximum afterburning to maximum dry power.

IPC = 2 Provides a maximum dry power point only.

IPC = 3 Provides power points from maximum afterburning to maximum dry power and on through minimum dry partial power.

IPC = 4 Provides power points from maximum dry power through minimum dry partial power.

ZTHRUST This control is used when data is required at a specific thrust value.

ZTHRUST=0 This control is inoperative and the engine operating mode is determined by the IDDBS and IPC controls.

ZTHRUST>0 When this control is specified the IPC control must be set to 1, 3, or 4, since the ZTHRUST control causes tables of data from maximum through minimum partial power to be generated. From these tables at the specified ZTHRUST are interpolated the specific engine parameters required for engine acoustic analysis. Use of this control overrides the normal output control and provides a printed output as shown in Example 6 of Appendix B. It also causes the program to write the parameters required for acoustics analysis on tape 8.
which can be saved. The parameters written on tape 8 and the format in which they are written are given below:

Parameters: CAPA8, WG, V8, FN, EMACH, T8
(For parameter definitions, see output parameter identification)

Format: (F10.4, F10.3, F10.2, F10.1, F10.4, F10.2)

C. Fuel Code - IFUEL

The fuel code will cause the program to select the thermodynamic properties of the desired fuel with which to compute the thermodynamic properties of combustion and subsequently, engine performance.

IFUEL = 1 Selects JP4 (CH₂) fuel.
IFUEL = 2 Selects methane (CH₄) fuel.
IFUEL = 3 Selects hydrogen (LH₂) fuel.

D. Variable Geometry Turbine - A4A4DN

The variable geometry turbine can only be employed for partial power engine performance calculations, therefore, use of this control can only be accomplished when IPC = 3 or 4 which causes entry into the part power routine.

A4A4DN ≥ 1.0 will produce part power performance for standard fixed area turbine engines.

A4A4DN < 1.0 defines the lower limit of turbine area variation from the design area. The routine will divide the difference between 1.0 and the input value of A4A4DN into 0.05 increments, from which the program will adjust the turbine inlet temperature to provide a flow match while maintaining a constant compressor pressure ratio and compressor corrected inlet flow. When the incremented value comes within 0.025 of the input value of A4A4DN, the routine will iterate to define performance conditions at A4A4DN.

A7A7DN ≥ 1.0 with A4A4DN < 1.0 will provide partial power data at values lower than that permitted by the A4A4DN control alone. With A4A4DN ≥ 1.0 will provide partial power data by standard routine for a fixed geometry turbine.

A7A7DN < The partial power data will be determined by the A4A4DN control only.
E. Afterburner

IPS - Number of afterburner points from maximum afterburning through minimum afterburning.

IPS = 1 with IPC = 1 or 3 produces maximum dry power only.

IPS = 2 with IPC = 1 or 3 produces no data and causes the program to dump.

IPS = 3 with IPC = 1 produces maximum afterburning power, minimum afterburning and maximum dry power. With IPC = 3, in addition to the above, the program will produce data from maximum dry power through minimum partial power.

IPS > 3 with IPC = 1 or 3 will produce data similar to the data when IPS = 3 except that there will be additional data points between the maximum and minimum afterburning data points.

F. Nozzle Codes

NFINAL - Number of partial power cases desired - must be equal to or less than the number of values contained in TABA7 or TABN.

NSTART - Counter to determine the interval in the TABA7/TABN tables for the part power calculation:

NSTART = 1 Read the first table value for the first calculation.

NSTART = 2 Read the second table value for the first calculation.

NUMBER - Sequence of TABA7/TABN lookup.

NUMBER = 1 Use each value.

NUMBER = 2 Use every other value.

PBOP8 - Exhaust nozzle exit static pressure ratio - equal to 1.0 provides performance for a fully expanded convergent-divergent nozzle.

NOTE: At the present time this is the only option available.

G. Output Code - IPUNCH

IPUNCH = 0 Long form printed output only (Examples 1-4, Appendix B)

IPUNCH = 1 Long form printed output plus punched cards in the missions analysis format.
Card output parameters and mission format are:

Parameters: EMACH, ALT, POWER, FG, FD, WF, VB, CAPA8, WG
(For parameter definitions, see output parameter identification.)

Mission Format: (F5.2, F10.1, F5.0, 4F10.1, F10.3, F10.1)

IPUNCH = 2 Short form printed output only (Example 5, Appendix B)
IPUNCH = 3 Short form printed output plus punched cards in the missions analysis format.

(See also the explanation of the ZTHRUST for other modes of output.)

The output parameters along with their definitions are presented in the following list:

Output Parameter Identification

A4/A4D - Turbine flow area ratio - actual to design.
A7/A7D - Nozzle throat area ratio - actual to design.
A8 - Acoustic velocity of the exhaust gas at the nozzle exit. (ft/sec)
A8/A7 - Nozzle area ratio - exit to throat.
ALT - Geometric altitude (ft) (input).
CAPA8 - Nozzle exit area (ft).
CASE = ICASE - Case number - program has no provision for indexing (input).
CV - Nozzle internal gross thrust coefficient (input).
DFGS - Gross thrust loss due to exhaust jet noise suppression (lbf).
DH2-1 - The actual enthalpy change across the compressor minus 1. (Btu/lbm) (design case only).
DLDB - Available exhaust jet noise suppression (dB).
DTEMP - Temperature variation from standard day temperature (°C) (input).
ETA2 - Compressor adiabatic efficiency (decimal value).
ETA5 - Turbine polytropic efficiency (decimal value-input) (design case only).
ETAC - Cycle efficiency (decimal value).
ETAO - Overall propulsion efficiency (decimal value)
ETAP - Propulsive efficiency (decimal value)
F4 - Primary combustor fuel air ratio
F6 - Afterburner fuel air ratio (if nonafterburning then F6 = F5A = fuel air ratio at afterburner inlet).
FD - Ram drag (lbf).
FG - Gross thrust (lbf).
FG1 - Gross thrust corrected for exhaust jet suppression loss (lbf).
FN - Net engine thrust (lbf).
FN1 - Net engine thrust corrected for exhaust jet suppression loss (lbf).
FN/W1 - Specific net thrust (lbf/lbm/sec).
FN/W1D - Specific net thrust based on sea level static design airflow (lbf/lbm/sec).
HPext - Power extracted (horsepower) (input).
HT1 - Enthalpy of the air entering the compressor (Btu/lbm) (design case only).
HT2I - Ideal enthalpy of the air at the compressor discharge. (Btu/lbm) (design case only).
IDDBS - Exhaust jet suppressor control parameter. (input)
MB - Nozzle exit Mach number.
MACH = EMACH - Flight Mach number. (input)
N - Compressor rotational speed (%RPM).
N/SRT - Corrected compressor rotational speed - N/√ΘTI (%RPM)
ONSRT - Corrected compressor rotational speed - N/√ΘTI (%RPM)
Afterburner power point index - varies from 1 through IPS. For a nonafterburning case, it is equal to I = indeterminant.

Engine power setting code. (input)

Turbine inlet temperature (°R).

Inlet pressure recovery (design case only).

Inlet pressure recovery.

Engine pressure ratio.

Design compressor pressure ratio (input) (design case only).

Compressor pressure ratio.

Combustor pressure ratio.

Turbine expansion ratio.

Pressure ratio - total pressure before turbine cooling air is returned to the cycle to total pressure after the turbine cooling air is returned to the cycle - PT5/PT5A.

Afterburner total pressure ratio.

Afterburner total pressure ratio - PT6/PT5A.

Total to static pressure ratio at exhaust nozzle throat.

Exhaust nozzle exit to afterburner total pressure ratio.

Total to static pressure ratio at the nozzle exit.

Specific fuel consumption (lbf/hr/lbf).

Specific fuel consumption corrected for exhaust jet suppression loss (lbf/hr/lbf).

Nozzle exit total temperature (°R).

Free stream total temperature (°R).

Total temperature at the compressor inlet (°R).

Compressor discharge total temperature (°R).
TT4 - Combustor exit (turbine inlet) total temperature (°R).
TT5 - Turbine discharge total temperature (°R).
TT5A - Total temperature at the afterburner inlet (°R).
   (Temperature after the turbine cooling air has been returned to the cycle.)
TT6 - Afterburner exit total temperature (°R).
VO - Flight velocity (ft/sec).
V8 - Nozzle exit velocity (ft/sec).
W1 - Actual compressor inlet air flow (lbm/sec).
W1DCOR - Corrected compressor air flow ratioed to the surge value at a given speed ratio (design case only).
W1K - Corrected compressor inlet airflow ($W1\sqrt{T1}/\delta T1$ - lbm/sec).
WB - Service air bleed (lbm/sec) (input).
WBO/W1 - Ratio of service air bleed to actual compressor air flow (WB/W1).
WC - Turbine cooling air flow (lbm/sec).
WCO/W1 - Turbine cooling bleed factor [Turbine cooling air bleed ratio = WC/W1 = WCO/W1 (TT4-2160°R)] (input).
WF - Total engine fuel flow = engine fuel flow plus afterburner fuel flow (lbm/hr).
WG - Engine exhaust gas flow (lbm/sec).
Z - Compressor pressure ratio function.
ZTHRUST - Engine power control (input).
REFERENCES


(a) Surge Line Pressure Ratio Ratio as a Function of Rotational Speed Ratio

Figure 1 - Nondimensional Compressor Map
(b) Pressure Ratio as a Function of Corrected Flow

Figure 1 - Continued
(c) Efficiency as a Function of Corrected Flow

Figure 1. - Concluded
Figure 2 - Variation of Compressor Corrected Inlet Flow with Mach Number for a Range of Design Engines.
Figure 3 - Schedule of Exhaust-Nozzle-Throat Area Ratio used for Partial Power Control.

Figure 4 - Schedule of Air-Inlet Total Pressure Recovery.
Figure 5 - Predicted Jet Noise Suppressor Effectiveness
Figure 6 - Engine Station Identification

<table>
<thead>
<tr>
<th>Station</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Free stream</td>
</tr>
<tr>
<td>1</td>
<td>Compressor inlet</td>
</tr>
<tr>
<td>2</td>
<td>Compressor outlet</td>
</tr>
<tr>
<td>3</td>
<td>Combustor inlet</td>
</tr>
<tr>
<td>4</td>
<td>Combustor outlet (Turbine nozzle inlet)</td>
</tr>
<tr>
<td>5</td>
<td>Turbine outlet</td>
</tr>
<tr>
<td>5A</td>
<td>Turbine cooling air returned to cycle (Afterburner inlet)</td>
</tr>
<tr>
<td>6</td>
<td>Afterburner outlet</td>
</tr>
<tr>
<td>7</td>
<td>Exhaust-nozzle throat</td>
</tr>
<tr>
<td>8</td>
<td>Exhaust-nozzle exit</td>
</tr>
</tbody>
</table>
APPENDIX A

ENGINE

PROGRAM LISTING
PROGRAM ENGINEL (INPUT, OUTPUT, TAPE5=INPUT, TAPE6=OUTPUT, PUNCH, TAPE8)
COMMON /IEP/ IE
IE=0
CALL MAIN
END

SUBROUTINE MAIN
MAIN PROGRAM
DIMENSION ALTSAV(15), EMSAV(15), NOSAV(15), FNSAV(15), W2SAV(15),
1SFCSAV(15)
DIMENSION TABTEM(78), TABH(78), TABPHI(78), TABPSH(78), TABM(19),
1TABPT2(19), TABNST(9), TABPT2(09), TABZ(11), TABW1(99), TABETA(99)
2, ANS(5), SFCC(25), TABPS(78)
DIMENSION TABPH5(78), TABH4(78)
DIMENSION TABB1(12), TABA7(12), RAB(2), T4(3)
DIMENSION P8T8AB(8), HDT(20), DTTAB(20)
DIMENSION ZFN(50), YFN(50,10), ZEE(10)
DIMENSION TABVJ(17), TABDLD(17)
DIMENSION HJ(3), HSJ(3), TFJ(3), FSJ(3), AMPJ(3)
DIMENSION TAEH4(78,3), TABPH5(78,3), TABPSH(78,3), TABSPJ(78,3)
1
DIMENSION ZZ(936)
EQUIVALENCE (TABH4J(1),ZZ(1)), (TABPH5J(1),ZZ(235))
EQUIVALENCE (TABPSHJ(1),ZZ(469)), (TABSPJ(1),ZZ(703))
COMMON /ZPARAM/ ZFN, YFN, NZCNT, ZTHRUST
COMMON /BK1/ ALT, EMACH, PT2T1D, TT4N, WCOWI, WB, A7A7DN, PT65AD, A44DN, P
180P8W1D, HETA2D, EENN, XY, TF, P8PT6, CVTT6MAX, PT65A, ETA6, IDES, VAL
2GAMO, RO, AJ, TSL8, PSL8, G, TABTEM, TABH, TABPHI, TABPSH, TABSP, TABM, TABNS
3T, TABPT2, TABZ, TABW1, TABETA, TABPT1, IDBS, TABVJ, TABDLDB, IFUEL
COMMON /BK2/ WBOI, AOA, ABCOR, ABO, A7A7D, ANS, APO, A44D, A7A8, A0A
180W1, A7EM7, TO, T8, T7, T71, T51, TO, TT2, TT1, TT2I, TT2I, TT5, TT5A, TT7T
21, TT6, TT7T6, TT4, PO, P8PO, PT7, HF, H8M, H8, H81, H81M, H7M, H7, H7M1, HAB, H
3AB5, H0, HT0, HT2, HT2I, HT4, HT4, HT5M, HT5, HT505, HT5AM, HT5H, HT7M, HT7M1,
4HT6M, HT8M, HT5A05, PHI0, PHITO, PHIT2I, PHIT1, PHIT4, PHIT4, PHIT5A, PHIT5A
COMPUTED VALUES
COMMON /BK2/ WBO1, AOAS, ABCOR, A80A7, A7A7D, ANS, APO, A44D, A7A8, A0A
180W1, A7EM7, TO, T8, T7, T71, T51, TO, TT2, TT1, TT2I, TT2I, TT5, TT5A, TT7T
21, TT6, TT7T6, TT4, PO, P8PO, PT7, HF, H8M, H8, H81, H81M, H7M, H7, H7M1, HAB, H
3AB5, H0, HT0, HT2, HT2I, HT4, HT4, HT5M, HT5, HT505, HT5AM, HT5H, HT7M, HT7M1,
4HT6M, HT8M, HT5A05, PHI0, PHITO, PHIT2I, PHIT1, PHIT4, PHIT4, PHIT5A, PHIT5A
DATA (ZZ(I), I=1, 157) / 0.00000, 229.51000, 307.33000, 320.30000, 333.35000 B 79
1000.346, 47000, 359.66000, 372.92000, 386.25000, 399.66000, 413.16000, 42 B 80
26, 37300, 440.38000, 454.13000, 467.97000, 481.91000, 495.94000, 510.1000 B 81
30, 524.34000, 538.70000, 553.15000, 567.41000, 582.48000, 597.27000, 612 B 82
425000, 627.14000, 642.33000, 657.37000, 672.89000, 688.29000, 703.78000 B 83
5719.39000, 735.66000, 750.82000, 766.67000, 782.60000, 798.61000, 814.70000 B 84
6000, 830.87000, 847.10000, 863.42000, 879.79000, 896.24000, 912.74000, 93 B 85
79, 32000, 945.96000, 962.65000, 979.40000, 996.21000, 1013.07000, 1029.990 B 86
8000, 1046.96000, 1063.97000, 1081.04000, 1098.15000, 1115.31000, 1132.510 B 87
9000, 1149.55000, 1167.05000, 1184.37000, 1201.73000, 1219.13000, 1236.570 B 88
$000, 1254.05000, 1271.56000, 1289.10000, 1306.68000, 1324.28000, 1341.930 B 89
$000, 1359.59000, 1377.29000, 1395.01000, 1412.77000, 1430.55000, 1448.35000 B 90
$000, 1466.18000, 1484.99000, 1503.80000, 1522.61000, 1541.42000, 1559.23000 B 91

