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 On-line information is also available on recently issued publications, withdrawn and replaced publications, as well as corrigenda.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.

- **Customer Service Centre**

  If you have any questions regarding this publication or need further assistance, please contact the Customer Service Centre:

  Email: custserv@iec.ch
  Tel: +41 22 919 02 11
  Fax: +41 22 919 03 00

INTERNATIONAL STANDARD

IEC 60041

Third edition
1991-11

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

International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch

Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

PRICE CODE XK

For price, see current catalogue

CONTENTS

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.

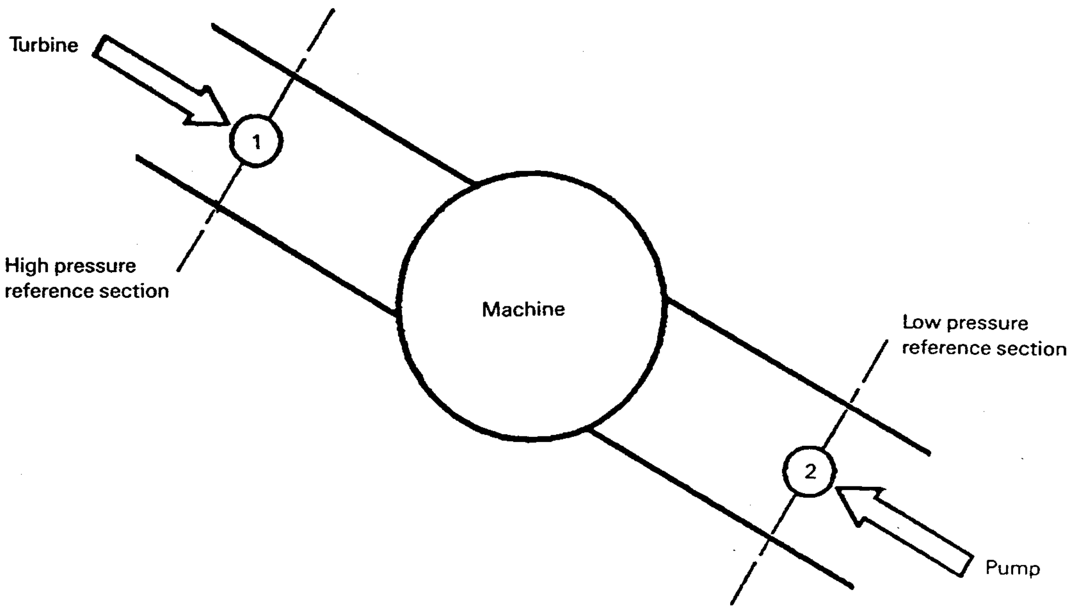
2.3 *List of terms, definitions, symbols and units*

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″, ...
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″, ...
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



IEC 362/91

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

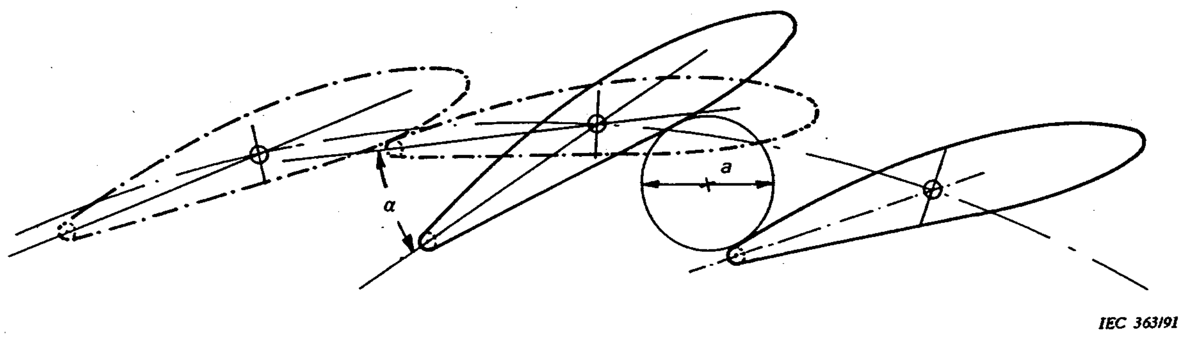


Figure 2 – Guide vane opening (from closed position)

* Under normal working oil pressure.

