



AEROSPACE STANDARD

AS681™**REV. L**Issued 1959-06
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Superseding AS681K

(R) Gas Turbine Engine Performance Presentation for Computer Programs

RATIONALE

The purpose of this revision is to identify and standardize common unit descriptors for programmatic use. Also, the S-15 document family tree was updated. In addition, references to ARP1210 were deleted since that document was canceled.

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For more information on this standard, visit
<https://www.sae.org/standards/content/AS681L>

Documents

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1. SCOPE

This SAE Aerospace Standard (AS) provides the method for presentation of gas turbine engine steady-state and transient performance calculated using computer programs. It also provides for the presentation of parametric gas turbine data including performance, weight, and dimensions computed by computer programs.

This standard is intended to facilitate calculations by the program user without unduly restricting the method of calculation used by the program supplier. This standard is applicable, but not limited to, the following program types: data reduction, steady-state, transient, preliminary design, study, specification, status, and parametric 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 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.

AIR4548	Real-Time Modeling Methods for Gas Turbine Engine Performance
AIR5509	Using Engine Test Data to Model Engine Performance
AIR6508	Supplemental Propulsion System Performance Station Designation
ARP1420	Gas Turbine Engine Inlet Flow Distortion Guidelines
ARP4148	Gas Turbine Engine Real Time Performance Model Presentation
ARP4868	Function-Based API for Gas Turbine Engine Performance Programs
ARP5571	Gas Turbine Engine Performance Presentation and Nomenclature for Object-Oriented Computer Programs
ARP7998	Shared Memory Interface for Gas Turbine Engine Performance Programs
AS210	Definition of Commonly Used Day Types (Atmospheric Ambient Temperature Characteristics Versus Pressure Altitude)
AS755	Aircraft Propulsion System Performance Station Designation
AS4191	Gas Turbine Engine Performance Presentation for Computer Programs Using Fortran
AS6502	Aircraft Propulsion System Performance Nomenclature

Figure 1 presents a family tree of SAE S-15 documents and illustrates the relationship between the various SAE S-15 documents referenced in this document.

