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The Engineering Resource For Advancing Mobility

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AEROSPACE STANDARD

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GAS TURBINE ENGINE STEADY STATE PERFORMANCE PRESENTATION FOR DIGITAL COMPUTER PROGRAMS

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1. PURPOSE

1.1 This Aerospace Standard (AS) provides a method for the presentation of gas turbine engine steady state performance as calculated by means of digital computer programs.

1.2 It is intended to facilitate calculations by the program user without unduly restricting the method of calculation used by the program supplier.

Note: Applicable reference documents are listed in Paragraph 10.

2. GENERAL REQUIREMENTS

2.1 General Engine Description: A general description of the engine will be provided. This description will include the type of engine, engine configuration and all general characterisitcs that are necessary to understand the performance and operation of the engine represented by the computer program. Examples are: thrust or power class, airflow, pressure ratios, airbleed stations, nozzle type, bypass ratio, method of thrust augmentation and engine control characteristics.

2.2 Program Operation:

2.2.1 The program will be supplied in a form readily adaptable to the user's computer. Provision for operating the program on more than one computer type or operating system should be individually coordinated between user and supplier.

2.2.2 The program will have the capability of functioning both as a subroutine (herein called the engine subroutine) and as an independent program (consisting of a MAIN program containing a CALL statement to the engine subroutine).

2.3 User's Manual:

2.3.1 The program supplier will deliver the User's Manual with the program. The User's Manual will stand alone in that it will be independent of previous Users' Manuals.

2.3.2 The following information will be contained in the User's Manual under the following headings.

1. Introduction:

2. Table of Contents:

3. Engine Description: This section will enable the user to identify the engine and its general characteristics including operating and control limits which are functionally dependent on variable engine parameters.

4. Program Description: This section will enable the user to identify the computer equipment and programming practices upon which the program relies.

5. Nomenclature: This section will include program variable names, station identification and other information required to understand the User's Manual.

6. Program Set-Up: This section will include instructions and information to enable the program user's computer staff to set-up the program. It will include an overall program structure flowchart and sufficient information to understand the program overlay structure, if applicable. An example of a flowchart for a user calling program is included as Appendix A.

7. Engine Program Performance Options: This section will describe the interfaces, options, limitations and other features contained in the program, to enable the user to understand fully the capability of the program. For specification programs, this section will also include an overall flowchart that illustrates the performance calculation flowpath between major engine components. Examples of calculation flowcharts are included as Appendix B.

8. Input/Output: This section will describe all program inputs and outputs in sufficient detail to avoid ambiguity and will list the units of all input and output parameters.

9. Program Messages: This section will explain the messages produced during program operation and identify the Numerical Status Indicator codes.

10. Listings: This section will contain FORTRAN listings of the calling program and of the input and output FORTRAN statements utilized directly by the calling program. The supplier is encouraged to inlude descriptive comments in the listings to facilitate user understanding of the FORTRAN statements.

11. Test Cases: This section will describe the test cases that the supplier provides for program checkout by the user. All test case inputs and printouts will be supplied with the computer program, or in the User's Manual.

12. Identification and Revision Procedure:

13. References:

2.4 Program Scope:

2.4.1 Categories of Data: Steady state engine performance programs discussed in this Standard will be confined to two basic performance categories: preliminary design or specification. Preliminary design programs may vary in scope, but will be representative of the defined engine performance until the engine is defined by a specification. A specification program will accurately represent the engine described by the specification and will identify the appropriate model specification. Normally, the computer program will be the primary source of performance data.

Two additional categories of program are status and data reduction interface programs, which are covered by ARP 1211 and 1210 respectively.

2.4.2 Limits: Limits observed by the computer program will be defined in the User's Manual. When limits are functionally dependent on other parameters, it will be so stated in the User's Manual.

When the input calls for an operating point outside limits, the program will proceed to complete its calculation, if possible, and output the appropriate Numerical Status Indicator.

The Numerical Status Indicator will clearly define output validity, limiting parameters and the applicable limiting engine controlling variable.

The program will always be capable of continuing with the next case provided the user's subroutines and/or computer operating system do not override this capability.

