TECHNICAL REPORT

IEC 61366-5

First edition
1998-03

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

Part 5: Guidelines for technical specifications for tubular turbines

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

Partie 5:
Guide des spécifications techniques pour les turbines tubulaires

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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.

TECHNICAL REPORT – TYPE 3

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Part 5: Guidelines for technical specifications for tubular 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 61366-5, 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/RVC

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 61366-5 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).

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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2		Francis turbines
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 2: Guidelines for technical specifications for tubular 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 of 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 tubular turbine specifications include technical specifications for the following:

– Design conditions: Project arrangement, hydraulic conditions, mode of operation, generator characteristics, transient behaviour data, stability of the system, noise, vibration, pressure fluctuations and safety requirements.
– Technical performance and other guarantees:
  • power;
  • discharge;
  • 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.
- Design documentation: Contractor's input needed for the Employer's design, the 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 and personnel, 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: generator hatch cover or pit, stay ring, discharge ring (if any), draft tube, draft tube liner foundations anchorage, upstream and downstream pressure taps and pipes.
- Stationary/removable components: bulb nose, generator access shaft inner and outer guide rings and guide vanes.
- Regulating apparatus: servomotor, counterweight, connecting rods, regulating ring, guide vane linkage, system, guide vane overload protection and locking devices.
- Rotating parts, bearings and seals: runner, main shaft, guide bearing, main shaft seal, oil head and runner blade regulation system with servomotor assembly with oil supply, linkage system, crosshead and oilhead.
- Thrust and counter-thrust bearing: bearing support, thrust collar and counter-thrust bearing pads and rings, oil sump and instrumentation.
- Gear box: gear box and related components.
- Miscellaneous components: walkways, platforms, lifting fixtures, special tools, standard tools and nameplate.
- Auxiliary systems: water supply to main shaft seal, turbine drainage, lubrication-guide vane regulating system, and oil supply to bearings.
- Instrumentation: controls, indication and protection.
- Spare parts: basic spare parts.
- Model acceptance tests: test requirements.
- Site installation and commissioning test: installation procedures and commissioning.
- Field acceptance tests: scope of field test scope and 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, relief valves, or high and low pressure slide valves or gates which, at the Employer's option, may be included in the Tendering documents for the turbine or may be specified in separate 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 guide vane 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 gear box;

1 Scope

This technical report, referred to herein as the 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 tubular 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 and maintenance of hydraulic turbines*

IEC 60609:1978, *Cavitation pitting evaluation in hydraulic turbines, storage pumps and pump-turbines*

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

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 preparation 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)] subsection 2.1 (5.1 ofIEC 61366-1) shall be consistent with what is presented here. In a similar manner, pay items in the tender form, TD section 1.2 (4.2 of IEC 61366-1) 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.

[1)] To be published.

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

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:

Item Description

1 Six (6) complete bulb type Kaplan turbines each with a specified power of not less than 10 200 kW at the shaft coupling under a specified hydraulic energy of 98 J/kg (specified head of 10 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 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 the Employer's drawings and data, should describe the limits of the contract considering the following:

– details and location of the upstream high-pressure reference section;
– responsibility for connection of high-pressure reference section at site;
– details and location of the downstream low-pressure reference section;
– details and location of the upstream termination of the water passage liner;
– details and location of the downstream termination of the draft tube liner;
– orientation and location of the turbine/generator shaft flange interface;
– responsibility for flange coupling bolts, nuts and nut guards at generator/turbine coupling, including drilling jig;
– responsibility for bolts, nuts, gaskets at piping termination;
– termination of governor piping;
– termination of drainage piping;
– termination of bearings lubricating oil piping;
– termination of shaft seal piping (if any);
– termination points and junction boxes for wiring power, control, indication, protection, and lighting;
– compressed air for service and other functions.

NOTE – Contract limits will change considerably if other major items of equipment (such as speed governor system, turbine downstream gate, generators, excitation systems, control metering and relaying systems, switchgear, and power transformers) are included with the turbine equipment 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 2.6) and should list the items and services which will be the responsibility of the Employer. The following 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 provided by the Contractor;

- concrete for embedment of turbine components - supply, placement and control 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;
- 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 the contract.

