IEC 60545

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

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

Lignes directrices pour la mise en service et l'exploitation des turbines hydrauliques, des pompes-turbines et des pompes d'accumulation

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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COMMISSION ELECTROTECHNIQUE INTERNATIONALE

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

GUIDELINES FOR COMMISSIONING AND OPERATION OF HYDRAULIC TURBINES, PUMP-TURBINES AND STORAGE PUMPS

FOREWORD

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International Standard IEC 60545 has been prepared by IEC technical committee 4: Hydraulic turbines.

This second edition cancels and replaces the first edition published in 1976 and the first edition of IEC 60805 published in 1985. This edition constitutes a technical revision.

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

a) the focus is on the commissioning and operation of the hydraulic machine. Interfaces to the electric machine are mentioned only for a better understanding of the context;
b) the definitions of tests for commissioning and adjustable speed are updated to state of the art;
c) the record sheets ‘measurements during erection’ are excluded (see IEC 63132 (all parts);
d) the maintenance is excluded (see IEC 62256).

The text of this International Standard is based on the following documents:

FDIS	Report on voting
4/407/FDIS	4/420/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/standardsdev/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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GUIDELINES FOR COMMISSIONING AND OPERATION OF HYDRAULIC TURBINES, PUMP-TURBINES AND STORAGE PUMPS

1 Scope

The purpose of this document is to establish, in a general way, suitable procedures for commissioning and operation of hydraulic machines and associated equipment, and to indicate how such machines and equipment should be commissioned and operated.

Commissioning and operation of the associated equipment are not described in detail in this document but is considered in the commissioning and operation procedure as a separate step.

Machines of up to about 15 MW and reference diameters of about 3 m are generally covered by IEC 62006.

It is understood that a guideline of this type will be binding only if the contracting parties have agreed upon it.

The guidelines exclude matters of purely commercial interest, except those inextricably connected with the conduct of commissioning and operation.

The guidelines are not concerned with waterways, gates, drainage pumps, cooling-water equipment, generators, motor-generators, electrical equipment (e.g. circuit breakers, transformers) etc., except where they cannot be separated from the hydraulic machinery and its equipment.

Wherever the guidelines specify that documents, drawings or information are supplied by a supplier (or by suppliers), each individual supplier should furnish the appropriate information for its own supply only.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1 Machine and equipment

3.1.1
hydraulic machinery
turbines, storage pumps, pump-turbines, valves, guide and thrust bearings used in hydroelectric power and pumped storage stations

Note 1 to entry: The term hydraulic machinery includes hydraulic torque converter and all type of main inlet valves.

Note 2 to entry: Terms related to hydro turbine governing systems are not included; refer to IEC 60308.

[SOURCE: IEC TR 61364:1999, 3.1, modified – Addition of Note 1 to entry.]

3.1.2
hydraulic machine
hydraulic impulse and reaction turbines, storage pumps and pump-turbines

[SOURCE: IEC TR 61364:1999, 3.1]

3.1.3
turbine
machine for transforming hydraulic energy into mechanical energy

Note 1 to entry: The term turbine includes a pump-turbine functioning as a turbine.

Note 2 to entry: The term turbine does not include the inlet or outlet valves nor the associated generator or governor.

[SOURCE: IEC TR 61364:1999, 4.1, modified – Addition of Note 1 to entry.]

3.1.4
pump
machine for transforming mechanical energy into hydraulic energy in order to store water that will be used later on to produce electric energy

Note 1 to entry: The term pump includes a storage pump and a pump-turbine functioning as a pump.

Note 2 to entry: The term pump does not include the inlet or outlet valves nor the associated motor.

[SOURCE: IEC TR 61364:1999, 4.1, modified – Replacement of "storage pump" with "pump" in the main term, and addition of Note 1 to entry.]

3.1.5
starting device
starting equipment for a motor-generator or motor

EXAMPLE 1 pony motor

EXAMPLE 2 starting turbine

EXAMPLE 3 frequency converter

EXAMPLE 4 hydraulic torque converter

EXAMPLE 5 back to back

Note 1 to entry: Each example is representing a different method to start the hydraulic machine functioning as a pump.

