Field acceptance tests to determine the hydraulic performance of hydraulic turbines, storage pumps and pump-turbines

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EESTI STANDARDI EESSÕNA

Käesolev Eesti standard EVS-EN 60041:2003 sisaldab Euroopa standardi EN 60041:1994 ingliskeelset teksti. Käesolev dokument on jõustatud 05.06.2003 ja selle kohta on avaldatud teade Eesti standardiorganisatsiooni ametlikus väljaandes. Standard on kättesaadav Eesti standardiorganisatsioonist.	This Estonian standard EVS-EN 60041:2003 consists of the English text of the European standard EN 60041:1994. This document is endorsed on 05.06.2003 with the notification being published in the official publication of the Estonian national standardisation organisation. The standard is available from Estonian standardisation organisation.

NATIONAL FOREWORD

Käsitlusala: Specifies methods for any size and type of impulse or reaction turbine, storage pump or pump turbine. Determines whether the contract guarantees have been fulfilled and deals with the rules governing these tests as well as the methods of computing the results and the content and style of the final report. Replaces IEC 60198 (1966) and IEC 60607 (1978)	**Scope:** Specifies methods for any size and type of impulse or reaction turbine, storage pump or pump turbine. Determines whether the contract guarantees have been fulfilled and deals with the rules governing these tests as well as the methods of computing the results and the content and style of the final report. Replaces IEC 60198 (1966) and IEC 60607 (1978)

ICS 27.140

Võtmesõnad: acceptance inspection, acceptance testing, hydraulic equipm, hydraulically- operated devices, hydraulics, measurement, properties, proving, pumps, storage pumps, test conditions, turbines, water turbines

EUROPEAN STANDARD

NORME EUROPEENNE

EUROPÄISCHE NORM

EN 60041

September 1994

ICS 23.080;23.100.10

Descriptors: Turbine, hydraulic turbomachine, pump, pump-turbine, acceptance test, field test, hydraulic caracteristics, measurement, test conditions, calculation

ENGLISH VERSION

Field acceptance tests to determine the hydraulic performance of hydraulic turbines, storage pumps and pump-turbines
(IEC 41:1991, modified)

Essais de réception sur place des turbines hydrauliques, pompes d'accumulation et pompes-turbines, en vue de la détermination de leurs performances hydrauliques
(CEI 41:1991, modifiée)

Abnahmeversuche zur Bestimmung der hydraulischen Eigenschaften von Wasserturbinen, Speicherpumpen und Pumpturbinen
(IEC 41:1991, modifiziert)

This European Standard was approved by CENELEC on 1994-03-08. 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, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, 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 CENELEC questionnaire procedure, performed for finding out whether or not the International Standard IEC 41:1991 could be accepted without textual changes, has shown that one common modification was necessary for the acceptance as European Standard.

The reference document together with the common modifications prepared by the French National Committee was submitted to the CENELEC members for formal vote and was approved by CENELEC as EN 60041 on 1994-03-08.

The following dates were fixed:

- latest date of publication of an identical national standard (dop) 1995-03-15

- latest date of withdrawal of conflicting national standards (dow) 1995-03-15

Annexes designated "normative" are part of the body of the standard.
In this standard, annex ZA is normative.

Endorsement notice

The text of the International Standard IEC 41:1991 was approved by CENELEC as a European Standard with an agreed common modification as given below.

COMMON MODIFICATION

Clause	Modification
1	**Scope and object** (see editorial corrections)
1.3	*Types of machines* Add between the two present paragraphs: This standard applies to machines with unit power greater than 5 MW or with reference diameter greater than 3 m. Although the complex and detailed procedure involved is not generally justified for machines with smaller power and size, nevertheless this standard may be used for such machines by agreement between purchaser and supplier.

The following editorial corrections apply to the English text of IEC 41:1991:

(Sub)clause	Correction
Page 13	Add the first figure "1" to each of the clause and subclause numbers to read as follows: 1 **Scope and object** 1.1 *Scope* 1.1.1 This ... 1.1.2 Model ..; 1.1.3 Tests ... 1.2 *Object* 1.3 *Type of machines*
2.3.1.7	Replace the symbols as follows: - not to be exeeded /////// - to be reached ◯ or //////////
2.3.6.4	Delete the – (minus) sign in the formula of $\bar{g}$.
2.3.7 Figure 5b	Group the equations for Z_1 and Z_2 to avoid creating the impression that each one is devoted to only half of the figure.
Figure 5c	Add "$z_1 = z_2$" at the right of the figure.
10.2.3.2	Replace "Annexes F and G of ISO 3354" by "Annexes H and J of ISO 3354".
10.2.5.6	In the definition of "m", replace "the coefficient" by "a coefficient".
11.2.2.3 Figure 34b	Replace the last but one equation by: $Z_{B'} = z_{B'} - z_B$
11.2.5.2.2 Figure 37	Group the equations for Z_1 and Z_2 to avoid creating the impression that each one is devoted to only half of the figure.
Figure 38	Add "$z_1 = z_2$" at the right of the figure.
11.4.3 Figure 42	Replace "d = 3 mm à 6 mm" by "d = 3 mm to 6 mm".
11.4.6.2 Figure 45	In the formula for p_M, replace "ΔΔp" by "Δp"
12.1.1.1.2	In the formula for cos φ_s replace "$P_{as}(2w)$" by "$P_{as(2w)}$".

