

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

Part 1: General and annexes

ICS 27.140

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the IEC title page, pages ii to iv, pages 1 to 40, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

This British Standard, having been prepared under the direction of the Engineering Sector Board, was published under the authority of the Standards Board and comes into effect on 15 September 1998

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ISBN 0 580 30316 0

Amendments issued since publication

Amd. No.	Date	Comments

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TECHNICAL REPORT

IEC
61366-1

First edition
1998-03

**Hydraulic turbines, storage pumps
and pump-turbines –
Tendering Documents –
Part 1:
General and annexes**

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

*Partie 1:
Généralités et annexes*



Reference number
IEC 61366-1:1998(E)

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

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1		General and annexes	1	Tendering requirements
1	—		2	Project information
1	1	Object and scope of this guide	3	General conditions
1	2	Reference documents and definitions	4	Special conditions
1	3	Arrangement of Tendering Documents	5	General requirements
1	4	Guidelines for tendering requirements	6	Technical specifications
1	5	Guidelines for project information	6.1	Technical requirements
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2		Francis turbines	6.5	Technical specifications for rotating parts, bearings and seals
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4		Kaplan and propeller turbines	6.7	Technical specifications for miscellaneous components
5		Tubular turbines	6.8	Technical specifications for auxiliary systems
6		Pump-turbines	6.9	Technical specifications for instrumentation
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			6.13	Field acceptance tests

0 Introduction

The application of hydraulic machines to a specific project is made from design criteria uniquely adapted to that particular site. Accordingly, the possibility of using identical machines from one site to another is usually remote because of many variations in basic design and operating conditions. For this reason, it is not feasible in a single publication of this type to develop standard documents which cover a wide range of site specific applications or to specify in detail the various machine types. However, the technical report will assist in preparation of Tendering Documents (TD) through the use of a common layout which takes advantage of uniformity and the time-saving features of word processing software. A uniform approach of the type proposed will make it easier for the Employer to prepare the Tendering Documents and for the Tenderer to prepare its proposal.

The report outlines the various chapters needed for a complete set of Tendering Documents, together with comments on the purpose of each and discussions as necessary. The guide is intended to assist in making certain that information is placed in the appropriate section; thereby avoiding possible conflict or duplication. This results in a greater degree of completeness in the documents and adds to their adaptability and ease of updating while minimizing misinterpretations.

The main objective for inviting competitive tenders for hydraulic machines is to purchase the most economical equipment which will meet the performance requirements of the specific site. The capital investment in machinery is a significant one; it can range from 20 % to 50 % of project costs. The value of machine performance becomes an important item of concern in the purchasing process. This guide contains some information on methods of evaluation and means of establishing performance criteria to assist in achieving optimum equipment selection.

In preparing Tendering Documents, cognisance should be taken of problems which may be encountered by unnecessarily restrictive specifications, particularly when applied to machines of small to moderate sizes within the range covered by the guide. Restrictive requirements may add significantly to the cost of the equipment without a proportional gain in its reliability or performance. It is important therefore that Tendering Documents properly define and describe, in an effective manner, the specific conditions of operation, size, number of units to be installed, and special features required, if any.

Tendering Documents which require an inordinate amount of information from Tenderers can also unnecessarily increase the costs for preparing and evaluating tenders. This may also unnecessarily restrict the successful Contractor's freedom to apply an optimal design and may deter the Tenderer from tendering at all. Information requested in the technical data sheets, therefore, should be limited to that which is really essential for evaluation and comparison of tenders by the Employer and engineer.

In conclusion, this guide should not be used to replace the engineering effort needed in the selection, design, manufacturing, installation, and testing of the machines and associated systems; nor does it contain complete detailed specifications and descriptions of conditions or components. It is assumed that qualified engineering personnel will be engaged on the project to undertake the necessary evaluation of site conditions and selection of equipment which will meet the performance, operation, reliability, and maintainability criteria established for the project.

1 Scope and object

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.

The object of this technical report is to provide a general guide for preparation of Tendering Documents (TD) for the supply, installation and testing of hydraulic turbines, storage pumps, and pump-turbines herein referred to as hydraulic machines as defined in 2.2 of this publication. This technical report considers the case where both equipment supply and site installation are carried out by the same Contractor. In those cases where site installation is not included in the scope of work, the Tendering Documents should include supplementary provisions for site supervisory services to be provided by the equipment supply Contractor and for day-to-day interface with the site installation Contractor.

