SLOVENSKI STANDARD
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Rules for steam turbine thermal acceptance tests - Part 1: Method A - High accuracy for large condensing steam turbines

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Regeln für thermische Abnahmeprüfungen für Dampfturbinen -- Teil 1: Methode A - Hohe Präzision für große kondensierende Dampfturbinen

Règles pour les essais thermiques de réception des turbines à vapeur -- Partie 1: Méthode A - Haute précision pour les turbines à vapeur à condensation de grande puissance

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English version

Rules for steam turbine thermal acceptance tests
Part 1: Method A
High accuracy for large condensing steam turbines
(IEC 953-1:1990)

Règles pour les essais thermiques
de réception des turbines à vapeur
Partie 1: Méthode A
Haute précision pour les turbines
à vapeur à condensation de grande puissance
(CEI 953-1:1990)

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(IEC 953-1:1990)

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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.

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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 the International Standard IEC 953-1:1990, prepared by IEC TC 5, Steam turbines, was submitted to the Unique Acceptance Procedure and was approved by CENELEC as EN 60953-1 on 1995-11-28 without any modification.

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) 1996-12-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 1996-12-01

Annexes designated "normative" are part of the body of the standard.
Annexes designated "informative" are given for information only.
In this standard, appendices B, C and annex ZA are normative and appendix A is informative.
Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 953-1:1990 was approved by CENELEC as a European Standard without any modification.

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.

Publication	Year	Title	EN/HD	Year
IEC 34-2	1972	Rotating electrical machines Part 2: Methods for determining losses and efficiency of rotating electrical machinery from tests (excluding machines for traction vehicles)	HD 53.2 S1[1)]	1974
ISO 5167	1980	Measurement of fluid flow by means of orifice plates, nozzles and Venturi tubes inserted in circular cross-section conduits running full	-	-

1) HD 53.2 S1:1974 is based on IEC 34-2:1972 + IEC 34-2A:1974.

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Première partie:
Méthode A — Haute précision, pour turbines à vapeur à condensation de grande puissance

Rules for steam turbine thermal acceptance tests

Part 1:
Method A — High accuracy for large condensing steam turbines

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

RULES FOR STEAM TURBINE THERMAL ACCEPTANCE TESTS

Part 1: Method A — High accuracy for large condensing steam turbines

FOREWORD

1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.

2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.

3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

PREFACE

This standard has been prepared by IEC Technical Committee No. 5: Steam turbines.

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

Six Months' Rule	Report on Voting
5(CO)23	5(CO)27

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

The following IEC publication is quoted in this standard:

Publication No. 34-2(1972): Rotating electrical machines. Part 2: Methods for determining losses and efficiency of rotating electrical machinery from tests (excluding machines for traction vehicles).

Other Publication quoted:

ISO Standard 5167(1980): Measurement of fluid flow by means of orifice plates, nozzles and Venturi tubes inserted in circular cross-section conduits running full.

RULES FOR STEAM TURBINE THERMAL ACCEPTANCE TESTS

Part 1: Method A — High accuracy for large condensing steam turbines

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INTRODUCTION

The rapid development of measuring techniques, the increasing capacity of steam turbines and the introduction of nuclear power plants necessitated a revision of IEC Publication 46 (1962) regarding acceptance tests.

Since all the needs of the power industry in the different parts of the world could not be satisfied by one single publication, the complete standard is divided into two parts, describing two different approaches for conducting and evaluating thermal acceptance tests of steam turbines and which can be used separately:

a) Method A, which is Part 1 of the standard (IEC 953-1), deals with thermal acceptance tests with high accuracy for large condensing steam turbines.

b) Method B, which is Part 2 of the standard (IEC 953-2), deals with thermal acceptance tests with a wide range of accuracy for various types and sizes of steam turbines.

1) Basic philosophy and figures on uncertainty

Part 1 provides for very accurate testing of steam turbines to obtain the level of performance with minimum measuring uncertainty. The operating conditions during the test are stringent and compulsory.

Method A is based on the exclusive use of the most accurate calibrated instrumentation and the best measuring procedures currently available. The uncertainty of the test result is always sufficiently small that it normally need not be taken into acount in the comparison between test result and guarantee value. This uncertainty will not be larger than about 0.3% for a fossil fired unit and 0.4% for a nuclear unit.

The cost for instrumentation and the efforts for preparing and conducting the tests will generally be justified economically for large and/or prototype units.

Method B provides for acceptance tests of steam turbines of various types and capacities with appropriate measuring uncertainty. Instrumentation and measuring procedures have to be chosen accordingly from a scope specified in the standard which is centred mainly on standardized instrumentation and procedures, but may extend eventually up to very high accuracy provisions requiring calibration. The resulting measuring uncertainty of the test result is then determined by calculating methods presented in the standard and normally, if not stated otherwise in the contract, taken into account in the comparison between test result and guarantee value. The total cost of an acceptance test can therefore be maintained in relationship with the economic value of the guarantee values to be ascertained.

The specifications of the operating conditions during the test are somewhat more flexible in this method; furthermore, procedures are recommended for treating cases where these specifications cannot be met.

When good-standardized instrumentation and procedures are applied in a test, the measuring uncertainty of the result will usually amount to 0.9% to 1.2% for a large fossil fuel fired condensing unit, to 1.1% to 1.4% for a nuclear unit and to 1.5% to 2.5% for back pressure, extraction and small condensing turbines. It is possible to reduce these values by additional improvement in instrumentation, primarily by additional measurements of primary mass flows and/or calibration of measuring devices for primary mass flow.

