TECHNICAL REPORT

IEC 61366-3

First edition
1998-03

Hydraulic turbines, storage pumps and pump-turbines –
Tendering documents –

Part 3:
Guidelines for technical specifications for Pelton turbines

Turbines hydrauliques, pompes d'accumulation et pompes-turbines –
Documents d'appel d'offres –

Partie 3:
Guide des spécifications techniques pour les turbines Pelton

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IEC publications prepared by the same technical committee

The attention of readers is drawn to the end pages of this publication which list the IEC publications issued by the technical committee which has prepared the present publication.

* See web site address on title page.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

HYDRAULIC TURBINES, STORAGE PUMPS AND PUMP-TURBINES – TENDERING DOCUMENTS –

Part 3: Guidelines for technical specifications for Pelton 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 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.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical report of one of the following types:

- type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;
- type 2, when the subject is still under technical development or where for any other reason there is the future but no immediate possibility of an agreement on an International Standard;
- type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

Technical reports of types 1 and 2 are subject to review within three years of publication to decide whether they can be transformed into International Standards. Technical reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

IEC 61366-3, which is a technical report of type 3, has been prepared by IEC technical committee 4: Hydraulic turbines.

The text of this technical report is based on the following documents:

Committee draft	Report on voting
4/110/CDV	4/122/RCV

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

Technical Report IEC 61366-3 is one of a series which deals with Tendering documents for hydraulic turbines, storage pumps and pump-turbines. The series consists of seven parts:

Part 1: General and annexes (IEC 61366-1)

Part 2: Guidelines for technical specification for Francis turbines (IEC 61366-2)

Part 3: Guidelines for technical specification for Pelton turbines (IEC 61366-3)

Part 4: Guidelines for technical specification for Kaplan and propeller turbines (IEC 61366-4)

Part 5: Guidelines for technical specification for tubular turbines (IEC 61366-5)

Part 6: Guidelines for technical specification for pump-turbines (IEC 61366-6)

Part 7: Guidelines for technical specification for storage pumps (IEC 61366-7)

Parts 2 to 7 are "stand-alone" publications which when used with Part 1 contain guidelines for a specific machine type (i.e. Parts 1 and 4 represent the combined guide for Kaplan and propeller turbines). A summary of the proposed contents for a typical set of Tendering documents is given in the following table 1 and annex A. Table 1 summarizes the arrangement of each part of this guide and serves as a reference for the various chapters and sections of the Tendering documents (see 3.2 of this part).

A bilingual edition of this technical report may be issued at a later date.

Table 1 – Summary of guide for the preparation of Tendering Documents for hydraulic turbines, storage pumps and pump-turbines

CONTENTS OF GUIDE IEC 61366-1 TO IEC 61366-7

Part	**Clause**	**Title**
1		General and annexes
1	–	
1	1	Object and scope of this guide
1	2	Reference documents and definitions
1	3	Arrangement of Tendering Documents
1	4	Guidelines for tendering requirements
1	5	Guidelines for project information
1	6	Guidelines for general conditions, special conditions and general requirements
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A		Sample table of contents of Tendering Documents for Francis turbines
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3		Pelton turbines
4		Kaplan and propeller turbines
5		Tubular turbines
6		Pump-turbines
7		Storage pumps

SAMPLE TABLE OF CONTENTS OF TENDERING DOCUMENTS (TD)
(Example for the Francis turbines; see 61366-1, annex A)

Chapter	**Title**
1	Tendering requirements
2	Project information
3	General conditions
4	Special conditions
5	General requirements
6	Technical specifications
6.1	Technical requirements
6.1.1	Scope of work
6.1.2	Limits of the contract
6.1.3	Supply by Employer
6.1.4	Design conditions
6.1.5	Performance and other guarantees
6.1.6	Mechanical design criteria
6.1.7	Design documentation
6.1.8	Materials and construction
6.1.9	Shop inspection and testing
6.2	Technical specifications for fixed/embedded components
6.3	Technical specifications for stationary/removable components
6.4	Technical specifications for guide vane regulating apparatus
6.5	Technical specifications for rotating parts, bearings and seals
6.6	Technical specifications for thrust bearings
6.7	Technical specifications for miscellaneous components
6.8	Technical specifications for auxiliary systems
6.9	Technical specifications for instrumentation
6.10	Spare parts
6.11	Model tests
6.12	Installation and commissioning
6.13	Field acceptance tests

HYDRAULIC TURBINES, STORAGE PUMPS AND PUMP-TURBINES – TENDERING DOCUMENTS –

Part 3: Guidelines for technical specifications for Pelton turbines

0 Introduction to technical specifications

The main purpose of the technical specifications is to describe the specific technical requirements for the hydraulic machine for which the Tendering documents (TD) are being issued. To achieve clarity and to avoid confusion in contract administration, the Employer should not specify anything in the technical specifications which is of importance only to the preparation of the tender. Such information and instructions should be given only in the Instructions to Tenderers (ITT). Accordingly, the ITT may refer to other chapters and sections the Tendering documents but not vice versa. As a general rule the word "Tenderer" should be confined in use only to TD chapter 1 "Tendering requirements"; elsewhere the term "Contractor" should be used.

Special attention should be given to items of a project specific nature such as materials, protective coating systems, mechanical piping systems, electrical systems and instrumentation. It is common for the Employer to use technical standards for such items which would apply to all contracts for a particular project or projects. In this event, detailed technical standards should be specified in TD chapter 5 "General requirements".

Technical specifications for the various types of hydraulic machines included in this guide are provided in the following parts:

- Francis turbines (Part 2);
- Pelton turbines (Part 3);
- Propeller and Kaplan turbines (Part 4);
- Tubular turbines (Part 5);
- Pump-turbines (Part 6);
- Storage pumps (Part 7).

The guidelines for preparation of Pelton turbine specifications include technical specifications for the following:

- Design conditions: Project arrangement, hydraulic conditions, specified conditions, mode of operation, generator characteristics, synchronous condenser characteristics, transient behaviour data, stability of the system, noise, vibration, pressure fluctuations and safety requirements.
- Technical performance and other guarantees:
  - power;
  - discharge (if required);
  - efficiency;
  - maximum momentary pressure;
  - minimum momentary pressure;
  - maximum momentary overspeed;
  - maximum steady-state runaway speed;

  - cavitation pitting;
  - hydraulic thrust;
  - maximum weights and dimensions for transportation, erection and maintenance.

- Mechanical design criteria: design standards, stresses and deflections and special design considerations (earthquake acceleration, etc.).
- Design documentation: Contractor's input needed for the Employer's design, Contractor's drawings and data, Contractor's review of the Employer's design and technical reports by Contractor.
- Materials and construction: material selection and standards, quality assurance procedures, shop methods, corrosion protection and painting.
- Shop inspection and testing: general requirements and reports, material tests and certificates, dimensional checks, shop assembly and tests.
- Fixed/embedded components: manifold for multi-jet turbines and turbine housing.
- Stationary/removable components: branch pipe for horizontal turbines, upper turbine housing (if not embedded), turbine cover, brake jet assembly).
- Injector and deflector systems: nozzles, needles, needle servomotors, deflectors or cut-in deflectors, deflector servomotors, links, needle-deflector combining mechanism and oil piping.
- Rotating parts, bearings and seals: runner, main shaft, guide bearing with oil supply, oil/water cooler, shaft seal.
- Thrust bearing (when part of the hydraulic machine supply): bearing support, thrust block, rotating ring, thrust bearing pads and pivots, oil sump with oil supply (common with guide bearing, if any), oil/water coolers, instrumentation.
- Miscellaneous components: walkways, lifting fixtures, special tools, standard tools, turbine pit hoist, nameplate, runner inspection platform (if required).
- Auxiliary systems: bearing lubrication system (if required), tailwater air admission system, turbine pit drainage (if required), turbine housing ventilation, tailwater depression (if required).
- Instrumentation: controls, indication and protection.
- Spare parts: basic spare parts.
- Model acceptance tests: test requirements.
- Site installation and commissioning tests: Installation procedures and commissioning tests.
- Field acceptance tests: scope of field tests, reports and inspection of cavitation pitting.