2.3.3 *Physical quantities and properties*

Sub-clause	Term	Definition	Symbol	Unit
2.3.3.1	Acceleration due to gravity	Local value of g as a function of altitude and latitude of the place of testing (see Appendix E, Table EI)	g	$m \cdot s^{-2}$
2.3.3.2	Temperature	Thermodynamic temperature; Celsius temperature $\vartheta = \Theta - 273,15$	Θ ϑ	K °C
2.3.3.3	Density	Mass per unit volume *a)* Values for water are given in Appendix E, Table EII (ϱ is commonly used instead of ϱ_w) *b)* Values for air are given in Appendix E, Table EIII. Usually the value of air density at the reference level of the machine (see 2.3.7.10) is used *c)* Values for mercury are given in Appendix E, Table EIV	ϱ ϱ_w ϱ_a ϱ_{Hg}	$kg \cdot m^{-3}$ $kg \cdot m^{-3}$ $kg \cdot m^{-3}$ $kg \cdot m^{-3}$
2.3.3.4	Specific volume	Volume per unit mass. Used only for water in this standard	$1/\varrho$	$m^3 \cdot kg^{-1}$
2.3.3.5	Isothermal factor	Factor characterizing a thermodynamic property. Values for water are given in Appendix E, Table EV	a	$m^3 \cdot kg^{-1}$
2.3.3.6	Specific heat capacity	The rate of change of enthalpy per unit mass with change in temperature at constant pressure. Values for water are given in Appendix E, Table EVI	c_p	$J \cdot kg^{-1} \cdot °C^{-1}$ or $J \cdot kg^{-1} \cdot K^{-1}$
2.3.3.7	Vapour pressure (absolute)	For purposes of this standard the absolute partial pressure of the vapour in the gas mixture over the liquid surface is the saturation vapour pressure corresponding to the temperature. Values for distilled water are given in Appendix E, Table EVII	p_{va}	Pa
2.3.3.8	Dynamic viscosity	A quantity characterising the mechanical behaviour of a fluid (see ISO 31-3)	μ	$Pa \cdot s$
2.3.3.9	Kinematic viscosity	Ratio of the dynamic viscosity to the density: $\nu = \frac{\mu}{\varrho}$	ν	$m^2 \cdot s^{-1}$

