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REV.
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GAS TURBINE ENGINE TRANSIENT PERFORMANCE PRESENTATION FOR DIGITAL COMPUTER PROGRAMS

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1. PURPOSE:

- 1.1 This Aerospace Recommended Practice provides a method for the presentation of gas turbine engine transient performance as calculated by means of digital computer programs and is compatible with AS681, Gas Turbine Engine Steady-State Performance Presentation for 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 Section 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 characteristics 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 General Program Requirements: The transient program is intended to provide simulation of engine response to input variables with an equivalent sine wave frequency content of up to approximately 30 Hz. Although programs can be constructed to respond to much higher frequencies there is insufficient practice at this time to establish procedures in this area. A minimum requirement of the transient program is the ability to adequately simulate the effects of normal throttle and mission profile transients.
- 2.3 Program Operation:
 - 2.3.1 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.
 - 2.3.2 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).

2.4 User's Manual:

2.4.1 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 User's Manuals.

2.4.2 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 that 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 in 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. An example of a calculation flowchart is included in 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 include descriptive comments in the listings to facilitate user understanding of the FORTRAN statements.



2.4.2 (Continued):

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:

2.5 Program Scope: Transient engine performance computer programs will be the primary source for time-dependent variations of engine performance. Steady-state engine performance computer programs will be the primary source for steady-state engine performance. Transient engine performance calculations will be based on one of three steady-state performance categories: preliminary design, status, or specification.

2.5.1 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.

2.5.1.1 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 that 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.

- 2.5.2 Consistency: Consistency herein means the agreement between transient program output of steady-state conditions and steady-state program output for the engine or group of engines represented. Transient and steady-state program requirement differences can cause program output differences. For status and specification programs at all power settings higher than 30% of maximum nonaugmented power, the transient performance program gross thrust, shaft power, total fuel flow, and airflow output should agree with that of the corresponding steady-state performance program output within $\pm 3\%$. Different consistency requirements will be coordinated between user and supplier.
- 2.5.3 Prediction Capability: When coordinated between user and supplier, the program supplier will furnish estimates of the expected agreement between the engine transient program performance predictions and the engine transient performance at selected conditions.
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 transient engine performance program normally requires at least 40000 (decimal) 32-bit words of high-speed memory for a simple engine configuration. Execution time will be dependent on memory cycle time, the complexity of the engine simulation, and the frequency range of the problem being investigated with the program. Requests for programs on computers with lesser capabilities must be individually coordinated.
- 3.1.1 The frequency effects normally studied with engine transient programs range from 0 to 5 Hz. For computers having a 1 μ s cycle time, execution times of approximately 10 times real time can be expected for simple engine configurations. Transient studies using complex engine configurations dealing with effects in the neighborhood of 30 Hz may require execution times of 1000 times real time and may require additional computer resources.
- 3.2 Program Language: Engine computer programs will use 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 supplied test cases smaller than $\pm 0.25\%$ should be considered normal for the initial value point. Differences smaller than $\pm 1.0\%$ at a given output time should be considered normal for transients of 10 s or less real time. Larger differences should be coordinated between the user and the supplier.

3.4 Station Identification: The numbering system described in SAE ARP755 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 ARP755 that are necessary will be detailed in the User's Manual.

3.5 Nomenclature:

3.5.1 The list of symbols contained in ARP755 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 ARP755:

CASE	Numerical case identification
CLASS	Engine program security classification
FYPH	Primary maximum response frequency
FYSH	Secondary maximum response frequency
IDENT	Engine program titles - for printout
NIN	Input file number
NOUT	Output file number
NSI	Numerical Status Indicator
PC	Power Code
SDIST	Inlet pressure and temperature distortion selection
SERAM	Ram pressure recovery selection
SIM	Inlet mode selection
TIMEF1	Secondary response frequency initiation time
TIMEF2	Secondary response frequency termination time
TIMEØ	Output time interval
TIMET	Termination time
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:

3.6.1 One of the inputs to the transient program will be Power Lever Angle (PLA) or its equivalent, Power Code (PC). The Power Code is intended to represent and, when known, should be replaced by Power Lever Angle.

3.6.2 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

3.7 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 reallocation 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.