An example of the proposed table of contents for Tendering documents for a Francis turbine is given in annex A of IEC 61366-1. The example does not include technical specifications for the control system, or high-pressure side valves which, at the Employer's option, may be included in the Tendering documents for the Pelton turbine or may be specified in separate Tendering documents.

Chapter 6 (technical specifications) of the Tendering documents should be arranged as follows:

6.1 Technical requirements;

6.2 Technical specifications for fixed/embedded components;

6.3 Technical specifications for stationary/removable components;

6.4 Technical specifications for deflector/cut-in deflector regulating apparatus;

6.5 Technical specifications for rotating parts, guide bearings and seals;

6.6 Technical specifications for thrust bearing;

6.7 Technical specifications for miscellaneous components;

6.8 Technical specifications for auxiliary systems;

6.9 Technical specifications for instrumentation;

6.10 Spare parts;

6.11 Model acceptance tests;

6.12 Site installation and commissioning tests;

6.13 Field acceptance tests.

1 Scope

This Technical Report, referred to herein as “Guide”, is intended to assist in the preparation of Tendering documents and Tendering proposals and in the evaluation of tenders for hydraulic machines. This part of IEC 61366 provides guidelines for Pelton turbines.

2 Reference documents

IEC 60041:1992, *Field acceptance tests to determine the hydraulic performance of hydraulic turbines, storage pumps and pump-turbines*

IEC 60193:1965, *International code for model acceptance tests of hydraulic turbines*

IEC 60308:1970, *International code for testing of speed governing systems for hydraulic turbines*

IEC 60545:1976, *Guide for commissioning, operation an maintenance of hydraulic turbines*

IEC 60609-2:1997, *Cavitation pitting evaluation in hydraulic turbines, storage pumps and pump-turbines – Part 2: Evaluation in Pelton turbines*

IEC 60994:1991, *Guide for field measurement of vibrations and pulsations in hydraulic machines (turbines, storage pumps and pump-turbines)*

IEC 60995:1991, *Determination of the prototype performance from model acceptance tests of hydraulic machines with consideration of scale effects*

IEC 61362,— *Guide to specification of hydro-turbine control systems* [1)]

ISO 3740:1980, *Acoustics – Determination of sound power levels of noise sources – Guidelines for the use of basic standards and for the propagation of noise test codes*

3 Technical requirements

3.1 Scope of work

This subclause should describe the scope of work and the responsibilities which are to be conferred upon the Contractor. The general statement of scope of work presented in TD [2)] section 2.1 (5.1) shall be consistent with what is presented here. In a similar manner, pay items in the tender form, TD section 1.2 (subclause 4.2) should be defined directly from TD subsection 6.1.1.

The scope of work should begin with a general statement which outlines the various elements of the work including (where applicable) the design, model testing, supply of materials and labour, fabrication, machining, quality assurance, quality control, shop assembly, shop testing, spare parts, transportation to site, site installation, commissioning, acceptance testing, warranty and other services specified or required for the items of work. The general statement should be followed by a specific and detailed list of the major items which the Employer wishes to have as separate payment items in the tender form, for example:

[1)] To be published.

[2)] All references to Tendering documents (TD) apply to annex A of IEC 61366-1.

Item Description

1 Two (2) vertical shaft Pelton type hydraulic turbines each with a specified power of not less than 180 000 kW under a specified specific hydraulic energy of 11 500 J/kg (specified head of 1 172 m);

2 Turbine model testing;

3 Tools, slings and handling devices required for maintenance of the turbines;

4 Transportation and delivery to site;

5 Site installation, commissioning, and acceptance testing of the turbines;

6 Preparation and submission of operation and maintenance manual and training of Employer's operating and maintenance staff in the optimum use of these manuals; and

7 Spare parts required for operation and maintenance.

3.2 Limits of the contract

This subclause, making reference to Employer's drawings and data, should describe the limits of the contract considering the following:

– details of the design and supply limits of the high and low-pressure sides of the machine;
– details, location, and responsibility for field connection of manifold/branch pipe to penstock or valve on high-pressure side;
– details and location of the downstream termination of the turbine housing (including inspection platform, if required);
– details and location of gate(s) on low-pressure side (if required);
– orientation and location of turbine/generator shaft flange interface;
– responsibility for supply and installation of flange coupling bolts, nuts and guards at generator/turbine coupling, including drilling jig;
– responsibility for supply and installation of bolts, nuts, gaskets at piping terminations;
– termination of governor piping;
– termination of manifold dewatering piping;
– termination of manifold or branch pipe air exhaust piping (if any);
– termination of pit drainage piping (if required);
– termination of bearing lubricating oil piping (if required);
– termination of shaft seal piping (if specified);
– termination of cooling water piping for bearings;
– turbine mounted thrust bearing (if desired);
– termination points and junction boxes for wiring for power, control, indication, protection, and lighting;
– compressed air for service and other functions.

NOTE – Contract limits will change if other major items of equipment (such as hydro-turbine control systems, valves, gates, generators, excitation systems, control metering and relaying systems, switchgear, and power transformers) are included with the hydraulic machine in a common set of Tendering documents.

3.3 Supply by Employer

This subclause should be complementary to 5.6 of IEC 61366-1 (TD section 2.6) and should list the items and services which will be the responsibility of the Employer. The following items should be considered:

– services during site installation and testing;
– temporary enclosures for site storage of turbine parts or for erection;

- installation in primary concrete of small items provided by the Contractor, such as anchors, sole plates, and piping;
- concrete for embedment of turbine components-supply, placement and controls, including monitoring and verification during and after concrete placement by others;
- grout injection, if required, either within or around turbine components;
- powerhouse crane and operator;
- connections to powerhouse air, oil and water piping systems;
- supply of filtered water for turbine shaft seal (if by Employer);
- electrical wiring and hardware external to specified termination points;
- electric motor starters and controls;
- control, annunciation and protection systems external to specified termination points;
- external lubricating oil storage, distribution, and purification systems;
- lubricants, bearing and governor oil to the Contractor's specifications.

It should be stated that any materials or services required for installation and commissioning of the units, and not specifically mentioned in the above list of the Employer supplied items and services are to be provided by the Contractor under contract.

3.4 Design conditions

3.4.1 Project arrangement

The project arrangement should contain the Employer's detailed description together with general arrangement drawings (by the Employer) of the powerhouse and waterways at the low and high-pressure sides including channels, galleries, penstocks, surge tanks, gates, valves, etc. The description should be an extension of the applicable data provided in TD chapter 2 "Project information". The data shall be sufficiently clear so that the Contractor is aware of physical conditions which may influence its detailed design.

In any event, the Employer should retain responsibility for specifying values of all parameters on which guarantees are based, as part of the overall design of the plant. This applies particularly to the correct inlet and outlet conditions and in co-ordination of the interaction between the hydraulic machine and the waterways.