2.3.4 *Discharge, velocity and speed terms*

Sub-clause	Term	Definition	Symbol	Unit
2.3.4.1	Discharge (volume flow rate)	Volume of water per unit time flowing through any section in the system	Q	$m^3 \cdot s^{-1}$
2.3.4.2	Mass flow rate	Mass of water flowing through any section of the system per unit time. Both ϱ and Q must be determined at the same section and at the conditions existing in that section *Note.* – The mass flow rate is constant between two sections if no water is added or removed.	(ϱQ)	$kg \cdot s^{-1}$
2.3.4.3	Measured discharge	Volume of water per unit time flowing through any measuring section, for example 1′ (see 2.3.1.3 and 2.3.1.4)	$Q_{1'}$ or $Q_{2'}$	$m^3 \cdot s^{-1}$
2.3.4.4	Discharge at reference section	Volume of water per unit time flowing through the reference section 1 or 2	Q_1 or Q_2	$m^3 \cdot s^{-1}$
2.3.4.5	Corrected discharge at reference section	Volume of water per unit time flowing through a reference section referred to the ambient pressure (see 2.3.5.2) e.g. $Q_{1c} = (\varrho Q)_1 / \varrho_{p\,amb}$ (see 3.2.3) where $\varrho_{p\,amb}$ is the density at ambient pressure and the water temperature at the reference section	Q_{1c} or Q_{2c}	$m^3 \cdot s^{-1}$
2.3.4.6	No-load turbine discharge	Turbine discharge at no-load, at specified speed and specified specific hydraulic energy and generator not excited	Q_0	$m^3 \cdot s^{-1}$
2.3.4.7	Index discharge	Discharge given by relative (uncalibrated) flow measurement (see Clause 15)	Q_i	$m^3 \cdot s^{-1}$
2.3.4.8	Mean velocity	Discharge divided by the area A	v	$m \cdot s^{-1}$
2.3.4.9	Rotational speed	Number of revolutions per unit time	n	s^{-1}
2.3.4.10	No load turbine speed	The steady state turbine speed at no load with governor connected and generator not excited	n_0	s^{-1}
2.3.4.11	Initial speed	The steady state turbine speed just before a change in operating conditions is initiated (see Figure 3)	n_i	s^{-1}
2.3.4.12	Final speed	The steady state turbine speed after all transient waves have been dissipated (see Figure 3)	n_f	s^{-1}
2.3.4.13	Momentary overspeed of a turbine	The highest speed attained during a sudden specified load rejection from a specified governor setting (see Figure 3)	n_m	s^{-1}
2.3.4.14	Maximum momentary overspeed of a turbine	The momentary overspeed attained under the most unfavourable transient conditions (in some cases the maximum momentary overspeed can exceed the maximum steady state runaway speed)	$n_{m\,max}$	s^{-1}
2.3.4.15	Maximum steady state runaway speed	The speed for that position of needles or guide vanes and/or runner/impeller blades which gives the highest value after all transient waves have been dissipated with electrical machine disconnected from load or network and not excited, under the maximum specific hydraulic energy (head). The runaway speed particularly of high specific speed machines may be influenced by cavitation and thus depends on the available NPSE (see 2.3.6.9)	$n_{R\,max}$	s^{-1}