DATA (ZZ(I), I=235, 312) / 0.00000, 1.29510, 1.49442, 1.52764, 1.55711, 1.5 B 105
18363, 1.60778, 1.52995, 1.55505, 1.66965, 1.68766, 1.70455, 1.72053, 1.735 B 106
271, 1.75017, 1.76398, 1.77723, 1.79891, 1.80216, 1.81398, 1.82540, 1.83 B 107
351, 1.84722, 1.85758, 1.86770, 1.87754, 1.88711, 1.89645, 1.90595, 1.9148 B 108
49216, 1.93166, 1.93996, 1.94809, 1.95604, 1.96383, 1.97147, 1.97896, 1.9 B 109
58631, 1.99351, 2.00059, 2.00754, 2.01436, 2.02107, 2.02766, 2.03414, 2.04 B 110
652, 2.05708, 2.05296, 2.05930, 2.0650, 2.07090, 2.07670, 2.08241, 2.08 B 111
72, 2.09359, 2.09097, 2.10464, 2.10978, 2.11503, 2.12021, 2.12531, 2.13 B 112
81353, 2.14024, 2.14509, 2.14968, 2.15461, 2.15929, 2.16391, 2.16847, 2.1 B 113
97298, 2.17743, 2.18184, 2.18619, 2.19050, 2.21072, 2.26774 B 114

DATA (ZZ(I), I=313, 390) / 0.00000, 1.34074, 1.54894, 1.58364, 1.61439, 1.6 B 115
14204, 1.66719, 1.69026, 1.71162, 1.73150, 1.75020, 1.77671, 1.78427, 1.79 B 116
299, 1.81496, 1.82926, 1.84296, 1.85508, 1.86905, 1.88097, 1.89279, 1.90 B 117
31, 1.91525, 1.92606, 1.93631, 1.94670, 1.95660, 1.96625, 1.97570, 1.98 B 118
499387, 2.00265, 2.01124, 2.01965, 2.02788, 2.03595, 2.04385, 2.05 B 119
55922, 2.06664, 2.07401, 2.08121, 2.08829, 2.09524, 2.10207, 2.10 B 120
641, 2.12191, 2.12832, 2.13462, 2.14083, 2.14694, 2.15296, 2.15890, 2.16 B 121
72, 2.17052, 2.17621, 2.18181, 2.18734, 2.19280, 2.19819, 2.20350, 2.20 B 122
DATA (227), I = 703, 780, 1000, 1219, 6500, 1224, 9600, 73  
561, 9000, 1248, 5000, 1250, 6300, 1273, 8800, 1286, 9000, 1295, 8000  
600, 1311, 1000, 1324, 4000, 1337, 5000, 1342, 8000, 1347, 2000  
778, 8000, 1391, 6000, 1405, 5000, 1419, 5000, 1433, 7000, 1448, 6000  
800, 1462, 7000, 1467, 5000, 1507, 4000, 1511, 7000, 1517, 5000  
968, 8000, 1552, 1000, 1567, 3000, 1583, 4000, 1598, 6000, 1614, 4000  
100, 1630, 2000, 1642, 5000, 1662, 1000, 1678, 5000, 1694, 7000  
116, 8000, 1727, 3000, 1744, 1000, 1768, 3000, 1777, 7000, 1794, 7000  
500, 2162, 5000, 2352, 3000  

DATA (227), I = 781, 850, 0.0000, 60560, 1920, 9726, 1000, 1020, 1.065  
10, 1020, 1.0590, 1.1450, 1.8240, 1.2180, 1.25370, 1.2266, 1.31820, 1.34900  
2, 37950, 1.4260, 1.4630, 1.4880, 1.5410, 1.5590, 1.56400  
358830, 1.6130, 1.6340, 1.6570, 1.6790, 1.70370, 1.7210, 1.74300  
4379, 1.78350, 1.8035, 1.8233, 1.84290, 1.86210, 1.88120, 1.90000, 1.9185  
50, 1.93690, 1.95500, 1.97290, 1.99600, 2.0060, 2.02540, 2.04260, 2.05950  
62, 0.0750, 1.20920, 1.2240, 1.2450, 1.2450, 1.2640, 1.2880, 1.3076, 1.3206  
720410, 1.2340, 1.2340, 1.2490, 1.2640, 1.2640, 1.2880, 1.29330, 1.3076, 1.3206  
8180, 1.3350, 1.3350, 1.3490, 1.3770, 1.39070, 1.40400, 1.41720, 1.4303  
90, 2.4430, 2.4510, 2.46890, 2.48150, 2.6080, 2.70950  

DATA (227), I = 859, 930, 0.0000, 8.18860, 7.78760, 8.03310, 8.26620, 8.4  
260, 9.78600, 9.93400, 10.08340, 10.19400, 10.28600, 10.37950, 10.5  
34700, 10.63500, 10.69700, 10.78330, 10.83040, 10.88110, 10.95770, 11.033  
4301, 1.10700, 1.11790, 1.12491, 1.13490, 1.143880, 1.145700, 1.152430  
511, 1.50970, 1.16530, 1.17200, 1.187470, 1.187470, 1.187470, 1.19120, 1.197180  
697300, 12.09290, 12.15250, 12.21400, 12.26890, 12.32700, 12.38440, 12.440  
790, 1.49680, 1.55210, 1.60680, 1.66110, 1.71470, 1.76790, 1.82020  
812, 1.87260, 1.92420, 1.97530, 1.102580, 1.102580, 1.102580, 1.102580  
920, 1.59590, 1.64050, 1.681470, 1.105000, 1.1408700  

CONTINUE
KTEST=0
IP=-1

B 167
B 168
B 169
B 170
B 171
B 172
B 173
B 174
B 175
B 176
B 177
B 178
B 179
B 180
B 181
B 182
B 183
B 184
B 185
B 186
B 187
B 188
B 189
B 190
B 191
B 192
B 193
B 194
B 195
B 196
B 197
B 198
B 199
B 200
B 201
B 202
B 203
B 204
B 205
B 206
B 207
B 208
B 209
B 210
IF (IE.EQ.0.0) GO TO 5
IF (ZTHRUST.EQ.0.0) GO TO 5
NLC=NZCNT-1
IF (IDDBS.EQ.0.0) GO TO 3
CALL MTLUP (ZTHRUST,ZEE+2*NLC+50+10,IP,ZFN,YFN)
GO TO 4
CALL MTLUP (ZTHRUST,ZEE+2*NLC+50+10,IP,ZFN,YFN)
DLDB=0.0
WRITE (6,19) ZTHRUST (ZEE(I),I=1,10)
WRITE (8,20) ZEE(3),ZEE(1),ZEE(2),ZEE(5),EMACH,ZEE(10)
READ (5,ENPUT)
IF (EOF(5)) 18,5
H=HJ(IFUEL)
HS=HSJ(IFUEL)
TF=TFJ(IFUEL)
FS=FSJ(IFUEL)
AMP=AMPJ(IFUEL)
DO 7 I=1,78
TABH4(I)=TABH4J(I,IFUEL)
TABPH5(I)=TABPH5J(I,IFUEL)
TABPSH(I)=TABPSHJ(I,IFUEL)
TABPSJ(I)=TABPSJ(I,IFUEL)
7     IF (IE) 8,8,9
WRITE (6,ENPUT)
IE=IE+1
9     NO=0
NZCNT=1
AMP28=AMP*28.97
FS28MP=((1*FS)*28.97-AMP)/FS
WRITE (6,23) ICASE,IPC,PS,ALT,EMACH,HPEXT,IDDBS,WCOWI,VB,CV,ZTHRUS
IT
IPP=0
EN=ENN
P80P0=P80P8
TT4=TT4N
CALL FREJ
HNEW=ALT
ICODE=1
IF (IDES-1) 10,11,11

C
DESIGN CASE
C
10   PT2PT1=PT2T1D
C WIDE IS INPUT FOR WID
WID=WIDE
DELTOD=STTO/DELT0*1.0/PT1PTO
EN=ENN
A4A4D=1.
CALL COND
CALL TURB
CALL COOL
HT6M=HT5AM
PHIT6M=PHT5AM
F6=F5A
TT6=TT5A
OF6=F+F6
PT6T5A=PT65AD
CALL NOZZ
CALL ENG
WRITE (6,21) PT2T1D,WIDCOR,Z,ONSRT,ETA2,PT1PTO,TTO,TT2,TT4,DH2MI,E
ITA5
WRITE (6,22) HT1,HT2I
GO TO 16
C C REGULAR CASE
C C
11 CALL MATCH
CALL TURB
CALL COOL
IF (IPC-2) 13,12,17
B 281
12 HT6M=HT5AM
PHIT6M=PHT5AM
F6=F5A
TT6=TT5A
OF6=F+F6
PT6T5A=PT65AD
CALL NOZZ
CALL ENG
GO TO 16
C C NO AFTERBURNER
C C AFTERBURNER
13 CALL AFTER
14 IF (IPP-1) 2,15,15
B 294
15 CALL PARP
GO TO 2
16 POWER=TT4
CALL OUTPUN (POWER)
B 298
GO TO 14
17 IPP=1
IF (IPP-3) 13,13,12
18 STOP
C
19 FORMAT (/30X,58HOUTPUT ENGINE PARAMETERS CORRESPONDING TO THUST V
VALUE OF .IF8.1.5HLBS. /1X,10HGSFLOW = .IF7.1.8H LBS/SEC.2X15HJET
2VELOCITY = .IF7.2.7HFT/SEC.2X11HJET AREA = .IF7.3.7HSQ.FT.2X11HR
3AM DRAG = .IF8.1.5HLBS. /1X13HMET THRUST = .IF8.1.5HLBS. .2X19HTUR
4BINE IN TEMP. = .IF7.2.2HR.2X18HNOISE REDUCTION = .IF7.3.3HDB..2X1
59HATMOSPHERE = STD + .IF3.1.3H .C/.X28HSPECIFIC FUEL CONSUMPTION =
6 .1F6.4.11HLBM/HR/LBF. .1X20HTURBINE EXIT TEMP = .IF6.1.2H R)
20 FORMAT (1F10.4,1F10.3,1F10.2,1F10.4,1F10.2)
21 FORMAT (1H06X11HDESIGN CASE5X6HPT2TID16.E16.8.4X6HW1DC0RE16.8.9X1HZE
16.8.5X5HONSRT16.8.5X4HETA2E16.8.4X6HPT1PT0E16.8.7X3HTOE16.8.7X3H
2T2IE16.8.7X3HTT4E16.8.6X5HDH2.1E16.8.6X4HETAE51E16.8)
22 FORMAT (1H06X3HHT15XE16.8.5X4HTT214XE16.8/)
23 FORMAT (1H06X9HINPUT5X4HCA5E4X14.5X2HPC56XI4.5X2HP36XE16.8/7X3HALTE
116.8.6X4HMACHE16.8.5X5HPPEXT16.8.5X5HDBS5X14.5X5HWC0W1E16.8.8X2
2HWE16.8.6X2HCE16.8.3X7H2THRUSTE16.2/)
END
SUBROUTINE MATCH
C
DIMENSION ALTSAV(15), EMSAV(15), NOSAV(15), FNSAV(15), W2SAV(15)
1SFC5AV(15)
DIMENSION TABTEM(78), TABH(78), TABPHI(78), TAPPSH(78), TABM(19)
1TABP1T(19), TABNST(9), TABPT2(09), TABZ(11), TABW1(99), TABETA(99)
2, ANS(5), SFC5(25), TABPSP(78)
DIMENSION PBTAB(8), HDT(20), DTTAB(20)
DIMENSION TABPH(78), TABH4(78)
DIMENSION TABN(12), TABA7(12), RAT(2), T4(3)
DIMENSION TABVJ(17), TABDLDB(17)
C
C
C
COMMON /BK1/ ALT, EMACH, PT2T1D, TT4N, WCOW1, WB, A7A7DN, PT65AD, A4A4DN, P
180P6, W1D, H4ETA2D, ENN, X, Y, TF, PT8PT6, CV, TT5MAX, PT6T5A, ETA6, IDES, VAL, C
2GAMO, RO, AJ, TSL5, PLS, G, TABTEM, TABH, TABPHI, TAPPSH, TABPS, TABM, TABNS
3T, TABPT2, TABZ, TABW1, TABETA, TABPT1, IDDBS, TABVJ, TABDLDB
C
CALL COMB
DW2=W4DCOR-W4COR*1./A4A4D
ABCOR=ABS(DW2)
W4TEST=.001*W4DCOR
IF (JCOUNT-2) Z*8*7
2 IF (DW2) 4,5,3
3 IF (ABCOR-W4TEST) 5,5,6
4 WRITE (6+12) W4DCOR+W4COR
ICOUNT=2
5 Z=Z2
RETURN
6 JCOUNT=JCOUNT+1
DW1=DW2
Z2=0
Z1=Z
Z=Z2
GO TO 1
7 IF (ABCOR-W4TEST) 5,5,10
8 IF (DW2) 9,5,4
9 IF (ABCOR-W4TEST) 10,5,10
10 Z3=Z1-(((Z1-Z2)*DW1)/(DW1-DW2))
IF (Z3*LT*0) Z3=0.5*Z2
IF (Z3*GT*1) Z3=0.5*Z1
Z1=Z2
Z2=Z3
Z=Z2
DW1=DW2
JCOUNT=JCOUNT+1
IF (JCOUNT-25) 1,1,4
11 WRITE (6+13) PT2PT1+X,Z,PT2T1L
WRITE (6+14) Z1,Z2,Z3,DW1,DW2
STOP

C
12 FORMAT (1H06X11HNO SOLUTION6X6HW4DCOR2XE1E6.8*5X5HW4COR3XE1E6.8/)
13 FORMAT (1H06X4E15.8)
14 FORMAT (1H05X2HZ1E15.8*2X2HZ2E15.8*2X2HZ3E15.8*2X3HD1E15.8*2X3HDW
12E15.8/)
END
SUBROUTINE NOZZ