3.4.2 Hydraulic conditions

This subclause should present the hydraulic conditions under which the Employer proposes to operate the completed facility such as:

- range of specific hydraulic energy (head) of the plant;
- specific hydraulic energy losses between headwater level and high-pressure reference section of the machine ($E_{L\ 3\text{-}1}$);
- specific hydraulic energy (head) of the machine (see subclause 2.5);
- headwater levels, maximum, minimum and normal and when no water is flowing;
- tailwater levels, maximum, minimum and normal, and when no water is flowing;
- tailwater level as a function of discharge;
- power or discharge values in the range of specific hydraulic energy (head);
- maximum specific hydraulic energy (head) for runaway speed guarantee;
- range of water temperatures;
- water quality analysis (chemical, corrosive nature, biological, and suspended solids);
- range of ambient (interior and exterior) temperatures and humidity (tropical environment or extreme cold needs to be clearly defined).

3.4.3 Specified conditions

a) Modes of operation: As an extension to TD section 2.5, the Employer should provide sufficient data to enable the Contractor to understand the Employer's intended mode(s) of operation, e.g. base load or peaking. Data should include, wherever possible, the anticipated number of start-stops per year and the capacity factor of the plant. Special operating uses shall also be clearly identified such as synchronous condenser, spinning reserve, isolated and black start operations and requirements, waterway/penstock draining-through turbine.

b) Power (*P*), Specific Hydraulic Energy (*E*) [Head (*H*)], and Discharge (*Q*): The specified specific hydraulic energy (head) and discharge of the machine are determined from an analysis of available discharge, specific hydraulic energy (head) of the plant and hydraulic losses external to the machine with respect to statistical duration (refer to 2.3 to 2.6 of IEC 61366-1). The relevant power can be established from a predetermined value of efficiency.

   If the range of specific hydraulic energy (head) is wide, more than one specified value for *E*, *Q* and *P* may need to be selected to define the operational range of the machine.

   In the case of an unregulated turbine and if there are any limitations on maximum discharge at any specific hydraulic energy (head), the Employer shall provide adequate data in the technical specifications to enable the Contractor to optimize turbine design while respecting these limitations.

c) Speed: The choice of speed of the unit has an impact on turbine, generator costs and powerhouse costs. The choice of speed may be influenced by strength considerations. Reduced turbine efficiency and cavitation may be introduced by increasing speed beyond a certain limit.

   In most cases, the project schedule dictates an early decision with respect to speed. Under such conditions, discussions should be held with potential suppliers of turbines and generators to fix a preferred speed; alternative proposals may be invited in the ITT.

d) Direction of rotation: The direction of rotation of the turbine is dictated by the optimum orientation of the manifold pipe with respect to intake, penstock and powerhouse costs. The direction should be specified clockwise or counter-clockwise looking from the generator toward the turbine.

3.4.4 Generator characteristics

The specifications should state the principal characteristics of the generators to which the turbines will be coupled, for example:

– capacity (kVA);
– power factor;
– frequency (normal and exceptional range);
– inertia or flywheel effect of generator;
– preferred speed (if established);
– preferred bearing arrangement (if established);
– approximate diameter of rotor (if available).

3.4.5 Transient behaviour data

The Employer should, during preliminary design phase of the project and prior to turbine selection, determine the various factors relating to power acceptance and power rejection by the turbine. These factors may include:

– acceptable variation in electrical system frequency;
– inertia of the rotating parts or mechanical starting time;
– details of high-pressure conduit for the turbine, including surge tank, if used;

- water starting time;
- velocity of pressure wave (sound velocity in the water passages);
- turbine needle opening and closing times;
- high-pressure side valve/gate opening and closing time;
- transient pressure variations in the turbine manifold/branch pipe and penstock;
- transient water level variations in the turbine housing;
- pressure fluctuations at high-pressure side of turbine.

Transient data established by the Employer should be provided and those data which require verification by the Contractor should be specified. Other data not specified by the Employer may have to be established by the Contractor. (Refer to guarantees in subclauses 3.5.5 and 3.5.6).

3.4.6 Stability of the system

The hydro-turbine control system should be specified in accordance with IEC 61362. The performance of the hydro-turbine control system should be specified in accordance to IEC 60308. The Employer should furnish the information necessary to predict possible resonance in the water passages of the power plant and in the unit. Admissible limits may be specified for fluctuation of turbine shaft torque.

3.4.7 Noise

Noise level limits may be legislated by national or local statutes. Noise abatement measures may be the combined responsibility of the Employer and the Contractor. Reference should be made by the Employer to ISO 3740 together with other standards, statutes or guides to establish noise level measurement and acceptance criteria. The limits and the means by which they can be achieved should be specified in TD subsection 6.1.4.7.

NOTE – The Employer should be aware that any additional protection to reduce noise level may have a substantial effect on the cost of the machine.

3.4.8 Vibration

The specifications should require that the machine operates through its full range of specified conditions without vibration which would be detrimental to its service life. Reference should be made by the Employer to IEC 60994 together with other standards or guides to establish deflection measurements and acceptance criteria. In any event, limits of vibration may be established for steady-state conditions and for normal transient regimes as criteria for final acceptance.

3.4.9 Sand erosion considerations

Risk of sand erosion may influence the design and operation of the hydraulic machine. In this event, the technical specifications should indicate the content of suspended solids, their type, hardness, size and shape. See IEC 61366-1, annex H.

3.4.10 Safety requirements

The Employer should state specific safety requirements which shall be met in the design of the turbine. These requirements are in addition to the general safety related items outlined in 5.6 of IEC 61366-1.

3.5 Technical performance and other guarantees

3.5.1 General

Hydraulic performance guarantees for hydraulic machines are presented in clause 3 of IEC 60041. The main guarantees to be specified are outlined in IEC 61366-1, annex E and should be read in conjunction with IEC 60041.

The main steady-state hydraulic performance guarantees (i.e. power, discharge, efficiency and runaway speed) may be verified by field acceptance tests or by model tests. Guarantees may be referred directly to the hydraulic performance of the prototype computed from model tests with allowance for scale effects or to the hydraulic performance of the model (without scale effects). Refer to IEC 60193.

The Employer should establish and specify the parameters on which the performance guarantees are to be based. These parameters include plant specific hydraulic energy (plant head) and energy losses external to the high-pressure reference section of the machine. The Employer should retain responsibility for specifying acceptable inlet and outlet conditions of the machine and for co-ordinating the study of the interaction between the machine and the external waterways under transient and steady-state oscillating conditions.

In those cases where it is not possible to perform field acceptance tests under specified conditions, refer to IEC 60041.

The Employer should specify measurement methods and measurement uncertainties which are contractually applied if different than those established by relevant IEC publications.

In addition to specifying the guaranteed performance provisions in the technical specification, it is important that the Employer summarize these provisions in TD subsection 1.1.13 of the ITT. Also, it is desirable that the manner in which Tenderers present and state their performance guarantees be clearly specified.

The Employer should select the appropriate level and type of performance guarantees for the machine taking into consideration the intended mode of operation and the importance of the machine in the electrical system.

When it is necessary to include other aspects of the machine under performance guarantees (such as stability, noise, and vibration). The Employer should include these provisions at the end of this clause taking into consideration that available data may not be sufficient based on extended experience. In any event, conditions under which guarantees are evaluated shall be specified.

3.5.2 Guaranteed power

In specifying the guarantee for power, refer to TD subsection 6.1.4.3 of Specified conditions (see IEC 61366-1, annex A), and state clearly the basis of the guarantee. It is necessary in this subclause, to establish the contractual obligations of the Contractor if the guaranteed power is not met. The method(s) of measurements, method of comparison with guarantees and application of IEC 60041 shall be defined.

3.5.3 Guaranteed minimum discharge

It is normally not necessary to specify a particularly low, continuous and stable discharge guarantee for Pelton turbines. This may, however, be considered in cases of sand erosion. the Employer should indicate the expected duration of operation and any special discharge conditions. The method of measurement should be specified.

