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(R) Gas Turbine Engine Performance Presentation for Computer Programs Using Fortran

RATIONALE

This document has been revised to align with the creation of standard document AS6502 and updates to standard document AS681. Other minor changes were also made for clarification purposes

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1. SCOPE

This SAE Aerospace Standard (AS) provides a method for gas turbine engine performance computer programs to be written using Fortran COMMON blocks. If a “function-call application program interface” (API) is to be used, then ARP4868 and ARP5571 are recommended as alternatives to that described in this document.

When it is agreed between the program user and supplier that a particular program shall be supplied in Fortran, this document shall be used in conjunction with AS681 for steady-state and transient programs.

This document also describes how to take advantage of the Fortran CHARACTER storage to extend the information interface between the calling program and the engine subroutine.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AS681 Gas Turbine Engine Performance Presentation for Computer Programs

AS6502 Aircraft Propulsion System Performance Nomenclature

2.2 Related Documents

The following publications are provided for information purposes only and are not a required part of this SAE Aerospace Technical Report.

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AS755 Aircraft Propulsion System Performance Station Designation

ARP4868 Function-Based API for Gas Turbine Engine Performance Programs

ARP5571 Gas Turbine Engine Performance Presentation and Nomenclature for Object-Oriented Computer Programs

2.3 Definitions

As per AS681.

3. GENERAL REQUIREMENTS

As per AS681.

4. PROGRAMMING PRACTICES

'Fortran' when used in this document refers to ANSI X3.9 1978 (Fortran 77). Features beyond this reference should only be used per agreement between user and supplier.

Fixed character data shall be held in the labeled character COMMON blocks CHRIN and CHROUT.

The program may provide an extra text interface in the character COMMON block CHREXP which contains information that is not available from CHRIN or CHROUT. The storage defined in CHREXP is quite large and, therefore, use of CHREXP must be coordinated between user and supplier.

(See Section 6 for details of CHRIN, CHROUT and CHREXP).

5. PROGRAM CAPABILITIES

5.1 Inlet Mode Selection (SIM)

The engine program will calculate performance when provided with any of the combinations described herein:

Table 1 - Inlet mode selection

SIM Number	Description
1	Selects altitude, free stream Mach number, deviation of ambient temperature from standard, and inlet ram pressure recovery, and a temperature increment for inlet heating to be added to the free stream total temperature: T1(A) = T0 + DT1(A)
2	Selects ambient pressure and temperature, total pressure and total temperature at the inlet/ engine interface, and a temperature increment for inlet heating to be added to the free stream total temperature: T0= T1(A) - DT1(A).
Other than 1 or 2	Other options, coordinated between user and supplier

5.2 Inlet Ram Pressure Recovery Selection (SERAM)

SERAM options 1, 2, and 3 are used for engine inlet average recovery, options 4, 5, and 6 provides the ability to differentiate primary and secondary stream recoveries. Table 2 briefly describes options 1 through 6, but more detail can be found in AS681.

Table 2 - Inlet ram pressure recovery options (SERAM)

SERAM	Description
	Average Options
1	Selects a specified inlet ram pressure recovery standard
2	Selects inlet ram pressure recovery input as the ratio of engine inlet total pressure to free stream total pressure.
3	Selects inlet ram pressure recovery from user supplied subroutine (ERAMX) and is a function of referred engine airflow and/or free stream Mach number.
	Differentiated Primary and Secondary Stream Options
4	Selects input values of primary and secondary stream ram pressure recovery
5	Selects input value of primary stream ram pressure recovery from ZERM1A and calls user supplied subroutine (ERAMX) for secondary stream ram pressure recovery.
6	Selects primary and secondary stream inlet ram pressure recoveries from user supplied subroutine (ERAMX).
	(Note that SERAM options 1, 2, and 4 do not require a user routine to be supplied.)

SERAM options 1, ,2 and 4 require user input, whilst options 3, 5, and 6, which provide for a functional relationship between ram recovery and engine airflow and/or free stream Mach number, require a user supplied subroutine with the following call sequence:

CALL ERAMX (M0, WR, SECALC, ERAM)

Table 3 describes the arguments to the ERAMX call in detail.

Table 3 - ERAMX arguments

Argument	Description
M0 (XM)	Free stream Mach number. Supplied from engine routine.
WR	Referred inlet mass flow (e.g., W1R, W1AR or W2R as appropriate). Supplied from engine routine.
SECALC	Switch for which portion of the flow the calculation is to be performed. The options are as follows: = 1 Average (ERAM) = 2 Primary Stream (ERAM1) = 3 Secondary Stream (ERAM11)
ERAM	Inlet ram recovery to be returned to model.