DIMENSION ALTSAV(15), EMSAV(15), NOSAV(15), FNSAV(15), W2SAV(15)
1SFCSAV(15)

DIMENSION TABTEM(78), TABH(78), TABPHI(78), TABPSH(78), TABM(19),
1TABPT1(19), TABNST(19), TABT2(09), TABZ(11), TABW1(99), TABW2(99)

2, ANS(5), SFCC(25), TABPS(78)

DIMENSION PBTAB(8), HDT(20), DTTAB(20)

DIMENSION TABPSH(78), TABH4(78)

DIMENSION TABN(12), TABA7(12), RAT(2), T4(3)

DIMENSION TABVJ(17), TABDLO(17)

INPUT

COMMON /BK1/ ALT, EMACH, PT2TID, TT4N, WCOW1, WB, A7A7DN, PT65AD, A4A4DN, P
180P8, W1D, H, ETA2D, ENNXY, TF, PT8PT6, CV, TT6MAX, PT6T5A, ETA6, IDES, VAL,
2GAMO, RO, AJ, TLS, PSLS, G, TABTEM, TABPHI, TABPSH, TABPS, TABM, TABNS
3T, TABPT2, TABZ, TABWI, TABETA, TABPT1, IDDBS, TABVJ, TABDLO

COMPUTED VALUES

COMMON /BK2/ WBOW1, A0AS, ABCOR, AB20A7, A7A7D, ANS, AP0, A4A4D, A7, AB, A0, A
180W1, ABEM7, TO, T8, T7, T7I, T8I, TTO, T2T, T2T, TT2T, TT2T, TT5, TT5A, TT7T
2, TT6T, TT7T, TT4P, P8P0, PT7, HF, H8M, H8I, H8I, H8M, H7M, H7H, H7M, HABH
3AB5, HO, HT2, HT2, HT4, HT4, HT5M, HT5, HT5M, HT5M, HT5H, HT5M, HT5H, HT5M,
4HT6M, HT8M, HT5A50, PHI0, PHIT0, PHIT2, PHI2, PHIT2, PHI2, PHIT5A, PHIT5A
5M, PHI18, PHIT3M, PHIT2, PHIT2, PHIT6M, PHIT6M, PHOF6, PHOH6, PT
6PO, PT1PO, PT2TIS, PT2PT2, PT4PT2, PT5PT4, PT5PT5A, PT8PT8, PT1PT7, PT7PT7
7PT7PT7, PT5PT5D, PT5T5A, PT5T5A, PT5, PT5PT5A, PT5PT5A, PT5PT5A, PT5PT5A
8, PT5PT5A, PT5PT5A, PT5PT5A, PT5PT5A, PT5PT5A, PT5PT5A, PT5PT5A, PT5PT5A
9, PT5PT5A, PT5PT5A, PT5PT5A, PT5PT5A, PT5PT5A, PT5PT5A, PT5PT5A, PT5PT5A
10T6PT5, PT5T5A, PT5T5A, PT5T5A, PT5T5A, PT5T5A, PT5T5A, PT5T5A
11T6PT5, PT5T5A, PT5T5A, PT5T5A, PT5T5A, PT5T5A, PT5T5A, PT5T5A
12T6PT5, PT5T5A, PT5T5A, PT5T5A, PT5T5A, PT5T5A, PT5T5A, PT5T5A
13T5T5A, PT5PT5A, PT5PT5A, PT5PT5A, PT5PT5A, PT5PT5A, PT5PT5A, PT5PT5A
14T5T5A, PT5PT5A, PT5PT5A, PT5PT5A, PT5PT5A, PT5PT5A, PT5PT5A, PT5PT5A
15T5T5A, PT5PT5A, PT5PT5A, PT5PT5A, PT5PT5A, PT5PT5A, PT5PT5A
16T5T5A, PT5PT5A, PT5PT5A, PT5PT5A
17T5T5A, PT5PT5A
18T5T5A, PT5PT5A
19T5T5A, PT5PT5A
20T5T5A, PT5PT5A

COMMON /RRR/ AMP28, FSC28MP, AMP

PHIT2 = PHIT5M
IKONT = 0
F0F6 = F6/(1.0 + F6)
PT8PT8 = PT0PO*PT1PO*PT2PT1*PT4PT2*PT5PT4*1

D 1 
D 2 
D 3 
D 4 
D 5 
D 6 
D 7 
D 8 
D 9 
D 10 
D 11 
D 12 
D 13 
D 14 
D 15 
D 16 
D 17 
D 18 
D 19 
D 20 
D 21 
D 22 
D 23 
D 24 
D 25 
D 26 
D 27 
D 28 
D 29 
D 30 
D 31 
D 32 
D 33 
D 34 
D 35 
D 36 
D 37 
D 38 
D 39 
D 40 
D 41 
D 42 
D 43 
D 44
IF (PT8P8-1.005) 1,1,2
WRITE (6,31)
GO TO 8
IF (F6=F5A) 3,4,3
RT6=(1545.*FOF6*(FS28MP+AMP/F6))/AMP28
GO TO 5
RT6=RT5A
TT6=TT5A
PHIT8M=PHIT6M
PHI8M=PHIT8M-(RT6/AJ*ALOG(PT8P8))
IROU=0
CALL ITT (PHI8M,TABPH5,TABPHI,TABTEM,TABPSP,T8VAL,FOF6,IROU,T8,PHI
18,PSP18)
CALL DISCOT (T8,T8,TABTEM,TABH,TABH,-11,78,0,H8)
CALL DISCOT (T8,T8,TABTEM,TABPSH,TABPSH,-11,78,0,PSIH8)
H8M=H8+PSIH8*FOF6
HT8M=HT6M
IF (HT8M-H8M) 6,6,9
WRITE (6,32)
IF (IDES) 7,7,8
STOP
A4A4D=1.
CALL MAIN
VB=SQRT(2.*G*AJ*(HTBM-HBM))
TBI=T8+2.
CALL DISCOT (T81,T81,TABTEM,TABH,TABH,-11,78,0,H8I)
CALL DISCOT (T81,T81,TABTEM,TABPSH,TABPSH,-11,78,0,PSIH8I)
H8IM=H8I+PSIH8I*FOF6
CPB=(H8IM-H8M)/(TBI-TB)
W8=W1*OF6*OWB
CAPAB=(W8*RT6*T8)/(V8*P9OPO*PO)
GAMAB=CPB/(CPB-RT6/AJ)
AB=SQRT(GAMAB*RT6*T8*G)
PT1PT7=(PT2PT1*PT4PT2*PT5PT4*1/PT5T5A*PT6T5A*PT8PT6)**(-1)
TT7TTI=TT2TTI*TT4/TT2*TT5/TT4*TTSA/TT5*TT6/TT5A
IF (IDES-1) 10,11,11
W7DCOR=WIDCOR*(1.-WBO1)*OF6*SQRT(TT7TT1)*PT1PT7
A7A7D=1.
GO TO 12
W7COR=WICOR*(1.-WBO1)*OF6*SQRT(TT7TT1)*PT1PT7
EM8=V8/A8
IF (EM8-1e) 13,13,16
A80A7=1.

ORIGINA L PAGE QUALITY
EM7=EM8
GAMA7=GAMAB
V7=V8
GAM7P1=GAMA7+1
GAM7M1=GAMA7-1
AOAS=(2*GAM7P1)*(GAM7P1/2*GAM7M1)*1/EM7*(1+GAM7M1/2*EM7**2)**2
IF (IDES=1) RETURN
AOASD=AOAS
RETURN
A7AD=(W7COR*AOAS)/(W7DCOR*AOASD)
RETURN
AOAS=1.
PT7P71=1.8
PT7P7=PT7P71
CONTINUE
IF (PT7P7) RETURN
WRITE (6,33) PT7P7
CALL MAIN
CONTINUE
PHI7M=PHI7M-RT6/AJ*ALOG(PT7P7)
PRINT 35, PHI7M,HT7M
CALL ITT (PHI7M,TABPHI,TABTEM,TABPSP,T7VAL,FOF6,IROU,T7,PHI)
CALL DISCOT (T7,T7,TABTEM,TABH,TABH,-11,78,0,H7)
CALL DISCOT (T7,T7,TABTEM,TABPSP,TABPSP,-11,78,0,PSIH7)
TH7M=H7+FOF6*PSI7
HT7M=HT6M
IF (HT7M-H7M) RETURN
WRITE (6,34) H7M,HT7M
IF (IDES) RETURN
V7=SQRT(2*G*AJ*(HT7M-H7M))
T7I=T7+2*
CALL DISCOT (T7I,T7I,TABTEM,TABH,TABH,-11,78,0,H7I)
CALL DISCOT (T7I,T7I,TABTEM,TABPSP,TABPSP,-11,78,0,PSI7)
H7IM=H7I+FOF6*PSI7
CP7=(H7M-H7IM)/(T7-T7I)
GAMA7=CP7/(CP7-RT6/AJ)
A7=SQRT(GAMA7*RT6*T7G)
EM7=V7/A7
I1KONT=I1KONT+1
IF (I1KONT-2) RETURN
EM7I=EM7
IF (EM7*GE.*999.*AND.*EM7.LE.*1.*001) GO TO 30
IF (EM7-1.*) 23,30,26
23 PT7P72=PT7P71+VAL
24 IIKONT=IIKONT+1
25 IF (IIKONT-10) 17,17,29
26 PT7P72=PT7P71-VAL
GO TO 24
27 IF (EM7*GE.*999.*AND.*EM7.LE.*1.*001) GO TO 30
IF (EM7<999.0R.EM7.GT.1.001) GO TO 28
28 EM72=EM7
PT7P73=PT7P71-((EM71-1.)/(EM71-EM72)*(PT7P71-PT7P72))
PT7P71=PT7P72
PT7P72=PT7P73
EM71=EM72
PT7P7=PT7P73
IIKONT=IIKONT+1
GO TO 25
29 WRITE (6,36)
PRINT 37, T7,H7,PSIH7,H7M,V7,HT7M,PHI7,PSPI7,FOF6,T71,H7I,PSIH7I,H17IM,A7,CP7,GAMA7,PT7P73,IIKONT,PT7P7
31 FORMAT (1H06X37HNOZZLE PRESSURE RATIO LESS THAN 1.005)
32 FORMAT (1H0,6X,*HT8MISLESSTHANH8M*)
33 FORMAT (1H0,6X,*PT7P7ISNEGATIVE=*,E14.6)
34 FORMAT (1H0,6X,*HT7MISLESSTHANH7M*)
35 FORMAT (1H,2X,3H7M,F12.5,2X,4HHT7M,F12.5)
36 FORMAT (1H06X24HSTOPPED IN M7 ITERATION)
37 FORMAT (1H,2X,2HT7,F12.5,2X,4HHT7M,F12.5,2X,4HPHI7,F12.5,2X,3H7M,F12.5,2X,4HPFO6,F12.5,2X,6H
3X3HCP7,F12.5,1X,5HGA7M,F12.5,1X,3HEM7,F12.5,1X,4HFO6,F12.5,2X,6H
4XIIKONT,14,1X,5HPSPI7,F12.5,1X,5HPT7P7,F12.5,1X,6HPT7PT3,F12.5)
END
CALL DISCOT (TTSA.TTSA.TABTEM.TABPHI.TABPHI.-11.78.0.PHITSA)
CALL DISCOT (TTSA.TTSA.TABTEM.TABPSH.TABPSH.-17.78.0.PSP1SA)
RTSA=1545.*FOSA*(FS28MP+AMP/F5A)/AMP28
PHTSAM=PHITSA+PSP1SA*FOSA
PT5TSA=1
RETURN
END

SUBROUTINE ITT (PHOM,H4STAB,PHOTAB,TEMTAB,PSITAB,TVAL,FOFF,IRON,T3
1SFCSAV(IS)
2. ANS(5). SFCC(25). TABPSH(78)
DIMENSION PBTAB(8). HDT(20). DTTAB(20)
DIMENSION TABPHS(78). TASH4(78)
DIMENSION TABN(12). TABA7(12). RAT(2). T4(3)
DIMENSION TABVJ(17). TABDLDB(17)

INPUT
COMMON /BK1/ ALT.EMACH.PT2T1D.TT4N.WCOW1.WB.A7A7DN.PT65AD.A4A4DN.P
180P8.WID.H.E1.ET2D.EMXN.XY.TF.PT8PT6.CV.TT6MAX.PT6T5A.ETA6.IDES.VAL.
2GAMO.R0.AJ.TSLS.PSLS.G.TABTEM.TABH.TABPHI.TABPSH.TABPS.TABM.TABNS
3T.TABPT2.TABZ.TABW1.TABETA.TABPT1.1DDES.TABVJ.TABDLDB

COMPUTED VALUES
COMMON /BK2/ WBOW1.AOAS.ABCOR.A80A7.A7A7D.ANS.APO.A4A4D.A7.AB.AO.A
18OW1.ABEM7.T0.T8.T7.71.T81.T00.TT2.TT1.TT2TT1.TT5.TT5A.TT7TT
4HT6M.HT8.MHT5A5.PHI0.PHI0.THI1.PHI21.PHI1.PHI1.PHI1.PHI1.PHI1.PHI1.
5M.PHI1M.PHI1M.PHI1M.PHI1M.PHI1M.PHI1M.PHI1M.PHI1M.PHI1M.PHI1M.
60POP.PT1PT0.PT2T1S.PT2PT1.PT4PT2.PT5PT4.PT5T5A.PT8PT8.PT1PT7.PT7PT7
7T7PT5.PT6T5D.PT5SIM.PT5SIM.PSIH.PSIH5.PSIH5.PSIH5.PSIH5.PSIH5.
8PT1.PTIPT1.PT1PT2.PT1PT2.PT1PT2.PT1PT2.PT1PT2.PT1PT2.PT1PT2.
0.WDCOR.WDCOR.WDCOR.WDCOR.WDCOR.WDCOR.WDCOR.WDCOR.WDCOR.WDCOR.
1.WDCOR.WDCOR.WDCOR.WDCOR.WDCOR.WDCOR.WDCOR.WDCOR.WDCOR.WDCOR.