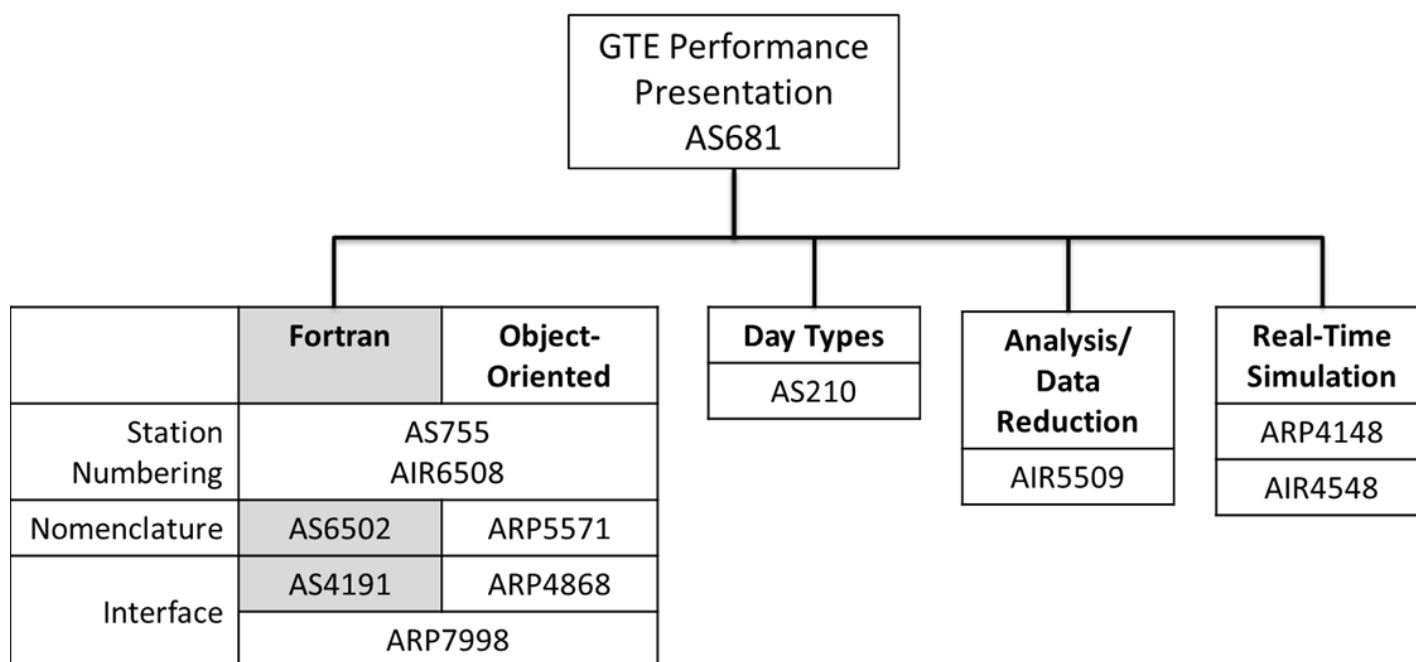


Figure 1 - S-15 document family tree

2.1.2 ISO Publications

Copies of these documents are available online at <https://webstore.ansi.org/>.

ISO 2533 ISO standard atmosphere

2.1.3 NIST Publications

Available from NIST, 100 Bureau Drive, Stop 1070, Gaithersburg, MD 20899-1070, Tel: 301-975-6478, www.nist.gov.

NIST-JANAF Thermochemical Tables, Fourth Edition, Parts I and II

2.1.4 U.S. Government Publications

Copies of these documents are available online at <https://quicksearch.dla.mil>.

MIL-E-5007D Engine, Aircraft, Turbojet and Turbofan, General Specification for [Inactive]

2.2 Related Publications

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

2.2.1 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.

TSB 003 Rules for SAE Use of SI (Metric) Units

2.2.2 ISO Publications

Copies of these documents are available online at <https://webstore.ansi.org/>.

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

2.3 Program Categorizations

Computer programs which calculate engine performance may be categorized according to their time dependency, method of calculation, and their life cycle phase (concept design, development, production, field use, and overhaul). The program types defined below are not mutually exclusive; in fact, it is quite common for two or more of the functions listed to be combined in a single program.

2.3.1 Program Time Dependency

Engine programs can be defined based on their time dependency:

- Steady-state program
- Transient program (real-time or non-real-time)

2.3.2 Engine Program Life Cycle Phase

Engine programs can be defined based on their life cycle phase:

- Preliminary Design program/study program
- Specification program
- Status program
- Parametric program

2.4 Definitions

2.4.1 Program Type Definitions

2.4.1.1 DATA REDUCTION PROGRAM

Program used to interpret results from performance testing. A data reduction program may directly compute component performance characteristics (e.g., efficiency) from measured data using standard engineering equations. Alternatively, a data reduction program may employ a steady-state or transient engine program as its core, and extend its iteration scheme to match predicted component parameters to engine test data. In the latter case, the predictive capability of the engine model can be used to extrapolate the test results to the desired test condition (which may be unattainable with the given hardware or test facility). The engine model used as the core of this type of data reduction program will nearly always be a status model as defined below. Applications of data reduction programs include:

- a. Interpretation of test data to facilitate the generation of status models.
- b. Analysis of performance verification tests.
- c. Interpretation of engine/airframe performance issues based on aircraft flight tests.

2.4.1.2 PARAMETRIC PROGRAM

A special type of preliminary design program. Program which estimates the performance and possibly other figures of merit (e.g., weight and dimensions) of a class of engines of similar configuration over a range of design parameters (e.g., compressor pressure ratio, turbine inlet temperature, airflow). The performance, weight, and dimensions generally result from a less detailed analysis than a conventional preliminary design, specification, or status program. A typical application of a parametric engine program is to provide data to narrow the range of system design parameters for more detailed studies.

2.4.1.3 PRELIMINARY DESIGN PROGRAM

Program which estimates the engine performance prior to the point in the development of the engine when its performance is defined by a specification. A typical application of a preliminary design program is to provide data to support preliminary aircraft design.

2.4.1.4 REAL-TIME PROGRAM

Transient performance program whose outputs are generated at a rate at least as fast as the physical system represented.

ARP4148 and AIR4548 provide additional information on real-time programs.

2.4.1.5 SPECIFICATION PROGRAM

Program which establishes the guaranteed performance for a specific engine model. A typical use of specification programs is to generate performance data for engine and aircraft guarantees.