6. INPUT/OUTPUT

6.1 Program Interface Definition

6.1.1 Overview

The communication between the calling program and the engine subroutine shall be handled completely by nine labeled COMMON blocks. These shall be FIXIN, VARIN, EXPIN AND CHRIN (character input) for input and FIXOUT, VAROUT, EXPOUT, CHROUT (character output) and CHREXP (extra character output) for output. The engine subroutine shall never store computed values in FIXIN, VARIN, EXPIN, or CHRIN. Both INTEGER and REAL items in the COMMON blocks have the length of a single precision full word. This restriction does not apply to character storage as it is independent of the length of a byte or word on any particular computer.

6.1.2 Requirements

The Fixed Input parameters placed in labeled COMMON FIXIN shall be limited to the order and quantity defined in 6.2. The Fixed Output (FIXOUT) shall be limited to the order and quantity of parameters defined in 6.3. If any parameter in the FIXIN or FIXOUT list is not used for a particular application, then that location in COMMON shall be left unused so that the parameters which follow it may be found in the locations indicated in the tables. The remaining required input and output shall be dependent on engine configuration and contained in labeled COMMONs VARIN and VAROUT, respectively. Labeled COMMONs EXPIN and EXPOUT shall be reserved for additional parameters available through coordination between the program supplier and user.

6.1.3 Nomenclature

The nomenclature utilized in the Fixed Input and Output COMMON blocks (FIXIN and FIXOUT) of 6.2 and 6.3 is for clarification only. Logically equivalent nomenclature consistent with AS6502 is permitted, e.g., W1 may be substituted for W1A in FIXOUT when multiple streams have not been distinguished.

In addition some parameters have been updated to a more modern naming convention as per AS6502, but the tables show the alternate name in brackets alongside for historical purposes. There are situations where the symbol X may be prefixed to leading symbols I, J, K, L, M, N for computer purposes.

6.1.4 Conventions for FIXIN and FIXOUT

Some output parameters have corresponding inputs in FIXIN, where their names are prefixed by the letter Z. The output locations in FIXOUT shall contain the values of each parameter as used in the computation, irrespective of whether they have been specified in the input or overridden by the program.

6.2 Input

6.2.1 FIXIN

The Fixed Input is defined in the labeled Fortran COMMON block FIXIN. The fixed sequence list of the parameters and the identity of these parameters (with typical nomenclature consistent with AS6502) are shown in Table 4 and represent the minimum input list detailed in AS681 (all parameters are REAL floating point numbers, except as indicated). Note that there is a difference between the array position of a parameter in relation to its position in the FIXIN COMMON block. The array position is the one that is normally used (e.g., Case is array position 5, not 22 in the FIXIN COMMON block).

Table 4 - Minimum input list - FIXIN

Array Position	Position in COMMON	Name	Description
1	1	NIN	Input file number (INTEGER)
2	2	NOUT	Output file number (INTEGER)
3	3	IND	Engine program indicator (INTEGER)
4	4 to 21	TITLE(18)	Reserved for historical consistency only[1]
5	22	CASE	Numerical case identification
6	23	ZALT	Pressure altitude
7	24	ZDTAMB	Ambient temperature minus standard atmospheric temperature
8	25	ZDT1(A)	Temperature increment for inlet heating to be added to free stream total temperature at station 0
9	26	ZERM1(A)	Inlet ram pressure recovery at station 1(A)[2]
10	27	ZPWXH	Customer high pressure shaft power extraction
11	28	ZPAMB	Ambient pressure
12	29	ZPC	Power code
13	30	ZPLA	Power lever angle
14	31	ZP1(A)	Engine inlet total pressure at station 1(A)[2]
15	32	ZRC	Rating code
16	33	SERAM	Inlet ram pressure recovery selection
17	34	SIM	Inlet mode selection
18	35	ZTAMB	Ambient temperature
19	36	ZT1(A)	Engine inlet total temperature at station 1(A)[2]
20	37	ZWB3	High pressure compressor bleed flow
21	38	ZWB3Q	High pressure compressor bleed flow ratio (bleed flow over reference flow)
22	39	ZM0 (ZXM)	Free stream Mach number
23	40	ZERAM1	Primary stream inlet ram pressure recovery[3]
24	41	ZERM11	Secondary stream inlet ram pressure recovery[3]
25	42	--	Reserved for historical consistency
26	43	--	Reserved for historical consistency
27	44	--	Reserved for historical consistency
28	45	--	Reserved for historical consistency
29	46	SDIST	Inlet pressure and temperature distortion selection
30	47	FYPH	Primary maximum response frequency
31	48	FYSH	Secondary maximum response frequency

