IEC 63230

Edition 1.0 2026-05

# INTERNATIONAL STANDARD

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



IEC 63230:2026-05(en)

ICS 27.140

ISBN 978-2-8327-1164-4

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

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

**About the IEC**
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

**About IEC publications**
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

**IEC publications search - webstore.iec.ch/advsearchform**
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, …). It also gives information on projects, replaced and withdrawn publications.

**IEC Just Published - webstore.iec.ch/justpublished**
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

**IEC Customer Service Centre - webstore.iec.ch/csc**
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

**IEC Products & Services Portal - products.iec.ch**
Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

**Electropedia - www.electropedia.org**
The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.



**Warning! Make sure that you obtained this publication from an authorized distributor.**

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

## FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch. IEC shall not be held responsible for identifying any or all such patent rights.



IEC 63230 has been prepared by IEC technical committee TC 4: Hydraulic turbines. It is an International Standard.

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

| Draft | Report on voting |
|---|---|
| 4/544/FDIS | 4/552/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.

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

– reconfirmed,
– withdrawn, or
– revised.

## 1 Scope

This International Standard applies to runners of reaction turbines, regardless of their size and capacity. These can 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. Pelton turbines, storage pumps and pump-turbines are not covered in this first edition, even though several topics are applicable to these types of hydraulic machines. Specificities and applicability to Pelton turbine and pump-turbines will be discussed in a later revision of the standard

This document outlines the 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 to 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 analysing 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 should be performed or not for a given runner. However, Annex B 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, it is important to consider that the assessed runner materials' fatigue properties and quality level could differ from the prescriptions found in the manufacturing and quality assurance section of this document which have been defined for new runners. It is also important to mention 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 document are typically 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 60193:2019, *Hydraulic turbines, storage pumps and pump-turbines - Model acceptance tests*

BS 7910:2019, *Guide to methods for assessing the acceptability of flaws in metallic structures*

CCH 70-4, *Specification for Inspection of Steel Castings for Hydraulic Machines*

# 3 Terms, definitions, symbols and units

## 3.1 General

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

NOTE Specialized terms are explained where they appear. Where terms are not explicitly defined in this document, the terms and definitions of IEC TR 61364[1][1], as well as those of ASTM E1823-21[2] can be considered where applicable.

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

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

## 3.2 General terms and definitions

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.

**3.2.1**
**continuous normal operating range**
operating range of the turbine for unrestricted 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



**3.2.2**
**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)



**3.2.3**
**design fatigue life**
the minimum period of time during which the runner is expected to function, according to its corresponding stress history

**3.2.4**
**design S-N curve**
S-N curve defined for design purposes of specific components

Note 1 to entry: 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.

**3.2.5**
**designer**
entity responsible for analysing and translating technical specifications into design solutions that have the required reliability, safety, integrity and performance levels

**3.2.6**
**dynamic stress**
variation of stress over time around a mean stress

[1] Numbers in square brackets refer to the Bibliography.

**3.2.7**
**fatigue crack initiation**
fatigue phase during which damage is accumulated in a runner under the action of stress cycles

Note 1 to entry: In the context of a fatigue crack initiation assessment as part of this document, the runner material is considered to be continuous, and stress is determined according to the principles of continuum mechanics.

**3.2.8**
**fatigue crack propagation**
fatigue phase during which a crack propagates in a runner under the action of stress cycles

Note 1 to entry: In the context of a fatigue crack propagation assessment as part this document, the runner material is considered to contain a discontinuity and stress is determined according to the principles of fracture mechanics.

**3.2.9**
**hotspot**
location on the runner with the highest fatigue damage sums for a given stress history

Note 1 to entry: 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.

**3.2.10**
**load event**
loading applied to the runner during a specific steady state or transient condition (e.g. start-up, speed-no-load)

**3.2.11**
**load rejection**
transient operating condition characterized by an emergency automatic sequence where sudden decoupling from the grid and subsequent closing of the guide vanes result in a turbine-generator unit going from a given power output to transient overspeed and back to speed-no-load or standstill



**3.2.12**
**load sequence**
series of load events, which can 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)

**3.2.13**
**manufacturer**
entity responsible for carrying out the entire manufacturing process until completion of the hydraulic machine component

**3.2.14**
**maximum power output**
highest turbine or unit power output within the continuous normal operating range under a given net head

**3.2.15**
**mean stress**
constant average stress of a steady state condition or moving average stress of a transient stress history

Note 1 to entry: This term can also refer to the mean stress of a single fatigue cycle from a stress spectrum as obtained from a cycle counting algorithm.

**3.2.16**
**owner**
entity which is either the buyer or user, or both, of the hydraulic machine component, or its representative

**3.2.17**
**periodic stress**
dynamic stress of constant amplitude and frequency

**3.2.18**
**rainflow algorithm**
specific cycle counting method used in this document

Note 1 to entry: In this document, rainflow refers to the method named "simplified rainflow counting for repeating Histories" as per ASTM E1049-85.