Hydraulic machines for small units with power less than 5 MW and with runner/impeller diameters less than 3 m are covered in IEC 61116. These limitations are not intended to be absolute and will depend on the type of machine and on other project characteristics.

2 Reference documents and definitions

2.1 Reference documents

2.1.1 Application of reference documents

The adoption of reference documents can greatly assist users of this guide by avoiding unnecessary duplication of standards and codes which have gained industry acceptance. There are a number of sources for reference documents such as IEC, ISO, regional or national standards, and other recognized standards. It is strongly recommended that users take advantage of such standard documents in preference to developing new versions for similar requirements. The Employer should be prepared to provide copies of non-international standards to the Tenderers and/or the Contractors upon request.

2.1.2 IEC publications

IEC publications (in their latest revision), as they apply, should be used and referenced in the preparation of Tendering Documents and the related technical specifications. The list of IEC publications relating to hydraulic machinery is as follows:

IEC 60027, (all parts), *Letter symbols to be used in electrical technology*.

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

IEC 60617, (all parts), *Graphical symbols for diagrams*.

IEC 60193, — *Model acceptance tests to determine the hydraulic performance of hydraulic turbines, storage pumps and pump-turbines (to be published)*.

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

IEC 61362, — *Guide to specification of hydroturbine control systems*.

IEC 61116:1992, *Electromechanical equipment guide for small hydroelectric installations*.

IEC 61364:1998, *Nomenclature of hydraulic machinery*.

IEC 60034, (all parts), *Rotating electrical machines*.

2.1.3 ISO standards

In addition to IEC publications, numerous internationally accepted recommendations have been prepared by ISO, some of which may apply to specific items. If a contradiction is found between IEC standards and ISO standards, the IEC standards shall govern.

2.1.4 National standards

Where no applicable international standards exist, regional and/or national standards should be used in preference to developing unique requirements. In this connection, where equivalence of national standards has been previously established by the Employer, this equivalence should be accepted for subsequent projects.

Where national standards are mandatory by law, such requirements shall be specified in the documents. The Employer should provide copies of mandatory standards to Tenderers and/or Contractors upon request or specify where such standards may be obtained.

2.2 Definitions

The following definitions apply to this guide:

Words for which definitions are given in IEC publications shall be used only with the meanings defined by IEC. No other definitions shall be used for such words.

2.2.1 employer

party named in the Tendering Documents which will employ the Contractor and the legal successors in title to the Employer but not, except with the consent of the Contractor, any assignee of the Employer. Employer shall also mean purchaser and owner

2.2.2 contractor

party whose tender has been accepted by the Employer and includes the Contractor's personal representatives, successors, and permitted assignees. The Contractor shall also mean supplier

NOTE The terms Employer and Contractor are in agreement with relative use in FIDIC documents, see 6.1.

2.2.3 guide

this technical report for the preparation of Tendering Documents for hydraulic turbines, storage pumps and pump-turbines

2.2.4**hydraulic machinery**

hydraulic impulse or reaction turbines, storage pumps, or pump-turbines

2.2.5**turbine**

hydraulic turbine. Its meaning shall also include a pump-turbine operating as a turbine

2.2.6**pump**

pump and it shall also include a pump-turbine operating as a pump

2.2.7**tendering Documents**

complete documents including the tendering requirements, project information, general conditions, special conditions, general requirements, technical specifications and drawings prepared for the purpose of soliciting tenders for hydraulic machines

2.2.8**tendering requirements**

instructions to Tenderers, tender proposal form, technical data sheets, and other contractual forms

2.2.9**tenderer**

as the context requires, any party or parties tendering on the various classes of work and services covered by the Tendering Documents

2.2.10**tender**

proposal prepared by Tenderer and submitted to the Employer in response to Tendering Documents

2.2.11**contract documents**

includes the Employer-Contractor agreement, the Tendering Documents, all addenda issued prior to execution of contract, and all modifications thereto, and any other items specifically stipulated as being included in the contract documents

2.2.12**contract**

agreement entered into between the Employer and the Contractor for work to be done and/or material and equipment to be furnished in accordance with the Tendering Documents and the Contractor's tender proposal which will be either referred to in or attached to and form part of said agreement. Contract shall also mean all written information, specifications, and drawings which further detail, explain or modify by mutual agreement the work even though such written information, specifications, and Contractor's and Employer's drawings are issued after execution of said agreement

2.2.13**work**

material, labour, equipment, services, and all the various classes of work to be executed, whether temporary or permanent, under the contract. It also means the place of working where the context so indicates

