IEC 62006

Edition 1.0 2010-10

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Hydraulic machines – Acceptance tests of small hydroelectric installations

Machines hydrauliques – Essais de réception des petits aménagements hydroélectriques

IEC 62006:2010

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

PRICE CODE
CODE PRIX XE

ICS 27.140

ISBN 978-2-88912-228-8

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

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International Standard IEC 62006 has been prepared by IEC technical committee 4: Hydraulic turbines.

The text of this standard is based on the following documents:

FDIS	Report on voting
4/254/FDIS	4/257/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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HYDRAULIC MACHINES – ACCEPTANCE TESTS OF SMALL HYDROELECTRIC INSTALLATIONS

1 Scope

This International Standard defines the test, the measuring methods and the contractual guarantee conditions for field acceptance tests of the generating machinery in small hydroelectric power installations. It applies to installations containing impulse or reaction turbines with unit power up to about 15 MW and reference diameter of about 3 m. The driven generator can be of synchronous or asynchronous type.

This International Standard contains information about most of the tests required for acceptance of the hydraulic turbine such as safety approval tests, trial operating and reliability tests, as well for verification of cavitation, noise and vibration conditions, if required.

This standard represents the typical methods used on smaller hydroelectric installations, and is divided into three classes as follows (see Table 1 for more detail):

Class A	Normal test program (panel measurement) To determine the maximum power output of the installation.	**Default**
Class B	Extended test program To determine the performance characteristics of the installation.	**Recommended**
Class C	Comprehensive test program To determine the absolute efficiency of the installation.	**Optional**

NOTE All classes contain safety tests, trial operating tests, and reliability tests.

This standard gives all necessary references for the contract in order to execute the test, evaluate, calculate and compare the result to the guarantee for all the classes A, B and C.

The manufacturer or consulting engineer is responsible for ensuring that standardized connections are installed for performing these tests. This standard does not cover the structural details of a hydroelectric installation or its component parts.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60041:1991, *Field acceptance tests to determine the hydraulic performance of hydraulic turbines, storage pumps and pump turbines*

IEC 60193, *Hydraulic turbines, storage pumps and pump-turbines – Model acceptance tests*

IEC 60308, *Hydraulic turbines – Testing of control systems*

IEC 60609 (all parts), *Hydraulic turbines, storage pumps and pump-turbines – Cavitation pitting evaluation*

IEC 60651, *Specification for sound level meters*

IEC 61362, *Guide to specification of hydraulic turbine control systems*

ISO 1680 *Acoustics – Test code for the measurement of airborne noise emitted by rotating electrical machinery*

ISO 1940-1:2003, *Mechanical vibration – Balance quality requirements for rotors in a constant (rigid) state – Part 1: Specification and verification of balance tolerances*

ISO 3746, *Acoustics – Determination of sound power levels of noise sources using sound pressure – Survey method using an enveloping measurement surface over a reflecting plane*

ISO 4412 (all parts), *Hydraulic fluid power – Test code for determination of airborne noise levels*

ISO 5168, *Measurement of fluid flow – Procedures for the evaluation of uncertainties*

ISO 7919-5, *Mechanical vibration – Evaluation of machine vibration by measurements on rotating shafts – Part 5: Machine sets in hydraulic power generating and pumping plants*

ISO 10816-3, *Mechanical vibration – Evaluation of machine vibration by measurements on non-rotating parts – Part 3: Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15 000 r/min when measured in situ*

ANSI/IEEE 810, *Hydraulic Turbine and Generator Integrally Forged Shaft Couplings and Shaft Runout Tolerances*

