TECHNICAL REPORT

IEC 61366-7

First edition
1998-03

Hydraulic turbines, storage pumps and pump-turbines –

Tendering Documents –

Part 7: Guidelines for technical specifications for storage pumps

Turbines hydrauliques, pompes d'accumulation et pompes-turbines –

Documents d'appel d'offres –

Partie 7:
Guide des spécifications techniques pour les pompes d'accumulation

Reference number
IEC 61366-7:1998(E)

Numbering

As from 1 January 1997 all IEC publications are issued with a designation in the 60000 series.

Consolidated publications

Consolidated versions of some IEC publications including amendments are available. For example, edition numbers 1.0, 1.1 and 1.2 refer, respectively, to the base publication, the base publication incorporating amendment 1 and the base publication incorporating amendments 1 and 2.

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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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Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

PRICE CODE V

For price, see current catalogue

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Part 7: Guidelines for technical specifications for storage pumps

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 61366-7, 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 61366-7 is one of a series which deals with Tendering Documents for hydraulic turbines, storage pumps and pump-turbines. The series consists of seven parts:

IEC 61366-1: 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 IEC 61366-1 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
1		Annexes
A		Sample table of contents of Tendering Documents for Francis turbines
B		Comments on factors for evaluation of tenders
C		Check list for tender form
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F		Example of cavitation pitting guarantees
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2 to 7		Technical specifications
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 7: Guidelines for technical specifications for storage pumps

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" of the Tendering Document, 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, instrumentation. It is common for Employers 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 clauses:

Francis turbines (Part 2);

Pelton turbines (Part 3);

Kaplan and propeller turbines (Part 4);

Tubular turbines (Part 5);

Pump-turbines (Part 6);

Storage pumps (Part 7).

The guidelines for preparation of storage pump specifications include technical specifications for the following:

– Design conditions: project arrangement, hydraulic conditions, specified conditions, modes of operation, generator characteristics, motor characteristics, synchronous condenser characteristics, speed-up procedure for pump-mode, transient behaviour data, change-over times and characteristics, stability of the system, noise, vibration, pressure fluctuations and safety requirements.
– Technical performance and other guarantees:
  - power;
  - discharge;
  - specific hydraulic energy (head);
  - efficiency;
  - maximum momentary pressure;
  - minimum momentary pressure;
  - maximum momentary reverse overspeed;

- maximum steady-state reverse runaway speed;
- cavitation pitting;
- hydraulic thrust;
- change over times;
- 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, the Contractor's drawings and data, the Contractor's review of the Employer's design and technical reports by the 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: Spiral case with compressible wrapping (if any), diffuser, suction tube, suction tube liner, pit liner, and foundation plates and anchorage.

– Stationary/removable components: Headcover, bottom ring, facing plates, stationary wearing ring, diffuser ring.

– Rotating parts, bearings and seals: Impeller, main shaft, guide bearing with oil supply, oil/water cooler, main shaft seal, standstill shaft seal.

– Thrust bearing (when specified as 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, pump pit hoist, nameplate, suction tube maintenance platform.

– Auxiliary systems: Impeller pressure balancing and pressure relief lines, pump pit drainage and other drainage systems; lubrication, tailwater depression, cooling water supply for impeller seal for blow-down operation.

– 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, 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 relief valves, high and low-pressure side valves or gates which, at the Employer's option, may be included in the Tendering Documents for storage pumps or may be specified in separate documents.

A storage pump may be driven by a motor or by a motor-generator in case of a tandem unit. In Part 7, the term motor is also used in the case of a motor-generator (tandem unit). Part 7 does not include the motor and electrical system which may, at the Employer's option, be included in the Tendering Documents for the storage pump or specified as separate documents.

Chapter 6 "technical specifications" of the Tendering Documents should be arranged as follows:

6.1 Technical requirements;

6.2 Technical specifications for embedded components;

6.3 Technical specifications for stationary/removable components;

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

6.5 Technical specifications for thrust bearing;

6.6 Technical specifications for miscellaneous components;

6.7 Technical specifications for auxiliary systems;

6.8 Technical specifications for instrumentation;

6.9 Spare parts;

6.10 Model acceptance tests;

6.11 Site installation and commissioning;

6.12 Field acceptance tests.

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 storage pumps.