2.4.2.1 Limits are divided into three categories as follows:

1. Engine limits as used herein are those limits that are neither automatically applied by the engine control nor precluded by the engine design, e.g. maximum temperature limit if automatic over-temperature control is not provided and pilot action is necessary.

2. Environmental operating limits are defined by the operating envelope of inlet temperature and pressure; or equivalent altitude, free stream Mach number, ram recovery and atmospheric conditions.

3. Program limits are those which define the bounds within which the program will function and will adequately simulate the engine. Program limits will exceed corresponding engine limits, but preliminary design programs may be incomplete because component definition is inadequate.

3. PROGRAMMING PRACTICES

3.1 Computer Capabilities: Computer size requirement and program execution time depend on the complexity of the engine simulation and the type of computer. The standard steady state engine performance program normally requires at least 32000(decimal)32 bit words of highspeed memory for a simple engine configuration. Such a program will normally execute in 5 seconds CPU time or less per case on a computer with a one micro-second memory. Requests for programs on computers with less capabilities must be individually coordinated.

3.2 Program Language: Engine computer programs will use as a minimum language ISO 1539 FORTRAN (level: full FORTRAN [Number 1]). This language may be augmented by features found in the commonly used FORTRAN languages of industry when these features are known to be acceptable to the program users.

3.3 Precision: Hardware and software differences (e.g. word length, compiler and operating system) among computers can cause differences in performance output from otherwise identical programs. Differences from the supplied test cases greater than ±0.25% should be coordinated between user and supplier.

3.4 Station Identification: The numbering system described in SAE Aerospace Recommended Practice ARP 755 will be used in program input and output to identify the points in the gas flow path that are significant to engine performance definition. Supplements to the system of ARP 755 that are necessary will be detailed in the User's Manual.

3.5 Nomenclature:

3.5.1 The list of symbols contained in ARP 755 will be used for identification of input and output parameters. These symbols are not required to be used for FORTRAN names within the engine subroutine.

While the use of the same nomenclature within the engine subroutine may have merit in certain instances, such use will unduly restrict the program supplier and thus will be left to the discretion of the program supplier or to coordination between program user and supplier.

3.5.2 The following symbols, which refer specifically to computer programs, are added to those of ARP 755:

CASE	Numerical case identification
CLASS	Engine program security classification
IDENT	Engine program titles - for printout
NIN	Input file number

NØUT	Output file number
NSI	Numerical Status Indicator
PC	Power Code
RC	Rating Code
SDIST	Inlet pressure and temperature distortion selection
SERAM	Ram pressure recovery selection
SIM	Inlet mode selection
SWIND	Windmilling performance selection
TITLE	Title supplied by program user
Z (leading)	Prefix for a variable name used in input that may also be used in output. All physical parameters in the labeled common FIXIN will have the leading Z.

3.5.3 Compilers limit the number of characters per parameter name. When this limitation is not compatible with 3.5.1 and 3.5.2, each parameter name abbreviation will be determined by the program supplier and defined in the appropriate section of the User's Manual.

3.6 Power Definition: Power level and other performance parameters for the significant engine ratings (e.g. Intermediate, Take-off) will be available from the program by simple input.

The power level selection will be implemented using the following input items: Rating Code (RC), Power Code (PC), Power Lever Angle (PLA) and additional performance selection.

3.6.1 Rating Code: The Rating Code permits selection of specified ratings that may require different Power Lever Angles as flight or atmospheric conditions vary. Rating Code will always be input.

Rating Codes are defined as follows. Unassigned Rating Codes may be used for additional ratings in which case they must be coordinated between program user and supplier and defined in the User's Manual.

