RATIONALE

ARP1210D has been reaffirmed to comply with the SAE five-year review policy.

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1. SCOPE:

This SAE Aerospace Recommended Practice (ARP) describes a class of digital computer programs for use by organizations other than the engine supplier for reduction of engine test data relating to the interface of the engine in the airframe or test facility. This ARP also is intended as a guide for the preparation of such computer programs.

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, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AS681	Gas Turbine Engine Steady State and Transient Performance Presentation for Digital Computer Programs
AS755	Gas Turbine Engine Performance Station Identification and Nomenclature
ARP4191	Gas Turbine Engine Performance Presentation for Digital Computer Programs Using FORTRAN 77

2.1.2 International Organization for Standardization (ISO): Available from National Institute of Standards and Technology, Public Inquiries, Administration Building A903, NIST, Gaithersburg, MD 20899-0001.

ISO 1000	SI units and recommendations for the use of their multiples and of certain other units
ISO 2533	Standard Atmosphere
ISO 2955	Representations for SI and other units to be used in systems with limited character sets

2.1.3   Other Documents:

NIST-JANAF Thermochemical Tables, Fourth Edition, Parts I and II, Malcolm W. Chase, Jr., Editor, August 1998, ISBN: 1-56396-831-2

3.   GENERAL REQUIREMENTS:

3.1   Engine Description:

A description of the engine will be provided. This description will include the type of engine, the general arrangement of components, and such general characteristics as are necessary to understand the data reduction procedure.

3.2   Instrumentation Description:

A list of the instrumentation needed to obtain data for this program will be included. Calibration for engine supplied instrumentation will be provided or included in the computer program.

3.3   Modes of Program Operation:

The program will have the capability of functioning both as a subroutine and as an independent program. The latter may incorporate additional procedures and input data supplied by the responsible organization and required for propulsion system performance calculation (e.g., inlet, environmental control, and exhaust system analysis), and will consist of a MAIN program containing a CALL statement to the subroutine. Where unprocessed data are to be input, correction procedures and instrument calibration will also be supplied by the responsible organization.

3.4   User's Manual:

The program supplier will deliver the User's Manual with the program.

The following format and content shares common sections with AS681 and is recommended for the User's Manual:

1.   Introduction.

2.   Table of Contents.

3.   Engine Description. This section will enable the user to identify the engine and its general characteristics.

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

3.4   (Continued):

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 users computer staff to set up the program.

7. Program Capabilities. This section will describe the interfaces, logic options, limits, and other program features that enable the user to understand fully the capability of the program.

8. Input/Output. This section will describe in detail the input required to use the features described in Item 7 of this section, the output the program produces, and will list the units of all input and output parameters.

9. Program Messages. This section will explain the messages produced during program operation that identify output status, program logic paths, and, if applicable, data reject and substitution procedures that were used and will identify the numerical status indicator codes.

10. Listings. This section will list the computer code statements comprising the subroutines that are supplied in source form.

11. Test Cases. This section will describe the test cases that the supplier provides for program checkout by the user.

12. Identification and Revision Procedures.

13. Instrumentation. This section will list the instrumentation and its characteristics.

14. Error Analysis. This section will describe the computer program test data reduction error analysis procedures and the results of error analysis, when requested by the customer.
15. References.

3.5   Program Scope:

3.5.1 Categories of Programs to be Considered: Engine test data reduction programs may range from programs that are limited to calculation of external performance, e.g., thrust, fuel flow, and airflow, to those that include an analysis of component performance for consistency checks.

3.5.2 Limits: All known limits will be defined in the User's Manual, e.g., range of input pressure and temperature limits for which calibration curves are supplied, range of component performance which is supplied, or range of thermodynamic data for which calculations are valid. When the input data calls for an operating point outside limits, the program will proceed to complete its calculation, if possible, and output the appropriate status indicator. The status indicators will clearly define the validity of the data. 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.