(Sub)clause	Correction
14.3.4	Replace "ou" by "or" between the two formulas.
15.2.1.1	In the first paragraph, replace "and *n* theoretically" by "and exponent *n* is theoretically".
Appendix C C2	In the first paragraph after the table, replace "$\bar{Y}$" and "$\bar{Y}_r$" by "Y_r".

Annex ZA (normative)

Other international publications quoted in this standard with the references of the relevant 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.

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

IEC Publication	Date	Title	EN/HD	Date
34-2	1972	Rotating electrical machines Part 2: Methods for determining losses and efficieny of rotating electrical machinery from tests (excluding machines for traction vechicles)	HD 53.2 S1	1982
34-2A	1974	First supplement: Measurements of losses by the calorimetric method		
185 (mod)	1987	Current transformers	HD 553 S2[1)]	1993
186 (mod)	1987	Voltage transformers	HD 554 S1[2)]	1992
193 A1	1965 1977	International code for model acceptance test of hydraulic turbines	-	-
193A	1972	First supplement to IEC 193	-	-
308	1970	International code for testing of speed governing systems for hydraulic turbines	-	-
497	1976	International code for model acceptance tests of storage pumps	-	-
545	1976	Guide for commissioning, operation and maintenance of hydraulic turbines	-	-
609	1978	Cavitation pitting evaluation in hydraulic turbines, storage pumps and pump-turbines	-	-
805	1985	Guide for commissioning, operation and maintenance of storage pumps and of pump-turbines operating as pumps	-	-

1) HD 553 S2 includes A1:1988 to IEC 185
2) HD 554 S1 includes A1:1988 to IEC 186

ISO publications

31-3	1978	Quantities and units of mechanics (Amendment 01:1985)
748	1979	Liquid flow measurements in open channels - Velocity-area methods
1438-1	1980	Water flow measurement in open channels using weirs and Venturi flumes Part 1: Thin plate weirs
2186	1973	Fluid flow in closed conduits - Connections for pressure signal transmissions between primary and secondary elements
2533	1975	Standard Atmosphere (Addendum 01:1985)
2537	1988	Liquid flow measurement in open channels - Rotating element current-meters
2975		Measurement of water flow in closed conduits - Tracer methods
2975-1	1974	Part I: General
2975-2	1975	Part II: Constant rate injection method using non-radioactive tracers
2975-3	1976	Part III: Constant rate injection method using radioactive tracers
2975-6	1977	Part VI: Transit time method using non-radioactive tracers
2975-7	1977	Part VII: Transit time method using radioactive tracers
3354	1988	Measurement of clean water flow in closed conduits - Velocity area method using current-meters in full conduits and under regular flow conditions
3455	1976	Liquid flow measurement in open channels - Calibration of rotating-element current-meters in straight open tanks
3966	1977	Measurement of fluid flow in closed conduits - Velocity area method using Pitot static tubes
4373	1979	Measurement of liquid flow in open channels - Water level measuring devices
5167	1980	Measurement of fluid flow by means of orifice plates, nozzles and Venturi tubes inserted in circular cross-section conduits running full
5168	1978	Measurement of fluid flow - Estimation of uncertainty of flow-rate measurement
7066		Assessment of uncertainty in the calibration and use of flow measurement devices
7066-1	1989	Part 1: Linear calibration relationships
7066-2	1988	Part 2: Non-linear calibration relationships

INTERNATIONAL STANDARD

IEC 60041

Third edition
1991-11

Field acceptance tests to determine the hydraulic performance of hydraulic turbines, storage pumps and pump-turbines

*This **English-language** version is derived from the original **bilingual** publication by leaving out all French-language pages. Missing page numbers correspond to the French-language pages.*

Reference number
IEC 60041:1991(E)

Publication numbering

As from 1 January 1997 all IEC publications are issued with a designation in the 60000 series. For example, IEC 34-1 is now referred to as IEC 60034-1.

Consolidated editions

The IEC is now publishing consolidated versions of its publications. For example, edition numbers 1.0, 1.1 and 1.2 refer, respectively, to the base publication, the base publication incorporating amendment 1 and the base publication incorporating amendments 1 and 2.

