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Guide for commissioning, operation and maintenance of hydraulic turbines

Guide pour la réception, l'exploitation et l'entretien des turbines hydrauliques

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Guide for commissioning, operation and maintenance of hydraulic turbines

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

GUIDE FOR COMMISSIONING, OPERATION AND MAINTENANCE OF HYDRAULIC TURBINES

FOREWORD

1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.

2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.

3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

PREFACE

This standard has been prepared by IEC Technical Committee No. 4, Hydraulic Turbines.

Work concerning the commissioning, operation and maintenance of hydraulic turbines was initiated during the meeting held in Madrid in 1959. The Committee of Action confirmed that this activity fell within the scope of Technical Committee No. 4. After the meetings held in Aix-les-Bains in 1964 and in Paris in 1966, a first draft was prepared in 1970 and a revised draft was circulated in 1972. As a result of the meeting held in Munich in 1973, a draft, Document 4(Central Office)30, was submitted to the National Committees for approval under the Six Months' Rule in February 1974.

The following countries voted explicitly in favour of publication:

Australia	Portugal
Austria	Romania
Belgium	South Africa (Republic of)
Canada	Spain
France	Sweden
Germany	Switzerland
Italy	Turkey
Japan	Union of Soviet Socialist Republics
Norway	United Kingdom
Poland	United States of America

Other IEC publications quoted in this standard:

Publications Nos. 41 : International Code for the Field Acceptance Tests of Hydraulic Turbines.
193 : International Code for Model Acceptance Tests of Hydraulic Turbines.
193A: First supplement to Publication 193 (1965).
308 : International Code for Testing of Speed Governing Systems for Hydraulic Turbines.

GUIDE FOR COMMISSIONING, OPERATION AND MAINTENANCE OF HYDRAULIC TURBINES

CHAPTER I: GENERAL

1. Scope and object

The purpose of this guide is to establish, in a general way, suitable procedures for commissioning hydraulic turbines and associated equipment, and to indicate how such turbines and equipment should be operated and maintained.

It is understood that a publication of this type will be binding only if, and to the extent that, both contracting parties have agreed upon it.

The guide excludes matters of purely commercial interest, except those inextricably bound up with the conduct of commissioning, operation and maintenance.

The guide applies to impulse and reaction turbines of all types, and especially to large turbines directly coupled to electric generators. It applies also to pump-turbines when operating as turbines.

The guide is not concerned with water conduits, gates, valves, drainage pumps, cooling-water equipment, generators, etc., except where they cannot be separated from the turbine and its equipment.

Wherever the guide specifies that documents, drawings or information shall be supplied by a manufacturer (or by manufacturers), each individual manufacturer shall be required to furnish the appropriate information for his own supply only.

2. Terms and definitions

Terms	*Definitions*
2.1 *Commissioning*	Testing of new equipment to check its conformity with contractual specifications, as well as operation of the equipment until formally accepted by the purchaser.
2.2 *Operation*	Utilization of the equipment to produce energy, or a state of readiness for such production.
2.3 *Maintenance*	Activity on the equipment directed to its conservation in a state of optimum operating condition.
2.4 *Pre-start tests*	Test between completion of erection of the equipment and initial run.
2.5 *Initial run*	First movement of rotating parts after erection.
2.6 *Test run*	Operation to obtain one set of data for a specific test.
2.7 *Test operation*	Utilization of the equipment for testing purposes.
2.8 *Test operation period*	Test period following initial run and followed by test service. It includes no-load runs for checking power plant equipment, as well as load runs and load rejection tests.

2.9. *Test service*	Operation of the equipment for an agreed period, during which the manufacturer is generally responsible for the way in which it is operated.
2.10 *Commercial service*	Operation of the equipment, under the purchaser's responsibility, to produce energy, or a state of readiness for such operation.
2.11 *Commercial service period*	Period starting after acceptance and including service periods, as well as periods when the equipment may be out of operation for maintenance, inspection, repairs, etc.
2.12 *Guarantee period*	Time, extending through an agreed part of the commercial service period, during which the manufacturer has commercial obligations to correct defects in his equipment in order to bring it into conformity with the contract. For this purpose, tests in accordance with the appropriate parts of Sub-clause 11.1.4, shall be performed.
2.13 *Inspection*	Check on the condition of equipment.
2.14 *Maintenance inspection*	Inspection at regular intervals, often combined with incidental repairs.
2.15 *Repair*	Restoration after wear or damage.
2.16 *Modification*	Change intended to improve performance.
2.17 *Overhaul*	Complete inspection with necessary repairs and/or modifications intended to bring the unit or part of it to, or nearly to, the optimum functioning condition.