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

IEC 60805:1985, *Guide for commissioning operation and maintenance of storage pumps and of pump-turbines operating as pumps*

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

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 Contractor. The general statement of scope of work presented in TD [1)] Section 2.1 (5.1 in IEC 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 in 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 layout, 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.

It is important to study in detail the general arrangement of a storage pump, especially in case of a ternary unit. The choice of a vertical or horizontal shaft arrangement may be influenced by civil engineering costs and cavitation behaviour of the pump.

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1) All references to Tendering Documents (TD) apply to annex A of IEC 61366-1.

The layout of a storage pump may lead to single or multistage and/or to single or double-suction arrangement. Economical operation and operational flexibility of a ternary unit may require additional machines and equipment such as starting turbine, engageable coupling, hydraulic converter as well as a booster pump to provide the necessary net positive suction specific energy (net positive suction head). There is the possibility to apply a motor with two or with variable speeds. Accordingly, it is recommended to evaluate in a preliminary study the most feasible solution.

The Employer should indicate the type of the main valve (shut-off valve) at the high-pressure side of the machine, eventually also the type of the valve at the low-pressure side.

Rare types of storage pumps, e.g. diagonal and axial storage pumps with adjustable impeller blades including tubular pump types are not presented in this part. For the description of additional components such as impeller blade servomotor assembly, oil pressure unit and regulator may be referred to Part 4 (Kaplan and propeller turbines) and Part 5 (tubular turbines).

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 Two vertical shaft, single flow, three stage storage pumps, each designed for a pump discharge of 4,5 m^3/s, at a specified hydraulic energy of 4 412.7 J/Kg (specified pump head of 450 m) and a rotational speed of 10 revolutions per second (600 rpm), directly coupled to a motor-generator with a maximum apparent power of 25 000 kVA;

2 Pump model testing;

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

4 Transportation and delivery to site;

5 Site installation, commissioning, and acceptance testing;

6 Preparation and submission of operation and maintenance manual and training of the 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 the Employer's drawings and data should give in detail 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 spiral case to penstock or valve on high-pressure side;

– details and location of the low-pressure side termination of the suction tube liner;

– details and location of valve(s) or gate(s) on low-pressure side;

– orientation and location of the pump/motor shaft coupling flange interface;

– responsibility for supply and installation of flange coupling bolts, nuts and guards at motor/storage pump coupling, including drilling jig;

– responsibility for supply and installation of bolts, nuts, gaskets at piping termination;

– termination of spiral case and suction tube dewatering piping;

– termination of spiral case air exhaust piping (if any);

– termination of pit drainage piping;

– termination of bearing lubricating oil piping;

– termination of shaft seal piping (if any);

– termination of piping (if required) to carry upper impeller seal leakage to the suction tube or to the drainage system;
– termination of cooling water piping for bearings;
– thrust bearing (if specified);
– 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 shut-off valves, motors, excitation systems, control metering and relaying systems, switchgear, power transformer, starting equipment, engageable couplings, hydraulic converters and booster pumps) are included with the storage pump 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 items should be considered:

– services during erection;
– temporary enclosures for site storage of storage pump 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 storage pump components - supply, placement and control, including monitoring and verification during and after concrete placement by others;
– grout injection if required either within or around storage pump components;
– powerhouse crane and operator;
– connections to powerhouse air, oil and water piping systems;
– supply of filtered water for storage pump 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 and bearing 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 Employer supplied items, are to be provided 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 all water ways at the low and high-pressure side, such as channels, galleries, penstocks, surge tank 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 the application of 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 the coordination of the interaction between the hydraulic machine and the water ways.

3.4.2 Hydraulic conditions

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

– specific hydraulic energy (pump 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;
– range of specific hydraulic energy (pump head) of the plant;
– specific hydraulic energy losses between tailwater level and low-pressure reference section of the machine ($E_{L\ 4\text{-}2}$);
– specific hydraulic energy losses between high-pressure reference section of the machine and headwater level ($E_{L\ 1\text{-}3}$);
– power values in the range of specific hydraulic energy (pump 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 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 storage pump starting and 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 synchronous condenser, isolated and black start operations and requirements, penstock filling through pump, etc.

b) Starting mode procedures and changeover sequences.