3.4 Design conditions

3.4.1 Project arrangement

The detailed project arrangement should contain the Employer's description together with general arrangement drawings (by the Employer) of the powerhouse and waterways at the low and high-pressure sides such as channels, galleries, penstocks, gear box, valves/gates, 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 the 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 the coordination of the interaction between the hydraulic machine and 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 losses between the low-pressure reference section and tailwater level ($E_{L\ 2\text{-}4}$);
- specific hydraulic energy (head) of the machine (see 2.5 of IEC 61366-1);
- headwater levels, maximum, minimum and normal and when no water is flowing;
- tailwater levels, maximum, minimum and normal and when no water is flowing;
- minimum tailwater level as a function of discharge for cavitation guarantee;
- power 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, biological, corrosive nature and suspended solids); and
- range of ambient temperatures and humidity (tropical or extreme cold environment 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, peaking or sluice operation. Data should include, wherever possible, the anticipated number of start-stops per year and the capacity factor of the plant. Special uses shall also be clearly identified such as spinning reserve, isolated and black start operations, etc.

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). Relevant power can be established from a predetermined value efficiency.

   If the range of specific hydraulic energy 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, and generator costs, on the setting of the turbine with respect to tailwater levels and on powerhouse costs.

   If permitted by the project schedule, the approximate cost per meter of powerhouse setting (see annex B, clause B.3), and the approximate cost per kVA for various possible speed options for the generator should be specified by the Employer in the ITT (subsection 1.1.15) so that the Tenderer may quote the turbine which best suits site conditions and its available design.

   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 instructions to Tenderers.

d) Direction of rotation: 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 rotor diameter (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;
– velocity of pressure waves (sound velocity in the water passages);

– details of high-pressure and low-pressure conduits for the turbine;
– water starting time;
– turbine guide vane opening and closing times;
– transient pressure variations in the turbine;
– transient pressure variations in the turbine draft tube;
– limitation of sudden decrease of discharge with respect to surge control.

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 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 according 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 fluctuations of turbine shaft torque and of pressure in the draft tube.

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 measurement and acceptance criteria. The limits and the means by which they can be achieved should be specified in TD subsection 6.1.5.11.

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 suitable standards or guides to establish deflection measurements and acceptance criteria. 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 annex H of IEC 61366-1.

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 outlined in Part 1, annex E of this guide, 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 model tests or by field acceptance tests. Guarantees may be referred directly to the hydraulic performance of the model (without scale effect) or alternatively to the hydraulic performance of the prototype computed from model tests with allowance for scale effects (refer to IEC 60193).

The Employer should establish and specify the essential 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 and low-pressure reference sections of the machine. The Employer should retain responsibility for specifying acceptable inlet and outlet conditions of the machine and for co-ordination 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 section taking into consideration that available data may not be sufficient, based on extended experience. In any event, conditions under which guarantees are to be evaluated shall be specified.

3.5.2 Guaranteed power

In specifying the guarantee for power, refer to TD subsection 6.1.4.3 of the specified conditions, 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

In some cases, it may be necessary to specify guaranteed requirements for a particularly low, continuous and stable discharge. 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 model acceptance tests in Contractor's laboratory or in another laboratory acceptable to both parties using test results with a mutually agreed step-up formula (see IEC 60193), or

   – by field acceptance tests of one or more prototype turbines (see IEC 60041);

c) Efficiency weighting formula to allow 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 (refer to annex B of IEC 61366-1);

d) applicable codes (see 2.1 of IEC 61366-1);

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 Contractor exceeding the guaranteed efficiency (penalty or premium).

The technical data sheets of the tender forms should provide space for the Tenderer 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, the 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 Part 1, 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 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 the 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 Contractor guarantees 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 guide vane opening for propeller turbines and worst off-cam condition for Kaplan turbines considering variations in the plant cavitation factor. 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 should be verified by model tests (if any).

3.5.8 Cavitation pitting guarantees

Severe cavitation pitting creates three major problems for hydraulic machines; high cost of pitting repairs; loss of revenue caused by outages and decrease in efficiency. With careful planning of the technical specifications the impacts of severe pitting can be greatly reduced.

In the design of turbines and their application to a specific site, it is necessary to balance the increase in cost for a lower turbine setting, larger runner diameter, slower operating speed and increase in powerhouse excavation with the potential loss of revenue caused by any outage.

