INTERNATIONAL STANDARD

IEC 60041

Third edition
1991-11

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

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CONTENTS

SECTION FOUR – METHODS OF MEASUREMENT

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.
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 a 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.

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.

1.4 *Reference to IEC and ISO Standards*

IEC and ISO Standards referred to in this standard are listed in the preface. If a contradiction is found between this standard and another IEC or ISO standard, this standard shall prevail.

1.5 *Excluded topics*

1.5.1 This standard excludes all matters of a purely commercial interest except those inextricably bound up with the conduct of the tests.

1.5.2 This standard is concerned neither with the structural details of the machines nor with the mechanical properties of their components.

2. Terms, definitions, symbols and units

2.1 *General*

The common terms, definitions, symbols and units used throughout the standard are listed in this clause. Specialised terms are explained where they appear.

The following terms are given in 5.1.2 and Figure 11:

1) A *run* comprises the readings and/or recordings sufficient to calculate the performance of the machine at one operating condition.
2) A *point* is established by one or more consecutive runs at the same operating conditions and unchanged settings.
3) A *test* comprises a collection of data and results adequate to establish the performance of the machine over the specified range of operating conditions.

The clarification of any contested term, definition or unit of measure shall be agreed to in writing by the contracting parties, in advance of the test.

2.2 *Units*

The International System of Units (SI) has been used throughout this standard*.

All terms are given in SI base units or derived coherent units (e.g. N instead of $kg \cdot m \cdot s^{-2}$). The basic equations are valid using these units. This has to be taken into account, if other than coherent SI Units are used for certain data (e.g. kilowatt or megawatt instead of watt for power, kilopascal or bar ($= 10^5$ Pa) instead of pascal for pressure, min^{-1} instead of s^{-1} for rotational speed, etc.). Temperatures may be given in degrees Celsius because thermodynamic (absolute) temperatures (in kelvins) are rarely required.

Any other system of units may be used but only if agreed to in writing by the contracting parties.

2.3 *List of terms, definitions, symbols and units*

2.3.1 *Subscripts and symbols*

The terms high pressure and low pressure define the two sides of the machine irrespective of the flow direction and therefore are independent of the mode of operation of the machine.

* See ISO 31–3.

Sub-clause	Term	Definition	Subscript symbol
2.3.1.1	High pressure reference section	The high pressure section of the machine to which the performance guarantees refer (see Figure 1)	1
2.3.1.2	Low pressure reference section	The low pressure section of the machine to which the performance guarantees refer (see Figure 1)	2
2.3.1.3	High pressure measuring sections	Whenever possible these sections should coincide with section 1: otherwise the measured values shall be adjusted to section 1 (see 11.2.1)	$1', 1'', \ldots$
2.3.1.4	Low pressure measuring sections	Whenever possible these sections should coincide with section 2: otherwise the measured values shall be adjusted to section 2 (see 11.2.1)	$2', 2'', \ldots$
2.3.1.5	Specified	Subscript denoting values of quantities such as speed, discharge etc. for which other quantities are guaranteed	sp
2.3.1.6	Maximum Minimum	Subscripts denoting maximum or minimum values of any term	max min
2.3.1.7	Limits	Contractually defined values: – not to be exceeded – to be reached	
2.3.1.8	Ambient	Subscript referring to surrounding atmospheric conditions	amb

