SLOVENSKI STANDARD

SIST IEC 60609:1999

01-april-1999

Ovrednotenje kavitacijskih razjed vodnih turbin, akumulacijskih črpalk in črpalnih turbin

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

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

Ta slovenski standard je istoveten z: **IEC 60609 Ed. 1.0**

ICS:

27.140	Vodna energija	Hydraulic energy engineering

SIST IEC 60609:1999 **en**

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

NORME DE LA CEI

INTERNATIONAL ELECTROTECHNICAL COMMISSION

IEC STANDARD

Publication 609

Première édition — First edition

1978

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

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

Bureau Central de la Commission Electrotechnique Internationale

1, rue de Varembé

Genève, Suisse

Prix
Price Fr. s. 33.–

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Drafts were discussed at meetings held in Munich in 1973 and in Tokyo in 1975. As a result of this second meeting, a draft, Document 4(Central Office)35, was submitted to the National Committees for approval under the Six Months' Rule in January 1976.

The following countries voted explicitly in favour of publication:

Australia
Austria
Belgium
Brazil
Bulgaria
Canada
Czechoslovakia
Egypt
France
Germany
Italy
Japan
Norway
Romania
South Africa (Republic of)
Spain
Sweden
Switzerland
Turkey
Union of Soviet Socialist Republics
United Kingdom

Other IEC publications quoted in this standard:

Publications Nos. 193A: First supplement to Publication 193: International Code for Model Acceptance Tests of Hydraulic Turbines.

497: International Code for Model Acceptance Tests of Storage Pumps.

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

SECTION ONE – GENERAL

1. Introduction

Guarantees applying to cavitation pitting in hydraulic turbines, storage pumps and pump-turbines are quite different from other guarantees stated in a contract representing inherent characteristics of the machine, such as efficiency. The amount of cavitation pitting depends essentially on four factors:

a) The type and design of the machine.

b) The material and surface condition of the parts subjected to cavitation.

c) The setting of the machine in the plant, i.e. the σ value of the plant.

d) The duration of operation and operating conditions.

Items *a)* and *b)* describe the machine and Items *c)* and *d)* depend on the design of the plant and on its operation. Therefore the guarantee for cavitation pitting can be established only by mutual agreement between the customer and the supplier during the planning of the plant or during the contract negotiations.

Negotiating such a guarantee may be done in two ways:

either the setting of the machine (and therefore the σ value of the plant) is given, and the amount of the cavitation pitting shall be agreed upon with due regard to turbine/pump size, speed, material, surface conditions, operation, etc., (see Figures 1a and 1b, page 9).

or the amount of the cavitation pitting is limited and the setting of the machine shall be agreed upon (see Figures 1a and 1c, page 9).

In some cases a machine can be operated normally without any cavitation (e.g. Pelton turbines in installations with small head variations, horizontal shaft turbines of storage pump installations, etc.), or may be required to operate without any cavitation, but generally it is more economical to accept a slight amount of cavitation pitting, which means using a higher setting than would be required for operation of the machines without cavitation pitting.