IEC 60609 outlines factors which need to be considered when specifying cavitation guarantees. Refer to Part 1, annex F of this guide which provides an example of an interpretation of IEC 60609.

Factors which can influence the amount of cavitation pitting damage and the limits of the cavitation guarantee include plant operating range and conditions, low tailwater level, water quality, material selection, shop inspection, quality control and field inspection after commissioning.

3.5.9 Guaranteed hydraulic thrust

This subclause should outline the conditions of operation which can be used by the Contractor to determine the maximum and minimum hydraulic thrust. This information will be needed for design of the thrust bearing.

3.5.10 Guaranteed maximum weights and dimensions (optional)

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 subsection and may include, for example, such items as turbine runner and shaft weights and maximum component dimensions and/or weights (for transportation and project handling restrictions), intake gate and draft tube gate size, etc.

3.5.11 Other technical guarantees

This subclause may cover other technical guarantees such as vibration, 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 guidance for measurement procedures.

If the Employer specifies a guarantee for the guide vane hydraulic torque tendency, this guarantee may be confirmed by model tests.

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

3.6 Mechanical design criteria

3.6.1 Design standards

This subclause should list the appropriate standards and codes which the purchaser proposes to apply directly to 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 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 his 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 subclause should be expanded as necessary under the headings of the particular components concerned.

The turbine and generator equipment Contractors 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 obligated 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 Contractor's design documentation will be submitted for review. It shall be recognized that design responsibilities which are assigned to the Contractor by the Employer shall remain under Contractor's direct control. The provisions of TD subsection 6.1.7 shall be consistent with those given in TD section 5.2, "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 will include such items as embedded component weights and dimensions, loads to be transferred to the structure, water passage dimensions (i.e. bulb support and draft tube), size and location of anchor bolts, dimensions of first stage concrete voids for installation of embedded components, weights and dimensions of heaviest and largest components to establish crane capacity and lift height requirements (when not specified by the Employer, refer to 3.5.10), details of lifting devices handled by crane, electrical inter-connections, 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 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 to 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 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 turbine anchor bolt and installation details, draft tube water passages 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 subsection 6.1.8 could be specified in TD section 5.4, and 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 to the intended purpose as demonstrated by the Contractor's prior experience or demonstrated by tests whose results are divulged to the Employer for acceptance.

– Specifications should be limited, where possible, to generic types of materials to leave the Contractor the choice of 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 general requirements in TD section 5.5.

– Required documentation attesting quality checks shall be established.

– Material test certificates including certificates for materials of doubtful origin.

– 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 verification points 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 finishing coats should be given to facilitate the preparation of estimates during the tender period.

– Minimum 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 5.8 and 5.9.

– 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 to be specified in these 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.

– Where 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, and
  – weldments.

3.9.3 Dimensional checks

Specifications should require that critical dimensions are 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 effects 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. guide vane servomotors);
– 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 present concisely the Employer's 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 should 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 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.

4.1 Bulb structure and hatch cover

A general description of the bulb structure and related generator hatch cover or pit should be given here.

4.1.1 Design data

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

– design pressure;
– concrete embedment pour rates, monitoring, verification, etc.;
– material by generic type or recognized national standards (indicate if alternatives will be accepted).

4.1.2 General data for connections and auxiliaries

The Employer should provide general data such as:

– generator overall dimensions (if applicable);
– location, size, and type of all other connections for peripheral or auxiliary systems (cooling water, potable water, service water, service air, etc.);
– location, size and details of access for maintenance.

4.2 **Stay ring** (if employed in design)

The Employer should provide a short description of the stay ring.

4.2.1 Design data

– Type of material.
– Loads to be supported.

4.2.2 General data for connections and auxiliaries

– Tolerances on location in plan and elevation.
– Provisions for concrete placement and grouting.
– Transportation and erection support and handling devices.

4.3 Discharge ring

Brief description of discharge ring.

4.3.1 Design data

– Special loading conditions, if any.
– External pressure.
– Minimum thickness.
– Minimum external rib arrangement.
– Removal of runner.
– Location of access hatch (if any).
– Material .

NOTE – Since the discharge ring is in close running clearance with the rotating runner blades, consideration should be given to the use of stainless steel plate construction for the ring because of the high cost of repairs if cavitation pitting damage occurs. Such protection should be extended to the draft tube liner immediately adjacent to the discharge ring for a defined distance (e.g. in the range of 0,15D to 0,25D).