3.6   Error Analysis:

Upon request by the customer, an error analysis will be conducted by the participating organizations to determine the accuracy of significant output parameters.

4.   PROGRAMMING PRACTICES:

4.1   Equipment Capabilities:

The user's measurement system and computer capabilities may limit the program. Program development must be preceded by user/supplier coordination.

4.2   Program Language:

Any computer language (e.g., C, ADA, FORTRAN 77) may be used for engine computer programs if the language has been coordinated between the user and the supplier. If not otherwise coordinated, engine computer programs will use as a minimum language FORTRAN 66 [level: full FORTRAN (Number 1)] as originally defined in ANSI X3.9, 1966a. 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. ARP4191 contains additional information for FORTRAN 77 applications.

4.3   Station Identification and Nomenclature:

Station identification and nomenclature will be consistent with AS755. Supplements to the system of AS755 that are necessary will be detailed in the User's Manual.

Nomenclature symbols are not required to be used for variable names within the program. While the use of the same nomenclature within the program 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.

4.4   Standard Atmosphere:

Ambient temperature and pressure will be consistent with the geopotential pressure altitude of ISO 2533.

4.5   Program Thermodynamics:

4.5.1   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 upon request by the customer.

4.5.2   Fuel: Fuel heating value assumed by the computer program will be specified in the User's Manual. Fuel specific gravity will also be specified if it is used in the performance calculation or its associated control model. Other fuel characteristics used in the program will be provided in an appendix to the User's Manual, upon request by the customer.

4.5.3 Thermochemical Data: Thermochemical data used in the computer program will be defined in the User's Manual upon request by the customer. Thermochemical data for the purpose of gas turbine engine performance calculations will be consistent with data presented in the NIST-JANAF Thermochemical Tables, Fourth Edition, Parts I and II, within the limitations of physical representation (e.g., reaction rates, heat transfer), engineering accuracy, and computational efficiency requirements. Upon request by the customer, the supplier will supply a comparison of the thermodynamic process calculations based on his/her thermochemical data and that given by the NIST-JANAF Thermochemical Tables within the range of applicable engine operating conditions.

4.6 Programming Standards:

The level of compiler optimization requires coordination between user and supplier.

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. 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.

5. PROGRAM CAPABILITIES:

5.1 Installed Performance Effects:

The program will be capable of processing applicable installed performance and variable geometry position data.

5.2 Program Logic:

Where practical, the program will supply the logic for a course of action:

a. When a data element is missing
b. When the data element is present but is rejected based on instrumentation evaluation
c. When bad data are recognized through program consistency checks
d. When bad data are recognized to be present on the basis of the test history

These items may require special input signals to the program. The program will indicate which logic paths have been rejected, which input data values have been rejected, and what alternate assumptions have been made to complete the analysis.

6. INPUT/OUTPUT:

6.1 Program Interface Definition:

The communication between the calling program (written by either the program supplier or user) and the remainder of the reduction program will be coordinated individually between user and supplier.

6.2   Units:

Input and output parameter values will be based on the pound, foot system of measurement commonly used in the United States. However, the (SI) metric system is an acceptable alternate. Appendix A and B define the units that will be used for either system.

6.3   Numerical Status Indicators:

Numerical status indicators will be used where applicable to notify the program user of any limitations or qualification of the output data. The numerical status indicators will uniquely identify the actions described in 5.2.

7.   PROGRAM IDENTIFICATION:

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

The program will be transmitted in a fashion that is mutually acceptable to both user and supplier (e.g., magnetic tape, diskette, electronic transmission). The following information must be provided for every program transmitted:

a.   Program identification and date
b.   Originator
c.   Engine identification

In addition the following information must be provided for each file transmitted:

a.   Type of information (source or object; data in internal form (unformatted) or in external form (formatted)).
b.   Type of machine used, operating system, and compiler (including version).
c.   Any other information necessary to retrieve the program from the media.

8.   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 the engine program input options described in the User's Manual.

Source code will be provided for the calling program.