

Rules for steam turbine thermal acceptance tests - Part 3: Thermal performance
verification tests of retrofitted steam turbines

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English version

**Rules for steam turbine thermal acceptance tests
Part 3: Thermal performance verification tests of
retrofitted steam turbines
(IEC 60953-3:2001)**

Règles pour les essais thermiques
de réception des turbines à vapeur
Partie 3: Essais de vérification des
performances des turbines à vapeur
rénovées
(CEI 60953-3:2001)

Regeln für thermische
Abnahmeprüfungen für Dampfturbinen
Teil 3: Thermische
Leistungsangabenüberprüfung für
modernisierte Dampfturbinen
(IEC 60953-3:2001)

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This European Standard was approved by CENELEC on 2001-10-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of document 5/130/FDIS, future edition 1 of IEC 60953-3, prepared by IEC TC 5, Steam turbines, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60953-3 on 2001-10-01.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2002-08-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2004-10-01

This European Standard should be read in conjunction with EN 60953-2.

Annexes designated "normative" are part of the body of the standard.

Annexes designated "informative" are given for information only.

In this standard, annexes H, K and ZA are normative and annexes I, J and L are informative.

Annex ZA has been added by CENELEC.

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Endorsement notice (standards.iteh.ai)

The text of the International Standard IEC 60953-3:2001 was approved by CENELEC as a European Standard without any modification.

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Annex ZA
(normative)

**Normative references to international publications
with their corresponding European publications**

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60953-1	- 1)	Rules for steam turbine thermal acceptance tests Part 1: Method A - High accuracy for large condensing steam turbines	EN 60953-1	1995 2)
IEC 60953-2	- 1)	Part 2: Method B - Wide range of accuracy for various types and sizes of turbines	EN 60953-2	1995 2)

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1) Undated reference.

2) Valid edition at date of issue.

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NORME
INTERNATIONALE
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CEI
IEC

60953-3

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First edition
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Règles pour les essais thermiques de réception
des turbines à vapeur –

Partie 3:
Essais de vérification des performances
des turbines à vapeur rénovées

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Rules for steam turbine thermal
acceptance tests –

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Part 3:
Thermal performance verification tests
of retrofitted steam turbines

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Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

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For price, see current catalogue

CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope and object.....	13
2 Units, symbols, terms and definitions.....	15
3 Guiding principles.....	31
4 Measuring techniques and measuring instruments.....	35
5 Evaluation of tests.....	39
6 Corrections of test results and comparison with guarantee.....	49
<i>Annexes A to G are given in IEC 60953-2</i>	
Annex H (normative) Measuring uncertainty of results – retrofit application.....	53
Annex I (informative) Retrofit improvement calculation – numerical examples (fossil and nuclear).....	65
Annex J (informative) Uncertainty calculation – numerical examples (fossil and nuclear)....	117
Annex K (normative) Tracer technique – retrofit application.....	139
Annex L (informative) Temperature variation method.....	147

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

RULES FOR STEAM TURBINE THERMAL ACCEPTANCE TESTS –

Part 3: Thermal performance verification tests
of retrofitted steam turbines

FOREWORD

- 1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
- 3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
- 4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
- 5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
- 6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60953-3 has been prepared by IEC technical committee 5: Steam turbines.

The text of this standard is based on the following documents:

FDIS	Report on voting
5/130/FDIS	5/137/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 3.

This standard should be read in conjunction with IEC 60953-2. It follows the same structure, extending the clause numbering where necessary with complementary text.

The committee has decided that the contents of this publication will remain unchanged until 2010. At this date, in accordance with the committee's decision, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

INTRODUCTION

Retrofitting steam turbines in an existing power plant frequently involves an improvement of performance. IEC 60953-1 and IEC 60953-2, which define the rules for steam turbine thermal acceptance tests of a new power plant, do not cater for all the requirements specific to retrofit projects. It has, therefore, been deemed necessary to draw up a supplementary retrofit code (RC) for guidance on the thermal acceptance tests of retrofitted steam turbines.