2.2.14**licensor**

owner of intellectual property such as patents, proprietary information, know-how who authorises another party, the licensee, to use said intellectual property

2.2.15**engineer**

person, firm, or company appointed and designated by the Employer to act as the engineer for the purposes of the contract

2.2.16**engineer's representative**

any engineer or assistant of the engineer appointed from time to time by the Employer or the engineer to perform the duties set forth in the Tendering Documents whose authority shall be notified in writing to the Contractor by the engineer
terminology for different machine components shall be as defined in the IEC 61364

2.3 Schematic representation of a hydraulic machine

The limits of a hydraulic machine are represented in Figure 1 and Figure 2 in which the terms “high-pressure reference section” and “low-pressure reference section”, as well as “high-pressure side” and “low-pressure side” are identified.

The terms “high-pressure reference section” and “low-pressure reference section” define the high-pressure and low-pressure sides of the hydraulic machine irrespective of the flow direction. Therefore, the terms are independent of the mode (turbine or pump) of operation of the machine. The “high-pressure reference section” and “low-pressure reference section” of the machine are those to which hydraulic performance guarantees apply.

Refer to IEC 60041 for other technical terms, definitions, symbols and units.

2.4 Use of SI units

The International system of units (SI) applies to this guide. All terms used in the Tendering Documents should be given in SI units in order to comply with the IEC publications which relate to performance tests of hydraulic machines (either model or prototype).

In the SI system, mass (kg) is one of the base units. The energy per unit mass, known as “*specific hydraulic energy*”, is used in this guide as a primary term instead of energy per local unit weight, known as “*head*”.

The term “head” has the disadvantage that weight depends on acceleration due to gravity (g) which changes with both latitude and altitude. These changes can influence the absolute measurements of hydraulic performance of a machine and could lead to unnecessary confusion in the interpretation of the final test results. The term “head” differs from the term “specific hydraulic energy” only by the factor “ g ” which is the local value of acceleration due to gravity. Accordingly, the term “specific hydraulic energy” should be used when specifying performance guarantees and related requirements in the Tendering Documents. The term “head” may remain for some time because it has been in use for many decades. In this guide, the term “specific hydraulic energy” will be followed by the term “head” in parenthesis.

2.5 Specific hydraulic energy

The “specific hydraulic energy of the machine”, with the symbol E , is the specific energy of water (J/kg) available between the high and low-pressure reference sections of the machine taking into account the influence of compressibility. For a more definitive definition for practical application, refer to 2.3.6 of IEC 60041.

$$E = \frac{(\rho_{\text{abs}} - \rho_{\text{abs2}})}{\bar{\rho}} + \frac{(v_1^2 - v_2^2)}{2} + (z_1 - z_2) \times \bar{g}$$

where

ρ_{abs}	is the absolute pressure (Pa)
ρ	is the density (kg/m ³)
v	is the velocity (m/s)
z	is the elevation of point in the system above reference datum (usually mean sea level)
g	is the acceleration due to gravity (m/s ²)
$\bar{\rho}$	$0,5 \times (\rho_1 + \rho_2)$
$\bar{g}$	$0,5 \times (g_1 + g_2)$

The application of “specific hydraulic energy” to a particular project requires care in identifying losses:

E_g	is the specific hydraulic energy of the plant which is defined as the specific hydraulic energy of water (J/kg) available between headwater level and tailwater level;
E_L	are the specific hydraulic energy losses between any two sections (J/kg);
E	is the specific hydraulic energy of the machine (J/kg).

Assume $E_L = E_{L3-1} + E_{L2-4}$ (refer to Figure 1)

where

E_{L3-1}	is the specific hydraulic energy loss between headwater level 3) and high-pressure reference section 1);
E_{L2-4}	is the specific hydraulic energy loss between the low-pressure reference section 2) and tailwater level 4).

