IEC 60953-4

Edition 1.0 2026-09

INTERNATIONAL STANDARD

Rules for steam turbine thermal acceptance tests - Part 4: Routine testing

ICS 27.040

ISBN 978-2-8327-1491-1

IEC 60953-4:2026-09(en)

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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Rules for steam turbine thermal acceptance tests - Part 4: Routine testing

FOREWORD

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IEC 60953-4 has been prepared by IEC technical committee 5: Steam Turbines. It is an International Standard.

The text of this International Standard is based on the following documents:

Draft	Report on voting
5/298/FDIS	5/302/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

This part of IEC 60953 is to be read in conjunction with IEC 60953-0, and the words 'routine test' are to be read in place of 'acceptance test', the words' reference conditions' are to be read in place of 'guarantee conditions', and the words 'reference value' are to be read in place of 'guarantee value'. IEC 60953-0 is taken as a reference standard.

A list of all parts in the IEC 60953 series, published under the general title *Rules for steam turbine thermal acceptance tests*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

– reconfirmed,
– withdrawn, or
– revised.

INTRODUCTION

Routine test in an existing power plant mainly involves an analysis, monitoring and supervision of steam turbine performance. IEC 60953-0, which defines the rules for steam turbine thermal acceptance tests in power plants, does not cater for all the requirements specific to routine test. It was considered necessary to draw up a Supplementary Standard (this document) for guidance on the routine tests of existing steam turbines.

However, a large number of the provisions and recommendations of IEC 60953-0 are still applicable to routine tests and, therefore, in order to avoid a repetitive and bulky document, only the routine-specific addenda will be found in this document.

Although this document is intended to apply to the routine test of large condensing steam turbines, it can nevertheless be used for other types and sizes of turbines to define the basis of a specific procedure to be agreed upon by the parties involved.

The purpose of this document is to cover the existing steam turbine components which influence the efficiency of the power plant. This document helps the parties determine the most appropriate parameters that characterize the relative performance change and that could be used as long-term performance monitoring and analysis.

The relative performance rather than absolute value is emphasized in this document. The repeatability of test results rather than absolute test uncertainty is emphasized. In addition, depending on the type of test and thermodynamic boundary chosen, the full condition of each component might not be known. In some cases, as per the result of routine test, full or further diagnostic test may be needed.

For reference purposes only, a numerical sample calculation and analysis of a fossil steam turbine unit is presented in Annex J.

The structure and clause numbering of this document follow that of IEC 60953-0. Subclauses found in this document supersede the whole of the equivalent subclause in IEC 60953-0. Subclause numbering has been extended whenever new items have been included.

The main differences between this document and IEC 60953-0 are listed below:

– Clause 1: Scope

  This document gives additional clauses for routine tests of steam turbines, regarding the analysis and supervision of relative performance by routine testing.

  General principles and the determination of the measurement uncertainty of periodic routine tests are given.

  The purpose of this document is to provide a simple and economic test procedures guide for long-term and relative performance of turbines and turbine cycles.

  Specific simplified testing procedure is allowed, which results in less accuracy for absolute values and wider uncertainty range. The accuracy for the results of performance changes is sufficient for the purpose of the test.

– Clause 2: Normative references

  IEC 60953-0:2022 was added as reference.

– Clause 3: Units symbols, terms and definitions

  The definitions given in IEC 60953-0:2022 apply to this document. Some new definitions involving features of routine testing were added.

– Clause 4: Guidance principles

  The majority of the guiding principles contained in IEC 60953-0 are also applicable to the routine testing. This document gives further guidelines on the planning, timing, leadership of the tests, the setting of the test and cycle isolation, and allowable test conditions.

– Clause 5: Measuring techniques and measuring instruments

  According to the purpose and scope of routine tests, the specific requirements of the consistency of the test instruments, the calibration of the instruments and the usage of permanently installed instruments are given.

– Clause 6: Evaluation of tests

  This document gives further advice on allowable cycle leakages.

– Clause 7: Correction of test results and comparison

  Additional considerations for routine test results comparison including performance parameters trending and heat rate diagnosis are given.

– Clause 8: Measuring uncertainty

  This clause of IEC 60953-0:2022 is supplemented by provisions for special cases encountered in routine testing in Annex K. The examples can be used as reference basis.

– Annexes:

  Annexes A to E of IEC 60953-0:2022 apply.

  Six new annexes were added to the existing ones.

  - Annex F: Measuring uncertainty of results – routine test application
  - Annex G: Guidance on selection a type of routine test to be performed
  - Annex H: Sensitivity factors for some component performance on overall cycle efficiency
  - Annex I: Typical thermodynamic boundary and instrument layout for routine tests
  - Annex J: Calculation and analysis of test results – numerical example
  - Annex K: Numerical examples of routine testing uncertainty calculation (fossil)

1 Scope

1.1 General

This part of IEC 60953 establishes a Supplementary Standard for routine testing of steam turbines.