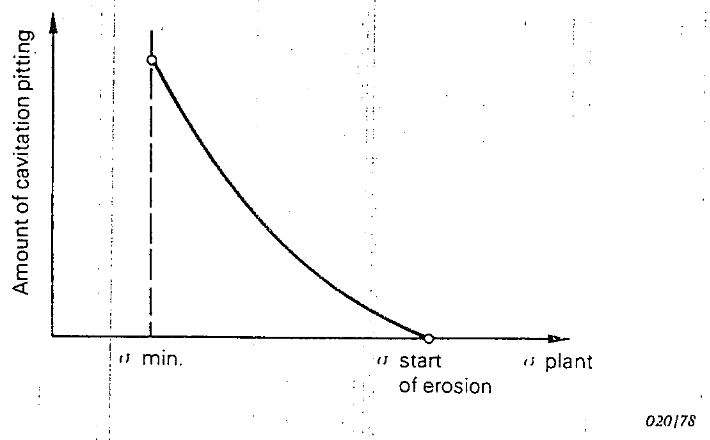

FIGURE 1a

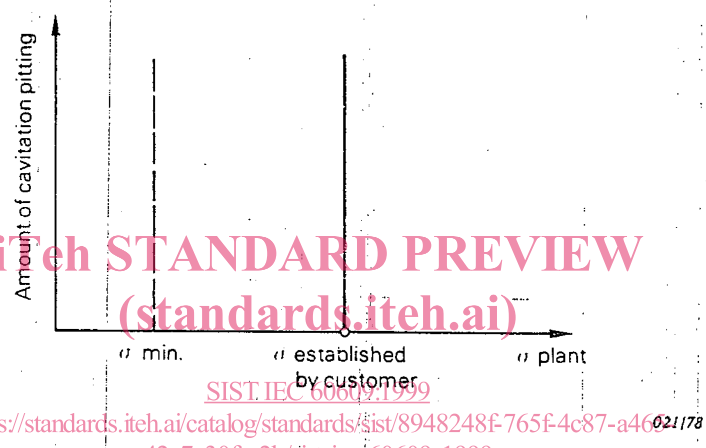

FIGURE 1b

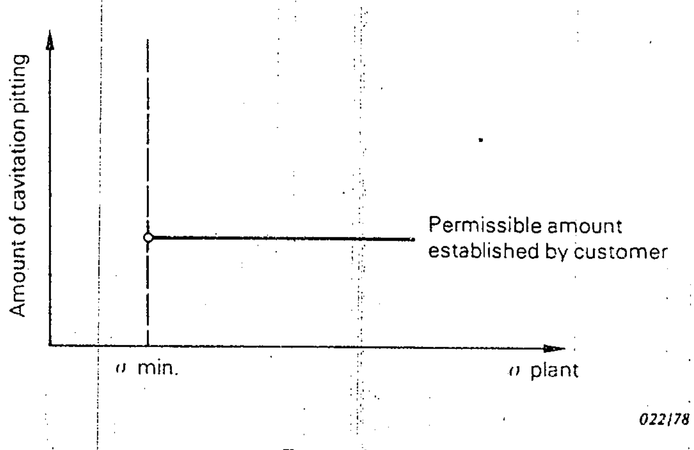

FIGURE 1c

Where: σ min. is the limitation of σ due to effects other than cavitation pitting such as unacceptable vibrations.

FIG. 1. – Amount of cavitation pitting as a function of σ plant for a given machine at constant discharge.

It is not possible to make general recommendations to the customer for an acceptable amount of cavitation pitting; economic problems must be investigated and decided upon in each individual case. For example, a smaller amount of cavitation pitting requires a higher σ value for the plant, i.e. a deeper setting of the hydraulic machine and therefore higher costs for civil engineering work. On the other hand it reduces the cost and/or the frequency of repair, as well as the cost of the loss of energy production during the shut-down of the unit. The acceptable amount of cavitation pitting may also be influenced by the feasibility of repair *in situ* without dismantling the machine e.g. by the possibility of crackfree welding, by the possibility of applying the necessary heat treatment, etc.

Examples of amounts of cavitation pitting expressed as depth, area and volume (see Sub-clauses 5.22 to 5.24 and 5.32) as a function of diameter D are given in Appendix A.

2. Scope and object

This standard serves as a basis for the formulation of guarantees applying to cavitation pitting in hydraulic turbines, storage pumps and pump-turbines, and for the measurement and evaluation of the amount of cavitation pitting on certain specified machine components of a given machine, which is defined in the contract by output, head, speed, material, operation, etc. The evaluation is to be based on the loss of material during a given time and under accurately defined operating conditions.

The supply contract should state whether cavitation pitting on the hydraulic machine should or should not be anticipated in all or in some operating ranges.

Guarantees which restrict the extent of cavitation pitting on the hydraulic machine at the end of an operating period specified in the contract are necessary whenever occurrence of cavitation pitting on the machine has been accepted by both the customer and the supplier for the specified operating ranges.

3. Excluded topics and limitations

Other effects which cavitation may possibly have on the operating characteristics of the machine such as output, efficiency, vibration and noise are not covered by this standard.

It is assumed in this standard 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 must be taken into consideration when judging whether the given guarantees have been met.

Abrasion due to water contaminated with solids (e.g. sand) cannot be considered as cavitation pitting. The solids content of the water must be stated in the water analysis and, if it reaches significant proportion, must be the subject of a special agreement.

If cavitation pitting occurs in zones where damage can be separately attributable to abnormal chemical or electrochemical corrosion, abrasion or 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.

Material defects revealed by wear on the machine surfaces during operation are not included in a guarantee against cavitation pitting.

SECTION TWO – TERMS, SYMBOLS AND DEFINITIONS

4. Measuring system

The International System of Units (S.I.) is adopted throughout this standard but other systems are allowed.

5. List of terms

The terms, symbols and definitions adopted in this standard are listed below:

5.1	*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
5.2	*Cavitation pitting*	Loss of material caused by cavitation
5.3	σ	Cavitation factor (Thoma's coefficient) characterizing the setting of a hydraulic machine referred to the tailwater level or suction water level (see IEC Publication 193A, First supplement to IEC Publication 193, International Code for Model Acceptance Tests of Hydraulic Turbines, Sub-clause 5.1.1, and IEC Publication 497, International Code for Model Acceptance Tests of Storage Pumps, Sub-clause 57.1.1)
5.4	*Cavitation guarantee period*	Number of months or years of service of a machine during which the cavitation pitting guarantee is valid
5.5	*Cavitation guarantee duration of operation*	Number of machine operating hours during which the cavitation pitting guarantee is valid
5.6	*Reference duration of operation* t_R (h)	Number of machine operating hours used as a reference value for establishing cavitation pitting guarantees
5.7	*Actual duration of operation* t_A (h)	The actual number of machine operating hours at the time of cavitation pitting examination
5.8	P_{CL}	Lower turbine power limit for normal continuous operation specified for each head and each permissible tailwater level (Figure 2, page 17)
5.9	P_{CU}	Upper turbine power limit for normal continuous operation specified for each head and each permissible tailwater level (Figure 2)
5.10	P_{TL}	Lower turbine power limit for temporary abnormal operation specified for each head and each permissible tailwater level (Figure 2)
5.11	P_{TU}	Upper turbine power limit for temporary abnormal operation specified for each head and each permissible tailwater level (Figure 2)
5.12	H_{CL}	Lower pump head limit for normal continuous operation specified for each permissible suction water level (Figure 3, page 17)