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Cavitation pitting evaluation in hydraulic turbines, storage pupms and pump-turbines - Part 2: Evaluation in Pelton turbines

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Evaluation de l'érosion de cavitation dans les turbines, les pompes d'accumulation et les pompes-turbines hydrauliques - Partie 2: Evaluation dans les turbines Pelton

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Partie 2: Evaluation dans les turbines Pelton

Cavitation pitting evaluation in hydraulic turbines, storage pumps and pump-turbines –

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

CAVITATION PITTING EVALUATION IN HYDRAULIC TURBINES, STORAGE PUMPS AND PUMP-TURBINES –

Part 2: Evaluation in Pelton turbines

FOREWORD

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International Standard IEC 60609-2 has been prepared by IEC technical committee 4: Hydraulic turbines.

The text of this standard is based on the following documents:

FDIS	Report on voting
4/127/FDIS	4/139/RVD

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

Annex A forms an integral part of this standard.

Annex B is for information only.

INTRODUCTION

IEC 60609 (1978) treats cavitation pitting in reaction machines but does not refer to Pelton (impulse) turbines. Appendix A of IEC 60609 states that Pelton turbines "usually are not subjected to cavitation pitting".

However, experience shows that with increase of specific speed (especially of multijet turbines) and of specific hydraulic energy (head) the probability of cavitation pitting and drop erosion on Pelton turbines increases. Consequently weight loss guarantees on Pelton turbines may be required.

Various types of damage are observed, each the result of different flow phenomena, such as pitting due to:

– profile errors;
– unfavourable inflow conditions;
– erosion due to travelling droplets
(drop erosion, also called jet impingement);

and in some instances

– setting conditions
(e.g. setting of the runner referred to the tailwater level, or tailwater depression).

The causes of damage are often complex and have to be carefully investigated, taking into account also conditions which are excluded in the cavitation guarantee (see 1.2). However it is not the objective of this part of IEC 60609 to describe the requirements and measures needed for avoiding cavitation pitting due to

– hydraulic shape and surface roughness of turbine parts (buckets, nozzles, etc.), or
– installation requirements (setting, inflow conditions).

Those requirements are part of the know-how of the turbine contractor.

The damage (i.e. pitting respective weight loss) due to these various causes (cavitation pitting and drop erosion) is combined in the following clauses as the term "cavitation pitting".

CAVITATION PITTING EVALUATION IN HYDRAULIC TURBINES, STORAGE PUMPS AND PUMP-TURBINES –

Part 2: Evaluation in Pelton turbines

1 General

1.1 Scope and object

This part of IEC 60609 serves as a basis for the formulation of guarantees on cavitation pitting on Pelton turbine runners and also for the measurement and evaluation of the amount of cavitation pitting on Pelton turbine runners of a given turbine, which is defined in the contract by power, specific hydraulic energy of machine (head), rotational speed, material, operation, etc.

The sequence of clauses in this part of IEC 60609 is the same as in IEC 60609 (1978). The clauses on measurements and evaluation of the amount of cavitation pitting are practically identical to those of IEC 60609. Evaluation has to be based on the loss of material during a given time and under accurately defined operating conditions.

Guarantees which restrict the extent of cavitation pitting and drop erosion on Pelton turbines at the end of an operating period specified in the contract are necessary when cavitation pitting is expected in all or in some operating ranges. Such guarantees should include limits for operation which are consistent with specified operating conditions.

1.2 Excluded topics

It is assumed in this part of IEC 60609 that the water is not chemically aggressive to a significant degree and that it is essentially free from abrasive solids.

The cavitation guarantee shall, however, be given on the basis of an agreed water analysis. If it becomes apparent in the course of later analysis that the water is in fact more aggressive than the agreed analysis indicated, this shall be taken into consideration when judging whether the given guarantees have been met.

In case of a distorted inflow condition at the inlet of the turbine due to irregularities upstream of the turbine, hydraulic effects may be raised, which beyond the influence on hydraulic performance also may cause cavitation pitting. Therefore it is claimed for the basis of cavitation pitting guarantees that a satisfactorily uniform and vortex-free flow condition shall be provided. In case of damage, the influence of improper inflow condition shall be taken into account.