2.4.1.6 STATUS PROGRAM

Program which reflects the current performance status of a specific engine or group of engines. They are normally based on greater test experience than specification programs. Status programs do not alter the commitments established by specification programs. Applications of status programs include:

- a. Pre-test performance prediction for a specific engine.
- b. Modeling an engine to investigate test operating procedures for ground test and/or flight test.
- c. Extrapolation and/or interpolation of limited test data.
- d. Generation of data or simulation of engine for use in simulators.
- e. Prediction of the average performance of a group of engines (e.g., the average of all production engines shipped).
- f. Generation of data for aircraft flight manuals.

AIR5509 discusses how test data is reduced and used to create engine models. These could include status programs.

2.4.1.7 STEADY-STATE PROGRAM

Program which predicts engine performance for steady-state conditions (i.e., when time derivatives are zero).

2.4.1.8 STUDY PROGRAM

A program that reflects perturbations or updates to a previously defined engine configuration for investigative purposes (e.g., an impact assessment of a proposed change). Such a program may or may not become a new definition of the engine configuration.

2.4.1.9 TRANSIENT PROGRAM

Program which predicts engine performance under time-varying conditions. Transient programs may simulate the engine with a simplified control algorithm, or with a detailed simulation of the actual engine control system. Applications of transient programs include:

- a. Prediction of engine acceleration and deceleration performance;
- b. Support of airframe/engine integration studies, including flight control development;
- c. Generation of data or simulation of engine for use in simulators;
- d. Simulation of the engine for control bench testing.

2.4.2 Other Definitions

2.4.2.1 MODEL

Two applicable definitions:

- a. A computer program together with the appropriate input which simulates the performance (and possibly other characteristics) of a particular gas turbine engine design.
- b. A specific member of a gas turbine product line (e.g., PW120 or CFM56-7).

2.4.2.2 REFERRED ENGINE AIRFLOW (W^*R)

Airflow (W) at a given engine station, indicated by the asterisk, adjusted for the conditions (pressure and temperature) of that reference station (e.g., $W1R$, $W1AR$, $W2R$).

3. GENERAL REQUIREMENTS

This aerospace standard describes a class of software whose audience is one or a few specific users. It offers standards or recommended practices for the delivery of that software. However, there is every opportunity for the developer and the user to meet to establish the specific needs for that software. This standard provides a basis for identifying the issues of that discussion. Elements of this standard may only be waived by mutual consent of the supplier and the user. Failing agreement to a waiver by both parties, this standard establishes the requirements for the delivered program.

3.1 Program Implementation

3.1.1 Program Adaptability

The program shall be supplied in a form adaptable to the user's computer. Provision to operate the program on more than one computer type or operating system shall be coordinated between user and supplier.

3.1.2 Program Functionality

The program shall be able to function as a subprogram (herein called the engine subprogram) and as an independent program consisting of a main program which calls the engine subprogram.

3.1.3 Points of Consideration

The supplier and user shall consider the following points:

- Software end user contact information.
- Software supplier contact information.
- List of compiler/hardware combinations to which the supplier has easy access.
- Operating system and hardware for which the customer requires software.
- What compiler, versions, and options are required.
- Build for 32 or 64 bit.
- Which interfaces should the software support (e.g., command line, , API, DLL, Matlab, VBA, etc.).
- On which media shall the supplier provide the software.
- Any test-bed/test-stand/flight-test software specifics.
- Correct setting of any applicable environment variables.

3.2 Program Operation

3.2.1 Limits

Limits observed by the computer program shall be specified in the user documentation.

The engine program will allow inputs set beyond their specified limit, upon request, provided the supplier believes the results to be credible. If not, the input will be limited. Regardless of the situation, an appropriate numerical status indicator will be provided in the output. The numerical status indicator shall clearly define output validity, limiting parameters and/or the applicable limiting engine controlling parameter.

3.2.2 Program Consistency

Consistency is used here to mean the agreement between model outputs and reference data. Reference data may be a more rigorous model or test data. Consistency criteria vary significantly and depend upon the specific application. The coordination of model consistency is a key element of model delivery.

3.3 User Documentation

The program supplier shall deliver user documentation with the program. User documentation may be in the form of paper manuals, electronic media, online help or remotely accessible instructions (e.g., via the internet). User documentation shall normally be completely independent of documentation for earlier releases of the program. With the explicit approval of the program user, it is permitted to provide an update to prior documentation.

The program supplier is urged to provide separate documentation that describes installation and checkout of the program from the documentation that describes program operation and interpretation of program output.