3.5.4 Guaranteed efficiency

The Employer shall establish and specify:

a) Basis of guarantee; model or prototype.

b) Method proposed to measure guaranteed efficiency
   - by field acceptance tests of one or more prototype turbines (see IEC 60041),
   - by model acceptance tests in the Contractor's laboratory or in another laboratory acceptable to both parties using test results with a mutually agreed step-up formula (see IEC 60193).

c) Efficiency weighting formula to allow the Tenderer to optimize the guaranteed efficiency in the normal operating range of the turbine with respect to both power and specific hydraulic energy (head) while taking into consideration the value specified by the Employer for gain or loss in efficiency.

d) Applicable codes (see 2.1 of this guide).

e) Measurement methods and preliminary estimated measurement uncertainties to be contractually applied if different than those established by relevant IEC publications.

f) Contractual consequences, if any, of the Contractor's failure to fulfil the guaranteed efficiency or of the Contractor exceeding its guaranteed efficiency (penalty or premium).

The technical data sheets (IEC 61366-1, annex D) of the tender forms should provide space for Tenderers to record the guaranteed weighted efficiency.

In large multi-unit projects which justify the expense, the Employer may choose to preselect two or more competing Tenderers for the performance of turbine model tests at the Employer's expense. In this event, results of the model tests can be used in the final award of the contract to the successful Tenderer.

3.5.5 Guaranteed maximum/minimum momentary pressure

It is usual for the Contractor to guarantee momentary pressure even when there is no contractual responsibility for complete design of the plant. (Refer to annex E, E.2.6). The Contractor should be required to calculate and guarantee the maximum momentary pressure under load rejection from specified conditions (specified power and specified specific hydraulic energy) and under the most unfavourable transient conditions established by the Employer. However, the Employer shall specify all relevant data because of the involvement and influence of the electrical generator, speed regulator, and waterway system in the transient phenomenon (see 3.4.5).

3.5.6 Guaranteed maximum momentary overspeed

The maximum momentary overspeed is the overspeed attained under the most unfavourable transient conditions. Under certain conditions, it may exceed maximum steady-state runaway speed. The maximum momentary overspeed should be guaranteed by Contractor. However, the Employer shall specify all relevant data because of the involvement and influence of the electrical generator, speed regulator, and waterway system in the transient phenomenon (see 3.4.5).

3.5.7 Guaranteed maximum steady-state runaway speed

The specifications should require that the Contractor guarantee the maximum steady-state runaway speed under the worst combination of conditions established by the Employer, for example, maximum specific hydraulic energy (head) and physical maximum needle opening on the turbine and the worst combination of nozzles in operation. Taking into consideration powerhouse arrangement, number and type of independent shut-off devices, local or remote control and type of control and protection systems, the specifications should state the duration for which the unit shall be capable of functioning at maximum steady-state runaway speed. The duration may vary from a few minutes to several hours at this speed, but the design of the plant should keep this duration to a minimum. The guarantee should be stated in the technical data sheets submitted by Tenderers.

NOTE – It is recommended not to specify or to conduct steady-state runaway speed tests at site. If it is mutually agreed to conduct such tests, they should be performed at reduced specific hydraulic energy (head); refer to IEC 60041. The purpose of this precaution is to reduce the physical stresses on the civil structures and the generating unit (particularly the electrical machinery). The value of maximum steady-state runaway speed could be verified by model tests (if wanted).

3.5.8 Cavitation pitting guarantees

Severe cavitation pitting creates three major problems for Pelton turbines; high cost of pitting repairs, loss in revenue caused by outages and potential decrease in efficiency. With careful planning by both the Employer and Contractor the impacts of severe pitting can be greatly reduced. Cavitation pitting in Pelton turbines is defined in IEC 60609-2.

The tendency to cavitation pitting damage may become greater by increasing the hydraulic energy of the machine, by decreasing the number of buckets (under a certain limit), by increasing nozzle and bucket roughness, by increasing bucket entrance size or by decreasing the distance from tailwater. The turbine designer is sometimes required to reach a compromise between low cavitation pitting damage and the Employer's need for higher efficiency and low equipment price. Factors to be considered when specifying cavitation pitting guarantees are outlined in IEC 60609-2.

3.5.9 Guaranteed hydraulic thrust (optional)

It is not normal to specify a guarantee for hydraulic thrust for a Pelton turbine.

3.5.10 Guaranteed maximum weights and dimensions

In some cases, the Employer may need to establish and fix without subsequent change, certain features of the turbine to be incorporated in the design of the project. These features should be specified in this subclause and may include, for example, such items as inlet valve size, turbine runner and shaft weights and maximum component dimensions and/or weights (for transportation and project handling restrictions), etc.

3.5.11 Other technical guarantees

This subclause may cover other technical guarantees such as vibration [1)], noise [2)], fluctuations of pressure and power and behaviour of protective coatings. If guaranteed limits for vibration are specified by the Employer or agreed upon by the parties to the contract, reference should be made to IEC 60994, which gives guidelines for measurement procedures.

The Employer may specify a guarantee to cover an emergency shut-down of the turbine without cooling and/or lubrication in the bearings.

3.6 Mechanical design criteria

3.6.1 Design standards

This subclause should list the appropriate standards and codes which the Employer wishes to apply directly to the design of the turbine equipment.

3.6.2 Stresses and deflections

The Contractor should be required to adopt design methods and practices in regard to allowable stresses and deflections to ensure an extended service life from the turbine with

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1) Refer to 3.4.8.

2) Refer to 3.4.7.

reasonable care and maintenance. The correlation of allowable stresses to the following load conditions shall be specified for:

– normal load conditions;
– extraordinary load conditions; and
– load case for emergency conditions (including earthquake acceleration).

The Employer should indicate the anticipated service life. Whenever the Contractor proposes to deviate from its conventional successful practice, it should be obliged to justify such deviation in advance to the Employer.

3.6.3 Special design considerations

The technical specifications should describe clearly the particular criteria and requirements relating to operation, reliability and maintainability (for erection, dismantling and maintenance of the main components). Any general statement in this subsection should be expanded, if necessary, under the headings of the particular components concerned.

The Contractors for the turbine and generator equipment should, as a part of their respective contract, be required to carry out design of the dynamic behaviour of the combined generator and turbine with respect to critical speed calculations and shaft system alignment criteria. The two Contractors should be obliged to participate in the analysis and mutual agreement for resolution of any problems which may arise in this regard.

3.7 Design documentation

3.7.1 General

The Tendering documents should provide a general statement on the manner in which the Contractor's design documentation will be submitted for review. It shall be recognised that design responsibilities which are assigned to the Contractor by the Employer shall remain under the Contractor's direct control. The provisions of TD subsection 6.1.7 shall be consistent with those given in TD section 5.2 of the technical documents.

3.7.2 Data for Employer's design

The Employer should outline data to be submitted by the Contractor relating to design and layout of the turbine. Data should include such items as embedded component weights and dimensions, loads to be transferred to the structure, water passage dimensions (i.e. manifold and turbine housing), size and location of anchor bolts, dimensions of first stage concrete voids for subsequent installation of embedded components, weights and dimensions of heaviest and largest components to determine crane capacity and lift height requirements when not specified by the Employer (see 3.5.10), details of lifting devices handled by crane, electrical interconnections, governor system connections, generator coupling data, etc.

3.7.3 Requirements for Contractor's drawings, technical calculations and data

Requirements for the Contractor's drawings, technical calculations and data should be described so that the Contractor is fully aware of information to be submitted. Associated with this is the need for the Employer to specify a predetermined number of design meetings with the Contractor to expedite necessary action items. The extent of review intended by the Employer should be defined. The Contractor is normally responsible for design of the turbine and the Employer's review should only be to the extent that the product conforms with the requirements of the technical specifications in particular, and the contract documents in general.

