ASME PTC 55-2013

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Gas Turbine Aircraft Engines

Performance Test Codes

AN AMERICAN NATIONAL STANDARD



The American Society of Mechanical Engineers

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NOTICE

All Performance Test Codes must adhere to the requirements of ASME PTC 1, General Instructions. The following information is based on that document and is included here for emphasis and for the convenience of the user of the Code. It is expected that the Code user is fully cognizant of Sections 1 and 3 of ASME PTC 1 and has read them prior to applying this Code.

ASME Performance Test Codes provide test procedures that yield results of the highest level of accuracy consistent with the best engineering knowledge and practice currently available. They were developed by balanced committees representing all concerned interests and specify procedures, instrumentation, equipment-operating requirements, calculation methods, and uncertainty analysis.

When tests are run in accordance with a Code, the test results themselves, without adjustment for uncertainty, yield the best available indication of the actual performance of the tested equipment. ASME Performance Test Codes do not specify means to compare those results to contractual guarantees. Therefore, it is recommended that the parties to a commercial test agree before starting the test and preferably before signing the contract on the method to be used for comparing the test results to the contractual guarantees. It is beyond the scope of any Code to determine or interpret how such comparisons shall be made.

FOREWORD

The Performance Test Code Committee No. 55 was established to develop a test code on gas turbine aircraft engines. This Code was published in 2013.

The Committee consists of manufacturers, consultants, users such as members of the U.S. Armed Forces, and other governmental agencies involved both in the development of specifications of gas turbines and testing of these engines, airlines, and other aviation companies involved in aviation gas turbines. These groups of gas turbine engineers have taken into account the development of the many different technologies that are involved in aircraft gas turbine technology. The PTC 55 Code addresses the increasingly important topic of aircraft emissions and the need for high speed measurements to document dynamic phenomena such as combustion instability, forced vibrations, and aerodynamic flutter. The importance of understanding and documenting the uncertainty of the measurements used to characterize gas turbine performance is also addressed.

This Code was approved as an American National Standard, by the ANSI Board of Standards Review, on July 29, 2013.

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Performance Test Codes

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Secretary, PTC Standards Committee
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Proposing Revisions. Revisions are made periodically to the Code to incorporate changes that appear necessary or desirable, as demonstrated by the experience gained from the application of the Code. Approved revisions will be published periodically.

The Committee welcomes proposals for revisions to this Code. Such proposals should be as specific as possible, citing the paragraph number(s), the proposed wording, and a detailed description of the reasons for the proposal, including any pertinent documentation.

Proposing a Case. Cases may be issued for the purpose of providing alternative rules when justified, to permit early implementation of an approved revision when the need is urgent, or to provide rules not covered by existing provisions. Cases are effective immediately upon ASME approval and shall be posted on the ASME Committee Web page.

Requests for Cases shall provide a Statement of Need and Background Information. The request should identify the Code, the paragraph, figure or table number(s), and be written as a Question and Reply in the same format as existing Cases. Requests for Cases should also indicate the applicable edition(s) of the Code to which the proposed Case applies.

Interpretations. Upon request, the PTC Standards Committee will render an interpretation of any requirement of the Code. Interpretations can only be rendered in response to a written request sent to the Secretary of the PTC Standards Committee.

The request for interpretation should be clear and unambiguous. It is further recommended that the inquirer submit his/her request in the following format:

Subject:	Cite the applicable paragraph number(s) and the topic of the inquiry.
Edition:	Cite the applicable edition of the Code for which the interpretation is being requested.
Question:	Phrase the question as a request for an interpretation of a specific requirement suitable for general understanding and use, not as a request for an approval of a proprietary design or situation. The inquirer may also include any plans or drawings that are necessary to explain the question; however, they should not contain proprietary names or information.

Requests that are not in this format will be rewritten in this format by the Committee prior to being answered, which may inadvertently change the intent of the original request.

ASME procedures provide for reconsideration of any interpretation when or if additional information that might affect an interpretation is available. Further, persons aggrieved by an interpretation may appeal to the cognizant ASME Committee or Subcommittee. ASME does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity.

Attending Committee Meetings. The PTC Standards Committee and PTC Committees hold meetings regularly, which are open to the public. Persons wishing to attend any meeting should contact the Secretary of the PTC Committee.