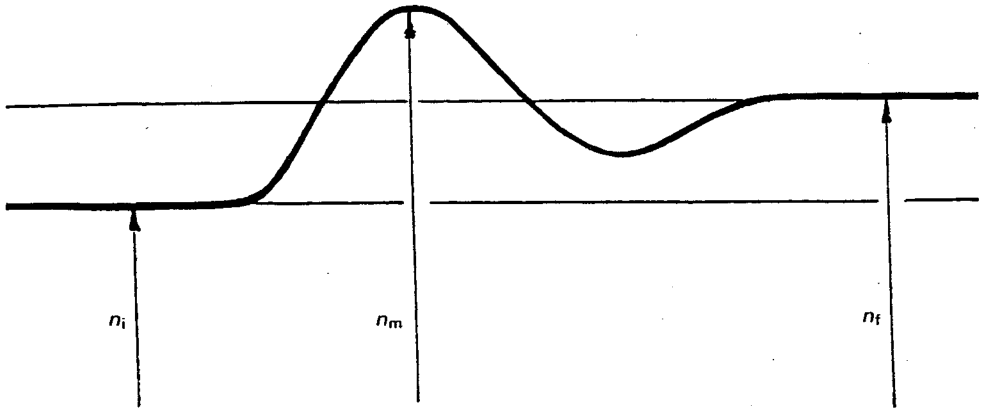


Figure 3 – Variation of turbine speed during a sudden load rejection

2.3.5 *Pressure terms*

Sub-Clause	Term	Definition	Symbol	Unit
2.3.5.1	Absolute pressure	The static pressure of a fluid measurement with reference to a perfect vacuum	p_{abs}	Pa
2.3.5.2	Ambient pressure	The absolute pressure of the ambient air	p_{amb}	Pa
2.3.5.3	Gauge pressure	The difference between the absolute presssure of a fluid and the ambient pressure at the place and time of measurement: $$p = p_{abs} - p_{amb}$$	p	Pa
2.3.5.4	Initial pressure	The steady state gauge pressure which occurs at a specified point of the system just before a change in operating conditions is initiated (see Figure 4)	p_i	Pa
2.3.5.5	Final pressure	The steady state gauge pressure which occurs at a specified point of the system after all transient waves have been dissipated (see Figure 4)	p_f	Pa
2.3.5.6	Momentary pressure	The highest/lowest gauge pressure which occurs at a specified point of the system under specified transient conditions (see Figure 4)	p^+_m p^-_m	Pa Pa
2.3.5.7	Maximum/ minimum momentary pressure	The momentary pressure under the most unfavourable transient conditions	$p^+_{m\,max}$ $p^-_{m\,min}$	Pa Pa

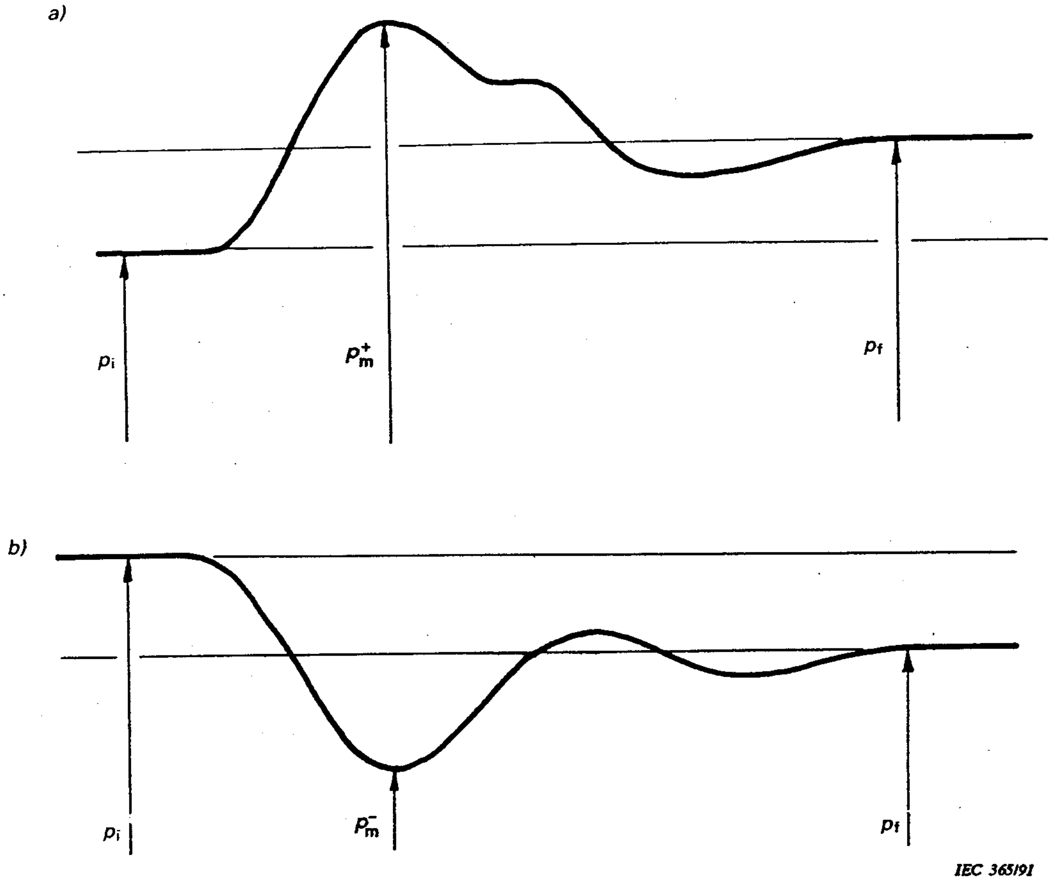


Figure 4a – Variation of pressure at the turbine high pressure reference section
a) when a specified load is suddenly rejected
b) when a specified load is suddenly accepted