However, a large number of the provisions and recommendations of IEC 60953-1 and IEC 60953-2 are still applicable to retrofits and, therefore, in order to avoid a repetitive and bulky document, only the retrofit-specific addenda will be found in this RC.

This part of IEC 60953 shall be read in conjunction with IEC 60953-2, and the words 'verification test' should be read in place of 'acceptance test'. IEC 60953-2 is taken as a RS. The structure and clause numbering of this standard follow that of IEC 60953-2. Subclauses found in this standard supersede the whole of the equivalent subclause in the RS. Subclause numbering has been extended whenever new items have been included the numbering following on chronologically. The subclauses of the RS requiring no amendment have not been repeated here.

IEC 60953-2 has been used as reference rather than IEC 60953-1 since it is more versatile and appropriate to retrofits. Although this standard is intended to apply to the retrofit of large condensing steam turbines, it can nevertheless be used for other types and sizes of turbines to define the bases of a specific procedure to be agreed upon by the parties involved.

The fact that IEC 60953-2 has been given preference over IEC 60953-1 does not mean that a less accurate option has been taken. The rules it contains are defined so as to obtain the appropriate testing accuracy for the retrofit project and for the relevant type of guarantee. In some cases, the more stringent rules of IEC 60953-1 are needed to meet these objectives and this is indicated in this standard.

The rules given in this standard cover all hardware change in the steam turbine equipment. Changes to other hardware components (e.g. boiler, feedwater heaters, etc.) are not covered by this code although these changes may affect the thermodynamic cycle.

The purpose of this RC is to cover the retrofit of steam turbine components which influence the efficiency of the power plant and are subject to a performance guarantee. Many different situations are likely to be encountered: for example, the replacement of steam valves, the replacement of part of the turbine blading, of a rotor, of a complete module, etc. The guarantee values will depend on the retrofit considered and are subject to agreement between the parties involved in the contract. This standard helps the parties determine the most appropriate parameters that characterise the retrofit and that could be used as guaranteed values.

A major difficulty in retrofit projects is the choice of parameters to be guaranteed. Although the original manufacturer will generally favour a relative improvement guarantee, another vendor who does not necessarily know all the details of the equipment installed may prefer to have an absolute guarantee value for the retrofitted equipment. This standard gives guidance on the parameters to be guaranteed. Once the guaranteed values are established, they may need to be re-evaluated after a pre-retrofit performance test. This standard provides such rules required for the verification of the guaranteed values.

The many variations of retrofits possible make it difficult to cover all cases comprehensively but a few detailed examples illustrating the application of this standard are presented in the annexes.

The main differences in the main clauses between this standard and the RS are listed below.

Clause 1: Scope and object

Specifically, this standard requires the definitions of new options regarding guarantees. It is possible to guarantee parameters typical of the retrofitted equipment (turbine cylinder efficiency, pressure drop in valve chest, etc.). The RS defines absolute guarantees that are not suitable for specifying improvements between initial and retrofitted equipment, and therefore, relative guarantee values are introduced in this standard.

This standard reviews the contractual provisions, which can vary from one case to another, on account of the wide range of feasible retrofits. These will be subject to an agreement between the parties involved at the time the guarantees are defined i.e. during the formulation of the contract prior to the performance of the verification tests.

Clause 2: Units, symbols, terms and definitions

All the units, symbols, terms and definitions of the RS apply to this RC. The RC, however, includes new concepts and terms associated with the retrofit situation, especially in the definition of guarantees which can be offered, either additionally or in lieu of those of the RS. A guide matrix has been included to allow the parties involved to choose the parameters to be guaranteed, as appropriate to the project.

The guarantees provided by the manufacturer can be

a) Guarantees of absolute values

- Turbine plant thermal efficiency or heat rate;
- turbine thermodynamic efficiency or steam rate or power output at specified steam flow conditions;
- main steam flow capacity and/or maximum power output;
- internal efficiency of turbine sections.

b) Guarantees of relative values

- Improvement of turbine plant thermal efficiency or heat rate;
- improvement of thermodynamic efficiency or steam rate or power output;
- improvement of main steam flow capacity and/or maximum power output;
- improvement of internal efficiency of turbine sections.