CALL DISCOT (TO, TO, TEMTAB, PHOTAB, PHOTAB, -11.78, 0, PHO)
CALL DISCOT (TO, TO, TEMTAB, PSITAB, PSITAB, -11.78, 0, PSIO)
RATIO = PHOM / (PHO + PSIO * FOFF)
KONT = KONT + 1
IF (KONT - 2) .GT. 2 * 3 * 5

R1 = RATIO
T2 = T1 * R1
T0 = T2
GO TO 1

R2 = RATIO
T3 = (T1 - R2) / (R2 - R1) * (T2 - T1) + T2
T0 = T3
GO TO 1

R3 = RATIO
TPLUS = TPLUS + TVAL
TMIN = TMIN - TVAL
IF (R3 - TPLUS) .LE. 9, 7
IF (R3 - TMIN) .LE. 9, 9

R1 = R2
R2 = R3
T1 = T2
T2 = T3
IF (KONT - NLIM) .LT. 4, 8, 8

WRITE (6, 10) IROU
RETURN

FORMAT (1H06X16HDID NOT CONVERGE3X14)
END
SUBROUTINE OUTPUN (POWER)
DIMENSION ALTSAV(15), EMSAV(15), NOSAV(15), FNSAV(15), W2SAV(15),
1SFCSAV(15)
DIMENSION TABTEM(78), TABH(78), TABPHI(78), TABPSH(78), TABM(19),
1TABPT1(19), TABNST(9), TABPT2(09), TABZ(11), TABW1(99), TABETA(99)
2, ANS(5), SFCC(25), TABPSP(78)
DIMENSION TABPHS(78), TABH4(78)
DIMENSION TABN(12), TABA7(12), RAT(2), T4(3)
DIMENSION PBTAB(8), HDT(20), DTTAB(20)
DIMENSION ZFN(50), YFN(50, 10)
DIMENSION TABVJ(17), TABDLDB(17)

COMMON /ZPARAM/ ZFN, YFN, NZCNT, ZTHRUST

COMMON /BK1/ ALT, EMACH, PT2T1D, TT4N, WCO, W8, A7A7DN, PT65AD, A44ADN,
P180PB, W1H, ETA2D, ENS, X, Y, SF, PT8PT6, CV, TT6MAX, PT65A, ETA6, IDES, VAL,
2GAM0, RO, AJ, TLS, PSLS, G1TABTEM, TABH, TABPHI, TABPSH, TABPSP, TABM, TABNS,
3T, TABPT2, TABZ, TA3W1, TABETA, TABPT1, I00BS, TABVJ, TABDLDB

COMPUTED VALUES

COMMON /BK2/ WBO, AOAS, ABCOR, ABOA7, A7A7D, ANS, APO, A44AD, A7A, A9A9,
1BOA9, ABEM7, TO, TB, T7, T1, T0, TT2, TT1, TT2T1, TT5, T75A, TT7T,
21, TT6, T77T6, TT4, P0, P8POL, PT7, HF, H8M, H8, H81, H81M, H7M, H7H7,
3AB5, H0, HT0, HT2, HT2I, HT4M, HT4, HT5M, HT5, HT505, HT5AM, HT5H, HT7H7,
4HT6M, HT8H8, HT8A05, PHI0, PHI1, PHI2, PHI7, PHI7M, PHI7T, PHI7M, PHI7H,
5M, PHI8M, PHI8T, PHI8M, PHI8H, PHI8TH, PHI8M, PHI8H, PHI8TH, PHI8M, PHI8H,
60PC, P1PTO, PT2T1S, PT2PT1, PT4PT2, PT5PT4, PT5PTA, PT8BP, PT1PT7, PT7P7,
P7T6PT5, P76PT5D, P75AM, P75AD, P5I, P5I, P5I, P5I, P5I, P5I, P5I, P5I, P5I,
8HE, P5I, P5I, P5I, P5I, P5I, P5I, P5I, P5I, P5I, P5I, P5I, P5I, P5I, P5I,
9+ET2D, EM7, EM8, W1C, WDCOR, W4COR, W4COR, W4COR, W4COR, W4COR, W4T2,
3W1, W1K, DH2M1, STTO, DELTO, DELTO, GAMAM, GAMAM, VM, V7, VB, GAMAM, GAMAM,
3ON5R, SFC, SFC, OF4, OF6, FOFO, FOFA, F6A, F6A, F6A, F6A, F6A, F6A, F6A,
SW8, W8T, RTA, RT6, RT5, CP7, CP8, CPT8, CPT8, CPT8, CPT8, CPT8, CPT8, CPT8,
5AO, FNOWN1D, HT6, PHI6, T5A, T4, RAT, WCO, PBTAB, HDT, DTTAB, IPS, DTEMP,
6AP, ALTSAV, EMSAV, NOSAV, FNSAV, W2SAV, SFCSAV, NO, INOZ, TT2T1D, HT5A, PH1,
7TT4T2, PH1, PSIP5, PH1, PT5M, HT1, PT2T1L, PS, TABA7, T8VAL, T7VAL, NLI,
8MBER, NSTART, NFINAL, AVAL, XMNSLU, TABN, ETA4, ETA5, TABPH5, TABH4, HPEXT,
9CASE, IPC, PT4T2D, HS, T5VAL, WC

COMMON /NEW/ FD, FG, WF, DLDB, DFGS, FG1, FN1, SFC1

COMMON /PPP/ IPUNCH

G 1
G 2
G 3
G 4
G 5
G 6
G 7
G 8
G 9
G 10
G 11
G 12
G 13
G 14
G 15
G 16
G 17
G 18
G 19
G 20
G 21
G 22
G 23
G 24
G 25
G 26
G 27
G 28
G 29
G 30
G 31
G 32
G 33
G 34
G 35
G 36
G 37
G 38
G 39
G 40
G 41
G 42
G 43
IN
WG=W1*{1+F6)
IF (ZTHRUST.GT.0.0) GO TO 2
IF (IPUNCH.GT.0) GO TO 3
WRITE (6,7) FN,SFC,FNOW1,PT1PTO,PT2PT1,ETA2,W1K,ONSRT,TT0,TT2,TT4
1
PT4PT2,TT5,PT5PT4,TT5A,TT6,PT6PT5,F6,T8,PT8PB,VO,V8,EM8,EN,A4A4D,A
27A7D,A80A7,A8,CAPA8,W1,ETAP,ETAC,ETAO,FNOW1D,WF,WG,PT7PT7,PT1PT7,PT
3S5T5A,PT6PT5A,PT8PT6,TT1,WB,WBOW1,DLDB,DFGS,FG1,FG1,FN1,SFC,DTEMP,WC,F
4
IF (IPUNCH.EQ.0) GO TO 6
IF (IPUNCH.EQ.1) GO TO 4
2
ZFN(NZCNT)=FN1
YFN(NZCNT,1)=WG
YFN(NZCNT,2)=V8
YFN(NZCNT,3)=CAPAB
YFN(NZCNT,4)=FD
YFN(NZCNT,5)=FN2
YFN(NZCNT,6)=TT4
YFN(NZCNT,7)=DLDB
YFN(NZCNT,8)=DTEMP
YFN(NZCNT,9)=SFC
YFN(NZCNT,10)=T8
NZCNT=NZCNT+1
RETURN
3
IF (IPUNCH.EQ.1) GO TO 1
IF (IPUNCH.EQ.2) GO TO 5
IF (IPUNCH.EQ.3) GO TO 5
4
PUNCH 8,EMACH,ALT,POWER,FG1,FD,WF,V8,CAPAB,WG
RETURN
5
WRITE (6,9) FN,FG,FD,SFC,WF,W1,WG,FN1,FG1,EN,SFC,1,W1,V8,CAPAB,TT4
1,A4A4D,TT1
IF (IPUNCH.EQ.3) GO TO 4
6
CONTINUE
RETURN
7
FORMAT (1H07X2HFNF12.5,6X3HSFCF12.5,4X5HF/N/W1F12.5,2X7HPT1/PT0F12.5
15,2X7HPT2/PT1F12.5,5X4HET2F12.5,6X3HWF12.5,4X5HNF/5RTF12.5,6X3HT
2TOF12.5,6X3HTTHTF12.5,6X3HTTF4F12.5,2X7HPT4/PT2F12.5,6X3HTT5F12.5,2X
37HPT5/PT4F12.5,5X4HTT5F12.5,6X3HTT6F12.5,1XBP16/PT5AF12.5,7X2HF6
4F12.5,7X2HTBF12.5,3X6HPT8/PBF12.5,7X2HV8F12.5,7X2HM8F1
52.5,8X1HNF12.5,3X6HA4/A4DF12.5,3X6HA7/A7DF12.5,4X5HA8/A7F12.5,7X2H
6A8F12.5,4X5HCAPABF12.5,7X2HWF12.5,5X4HETAPF12.5,5X4HEATCF12.5,5X4
7HEATOF12.5,3X6HFN/W1DF12.5,7X2HWF12.5,7X2HWF12.5,4X5HPT7PF12.5
83X6HPT1PT7F12.5,3X5HPT5AF12.5,3X6HPT6T5AF12.5,3X6HPT8PT6F12.5,6X
93HTTF12.5,7X2HW8F12.5,4X5HDBD3F12.5,5X4HDFGSF12.5,5X4HDFGSF12.5
56X3HFG1F12.5,6X3HFN1F12.5,5X4HSCF1F12.5,5X4X5HDTEMPF12.5,7X2HWC12.5
SUBROUTINE TURB
DIMENSION ALTSAV(15), EMSAV(15), NOSAV(15), FNSAV(15), W2SAV(15)
1SFCSAV(15)
DIMENSION TABTEM(78), TABH(78), TABPHI(78), TABPSH(78), TABM(19)
1TABPT1(19), TABNST(9), TABT2(09), TABZ(11), TABW1(99), TABETA(99)
2, ANS(5), SFCC(25), TABPSP(78)
DIMENSION PBTA(8), HDT(20), DTTAB(20)
DIMENSION TABPSH5(78), TABH4(78)
DIMENSION TABN(12), TABA7(12), RATS(2), T4(3)
DIMENSION TABVJ(17), TABDLDB(17)

INPUT
COMMON /BK1/, ALT, EMACH, PT2T1D, TT4N, WCO1W1, WB, A7A7DN, PT65AD, A44ADN, P
180P8, WIDH, ETA2D, ENN, XYTF, PBT8PT6, CV, TT6MAX, PT6T5A, ETA6, IDES, VAL
2GAM0, ROA, JA, TSL5, PSL5, TABTEM, TABH, TABPHI, TABPSH, TABPSP, TABM, TABNS
3TABPT2, TABZ, TABW1, TABETA, TABPT1, IDDBS, TABVJ, TABDLDB

COMPUTED VALUES
COMMON /BK2/, WBOW1, A0AS, BDCOR, ABOA7, A7A7D, ANS, APO, A44AD, A7A8A0A
180W1, ABEM7, T0, TB8, T7, T71, T81, TTO, TT2, TT1, TT2TT1, TT5, TT5A, TT7TT
2, 1TT6, TT7TT6, TT4P0, P60PO, P7T7H, H6M, H8, H81, H81M, H7M, H71M, H81H
3AB5, HO, HT0, HT2, HT21, HT4M, HT4, HT505, HT5AM, HT5H, HT7M, HT71M, HT7H
4HT6M, HT8M, HT5A05, PHIO, PHIT0, PHIT1, PHIT4M, PHIT4, PHTSA, PHTSA
5M, PHIT8M, PHIT8M, PH12I, PH17M, PH17M, PH17M, PH06, PH06H, P7
60P0, P7PT0, P2T2T1, P2TPT1, P4PT2, P4PT2, P7T5A, P18P8, P1T1P7, P17P7P7
7T6T5P, PT6T5D, PT5AM, PT5AM, PT5AD, PS1H, PS1H, PS1H, PS1H, PS1P15A, PS1H5A, PS18P
8, PS1H5, P5PS16, P5PS1, P5PS1H, P5PS1H, P5PS1H, P5PS1H, P5PS1H, P5PS1H, P5PS1H, P5PS1H
9, ET2D, EN7, EMB, W1COR, W1DCOR, W4COR, W4DCOR, W7COR, W7DCOR, W4T4, W4TEST
s, 1W1, W1K, DH2M1, STTO, DLOT0, DLOT0D, GAMAB, GAMA7, V0, V7, V8, GAM7P1, GAM7M1
COMMON /RRR/ AMP2B, FS2BMP, AMP

FOF4=F4/0F4
HT4M=HT4+PSIH4*FOF4
CALL DISCOT (TT4, TT4, TABTEM, TABPHI, TABPHI, -11, 78, 0, PHIT4)
CALL DISCOT (TT4, TT4, TABTEM, TABPSP, TABPSP, -11, 78, 0, PSPI4)
PHIT4M=PHIT4+PSPI4*FOF4
DDHP=.706S*HPEXT/W1

DDH2M1=DH2M1+DDHP
HT5M=HT4M-DH2M1/(OF4*WCBl
IROU=5
CALL ITT (HT5M, TABH4, TABH, TABTEM, TABPSH, T5VAL, FOF4, IROU, TT5, HT5, PS, H5)
CALL DISCOT (TT5, TT5, TABTEM, TABPHI, TABPHI, -11, 78, 0, PHIT5)
CALL DISCOT (TT5, TT5, TABTEM, TABPSP, TABPSP, -11, 78, 0, PSPI5)
PHIT5M=PHIT5+PSPI5*FOF4

RT5=1545.*FOF4*(FS2BMP+AMP/F4)/(AMP2B

PT5PT4=EXP(((PHIT5M-PHIT4M)*AJ)/(ETA5*RT5))
RETURN
END

SUBROUTINE COND
DIMENSION ALTSAV(15), EMSAV(15), NOSAV(15), FNOSAV(15), W2SAV(15),
1 SFCSAV(15)
DIMENSION TABTEM(78), TABH(78), TABPHI(78), TABPSPH(78), TABM(19),
1 TABPT1(19), TABNST(9), TABPT2(09), TABZ(11), TABW1(99), TABETA(99)
2, ANS(5), SFCC(25), TABPSP(78)
DIMENSION PBTAB(8), HDT(20), DTTAB(20)
DIMENSION TABPSH(78), TABH4(78)
DIMENSION TABN(12), TABA7(12), RAT(2), T4(3)
DIMENSION TABVJ(17), TABDLDB(17)
COMPUTED VALUES

CALL DISCOT (PHIT2I, PHIT2I, TABEL, TABEL, 11, 99, 11, ETETS)
CALL DISCOT (ONSR, Z, TABNST, TABW, TABZ, 11, 99, 11, ETETS)
ETA2S = ETA2D/ETETS
ETA2 = ETETS*ETA2S
PHIT1 = PHITO
PHIT2I = PHIT1 + RO/AJ*ALOG(PHIT2I)
CALL DISCOT (PHIT2I, PHIT2I, TABEL, TABEL, -11, 97, 0, TT2I)
CALL DISCOT (TT2I, TT2I, TABEL, TABH, TABH, -11, 97, 0, HT2I)
DH2M = (HT2I - HT1)/ETA2
HT2 = HT1 + DH2M
CALL DISCOT (HT2, HT2, TABH, TABH, -11, 97, 0, TT2I)
TT2T1D = TT2/TTT1
SUBROUTINE FRES

DIMENSION ALTSAV(15), EMSAV(15), NOSAV(15), FNSAV(15), W2SAV(15),
1SFCSAV(15)
DIMENSION TABTEM(78), TABH(78), TABPHI(78), TABPSH(78), TABM(19),
1TABPT1(19), TABBST(9), TABT2(09), TABZ(11), TABW1(99), TABETA(99)
2, ANS(5), SFCC(25), TABPS(78)
DIMENSION PTAB(8), HDT(20), DTTAB(20)
DIMENSION TABPHS(78), TABH4(78)
DIMENSION TABB(12), TABA7(12), RAT(2), T4(3)
DIMENSION TABVJ(17), TABDLDB(17)