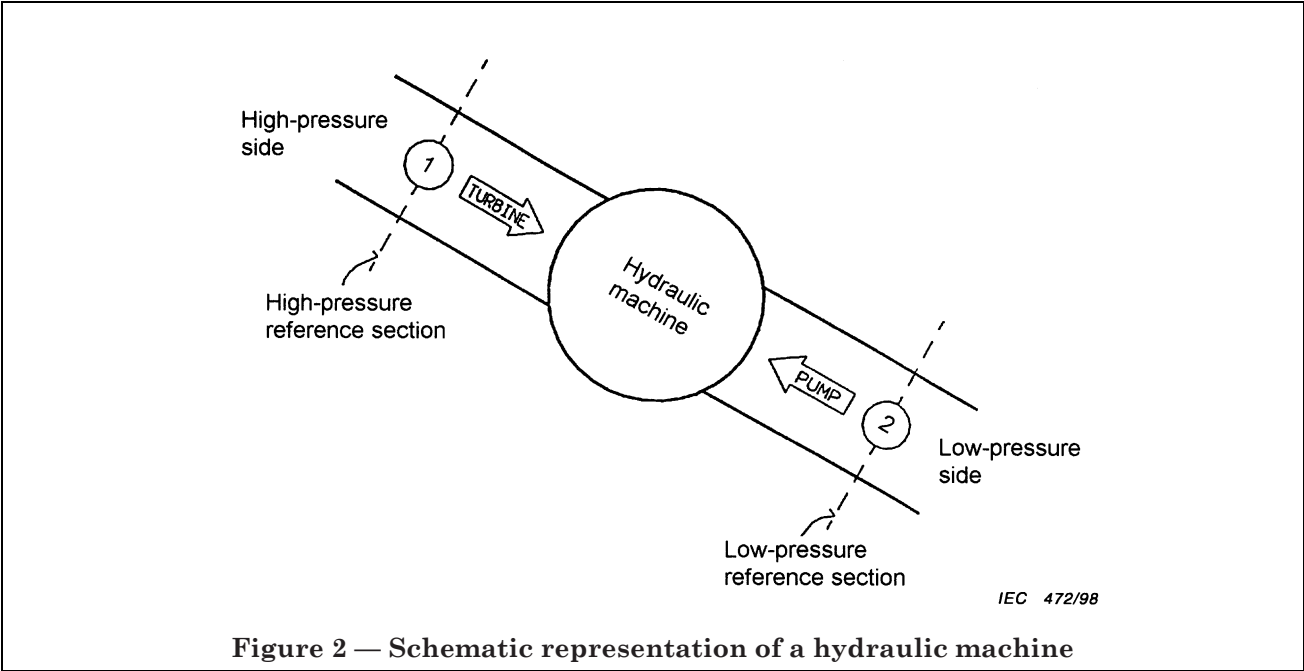
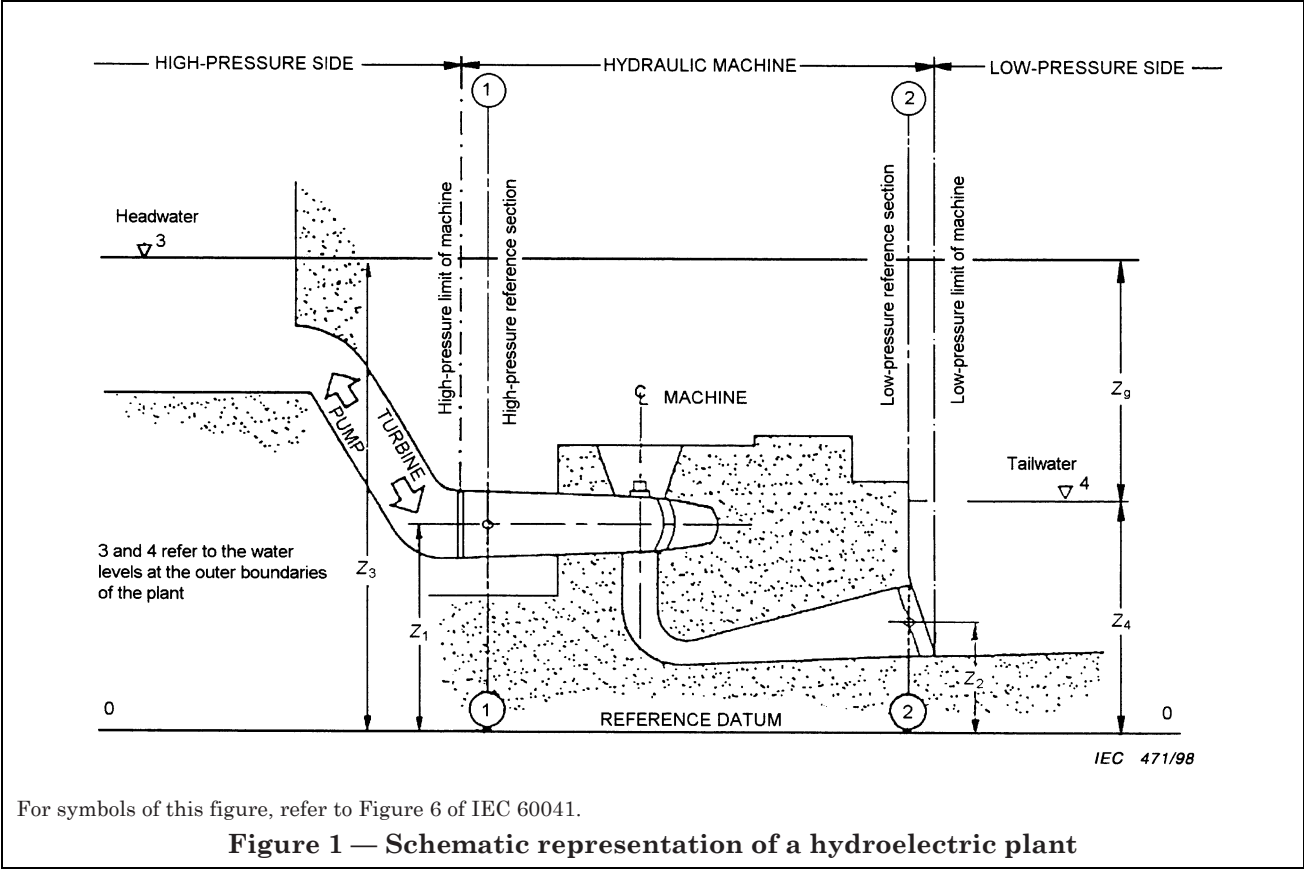
For a turbine: $E = E_g - E_L$ (J/kg)