	Rating Code	Definition	
		Military	Commercial
Augmented	100.0 90.0 60.0 55.0	Maximum Maximum Continuous Minimum Augmented --	Emergency Maximum Minimum Wet Take-off
Non Augmented	55.0 50.0 45.0 40.0 35.0 21.0 20.0	Maximum Intermediate Maximum Continuous -- -- Idle (Flight) Idle (Ground)	-- Dry Take-off Maximum Continuous Maximum Climb Maximum Cruise Flight Idle Ground Idle
Reverse	15.0 5.0	Idle Maximum Reverse	Idle Maximum
--	0.0	Use PC (or PLA) only	Use PC (or PLA) only

3.6.2 Power Code or Power Lever Angle: The Power Code has three uses:

3.6.2.1 When positive, it is intended to represent, and, when known, should be replaced by Power Lever Angle. Positive Power Code values are assigned as follows:

	Power Code	Definition
Augmented	100.0 to 60.0	Maximum to Minimum
Non Augmented	50.0 to 20.0	Maximum to Idle
Reverse	15.0 to 5.0	Idle to Maximum

3.6.2.2 When zero, performance consistent with the input value of Rating Code will be calculated.

3.6.2.3 When negative, Power Code may be used to select alternative methods of power level specification, e.g. iteration to a specified net thrust or selection of an incremental power series. The values and uses of these negative values of PC will be defined in the User's Manual.

3.6.3 Additional Performance Selection: Additional performance selection may be required e.g. windmilling performance by use of windmilling selection, SWIND.

3.7 Standard Thermodynamics: The following references will be used for engine performance determination:

3.7.1 Standard Atmosphere: Ambient temperature and pressure will be consistent with the geopotential pressure altitude of ISO 2533.

3.7.2 Standard Dry Air: The composition of standard dry air is to be based on that used for ISO 2533, but with the number of molecular species reduced by the re-allocation of trace elements. The composition will be defined in the User's Manual.

3.7.3 Fuel: Fuel characteristics used in the computer program will be defined in the User's Manual.

3.7.4 Thermochemical Data: Thermochemical data used in the computer program will be defined in the User's Manual. Thermochemical data for the purpose of gas turbine engine performance calculations will be consistent with data presented in NASA Technical Papers 1906, 1907, 1908, and 1909 within the limitations of physical representation (e.g., reaction rates, heat transfer), engineering accuracy, and computational efficiency requirements. Upon request by the user, the supplier will supply a comparison of the thermodynamic process calculations based on his thermochemical data and that given by NASA Technical Papers 1906, 1907, 1908, and 1909 within the range of applicable engine operating conditions.

3.8 Programming Standards:

3.8.1 The highest level of compiler optimization operationally available to the program supplier is preferred but requires coordination between user and supplier.

3.8.2 The program supplier will provide automatic preventive action for the following illegal arithmetic operations or processes: the square root of a negative number, illegal arguments to exponential, logarithmic and inverse trigonometric subroutines. This preventive action will preclude these illegal arguments from being transferred to the user's system supplied subroutines. The Numerical Status Indicator will clearly define the validity of the output. The program will always be capable of continuing with the next case provided the user's subroutines and/or computer operating system do not override this capability.

3.8.3. The program supplier will assume that the computer memory is not cleared when the program is loaded.

3.8.4 The engine program, while operating in the subroutine mode (see 2.2), will be available as one subroutine call rather than separate calls to a collection of subroutines which, when taken in combination, represent the engine.

4. PROGRAM CAPABILITIES

Program provisions for the effects described in this section will be included when they are applicable. However, it should be recognized that, generally, each addition to the program increases core requirements and running time and delays delivery. Coordination of program requirements between user and supplier is recommended.

4.1 Inlet Representation:

4.1.1 Inlet Mode: The engine program will calculate performance when provided with either of the following combinations (selected by inlet mode selection, SIM):

1. Altitude, free stream Mach number, deviation of ambient temperature from standard and one of the options of 4.1.2.

2. Ambient pressure and temperature, inlet/engine interface total pressure and total temperature, and a temperature increment for inlet heat transfer to be added to the inlet total temperature.