3.7.4 Contractor's review of Employer's design

A number of items in the design of the turbine have an impact on the design of the powerhouse. The Employer should outline the requirements for review by the Contractor of the

Employer's design. This could include a review of substructure construction drawings showing the turbine anchor bolt installation and other details which influence the turbine layout.

3.7.5 Technical reports by Contractor

The Employer should specify submittal requirements for the Contractor's technical reports. These reports could include model tests, dynamic behaviour of turbine/generator, installation procedures, commissioning and acceptance test procedures and similar items.

3.8 Materials and construction

3.8.1 Scope

Care shall be taken that specifications for materials and construction in TD subsection 6.1.8 are consistent and do not conflict with the general requirements specified in TD section 5.4 – Materials and workmanship. A number of items included in TD, 6.1.8 could be specified in TD section 5.4 but this is left to the Employer's preference.

It should be stated that it is not the intent of the Employer, in its specifications, to dictate how the turbine should be constructed but rather to provide sufficient data for the Contractor to establish the class of equipment for which the Employer is willing to pay. The Contractor should be permitted to offer alternatives to the minimum specified requirements thereby offering the maximum benefit of the Contractor's experience. The basis of such alternatives shall be justified and documented.

3.8.2 Material selection and standards

- All materials shall be new and suited for the intended purpose as demonstrated by the Contractor's prior experience or demonstrated by tests whose results are divulged to the Employer for acceptance.
- Specification should be limited, where possible, to generic types of materials to leave the Contractor the flexibility of to procurement from its usual sources.
- Where national material standards are specified, demonstrated equivalents should be accepted.
- Any change of material during the contract period shall be subject to approval by the Employer.

3.8.3 Quality assurance procedures

- Minimum quality requirements should be specified preferably with reference to international or national standards and should not conflict with the general requirements specified in TD section 5.5.
- Required documentation attesting quality checks shall be established.
- Material test certificates including certificates for material of doubtful quality or origin shall be established.
- Procedures for repair of defects shall be established.
- Need for the Employer's witness and notice in advance of same.

3.8.4 Shop methods and personnel

- Shop methods and routing information should be divulged to the Employer's representative(s) to the extent necessary to permit evaluation of same and to schedule attendance at important verifications in the manufacturing sequence.
- The Contractor should be required to demonstrate upon request, that the qualifications of its staff and workers for specific tasks such as welding are adequate for the class of work being done.

3.8.5 Corrosion protection and painting

- Minimum general grade of corrosion protection should be specified and it should be consistent with the environment to which the turbine components will be subjected, both atmospheric and hydraulic.
- International or national standards may be used to define minimum surface preparation and painting requirements.
- If a particular paint system is specified, its generic type and number of primer and finish coats should be given to facilitate the preparation of estimates during the tender period.
- Minimum or maximum dry film thickness for each coat in the specified paint system should also be given.
- Minimum corrosion protection requirements for machined surfaces, prior to shipment should be given along with packaging, transportation and site storage requirements in TD sections 5.7 and 5.8.
- If standard coating systems are specified by the Employer in TD section 5.4 of the general requirements, only the system code number and colour schedules need be specified in the technical specifications with cross reference to TD section 5.7.

3.9 Shop inspection and testing

As with 3.8, some of the requirements set forth in 3.9 could be specified in TD section 5.6. This is left to the author of the documents.

3.9.1 General requirements and reports

- This subclause should make reference to and be consistent with TD section 5.6 giving the shop test, inspection and report requirements to be met. Reference should be made to TD section 5.5 so that reporting standards and record keeping are consistent with the specified level of quality assurance.
- Method for handling non-conformance cases should be stated.

3.9.2 Material tests and certificates

- Specifications should require that material, used in the fabrication of major components of the turbine should be identifiable in the Contractor's records for the project in terms of type, grade and source. Copies of such records for major components should be supplied to the Employer's representative upon request.
- Tests for physical or chemical properties or other characteristics shall be specified for major components and the results reported to the Employer in writing. The Employer's representative shall be given the opportunity to witness such tests.
- The Employer may specify the supply of sample material.
- Where materials are purchased outside of the Contractor's organization, it shall require, as a minimum, that certificates be provided for major components at the time of material shipment, attesting to the type and grade of material being supplied.
- Wherever no specific tests are specified for major components, it shall be assumed that the tests required by the national standard for a material with the most similar chemical and physical properties shall apply. This is true for:
  - plate and structural steel;
  - castings;
  - forgings;
  - weldments.

3.9.3 Dimensional checks

– Specifications should require that critical dimensions be checked prior to shipment of the component to the job site. The nature of the records to be kept from such checks will be determined by the specified level of quality assurance to be maintained and by the Contractor's experience regarding the effect of such checks on its ability to assemble erect, test and guarantee the turbine.

– If model acceptance tests are performed, geometric similarity with the model turbine shall be checked in accordance with IEC 60193.

3.9.4 Shop assembly and tests

Detailed specifications of each major component should establish minimum requirements for shop assembly and tests. The following factors should be considered:

– remoteness of project site;
– possibility of shipment of part or all of the turbine fully assembled;
– thoroughness of dimensional checks;
– need for hydrostatic pressure test (e.g. injector and deflector systems);
– importance of a possible error in dimensional checks; and
– match marking to reassemble at site.

Designated auxiliary components and systems should be tested in the shop for proper functioning.

4 Technical specifications for fixed/embedded components

General notes

Clauses 4 to 11 inclusive, outline the technical specifications for major components of the machine. These specifications shall outline concisely the Employers' specific technical requirements and preferences for these components. It is suggested that the technical specifications for major components be arranged using the following headings wherever possible:

– general description;
– design data;
– general data.

Although the guide may appear somewhat repetitive in the clauses which follow, it shall be understood that the purpose of the guide is to illustrate preferred and consistent methods for specifying turbine components without presenting detailed specifications. Such details are the responsibility of the Employer.

As noted in 3.3.1.1 of IEC 61366-1 and to avoid confusion, requests for information from the Tenderers shall be provided in the instructions to Tenderers and not in the technical specifications.

Consistent with the foregoing notes, TD section 6.2 should begin with a general description of the major embedded components, for example.

The embedded components for the Pelton turbine to be provided shall normally include:

– manifold (for vertical shaft turbines only);
– turbine housing.

4.1 Manifold

Manifold is a term used for vertical shaft Pelton turbines. A general description of the manifold and the bifurcation should be given here.

4.1.1 Design data

The Employer's design data should be carefully outlined including such items as:

- number of jets (if specified by the Employer);
- design pressure;
- test pressure and location of test (shop or site);
- internal pressure during embedment;
- concrete embedment pour rates and other details;
- material by generic type or recognized national standards (indicate if alternatives will be accepted);
- protective coatings.

4.1.2 General data, connections and auxiliaries

The Employer should provide general data which applies to the manifold such as:

- location, size and type of turbine inlet connection (specify tolerances);
- location, size, and type of all other connections for peripheral or auxiliary systems (brake jets, cooling water, potable water, service water, irrigation devices, etc.);
- location, size and details of access for maintenance/inspection;
- details of all indication and test connections and devices;
- temporary and permanent transportation and erection support and handling devices.

4.2 Turbine housing

As with the manifold, the Employer should provide similar subsections beginning with a short description of the turbine housing.

4.2.1 Design data

- See 4.1.1.
- Generator supported by turbine cover and turbine housing (if required).

4.2.2 General data, connections and auxiliaries

- Tolerances on location in plan and elevation (if stated by the Employer).
- Provisions for concrete placement and grouting.
- Location, size, type and other details of connections (e.g. turbine pit drains, test connections, etc.).
- Transportation and erection support and handling devices.

5 Technical specifications for stationary/removable components

The Employer should give a general description of the stationary removable components.