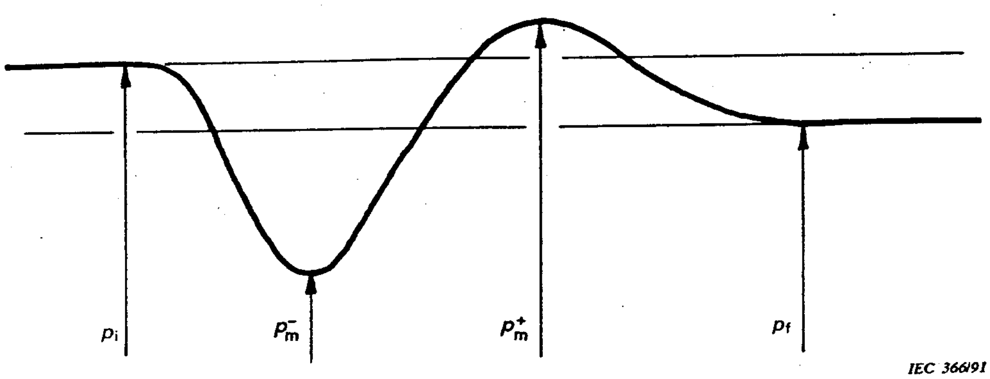


Figure 4b – Variation of pressure at the pump high pressure reference section during a power failure

2.3.6 *Specific energy terms*

In the International System of Units the mass (kg) is one of the base quantities. The energy per unit mass, known as specific energy, is used in this standard as a primary term instead of the energy per local unit weight which is called head and was exclusively used in the former IEC 41 and 198.

The latter term (head) has the disadvantage that the weight depends on the acceleration due to gravity g, which changes mainly with latitude but also with altitude. Nevertheless, the term head will still remain in use because it is very common. Therefore both related energy terms are listed, the specific energy terms in this sub-clause and the head terms in 2.3.7. They differ only by the factor g, which is the local value of acceleration due to gravity.

The symbol for specific energy at any section of flow is the small letter e; the symbol for the difference of specific energies between any two sections is the capital letter E. The same applies to h and H.

Sub-clause	Term	Definition	Symbol	Unit
2.3.6.1	Specific energy	The energy per unit mass of water at any section	e	$J \cdot kg^{-1}$ ($m^2 \cdot s^{-2}$)
2.3.6.2	Specific hydraulic energy of machine	Specific energy of water available between the high and low pressure reference sections of the machine, taking into account the influence of the compressibility $$E = \frac{p_{abs1} - p_{abs2}}{\bar{\varrho}} + \frac{v_1^2 - v_2^2}{2} + \bar{g}(z_1 - z_2)$$ with $\bar{\varrho} = \frac{\varrho_1 + \varrho_2}{2}$ and $\bar{g} = \frac{g_1 + g_2}{2}$ *,** *Note.* – The value of gravity acceleration at the reference level of the machine (see 2.3.7.10) may be assumed as $\bar{g}$. The values of ϱ_1 and ϱ_2 can be calculated from p_{abs1} and p_{abs2} respectively, taking into account ϑ_1 or ϑ_2 for both values, given the negligible influence of the difference of the temperature on ϱ	E	$J \cdot kg^{-1}$
2.3.6.3	Specific mechanical energy at runner(s)/ impeller(s)	Mechanical power transmitted through the coupling of the runner(s)/impeller(s) and shaft (see Clause 14) divided by mass flow rate: $$E_m = \frac{P_m}{(\varrho Q)_1}$$ (for P_m, see 2.3.8.4)	E_m	$J \cdot kg^{-1}$
2.3.6.4	Specific hydraulic energy of the plant	Specific hydraulic energy available between head water level and tailwater level of the plant (see Figure 6) It is given by: $$E_g = \frac{p_{abs3} - p_{abs4}}{\bar{\varrho}} + \frac{v_3^2 - v_4^2}{2} + \bar{g}(z_3 - z_4)$$ with $\bar{\varrho} = \frac{\varrho_3 + \varrho_4}{2}$ and $\bar{g} = \frac{g_3 + g_4}{2}$ The water density at ambient pressure may be assumed as $\bar{\varrho}$	E_g	$J \cdot kg^{-1}$