**3.2.19**
**residual stress**
internal stress in static equilibrium that remains in the absence of any external loading

Note 1 to entry: In runners, such residual stresses most often stem from welding, casting, machining and forming.

**3.2.20**
**rework**
process of correcting defective, failed, or non-conforming features in a prototype runner after inspection

Note 1 to entry: In the context of this document, this process can include weld repair, machining, grinding and polishing.

**3.2.21**
**runaway**
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, under the maximum net head of the continuous operating range, or whichever condition results in the highest rotational speed



**3.2.22**
**shutdown**
transient operating condition characterized by a normal automatic sequence where a turbine-generator unit goes from a given power output to standstill

**3.2.23**
**speed-no-load**
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

Note 1 to entry: The generator field winding can be excited or not.

**3.2.24**
**start-up**
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

**3.2.25**
**static stress**
constant mean stress, linearized or not, calculated by static structural finite element analysis for a given steady state condition

**3.2.26**
**steady state conditions**
operating condition of the turbine characterised by constant (or almost constant) values of net head, turbine power output, net positive suction head and rotational speed

Note 1 to entry: Runner mean stresses and characteristics of runner dynamic stresses (amplitude, range, frequency spectrum, standard deviation, etc.) remain constant for a given steady state condition.

**3.2.27**
**stochastic stress**
dynamic stress of randomly varying amplitudes and wideband frequency contents

**3.2.28**
**stress amplitude**
one half of the stress range of a cycle (see Figure 1)

**3.2.29**
**stress cycle**
variation of stress at a particular point in the runner as obtained from a cycle counting method and consisting of a change in stress between defined minimum (valley) and maximum (peak) values and back again

**3.2.30**
**stress history**
record or calculation of the stress over time at a particular point in the runner during a load event or during one or successive load sequences



**3.2.31**
**strain history**
record or calculation of the strain over time at a particular point in the runner during a load event or during one or successive load sequences



**3.2.32**
**stress range**
algebraic difference between successive peak and valley stress (see Figure 1)

Note 1 to entry: In constant amplitude loading (see Figure 1), the range is given as follows:

$$\Delta S = S_{\text{max}} - S_{\text{min}} .$$

**3.2.33**
**stress ratio**
algebraic ratio of the lowest algebraic value of an applied stress cycle ($S_{\text{min}}$) and the highest algebraic value of applied stress load in a cycle ($S_{\text{max}}$) (see Figure 1)

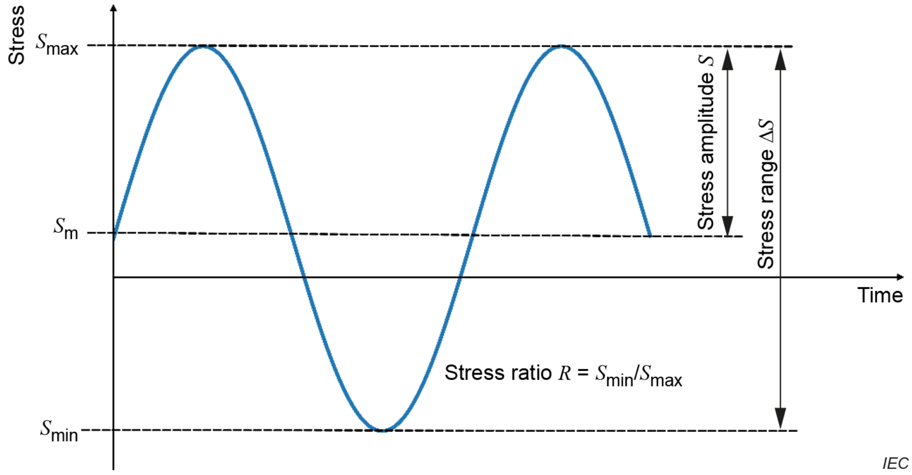


**Figure 1 – Constant amplitude loading illustration of the main fatigue stress parameters**

**3.2.34**
**stress spectrum**
tabulation of the number of all discrete stress cycles of a given amplitude and mean stress level, as obtained from the rainflow algorithm applied to a stress history

**3.2.35**
**supplier**
entity responsible for supplying to the owner the equipment in conformity with contractual specifications



**3.2.36**
**temporary operating range**
operating range of the turbine outside the continuous normal operating range subject to a specified allowed maximum number of yearly operating hours



**3.2.37**
**transient condition**
fast or slow transition from one steady state condition to another (including standstill)

Note 1 to entry: Runner mean stress and characteristics of runner dynamic stresses (amplitude, range, frequency spectrum, standard deviation, etc.) vary during a given transient condition.

## 3.3 Units

The International System of Units (SI, see ISO 80000-4[3]) has been used throughout this document.

All terms are given in SI base units or derived coherent units. The basic equations are valid using these units. This is taken into account if other than coherent SI units are used for certain data (e.g. kilowatt instead of watt for power, kilopascal or bar instead of pascal for pressure, min-1 instead of s-1 for rotational speed, etc.). Temperatures can be given in degrees Celsius since absolute temperatures (in kelvins) are rarely required.

Any other system of units can be used if agreed in writing by the contracting parties.