5.1 Branch pipe (including intake pipe and nozzle pipe)

The term branch pipe is used for horizontal shaft Pelton turbines. A general description of the branch pipe should be given.

5.1.1 Design data

- Number of jets (if specified by the Employer).
- Design pressure.
- Test pressure and location of test (shop or site).
- Material by generic type or recognised national standards (indicate if alternatives will be accepted).
- Protective coatings.
- Transportation limitations (dimensional and weight).
- Site handling limitations (dimensional and weight).

5.1.2 General data, connections and auxiliaries

The Employer should provide general data which applies to the branch pipe such as:

- location, size and type of turbine inlet connection (specify tolerances);
- location, size, and type of all other connections for peripheral or auxiliary systems (brake jets, cooling water, potable water, service water, irrigation devices, etc.);
- location, size and details of access for maintenance and inspection;
- details of all indication and test connections and devices;
- temporary and permanent transportation and erection support and handling devices.

5.2 Upper turbine housing (if not embedded)

Short description of the upper turbine housing.

5.2.1 Design data

The Employer's design data should be carefully outlined including such items as:

- functional criteria, dismantling joints, etc.;
- design pressure (if any);
- material by generic type or recognized national standards (indicate if alternatives will be accepted);
- protective coatings;
- transportation limitations (dimensional and weight);
- site handling limitations (dimensional and weight).

5.2.2 General data, connections and auxiliaries

- Tolerances on location in plan and elevation (if stated by the Employer).
- Transportation and erection support and handling devices.
- Details of connections.

5.3 Turbine cover

The turbine cover for a horizontal shaft Pelton turbine is bolted to the turbine housing. Dismantling the turbine cover for this type of turbine provides service access to the runner. For vertical shaft Pelton turbines, the turbine cover may have a separate central cover and a pit flooring.

5.3.1 Design data

- Comments on preferred arrangement (separate parts).
- Protective coatings.
- Special loading conditions (if any).
- Type of material.
- Preferred pit drainage (if internal pressure in the turbine housing).
- Transportation and site handling limitations.
- Forces from turbine mounted thrust bearing (if specified).

5.4 Brake jet assembly

Brief description of the brake jet assembly.

- Comments on preferred arrangement (if any).
- Number of jets (if specified by the Employer).
- Control system (if specified by the Employer).

6 Technical specifications for injector/deflector system

Brief description of injector/deflector system. The two systems may be closely related to each other and should be considered together. Mechanical locking devices are not normally used. For internal servomotor designs, it is recommended to evaluate the need for such devices before they are specified.

6.1 Injector system

Description of injector (nozzle assembly) and servomotor. Components may include:

- Nozzle:
  - nozzle body;
  - nozzle;
  - nozzle tip ring.
- Needle:
  - needle rod;
  - needle tip;
  - needle servomotor.
- Oil piping.
- Lever-link connection in feed-back system.

6.1.1 Design data

- Comments on preferred arrangement (e.g. number of jets, internal/external servomotor, etc.).
- Need for operation with reduced number of jets (TD subsection 6.1.4.3).

- Full range of manifold/branch pipe pressures.
- Oil pressure (if specified) or maximum and minimum allowable operating pressure (if governor supplied separately).
- Opening and closing rates.
- Other requirements regarding operation and maintenance.
- Type of material.
- Preferred hydraulic balance of needle.

6.2 Deflector system

Description of deflector system; components are:

- deflector or cut-in deflector;
- deflector servomotor;
- oil piping;
- needle-deflector link;
- needle-deflector combining mechanism.

NOTE – A "cut-in" deflector has, in some cases, been used for regulating turbine power. This is not recommended because of possible negative effects on efficiency, cavitation and turbine housing erosion. Both the main deflector and "cut-in" deflector should be mainly used for preventing water hammer and steady-state stability problems.

6.2.1 Design data

- Comments on preferred arrangement (e.g. deflector or cut-in deflector).
- Full range of manifold/branch pipe pressures.
- Oil pressure (as for injectors).
- Type of material.
- Cross-reference TD subsection 6.4.1.1.

7 Technical specifications for rotating parts, guide bearings and seals

Description of rotating parts and preferred method for erection and dismantling.

7.1 Runner

Description of runner.

7.1.1 Design data

- Minimum material requirements by generic type (weldable, corrosion resistant, erosion resistant, cavitation resistant). It should be noted that most runners are manufactured from one piece martensitic/austenitic stainless steel castings; or in some cases by welded construction.
- Support of runner and shaft during erection and subsequent maintenance.
- Static balancing requirements.

7.1.2 Bucket shape and surface finish

Proper control of bucket shape and surface conditions is an important step in limiting potential cavitation erosion damage. Proper quality control shall be provided during all phases of fabrication and manufacture to ensure that the final product is a good representation of the model runner or hydraulic design.

7.2 Main shaft

Description of shaft.

7.2.1 Design data

- Coupling standard, if any.
- Material type.
- Distance of main shaft coupling flange(s) from runner centreline.
- Coupling bolt holes, interchangeability requirement.
- Define co-ordination with generator supplier for combined alignment, dimensional interface and critical speed.

7.2.2 Coupling bolts, nuts and nut guards

- Material type.
- Responsibility for supply and installation, including drilling template.
- Turbine end.
- Generator end.
- Interchangeability.
- Locking devices.
- Nut guards for turbine and generator ends.

7.3 Turbine guide bearing

- General description for type and construction.
- Access for maintenance.
- Material types.
- Lubrication.
- Cooling of bearing oil.
- Oil fill and drain piping.
- Oil circulation.
- Oil level detection for control and annunciation.
- Oil level indication.
- Contamination of oil (test connections).
- Bearing temperature.
- Bearing oil temperature.

7.4 Main shaft seal (if necessary)

- General description.
- Material for housing, wear elements and shaft sleeve.
- Design for longevity and ease of maintenance.

- Clean lubricating water and cooling water.
- Quality and quantity of cooling water.
- Shaft seal temperature detection and indication.
- Shaft seal cooling water flow detection and indication.
- Wear indicator.

7.5 Standstill maintenance seal (if necessary)

- General description.
- Material for housing and active seal ring.
- Actuation (e.g. by compressed air).

8 Technical specifications for thrust bearing (when specified as part of the hydraulic machine)

A Pelton turbine is not normally equipped with a thrust bearing. If, however, a thrust bearing is needed and is a part of the turbine supply, this section should start with a description of bearing assembly and location.

8.1 Design data

- Weights and loads on bearing external to turbine.
- Limitation for operation under runaway speed conditions.
- Cooling water temperature range.
- Deflection limitations.

8.2 Bearing support

- Location.
- Materials.
- Accessibility.

8.3 Bearing assembly

- General description of type or construction.
- Access for maintenance.
- Material types.
- Lubrication.
- Cooling of bearing oil.
- Oil fill and drain piping.
- Oil circulation.
- Oil level detection for control and annunciation.
- Oil level indication.
- Contamination of oil (test connections).
- Bearing temperature.
- Bearing oil temperature.

8.4 Oil injection pressure system

- Number and types of pumps (a.c. or d.c.).
- Filters.
- Flow regulators.
- Pressure detectors.

9 Technical specifications for miscellaneous components

Description of miscellaneous components.

9.1 Walkways, access platforms and stairs

- Inspection platform.
- Description of minimum requirements.
- Removal and handling weight limitations.
- Minimum design loading criteria.
- Reference to applicable safety codes.

9.2 Lifting fixtures

- Runner and shaft.
- Turbine cover.
- Injectors.
- Deflectors.
- Separate servomotors, if any.
- Coupling bolts.
- Guide bearing(s).