* Figures 5a, 5b (reaction machines) and 5c (impulse turbines) illustrate some common cases of application of the basic formula for the specific hydraulic energy. The applicable simplified formula is given under each figure. Measurement methods for the evaluation of the specific hydraulic energy of the machine are described in detail in Clause 11.

** See Appendix F.

Sub-clause	Term	Definition	Symbol	Unit
2.3.6.5	Zero-discharge (shut-off) specific hydraulic energy of the pump	Pump specific energy at specified speed and specified guide vane and runner/impeller blade settings with high pressure side shut-off	E_0	$J \cdot kg^{-1}$
2.3.6.6	Specific hydraulic energy loss	The specific hydraulic energy dissipated between any two sections	E_L	$J \cdot kg^{-1}$
2.3.6.7	Suction specific hydraulic energy loss	The specific hydraulic energy dissipated between the tailwater level and the low pressure reference section of the machine (see figure 41)	E_{Ls}	$J \cdot kg^{-1}$
2.3.6.8	Suction specific potential energy of the machine	Specific potential energy corresponding to the difference between the reference level of the machine (see 2.3.7.10) and the piezometric level at section 2: $E_s = g_2(z_r - z_{2'}) = g_2 Z_s$ (see Figure 7)	E_s	$J \cdot kg^{-1}$
2.3.6.9	Net positive suction specific energy	Absolute specific energy at section 2 minus the specific energy due to vapour pressure p_{va}*, referred to the reference level of the machine according to Figure 7 $NPSE = \frac{p_{abs2} - p_{va}}{\varrho_2} + \frac{v_2^2}{2} - g_2(z_r - z_2)$**	$NPSE$	$J \cdot kg^{-1}$

2.3.7 *Height and head terms*

Sub-clause	Term	Definition	Symbol	Unit
2.3.7.1	Geodetic height of plant***	Difference in elevation between headwater level and tailwater level of plant (see Figure 6)	Z_g	m
2.3.7.2	Head	Energy per unit weight of water at any section $h = e/g$ For definition of e, see 2.3.6.1	h	m
2.3.7.3	Turbine or pump head	$H = E/\overline{g}$ For definition of E, see 2.3.6.2	H	m
2.3.7.4	Plant head***	$H_g = E_g/\overline{g}$ For definition of E_g, see 2.3.6.4	H_g	m
2.3.7.5	Zero-discharge (shut-off) head of pump	$H_0 = E_0/\overline{g}$ For definition of E_0, see 2.3.6.5	H_0	m
2.3.7.6	Head loss	$H_L = E_L/\overline{g}$ For definition of E_L, see 2.3.6.6	H_L	m

* See 2.3.3.7 and Appendix E, Table EVII.