Abrasion due to water contaminated with solids (e.g. sand) cannot be considered as cavitation pitting. The solids content of the water and also – if relevant – the type of minerals and size and form of solid (sand) particles shall be stated in the water analysis and, if it reaches significant proportion, shall be the subject of a special agreement. Aspects of abrasive wear by sand erosion are dealt with in IEC 61366 (annex H).

Abrasion may cause a change of the geometry of the needle and/or the bucket and subsequently cavitation pitting as secondary damage. Such damage shall be excluded from the evaluation of cavitation.

If cavitation pitting occurs in zones where damage can be separately attributable to abnormal chemical or electrochemical corrosion, abrasion or mechanical impact, such damage shall be excluded from the evaluation of cavitation.

If cavitation pitting occurs in zones where damage can be shown to have been increased by chemical or electrochemical effects additional to those normal to cavitation in water of the agreed analysis, then such zones shall be excluded from the evaluation of cavitation.

In this context, attention should be paid to the material selection in reference to abrasion by sand erosion and/or chemical or electrochemical corrosion.

Material defects revealed by wear on the machine surfaces during operation are not taken into account to verify a guarantee against cavitation pitting.

Special operating conditions such as discharging by means of deflector or cut-in deflector shall be excluded from cavitation pitting guarantees.

1.3 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this part of IEC 60609. At the time of publication, the edition indicated was valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 60609 are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60609:1978, *Cavitation pitting evaluation in hydraulic turbines, storage pumps and pump-turbines*

2 Terms, symbols and definitions

2.1 Units

The International System of units (SI) has been used in this part of IEC 60609. Dimensions for pitting are given in centimetres.

2.2 List of terms

The terms, symbols and definitions adopted in this part of IEC 60609 are listed below [1)]:

2.2.1	cavitation	Vapour bubbles which form when the level of local pressure drops to approximately that of vapour pressure and which collapse when the level of local pressure rises above that of vapour pressure.
2.2.2	cavitation pitting	Loss of material caused by cavitation.
2.2.3	drop erosion	Loss of material caused by impact of travelling droplets (liquid impact erosion, jet impingement).

1) They are also based, where relevant, on IEC 61364.

2.2.4	abrasion	Loss of material caused by suspended solids (e.g. sand) eroding the material surface (abrasive wear, sand erosion).
2.2.5	cavitation guarantee	Number of months or years of service of a machine during which the period cavitation pitting guarantee is valid.
2.2.6	cavitation guarantee duration of operation	Number of machine operating hours during which the cavitation pitting guarantee is valid.
2.2.7	reference duration of operation t_R (h)	Number of machine operating hours used as a reference value for establishing cavitation pitting guarantees.
2.2.8	actual duration of operation t_A (h)	The actual number of machine operating hours at the time of cavitation pitting examination.
2.2.9	E (Jkg^{-1})	Specific hydraulic energy of machine (turbine), $E = gH$, see 2.2.11 and [2].
2.2.10	g (ms^{-2})	Acceleration due to gravity [1].
2.2.11	H (m)	Head of turbine $H = E/g$.
2.2.12	P (W)	Power, mechanical power of the turbine.
2.2.13	P_{CU}	Upper power limit for normal continuous operation specified for each specific hydraulic energy (see figure 1).
2.2.14	P_{TU}	Upper power limit for temporary abnormal operation specified for each specific hydraulic energy (see figure 1).
2.2.15	P_{CL}	Lower power limit for normal continuous operation specified for each specific hydraulic energy [3] (see figure 1).
2.2.16	Continuous normal operating range	Limited by P_{CU} and P_{CL} (see figure 1).
2.2.17	High turbine load temporary abnormal operating range	Limited by P_{CU} and P_{TU} (see figure 1).

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[2] For full information, see IEC 60041.

[3] P_{CL} may be defined by the restricted needle stroke: 15 % of the maximum needle stroke, if not otherwise agreed.