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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Hydraulic turbines – Testing of governing systems

Turbines hydrauliques – Essais des systèmes de régulation

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This third edition cancels and replaces the second edition published in 2005. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) adoption of parts of IEC 61362:2024 which deal with test matters;
b) introduction of new technical aspects;

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

Draft	Report on voting
4/497/FDIS	4/503/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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INTRODUCTION

The first and second editions of this document were developed to have a comprehensive description for the test of hydraulic turbine governing systems according to the corresponding state of the art. They were published independently of the guide to specification of hydraulic turbine governing systems (IEC 61362). This third edition was developed together with IEC 61362 in order to harmonize their contents and their publishing dates. Furthermore, the standards are kept open for state of the art by introducing new topics and harmonizing the structure as well as the terms and definitions for both standards.

HYDRAULIC TURBINES – TESTING OF GOVERNING SYSTEMS

1 Scope

This document covers acceptance tests and the related specific test procedures for hydraulic turbine governing systems. It can be used to fulfil following tasks:

– verification of system characteristics according to specification;
– verification of technical guarantees;
– verification of general proper functioning in the workshop and/or on site;
– assessment of the actual state of an existing governing system.

This document covers the tests for systems and devices described in IEC 61362.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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, *Field acceptance tests to determine the hydraulic performance of hydraulic turbines, storage pumps and pump-turbines*

IEC 60545, *Guidelines for commissioning and operation of hydraulic turbines, pump-turbines and storage pumps*

IEC 61362, *Guidelines to specification of hydraulic turbine governing systems*

ISO 4406, *Hydraulic fluid power – Fluids – Method for coding the level of contamination by solid particles*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61362 apply.

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- IEC Electropedia: available at https://www.electropedia.org/
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4 Recommendations on tests

4.1 General

In order to keep the commissioning period as short as possible, it is recommended that the largest part possible of the required contractual tests be carried out in the manufacturer's works (workshop tests). On site tests should be limited to the verification of such characteristics, which:

– are indispensable for the safety, and
– cannot be carried out without the generating unit and the pressure supply system.

In 4.2 and 4.3, some basic aspects are summarised.

4.2 Recommendations on workshop tests

The scope of the tests, the best set up and the extent of the test documentation should be stipulated in the contract in accordance with the requirements.

In case of type tests including EMC (electromagnetic compatibility), type tests already performed by the manufacturer of the equipment or assembly, the corresponding certificates shall be accepted in order to reduce the tests efforts to a reasonable level.

It should be early and clear enough stipulated, who will witness the tests.

For workshop tests, it is not necessary to set up all components of the governing system in a complete loop, the electronic governor and the oil hydraulic governor can rather be tested separately. During these independent tests, signals at interfaces between the electronic governor and the oil hydraulic governor shall be clearly defined and measurable.Only if it is explicitly required in the contract, the complete governing system, including the electronic and the oil hydraulic governor should be assembled in the workshop. In this case the individual testing of the systems is not needed.

In exceptional technically challenging situations, it can be an advantage to employ a plant simulator for the workshop test of the digital governor (see also Clause 7). The use of a plant simulator in the workshop test has to be clearly stipulated in the contract.

4.3 Recommendations on field tests

4.3.1 New governing systems

For governing systems, the following measures and steps apply.

– Safety devices, displays, alarms and trip settings shall be verified prior to conducting the field tests.
– Commissioning of the complete generating unit shall be performed including load rejection tests. The testing of governing systems shall be coordinated with the overall commissioning of the hydro generating equipment; refer to IEC 60545.

For the actual governing system tests:

- The relevant control mode and operational mode to be checked is set, for example speed control in island operation; subsequently defined test signals are superimposed and resulting changes for the specified values through the entire operating range are observed and/or recorded, whereby control settings can be optimized during the process. The results of such tests can be used as baseline values in order to be compared with the results of verification tests which are carried out during the lifetime of the equipment.

- The test of the insensitivity of the governing system is only needed if the power station will be participating in primary regulation of grid frequency, especially in peak load power stations and in power stations with special requirements for high control accuracy (for recommended insensitivities, see IEC 61362; acceptable measuring uncertainties are given in Clause 6).
- In some cases, the parameters of the governing system can be determined based on physical measurements. If the expected behaviour is not achieved and the reason for this has to be identified, then other factors influencing the governing system behaviour shall be examined. These factors can include: inertias, generator-load characteristics and the influence of hydraulic forces on actuating times. The determination of the governing system's parameters and of the turbine transfer function can be used to provide models of the power plant, in order to carry out studies of the power system's dynamic behaviour.
- Special attention shall be given to the test of pump-turbines because of their complex turbine characteristics (e.g. S-shape characteristic).

4.3.2 Existing governing systems

4.3.2.1 Motivation for a field test in an existing governing system

Existing governing systems can have deficiencies causing one or more of the following effects, which can lead to the decision to conduct a field test:

– long settling times of the controlled variable;
– long synchronization times;
– drifting operating points;
– changes in actuator speeds;
– unusual oscillations (e.g. in no-load and/or island grid operation);
– excessive insensitivities and/or hysteresis effects;
– excessive leakages (long pumping periods, high oil temperature, etc.);
– general inconsistent governor performance.