3. Data on operating conditions

3.1 A fundamental requirement for proper operation and maintenance is a satisfactory knowledge of the turbine and its accessories by the purchaser's personnel.

The manufacturer (manufacturers) shall deliver to the purchaser's responsible representatives all necessary documents, instructions and information. They shall include:

- general drawings and data;
- material lists, descriptions and test certificates for main parts;
- function diagrams;
- instructions for operation, inspection and maintenance of his supply and tables of measurements as given in the Appendix;
- assembly and dismantling instructions and/or exploded view of the parts;
- safety instructions;
- list of original spare parts, as stated in the contract.

These documents, even in a preliminary form, shall be given to the purchaser's representatives as soon as required and, in any case, before the initial run.

3.2 The documents submitted by the manufacturer (manufacturers) shall include the following data, some of which may be amended according to experience gathered during commissioning.

1) Diagram (such as a hill diagram) relating heads, tailwater elevations, flow and output, wicket-gate openings and operating limits; also, where applicable, runner blade or deflector position.

2) Statement of similitude of model and prototype, according to IEC Publication 193, International Code for Model Acceptance Tests of Hydraulic Turbines, if appropriate;

3) Information on turbine inlet and outlet gates, valves and pressure relief valves.

4) Wicket-gate 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.

5) Turbine governor and servomotor characteristics.

6) Adjustment of overspeed protection device.

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

8) Maximum steady-state runaway speed and maximum momentary speed and pressure variations at various operating heads.

9) Minimum continuous operating speed for initial run (depending on design of thrust bearing and other bearings).

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

11) If applicable, data on jacking system for rotating parts and maximum time after shut-down before re-start without operating the jacking system.

12) Speed limits below which operation of the thrust bearing oil injection system is necessary.

13) If applicable, maximum and minimum speeds for brake operation.

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

15) Maximum and minimum temperatures in bearings, seals and in the oil or fluid pressure circuits (alarm and shut-down values).

16) Maximum and minimum pressures, flows and levels in oil or fluid pressure systems and bearings, according to control system (alarm and shut-down values).

17) Maximum and minimum pressures and flows in coolers (alarm and shut-down values).

18) Maximum water levels in drainage pits (alarm and shut-down values).

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

20) Safety instructions for test and operating staff.

21) Other data of importance which are considered necessary by either purchaser or manufacturer for safe operation of the equipment or for instruction of personnel.

3.3 The manufacturer(s) shall give appropriate instructions to the purchaser's staff and provide the information stated in Sub-clause 3.2 on operating the equipment during the final stage of erection, initial run, test runs and test service period, particularly for all items not previously used by the purchaser.

During the final stage of erection, the start, the test runs and test service, the purchaser shall make his staff available to the manufacturer for instruction and training in order that they may be capable of operating properly the turbine and associated equipment.

3.4 During the guarantee period, the equipment shall not be operated outside the limits stated in the contract without agreement with the manufacturer.

CHAPTER II: COMMISSIONING

4. General

4.1 Commissioning occurs after first erection of a new unit. Similar procedures may also be utilized with or without formal acceptance after repair or overhaul.

4.2 The operating requirements given in Clause 3 shall be complied with during commissioning. If the operating conditions of the power station prevent commissioning within these requirements, the purchaser and manufacturer shall agree on the commissioning procedure.

4.3 For correct interpretation and determination of the causes of any unexpected phenomena, it will be advantageous to make simultaneous recordings of significant parameters on a recording instrument. Each recording shall mention the time and date.

4.4 It is the purchaser's responsibility to obtain from all the authorities concerned, agreements on specified conditions (flow, grid, etc.) for test operation.

5. Test co-ordinator

A test co-ordinator shall be chosen by the purchaser, the main contractors and the manufacturers. He is in charge of drawing up the programme of commissioning. His programme shall be checked and approved by the purchaser, the main manufacturers and contractors before and during the tests if changes appear to be necessary. He shall conduct the tests and check the results.

The test co-ordinator is responsible for the execution of all tests up to the beginning of the test service period. Operating and commissioning personnel shall report to the co-ordinator on all operations performed on the equipment.

6. Pre-start tests

6.1 *Prior to filling waterways*

Before the turbine casing is filled with water, the generator, as well as auxiliary and stand-by equipment, shall be checked. At least the following items shall be checked and results recorded by the test co-ordinator.

1) Inspection of all the turbine waterways and removal of all foreign or loose objects (these might cause damage). If required, the measuring sections and pressure taps for future turbine acceptance tests shall be checked and confirmed as satisfactory and dimensions recorded as appropriate.

2) Calibration of scales for wicket-gate openings and, where applicable, for runner blades, needles and deflectors, including their cam relationships; also measurement of clearances.