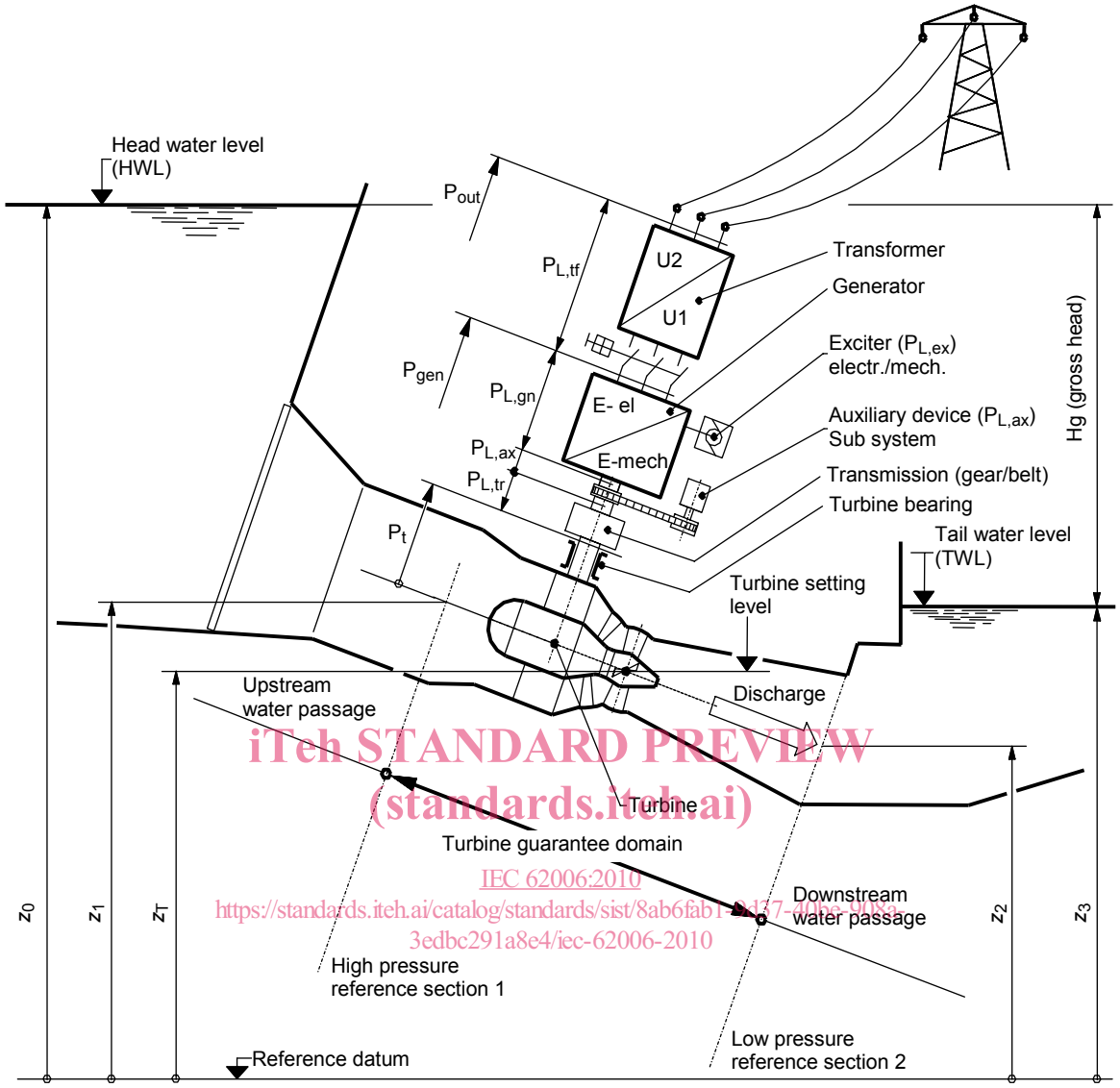
3 Terms, definitions and schematic layout

3.1 Terms and definitions

A complete list of terms and definitions is given in Annex A.

3.2 Schematic layout of a hydroelectric installation

In general, there are three connected hydraulic regimes in a hydroelectric installation as shown in Figure 1 below. These are the upstream water passage, the turbine guarantee domain, and the downstream water passage.



NOTE The losses in the upstream and downstream water passage are not part of the turbine losses. Nevertheless, they may influence the hydraulic conditions in the turbine guarantee domain and lower the efficiency of the turbine. Only the energy losses in the turbine guarantee section are to be considered when measuring the efficiency of a turbine. If it is not possible to measure the energy in the reference section 1 and 2, the measuring section should be changed in agreement with all parties.

The definition of the reference section 1 and 2 and that of net head and specific energy for the most common small turbines is given in Annex B.

Figure 1 – Schematic layout of a hydroelectric installation (water to wire system)

4 Nature and extent of guarantees

4.1 Grouping of classes A, B, C

4.1.1 General

The scope of the measurement classes for hydroelectric installations is shown in Table 1.