Further information on IEC publications

The technical content of IEC publications is kept under constant review by the IEC, thus ensuring that the content reflects current technology. Information relating to this publication, including its validity, is available in the IEC Catalogue of publications (see below) in addition to new editions, amendments and corrigenda. Information on the subjects under consideration and work in progress undertaken by the technical committee which has prepared this publication, as well as the list of publications issued, is also available from the following:

- **IEC Web Site (www.iec.ch)**

- **Catalogue of IEC publications**

  The on-line catalogue on the IEC web site (www.iec.ch/searchpub) enables you to search by a variety of criteria including text searches, technical committees and date of publication. On-line information is also available on recently issued publications, withdrawn and replaced publications, as well as corrigenda.

- **IEC Just Published**

  This summary of recently issued publications (www.iec.ch/online_news/ justpub) is also available by email. Please contact the Customer Service Centre (see below) for further information.

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Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

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For price, see current catalogue

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIELD ACCEPTANCE TESTS TO DETERMINE THE HYDRAULIC PERFORMANCE OF HYDRAULIC TURBINES, STORAGE PUMPS AND PUMP-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 International Standard has been prepared by IEC Technical Committee No. 4: Hydraulic turbines.

It replaces the second edition of IEC 41, the first edition of IEC 198 and the first edition of IEC 607.

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

Six Months' Rule	Report on Voting
4 (CO) 48	4 (CO) 52

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 publications are quoted in this standard:

Publications Nos. 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).
34–2A	(1974):	First supplement: Measurement of losses by the calorimetric method.
185	(1987):	Current transformers.
186	(1987):	Voltage transformers. Amendment No.1 (1988).
193	(1965):	International code for model acceptance tests of hydraulic turbines. Amendment No.1 (1977).
193A	(1972):	First supplement.
308	(1970):	International code for testing of speed governing systems for hydraulic turbines.
497	(1976):	International code for model acceptance tests of storage pumps.
545	(1976):	Guide for commissioning, operation and maintenance of hydraulic turbines.
609	(1978):	Cavitation pitting evaluation in hydraulic turbines, storage pumps and pump-turbines.
805	(1985):	Guide for commissioning, operation and maintenance of storage pumps and of pump-turbines operating as pumps.

ISO standards quoted:

Publications Nos. 31–3	(1978):	Quantities and units of mechanics. Amendment 01 – 1985.
748	(1979):	Liquid flow measurements in open channels – Velocity-area methods.
1438–1	(1980):	Water flow measurement in open channels using weirs and Venturi flumes-Part 1: Thin-plate weirs.
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2975–1	(1974):	Part I: General.
2975–2	(1975):	Part II: Constant rate injection method using non-radioactive tracers.
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2975–6	(1977):	Part VI: Transit time method using non-radioactive tracers.
2975–7	(1977):	Part VII: Transit time method using radioactive tracers.
3354	(1988):	Measurement of clean water flow in closed conduits – Velocity area method using current-meters in full conduits and under regular flow conditions.
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7066:		Assessment of uncertainty in the calibration and use of flow measurement devices.
7066–1	(1989):	Part 1: Linear calibration relationships.
7066–2	(1988):	Part 2: Non-linear calibration relationships.

FIELD ACCEPTANCE TESTS TO DETERMINE THE HYDRAULIC PERFORMANCE OF HYDRAULIC TURBINES, STORAGE PUMPS AND PUMP-TURBINES

SECTION ONE – GENERAL RULES

Scope and object

1 *Scope*

1.1 This International Standard covers the arrangements for tests at the site to determine the extent to which the main contract guarantees (see 3.2) have been satisfied. It contains the rules governing their conduct and prescribes measures to be taken if any phase of the tests is disputed. It deals with methods of computation of the results as well as the extent, content and style of the final report.

1.2 Model tests, when used for acceptance purposes, are dealt with in IEC 193 with Amendment No. 1, first supplement 193 A, and in IEC 497.

1.3 Tests of speed governing systems are dealt with in IEC 308.

2 *Object*

The purpose of this standard for field acceptance tests of hydraulic turbines, storage pumps or pump-turbines, also called the machine, is:

- to define the terms and quantities which are used;
- to specify methods of testing and ways of measuring the quantities involved in order to ascertain the hydraulic performance of the machine;
- to determine if the contract guarantees which fall within the scope of this standard have been fulfilled.

The decision to perform field acceptance tests including the definition of their scope is the subject of an agreement between the purchaser and the supplier of the machine. For this, it has to be examined in each case, whether the measuring conditions recommended in this standard can be realized. The influence on the measuring uncertainties, due to hydraulic and civil conditions has to be taken into account.

If the actual conditions for field acceptance tests do not allow compliance with the guarantees to be proved, it is recommended that acceptance tests be performed on models (see 1.1.2).

3 *Types of machines*

In general, this standard applies to any size and type of impulse or reaction turbine, storage pump or pump-turbine. In particular, it applies to machines coupled to electric generators, motors or motor-generators.

For the purpose of this standard the term turbine includes a pump-turbine functioning as a turbine and the term pump includes a pump-turbine functioning as a pump. The term generator includes a motor-generator functioning as a generator and the term motor includes a motor-generator functioning as a motor.