4.1.2 Ram Pressure Recovery: Several ram pressure recovery options will be provided (selected by ram pressure recovery selection, SERAM). Two categories of options are provided. The first category is to be used for engine inlet average recovery and the second provides the capability to differentiate primary and secondary stream recoveries. The following values of SERAM are defined:

SERAM	DEFINITION
Average Recovery Options	
1	A specified ram pressure recovery standard.
2	The input ratio of engine inlet total pressure to free stream total pressure.
3	The ratio of engine inlet total pressure to free stream total pressure (ERAM) as a function of referred engine airflow (W1AR) and/or free stream Mach number (XM).
Differentiated Primary and Secondary Stream Options	
4	The input ratio of primary stream engine inlet total pressure to free stream total pressure; and the input ratio of secondary stream engine inlet total pressure to free stream total pressure.
5	The input ratio of secondary stream engine inlet total pressure to free stream total pressure as a function of referred engine air flow (W1AR) and/or free stream Mach number (XM); and the input ratio of primary stream engine inlet total pressure to free stream total pressure.
6	The ratio of primary stream engine inlet total pressure to free stream total pressure as a function of referred engine airflow (W1AR) and/or free stream Mach number (XM); and the ratio of secondary stream engine inlet total pressure to free stream total pressure as a function of referred engine airflow (WIAR) and/or free stream Mach number (XM).

SERAM options 4, 5, and 6 are intended for use with high bypass ratio fan engines and may be omitted for other applications.

SERAM options 3, 5, and 6, which provide for a functional relationship between ram recovery and engine airflow and/or freestream Mach number, require a user suplied subroutine with the following call sequence:

CALL ERAMX (XM, WR*, SECALC, ERAM)

*W1R or W1AR as appropriate.

The user supplied subroutine will interpret the value of SECALC to return the following values of ERAM:

SECALC	ERAM
1.0	Average
2.0	Primary Stream
3.0	Secondary Stream

4.1.3 Distortion: The effects of inlet pressure and temperature distortion (radial, circumferential, and temporal) on the engine will be included in the program when data or estimates are available (selected by distortion selection, SDIST). The input used in pressure distortion calculations will consist of the following four parameters for each instrumented ring (See ARP-1420): circumferential distortion intensity (ZDPCQP), circumferential distortion extent (ZDANG), circumferential distortion multiple (ZXMPR), and radial distortion intensity (ZDPRQP).

4.2 Customer Services:

4.2.1 Air Bleed: The engine program will calculate performance when air bleed is extracted for customer services. The user will be able to input the amount of air extracted from each bleed station as a ratio to the component inlet gas flow from which it is being extracted and as a rate. The ratio and rate of bleed air are additive in the calculation of bleed flow. The corresponding output temperatures and pressures will include all engine induced heat transfer and pressure losses up to the bleed port interface, except in preliminary design programs prior to bleed system definition.

4.2.2 Power Extraction: The engine program will calculate engine performance when power is extracted for customer services.

4.3 Engine Supplied Nozzle Effects:

4.3.1 Nozzle parameters used in the calculation of engine performance will be provided as output. These nozzle parameters will include:

Nozzle area(s), all gas flows, all engine discharge gas temperatures and pressures, ideal gross thrust, and required user supplied nozzle cooling airflow.

4.3.2 When a separate subroutine or supplementary data is needed to define external geometry of an engine supplied nozzle for user performance calculations, the appropriate data will be provided in the program output.

4.4 Parasitic Flows: Parasitic flows include those planned flows other than the customer bleed flow which are discharged from the engine at points other than the exhaust nozzle. The engine program will calculate the effect on engine performance of such planned flows, and pressure, temperature and flow rate will be included in the program output.

4.5 Engine Anti-Icing: The engine program will have capability of calculating engine performance when operation involves use of engine anti-icing.

4.6 Liquid Injection: When operation involves the use of liquid injection for augmentation, e.g. water/alcohol, the engine program will have the capability of calculating engine performance for such operation. The flow rate used in the performance calculation will be included in the program output.

4.7 Windmilling: The engine program will provide performance under windmilling conditions. The User's Manual will include the Mach number versus altitude region in which program output is valid.

4.7.1 Preliminary design programs need only output net thrust (i.e. drag) and engine inlet airflow without bleed or power extraction.

4.7.2 Specification programs will have additional capability, as applicable.

4.8 Reverse Thrust: If the program supplier provides or has primary responsibility for the performance of an engine thrust reverser or spoiler, then the engine program will calculate this performance over the power range mutually agreed between the program supplier and user. The flight envelope, engine limits, or any other specific limitations on the use of this capability will be defined in the User's Manual.

