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TECHNICAL SPECIFICATION

colour inside

Hydraulic machines – Francis turbine pressure fluctuation transposition

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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HYDRAULIC MACHINES – FRANCIS TURBINE PRESSURE FLUCTUATION TRANSPOSITION

FOREWORD

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- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62882, which is a Technical Specification, has been prepared IEC technical committee 4: Hydraulic turbines.

The text of this Technical Specification is based on the following documents:

Enquiry draft	Report on voting
4/375/DTS	4/398/RVDTS

Full information on the voting for the approval of this technical specification 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- withdrawn,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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

With the increased amount of renewable energy that is being added to the electrical grid in the form of wind and solar, in addition to new energy in the form of nuclear, the grid needs to integrate more hydropower generation with flexible operation to balance loads. To meet this challenge, the hydraulic stability of the machine has become more and more important.

The current document provides a technical specification for Francis turbine pressure fluctuations. This document aims to describe pressure fluctuations, their phenomena and related problems, to define the relationship between model and prototype fluctuations, to identify methods to predict pressure fluctuations in prototypes through transposition of model measurements, and to suggest potential mitigations.

In this document, the term "turbine" refers to Francis turbines and pump-turbine operating as a turbine.

This document excludes all matters of purely commercial interest, except those inextricably bound within the conduct of the tests.

HYDRAULIC MACHINES – FRANCIS TURBINE PRESSURE FLUCTUATION TRANSPOSITION

1 Scope

IEC 62882, which is a Technical Specification, provides pressure fluctuation transposition methods for Francis turbines and pump-turbines operating as turbines, including:

– description of pressure fluctuations, the phenomena causing them and the related problems;

– characterization of the phenomena covered by this document, including but not limited to inter-blade vortices, draft tube vortices rope and rotor-stator interaction;

– demonstration that both operating conditions and Thoma numbers (cavitation conditions) are primary parameters influencing pressure fluctuations;

– recommendation of ways to measure and analyse pressure fluctuations;

– identification of potential resonances in test rigs and prototypes;

– identification of methods, to transpose the measurement results from model to prototype or provide ways to predict pressure fluctuations in prototypes based on statistics or experience;

– recommendation of a data acquisition system, including the type and mounting position of model and prototype transducers and to define the similitude condition between model and prototype;

– presentation of pressure fluctuation measurements comparing the model turbine and the corresponding prototype;

– discussion of parameters used for the transposition from model to prototype, for example, the peak to peak value at 97 % confidence interval, the RMS value or the standard deviation in the time domain and the relation of main frequency and the rotational frequency in the frequency domain obtained by FFT;

– discussion of the uncertainty of the pressure fluctuation transposition from model to prototype;

– discussion of factors which influence the transposition, including those which cannot be simulated on the model test rig such as waterway system and mechanical system;

– establishment of the transposition methods for different types of pressure fluctuations;

– suggestion of possible methods for mitigating pressure fluctuation;

– definition of the limitations of the specification.

This document is limited to normal operation conditions. Hydraulic stability phenomena related to von Karman vortices, transients, runaway speed and speed no load are excluded from this document.

This document provides means to identify potential resonances in model test rigs and prototype turbines. Scaling-up resonance conditions are not treated in this document. When resonance exists, the transposition methods identified in this document do not apply. Under these conditions, the relationship between model and prototype pressure fluctuations cannot be determined.

This document is concerned neither with the structural details of the machines nor the mechanical properties of their components, so long as these characteristics do not affect model pressure fluctuations or the relationship between model and prototype pressure fluctuations.

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*

3 Terms, definitions, symbols and units

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

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

The contracting parties shall, in advance of the test, agree to clarification in writing of any term, definition or unit of measure in question.

3.1 General terms and definitions

Entry number	Term	Definition
3.1.1	Point	item established by one or more consecutive sets of readings and/or recordings at unchanged operating condition and settings, sufficient to calculate the performance of the machine at this operating condition and these settings
3.1.2	Test	collection of points that is adequate to establish the performance of the machine over a specified range of operating conditions
3.1.3	Hydraulic performance	performance parameters attributable to the machine due to hydrodynamic effects
3.1.4	Main hydraulic performance data	subset of the hydraulic performance parameters, i.e. power, discharge and/or specific hydraulic energy, efficiency, pressure fluctuation, steady-state runaway speed and/or discharge[a]
3.1.5	Additional data	subset of hydraulic performance data, which can be determined for information on the model[b]
3.1.6	Guarantees	specified performance data contractually agreed to

[a] The influence of cavitation shall be considered.

[b] The prediction of the corresponding prototype data is less accurate than that achievable for the main hydraulic performance data, due to application of approximate similarity rules.

3.2 Units

The International System of Units (SI, see ISO 80000-4 [193][1]) has been used throughout this document.

All terms are given in SI base units or derived coherent units[2]. The basic equations are valid using these units. If other units are used for certain data which are not coherent SI units, proper consideration shall be provided. Examples of non-coherent units include kilowatt instead of watt

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

[2] $N = kg \cdot m \cdot s^{-2}$ $Pa = kg \cdot m^{-1} \cdot s^{-2}$ $J = kg \cdot m^2 \cdot s^{-2}$ $W = kg \cdot m^2 \cdot s^{-3}$