For a pump: $E = E_g + E_L$ (J/kg)

Derived quantities (also used in previous IEC publications):

H (turbine head) ^a	$= E/\bar{g}$ (m)
H_g (plant head) ^a	$= E_g/\bar{g}$ (m)
H_L (head losses) ^a	$= E_L/\bar{g}$ (m)

^a Use of these terms in Tendering Documents should be avoided.



2.6 Specified conditions

This guide uses the term “specified” to describe or denote values of quantities such as power, specific hydraulic energy (head), speed, discharge, etc. which dictate the design conditions for the hydraulic machine. Terms starting with the prefix “rated” (such as rated power, rated specific hydraulic energy, and rated discharge) should no longer be used.

3 Arrangement of Tendering Documents (TD)

3.1 General

It is recommended that the Tendering Documents (TD) used for procurement of hydraulic machinery be prepared in a standard layout. This should reduce the time taken to prepare the documents, ensure that they are presented in an orderly and thorough manner, and avoid confusion in their subsequent interpretation.

3.2 Table of contents

The sample table of contents for Tendering Documents for Francis turbines (Annex A) is based on the following arrangement of main chapters:

Chapter	Title
1	Tendering requirements (see clause 4)
2	Project information (see clause 5)
3	General conditions (see clause 6)
4	Special conditions (see clause 6)
5	General requirements (see clause 6)
6	Technical specifications for hydraulic machines (see Parts 2–7)
7 ^a	Technical specifications for hydro-turbine control systems
8 ^a	Technical specifications for oil pressure systems
9 ^a	Technical specifications for high-pressure side [shut-off] valves or gates
10 ^a	Technical specifications for relief valves
11 ^a	Technical specifications for low-pressure side valves or gates
12 ^a	Technical specifications for thrust bearings (when not part of hydraulic machine supply)

^a Use of these terms in Tendering Documents should be avoided.

Tendering Documents (TD) for hydroelectric power equipment procurement, may at the option of the Employer, include related equipment other than hydraulic machinery such as generators or motors; motor-generators; excitation and/or starting systems; control, metering and relaying panels; bus duct equipment; switchgear; power transformers; etc.

The Tendering Documents (TD) should be arranged in chapters, sections, and subsections as follows:

1 Chapter

1.1 Section

1.1.1 Subsection

1.1.1.1 Use only as required

Chapters 2 (Project information), 3 (General conditions), and 5 (General requirements), may be common to all Tendering Documents for machine procurement on a given project. These chapters contain much information which applies specifically to the project, therefore they need to be carefully co-ordinated between the Employer and the engineer.