INPUT

COMMON /BK1/ ALT, EMA, PT2T1D, TT4N, WCOW1, WB, A7A7DN, PT65AD, A4A4DN, P
180PB, WID, ETA2D, ENS, X, Y, TF, PT8PT6, CV, TT6MA, PT65A, ETA6, IDES, VAL
2GAMO, R0, AJ, TSLS, PSLG, TABTEM, TABH, TABPHI, TABPSH, TABPS, TABM, TABNS
3T, TABPT2, TABZ, TABW1, TABETA, TABPT1, IDDBS, TABVJ, TABDLDB

COMPUTED VALUES

COMMON /BK2/ WBOW1, A0A5, ABCCOR, A80A7, A7A7D, ANS, APO, A4A4D, A7, A8, A0, A
180W1, ABEM7, TO, TB, T7, T71, T81, TO, TT2, TTI, TT2, TT2T1, TT5, TTT5, TT7T
21, TT6, TT7T6, TT4, PO, PBOPO, PT7, HF, HB, H8, H81, H8M, H7M, H7, H71, HAB, H
3AB5, H0, HT2, HT21, HT4M, HT4, HT5, HT5M, HT5O5, HT5AM, HT5H, HT7M, HT71, HT7
4HT6M, HT8M, HT5AM, HT5H, HT7M, HT71, HT71M, PH10, PH10, PH1T2, PH1T1, PH1T4,
1PH1T4, PH1T5A, PHT5A, 5M, PH18M, PH18M, PH18M, PH18M, PH18M, PH18M, PH18M,
SUBROUTINE COMB

DIMENSION TABTEM(78), TABH(78), TABPHI(78), TABPSH(78), TABM(19),
  ITABPT1(19), TABNST(9), TABPT2(99), TABZ(11), TABW1(99), TABETA(99)
  2, ANS(5), SFCC(25), TABPSP(78)

STANDARD DAY

CALL DISCOT (TO, TO, TABTEM, TABH, TABH(-1), 78, 0, HO)
HTO=HO+(GAMO*EMACH**2*TO*RO)/12.*AJ)
HTI=HTO
CALL DISCOT (HTO, HTO, TABH, TABTEM, TABTEM(-1), 78, 0, TTO)
CALL DISCOT (TO, TO, TABTEM, TABPHI, TABPHI(-1), 178, 0, PHIO)
CALL DISCOT (TTO, TTO, TABTEM, TABPHI, TABPHI(-1), 178, 0, PHITO)
PTOPO=EXP(AJ/RO*(PHITO-PHIO))
STTO=SQR(TTO/TO/TSL)
THETO=STTO**2
TTI=TTO
PHTI=PHITO
DELT O=PTOPO*PO/PSLS

INLET CONDITIONS

CALL DISCOT (EMACH, EMACH, TABM, TABPT1, TABPT1(-1), 19, 0, PT1PTO)
RETURN
END
DIMENSION PBTAB(8), HDT(20), DTTAB(20)
DIMENSION ALTSAV(15), EMSAV(15), NOSAV(15), FNSAV(15), W2SAV(15),
  1SFCSAV(15)
DIMENSION TABPH5(78), TABH4(78)
DIMENSION TABN(12), TABA7(12), RAT(2), T4(3)
DIMENSION TABVJ(17), TABDLDB(17)

COMMON /BK1/ ALT, EMACH, PT2T1D, TT4N, WCOW1, WB, A7A7DN, PT65AD, A4A4DN, P
  180P8, W1D, H, ETA2D, ENN, X, Y, TF, PT8PT6, CV, TT6MAX, PT5T5A, ETA6, IDES, V4L,
  2GAMO, RO, AJ, TLS, PSL, G1, TABTEM, TABH, TABPH4, TABPSH, TABPSP, TABM, TABNS
  3T, TABPT2, TABZ, TABW1, TABETA, TABPT1, IDDS, TABVJ, TABDLDB

COMMON /BK2/ WBOW1, A0AS, ABCOR, A80A7, A7A7D, ANS, APO, A4A4D, A7A8, AO, A
  180W1, ABEM7, T0, T8, T7, T7I, T8I, T0T, T2T, T21, TT2TTI, TT5A, TT7T
  21, T6, TT7TT6, TT4, P0, P8PO, PT7, HF, H8, H8I, H8I, H8M, H7M, H7H7M, HAB, H
  3AB5, H0, HTO, HT2, HT2I, HT4M, HT4, HT5M, HT5, HT505, HT5AM, HT5H, HT7M, HT7H7M
  4HT6M, H78M, HT5A05, PH10, PHITO, PHIT2I, PHI1, PHIT4M, PHIT4, PHIT5A, PHIT5A
  SM, PPHIT8M, PHIT8M, PHA1, PHIT6M, PHIT6M, PHIT7M, PHIT8F, PHOH6, PHOH6, P
  60PO, PTIPPTO, PT2TT1S, PT2PT21, PT2PT54, PT5PT5A, PT8PT8, PT1PT7, PT2PT7, P
  7T6PT5, PT6PT5D, PT5PT5AD, PT5PT5AD, PT5PT5AD, PT5PT5AD, PT5PT5AD, PT5PT5AD
  28, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I,
  8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I,
  8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I,
  8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I,
  28, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I,
  8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I,
  8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I,
  28, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I,
  8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I,
  28, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I,
  8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I,
  8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I,
  28, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I,
  8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I,
  28, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I,
  8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I,
  28, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I,
  8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I,
  28, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I,
  8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I,
  28, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I,
  8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I, P8I,
WCB=1-WCOWIC-WBOWI
HF=5*(T5-536)
CALL DISCOT (TT4,TT4,TABTEM,TABH,TABH,-11.78,0,HT4)
CALL DISCOT (TT4,TT4,TABTEM,TABPSH,TABPSH,-11.78,0,PSIH4)
F4=(HT4-HT2)/(ETA4*(H-HS)-HT4-PSIH4+HS+HF)
OF4=1+F4
IF (IDES=1) 5,6,6
W4DCOR=W1DCOR*SQRTTT4/TT2*TT2TTI)*I./IPT2TTI*PT4PT2)*OF4*WCB
PT4PT2=PT4T2D
GO TO 7
PT4PT2=I-((1-PT4T2D)*W1COR**2*W1DCOR**(-2)*(PT2T1D/PT2PT1)**2*TT
12TTI/TT2T1D)
IF (PT4PT2LT.7) PT4PT2.7
W4COR=W1COR*SQRT(TT4/TT2*TT2TTI)*I./PT2PT1*PT4PT2)*OF4*WCB
RETURN
WCOWIC=0
GO TO 4
END

SUBROUTINE PARP
DIMENSION ALTSAV(15), EMSAV(15), NOSAV(15), FNSAV(15), W2SAV(15), SFCSAV(15)
DIMENSION TABTEM(78), TABH(78), TABPHI(78), TABPSH(78), TABM(19), ITABPT1(19), TABNST(9), TABPT2(09), TABZ(11), TABW1(99), TABETA(99)
2* ANS(5), SFCC(25), TABPSH(78)
DIMENSION PBTAB(8), HDT(20), DTTAB(20)
DIMENSION TABPSH(78), TABH4(78)
DIMENSION TABN(12), TABA7(12), RAT(2), T4(3)
DIMENSION TABVJ(17), TABDLDB(17)

INPUT

COMMON /BK1/ ALT,EMACH,PT2T1D,TT4N,WCOW1,WB,A7A7DN,PT65AD,A4A4DN,P
180P6,W1D,H,ETA2D,ENN,X,Y,TF,PT8PT6,CT,TT6MAX,PT75A,ETA6,IDES,VAL,
2GAMO,RO,AJ,TSLS,PSLS,G,TABTEM,TABH,TABPHI,TABPSH,TABPS,PAMB,TABNS
3T,TABPT2,TABZ,TABW1,TABETA,TABPT1,TDDBS,TABVJ,TABDLDB

COMPUTED VALUES

COMMON /BK2/ W3OW1,A0AS,ABCOR,A80A7,A7A7D,ANS,AP0,A4A4D,A7A7D,A9A9A
180W1 * ABEM7 * T0 * T8 * T7 * T7I * T81 * TTO * TT2 * TT1 * TT2TT1 * TT5 * TT5A * TT7TT
21 * TT6 * TT7TT6 * TT4 * P0 * P80P0 * PT7 * HF * H8M * H8 * H81 * H8M * H7M * H7H * MABH
3AB5 * H0 * HT0 * HT2 * HT21 * HT4M * HT4 * HT5M * HT5 * HT505 * HT5AM * HT5H * HT7M * HT7MI
4HT6M * HTBM * HTSA05 * PH1O * PHITO * PHIT1 * PHIT4M * PHIT4 * PHIT5A * PHIT5A
5M * PHIBM * PHITBM * PHIB1 * PHIT6M * PHIT6 * PHIT7M * PHIT7 * PHOF6 * PHOH6 * PT6
0PTP0 * PT1TP0 * PT2T1S * PT2PT1 * PT4PT0 * PT5PT5A * PT8PT8 * PT1PT7 * PT7PT7
P
7T6PT5 * PT650 * PT550M * PT55AD * PSI4H * PSI4P * PSI4 * PSI4H5 * PSI415A * PSIH5A * PSI18PS
81H8 * PSIH7 * PSIP16 * PSIPH1 * PSIH6 * PSIH81 * PSIH81 * PSI18PS
9ET2D * EM7 * EM8 * W1COR * W1DCOR * W4COR * W4DCOR * W7COR * W7DCOR * W4TO4 * W4TEST
$W1W1K * DW2M1 * STTO * DELTO * DELTOD * GAMAB * GAMAM7 * VO * V7 * V8 * GAMA7 * GAMAM7
$ONSRT * SFC * SFC1 * OF4 * OF6 * F0F6 * F4 * F5A * FAB * F6 * FNOW1 * FN * F6A * FOF4 * FO5A
$WB * RT5 * RTA * RT6 * RT5A * CP7 * CP8 * CAPAB * CAPAB * OWB * WCB * WCMB * ICP * IS * ICONT
$T1KONT * JCONT * IC * ICONT * THET1 * THETO * DW1 * DW2 * DDHP * Z1 * Z2 * Z3 * Z * ETAC * ET
$AO * FNOW1D * HT6 * HT5A * T4 * RT1 * WCOW1D * PBTAB * HDT * DTAB * IPS * DTTEM * ET
$AP * AⅠTSAV * EⅠTSAV * NOSAV * FⅠTSAV * WⅠTSAV * SFCⅠTSAV * NOⅠTSAV * TT2T1D * HT5A * PH1
$TT4TT2 * PH15T * PⅠ5P * PⅠ5H * PⅠ5H1 * PT2T1L * PSI5A * PSI5H1 * PSI5H * PSI5H1
$MBEⅠ * NSTARⅠ * NFⅠNⅠAL * AⅠVAL * XⅠNSLⅠU * TABN * ETA4 * ETA5 * TABPH5 * TABH4 * HPEXⅠT
$CASE * IPC * PT4T2D * HS * TSⅠVAL
ITJ=0
IPP=0
EN=ENN
ITT4=0
IM=0
W4C1=W4COR
IF (A4A4DN-1) .GT. 18.18
GO TO 35

C

VARIABLE A4/A4D ROUTINE
C
2 TT4=TT4N*A4A4DN**2
IF (TT4.LT.(TT2+100)) GO TO 3
GO TO 4
3 TT4=TT2+100
A4A4DN=SQRT(TT4/TT4N)
4 DELTAT=(TT4N-TT4)/((1-A4A4DN)/-05)
IF (IM) 5.5.6
5 TT4=TT4N-DELTAT
IM=1
GO TO 7
6 TT4=TT4-DELTAT
T4(1)=TT4
7 CALL COMB
W4C2=W4COR
A4A4D=W4C2/W4C1
IF (IM-1) 8,8,9
IF (A4A4D-(A4A4DN+.025)) 11,9,9
CALL TURB
CALL COOL
PT6T5A=PT65AD
HT6M=HT5AM
PHIT6M=PHT5AM
F6=F5A
0F6=1+F6
FOF6=F6/0F6
CALL NOZZ
CALL ENG
EN=ENN
IF (IM-1) 10,10,11
POWER=TT4
CALL OUTPUT (POWER)
IF (FNOW1.LT.0.) GO TO 35
IF (A4A4D-(A4A4DN+.025)) 11,11,6
ASSA4=ABS(A4A4D-A4A4DN)
ITJ=ITJ+1
IF (ITJ-1) 13,13,12
IF (ASSA4-.001) 17,17,13
IF (IM-2) 14,15,15
T4(?)=T4(1)*(A4A4DN**2)/(A4A4D**2)
A4C1=A4A4D
IM=2
TT4=T4(2)
GO TO 7
A4C2=A4A4D
IF (A4C1.EQ.A4C2) GO TO 35
T4(3)=T4(1)-((A4C1**2-A4A4DN**2)/(A4C1**2-A4C2**2))*(T4(1)-T4(2))
T4(1)=T4(2)
T4(2)=T4(3)
TT4=T4(3)
A4C1=A4C2
IM=IM+1
IF (IM-25) 7,7,16
WRITE (6,36)
GO TO 35
POWER=TT4
CALL OUTPUT (POWER)
IF (FNOW1.LT.0.) GO TO 35
IF (A7A7DN-1.) 35,18,18
PPCN
```
TPLUS = 1 * AVAL
TMIN = 1 - AVAL
A7A7DS = A7A7D
T4(1) = T4 - 100*
DO 34 JT = NSTART * NFINAL * NUMBER
  TTP = T4
  INUM = 0
  II = 1
  EN = TABN(JT)
  A7A7DL = TABA7(JT)
  A7A7DO = A7A7D * A7A7DL
  IF (EMACH - XMNSLU) 20, 19, 19
  EN = 1.
  TT4 = T4(1)
  CALL MATCH
  IF (ICOUNT - 2) 22, 1, 22
  IF (ONSRT - .4) 34, 34.23
  CALL TURB
  CALL COOL
  PT6T5A = PT65AD
  HT6M = HT5AM
  PH6M = PHT5AM
  F6 = F5A
  OF6 = 1 + F6
  F0F6 = F6 / OF6
  CALL NOZZ
  RAT(II) = A7A7DO / A7A7D
  INUM = INUM + 1
  IF (RAT(II) - TPLUS) 24, 31, 28
  IF (RAT(II) - TMIN) 25, 31, 31
  IF (INUM - 25) 30, 30, 32
  CONTINUE
  T4(2) = T4(1) + (TTP - T4(1)) * .5
  TT4 = T4(2)
  II = 2
  GO TO 21
  IF (INUM - 2) 29, 30, 26
  T4(2) = T4(1) - (TTP - T4(1)) * .5
  TT4 = T4(2)
  II = 2
  GO TO 21
  CONTINUE
  IF (RAT(1) .EQ. RAT(2)) RAT(2) = RAT(1) * 1.01
```
T4(3) = ((1 - RAT(2)) / (RAT(2) - RAT(1)) * (T4(2) - T4(1))) + T4(2)
IF (T4(3) > TTP) T4(3) = TTP - 25
IF (T4(3) < TT2) T4(3) = TT2 + 50
TT4 = T4(3)
T4(1) = T4(2)
T4(2) = T4(3)
RAT(1) = RAT(2)
II = 2
GO TO 21
31 CALL ENG
POWER = TT4
CALL OUTPUN (POWER)
GO TO 33
32 WRITE (6,36)
33 T4(1) = TT4 - 100
34 CONTINUE
35 A4A4D = 1
RETURN
C
36 FORMAT (1H06X26HITTERATION GREATER THAN 25)
END