INTRODUCTION

This Test Code provides direction and rules for the conduct and reporting of test(s) results for propulsion gas turbines, hereafter referred to as gas turbine aircraft engines. This Code provides a common set of test procedures that will yield results of the highest level of accuracy and fidelity, consistent with the best engineering knowledge and practice in the gas turbine industry.

ASME PTC 1, General Instructions; ASME PTC 2, Definitions and Values; ASME B133.1, Gas Turbine Terminology; and ASME PTC 22, Performance Test Code on Gas Turbines were used as guides in the preparation of this Code and are recommended as references when using this Code.

The performance testing of a gas turbine aircraft engine is complicated because they come in all sorts of configurations from turbines with single spools to turbines with three spools. It is important in every case to determine the type of engine from a pure-jet, to a fan-jet, to a prop-jet. In addition, the wide range of test missions from standard production, sea level acceptance testing to heavily instrumented altitude tank development testing of new designs require the use of different test cells that are described in this Performance Test Code. The test data in virtually every case needs correction for the differences between the test and specified conditions. The techniques used to do so are based upon the rules of fluid-dynamic similarity. Some familiarity with this fundamental technique will be a significant aid to the users of PTC 55.

Uncertainty analysis plays a very important role in gas turbine engine testing, from the design of the test to interpretation of the test reslults. In all but the very simplest of cases the development of an analytical formulation, i.e., in simple equation form, for overall uncertainty computation is formidable. The test uncertainty will always be increasingly more complex to evaluate with the complexity of the gas turbine configuration, and by the very nature of the test will be a function of engine thermodynamic cycle and model employed to calculate the engine performance.

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GAS TURBINE AIRCRAFT ENGINES

Section 1
Object and Scope

1-1 OBJECT

The objective of this Code is to recommend the methodology for determining the performance of thrust and power-producing gas turbine aircraft engines at test conditions and to correct these results to standard or specified operating conditions. In order to meet the stated objective the Code will define and standardize the methods used for conducting the tests, calculating the results, and making the corrections.

1-2 SCOPE

This Code covers the performance testing of gas turbine aircraft engines at steady-state conditions. This Code applies to turbojet, turbofan, turboshaft, and turboprop engines. Additionally, the Code will encompass ram and/or altitude test conditions, including sea level static test conditions.

The primary test results include

(a) Thrust or Power

(b) Engine Component Performance (operating lines, stall margin, efficiency)

(c) Auxiliary Power Extraction

(d) Core Fuel Flow

(e) Specific Fuel Consumption

(f) Total Engine Airflow

(g) Core Airflow

(h) Bypass Airflow

(i) Bleed Airflow

(j) Vibration Levels

In addition, oftentimes military and commercial contracts include specifications for the following secondary parameters:

(k) Pressures and Temperatures

(l) Humidity

(m) Rotor Speeds

(n) Engine Pressure Ratio

(o) Oil Flow

(p) Variable Geometry Settings

(q) Noise and Emissions

(r) Engine Control Signals

Brief guidance, procedures, and recommendations are included to address the measurement of these parameters. More detailed procedures and regulations for these are found elsewhere.

This Code is only applicable to measuring performance when the engine is installed in a test facility. This Code is not applicable to measuring performance when the engine is installed in an aircraft, and it does not address engine-specific limits and margins. The Code does not cover ground-based mechanical or electrical power-generating gas turbines, which is the subject of PTC 22. This Code is not sufficient for certification or qualification of engines under development, nor is it intended for determination of research data. While this Code does not cover the requirements for transient testing, it is recognized that transient testing may be required to meet some limited contractual requirements. Information on transient testing is provided herein to support a comprehensive test program.

1-3 TYPICAL OVERALL PERFORMANCE UNCERTAINTY

Test uncertainty is an estimate of the limit of error of a test's result. It is the interval about a result that contains the true value within a given probability, or level of confidence. It is based on calculations utilizing statistics, instrumentation information, calculation procedure, and actual test data. PTC 19.1 is the Performance Test Code Supplement that covers general procedures for calculation of test uncertainty. Performance Test Codes maintain a 95% level of confidence for which uncertainty is calculated as their standard. This confidence level therefore represents a 95% chance that the uncertainty interval contains the true value. An uncertainty analysis shall be performed prior to the test. The overall test uncertainty will vary because of the differences in the amount and type of instrumentation, test equipment, inlet pressure and temperature, loads, and the engine's configuration.