SLOVENSKI STANDARD
oSIST prEN IEC 63230:2025

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Ocena utrujenosti tekačev hidravlične turbine: od načrtovanja do zagotavljanja kakovosti

Fatigue assessment of hydraulic turbine runners: from design to quality assurance

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SECRETARIAT: Canada	SECRETARY: Mrs Christine Geraghty
OF INTEREST TO THE FOLLOWING COMMITTEES:	HORIZONTAL FUNCTION(S):
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TITLE:

Fatigue assessment of hydraulic turbine runners: from design to quality assurance

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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Fatigue assessment of hydraulic turbine runners: from design to quality assurance

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International Standard IEC 63230 has been prepared by subcommittee WG37: Fatigue of hydraulic turbines runners of IEC technical committee TC4: Hydraulic Turbines.

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

FDIS	Report on voting
XX/XX/FDIS	XX/XX/RVD

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

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

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

The National Committees are requested to note that for this document the stability date is 20XX..
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Fatigue assessment of hydraulic turbine runners: from design to quality assurance

1 Scope

This International Standard applies to runners of reaction turbines, regardless of their size and capacity. These may include radial turbines such as Francis turbines, axial turbines such as Kaplan and propeller turbines, as well as diagonal turbines, in all possible configurations. In the case of turbine runners with adjustable blades, the internal mechanical components of the blades' adjustment mechanism are excluded from this document.

This document outlines the recommended methodologies for conducting a fatigue assessment of turbine runners. It encompasses several key aspects, such as defining the load events to be considered during the assessment, determining stresses for each of these load events, as well as the detailed approaches for assessing fatigue of new and existing runners. Additionally, it includes manufacturing and quality assurance requirements that must be complied with to achieve the desired material fatigue properties and effectively apply the proposed fatigue assessment methodologies. This document also contains best practices for performing and analyzing on-site strain gauge measurements performed on existing runners to evaluate their fatigue life.

The purpose of this document is to provide guidelines to assess fatigue in new and existing turbine runners. It does not specify if a fatigue assessment must be performed or not for a given runner. However, it includes an annex that provides guidance to evaluate the necessity of realizing a fatigue assessment or not for a given new runner. The methods described in this document can also be used for remaining life assessments of in-service runners. However, caution should be exercised as the assessed runner materials' fatigue properties and quality level could differ from the prescriptions found in the manufacturing and quality assurance section of this standard which have been defined for new runners. Finally, it should be mentioned that fatigue assessment alone is not sufficient for a complete validation of the mechanical integrity of a new runner design. Other mechanical validations not covered in this standard typically have to be conducted.

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 60609-1:2004	Hydraulic turbines, storage pumps and pump-turbines - Cavitation pitting evaluation - Part 1: Evaluation in reaction turbines, storage pumps and pump-turbines
IEC 60994:1991/COR1:1997	Guide for field measurement of vibrations and pulsations in hydraulic machines (turbines, storage pumps and pump-turbines)
IEC TR 61364:1999	Nomenclature for hydroelectric powerplant machinery
IEC 62256:2017	Hydraulic turbines, storage pumps and pump-turbines - Rehabilitation and performance improvement
IEC TS 62882:2020	Hydraulic machines - Francis turbine pressure fluctuation transposition
CCH 70-4	Specification for inspection of steel castings for hydraulic machines
BS 7910:2019	Guide to methods for assessing the acceptability of flaws in metallic structures
ASTM E1049-85(2017)	Standard Practices for Cycle Counting in Fatigue Analysis
ASTM E1823-21	Standard Terminology Relating to Fatigue and Fracture Testing
ASME Section VIII, Division 2	ASME Boiler and Pressure Vessel Code, Section VIII, Division 2 : Alternative Rules

3 Terms, definitions, symbols and units

3.1 General

For the purposes of this document, the following terms, definitions, symbols and units apply. Specialized terms are explained where they appear.

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

3.2 General terminology

The terms below are defined specifically in the context of this document. The provided definitions may not be complete or coherent with definitions from other standards and codes.

Continuous normal operating range

Operating range of the turbine for unrestricted yearly operating duration, typically delimited by minimum and maximum values of net head, minimum values of net positive suction energy, as well as minimum and maximum values of either or a combination of flow, turbine power output and guide vane opening.

Cycle counting method

Method of counting the number of discrete stress (strain) cycles of different amplitude and mean from a history of varying stress (strain).

Design fatigue life

The minimum period of time during which the runner is expected to function, according to its corresponding stress history.