3) Operation of pressure oil units, hydraulic shut-off valves, pressure relief valves, governors, automatic and manually-operated starting and stopping devices and signalling devices.

4) Oil levels and pressures in governor system; condition of all oil filters.

5) Protective devices, such as oil level and temperature alarms and relays, with adjustment if needed.

6) Times of opening and closing of governing elements, i.e. wicket gates, runner blades of turbines with movable blades, needles and deflectors of impulse turbines, pressure relief valves together with safety devices for pressure relief valve malfunction and, if possible, command signal dead band.

7) Valve or gate opening and closing times.

8) Bearing and seal clearances. In the case of pressure-lubricated bearings, the oil injection system shall be checked.

9) Operation of leakage and drainage pumps and separately-driven lubricating pumps.

10) Oil, grease and water supply to all bearings and seals requiring lubrication or cooling.

11) Operation of the braking system of the unit.

12) Proper fastening of all man-hole covers.

13) Blades of movable-blade turbines set at rest position.

After the above checks, the valves or gates shall be closed, the wicket gates of reaction turbines or the needles of impulse turbines shall be closed (and locked, if applicable), the brakes applied and the control board energized.

When satisfied that all conditions have been met, the test co-ordinator shall give instructions for the waterways to be filled.

6.2 *After filling waterways*

The tailwater valve or gate shall be opened first. Depending on the tailwater level, a check for leaks shall be made.

The whole waterway shall be filled slowly, and preferably manually either through a by-pass or a small opening of the gate or stoplogs. When the waterway has been sufficiently filled, the gate shall be opened or the stop-logs removed.

If there is a turbine inlet valve, the turbine casing shall be carefully filled, pressurized and checked before the main valve is opened. The operation of automatic protection devices which actuate this valve shall then be checked and the functioning of the valve itself tested.

Automatic protection devices which actuate the intake or outlet gate or valve shall be checked, especially the emergency gate. If the protective devices and the emergency gate work satisfactorily and no unusual leakage or deformation has been observed, an operational test shall be carried out:

- on the pressure relief valve, if any;
- on the needles of impulse turbines (with deflectors diverting);
- on the tailwater depression system of impulse turbines, if applicable.

7. Initial run

After the test co-ordinator has given permission, locking devices and brakes are released and the turbine wicket gates or needles are opened under manual control, according to the manufacturer's requirements, to bring the speed up to at least the minimum stated value (see Sub-clause 3.2, Item 9).

If any noise, scraping or other abnormal phenomena is observed, or if an authorized representative of any manufacturer so requests, the unit shall be shut down immediately. (A tendency for the unit to rotate with leakage flow only shall be noted.)

8. Test runs

8.1 *No-load tests*

8.1.1 The unit is kept under manual control at or above the starting speed (see Sub-clause 3.2, Item 9) until bearing temperatures are satisfactory to the manufacturers' representatives.

If any temperature is excessive or increases too rapidly, the unit shall be shut down and the causes of this phenomenon investigated and corrected.

If all goes well, the unit speed shall be increased in pre-arranged steps up to the rated value, remaining at each successive speed until the rate of rise of all bearing temperatures is satisfactory to the manufacturers' representatives.

8.1.2 During each speed step of the test run, at least the following measurements and/or observations shall be made:

1) Deformation of covers and bearing supports.

2) Noise or vibration in the turbine and/or generator.

3) Water supply pressure in water-lubricated bearings and packings, and cooling of shaft-sealing devices.

4) Operating conditions of standby, turbine safety and signal devices, in particular those which could not be properly tested before water was admitted and the unit rotated.

5) Operating conditions for the oil pressure and other pumps.

6) Condition of oil in the bearings and pressure oil systems. If water is observed in oil, the leaks shall be located and eliminated. If oil foaming is observed, the cause shall be located and eliminated.

7) Oil pressure in pressure and lubrication systems; pressure, circulation and inlet and outlet temperature of cooling water.

8) Levels of oil in lubricating systems of bearings and in oil pressure systems.

9) Temperatures of bearings, packings and lubrication oil.

10) Shaft runout at turbine and generator bearings and axial displacement of rotating parts, if possible.

At some agreed speed value, usually after the rated-speed no-load test, the action of the braking system (also braking jets of impulse turbines) shall be checked.

8.1.3 The functioning of the governing system may be checked at this time and, with the governor operating correctly, the turbine may be used for dry-out and balancing of the unit, tests on the electrical equipment, protection and automatic devices, etc.

8.1.4 When the no-load test at rated speed is completed, the turbine speed is carefully increased, still under manual control, for checking the action of overspeed protection devices.

The set speed for each device shall be measured and any necessary adjustments made.

After the load rejection tests, a further adjustment of the overspeed device setting may be required.