The rules given in this document follow the guidance given in IEC 60953-0, but contain amendments and supplements regarding the analysis and supervision of relative performance by routine testing of steam turbine.

General principles for the preparation, performance evaluation, trends of performance parameters and the determination of the measurement uncertainty of periodic routine tests are given in this document.

This document is applicable to routine testing covering a wide range of accuracy on steam turbines of every type, rating and application, operating with superheated or saturated steam.

This document is not intended for application in acceptance tests of new units or retrofits and its application for such is strongly not recommended.

1.2 Object

The purpose of this document is to provide simple and economic test procedures for conducting analysis and supervision of relative performance throughout the life of the turbine and turbine cycles.

The major purposes of routine testing are:

a) To provide guidance in scheduling maintenance outage on the basis of performance;
b) To detect or diagnose performance change in specific areas of the turbine or turbine cycle;
c) To provide results for unit economic dispatch curves;
d) To provide relative magnitudes of losses in steam turbine cycle before priorities can be established to correct deficiencies.

Specific simplified testing procedures are intended to minimize test instrumentation and personnel. Relative accuracy and wide uncertainty range rather than acceptance test level results are expected.

The repeatability of test results rather than test accuracy is emphasized in this document.

Routine test results can include as follows:

e) Performance of the turbine and turbine cycle
    1) Thermal efficiency or heat rate;
    2) Power output;
    3) Steam rate;
    4) Main steam flow capacity;
    5) Nuclear: thermal load capacity of the steam turbine under defined conditions.

f) Component performance and trending parameters
   1) Turbine stage flow factors;
   2) Corrected turbine stage pressure;
   3) Cycle isolation;
   4) HP & IP turbine efficiency-expansion in superheated regions;
   5) Heater, deaerator, condenser, boiler feedwater pump (BFP) and BFP turbine;
   6) Gland Leakage flow from HP to IP (for HP/IP combined turbine).

1.3 Matter to be considered in the contract

Subclause 1.3 of IEC 60953-0:2022 applies.

2 Normative references

Clause 2 of IEC 60953-0:2022 applies with the following addition:

IEC 60953-0:2022, *Rules for steam turbine thermal acceptance tests - Part 0: Wide range of accuracy for various types and sizes of turbines*

3 Units, symbols, terms and definitions

Clause 3 of IEC 60953-0:2022 applies with the following additions:

3.1 General

Subclause 3.1 of IEC 60953-0:2022 applies.

3.2 Symbols, units

Subclause 3.2 of IEC 60953-0:2022 applies in addition to the following:

Quantity	Symbol	Unit	Examples of multiples and submultiples	Other ISO units
Efficiency (general)		1		
Wetness correction factor	WCF	1		
Flow-passing-capacity	FPC	m^2		
Valves wide open	VWO			
Terminal temperature difference	TTD	°C		
Drain cooler approach	DCA	°C		

3.3 Subscripts, superscripts and definitions

Subclause 3.3 of IEC 60953-0:2022 applies, with the following additions:

3.3.1
reference conditions
values of all the external parameters, i.e., parameters outside the test boundary to which the test results are corrected

Note 1 to entry: Reference conditions might be the boundary conditions of design or reference test.

3.3.2
reference test
test carried out under reference conditions, the result being used for comparing the performance change and diagnosing deficiency

Note 1 to entry: The reference test can be the original guarantee verification test, any other periodic test, or information from the manufacturer's heat balances or tests before or after overhaul.

Note 2 to entry: The result of reference test could be used as reference/baseline performance.

3.3.3
comparative test
current test or a series of tests carried out in order to prove a relative change of performance, relative to the reference test

Note 1 to entry: This kind of test could be carried out periodically or for specific purposes. For example, before or after a major overhaul.

3.3.4
repeatability
ability of the measurement system to produce test results of the same output/input relationship over extended time periods

Note 1 to entry: Repeatability is essential in periodic tests so that variations in performance indicated by test results are true indications of the deterioration of the equipment tested.

Note 2 to entry: Special care should be dedicated to the verification of primary flow element condition prior to testing.

3.3.5
primary parameters
measured variables which significantly affect the test result should be measured with instruments of a known calibration status

3.3.6
secondary parameters
measured variables which have a minor effect on test results

3.4 Definition of guarantee values and test results

3.4.1 Guidance on guarantee parameters

Subclause 3.4.1 of IEC 60953-0:2022 applies.

3.4.2 Thermal efficiency

Subclause 3.4.2 of IEC 60953-0:2022 applies.

3.4.3 Heat rate

Subclause 3.4.3 of IEC 60953-0:2022 applies.

3.4.4 Thermodynamic efficiency

Subclause 3.4.4 of IEC 60953-0:2022 applies.

3.4.5 Steam rate

Subclause 3.4.5 of IEC 60953-0:2022 applies.