Chapter 6 will vary according to the type of hydraulic machine for which the Tendering Documents are being prepared. Guidelines for the preparation of technical specifications for various types of hydraulic machines are provided in (parts 2 to 7 of this guide). There may be occasions, however, when it may be necessary because of the characteristics of the site to have the choice between two different types of machines remain open to Tenderers. This will permit Tenderers to prepare their tenders on the basis of their equipment designs which may offer performance and/or cost advantages for the particular site. In this event, chapter 6 (main tender) and chapter 6-1 (alternative) should be used for the main or alternate machine types, respectively, in which the contents and numbering systems would be similar for uniformity.

When the decision is made to include the full range of equipment and systems for a single unit or units in a combined set of Tendering Documents, additional chapters may be added to the technical specifications as illustrated above (i.e. chapters 7 to 12, inclusive). Guidelines for preparation of technical specifications for equipment and systems other than for hydraulic machines, however, are not given in this guide.

Technical specifications for machines and systems other than hydraulic machines should be prepared using the same or similar headings and numbering systems illustrated for TD chapter 6 in parts 2 to 7 for the various machine types. This will retain continuity throughout the Tendering Documents. In parts 2 to 7 of this technical report, subclause numbering corresponds to subsection numbering of chapters in the Tendering Documents (see Annex A).

A detailed sample table of contents for the Tendering Documents prepared in this case for Francis turbines is provided in Annex A. This guide follows the sequence of the various chapters and sections in Annex A in accordance with the general scheme explained above. The table of contents may have to be modified to accommodate other types of hydraulic machines.

3.3 Main sections of the Tendering Documents

The chapters of the Tendering Documents are briefly described in this clause. Reference is made to other clauses in the guide where more information is given for the main chapters.

3.3.1 *Tendering requirements* (see clause 4)

3.3.1.1 *Instructions to Tenderers* (herein referred to as ITT)

The main purpose of the ITT is to list, explain, and bring to the attention of the Tenderers, those items which specifically apply to the preparation of tenders. The ITT should contain instructions to the Tenderers clarifying the Employer's request for tenders, closing date, submittal of information, options to be considered, and data concerning evaluation of tenders. The Employer should make certain that matters of importance for the administrative validity of the tender are listed in the ITT only and not in the technical specifications. To avoid confusion, all requirements for preparation of the tenders should be stated only in the ITT and should not be hidden in other chapters of the Tendering Documents.

3.3.1.2 *Tender forms*

Tender forms are formal documents which are to be completed by the Tenderer. The tender forms include pricing information, formal signatures of the Tenderer, tendering bond (if used), and other related information such as license agreements. See Annex C for check list of tender forms.

3.3.1.3 *Technical data sheets*

Blank data sheets should be prepared by the Employer to show technical information required from each Tenderer. This will ensure that technical and project related information describing the product proposed by Tenderer is in a common tabular format for convenient evaluation of the tenders. An example of technical data sheets is given in Annex D.

3.3.1.4 *Tenderer's drawings*

Drawings referred to in this section are those which are to be prepared by the Tenderer to illustrate details of the equipment and systems to assist in the Employer's evaluation of the tenders.

3.3.1.5 *Other contract forms*

These forms, to be completed by the successful Tenderer, include performance bond, form of Agreement, and other forms specified by the Employer.

3.3.2 *Project information* (see clause 5)

This section provides a description of the scope of work, project conditions, scheduling requirements, operating conditions, project drawings, and other project-related information. The location of this section near the beginning of the Tendering Documents serves as an important reference summary of the work.

3.3.3 *General conditions, special conditions, and general requirements* (see clause 6)

3.3.3.1 *General conditions*

The general conditions are contractual requirements normally established by the Employer to meet corporate or business needs.

3.3.3.2 *Special conditions*

Special conditions are used to amplify, qualify, or alter the general conditions for the specific Tendering Documents.

3.3.3.3 *General requirements*

The purpose of general requirements is to consolidate those requirements which are of a general technical nature. Adaptation of these requirements should be possible from one contract to another within the project.

3.3.4 *Technical specifications*

Technical specifications contain engineering and technical details from which the Tenderers will prepare their tender, and from which the Contractor will design, manufacture, install, and test the machine. The technical specifications, as proposed in this guide, will make it possible to have the Tendering Documents in a convenient form for the purchase of a complete generating/pumping unit or units. Technical specifications for specific machine types are contained in the following parts of the guide:

- Guidelines for technical specifications for Francis turbines (Part 2)
- Guidelines for technical specifications for Pelton turbines (Part 3)
- Guidelines for technical specifications for Kaplan and propeller turbines (Part 4)
- Guidelines for technical specifications for tubular turbines (Part 5)
- Guidelines for technical specifications for pump-turbines (Part 6)