4.9 Variable Geometry: If the engine represented by the program incorporates variable geometry features that can be rescheduled at the user's option to optimize total system performance, then a physical and functional description of this variable geometry will be included in the User's Manual. Also, the engine program output will include definition of the position of the variable geometry for which performance is calculated. If the user has the option to reschedule the variable geometry without consulting the program supplier, then a description of the method of input and the permissible variation will be included in the User's Manual. This would not normally include variable geometry trim procedures used on production engines.

4.10 Engine Stability: The engine program will provide indication of the appropriate component stability, (e.g. compressor surge, burner blow-out) by use of an appropriate Numerical Status Indicator.

4.11 User Supplied Programs: The engine program, when used as a subroutine, may be required to interface with user supplied programs which represent such features as engine inlet, ejector inlet for an engine supplied nozzle, exhaust nozzle, ports for customer services or secondary nozzles for boundary layer control. The methods of operation of the user supplied program and the engine subroutine must be closely coordinated to allow for interaction between them, and to ensure any necessary input and output is provided. The program user will therefore provide to the program supplier documentation describing his intended usage of the interface items.

5. INPUT/OUTPUT

5.1 Program Interface Definition:

5.1.1 The communication between the calling program (written by either the program supplier or user) and the engine subroutine will be handled completely by six labeled commons. The CALL statement to the engine subroutine will contain no arguments. The six labeled commons will be FIXIN (Fixed Input), VARIN (Variable Input), EXPIN (Expanded Input), FIXØUT (Fixed Output), VARØUT (Variable Output) and EXPØUT (Expanded Output). The engine subroutine will never store computed values in FIXIN, VARIN or EXPIN.

5.1.2 The fixed input parameters placed in labeled common FIXIN will be limited to the order and quantity defined in 5.2. The fixed output (FIXØUT) will be limited to the order and quantity of parameters defined in 5.3. The remaining required input and output will be dependent on engine configuration and contained in labeled commons VARIN and VARØUT, respectively. Labeled commons EXPIN and EXPØUT will be reserved for additional parameters available through coordination between the program supplier and user.

5.1.3 The nomenclature utilized in the fixed input and output common blocks (FIXIN and FIXØUT) of 5.2 and 5.3 is for clarification only. Logically equivalent nomenclature consistent with ARP 755 is permitted, e.g. W1 may be substituted for W1A in FIXØUT when multiple streams have not been distinguished.

5.2 Input:

5.2.1 FIXIN: The fixed sequence list of the parameters that will be included in the fixed input labeled common (FIXIN), and the identity of these parameters (with typical nomenclature consistent with ARP 755) are as follows: All parameters are REAL floating point numbers, except as indicated.

1.	NIN	Input file number (INTEGER)
2.	NØUT	Output file number (INTEGER)
3.	IND	Engine program indicator (INTEGER)
4.	TITLE (18)	User title - dimension 18 (HOLLERITH)
5.	CASE	Numerical case identification
6.	ZALT	Geopotential pressure altitude
7.	ZDTAMB	Ambient temperature minus standard atmospheric temperature
8.	ZDT1A	Temperature to be added to T1A
9.	ZERM1A	Ram pressure recovery at station 1A
10.	ZPWXH	Customer high pressure rotor power extraction
11.	ZPAMB	Ambient pressure
12.	ZPC	Power code
13.	ZPLA	Power lever angle
14.	ZP1A	Engine inlet total pressure at station 1A
15.	ZRC	Rating code
16.	SERAM	Ram pressure recovery selection Average Options SERAM = 1, Selects Military Specification ram pressure recovery SERAM = 2, Selects input value of ram pressure recovery SERAM = 3, Selects ram pressure recovery from user supplied subroutine (ERAMX) Differentiated Options SERAM = 4, Selects input values of primary and secondary ram pressure recovery Seram = 5, Selects input value of primary stream ram pressure recovery and calls user supplied subroutine (ERAMX) for secondary stream ram pressure recovery. SERAM = 6, Selects primary and secondary stream ram pressure recoveries from user supplied subroutine (ERAMX)
17.	SIM	Inlet Mode Selection SIM = 1, Selects altitude and Mach number SIM = 2, Selects pressure and temperature
18.	ZTAMB	Ambient temperature
19.	ZT1A	Engine inlet total temperature at station 1A
20.	ZWB3	High pressure compressor discharge bleed flow rate
21.	ZWB3Q	High pressure compressor bleed flow ratio (discharge over component inlet)
22.	ZXM	Free stream Mach number
23.	ZERAM1	Primary stream ram pressure recovery
24.	ZERM11	Secondary stream ram pressure recovery
25.	--)	
26.	--)	Intentionally blank
27.	--)	
28.	--)	
29.	SDIST	Inlet pressure and temperature distortion selection
30.	--)	
31.	--)	Retained for consistency with ARP 1257
32.	ZPWSD	Delivered shaft power
33.	--)	
34.	--)	
35.	--)	Retained for consistency with ARP 1257
36.	--)	
37.	--)	
38.	--)	
39.	ZXNSD	Delivered shaft rotational speed
40.	ZTRQSD	Delivered shaft torque
41.	SWIND	Windmilling selection