– Transportation and site handling limitations.

4.3.2 General data, connections and auxiliaries

– Tolerances on location in plan and elevation.
– Provisions for concrete placement and grouting.
– Location, size, type and other details of connections (draft tube aeration, test, etc.).
– Temporary and permanent transportation and erection support and handling devices.

4.4 Draft tube and draft tube liner

Brief description of draft tube.

4.4.1 Design data

– Minimum external design pressure for liner.
– Minimum thickness (if pertinent).
– Minimum external rib stiffener arrangement.
– Type of material.
– Transportation and site handling limitations (dimensional).
– Concrete embedment rates and other details.
– Dimensional tolerances, concrete and liner.

4.4.2 General data, connections and auxiliaries

– Tolerances on location in plan and elevation.
– Provisions for concrete placement and grouting.
– Location, size, type and other details of connections (draft tube aeration, test, etc.).
– Temporary and permanent transportation and erection support and handling devices.

4.5 Upstream and downstream pressure taps and pipes

Brief description of pressure taps and pipes.

5 Technical specifications for stationary/removable components

Description of stationary/removable components.

5.1 Inner and outer rings

Description of inner and outer rings.

5.1.1 Design data

– Type of material.

5.1.2 Guide vane bushings

– Preferred material.
– Special features.

5.2 Guide vanes

Description of guide vanes.

5.2.1 Design data

– Rates for opening and closing when governor control system is not included in turbine supply.
– Requested type of material (resistant to corrosion and erosion).
– Preferred hydraulic torque characteristics.

5.2.2 Guide vane stems

– Material by generic type.
– Other requirements.

6 Technical specifications for guide vane regulating apparatus

Description of apparatus either with a regulating ring or an individual servomotor for each guide vane.

6.1 Servomotors

– Material type.
– Pressure test requirements.
– Maximum and minimum allowable operating pressure if governor supplied separately.
– Guide vane restoring device for governor.
– Other requirements regarding operation and maintenance.
– Cross-reference TD subsection 6.3.2.1 for opening and closing times.

6.2 Connecting rods

– Preferred arrangement.
– Minimum bushing requirements.
– Type of material.

6.3 Regulating ring

– Preferred arrangement.
– Type of material.

6.4 Guide vane linkage

– Preferred arrangement.
– Type of material.

6.5 Guide vane overload protection

– Preferred arrangement.
– Basic criteria.
– Criteria for readjustment.
– Overload indication.
– Overload annunciation.

6.6 Locking devices

– Preferred arrangement.
– Automatic or manual.
– "Closed" or "open" positions.
– Lock position detection.
– Lock position annunciation.

6.7 Counter weight

– Proposed function and arrangement.

7 Technical specifications for rotating parts, bearings, seals and gear box (if used)

Description of rotating parts and method of 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 now constructed from stainless corrosion resistant steel castings to minimize the adverse effects of cavitation pitting.
– Static balancing requirements.

7.1.2 Runner blades

Proper control of runner water passage shape and surface conditions is an important step in limiting potential cavitation damage. Proper quality control shall be provided during all phases of fabrication and manufacture to ensure that the final product is homologous to the model runner in the case of model tests or to the hydraulic design. Reference should be made to IEC 60193.

7.1.3 Runner hub, cone, blade packing, and bearings

– Description of runner hub, cone, blade packing, and bearings.
– Preferred arrangement.
– Material types.

7.2 Runner blade regulating apparatus

7.2.1 Blade servomotor and crosshead (if a Kaplan turbine is specified)

– General description.
– Preferred location (in shaft, in hub above or below blades).
– Material type.
– Pressure testing.
– Maximum and minimum allowable operating pressure if governor control system supplied separately.
– Other requirements regarding operation and maintenance.

7.2.2 **Runner blade trunnion** (if separate piece from runner)

– General description.
– Material type.

7.2.3 Rocker arm

– General description.
– Minimum bushing requirements.
– Material type.

7.2.4 Blade link

– General description.
– Minimum bushing requirements.
– Material type.

7.2.5 Oil head

– General description.
– Material type.
– Blade restoring device for governor (if furnished with turbine).
– Piping connections.

7.3 Main shaft

Description.

7.3.1 Design data

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

7.3.2 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 end.