Array Position	Position in COMMON	Name	Description
32	49	ZPWSD	Delivered shaft power
33	50	ZTIME	Time from start of transient case at which control is to be returned to calling program
34	51	TIMEF1	Time at which frequency is changed to secondary value, FYSH
35	52	TIMEF2	Time at which frequency reverts to primary value, FYPH
36	53	TIMEO	Output time interval
37	54	ZTIMET	Termination time of transient case
38	55	ZJPTL (ZXJPTL)	Polar moment of inertia of external load on the power turbine
39	56	ZNSD (ZXNSD)	Delivered shaft rotational speed
40	57	ZTRQSD	Delivered shaft torque
41	58	SWIND	Windmilling selection

[1] Items 4 to 21 are reserved for user Title (Hollerith), (obsolete use CTITLE, section 6.2.4).
[2] Station 1A applies to turbofan and other engines using Average of streams. In other cases e.g. turbo shafts, the station is 1.
[3] ZERAM1 & ZERAM11 only apply when primary & secondary streams have different inlet recoveries.

6.2.2 VARIN

The Variable Input is defined in the labeled Fortran COMMON block VARIN. It shall contain input dependent on engine configuration.

6.2.3 EXPIN

The Expanded Input is defined in the labeled Fortran COMMON block EXPIN. It shall contain input available through coordination between program supplier and user.

6.2.4 CHRIN

The Character Fixed Input is defined in the labeled Fortran COMMON block CHRIN. It shall contain the following:

1 CTITLE User Title - CHARACTER * 72

This supersedes the label TITLE described in 6.2.1 in FIXIN.

6.3 Output

6.3.1 FIXOUT

The Fixed Output is defined in the labeled Fortran COMMON block FIXOUT. The fixed sequence list of the parameters and the identity of these parameters (with typical nomenclature consistent with AS6502) are shown in Table 5 and represent the minimum output list detailed in AS681 (all parameters are REAL floating point numbers, except as indicated). Note that there is a difference between the array position of a parameter to its position in COMMON block. The array position is the one that is normally used (e.g., FN is array position 13 not 62).

Table 5 - Minimum output list - FIXOUT

Array Position	Position in COMMON	Name	Description
1	1 to 6	CLASS(6)	Reserved for historical consistency[4]
2	7 to 42	IDENT(36)	Reserved for historical consistency[5]
3	43 to 52	NSI(1-10)	Numerical Status Indicator (DIMENSION 10 INTEGER).
4	53	AE8	Primary or mixed exhaust nozzle throat effective area
5	54	AE18	Bypass exhaust nozzle throat effective area
6	55	ANGBT	Boat-tail angle
7	56	FRAM	Ram drag
8	57	FG	Gross thrust
9	58	FGI	Ideal gross thrust
10	59	FG19	Bypass stream gross thrust
11	60	FGI19	Bypass stream ideal gross thrust
12	61	FHV	Fuel lower heating value
13	62	FN	Net thrust
14	63	PB3	High pressure compressor discharge bleed flow total pressure
15	64	P7	Primary or mixed exhaust stream total pressure
16	65	P17	Bypass exhaust stream total pressure
17	66	SFC	Specific fuel consumption
18	67		Reserved for historical consistency
19	68	TB3	High pressure compressor discharge bleed flow total temperature
20	69	TC	Control temperature (cockpit display)
21	70	T7	Primary or mixed exhaust stream total temperature
22	71	T17	Bypass exhaust stream total temperature
23	72	WFE	Fuel flow, main combustor
24	73	WFT	Fuel flow, total of all combustors
25	74	W1(A)	Engine inlet flow at station 1(A)[6]
26	75	W7	Primary or mixed exhaust stream flow
27	76	W17	Bypass exhaust stream flow
28	77	W2*	First compressor inlet flow (Where W2* is the full number representing the relevant station designation, e.g., W21, W215, W2A, shall be defined by the program supplier.)
29	78	NH (XNH)	High pressure shaft rotational speed
30	79	NI (XNI)	Intermediate pressure shaft rotational speed
31	80	NL (XNL)	Low pressure shaft rotational speed
32	81	NSD (XNSD)	Delivered shaft rotational speed
33	82	ALT	Pressure altitude
34	83	ERAM1(A)	Inlet ram pressure recovery at station 1(A)[6]
35	84	PAMB	Ambient pressure
36	85	PLA	Power lever angle
37	86	P1(A)	Engine inlet total pressure at station 1(A)[6]
38	87	TAMB	Ambient temperature
39	88	T1(A)	Engine inlet total temperature at station 1(A)[6]
40	89	M0 (XM)	Free stream Mach number
41	90	SML	Low pressure compressor stability margin
42	91	SMI	Intermediate pressure compressor stability margin
43	92	SMH	High pressure compressor stability margin
44	93		Reserved for historical consistency