3.1.6
opening device
guide vanes or the turbine needle of impulse turbines and its driving components (governing systems)

3.1.7
electrical machine
generators and motor-generators of synchronous type including the excitation equipment as well as of the asynchronous type

3.1.8
associated equipment
all additional machinery which is necessary to allow operation of the hydraulic machine (if applicable)

EXAMPLE 1 inlet and outlet gates or valves, draft tube gates, cylindrical valves (ring gates)

EXAMPLE 2 pressure relief valves

EXAMPLE 3 couplings

EXAMPLE 4 gear drives

EXAMPLE 5 brake system

EXAMPLE 6 water depression system

EXAMPLE 7 air supply system

EXAMPLE 8 cooling-water systems

EXAMPLE 9 drainage systems

EXAMPLE 10 dewatering systems

EXAMPLE 11 oil supply systems

3.2 Tests, periods, operating modes

3.2.1
commissioning
testing of new or rehabilitated equipment to check its conformity with contractual specifications, as well as operation of the equipment until formally accepted by the purchaser

3.2.2
operation
utilization of the equipment to convert energy, or a state of readiness for such production

3.2.3
maintenance
activity performed on equipment in order to keep it in a state of optimum operating condition

3.2.4
pre-start test
test between completion of erection of the equipment and initial run

3.2.5
initial run
first movement of rotating parts after erection

3.2.6
test run
operation to obtain one set of data for a specific test

3.2.7
test operation
utilization of the equipment for testing purposes

3.2.8
test operation period
test period following initial run and followed by test service

Note 1 to entry: It includes no-load runs for checking power plant equipment, as well as load runs in turbine and pumping operation, load rejections and energy supply interruption pump-turbine tests.

3.2.9
no-load test
operation of the machine without connection to the electrical grid

3.2.10
no-discharge test
operation of the machine in pump-mode with the high pressure side valve closed

3.2.11
test service period
operation of the equipment for an agreed period

Note 1 to entry: During this test, the supplier is generally responsible.

3.2.12
commercial service
operation of the equipment, under the operator's responsibility

3.2.13
commercial service period
period starting after acceptance and including service periods, as well as periods when the equipment can be out of operation for maintenance, inspection, repairs, etc.

3.2.14
guarantee period
time, extending through an agreed part of the commercial service period, during which the supplier has commercial obligations to correct defects in his equipment in order to bring it into conformity with the contract

Note 1 to entry: For this purpose, tests in accordance with the appropriate parts of 6.3.1.5 are performed.

3.2.15
inspection
check on the condition of equipment

3.2.16
repair
restoration after wear or damage

3.2.17
modification
change intended to improve performance

3.2.18
rehabilitation
restoration of equipment capacity and/or equipment efficiency to near to "as-new" levels; extension of equipment life by re-establishing mechanical integrity

[SOURCE: IEC 62256:2017, Clause 3]

3.2.19
supplier
entity (for example manufacturer, contractor, installer, integrator) who provides equipment or services associated with the machine

Note 1 to entry: The user organization can also act in the capacity of a supplier to itself.

[SOURCE: IEC 60204-1:2016, 3.1.62, modified – Addition of Note 1 to entry.]

3.2.20
operator
entity (for example owner of the equipment or entity contracted by him) who is responsible for operation of the equipment

4 Information on operating conditions

4.1 General

This clause describes the information which should be given by the supplier(s) to the operator.

A fundamental requirement for proper operation and maintenance is a satisfactory knowledge of the machine and its accessories by the operator.

The supplier shall deliver to the operator all necessary documents, instructions and information. They shall include as a minimum:

- general drawings (e.g. general arrangement of the hydraulic machine, power house, …);
- material lists, descriptions and test certificates for main parts;
- function diagrams;
- instructions for operation (especially the range of operation), inspection and maintenance of the supplied equipment;
- assembly and dismantling instructions;
- safety instructions;
- list of spare parts, as stated in the contract;
- constraints.

These documents, even not final (but updated and finalised after test period), shall be given to the operator as soon as required and, in any case, before the initial run to be reviewed by the operator.

The operator shall define additional constraints (e.g. regarding shipping on rivers, slope stability, public safety, …).

4.2 Documents, data and instructions

The documents submitted by the supplier shall include the following data, some of which can be amended according to experience gathered during commissioning:

1) The characteristic diagrams relating to heads, flow, power, opening (e.g. guide vane or needle), speed, tailwater elevations, and operating limits; also, where applicable, runner blade or deflector position. Examples of such diagrams are the pump characteristic and the turbine hill chart.
2) Statement of similitude of model and prototype, depending on the contract.
3) Operation and safety instructions on inlet and outlet gates or valves of the machine and pressure relief valves. The interlocking between the valves and gates shall be considered.