** For definition of cavitation factor σ, see IEC 193A and 497.

*** Figure 6 shows the relationship between geodetic height of plant and plant head.

Sub-clause	Term	Definition	Symbol	Unit
2.3.7.7	Suction head loss	$H_{Ls} = \frac{E_{Ls}}{g}$ For definition of E_{Ls}, see 2.3.6.7	H_{Ls}	m
2.3.7.8	Suction height	$Z_s = \frac{E_s}{g_2}$ (see Figure 7) For definition of E_s, see 2.3.6.8	Z_s	m
2.3.7.9	Net positive suction head	$NPSH = \frac{NPSE}{g_2}$ For definition of $NPSE$, see 2.3.6.9	$NPSH$	m
2.3.7.10	Reference level of the machine	Elevation of the point of the machine taken as reference for the setting of the machine as defined in Figure 8	z_r	m

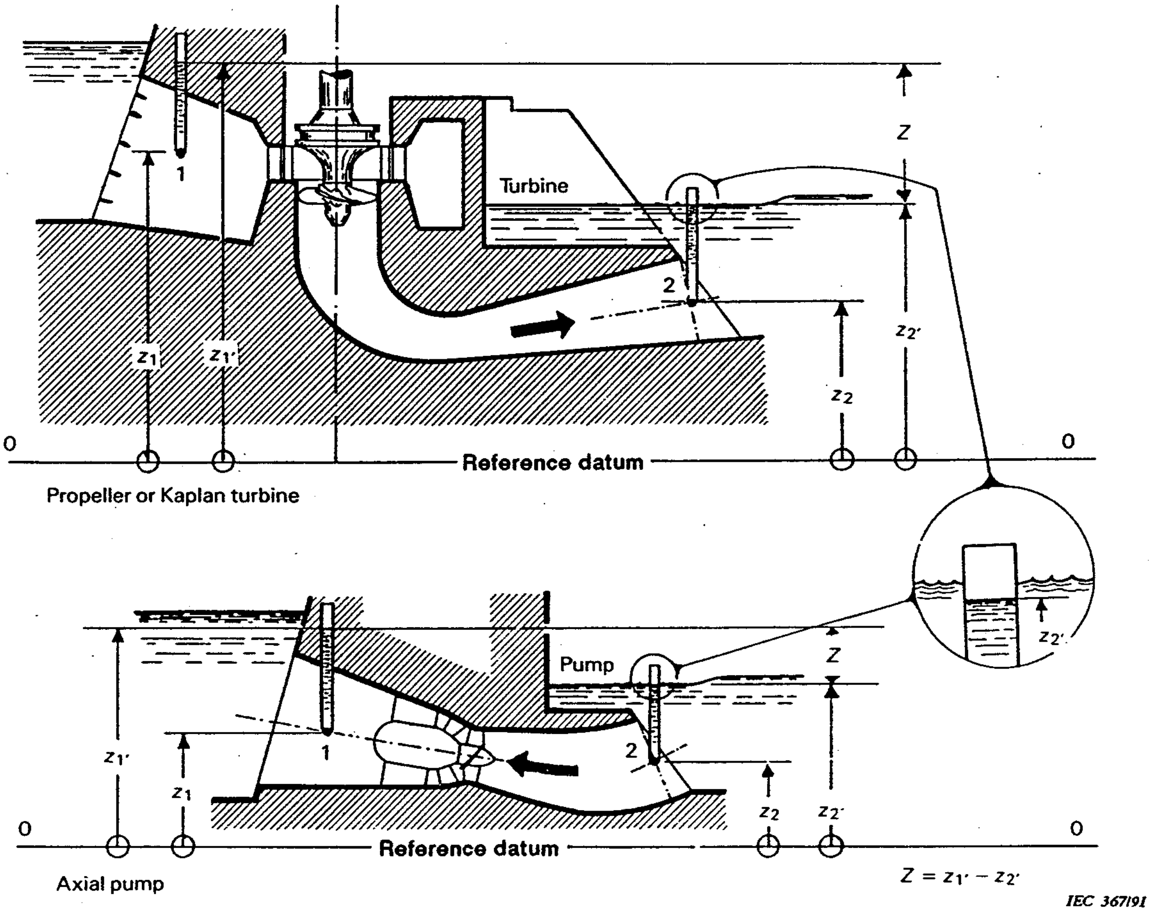


Figure 5a – Low-head machines – Determination of specific hydraulic energy of machine