5.2.2 VARIN: The variable input labeled common VARIN will contain input dependent on engine configuration.

5.2.3 EXPIN: The expanded input labeled common EXPIN will contain additional input available through coordination between program supplier and user.

5.3 Output:

5.3.1 FIXØUT: The fixed sequence list of the parameters that will be included in the fixed output labeled common (FIXØUT), and the identity of these parameters (with typical nomenclature consistent with ARP 755) are as follows: All parameters are REAL floating point numbers, except as indicated.

1.	CLASS (6)	Engine program security classification - Dimension 6 (HOLLERITH)
2.	IDENT (36)	Engine program titles - Dimension 36 (HOLLERITH)
3.	NSI (10)	Numerical Status Indicator - Dimension 10 (INTEGER). See Para. 5.5.
4.	AE8	Primary exhaust nozzle throat effective area
5.	AE18	Bypass exhaust nozzle throat effective area
6.	ANGBT	Boat-tail angle
7.	FRAM	Ram drag
8.	FG	Gross thrust
9.	FGI	Ideal gross thrust
10.	FG19	Bypass stream gross thrust
11.	FGI19	Bypass stream ideal gross thrust
12.	FHV	Fuel lower heating value
13.	FN	Net thrust
14.	PB3	High pressure compressor discharge bleed flow total pressure
15.	P7	Primary exhaust flow total pressure
16.	P17	Bypass exhaust flow total pressure
17.	SFC	Specific fuel consumption
18.	--	Retained for historical consistency with ARP 681B
19.	TB3	High pressure compressor discharge bleed flow total temperature
20.	TC	Control temperature (cockpit display)
21.	T7	Primary exhaust flow total temperature
22.	T17	Bypass exhaust flow total temperature
23.	WFE	Engine fuel flow rate
24.	WFT	Total fuel flow rate
25.	W1A	Engine inlet flow rate at station 1A
26.	W7	Primary exhaust flow rate
27.	W17	Bypass exhaust flow rate
28.	W2_ (+)	High pressure compressor inlet flow rate
29.	XNH	High pressure rotor rotation speed
30.	XNI	Intermediate pressure rotor rotational speed
31.	XNL	Low pressure rotor rotational speed
32.	XNSD	Delivered shaft rotational speed
33.	ALT	Geopotential pressure altitude (*)
34.	ERAM1A	Ram pressure recovery at station 1A (*)
35.	PAMB	Ambient pressure (*)
36.	PLA	Power lever angle (*)
37.	P1A	Engine inlet total pressure at station 1A (*)
38.	TAMB	Ambient temperature (*)
39.	T1A	Engine inlet total temperature at station 1A (*)
40.	XM	Free stream Mach number (*)
41.	--)	
42.	--)	
43.	--)	Retained for consistency with ARP 1257
44.	--)	
45.	--)	
46.	PWSD	Delivered shaft power (*)
47.	--)	Retained for consistency with ARP 1257
48.	TRQSD	Delivered shaft torque (*)
49.	ERAM1	Primary stream ram pressure recovery
50.	ERAM11	Secondary stream ram pressure recovery
51.	--)	
52.	--)	Intentionally blank
53.	--)	
54.	--)	
55.	DTAMB	Ambient temperature minus standard atmosphere temperature (*)

*These locations will contain the values of each parameter used in the computation. The input values of these parameters are contained in labeled common FIXIN where they are prefixed by the letter Z.