   The Employer should specify the method of starting procedure, e.g.:

   – Storage pump impeller(s) rotating in water
     • accelerated by the motor
     • accelerated by the turbine (ternary unit)
     • accelerated through a hydraulic converter
   – Storage pump impeller(s) rotating in air
     • accelerated by the motor
     • accelerated by a starting turbine
     • accelerated by the turbine (ternary unit)

   The Employer should indicate data (if any) required for changeover sequences, e.g.:

   – Standstill to pump mode
   – Pump mode to standstill

c) Specific hydraulic energy (*E*) [head (*H*)], discharge (*Q*) and power (*P*): The limits of specified specific hydraulic energy are determined from an analysis of the power plant situation, available discharge, power and specific hydraulic energy losses in the water ways. The Employer shall provide adequate data on any limitation on maximum and minimum discharge and on maximum power available to enable the Contractor to optimise the layout and design of the storage pump. The range of tolerance should be clearly defined (e.g. minus 6 % to plus 4 % of specified discharge).

   It is recommended to specify the maximum discharge or power under the lowest specific hydraulic energy or the minimum discharge under the highest specific hydraulic energy. In case of small ranges of specific hydraulic energy, it is sufficient to specify only one value of discharge or power.

d) Speed: The choice of speed of the unit has an impact on storage pump and motor costs, on the setting (see annex B, clause B.3 of IEC 61366-1) of the pump with respect to tailwater levels and on powerhouse costs. The choice of speed may also be influenced by strength considerations; e.g. in case of an underground powerhouse where, because of favourable cavitation conditions, a higher speed could be selected but the higher speed may be limited by strength considerations.

   If permitted by the project schedule, the approximate cost per meter of powerhouse setting, and the approximate cost per kVA for various possible speed options for the motor should be specified in the ITT (TD section 1.1.15) so that the Tenderers may quote the machine which best suits site conditions and their 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 storage pumps and motors to fix a "preferred speed"; alternative proposals may be invited in the ITT.

e) Direction of rotation: The direction of rotation of the storage pump is dictated by optimum orientation of the spiral case with respect to intake, penstock and power house costs. The direction should be specified clockwise or counterclockwise looking from the motor toward the pump.

3.4.4 Motor characteristics

The specifications should state the principle characteristics of the motor to which the storage pump will be coupled, for example:

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

3.4.5 Transient behaviour data

Transient operating conditions cause pressure and speed variations dependent on the type of machine and on the movement of the shut-off valve. Factors which need to be considered by the Employer in setting out criteria for calculation of transient phenomena (water hammer calculation) are:

– details of high-pressure and low-pressure conduits;
– inertia of rotating parts;
– velocity of pressure waves (sound velocity in water);
– high and low-pressure side valve(s)/gate(s) opening and closing time;

– transient characteristics (operating characteristics, four quadrant characteristics) of the pump;
– modes of operation;
– emergency conditions, e.g.
  • full or partial power failing
  • the main valve is closing
  • the valve does not close
  • when there are several units, one valve is closing only or all valves are closing.

The results of the water hammer calculation should confirm:

– pressure variations along the water conduits (maximum/minimum momentary pressure);
– pressure variations in the spiral case and suction tube;
– speed variations of the unit (maximum/minimum momentary speed and reverse runaway speed).

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 Contractor (refer to guarantees in 3.5.5 and 3.5.6).

3.4.6 Stability of the system

The Employer should furnish the information necessary in order to predict possible resonance in the water passages of the power plant and in the unit. Admissible limits may be specified for fluctuations of shaft torque and of pressure in the suction 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 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.

NOTE – The Employer should recognize that additional protection to reduce noise level may have a significant 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 suitable standards and 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 storage pump. 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 are outlined in annex E of IEC 61366-1 and should be read in conjunction with IEC 60041.

The main 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 model (without scale effect) or alternatively to the hydraulic performance of the prototype computed from model tests with allowance for scale effects, see IEC 60193. Efficiency guarantees on both model and prototype are not applicable.

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 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-ordinating the study of interaction between the machine and the external waterways under transient and steady-state oscillation 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 other 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 the Tenderer presents and states the 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 system.

When it is necessary to include other aspects of the machine under technical guarantees (such as noise and vibrations), the Employer should include these provisions at the end of this section taking into consideration that data available 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 refer to 3.4.3 (TD 6.1.4.3). Normally the maximum value of power in the whole range of operation is guaranteed. The Contractor should guarantee the power, which should not be exceeded (see annex E of IEC 61366-1). Increased frequency of the system should be considered (e.g. 52 Hz); refer to E.2.2c) and d) in Annex E of IEC 61366-1.