Clause 3: Guiding principles

The majority of the guiding principles contained in the RS are also applicable to the retrofit situation. Amendments or addenda to this clause mainly cover the precautions to be taken when tests are to be run before and after the retrofit, and address the reference to be taken when a guarantee on improvement in performance is offered.

Special attention is directed to the problems of isolation of the cycle, and allowable deviations of measured quantities which can greatly affect the interpretation of results.

Clause 4: Measuring techniques and measuring instruments

In the case of retrofit projects, rigid rules cannot be formulated for measuring techniques and instruments. The instruments should be chosen to suit the requirements of the installation and the guarantee value to be verified. Guidance is given in annex J on the sensitivity of the parameters guaranteed to the accuracy of the individual measurements, so that the most appropriate choice of instrumentation can be made.

Since flow is among the most important measurements, this standard gives guidance on the necessity to fit additional flow-measuring devices. Methods which allow simultaneous measurement and comparison of primary flows are recommended. The use of flow measurement methods using tracers as an appropriate alternative for some applications where it is difficult to remove flow meters for conventional calibration is given in annex K.

Clause 5: Evaluation of tests

This standard gives details of the evaluation of additional guarantees applicable to retrofit projects. Specific rules are also given for unaccounted leakages in retrofit applications.

Clause 6: Correction of test results and comparison with guarantee

The methods of correction defined in the RS are also applicable to this standard but are supplemented by specific rules which apply to the new types of guarantee. For delayed testing, guidance is given on ageing considerations.

This clause also covers the validation of the performance values which are used as a reference for determining improvement guarantee values; an amendment to the guarantee value is acceptable when the pre-retrofit tests have revealed that the actual condition of the turbine undergoing retrofit is different from the specified condition.

The retrofit of the steam turbine, or any part of it, may have consequences on the balance of the plant (feedheaters, condenser, boiler). If the retrofit affects conditions beyond the interface, then the manufacturer may be required to indicate the consequences of the modification on adjacent equipment items.

Clause 7: Measuring uncertainty

This clause of the RS is supplemented by provisions for special cases encountered in retrofit projects in annexes I and J. Since these cases can be diverse, it is recommended that an uncertainty calculation be run as early as possible, preferably before proceeding with the retrofit, so as to be able to define what instrumentation is required for the tests. The examples can be used as reference bases.

Annexes:

In this standard, five new annexes (H to L) have been added to the seven existing ones (A to G) of IEC 60953-2.

Annex H deals with uncertainties for retrofit applications and completes the information given in annex F of IEC 60953-2.

Annex I and J give examples of performance and uncertainty calculations for several retrofit applications, within fossil-fuel and nuclear power plants.

Annex K relates specifically to the tracer technique method of measurement of flow for retrofit applications.

Annex L gives suggestions how to determine, for example, the inter- labyrinth flow of combined HP/IP turbines using the "temperature variation method".

RULES FOR STEAM TURBINE THERMAL ACCEPTANCE TESTS –

Part 3: Thermal performance verification tests of retrofitted steam turbines

1 Scope and object

1.1 Scope

This part of IEC 60953, also called "retrofit code" (RC), establishes a supplementary retrofit code for thermal verification tests of retrofitted steam turbines.

The rules given in this standard follow the guidance given in IEC 60953-2, hereinafter called the RS but contain amendments and supplements regarding guarantees and verification of the guarantees by thermal acceptance tests on retrofitted steam turbines.

General principles for the preparation, performance, evaluation, comparison with guaranteed values and the determination of the measurement uncertainties of verification tests are given in this standard.

This standard is applicable only when the retrofit involves some hardware change in the steam turbine equipment. Conversely, any modification on the cycle or any retrofit of other equipment of the power plant (e.g. boiler, feedwater heaters, etc.) is not covered by this standard.

[SIST EN 60953-3:2002](https://standards.iteh.ai/catalog/standards/sist/f6eb8b7a-de19-49ed-b36c-507d3685013b/sist-en-60953-3-2002)

1.2 Object <https://standards.iteh.ai/catalog/standards/sist/f6eb8b7a-de19-49ed-b36c-507d3685013b/sist-en-60953-3-2002>

The purpose of this standard is to establish appropriate guaranteed parameters, to verify these guarantees and to determine measurement uncertainty.

