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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

- **Annotated drafts are not acceptable and will be rejected.**
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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



4/522/CDV

COMMITTEE DRAFT FOR VOTE (CDV)

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SECRETARIAT:

Canada

SECRETARY:

Mrs Christine Geraghty

OF INTEREST TO THE FOLLOWING COMMITTEES:

HORIZONTAL FUNCTION(S):

ASPECTS CONCERNED:

☒ SUBMITTED FOR CENELEC PARALLEL VOTING

☐ NOT SUBMITTED FOR CENELEC PARALLEL VOTING

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The CENELEC members are invited to vote through the CENELEC online voting system.

This document is still under study and subject to change. It should not be used for reference purposes.

Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Recipients of this document are invited to submit, with their comments, notification of any relevant "In Some Countries" clauses to be included should this proposal proceed. Recipients are reminded that the CDV stage is the final stage for submitting ISC clauses. (SEE [AC/22/2007](#) OR [NEW GUIDANCE DOC](#)).

TITLE:

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

PROPOSED STABILITY DATE: 2028

NOTE FROM TC/SC OFFICERS:

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

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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.

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

- 140 • reconfirmed,
- 141 • withdrawn,
- 142 • replaced by a revised edition, or
- 143 • amended.

144 The National Committees are requested to note that for this document the stability date
145 is 20XX..

146 THIS TEXT IS INCLUDED FOR THE INFORMATION OF THE NATIONAL COMMITTEES AND WILL BE DELETED
147 AT THE PUBLICATION STAGE.

148

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

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

252 **Hotspots**

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

256 **Load event**

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

259 **Load rejection**

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

264 **Load sequence**

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

268 **Manufacturer**

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

271 **Maximum power output**

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

274 **Mean stress**

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

278 **Owner**

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

280 **Periodic stresses**

281 Refers to dynamic stresses of constant amplitude and frequency.

282 **Rainflow algorithm**

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

285

286 **Rated power output**

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

289 Residual stress

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

293 Rework

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

297 Runaway

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

303 Shutdown

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

306 Speed-no-load

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

310 Start-up

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

313 Static stress

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

316 Steady state conditions

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

321 Stochastic stresses

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

323 Stress (strain) amplitude

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

325

326 Stress (strain) cycle

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

330 Stress (strain) history

Record or calculation of the stress (strain) over time at a particular point in the runner during a load event or during one or successive load sequences.

Stress (strain) range

The algebraic difference between successive peak and valley stress or strain. In constant amplitude loading, the range is given as follows:

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

Stress (strain) ratio

The algebraic ratio of the lowest algebraic value of an applied stress or strain cycle ($S_{\min}$ or $\varepsilon_{\min}$) and the highest algebraic value of applied stress or strain load in a cycle ($S_{\max}$ or $\varepsilon_{\max}$).

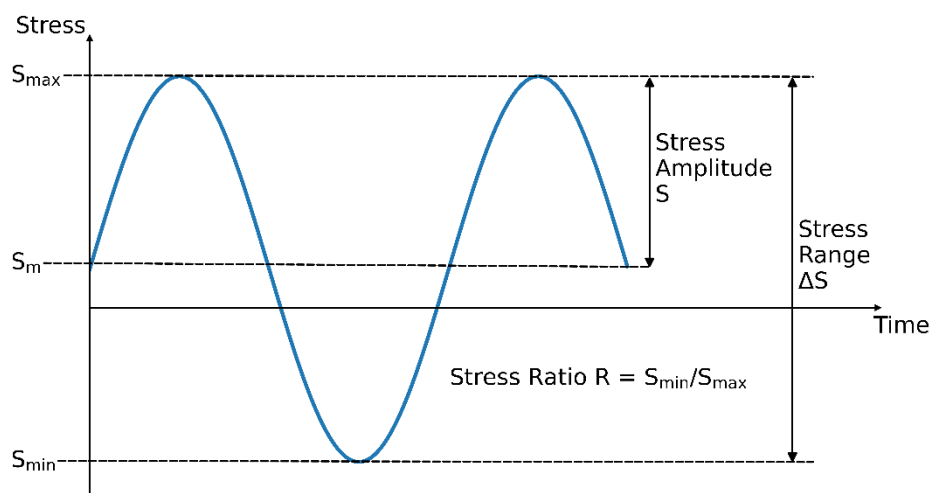


Figure 1 – Constant amplitude loading illustration of the main fatigue stress (strain) parameters

Stress (strain) spectrum or rainflow count

Tabulation of the number of all discrete stress (strain) cycles of given amplitude and mean stress (strain) level, as obtained from the Rainflow algorithm applied to a stress (strain) history.

Supplier

Entity responsible for supplying to the owner the equipment in conformity with contractual specifications.

Temporary operating range

Operating ranges of the turbine outside the continuous normal operating range subject to a specified allowed maximum number of yearly operating hours.

Transient conditions

Refers to a fast or slow transition from one steady state condition to another (including standstill). 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) 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 has to be 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 may be given in degrees Celsius since absolute temperatures (in kelvins) are rarely required.

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

364 **3.4 Acronyms**

365 Below is a list of acronyms used throughout the document.

- 366 • BHN Brinell hardness number
- 367 • CFD Computational fluid dynamics
- 368 • FEA/FEM Finite element analysis/method
- 369 • NDT Non-destructive testing
- 370 • PWHT Post-weld heat treatment
- 371 • RSI Rotor-stator interaction
- 372 • SNL Speed-no-load

373 **3.5 Subjective terms**

374 Some terms used in this standard may have a subjective interpretation, e.g. suitable, adequate,
375 sufficient, significant. This may lead to discussions between owners and suppliers. To provide
376 a degree of objectivity to these terms, the level of accuracy of the related assessment must be
377 considered. Any method, measurement, analysis, simulation, etc. may be considered suitable,
378 appropriate, adequate, sufficient, significant, etc., as long as it is consistent with the precision
379 of the overall assessment and doesn't increase the level of uncertainty by itself.

380 This also applies if the supplier proposes alternative methods, in which case the supplier shall
381 demonstrate to the owner that the accuracy achieved by the proposed alternative method is
382 equal to or better than the methods described in this standard. The supplier shall provide
383 documentation to support the alternative method such as internal or public documentation
384 reviewed by independent peers comparing the proposed alternative methods with relevant
385 benchmarks. The owner must evaluate the information provided and decide whether to accept
386 the method, failing which the original method must be used.

387