It is necessary, in this subclause, to establish the contractual obligations of the Contractor if the guaranteed power is not met or exceeded. The method(s) of measurements, method of comparison with guarantees and application for IEC 60041 shall be clearly defined.

3.5.3 Guaranteed discharge

The discharge is normally guaranteed for one or more specified values of specific hydraulic energy (pump head). This should take into account that the specific hydraulic energy E is the specific hydraulic energy of the plant E_g (plant head H_g) plus the specific hydraulic energy losses E_L (head losses H_L) in the water conduits on the low and high-pressure side (see 2.5 and figure 1 of IEC 61366-1).

It is necessary to establish in this subclause, the contractual obligations of the Contractor if the guaranteed discharge is not met. Method(s) of measurements, method of comparison with guarantees and application of IEC 60041 shall be clearly defined.

The Contractor guarantees the discharge, respectively the discharge to be reached or not to be exceeded (see annex E of IEC 61366-1).

3.5.4 Guaranteed efficiency

a) The Contractor guarantees the efficiencies for one or more specified value(s) of specific hydraulic energy (see 3.5.3). The Employer may establish and specify an efficiency weighting formula to allow an optimal layout of the storage pump.

b) Method proposed to measure guaranteed efficiency:
   - by model acceptance tests in the Contractor's laboratory or in another laboratory acceptable to both parties using test results without step-up. In this case, the guarantees have to be given for the model only (see clause 12); or
   - by using test results with a mutually agreed step-up formula (see IEC 60193 and clause 12); or
   - by field acceptance tests of one or more prototype storage pumps (see IEC 60041 and clause 14).

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

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

3.5.5 Guaranteed maximum zero-discharge (shut-off) specific hydraulic energy

The Contractor guarantees the maximum specific hydraulic energy generated by the storage pump when operating at specified speed against closed shut-off valve. The Employer should specify any higher speed in case a higher frequency of the electrical net has to be taken into account.

3.5.6 Guaranteed zero-discharge power

The Contractor should guarantee the zero-discharge power for the same conditions as indicated in 3.5.5. Depending on the starting procedure (see 3.4.3), the relevant power may be guaranteed for the power when the impeller(s) is/are rotating in air.

3.5.7 Guaranteed maximum/minimum momentary pressure

When the contract includes the contractual responsibility for an extended design of the plant including water hammer analysis, the Contractor should guarantee maximum and minimum momentary pressure (see 3.4.5). In the event, the Employer should specify all relevant data because of the involvement and influence of the motor and waterway system in the transient phenomenon.

3.5.8 Guaranteed maximum momentary reverse overspeed

The maximum momentary overspeed is the overspeed attained under the most unfavourable conditions. The maximum momentary overspeed should be guaranteed by the Contractor. However, the Employer should specify all relevant data because of the involvement and influence of the motor and waterway system in the transient phenomenon.

3.5.9 Maximum guaranteed steady-state reverse runaway speed

The technical specifications should require that the Contractor guarantees the maximum steady-state reverse runaway speed anticipated under maximum specific hydraulic energy (head) conditions of the storage pump.

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 clearly state the duration for which the unit shall be capable of functioning at maximum steady-state reverse runaway speed. The duration may vary from a few minutes to several hours operation 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 the 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 physical stresses of the civil structures and the ternary unit (particularly of the electrical machine) as compared with the high stresses which may occur with tests under full specific hydraulic energy (head). Value of maximum steady-state reverse runaway speed should be verified by model tests.

3.5.10 Partial runaway of the turbine in case of a tandem (ternary) unit (optional)

When a turbine of a tandem (ternary) unit is out of control and operates under runaway conditions and is rigidly coupled through the motor-generator with the filled storage pump, the storage pump generates a specific hydraulic energy at a certain speed (partial runaway of the turbine). It may be agreed that for such an abnormal condition, the Employer indicates the resulting speed and pump specific hydraulic energy.

3.5.11 Cavitation pitting guarantees

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

In the design of pumps and their application to a specific site, it is necessary to balance the increased cost for lower pump setting, larger impeller diameter, slower operating speed and increased 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 annex F of IEC 61366-1 which presents 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.

3.5.12 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 the design of the thrust bearing.