4) Detailed sequential diagrams, illustrating ordinary changes from one mode of operation to another (generating, pumping, synchronous condenser operation, standby) as well as actions due to various electrical or mechanical faults.

5) Guide vane opening (or needle opening of impulse turbines) for no-load, starting and cavitation limits, as functions of head and tailwater levels also, where appropriate, runner blade or deflector position.

6) Transient calculations (model presentation, input data, design criteria/admissible value, load cases and descriptions of maximum and minimum values for pressure, speed, flow, safety margin, references), depending on the contract.

NOTE 1 Closing and opening times of main valve sealings are considered.

7) Governor and servomotor characteristics (e.g. relationship between guide vane angle and servomotor stroke, cam relationship if applicable).

8) If applicable, description of the water-depression-system or de-watering and refilling system of the runner, data for compressed air tanks (including capacity of air tanks, control pressure, etc.), compressors, valves, automatic control devices (both for de-watering system and air leakage supplement system), maximum and minimum water level in the draft tube, etc.

9) Adjustment of overspeed protection device, information of set value (shutdown value).

10) If applicable, description of the coupling type between the hydraulic machine shaft and motor-generator shaft and of the synchronizing arrangement.

11) Characteristics of the fluids for the governing system. Filter specifications and information on purification frequency and method.

12) Control and servo systems. Description of type and control system of the main valve, the distributor and the movable blade of the runner (as applicable) as well as closing and opening laws for the main valve, the guide vanes and runner blades.

13) Maximum steady state runaway speed and maximum transient speed and pressure variations at some specific operating heads (maximum/minimum/rated water head).

NOTE 2 The speed value is below the maximum speed for machine safety.

14) Minimum continuous operating speed (depending on design of thrust bearing and other bearings).

15) Minimum operating water head for initial run.

16) Description of lubrication systems, stating amount and characteristics of lubricants and frequency of replacement.

17) If applicable, data on high pressure lifting oil injection system for rotating parts.

18) Speed or time limits below which operation of the thrust bearing high pressure lifting oil injection system is necessary.

19) If applicable, maximum and minimum speeds for mechanical and electrical brake operation.

20) Intermediate oil levels and pressures at which pumps and compressors should be started or alarms given; also data for automatic signalling and emergency devices.

21) Maximum and minimum temperatures in bearings, seals and in the oil or fluid pressure circuits (alarm and shutdown values).

22) Maximum and minimum pressures, flows and levels in oil or fluid pressure systems and bearings (alarm and shutdown values).

23) If applicable, maximum and minimum temperatures and pressures in oil head (alarm and shutdown values).

24) Maximum acceptable load of thrust bearing, if required.

25) Design values and tolerances for machine erection (bearings and seals clearances, inclination, circularities, concentricities).

26) Maximum and minimum pressures and flows in coolers (alarm and shutdown values).

27) Maximum water levels in drainage pits (alarm and shutdown values).

28) Data on electric motors, pumps and other accessories.

29) Safety instructions for test and operating staff.

30) Other data of importance which are considered necessary by either operator or supplier for safe operation of the equipment or for instruction of personnel (e.g. axial hydraulic thrust, weight force of the rotating parts of the turbine/pump-turbine and the generator/motor-generator.

4.3 Final stage of erection, before commissioning

During the final stage of erection, the supplier shall give appropriate instructions to the operator and provide the information stated in 4.2 on operating the equipment.

During the final stage of erection, the start, the test runs and test service period, the operator shall make his staff available to the supplier for instruction and training in order for them to be properly capable of operating the machine and associated equipment.

After first filling of bearing and governor oil tanks, it is recommended to take oil samples that should be kept as reference of the oil at the beginning of commissioning.

After first filling of “water-filled” Kaplan runners, it is recommended to take samples of the filling (water plus some additives) that should be kept as reference at the beginning of commissioning.

It is recommended that critical spare parts are available (e.g. parts with long delivery time).

5 Commissioning

5.1 General

5.1.1 Overview

This clause deals with the commissioning of hydraulic machinery. It describes and gives advice and recommendations about (pre-) conditions, measurements, health and safety, organization. Tests during commissioning and final documents are suggested.

In the lifetime of the hydraulic machine, the commissioning period is the time in which the supplier shall demonstrate to the operator (owner) that the equipment fulfils the requested characteristics and is ready to run in commercial operation. As the equipment is exposed to the actual loads for the first time, the commissioning procedure shall be carried out with the necessary care and coordination between the parties.

The process chart in Figure 1 shows different steps for a typical commissioning procedure.