SUBROUTINE ENG
DIMENSION ALTSAV(15), EMSAV(15), NOSAV(15), FNSAV(15), W2SAV(15)
SFCSAV(15)
DIMENSION TABTEM(78), TABH(78), TABPHI(78), TABPSH(78), TABM(19)
TABPT1(19), TABNST(9), TABPT2(09), TABZ(11), TABW1(99), TABETA(99)
DIMENSION TABVJ(17), TABDLDB(17)
DIMENSION ALTS(15), EMSACH, PT2T1D, TT4N, WCOW, WB, A7A7DN, PT65AD, ANS(5), SFCC(25), TABPS(78)
DIMENSION PBTAB(8), HDT(20), DTTAB(20)
DIMENSION TABPH5(78), TABH4(78)
DIMENSION T4(3)
DIMENSION DPBA7(12), TABA7(12), RAT(2), T4(3)
DIMENSION TABVJ(17), TABDLDB(17)

COMMON /BK1/ ALTB, EMACH, PT2T1D, TT4N, WCOW, WB, A7A7DN, PT65AD, ANS(5), SFCC(25), TABPS(78)
DIMENSION PBTAB(8), HDT(20), DTTAB(20)
DIMENSION TABPH5(78), TABH4(78)
DIMENSION T4(3)
DIMENSION DPBA7(12), TABA7(12), RAT(2), T4(3)
DIMENSION TABVJ(17), TABDLDB(17)

C

c

INPUT

C

23GAM0, RO, AJ, TLS, PLS, G, TABTEM, TABH, TABPHI, TABPSH, TABPS, TABM, TABNS
3T, TABPT2, TABZ, TABW1, TABETA, TABPT1, IDDBS, TABVJ, TABDLDB

M 1
M 2
M 3
M 4
M 5
M 6
M 7
M 8
M 9
M 10
M 11
M 12
M 13
M 14
M 15
M 16
M 17
COMPUTED VALUES

COMMON /BK2/ WBOW1, AOAS, ABCOR, ABOA7, A7A7D, ANS, APO, A4A4D, A7, A8, AO, A
180W1, ABE7M, T0, T8, T7, T71, TBI, TTO, TT2, TT1, TT2TT1, TT5, TT5A, TT7T
21TT6, TT7TT6, TT4, P80PO, P77, PF2, H8M, H8, H8I, H8IM, H7M, H7, H7MI, HAB
3AB5, H0, HTO, HT2, HTI, HTM, HT4, HT5, HT505, HT5AM, HTSH, HT7M, HT7NI, H
4HT6M, HT8M, HTSA05, PHI0, PH10, PH21, PH1T4, PH1T4, PH1TA, PH1SA, PH1TA
5M, PH18M, PH1BM, PH24M, PH1T6M, PH1M, PH1T6M, PH1T7M, PHOF6, PHOH6, PT
60PO, PT1PT0, PT2T1S, PT2T1T, PT4PT2, PT5PT4, PT5PTA, PT8PO, PT1PT7, PT7P
7T6PT5, PT6T5D, PT5AM, PT5AD, PSI1H4, P5S1P4, P5S1P5A, P5S1H5A, P5S1P8, P
81H8, P5S1H7, P5S1P6, P5S1PHI, P5S1H8I, P5S1P7, P5S1P7, EN, ETA2, ETA5, ETA
9Z, ETA2, EM7, EM8, WICOR, WICOR, W4COR, W4DCOR, W7COR, W7DCOR, W7TO4, W7T
*W1, W1K, DH2M1, STT0, DELTO, DELTO, DELTO, GABM1, GABM1, GABM1, GABM1
*ONSR, SFC, SFCC, OF6, OF6, OF6, OF6, F4, F5A, FAB, F6, FNW01, FN1, FGA, FOF4, F05A,
&W8, RT5, RTA, RT6, RT5A, CP7, CP8, CAPA8, CAPA7, OWB, WCB, WCB, CIBM, IPP, IS, I
*T1K, JCONT, IC, KTEST, THET1, THET0, DW1, DW2, DDHP, Z1, Z2, Z3, Z1, ETA1, ET
*AO, FNW1D, HT6, PHI6, T5A, T4, RAT, WCOW1C, PBTAB, HDT, DDTAB, IPS, DTEMP, ET
$AP, ALTSAV, EMSAV, NOSAV, FN Sav, W2Sav, SFC Sav, NO, INOZZ, TT2T1D, HT5A, PHT1
$T4T4, ST5, P5S1P5, PH1T5, P5S1P5, PH1T5, HT1, PT2T1, PS, TABA7, T8VAL, T7VAL, NL
&M, NSTART, NFINAL, AVAL, XMNSL, TABN, ETA4, ETA5, TABPH5, TABH4, HPEXT1
$CASE, IPC, PT4T2D, HS4, T5VAL

COMMON /NEW/ FD, FG, WF, DLDB, DFGS, FG1, FN1, SFC1
COMMON /WWW/ WWIDE

VO=EMACH*AO
A80W1=(OWB*OF6*RT6*/T8)/(P80PO*PO*V8)
FNW01=OWB*OF6/(V8*CV/G)-VO/G+(P80PO-1)*A80W1*PO
FN=FNW01*W1
SFC=F6*OWB/FNW01*3600*
FD=W1*VO/G
FG=FN+FD
WF=SFC*FN

IF (I1DBS.EQ.0) GO TO 1
IF (V8.LT.1000) GO TO 2
CALL FTLUP (V8, DLDB, 2, 17, TABV1, TABDLDB)

DFGS=1.0-0.005*DLDB
FG1=FG*DFGS
FN1=FG1-FD
SFC1=WF/FN1

1 IF (I1DBS.GT.0) GO TO 3
2 DLDB=0*
FG1=FG
FN1=FN
SFC1=SFC

A-32
IF (VO) 5.5.4
VJE=((FNOW1+VO/G)*G)/(OWB*OF6)
ETAP=(2*G*FNOW1/VO)/(OWB*OF6*(VJE**2-VO**2))
ETAC=(OWB*OF6*(VJE**2-VO**2))/(2*G*A1*OWB*F6*(H-HS))
FNOW1=FN/WIDE
ETAO=ETAP*ETAC
GO TO 6
ETAC=0
ETAP=0
ETAO=0
FNOW1=FN/WIDE
RETURN
END

SUBROUTINE AFTER
DIMENSION ALTSAV(15), EMMSAV(15), NOSAV(15), FNOSAV(15), W2SAV(15),
ISFCSAV(15)
DIMENSION TABTEM(78), TABH(78), TABPHI(78), TABPSH(78), TABM(19),
1TABP1(19), TABN1(9), TABPT2(09), TABZ(11), TABW1(99), TABETA(99)
2*ANS(5), SFCC(25), TABPSP(78)
DIMENSION PBTAB(8), HDT(20), DTTAB(20)
DIMENSION TABPHS(78), TABH4(78)
DIMENSION TABN(12), TABA7(12), RAT(2), T4(3)
DIMENSION TABVJ(17), TABDLDB(17)

INPUT
COMMON /BK1/ ALT, EMACH, PT2T1D, TT4N, WCOW1, WB, A7A7DN, PT65AD, A4A4DN, P
180P8, WID, H, ETA2D, ENN, X, TF, PT8PT6, CV, TT6MAX, PT65A, ETA6, IDES, VAL,
2GAM0, RO, AJ, TSL5, PSL5, X, TABTEM, TABH, TABPHI, TABPSH, TABPHS, TABM, TABNS,
3T, TABP1T, TABZ, TABW1, TABETA, TABPT1, IDDBS, TABVJ, TABDLDB

COMPUTED VALUES
COMMON /BK2/ WBOW1, A0A5, ABCOR, ABOA7, A7A7D, ANS, APO, A44A4D, A7A8, AO, A
180W1, ABEM7, TO, T8, T7, T71, T81, T70, TT2, TT1, TT2, TT1, TT5, TT5A, TT7T
21, TT6, TT7T6, TT4, P0, P80PO, PT7, HF, HBM, H8, H81, H81M, H7M, H7M, H7MI, HAB, H
3AB5, HO, HT0, HT2, HT21, HT4M, HT4, HT5M, HT5, HT505, HTAM, HT5H, HT7M, HT7MI,
4HT6M, HT8M, HT5A05, PH10, PHIT0, PHIT21, PHIT1, PHIT4M, PHIT4, PHIT5A
PHIT5A
5M, PHIT6M, PHIT8M, PH10, PH12I, PHIT6, PHIT7M, PHIT6, PHIT6F, PHOF6, PHOH6, PT

N 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
60 PO, PT1PT0, PT2T1S, PT2PT1, PT4PT2, PT5PT5A, PT8PT8, PT1PT7, PT7PT7P
7TPT5PT5TD, PT5AM, PT5AD, PS1H4, PSPI4, PS1H5, PSPI5A, PSIH5A, PSPI8PS
8ISO, PSIH7, PSPI6, PSIPHI, PSIH6, PS1H8I, PSPI7EN, ETA2, ETA5A, ETAETSES
9ET2D, EM7, EM8, W1COR, W1DOR, W4COR, W4DOR, W7COR, W7DOR, W4T0T4
sW1W1KDH2M1, STT0, DELT0, DELT0D, GAMAB, GAMABV, V0, V7, V8, GAMAT1, GAMAT1M
TONRTA, SPCC, OF4, O6, OF6, FOF6, F4, F5A, FAB, F6, FN0W1, FN, F6A, FOF4, FO5A
SW8, RT5A, RT6, RT5A, CP7, CP8, CAPAB, CAPA7, OWB, WCW, ICMB, IPP, IS, ICOUNT
S,TIKONT, JCONT, IC, KTEST, THET1, THET0, DW1, DW2, DDHP, Z1, Z2, Z3, Z3, ZETAC, ET
A0, FNOW1D, HT6, PHIH6, T5A, T4, RAT, WCW1C, PBTAB, HDT, DTTA8, IPS, DTEMP, ET
SAP, ALTSAV, EMSAV, NOSAV, FNSAV, W2SAV, SFCSAV, NO, INOZ, TTT2TD, T5A, PHT1
S, S, TTA4T2, PHIT5, PSPI5, PHIT5M, HT1, T5PT1L, PS, T8A7, T8VAL, T7VAL, NLI, N
$MER, NSTART, NFINAL, NVAL, XMSNLU, TABN, ETA4, ETA5, TABPH5, TABH4, HPEXT, I
$CASE, IPC, PT4T2D, HS, T5VAL
CPS=IPS
DO 4 I=1, IPS
PS=1
IF (I-I PS) 1, 3, 3
1 TT6=(TT5A+50*CTT6MAX-TT5A-50*)(CPS-1-PS)/(CPS-2)
PT6TA=PT6AD-2*(1+5*(TT6MAX-TT5A-50*)(CPS-1-PS)/(CPS-2)
CALL DISCOT (TT6, TT6, TABTEM, TABB, TABB+11, 78, 0, HT6)
CALL DISCOT (TT6, TT6, TABTEM, TABBPSH, TABBPSH-11, 78, 0, PSIH6)
FAB=(HT6-HT5A)/(ETA6*(H-HS)+HS-HT6-PSIH6+HF)*(1+F5A*(1+(PSIH6-PS
11H5A/(HT6-HT5A))))
F6=F5A+FAB
OF6=1+F6
HT6M=HT6+PSIH6*F6/(OF6)
CALL DISCOT (TT6, TT6, TABTEM, TABBPS, TABBPS-11, 78, 0, PSIH6)
CALL DISCOT (TT6, TT6, TABTEM, TABBPHI, TABBPHI-11, 78, 0, PHIT6)
PHIT6M=PHIT6+PSPI6*F6/OF6
2 CALL NOZZ
CALL ENG
POWER=TT6
CALL OUTFUN (POWER)
GO TO 4
3 TT6=TT5A
PHIT6M=PHIT5AM
HT6M=HT5AM
FAB=0
PT6TSA=PT65AD
F6=F5A
OF6=1+F6
GO TO 2
4 CONTINUE
RETURN
SUBROUTINE AT62SP (CH, ANS, DTEMP, PBTAB, HDT, DTTAB)

ANSWERS COMPATIBLE WITH THOSE OF AT62

AT62SP CONVERTED TO CDC 1-67

SUBROUTINE AT62SP WILL COMPUTE THE STANDARD DAY, 1962 ATMOSPHERIC PROPERTIES (PRESSURE, DENSITY, TEMP, SONIC SPEED, AND REYNOLDS NO. PER MACH - FT) AS A FUNCTION OF AN INPUT ALTITUDE (H, GEOMETRIC FT) FROM S.L. TO 200000 FT.

IN ADDITION A NON-STANDARD DAY MAY BE COMPUTED IN SEVERAL OPTIONAL WAYS.

BY INPUTING A TEMPERATURE INCREMENT (DTEMP, DEG KELVIN) A HOT DAY UTILIZING THE STANDARD DAY TEMPERATURE GRADIENTS MAY BE COMPUTED.

THIS ATMOS. WILL USE THE HYDROSTATIC EQUA. AND THE EQUA. OF STATE.

BY INPUTING A TABLE OF TEMPERATURE INCREMENTS AS A FUNCTION OF ALTITUDE (DTTAB VS HDT) A HOT DAY MAY BE COMPUTED WHICH WILL OBEY THE EQUA. OF STATE BUT NOT THE HYDROSTATIC EQUA.

COMBINATIONS OF THESE TWO OPTIONS MAY BE USED TO COMPUTE A WIDE VARIETY OF NON-STANDARD ATMOSPHERES.

FOR EITHER ATMOS. DESIRED, A TABLE OF PRESSURES AT SPECIFIED ALTITUDES MUST BE INPUT (PBTAB(8)). THIS TABLE WILL BE SUPPLIED BY ACG FOR SELECTED DTEMP VALUES.