3.5.13 Guaranteed maximum weights and dimensions

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

3.5.14 Other technical guarantees

This subclause may cover other technical guarantees such as vibration, noise, pressure fluctuations including operation at zero discharge, radial thrust and behaviour of protective coatings.

The Employer may specify a guarantee to cover an emergency shut-down of the pump 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 Employer wishes to apply directly to the storage pump 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 storage pump 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 its conventional successful practice, he should be required 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 storage pump and motor equipment suppliers, as a part of their respective contract, should be required to carry out design of the dynamic behaviour of the combined motor and pump 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 "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 storage pump. Data should include such items as embedded component weights and dimensions, loads to be transferred to the structure, water passage dimensions (i.e. spiral case, pump case, foundation ring and suction tube), 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 3.5.13), details of lifting devices handled by crane, electrical interconnections, motor 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.

3.7.4 Contractor's review of Employer's design

A number of items in the design and layout of the storage pump 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 storage pump anchor bolt and installation details, suction tube water passages and other details which influence storage pump 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 ternary unit, installation procedures, commissioning and acceptance test procedures and similar items.

3.8 Materials and construction

3.8.1 Scope

– Care should be taken that specifications for materials and construction in TD sub-section 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 in TD subsection 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 the specifications, to dictate how the storage pump should be constructed but rather to provide sufficient data for the Contractor to establish the class of equipment which the Employer is willing to pay. The Contractor should be permitted to offer alternatives to the minimum specified requirements to thereby offering the maximum benefit of the Contractor's experience. The basis of such alternatives should be justified and documented.

3.8.2 Material selection and standards

– All materials to 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.

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

– Required documentation attesting to quality checks shall be established.

– Material test certificates including certificates for material of doubtful quality or origin.

– Procedures for repair of defects shall be established.

– Need for 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 storage pump 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 and maximum dry film thickness for each coat in the specified paint systems 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 of Tendering Documents. This is left to the judgement of 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 with 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 storage pump 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 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 called for major component requirements, it shall be assumed by the Contractor 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 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 storage pump.

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

3.9.4 Shop assembly and tests

The following factors should be considered:

– remoteness of project site;

– possibility of shipment of part or all of the storage pump fully assembled;

– thoroughness of dimensional checks;

– need for hydrostatic pressure test (e.g. spiral case, pump case);

– importance of a possible error in dimensional checks;

– 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 10 inclusive cover technical specifications for major components of the machine. These specifications should 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 storage pump 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 ITT and not in the technical specifications.

Components which are listed under fixed/embedded components may be components which are stationary and removable depending on arrangement and design of the storage pump.

Consistent with these explanations, TD section 6.2 should begin with a general description of the major components, for example:

The fixed/embedded components under TD section 6.2 for the storage pump to be provided shall include

– spiral case;
– diffuser ring;
– foundation ring or plates;
– suction tube;
– pit liner; and
– conveyor case.

4.1 Spiral case

A general description of the spiral case (cast or welded) should be given here. In some cases the diffuser ring may be combined with the spiral case (see 4.2).

4.1.1 Design data

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

– material by generic type or recognized international or national standards (indicate if alternatives will be accepted);
– design pressure has to be settled with the Contractor as the zero-discharge specific hydraulic energy of a storage pump depends on the pump characteristic;
– test pressure and location of test (shop or site);
– internal pressure during embedment;
– concrete embedment pour rates and other details.

4.1.2 General data, connections and auxiliaries

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

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

4.2 Diffuser ring

The diffuser ring may be a separate component or a part of the spiral case (see 4.1).

Description of the diffuser ring with the indication whether a separate replaceable diffuser ring should be included.

4.2.1 Design data

– Welded or cast diffuser ring.
– Type of material (erosion and corrosion resistant).
– Loads (weight of concrete, motor and other vertical loads in case of a vertical unit).

4.2.2 General data, connections and auxiliaries

– Location, size and type of connections (specify tolerances).
– Transportation, erection support and handling devices.

4.3 Foundation ring

Brief description.

4.3.1 Design data

– Loading conditions, if any.
– Material.
– 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.
– Transportation, erection support and handling devices.

4.4 Suction tube and suction tube liner (if any)

Brief description of suction tube including suction tube inlet part.

4.4.1 Design data

– Type of material.
– Transportation and site handling limitations.
– Concrete embedment rates and details.
– Dimensional tolerances, concrete and liner.
– Minimum external design pressure for liner.
– Minimum thickness if pertinent.
– Minimum external rib arrangement for limiting infiltration to powerhouse.