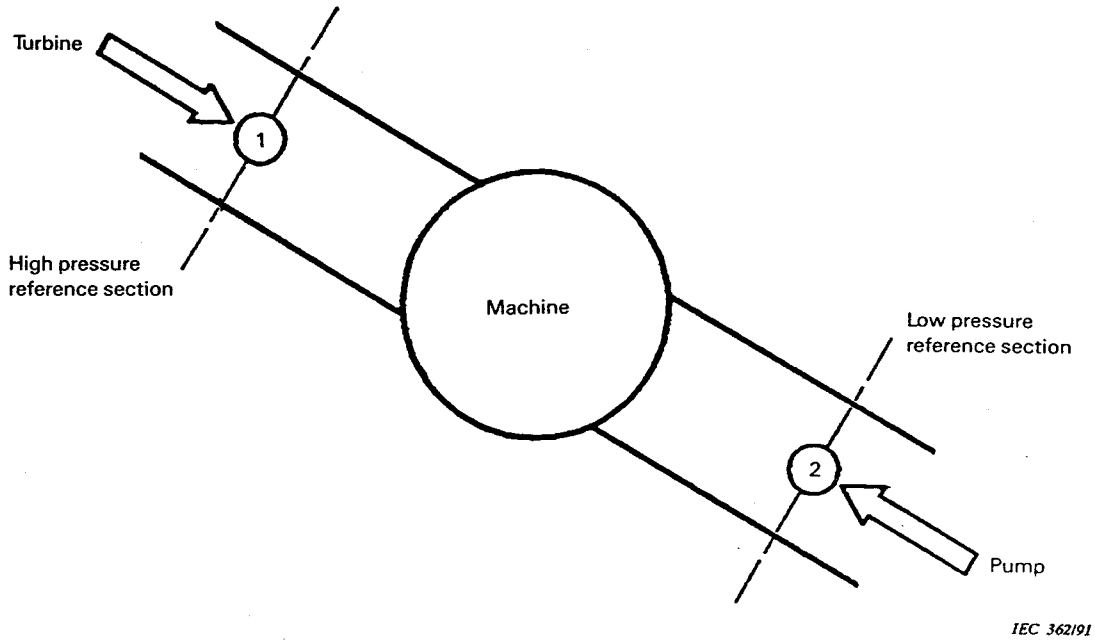
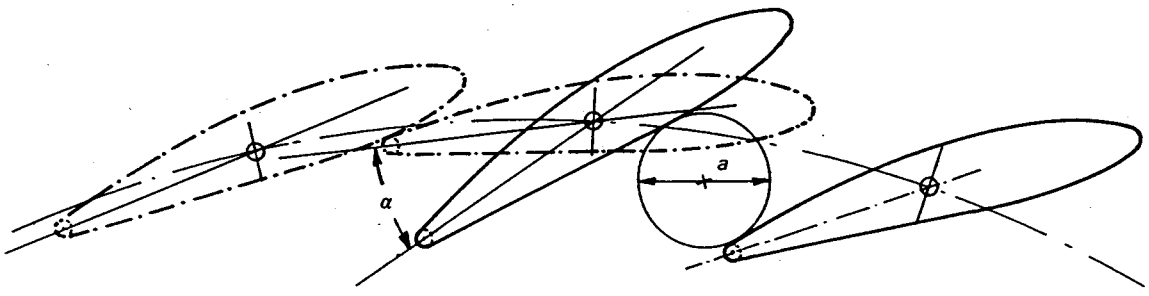


Figure 1 – Schematic representation of a hydraulic machine

2.3.2 *Geometric terms*

Sub-clause	Term	Definition	Symbol	Unit
2.3.2.1	Area	Net cross sectional area normal to general flow direction	A	m^2
2.3.2.2	Guide vane opening	Average vane angle measured from closed position* or average shortest distance between adjacent guide vanes (at a defined position, if necessary) (see Figure 2)	α a	degree m
2.3.2.3	Needle opening (impulse turbine)	Average needle stroke measured from closed position*	s	m
2.3.2.4	Runner blade opening	Average runner blade angle measured from a given position*	β	degree
2.3.2.5	Level	Elevation of a point in the system above the reference datum (usually mean sea level)	z	m
2.3.2.6	Difference of levels	Difference of elevation between any two points in the system	Z	m



IEC 363/91

Figure 2 – Guide vane opening (from closed position)

* Under normal working oil pressure.

IEC 60041 Ed. 3.0 (English 1991) Field acceptance tests to determine the hydraulic performance of hydraulic turbines, storage pumps and pump-turbines