+The full number representing the relevent station designation (e.g. W21, W215, W2A) will be defined by the program supplier.

56. DT1A — Temperature to be added to T1A (*)
57. PC — Power code (*)
58. RC — Rating code (*)
59. WB3 (@) — High pressure compressor discharge total bleed flow rate (*)
60. WB3Q (@) — High pressure compressor total bleed flow ratio (discharge over component inlet) (*)
61. PWXH — Customer high pressure rotor power extraction (*)

*These locations will contain the values of each parameter used in the computation. The input values of these parameters are contained in labeled common FIXIN where they are prefixed by the letter Z.

@Resultant from combined inputs 5.2.1.20 and 5.2.1.21.

5.3.2 VARØUT: The variable output labeled common VARØUT will contain output dependent on engine configuration but not included in FIXØUT.

5.3.3 EXPØUT: The expanded output labeled common EXPØUT will contain additional output available through coordination between program supplier and user.

5.3.4 Printout: In addition to the output parameters in labeled commons FIXØUT, VARØUT and EXPØUT, the output printout will include all input parameters (FIXIN, VARIN and EXPIN). All printout will be under the control of the calling program.

5.4 Units: Input and output parameter values will be based on the pound, foot system of measurement commonly used in the United States. The metric International System of Units (SI) is an acceptable alternate. Appendix C defines the units that will be used for either system.

5.5 Numerical Status Indicators:

5.5.1 Numerical Status Indicators will be used, where applicable, to notify the program user of any limitation or qualification of the output data. The Numerical Status Indicator codes defined in 5.5.2 will be used. The program supplier also may elect to print the actual words of the message in the output.

5.5.2 A four digit number will be used as the message indicator. The first digit will indicate the quality of the output, as defined in Table 1. The second digit will indicate the nature of the problem affecting the output, as defined in Table 2. The third and fourth digits will indicate specific messages that will be defined in the User's Manual. An array of ten Numerical Status Indicators (the first nine and the last one encountered) will be available for output.

TABLE 1

NSI	First Digit, Quality Indicators
0000	All output valid, no errors, no limits exceeded
0XXX	Input reset to limit, output valid as specified
1XXX	Limit exceeded, output provided for interpolation only
2XXX to 8XXX	Open for supplier's use with definitions supplied in the User's Manual
9XXX	Output not valid

TABLE 2

NSI	Second Digit, Category Indicators
X1XX	Computing problems (e.g. fails to converge, job in loop, failure unknown)
X2XX	Input problems (e.g. missing input, wrong order)
X3XX	Rating or power messages (e.g. thrust requested above or below engine capability, control limits)
X4XX	Installation problems (e.g. bleed flow pressure or percentage exceeded, power extraction exceeded, secondary flow limit exceeded, distortion limit exceeded)
X5XX	Envelope problems (e.g. engine structural limit exceeded, Mach limit exceeded, temperature limit exceeded)
X6XX	Stability problems (e.g. surge, burner blow-out)
X7XX to X9XX	See User's Manual

6. PROGRAM IDENTIFICATION

6.1 Every engine program will have a unique identification and date. Provision will be made to print out this identification on each set of output.

6.2 Every tape transmitted will be externally marked to show:

1. Identification of tape; originator; engine; program
2. Number of Channels (e.g., 7 or 9)
3. Density (e.g., 556, 800, 1600 bits per inch)
4. Whether labeled or unlabeled
5. Number of files on the tape

In addition, the following information must be provided for each file contained on the tape:

1. Type of information [source or object; data in internal form (unformatted) or in external form (formatted)]
2. If object code, type of machine used and operating system
3. Punch (character) code if card images are supplied (e.g., BCD, EBCDIC)
4. Any other information necessary for retrieval from the tape, e.g., file name; inter-record gap length; record length; block length; odd or even parity.