Table 1 – Scope of classes A, B, and C

Class A	**Normal (panel measurement) test program**
Class B	**Extended test program**
Class C	**Comprehensive test program**

Measurement of class		C	B	A	Clause
Safety tests	(commissioning)				5
Pre-start tests	(dry test)	yes	yes	yes	5.1
Closing devices	(dry and wet tests)	yes	yes	yes	5.2
First run operation and control	(wet tests)	yes	yes	yes	5.3
Bearing run at rated speed		yes	yes	yes	5.4
Emergency shutdown (no load)		yes	yes	yes	5.5
Electrical protection		yes	yes	yes	5.6
Overspeed test		yes	yes	yes	5.7
Runaway test		no/opt	no/opt	no/opt	5.8
Overpressure, emergency trip and load rejection tests		yes	yes	yes	5.9
Trial operating and reliability tests	(commissioning)				6
Temperature stability of rotating parts		yes	yes	yes	6.2
Speed controller system		yes/opt	yes/opt	yes/opt	6.3
Control of cam correlation (double regulated turbines)		yes	yes	yes	6.4
Performance guarantees and tests					7
Maximum generator (transformer) power output		[a]	[a]	yes	7.2
Index test					7.3
- Shape control		[a]	yes	–	7.3.3
- Index plant efficiency		[a]	yes	–	7.3.4
- Optimizing cam correlation		[a]	[a]	[a]	7.3.5
Turbine efficiency					7.4
- Absolute discharge measurement		yes	–	–	7.4.1
- Thermodynamic method		yes	–	–	7.4.2
Computation of results and comparison to the guarantee		yes	yes	yes	8
Error analysis		yes	yes	yes	9
Other guarantees					10
Cavitation		yes/opt	yes/opt	yes/opt	10.1
Noise		no/opt	no/opt	no/opt	10.2
Vibration		no/opt	no/opt	no/opt	10.3

NOTE Definitions used in Table 1 are the following:

yes – may be required.

yes/opt(ional) – normally yes, but depends on the turbine type and site conditions.

no/opt(ional) – normally no, but depends on the turbine type and site conditions.

[a] included in other tests.

– not required.

4.1.2 Contract conditions

The contract specifies the guarantees, and includes the scope of the tests, and the classification of measuring instruments. Safety tests shall always be included. The condition of the plant, water quality, and setting levels shall all be specified (see Annex F).

4.2 Scope of performance guarantee

4.2.1 General

All guarantees concern the hydraulic passage between reference section 1 and 2 (turbine guarantee domain) and the corresponding net head. The guaranteed data required for each class is given below:

4.2.2 Class A: Maximum power output

a) Maximum power output of the generator, including losses a) to d) of 4.2.5 — $P_{gen,\ max} = f\ (H)$

b) Maximum power output of the transformer, including losses a) to e) of 4.2.5 — $P_{out,\ max} = f\ (H)$

- Power output versus net head, see Figure 15
- Discharge versus turbine opening, see Figure B.18
- Electrical connection sheet, see Annex D

4.2.3 Class B: Index test

Shape control of turbine characteristic for newly commissioned turbines, and for refurbishment projects to compare pre- and post- refurbishment measurements.

a) Shape control — $\eta_{ix} = f\ (P_t)$

- Expected shape of plant efficiency, see Figure 16
- Possible deviation to the shape, see Figure 16
- Hill chart if the head differs by more than 3 %, see Figure 19

b) Index plant efficiency — $\eta_{plant\ Ix} = f\ (P_{out})$

- Hill chart, see Figure 19
- Generator losses, see Annex D
- Electrical connection sheet, see Annex D

c) Optimizing of cam correlation for double regulated turbines

- Pre-adjusted opening of guide vane versus runner blade opening as a function of static head, see Annex I

4.2.4 Class C: Turbine efficiency

a) Absolute discharge measurement — $\eta_t = f\ (P_t)$

b) Thermodynamic method — $\eta_t = f\ (P_t)$

- Hill chart, see Figure 19
- Generator losses, see Annex D
- Electrical connection sheet, see Annex D

4.2.5 Interpretation of losses

The parties shall agree on interpretation of losses due to the following mechanical and electrical equipment:

a) turbine bearings and additional equipment;