( THE BASIC TEMPS. AND GRADIENTS ARE BUILT IN )

DIMENSION ANS(5), HMTAB(9), HBTAB(8), ELMTAB(6), TMBTAB(8)
DIMENSION PBTAB(8), HDT(20), DTTAB(20)
DIMENSION ZDPR(1), HDPR(1)
DOUBLE PRECISION ZDPR, HDPR, Z6, Z6P, TEMP2
DOUBLE PRECISION TEM2, TEM3, TEM4, TEM5, TEM9
DOUBLE PRECISION SINZ, DSIN, DLOG, DCOS
DATA (HMTAB(1), I = 1, 9) = (HBTAB(1), I = 1, 8) = (ELMTAB(1), I = 1, 8) = (TMBTAB(1), I = 1, 8) = (-999999999, 11000, 20000, 32000, 47000, 52000, 61000, 79000, 20000, 32000, 47000, 52000, 61000, 79000, 30065, 0, 001, 0028, 0, 0004, 0, 004, 0, 288, 15, 216, 65, 216, 65, 228, 65, 4270, 65, 270, 65, 252, 65, 190, 65, 0, 37, 0, 38)
CONVERT Z FT. TO Z METERS
Z = ZFT * CONV1

CALL STORE(ZDPR, ZDPR(1), 1, Z)
ZDPR = Z

CALL STORE(ZDPR, ZDPR(2), 1, 0)
Z6 = ZDPR(1) * 0.00001
Z6 = ZDPR * 0.00001
Z6P = Z6 + 6 * 36757080
Z6P = Z6 + 6 * 3675708

TEMP2 = 0.0010559179 * Z6 + 1.5640943
TEMP2 = 0.0010559179 * Z6 + 1.5640943

TE12 = Z6P * Z6P
TEM3 = TEM2 * Z6P
TEM4 = TEM2 * TEM2
TEM5 = TEM2 * TEM3
TEM9 = TEM4 * TEM5

SINZ = DSIN(.00052795893 * Z6 + 78204713)
SINZ = DSIN(.00052795893 * Z6 + 78204713)

217 HDPR(I) = -40648635 / (Z6P) - 894899 * 28D0 / TEM3 - 16302410 * D0 / TEM9 - 7
217 HDPR(I) = -40648635 / (Z6P) - 894899 * 28D0 / TEM3 - 16302410 * D0 / TEM9 - 7
13724D0 / TEM4 - 135 * 5576D0 / Z6 * Z6 - 1724 * 8490D0 / Z6 + (2684697 * 8D0 / TEM3) *
13724D0 / TEM4 - 135 * 5576D0 / Z6 * Z6 - 1724 * 8490D0 / Z6 + (2684697 * 8D0 / TEM3) *
21NZ = SINZ
21NZ = SINZ

C 326 - 1634923.8D0 + 0.0079017959D0 * DLOG(ZDPR(1) + 6367570.8D0) * (DSIN(TEMP2)
C 326 - 1634923.8D0 + 0.0079017959D0 * DLOG(ZDPR(1) + 6367570.8D0) * (DSIN(TEMP2)
4P2) + (.74833436D0 / (Z6P) - 243160820.8D0) * (DCOS(TEMP2)) + 9646530
4P2) + (.74833436D0 / (Z6P) - 243160820.8D0) * (DCOS(TEMP2)) + 9646530

5284232D0
5284232D0

HDPR = -40648635 / (Z6P) - 894899 * 28D0 / TEM3 - 16302410 * D0 / TEM9 - 7
HDPR = -40648635 / (Z6P) - 894899 * 28D0 / TEM3 - 16302410 * D0 / TEM9 - 7
1 - 135 * 5576D0 / Z6 * Z6 - 1724 * 8490D0 / Z6 + (2684697 * 8D0 / TEM3) *(SINZ* SINZ) + (708 * 70509D0 / TEM2 - 256757.8D0
1 - 135 * 5576D0 / Z6 * Z6 - 1724 * 8490D0 / Z6 + (2684697 * 8D0 / TEM3) *(SINZ* SINZ) + (708 * 70509D0 / TEM2 - 256757.8D0
C 2509 / TEM2 - 256757.85 * Z6 - 1634923.8 + 0.0079017959D0 * DLOG(ZDPR(1) + 6367570.8D0)
2509 / TEM2 - 256757.85 * Z6 - 1634923.8 + 0.0079017959D0 * DLOG(ZDPR(1) + 6367570.8D0)
30) * (SIN(TEMP2)) + (.74833436D0 / (Z6P) - 243160820.8D0) * (DCOS(TEMP2)) + 9646530
30) * (SIN(TEMP2)) + (.74833436D0 / (Z6P) - 243160820.8D0) * (DCOS(TEMP2)) + 9646530

4.7284232
4.7284232

C H = PART(HDPR, HDPR(1), 1)
H = HDPR

IF (Z - 90000.0) 1, 1, 13
IF (Z - 90000.0) 1, 1, 13
    N = 1
N = 1
2 IF (H - HMTAB(N)) 5, 4, 3
2 IF (H - HMTAB(N)) 5, 4, 3
3 N = N + 1
3 N = N + 1
GO TO 2
GO TO 2
4   J=J
5   GO TO 6
6   N
7   FIND HB, PB, ELM, TMB, TM
8   HB=HSTAB(J)
9   PB=PSTAB(J)
10  ELM=ELMTAB(J)
11  TMB=TMBTAB(J)+DTMP
12  TM=TMB+ELM*(H-HB)
13  IF (HDT(I) .LT. 0.) GO TO 7
14  CALL DISCOT (ZFT, ZFT, HDT, DTTAB, DTSTAB, -011, 2000, DT)
15  IF (TM .IN. KELVIN)
16      TM = TM + DT
17      TMB = TMB + DT
18  TM SAVE = TMB - TMBTAB(J)
19      TM = TM - TM SAVE
20      TMB = TMB - TM SAVE
21  IF (ELM) 11, 12
22     IF ELM = 0 COMPUTE P
23     P = EXP (ALOG (PB) - (GO*EMOR/ELM)*ALOG (TM/TMB))
24     GO TO 14
25     IF ELM = 0 COMPUTE P
26     P = EXP (ALOG (PB) - (GO*EMOR)*((H-HB)/TMB))
27     Z = Z
28  C  CONVERT P NT/M2 TO PSF.
29      PRESS = P/47.880183
30  C  T DEGREES KELVIN
31      IF (22640.*-PSTAB(2)) 17, 17.15
32      IF (PSTAB(2)-22630.*) 17, 17.16
33      TM = TM + DT SAVE
34      T = TM
35      RHO KG/M3
36      RHO = EMOR*(P/TM)
37  C  CS M/SEC
38      CS = SQRT (GAM*TM/EMOR)
39      CONVERT RHO KG/M3 TO LB/FT3
40      RHO = RHO*CONV1*CONV1*CONV1/CONV2
41  C  CS FT/SEC
42      CS = CS/CONV1
43  C  VISCOS IN LB/FT-SEC
44      CONST = (CONV1/CONV2)*1.458/10**6
45      VISCOS = CONST*T**1.5/(T+110.4)
C
RNOML IN RN/MACH-FT
RNOML=RHO*CS/VISCOS
C
CONVERT RHO LB/FT3 TO SLUG/FT3
RHO=RHO/321740485E+02
ANS(1)=RHO
ANS(2)=PRESS
ANS(3)=T
ANS(4)=CS
ANS(5)=RNOML
H=ZFT
RETURN
END

SUBROUTINE FTLUP (X,Y,M,N,VARI,VARD)
DIMENSION VARI(1), VARD(1), V(3), YY(2)
DIMENSION II(43)
DATA (II(J),J=1,43)/43*/43-1/
MA=ABS(M)
LI=MOD(LOCF(VARI(1)),43)+1
I=II(LI)
IF (I*GE*0) GO TO 6
IF (N*LT*2) GO TO 6
IF (VARI(2)-VARI(1)) 2,2,4
1 K=LOCF(VARI(1))
PRINT 17, J,K*(VARI(J),J=1,N)*(VARD(J),J=1,N)
STOP
2 DO 3 J=2,N
IF (VARI(J)-VARI(J-1)) 3,1,1
3 CONTINUE
GO TO 6
4 DO 5 J=2,N
IF (VARI(J)-VARI(J-1)) 1,1,5
5 CONTINUE
6 IF (I*LE*0) I=1
IF (I*GE*0) I=N-1
IF (N*LE*1) GO TO 7
IF (MA*NE*0) GO TO 8
7 Y=VARD(1)
GO TO 16
8 IF (((VARI(I)-X)*(VARI(I+1)-X)) 11,11,9

P 1
P 2
P 3
P 4
P 5
P 6
P 7
P 8
P 9
P 10
P 11
P 12
P 13
P 14
P 15
P 16
P 17
P 18
P 19
P 20
P 21
P 22
P 23
P 24
P 25
P 26
P 27
IN = SIGN(1.0, (VARI(I+1) - VARI(I)) * (X - VARI(I)))

IF ((I+IN) LE 0) GO TO 11
IF ((I+IN) GE N) GO TO 11
I = I + IN
IF ((VARI(I) - X) * (VARI(I+1) - X)) 1.11.10

IF (MA EQ 2) GO TO 12
Y = (VARD(I) * (VARI(I+1) - X) - VARD(I+1) * (VARI(I) - X)) / (VARI(I+1) - VARI(I))
GO TO 16
GO TO 10

IF (N EQ 2) GO TO 1
IF (I EQ (N-1)) GO TO 14
IF (I EQ 1) GO TO 13
SK = VARI(I+1) - VARI(I)
IF ((SK * (X - VARI(I-1))) LT (SK * (VARI(I+2) - X))) GO TO 14

L = 1
GO TO 15

L = I - 1
V(1) = VARI(L) - X
V(2) = VARI(L+1) - X
V(3) = VARI(L+2) - X
YY(1) = (VARD(L) * V(2) - VARD(L+1) * V(1)) / (VARI(L+1) - VARI(L))
YY(2) = (VARD(L+1) * V(3) - VARD(L+2) * V(2)) / (VARI(L+2) - VARI(L+1))
Y = (YY(1) * V(3) - YY(2) * V(1)) / (VARI(L+2) - VARI(L))

GO TO 12

END
SUBROUTINE UNS (IC, IA, IDX, IDZ, IMS)

IF (IC) 1, 1, 2
1 IMS=1
NC=−IC
GO TO 3
2 IMS=0
NC=IC
3 IF (NC−100) 4, 5, 5
4 IA=0
GO TO 6
5 IF (IA) 3, 5, 3
6 IF (ZARG−TABZ(NZ)) 5, 5, 4
7 ZARG=TABZ(NZ)
8 CALL DISSER (ZARG, TABZ(1), 1, NZ, IDZ, NPZ)
9 NX=NY/NZ
10 NPZL=NPZ+IDZ
11 I=1
12 IF (IMS) 6, 6, 8
13 CALL DISSER (XA, TABX(1), 1, NX, IDX, NPX(1))
14 DO 7 JJ=NPZ, NPZL
15 NPY(I)=(JJ−1)*NX+NPX(I)
16 NPX(I)=NPX(I)
17 I=I+1
18 GO TO 10
19 DO 9 JJ=NPZ, NPZL
20 IS=(JJ−1)*NX+1
21 CALL DISSER (XA, TABX(1), IS, NX, IDX, NPX(1))
22 NPY(I)=NPX(I)
23 I=I+1
24 DO 11 LL=1, IP1Z
25 NLOC=NPX(LL)
26 NLOCY=NPY(LL)
27 CALL LAGRAN (XA, TABX(NLOC), TABY(NLOCY), IP1X, YY(LL))
28 CALL LAGRAN (ZARG, TABZ(NPZ), YY(1), IP1Z, ANS)
29 RETURN
30 END
SUBROUTINE DISSER (X, TAB, I, NX, ID, NPX)
DIMENSION TAB(2)

C
DIMENSION TAB(2)
NPT=ID+1
NPB=NPT/2
NPS=NPT-NPB
IF (NX-NPT) 2,1,2
NPX=1
RETURN
2 NLOW=I+NPB
NUPP=I+NX-(NPS+I)
DO 3 II=NLOW+NUPP
NLOC=II
IF (TAB(II)-X) 3,4,4
CONTINUE
NPX=NUPP-NPB+1
RETURN
4 NL=NLOC-NPB
NU=NL+ID
DO, 5 JJ=NL,NU
NDIS=JJ
IF (TAB(JJ)-TAB(JJ+1)) 5,6,5
CONTINUE
NPX=NL
RETURN
6 IF (TAB(NDIS)-X) 8,7,7
NPX=NDIS-ID
RETURN
8 NPX=NDIS+1
RETURN
END
SUBROUTINE LAGRAN (XA, X, Y, N, ANS)
DIMENSION X(2), Y(2)
C DIMENSION X(2), Y(2)
SUM=0.*0
DO 3 I=1, N
PROD=Y(I)
DO 2 J=1, N
A=X(I)-X(J)
IF (A) 102T!
B=(XA-X(J))/A
PROD=PROD*B
CONTINUE
3 SUM=SUM+PROD
ANS=SUM
RETURN
END

SUBROUTINE MTLUP (X, Y, M, N, MAX, NTAB, I, VARI, VARD)
DIMENSION VARI(I), VARD(MAX+1), Y(1), V(3), YY(2)
LOGICAL EX
IF (M*EQ*0) GO TO 17
IF (N*LE*1) GO TO 17
EX=.F.
IF (I*GE*0) GO TO 6
IF (N*LT*2) GO TO 6
IF (VARI(I+2)-VARI(I)) 2,2,4
1 K=LOCVF(VARI(I))
PRINT 19, J,K,(VARI(J), J=1, N)
STOP
2 DO 3 J=2, N
IF (VARI(J)-VARI(J-1)) 3,1,1
CONTINUE
3 GO TO 6
4 DO 5 J=2, N
IF (VARI(J)-VARI(J-1)) 1,1,5
CONTINUE
5 IF (I*LE*0) I=1
CONTINUE
IF (I.GE.N) I=N-1
7
IF ((VARI(1)-X)*(VARI(I+1)-X)) 10*10*7
IN=SIGN(I*O*(VARI(I+1)-VARI(I))*(X-VARI(I)))
B
IF ((I+IN).LE.0) GO TO 9
IF ((I+IN).GE.N) GO TO 9
I=I+IN
IF ((VARI(I)-X)*(VARI(I+1)-X)) 10*10*8
EX=.T.
IF (M.EQ.2) GO TO 12
DO II NT=I+NTAB
11
Y(NT)=(VARD(I+NT)*(VARI(I+1)-X)-VARD(I+1*NT)*(VARI(I)-X))/(VARI(I+1)-VARI(I))
IF (EX) I=I+IN
RETURN
12
IF (N.EQ.2) GO TO 1
IF (I.EQ.(N-1)) GO TO 14
IF (I.EQ.1) GO TO 13
SK=VARI(I+1)-VARI(I)
IF ((SK*(X-VARI(I-1))).LT.(SK*(VARI(I+2)-X))) GO TO 14
13
L=I
GO TO 15
14
L=I-1
15
V(1)=VARI(L)-X
V(2)=VARI(L+1)-X
V(3)=VARI(L+2)-X
DO 16 NT=I+NTAB
16
YY(1)=(VARD(L+NT)*V(2)-VARD(L+1*NT)*V(1))/(VARI(L+1)-VARI(L))
YY(2)=(VARD(L+1*NT)*V(3)-VARD(L+2*NT)*V(2))/(VARI(L+2)-VARI(L+1))
Y(NT)=(YY(1)*V(3)-YY(2)*V(2))/(VARI(L+2)-VARI(L))
IF (EX) I=I+IN
RETURN
17
DO 18 NT=I+NTAB
18
Y(NT)=VARD(1*NT)
RETURN
C
19
FORMAT (IH1,*TABLEBELOWOUTOFORDERFORMTLPATPOSITION*,15,*XTABLEIS
1STOREDINLOCATION*,06,*(8G15.8))
END
APPENDIX B.
SAMPLE PROBLEMS

B-1
The examples, which follow, were chosen to show the proper sequence for establishing an engine design and to show samples of the three modes of printed output.