6.3 Every card deck transmitted will be uniquely labeled with program supplier name, engine name and/or program identification and numerically sequenced where possible. Any special operating system control cards will be included.

7. PROGRAM CHECKOUT

Program checkout will be accomplished with the independent program as supplied. Input for test cases will accompany the engine program or be included with the User's Manual along with the resultant output for sufficient cases to demonstrate all engine program input options described in the User's Manual.

Source cards or card images will be provided for the calling program.

8. PROGRAM REVISIONS

8.1 The nature of, and reason for, changes or revisions to computer programs will be documented by the program supplier when the revision is submitted to the user. The User's Manual or program operating instructions will be kept current with the revision.

8.2 When revisions are made they will be identified by an appropriate change to the basic program identification number with a corresponding revision date. Documentation which refers to the program will include revision designations when practicable. Revision designations will be included on the printout.

8.3 Programs revised by the user without written consent of the supplier will be the responsibility of the user.

9. OPTIONAL FEATURES

Engine steady state performance programs will contain optional features and capabilities to the extent agreed upon between the program supplier and user. The intent of such optional features will be to facilitate the calculation of total propulsion system performance. Examples of these features are: iteration to a requested net thrust, a bleed interface procedure, iteration to a requested shaft power output, a ram recovery interface procedure, iteration to an externally monitored parameter, humidity effects, inlet water ingestion effects.

10. REFERENCE DOCUMENTS

The following documents are referenced in this standard.

10.1 International Organization for Standardization (ISO):

10.1.1 ISO 1000, SI units and recommendations for the use of their multiples and of certain other units.

10.1.2 ISO 1539, FORTRAN [level "Full FORTRAN (number 1)"]. This is the same as ANSI X3.9 FORTRAN.

10.1.3 ISO 2533, ISO Standard Atmosphere. This is consistent with the U.S. Standard Atmosphere, 1962, for altitudes up to 50,000 meters.

10.1.4 ISO 2955, Representations for SI and other units to be used in systems with limited character sets.

10.2 Society of Automotive Engineers (SAE):

10.2.1 ARP 755A, Gas Turbine Engine Performance Station Identification and Nomenclature, SAE.

10.2.2 ARP 1210, Gas Turbine Engine Interface Test Data Reduction Computer Programs, SAE.

10.2.3 ARP 1211, Gas Turbine Engine Status Performance Presentation for Digital Computer Programs, SAE.

10.2.4 ARP 1257, Gas Turbine Engine Transient Performance Presentation for Digital Computer Programs, SAE.

10.2.5 ARP 1420, Gas Turbine Engine Inlet Flow Distortion Methodology, SAE.

10.3 Others:

10.3.1 U.S. Standard Atmosphere, 1962, United States Committee on Extension of the Standard Atmosphere.

10.3.2 NASA Technical Paper 1906, Thermodynamic and Transport Combustion Properties of Hydrocarbons with Air, Part I - Properties in SI Units, Sanford Gordon, 1982.

10.3.3 NASA Technical Paper 1907, Thermodynamic and Transport Combustion Properties of Hydrocarbons with Air, Part II - Compositions Corresponding to Kelvin Temperature Schedules in Part I, Sanford Gordon, 1982.

10.3.4 NASA Technical Paper 1908, Thermodynamic and Transport Combustion Properties of Hydrocarbons with Air, Part III - Properties in U. S. Customary Units, Sanford Gordon, 1982.

10.3.5 NASA Technical Paper 1909, Thermodynamic and Transport Combustion Properties of Hydrocarbons with Air, Part IV - Compositions Corresponding to Rankine Temperature Schedules in Part III, Sanford Gordon, 1982.

PREPARED BY
SAE COMMITTEE S-15
ENGINE PERFORMANCE PRESENTATION FOR
ELECTRONIC DIGITAL COMPUTERS

APPENDIX A
FLOWCHART OF A USER CALLING PROGRAM