4.4.2 General data, connections and auxiliaries

– Location, size and details of access for maintenance.
– Location, size, type and details of impeller maintenance platform and devices.
– Extend of suction tube liner (if necessary).
– Location, size and details of all connections.
– Devices for suction tube water level controls.
– Transportation, erection support and handling devices.

4.5 Pit liner

– Location, size and details of piping connections (motor pit drainage, storage pump pit drainage, bearing cooling water, bearing lubricating oil, service air, central grease lubrication system, etc.).
– Transportation and erection support and handling devices.
– Permanent storage pump pit hoist, if required.

4.6 Conveyor case and return ring (if any)

These components have to be specified in case of multistage storage pumps.

4.6.1 Design data

– Type of material.
– Connections to other components.
– Shop assembly.
– Transportation and site handling limitations.

4.6.2 General data, connections and auxiliaries

The Employer should provide general data which applies to the conveyor case and return ring, such as:

– tolerances on location in plan and elevation;
– provision for concrete placement and grouting;
– location, size and type and details of connections;
– temporary and permanent transportation and erection support and handling devices.

5 Technical specifications for stationary/removable components

5.1 Headcover and bottom ring

Description of headcover and bottom ring.

5.1.1 Design data

– Comments on preferred arrangement (e.g. both headcover and bottom ring to be removable for maintenance; headcover as support component for the thrust bearing in case of a vertical unit).
– Type of material.

5.1.2 General data, connections and auxiliaries

– Location, size and details of all connections.
– Tolerances.
– Transportation, erection support and handling devices.

5.2 Stationary wearing rings

– Comments on preferred arrangements.
– Type of material, resistance against corrosion, erosion and cavitation.
– Compatibility of material used on rotating wearing rings, see 6.1.3.

5.3 Replaceable diffuser ring

See 4.2.

6 Technical specifications for rotating parts, bearings and seals

Description of rotating parts and method of erection and dismantling.

6.1 Impeller

Description of impeller.

6.1.1 Design data

– Minimum material requirements by generic type (weldable, corrosion resistant, erosion resistant and cavitation resistant).
– Support of impeller and shaft during erection and subsequent maintenance.
– Static balancing requirements.

6.1.2 Impeller water passage shape and surface

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

6.1.3 Rotating seal rings

– Compatibility with materials used on stationary wearing rings, see 5.2.

6.2 Main shaft

Description and specification of the main shaft and intermediate and/or auxiliary shafts (if any).

6.2.1 Design data

– Type of coupling (body bound studs, friction coupling, coin).
– Coupling standard, if any.
– Material type.
– Elevation of main shaft coupling flange(s) with respect to spiral case centreline.

– Coupling bolt holes interchangeability requirements.
– Define co-ordination with motor supplier for combined alignment, dimensional interface and critical speed.

6.2.2 Coupling bolts, nuts and nut guards

– Material type.
– Responsibility for supply and installation, including drilling template.
– Storage pump end.
– Motor end.
– Interchangeability.
– Locking devices.
– Nut guards for pump and motor ends.

6.3 Guide bearing

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

6.4 Main shaft seal

– General description.
– Material for housing and stationary wear elements.
– Design for longevity and easy 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.
– Shaft seal sleeve/sliding ring material type and special maintenance requirements.

6.5 Standstill (maintenance) seal

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

7 Technical specifications for thrust bearing (when specified as part of storage pump supply)

Description of bearing assembly and location.

7.1 Design

– Weights and loads on bearing external from storage pump or ternary unit.
– Conditions.
– Cooling water temperature range.
– Deflection limitations.

7.2 Bearing support

– Location.
– Materials.
– Accessibility.

7.3 Bearing assembly

– General description.
– 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.
– Oil contamination (test connections).
– Bearing temperature.
– Bearing oil temperature.

7.4 Oil injection pressure lift system

– General description.
– Number and type of pumps (a.c. and/or d.c.).
– Filter types.
– Flow regulators.
– Pressure detectors.

8 Technical specifications for miscellaneous components

Description of miscellaneous components.

8.1 Walkways, access platforms and stairs

– Pit access.
– Impeller inspection platform (removable).

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

8.2 Lifting fixtures

– Spiral case.
– Headcover.
– Pump case.
– Diffuser ring.
– Bottom cover.
– Impeller and shaft.
– Coupling bolts.
– Storage pump guide bearing.