Example 1 (Case 1) - The following input (ENPUT) data is required to establish an engine design.

$ENPUT

ALT=0 •• CV=.985 •• DTEMP=0 •• EMACH=0 •• ENN=1 •• ETA2D=.875 •• ETA4=.98 •• ETA5=.9 •• ETA6=.9
HPEXT=0 •• PT2T1D=15 •• PT4T2D=.95 •• PT65AD=1 •• PT8PT6=1 •• TT4N=3060 •• TT6MAX=4060
WID=700 •• WB=0 •• WCOW1=.0001 •• WIDE=700 •• X=.1 •• XMNSLU=1.5 •• Y=1.1

AJ=778.156 •• G=32.174 •• GAMO=1.4 •• PSLS=2116.2381 •• RO=53.330321 •• TSLN=518.66999
AVAL=.005 •• ICASE=1 •• NLIM=20 •• T5VAL=.001 •• T7VAL=.01 •• T8VAL=.0001 •• VAL=.025
PBTAB=101325 •• 22632.025 •• 22632.5474 •• 58705 •• 8680 •• 01404 •• 1109 •• 0547
59.000452 •• 18.209893 •• 1.0376983
TABM=0 •• 2 •• 4 •• 6 •• 8 •• 1•• 2 •• 1•• 4 •• 1 •• 6 •• 1 •• 8 •• 2 •• 2 •• 2 •• 4 •• 2 •• 6 •• 2 •• 8 •• 3 •• 3 •• 3 •• 3 •• 4 •• 3 •• 6
TABPT1=19*1

TABETA=7609 •• 8045 •• 86 •• 901 •• 87 •• 797 •• 777 •• 721 •• 695 •• 7538 •• 8139 •• 876 •• 927 •• 909
83 •• 807 •• 753 •• 735 •• 7409 •• 8245 •• 89 •• 951 •• 942 •• 886 •• 871 •• 807 •• 783 •• 7232 •• 8292
901 •• 968 •• 974 •• 933 •• 926 •• 87 •• 815 •• 7091 •• 8316 •• 912 •• 984 •• 1001 •• 973 •• 965 •• 903
839 •• 6867 •• 8216 •• 922 •• 991 •• 1016 •• 1005 •• 989 •• 919 •• 846 •• 6714 •• 8292 •• 923 •• 995
10251 •• 1025 •• 1005 •• 931 •• 848 •• 6476 •• 828 •• 919 •• 994 •• 1008 •• 131 •• 1013 •• 939 •• 847
6207 •• 8174 •• 91 •• 989 •• 1025 •• 1013 •• 1005 •• 942 •• 837 •• 5971 •• 8045 •• 895 •• 978 •• 1015
1021 •• 1009 •• 937 •• 806 •• 5689 •• 7845 •• 878 •• 961 •• 1007 •• 1919 •• 753

TABNT2=4 •• 5 •• 6 •• 7 •• 8 •• 91 •• 11 •• 12

TABW1(1)=1959 •• 276 •• 4027 •• 5975 •• 7751 •• 9428 •• 10359 •• 1108 •• 1165
1148 •• 2743 •• 4005 •• 5954 •• 7751 •• 9428 •• 10359 •• 1108 •• 1165 •• 1148 •• 2743
3994 •• 5943 •• 7751 •• 9428 •• 10359 •• 1108 •• 1165 •• 1148 •• 2743 •• 3994 •• 5943 •• 7751 •• 9428 •• 10359 •• 1108 •• 1165 •• 1148 •• 2743
10316 •• 1108 •• 1165 •• 1905 •• 2685 •• 394 •• 5878 •• 7718 •• 9396 •• 10316 •• 1108 •• 1165 •• 1884
2653 •• 3908 •• 5845 •• 7675 •• 9353 •• 10305 •• 1108 •• 1165 •• 1862 •• 2639 •• 3875 •• 577 •• 7621
9299 •• 10305 •• 1108 •• 1165 •• 184 •• 2607 •• 3843 •• 5716 •• 7532 •• 9221 •• 10305 •• 1108 •• 1165
1819 •• 2565 •• 3778 •• 5629 •• 7415 •• 9060 •• 10284 •• 1103 •• 1163 •• 1797 •• 2511 •• 3735 •• 5521
It should be noted that to establish an engine design that it must be done at sea level static standard day conditions and all parameters associated with installation effects must be zeroed out, that is the following parameters must be as specified below; for a non-afterburning engine.

- ALT = 0.
- DTEMP = 0.
- EMACH = 0.
- HPEXT = 0.
- PT65AD = 1.
- PT8PT6 = 1.
- WB = 0.
- TABPT1 = 19*1.
- IDES = 0.
- IDDS = 0.
- IPC = 2.
- ZTHRUST = 0.

For the afterburning design case values which are typical of afterburner pressure losses must be specified. That is PT65AD and PT8PT6 should have a value less than one and the control IPC = 1.

Example I is for a non-afterburning design point case with the long form printed output as follows:

```
INPUT CASE 1
--- PC 1 P3 I ---
ALT = 0. HPEXT = 0. IDDS = 0.
WCDW1 = 10000000E+03 CV = 98500000E+00 ZTHRUST = 0.
---
```

```
DESIGN CASE PT2T1D 15000000E+01 W1DCDR = 1019376E+01 Z 89247312E+01 DNSRT = 10000000E+01
--- ETA2 = 87500000E+01 PT1PTD = 10000000E+01 TT0 = 51857000E+03 TT2 = 11598770E+04 TT4 = 30600000E+04
--- DM2 = 1. HPEXT = 0. ETAS = 10000000E+00
---
```

```
W1 = 23310080E+03 W2 = 37743724E+03
---
```

```
FN 73466.09100 87996 10.95156 1.00000 PT1/PT0 = 1.00000 PT2/PT1 = 15.00000 ETA2 = 87500
--- WIK 73466.09100 87996 10.95156 1.00000 PT1/PT0 = 1.00000 PT2/PT1 = 15.00000 ETA2 = 87500
---
```

```
TT5 = 248.03128 PT5/PT4 = 356.655 TT5A = 2384.70808 TT6 = 2384.70808 PT6/PT5A = 1.00000 F8 = 02857
--- TT6 = 37743724E+03 ETA5 = 49500000E+00
---
```

```
--- ETAP = 0.00000 ETAU = 0.00000 ETAD = 0.00000 FN/W10 = 104.95156 HF 71994.10768 W10 = 71994.10768
--- PT7PT = 1.00000 PT1PT7 = 1.00000 PT5PTA = 1.00000 PT6PTA = 1.00000 PT8PT6 = 1.00000 W1 = 51857000E+03
---
```

```
--- SFC1 = 97996 DTEMP = 0.00000 WC = 63.00000 F4 = 03139
---
```
Example 2 (Case 2) - The second step in establishing an engine design is to lock in or fix the flow matching parameters established in the design point case. This is accomplished by setting IDES = 1.

$ENPUT
ICASE=2, IDES=1.$

At the same time that IDES is set equal to 1, the off-design data calculations may also be initiated, however, for simplicity off-design performance has been delayed until Example 3.

Case 2, which follows, is also in a long form printed output.
Example 3 (Case 3) - The next step in the normal operating sequence is to introduce the installation effects of service airbleed, power extraction inlet recovery, non-standard day temperatures and exercise the variable turbine geometry mode of operation. This is accomplished by changing the parameters shown below:

```
$ENPUT
ICASE=3, IPC=4
WB=1, HPEXT=200
TABP1=95, 968, 977, 982, 988, 978, 973, 967, 96, 952, 943, 934, 924, 914
902, 891, 877, 859, 831
DTEMP=8
A4A4DN=.8
```

Engine performance generated by introducing the above parameters is for full and part power without afterburning at sea level static standard +8°C atmospheric conditions. It should be noted that this step could have been combined with Step 2 (Example 2) above. Output is in the long format as follows:

```
INPUT CASE 3 PC 4 I
GWHI 1.1360000E-03 WB 1.1000000E+01 CV 98500000E+00 ZTHRUST 0

--- ALT 0' MACH 0 HPEXT 2000000050 ICDBS 0

--- WCG1 65972.78604 SFC .99745 FN/W P1 101.96592 PT1/PT2 .95000 PT2/PT1 1.454179 ETA2 .87684
--- WIL 605.37259 N/SRT .98640 TTD 533.07000 TT2 1269.09110 TT4 3060.00000 PT2/PT2 .94910
--- T5 2480.7097 PT5/PT4 .35170 TTS 2379.13398 TT6 2379.13398 PT6/PT5 .10000 F6 .02820
--- T8 1659.34116 PT8/P8 .461135 V0 .00000 VB 3243.98995 MB 1.67162 N .10000
--- A4A4D 1.00000 A7/A7D .101269 A8/A7 1.34675 AB 1904.63186 CAPA8 8.54264
--- ETA1 .00000 ETA1 .00000 FN/WID 93.993965 WF 65625.19385 W 663.50043
--- PT7P7 1.58500 PT7P7 1.28601 PT5P5A 1.00000 PT6P6A 1.00000 F1 533.07000
--- WB .100000 WCGW1 .90125 DL08 0.00000 DFGS I F61 65972.78604
--- SFC1 .99745 DTEMP 0.00000 WC 58.67195 F4 .03110
--- FN 60548.63215 SFC .92864 FN/WI 101.96591 PT2/PT0 .95000 PT2/PT1 1.454179 ETA2 .87684
--- WIL 605.37259 N/SRT .98640 TTD 533.07000 TT2 1269.09110 TT4 2784.00000 PT4/PT2 .94910
--- T5 2204.15092 PT5/PT4 .32019 TTS 2147.92019 TT6 2147.92019 PT6/PT5A .10000 F6 .02424
--- T8 1519.05934 PT8/P8 .419820 V0 .00000 VB 2997.09555 MB 1.60781 N .10000
--- A4A4D 1.00000 A7/A7D .107296 A8/A7 1.28324 AB 186.11783 CAPA8 8.43448
--- ETA1 .00000 ETA1 .00000 FN/WID 93.993965 WF 56220.11165 W 650.05046
--- PT7P7 1.58500 PT7P7 1.28601 PT5P5A 1.00000 PT6P6A 1.00000 F1 533.07000
--- WB .100000 WCGW1 .90125 DL08 0.00000 DFGS I F61 60548.63215
--- SFC1 .92364 DTEMP 0.00000 WC 40.30137 F4 .02586
```
Example 4 (Case 4) - To generate engine performance with afterburning requires changing the afterburner pressure losses and the power control parameter (IPC), as shown below.

```plaintext
$ENPUT
ICASE=4 IPC=1 PT8PT6=.98 PT65AD=.95
$
```

The values introduced for the pressure losses, above, are typical of current afterburners. It was not necessary in this case to introduce afterburner combustion efficiency or the maximum afterburner temperature since these were input in Example 1. It was possible to do this in Case 1 since these parameters are used in the cycle match calculation only if the power control calls for an afterburning case. Pressures, on the other hand, could not be input in Case 1 since they are used in the calculation regardless of whether or not the power control calls for an afterburning case.

Shown below is afterburning engine performance at sea level static standard +8°C atmospheric conditions from maximum afterburning to maximum non-afterburning, with the output in the long form format.

```plaintext
--- INPUT CASE 4 PC I P3 HPSXT 20000000E-03 IDD95 0
--- WC01 10000000E-03 WB 10000000E+01 CV .9856C000E+00 ZTHRUST 0

--- INPUT CASE 4 PC I P3 HPSXT 20000000E-03 IDD95 0
--- WC01 10000000E-03 WB 10000000E+01 CV .9856C000E+00 ZTHRUST 0

--- INPUT CASE 4 PC I P3 HPSXT 20000000E-03 IDD95 0
--- WC01 10000000E-03 WB 10000000E+01 CV .9856C000E+00 ZTHRUST 0

--- INPUT CASE 4 PC I P3 HPSXT 20000000E-03 IDD95 0
--- WC01 10000000E-03 WB 10000000E+01 CV .9856C000E+00 ZTHRUST 0
```

Example 5 (Case 5) - This case is similar to Case 4 except that this case is for a Mach number of 2.62 at an altitude of 65000 ft. with a fixed geometry turbine as determined by the input parameters shown below:

```
$INPUT
CASE=5 IPC=3 IPUNCH=2 A4A4DN=1.0 ALT=65000 EMACH=2.62
$

Engine performance for this case is generated from maximum afterburning through maximum non-afterburning to minimum non-afterburning power as determined by the program. Output is in the short form format.

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<th>HPEXT</th>
<th>20000000E+01</th>
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Example 6 (Case 6) - This case is an example of the use of the ZTHRUST control mode. When ZTHRUST is specified at an altitude and Mach number as shown below, and with a part power control operational, IPC = 3 from Case 5, the program will interpolate the generated data at the specified ZTHRUST, altitude and Mach number to determine specific data used in engine acoustic analysis.

```
$ENPUT
ICASE=6,ZTHRUST=70000.,ALT=1000.,EMACH=.3.
```

Output is for standard +8°C atmospheric conditions in the format shown below:

```
INPUT CASE 6 PC 3 PB .500000000+01
ALT .100000000+00 MACH .300000000+00 HPETR .200000000+00 IDOBS 0
WDWI .100000000+03 WB .100000000+01 CV .950000000+00 ZTHRUST .70000+05

NOZZLE PRESSURE RATIO LESS THAN 1.005

OUTPUT ENGINE PARAMETERS CORRESPONDING TO THRUST VALUE OF 70000.0LBS.

GASFLOW = 697.4 LBS/SEC JET VELOCITY = 3614.37FT/SEC JET AREA = 10.6095 SQ FT RAM DRAG = 7053.1LBS.
NET THRUST = 70000.0LBS TURBINE IN TEMP. = 5060.00F NOISE REDUCTION = 0.000DB ATMOSPHERE = STD + 6.0C
SPECIFIC FUEL CONSUMPTION = 1.3786LBM/HR/LBF TURBINE EXIT TEMP = 2194.9 R
```