9.3 Special tools

- Coupling bolt loosening and tightening device.
- Special wrenches.
- Special jacks.
- Shaft lifting device.
- Slings.

9.4 Standard tools

- Complete set for maintenance requirements (not for erection).

9.5 Turbine pit hoist

- If required by turbine size or arrangement.

9.6 Nameplate

- Minimum data.
- Size.
- Mounting location.

9.7 Runner cart and rails (if required)

For vertical shaft Pelton turbines, a runner cart and rails should be specified for transporting the runner out of the turbine housing (see also 5.3).

9.8 Access door to turbine housing interior (if required)

An access door to the inside of the turbine housing should be specified if this is part of the turbine supply. The access door will be used for inspection, service work and runner exchange, in particular for a vertical shaft installation.

10 Technical specifications for auxiliary systems

Description of systems included.

10.1 Bearing lubrication system

When an external oil cooling system is preferred, specify:

– number and type of pumps, filters and coolers;
– dimension criteria for external tank (e.g. with capacity to contain complete system volume);
– detectors for level, flow, humidity, etc.

10.2 Cooling water system for runner

Cooling water system in the event of synchronous condenser operation:

– general description of the system;
– quantity of water.

10.3 Tailwater air admission system

The tailwater air admission system may be:

– a ventilation system;
– a tailwater depressing system.

A tailwater depressing system will in most cases not be necessary. Its purpose is to keep high tailwater away from the turbine runner. If used, matters of specification may be:

– describe preferred system;
– number of compressors when required and if specified by the Employer; and
– define responsibility for all controls and piping when required.

10.4 Turbine pit drainage

The pit of a Pelton turbine usually does not need a drainage system. A drainage system may, however, be required when the turbine is equipped with a tailwater depressing system. In this case the internal pressure of the turbine housing will be higher than atmospheric:

– describe preferred system (if any); and
– define responsibility for all pumps, controls and piping when required.

11 Technical specifications for instrumentation

Description of instrumentation.

11.1 Controls

List controls included in the contract. Detailed cross-references should be given to the subsection dealing with the item involved; e.g. unit start interlocks, low flow to guide bearing cooling, low flow to shaft seal lubrication, etc.

11.2 Indication

Define devices for indication such as:

– bearing oil level;
– bearing temperature;
– vibration monitoring equipment (orbit deflection and phase angle if wanted);
– indicating system for turbine efficiency (if wanted) etc.

11.3 Protection

Define protection requirements for example:

– bearing high temperature;
– excessive shaft displacement (run-out);
– vibration monitoring equipment (if wanted).

12 Spare parts

Requirements for basic spare parts for turbines should be established by the Employer. Extent of spare parts will depend on operating criteria, location of project, and availability of replacement components. The basic spare parts list required by the Employer may be augmented by experience of the Contractor. Spare parts should be manufactured with the main contract and delivered with the turbine components.

Provide a list of minimum requirements, e.g.:

– runner;
– set of injector nozzles;
– set of needle tips;
– complete set of seals and/or gaskets for dismantling; and
– spare studs, nuts, bolts, etc.

In the ITT, request Tenderers to submit a list of recommended spare parts with their tender form.

13 Model acceptance tests

When evaluating model data only, the Employer should consider the Contractor's applicable existing model data available from previous homologous model tests. For some small units and for special cases where near homologous model data are available, it may be cost-effective to accept a model design which can be readily adapted to the site of the work. In this event, the Contractor should be required to provide the basis of numerically adapted performances.

Under certain circumstances, the Employer may wish to receive tenders, evaluate them and select two or three Tenderers to construct turbine models, at the Employer's expense, for competitive testing at an independent laboratory. A contract may then be awarded on the basis of best performance and price. Nevertheless, model tests should be carried out in accordance with IEC 60193. Only supplementary requirements need to be specified in detail.

When model acceptance tests are used for verification of performance, the end use of the data should be stated:

- model acceptance tests: verification of guarantees on the model;
- comparison of model test results with guarantees on prototype with due consideration of scale effects mutually agreed between the Employer and the Contractor;
- evaluation of specific operating characteristics, such as runaway speed;
- developmental model tests as the basis for prototype design; in this case model tests will provide information on performance and machine behaviour in an early stage of the project.

The schedule of conducting the model tests including witnessing by the Employer and for submitting the final report should be specified, taking into account that design, manufacturing, and tests of a model may require a 12 to 18 months programme.

A check list for model acceptance specifications is given in IEC 61266-1, annex G, where all items which need an agreement between the parties are listed.

14 Site installation and commissioning tests

14.1 General

- Refer to IEC 60545.
- Elaborate on what is stated in TD section 5.10 and in TD subsections 6.1.1, 6.1.2 and 6.1.3.
- Outline clearly the limits of Contractor's responsibilities.
- State method the Employer proposes to use to control, monitor and verify the Contractor's embedded parts and that anchor bolts are not disturbed during concrete placement and grouting operations by others. This should include such items as pour rate and pressure limitations imposed by the Employer on construction of civil works. The Contractor shall be permitted to comment on and agree to these provisions for control.

14.2 Installation procedures

- The specifications should stipulate that an erection procedure shall be prepared by the Contractor and submitted to the Employer before the start of erection and installation at site. This will allow the Employer to resolve any conflicts which may exist with other Contractors on the site. The procedures should contain cross-referencing to turbine drawings and to location of measuring points and should become a part of the Operating and maintenance manual TD section 2.5.
- Erection tolerances, if specified, should follow National or industry standards or guidelines.
- The procedures should incorporate the controls, monitoring and verification proposed by the Employer to limit distortion and/or movement of embedded parts and anchors during concreting and grouting by others.
- The procedures take into account the requirements of the connected generator.
- Requirements should be specified for measurement records to be made during alignment and installation; for example: clearances, relative location and rotational test results.

14.3 Tests during installation

- Functional tests on components and systems.
- Specify non-destructive testing such as radiographic, ultrasonic, dye penetrant, etc., proposed for structural field welds on major components.
- State pressure test requirements (if any) on spiral case; include specifications for test bulkheads.
- Specify other site tests which may be required during installation.

14.4 Commissioning tests

List all tests to be done upon completion of erection, for example:

- rotational checks;
- needle valve and deflector operating times in the dry (if conducted);
- operation of unit without load and at speeds specified for checking runout of rotating parts and for verifying guide and thrust bearing behaviour and for setting overspeed trip devices;
- operation of unit under load to full needle valve opening at the available specific hydraulic energy (head) to set servomotor stops (if provided) to check bearing behaviour and to check run-out of rotating parts under load, thereby, permitting the setting of shaft runout monitors (if provided) to check for vibration, pulsation and noise; load rejection tests (adjust needle valve and deflector operating times, if necessary);
- blow-down and refilling tests for synchronous condenser operation (if specified);
- operation of other turbine components.

15 Field acceptance tests

15.1 Scope and reports

Field acceptance tests should be done in accordance with IEC 60041 in particular with reference to clause 4. The methods of measurements should be fixed in the technical specifications.

Field acceptance tests for confirming that hydraulic performance guarantees have been met may comprise:

- efficiency tests, i.e. determination of absolute efficiency of the machine (if model acceptance tests were not performed);
- power tests as a function of hydraulic parameters (E, Q).

15.2 Inspection of cavitation pitting

- Refer to 3.5.8.
- Define participation of contracting parties (see IEC 61366-1, annex F).

Ensure that operating records are maintained during the guarantee period to verify that the machine has been operated within specified ranges of net positive suction specific hydraulic energy together with power, discharge, and specific hydraulic energy (head).

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Standards Survey

We at the IEC want to know how our standards are used once they are published.