4.3.2.2 Identification of deficiencies

Depending on the observed effects the following checks can be made:

– measurement of the insensitivity and dead time, see Clause A.1 and Clause A.2;
– recording of step responses/transient functions (unit step responses) by applying defined signals at the input (command signal, controlled variable, frequency, etc.), for example see Clause D.6 to Clause D.14;
– indexing the servomotors, see Clause A.3;
– checking the runner/guide vane relationship in Kaplan turbines, i. e. cam relation;
– checking the deflector/nozzle relationship in Pelton turbines;
– identifying possible resonances (with oscillations in the draft tube, surge tank, waterways: penstock and/or channel system, the generator, the grid, etc.);
– measurements of the parameters of the governing system and comparison to the original values recorded during the first commissioning, for example see Clause D.7 and Clause D.8;
– checking of the overall functionality of the oil hydraulic system, for example see Clause A.4.

4.3.2.3 Deciding whether to replace or to repair existing governing systems

The above-mentioned checks give information about the possible causes of the deficiencies, allowing to decide on the measures to be taken, such as for instance:

– overhauling of individual components;
– replacement of components or of complete governing systems;
– changes in the configuration.

Besides the above-mentioned points, the following facts can also influence the decision to replace or repair existing elements or systems:

- the assessment of operating costs;
- the assessment of repair costs;
- the potential for operating and efficiency improvement of replacement versus repair;
- general safety and any other demands required by authorities.

5 Governing system tests

5.1 Test conditions to be fulfilled

5.1.1 General

The following test conditions apply, unless there is an explicit exception made in this document. They can be modified by mutual agreement.

5.1.2 Turbine operation conditions

– Operating head on the turbine shall be within the limits specified in the turbine contract, otherwise the method of correction should be agreed upon.
– Tailwater elevation and power output of the turbine shall be such that the net positive suction head (NPSH), see IEC 60041, is not less than the lower limit of the turbine manufacturer's guarantee or recommendation.
– Steady-state power output of the turbine for constant position of the regulating devices (e.g. wicket gate, runner, needle, deflector) shall not deviate from the specified value by more than ±1,5 % of rated output.

5.1.3 Hydraulic pressure unit condition

Tests should be performed under approximately constant oil pressure. The fluctuations of the supply oil pressure shall not exceed ±10 % of average oil pressure.

5.1.4 Deviation of values from specified operating conditions

5.1.4.1 General

It is important that specified values stated in the contract, upon which stated guarantees are based, be adhered to as closely as possible. The relative deviations from specified values under which it is permissible to make a governing system acceptance test are specified in 5.1.4.2 and 5.1.4.3.

5.1.4.2 Speed

If acceptance tests cannot be performed at the specified speed, the permissible deviation from the specified speed and its effect on the acceptance test results shall be agreed upon prior to tests.

5.1.4.3 Oil hydraulic system

The acceptance tests of oil hydraulic systems pertain to the following parameters:

a) Pressure

Acceptance tests, performed on a governing system installed on site with the turbine running or at standstill, shall be performed with the oil pressure as specified in the contract; for tests performed in the workshop of the governing system manufacturer, because of the absence of regulating force required by the turbine, the oil pressure of the last amplification stage of the controller system can be reduced correspondingly after demonstrating satisfactory operation at the specified pressure. This reduction in oil pressure shall be mutually agreed upon prior to performing the tests.

b) Oil quality and temperature

Acceptance tests shall be performed with the oil quality specified in the contract. Otherwise the oil quality should be agreed upon.

The prescriptions of the manufacturers of components regarding oil purity and absence of foam in the oil shall be strictly observed.

Oil temperatures during the tests shall correspond to normal sustained operating conditions and lie within the range indicated by the manufacturers of components.

5.1.5 Provisions for instruments

The final report shall state the manufacturer and manufacturer's serial number of the instruments and completely describe special devices or modifications to standard instruments used in connection with the acceptance test.

5.1.6 Calibration of instruments

All instruments shall carry calibration certificates, valid on the date of the tests, issued by an institution which is acceptable to both parties. The provision of calibration certificates shall be the responsibility of the party providing the test instruments.

5.2 Electrical checks

5.2.1 General

Electronic systems like the digital governor are sensitive to electrical-magnetic interference. Therefore, the following shall be given special attention:

– quality of the power supply;
– overvoltage protection;
– filter and shielding measures;
– immunity of the components to interference;
– grounding;
– anti-static protection.

If certain basic safety measures are taken and guidelines adhered to, testing can concentrate on checking the governing systems for proper functioning. Electrical checking is usually performed in the form of type tests, because electrical checking is expensive and requires qualified personnel as well as special testing equipment. For specifications of the electromagnetic compatibility (EMC) tests refer to IEC 61362.