The guarantees with their provisions should be formulated completely and without contradiction (see 2.4 and 2.5 of IEC 60953-2). The verification tests may also include such measurements as are necessary for corrections according to the conditions of the guarantee and checking of the results.

1.3 Matters to be considered in the contract

Some matters in these rules have to be considered at an early stage. Deviations shall be identified and agreement reached between the parties before signing the contract. Such matters are dealt with in the following subclauses:

Clause (subclause)	Paragraph	Remark
Introduction	5 and 7	Specific procedure and guarantee value
1	2	Guarantee definition
2.5	All paragraphs	
2.5.1.1	2	
3.1	1 and 4	
3.2	4	
6.1.1	Last paragraph	
6.8	–	Guarantee comparison
6.9.1	–	Deterioration of performance of retrofitted components

1.4 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60953. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However parties to agreements based on this part of IEC 60953 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

IEC 60953-1, *Rules for steam turbine acceptance tests – Part 1: Method A – High accuracy for large condensing steam turbines* [SIST EN 60953-3:2002](https://standards.iteh.ai/catalog/standards/sist/f6eb8b7a-de19-49ed-b36c-000000000000/iec-60953-1-2002)

[https://standards.iteh.ai/catalog/standards/sist/f6eb8b7a-de19-49ed-b36c-](https://standards.iteh.ai/catalog/standards/sist/f6eb8b7a-de19-49ed-b36c-000000000000/iec-60953-2-2002)

IEC 60953-2, *Rules for steam turbine thermal acceptance tests – Part 2: Method B – Wide range of accuracy for various types and sizes of turbines*

2 Units, symbols, terms and definitions

2.2.1 Symbols and units for this standard

Quantity	Symbol	Unit	Examples of multiples and submultiples	Other ISO units
Efficiency (general)	η	1		
Wetness correction factor	WCF	1		
Leaving loss (isentropic equivalent)	LL	J/kg	kJ/kg	
Flow-passing-capacity	FPC	m ²		
Valves wide open	VWO			

2.3.1 Subscripts and superscripts for this standard

Quantity	Subscript	Position or definition
Efficiency	cyl	Global or overall cylinder isentropic efficiency (2.4.8.1, 2.4.8.2)
	cyl-dry	Overall cylinder efficiency on a dry basis (2.4.8.2)
	cyl-wet	Overall cylinder efficiency on a wet basis (I.1.1)
	cyl-HP	HP cylinder efficiency (I.1.1)
	cyl-IP	IP cylinder efficiency (I.1.1)
	cyl-LP	LP cylinder efficiency (I.1.1)
Enthalpy	UEEP	Useful energy end-point (2.4.8.2)
	ELEP	Expansion line end-point (I.1.1)
Enthalpy drop	s	Isentropic from cylinder inlet to outlet
	's	Refers to that part of the expansion in the wet region (I.1.1)
Component performance	tp	Steam conditions at terminal point (2.4.8.3)
	in	Steam condition at inlet to component (2.4.8.3)
	out	Steam condition at outlet from component (2.4.8.3)
Mass flow rate ¹⁾	loss	Mass flow balances (5.2.5)
	make-up	Mass flow balances (5.2.5)

¹⁾ Some mass flow rate and enthalpy subscripts are defined in the text itself (e.g. 5.2.5.1).

2.3.2 Definitions for this standard

For the purpose of this part of IEC 60953-3, the definitions given in IEC 60953-2 and the following definitions apply.

2.3.2.1

turbine retrofit

change of turbine hardware to improve thermal performance

2.3.2.2

retrofit code (RC)

the code presented in this standard, for 'thermal performance verification tests of retrofitted steam turbines'

2.3.2.3

reference standard (RS)

IEC 60953-2

2.3.2.4

absolute guarantee

guarantee on the retrofitted equipment, independent of the performance of the original equipment

2.3.2.5

relative guarantee

guarantee on the improvement due to the retrofitted equipment