The answers to this survey will help us to improve IEC standards and standard related information to meet your future needs

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Switzerland

or

Fax to: CSC at +41 22 919 03 00

Thank you for your contribution to the standards making process.

Nicht frankieren
Ne pas affranchir

Non affrancare
No stamp required

A Prioritaire

RÉPONSE PAYÉE

SUISSE

Customer Service Centre (CSC)
International Electrotechnical Commission
3, rue de Varembé
Case postale 131
1211 GENEVA 20
Switzerland

1.

No. of IEC standard:

....

2.

Tell us why you have the standard. (check as many as apply). I am:

- ☐ the buyer
- ☐ the user
- ☐ a librarian
- ☐ a researcher
- ☐ an engineer
- ☐ a safety expert
- ☐ involved in testing
- ☐ with a government agency
- ☐ in industry
- ☐ other..

3.

This standard was purchased from?

....

4.

This standard will be used (check as many as apply):

- ☐ for reference
- ☐ in a standards library
- ☐ to develop a new product
- ☐ to write specifications
- ☐ to use in a tender
- ☐ for educational purposes
- ☐ for a lawsuit
- ☐ for quality assessment
- ☐ for certification
- ☐ for general information
- ☐ for design purposes
- ☐ for testing
- ☐ other..

5.

This standard will be used in conjunction with (check as many as apply):

- ☐ IEC
- ☐ ISO
- ☐ corporate
- ☐ other (published by...................)
- ☐ other (published by...................)
- ☐ other (published by...................)

6.

This standard meets my needs (check one)

- ☐ not at all
- ☐ almost
- ☐ fairly well
- ☐ exactly

7.

Please rate the standard in the following areas as (1) bad, (2) below average, (3) average, (4) above average, (5) exceptional, (0) not applicable:

- ☐ clearly written
- ☐ logically arranged
- ☐ information given by tables
- ☐ illustrations
- ☐ technical information

8.

I would like to know how I can legally reproduce this standard for:

- ☐ internal use
- ☐ sales information
- ☐ product demonstration
- ☐ other................................

9.

In what medium of standard does your organization maintain most of its standards (check one):

- ☐ paper
- ☐ microfilm/microfiche
- ☐ mag tapes
- ☐ CD-ROM
- ☐ floppy disk
- ☐ on line

9A.

If your organization currently maintains part or all of its standards collection in electronic media, please indicate the format(s):

- ☐ raster image
- ☐ full text

10.

In what medium does your organization intend to maintain its standards collection in the future (check all that apply):

- ☐ paper
- ☐ microfilm/microfiche
- ☐ mag tape
- ☐ CD-ROM
- ☐ floppy disk
- ☐ on line

10A.

For electronic media which format will be chosen (check one)

- ☐ raster image
- ☐ full text

11.

My organization is in the following sector (e.g. engineering, manufacturing)

....

12.

Does your organization have a standards library:

- ☐ yes
- ☐ no

13.

If you said yes to 12 then how many volumes:

....

14.

Which standards organizations published the standards in your library (e.g. ISO, DIN, ANSI, BSI, etc.):

....

15.

My organization supports the standards-making process (check as many as apply):

- ☐ buying standards
- ☐ using standards
- ☐ membership in standards organization
- ☐ serving on standards development committee
- ☐ other................................

16.

My organization uses (check one)

- ☐ French text only
- ☐ English text only
- ☐ Both English/French text

17.

Other comments:

....

....

....

....

....

....

18.

Please give us information about you and your company

name: ....

job title:..

company: ....

address:..

....

....

....

No. employees at your location:.........

turnover/sales:.................................

Publications de la CEI préparées par le Comité d’Etudes nº 4

60041 (1991) Essais de réception sur place des turbines hydrauliques, pompes d'accumulation et pompes-turbines, en vue de la détermination de leurs performances hydrauliques.

60193 (1965) Code international concernant les essais de réception sur modèle des turbines hydrauliques.
Modification n° 1 (1977).

60193A (1972) Premier complément.

60198 (1966) Code international concernant les essais de réception sur place des pompes d'accumulation.
Modification n°1 (1971).

60308 (1970) Code international d'essai des régulateurs de vitesse pour turbines hydrauliques.

60497 (1976) Code international concernant les essais de réception sur modèle réduit des pompes d'accumulation.

60545 (1976) Guide pour la réception, l'exploitation et l'entretien des turbines hydrauliques.

60607 (1978) Méthode thermodynamique de mesure du rendement des turbines, pompes d'accumulation et pompes-turbines hydrauliques.

60609 (1978) Evaluation de l'érosion de cavitation dans les tur-bines, les pompes d'accumulation et les pompes-turbines hydrauliques.

60609-2 (1997) Part 2: Evaluation dans les turbines Pelton.

60805 (1985) Guide pour la réception, l'exploitation et l'entretien des pompes d'accumulation et des pompes-turbines fonctionnant en pompe.

60994 (1991) Guide pour la mesure in situ des vibrations et fluctuations sur machines hydrauliques (turbines, pompes d'accumulation et pompes-turbines).

60995 (1991) Détermination des performances industrielles des machines hydrauliques à partir des essais sur modèle en considérant les effets d'échelle.

61116 (1992) Guide pour l'équipement électromécanique des petits aménagements hydro-électriques.

61362 (1998) Guide pour la spécification des régulateurs des turbines hydrauliques.

61366.— (Publiée en langue anglaise seulement)

61366-1 (1998) (Publiée en langue anglaise seulement).

61366-2 (1998) (Publiée en langue anglaise seulement).

61366-3 (1998) (Publiée en langue anglaise seulement)

61366-4 (1998) (Publiée en langue anglaise seulement)

61366-5 (1998) (Publiée en langue anglaise seulement)

61366-6 (1998) (Publiée en langue anglaise seulement)

61366-7 (1998) (Publiée en langue anglaise seulement)

IEC publications prepared by Technical Committee No. 4

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

60193 (1965) International code for model acceptance tests of hydraulic turbines.
Amendment No. 1 (1977).

60193A (1972) First supplement.

60198 (1966) International code for the field acceptance tests of storage pumps.
Amendment No. 1 (1971).

60308 (1970) International code for testing of speed governing systems for hydraulic turbines.

60497 (1976) International code for model acceptance tests of storage pumps.

60545 (1976) Guide for the commissioning, operation and maintenance of hydraulic turbines.

60607 (1978) Thermodynamic method for measuring the efficiency of hydraulic turbines, storage pumps and pump-turbines.

60609 (1978) Cavitation pitting evaluation in hydraulic turbines, storage pumps and pump-turbines.

60609-2 (1997) Part 2: Evaluation in Pelton turbines.

60805 (1985) Guide for commissioning, operation and maintenance of storage pumps and of pump-turbines operating as pumps.

60994 (1991) Guide for field measurement of vibrations and pulsations in hydraulic machines (turbines, storage pumps and pump-turbines).

60995 (1991) Determination of the prototype performance from model acceptance tests of hydraulic machines with consideration of scale effects.

61116 (1992) Electromechanical equipment guide for small hydro-electric installations.

61362 (1998) Guide to specification of hydraulic turbine control systems.

61366.— Hydraulic turbines, storage pumps and pump-turbines – Tendering Documents.

61366-1 (1998) Part 1: General and annexes.

61366-2 (1998) Part 2: Guidelines for technical specifications for Francis turbines.

61366-3 (1998) Part 3: Guidelines for technical specifications for Pelton turbines.

61366-4 (1998) Part 4: Guidelines for technical specifications for Kaplan and propeller turbines

61366-5 (1998) Part 5: Guidelines for technical specifications for tubular turbines

61366-6 (1998) Part 6: Guidelines for technical specifications for pump-turbines

61366-7 (1998) Part 7: Guidelines for technical specifications for storage pumps.

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