2) Main difference between Methods A and B

In Method A, much more detailed information concerning the preparation and conduct of the tests and the measuring techniques are contained for guidance of the parties to the test than in Method B. In Method B, the detailed treatment of these objectives is left somewhat more to the discretion and decisions of the participants and necessitates sufficient experience and expertise on their part.

3) Guiding principles

The requirements concerning the preparation and conditions of the test and especially such conditions of the test as duration, deviations and constancy of test conditions and acceptable differences between double measurements are more stringent in Method A.

The test should be conducted preferably within eight weeks after the beginning of the operation. It is the intent during this period to minimize performance deterioration and risk of damage to the turbine.

Preliminary tests including enthalpy drop tests should be made during this period to monitor HP and IP turbine section performance. However, these tests do not provide LP section performance and for this reason it is imperative to conduct the acceptance tests as soon as practicable.

Whatever the case, when using Method A, if an enthalpy drop test indicates a possible deterioration of the HP or IP section, or if the plant conditions require that the tests be postponed more than four months after the initial start, then the acceptance tests should be delayed.

An adjustment of the heat rate test results to start-up enthalpy drop efficiencies or for the effects of aging is not permitted when using Method A.

If the test has to be postponed, Method A proposes that the test be carried out after the first major internal inspection; several methods are proposed for establishing the approximate condition of the turbine prior to the tests.

4) Instruments and methods of measurement

a) Measurement of electrical power

In addition to the conditions required for the measurement of electric power, which are similar in both methods, Method A requires a check of the instruments by a comparison measurement after each test run; the permissible difference between double measurements is limited to 0.15%.

b) Flow measurement

For the measurement of main flows the use of calibrated pressure difference devices is required in Method A. The application of a device not covered by international standardization, the throat-tap nozzle, is recommended therein and details of design and application are given.

The calibration of these devices shall be conducted with the upstream and downstream piping and flow-straightener. Methods for the necessary extrapolation of the discharge coefficient from the calibration values are given.

In Method B standardized pressure-difference devices are normally applied for flow measurement. Calibration is recommended where a reduction of overall measuring uncertainty

is desirable. Double or multiple measurement of primary flow is recommended for the reduction of measuring uncertainty and a method for checking the compatibility is described.

c) Pressure measurement
The requirements and recommendations for pressure measurements are essentially similar. Only the methods for the measurement of exhaust-pressure of condensing turbines differ to some extent.

d) Temperature measurement
The requirements are essentially similar in both methods. However detail requirements are more stringent in Method A:

- calibration before and after the test,
- double measurement of the main temperature with 0.5 K maximum difference,
- thermocouples with continuous leads,
- required overall accuracy.

e) Steam quality measurements
Methods A and B are identical.

5) Evaluation of tests

The preparatory work for the evaluation and calculation of the test results is covered in a very similar manner in Methods A and B. However, quantitative requirements are more stringent in Method A.

Method B contains some proposals for handling cases where some requirements have not been met to avoid rejection of the test.

In addition, Method B contains detailed methods for calculation of measuring uncertainty values of measured variables and test results.

Method B recommends other methods for conducting and evaluating of the tests after the specified period and without a previous inspection.

6) Correction of test results and comparison with guarantees

The correction of test results to guarantee conditions is covered in both Methods A and B.

Method A provides for the comparison of test results to guarantee without consideration of measuring uncertainty.

Method B gives a broader spectrum of correction procedures. Furthermore, the measuring uncertainty of the result is taken into account in the guarantee comparison.

7) Proposals for application

Since the acceptance test method to be applied has to be considered in the details of the plant design, it should be stated as early as possible, preferably in the turbine contract, which method will be used.

Method B can be applied to steam turbines of any type and any power. The desired measuring uncertainty should be decided upon sufficiently early, so that the necessary provisions can be included in the plant.

If the guarantee includes the complete power plant or large parts thereof, the relevant parts of either method can be applied for an acceptance test in accordance with the definition of the guarantee value.

1. Scope and object

1.1 *Scope*

The rules given in this standard are applicable primarily to thermal acceptance tests with high accuracy for condensing steam turbines driving generators for electric power services. Some of the provisions of these rules are relevant to turbines for applications other than driving electric power generators.

These rules provide for the testing of turbines operating with either superheated or saturated steam. They include measurements and procedures required to determine specific enthalpy within the moisture region and describe precautions necessary to permit testing while respecting radiological safety rules in nuclear plants.

These rules contain information also applicable to the testing of back-pressure turbines, extraction turbines and mixed-pressure turbines. Only the relevant portion of the rules need apply to any individual case.

Uniform rules for the preparation, carrying out and evaluation of the acceptance tests are defined in this standard. Details of the conditions under which the acceptance tests shall take place are included.

Should any complex or special case arise not covered by these rules, appropriate agreement shall be reached by manufacturer and purchaser before the contract is signed.

1.2 *Object*

The purpose of the thermal acceptance tests of steam turbines and turbine plants described in this standard is to verify any guarantees given by the manufacturer of the plant concerning:

a) turbine plant thermal efficiency or heat rate;

b) turbine thermodynamic efficiency or steam rate or power output at specified steam flow conditions;

c) main steam flow capacity and/or maximum power output.

The guarantees with their provisions shall be formulated completely and without contradictions (see 2.4). The acceptance 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. Such matters are dealt with in the following sub-clauses:

Sub-clause	
1.1	(paragraph 4)
1.2	(paragraph 2)
3.1	(paragraphs 3 and 4)
3.3.3	(paragraph 1)
6.6	
6.8	