Design S-N curve

S-N curve defined for design purposes of specific components. It includes sufficient reduction coefficients to ensure conservative results and corresponds to what is considered a sufficient level of reliability for its related specific components. As the determination of this curve includes the return of experience on past runners, it cannot be associated with specific levels of probability of survival.

Designer

Entity responsible for analysing and translating technical specifications into design solutions that have the required reliability, safety, integrity and performance levels.

Dynamic stresses

Refers to the variation of stress over time around a mean stress.

Fatigue crack initiation

Fatigue phase during which damage is accumulated in a runner under the action of stress cycles. In the context of a fatigue crack initiation assessment as part of this standard, the runner material is considered to be continuous, and stress is determined according to the principles of continuum mechanics.

Fatigue crack propagation

Fatigue phase during which a crack propagates in a runner under the action of stress cycles. In the context of a fatigue crack propagation assessment as part this standard, the runner material is considered containing a discontinuity and stress is determined according to the principles of fracture mechanics.

Hotspots

Locations on the runner with the highest fatigue damage sums for a given stress history. This normally corresponds to the location of the highest dynamic stress during steady state conditions or the highest stress range of the start-stop sequence.

Load event

Loading applied to the runner during a specific steady state or transient condition (e.g. start-up, speed-no-load)

Load rejection

A transient operating condition characterized by an emergency automatic sequence where sudden loss of load and subsequent closing of the guide vanes initiated by the triggering of a speed protection result in a turbine-generator unit going from a given power output to transient overspeed and back to speed-no-load or standstill.

Load sequence

Series of load events, which may include a combination of steady state and transient conditions, that are frequently repeated (e.g. start-stop load sequence: standstill – start-up - SNL- ramp-up - full load – stop – standstill).

Manufacturer

Entity responsible for carrying out the entire manufacturing process until completion of the hydraulic machine component.

Maximum power output

Highest turbine or unit power output within the continuous normal operating range under a given net head.

Mean stress

Refers to the constant average stress of a steady state condition or moving average stress of a transient stress history. May also refer to the mean stress of a single fatigue cycle from a stress spectrum as obtained from a cycle counting algorithm.

Owner

Entity buyer and/or user of the hydraulic machine component or its representative.

Periodic stresses

Refers to dynamic stresses of constant amplitude and frequency.

Rainflow algorithm

Specific cycle counting method. In this document, Rainflow refers to the method named “Simplified Rainflow Counting for Repeating Histories” as per ASTM E1049 [1].

Rated power output

Maximum turbine or unit power output within the continuous normal operating range under the rated net head.

Residual stress

Refers to internal stresses in static equilibrium that remain in the absence of any external loading. In runners, such residual stresses most often stem from welding, casting, machining and/or forming.

Rework

Refers to the process of correcting defective, failed, or non-conforming features in a prototype runner after inspection. In the context of this standard, this process may include weld repair, machining, grinding and polishing.

Runaway

A no-load and non-excited steady state operating condition where a turbine-generator unit is rotating at its maximum runaway speed achieved with guide vanes fully open, i.e. up to the mechanical stop of the operating mechanism or servomotor(s) under the maximum net head of the continuous operating range, or high turbine specific hydraulic energy temporary operating range, or whichever condition results in the highest rotational speed.

Shutdown

A transient operating condition characterized by a normal automatic sequence where a turbine-generator unit goes from a given power output to standstill.

Speed-no-load

A no-load steady state operating condition where a turbine-generator unit is rotating at synchronous speed, ready to be synchronized with the grid with positive speed direction and zero power output. The generator field winding may be excited or not.

Start-up

A transient operating condition characterized by a normal automatic sequence where a turbine-generator unit goes from standstill with guide vanes closed to speed-no-load.

Static stress

Refers to the constant mean stress, linearized or not, calculated by static structural finite element analysis for a given steady state condition.

Steady state conditions

Refers to operating conditions of the turbine characterised by constant (or almost constant) values of net head, turbine power output, net positive suction head and rotational speed. Runner mean stresses and characteristics of runner dynamic stresses (amplitude, range, frequency spectrum, standard deviation, etc.) remain constant for a given steady state condition.

Stochastic stresses

Refers to dynamic stresses of randomly varying amplitudes and wideband frequency contents.

Stress (strain) amplitude

One half of the stress (strain) range of a cycle.

Stress (strain) cycle

Variation of stress (strain) at a particular point in the runner as obtained from a cycle counting method and consisting of a change in stress (strain) between defined minimum (valley) and maximum (peak) values and back again.

Stress (strain) history