8.3 Special tools

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

8.4 Standard tools

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

8.5 Storage pump pit hoist

– If required by storage pump size to facilitate maintenance of storage pump guide bearing etc.

8.6 Nameplate

– Minimum data.
– Size.
– Mounting location.

9 Technical specifications for auxiliary systems

Description of systems included.

9.1 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.

9.2 Impeller pressure balancing and pressure relief lines

Define responsibility for external piping, if any.

9.3 Storage pump pit drainage

– Describe preferred system.
– Define responsibility for all pumps, controls and piping, where required.

9.4 Tailwater depression system

– When the unit is used for synchronous condenser or for starting with impeller in air under depressed tailwater level.
– Quantity of air required for initial depression (see technical data sheets).
– Quantity of air required to sustain depression (see technical data sheets).
– Impeller wearing rings cooling with water or air.
– Maximum duration to fill accumulator.
– Limits of supply items.
– General description of system and its controls if included.

10 Technical specifications for instrumentation

Description of instrumentation.

10.1 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.

10.2 Indication

Define devices for indication such as:

– bearing oil level;
– shaft seal wear; and
– bearing temperature, etc.

10.3 Protection

Define protection requirements for example:

– bearing high temperature;
– shaft seal high temperature;
– excessive shaft displacement, etc.

11 Spare parts

Requirements for basic spare parts for storage pump should be established by the Employer.

Extent of spare parts will depend on operating criteria, location of project, 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 storage pump components.

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

– bearing shell or pads;
– stationary and rotating wearing rings;
– replaceable diffuser ring;
– shaft seal wear elements;
– 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.

12 Model acceptance tests

It is recommended that model tests be performed. The results may be used to determine the guaranteed or anticipated performance of the storage pump. The Employer may elect to use the Contractor's applicable existing model data available from previous homologous model tests. The Employer may also consider use of results from previous field tests of homologous storage pump in lieu of new 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 explain 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 storage pump 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.

The end use of the model test results 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 in accordance with IEC 60193;
– evaluation of model performance with regard to cavitation behaviour (setting of the machine);
– evaluation of specific operating characteristics, such as runaway speed, quadrant tests, hydraulic thrust, guide vane torque, etc., in accordance with IEC 60193;
– comparative/competitive model tests performed according to the rules of the model acceptance tests;
– evaluation of competing designs from different Tenderers;
– development model tests as the basis for the prototype design; in this case model tests will provide information on performance and machine behaviour at 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 months to 18 months programme. A check list for model test specifications is given in annex G of IEC 61366-1.

13 Site installation and commissioning tests

13.1 General

– Refer to IEC 60805.

– Elaborate on what is stated in TD section 5.9 and in TD subsections 6.1.1, 6.1.2 and 6.1.3.

– Outline clearly the limits of the Contractor's responsibilities.

– State method the Employer proposes to use to control, monitor and verify the Contractor's embedded parts and 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 should be permitted to comment on and agree to these provisions for control.

13.2 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 storage pump drawings and to location of measurement 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 motor.

– Requirements should be specified for measurements records to be made during alignment and installation; for example, clearances, relative location and rotational tests.

13.3 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.

13.4 Commissioning tests

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

– rotational checks;

– 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 check bearing behaviour and runout of rotating parts to permit setting of shaft runout monitors (if provided) to evaluate vibration, pulsation and noise;

– blow-down and refilling tests for synchronous condenser operation (if specified);

– operation of other storage pump components;

– load rejection tests.

14 Field acceptance tests

14.1 Scope and reports

Field acceptance tests should be done in accordance with IEC 60041 in particular with reference to clause 4 "Organisation of tests". 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).

If model acceptance tests have been performed, informative field tests may be conducted for relative efficiency (index tests), see clause 15 of IEC 60041.

14.2 Inspection of cavitation pitting

– Refer to 3.5.8.

– Define participation of contracting parties (see annex F of IEC 61366-1).

– 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 (pump head).

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

Would you please take a minute to answer the survey on the other side and mail or fax to:

Customer Service Centre (CSC)

International Electrotechnical Commission
3, rue de Varembé
Case postale 131

1211 Geneva 20
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.

ISBN 2-8318-4325-1

ICS 27.140

Typeset and printed by the IEC Central Office
GENEVA, SWITZERLAND