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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Guide to specification of hydraulic turbine governing systems

Guide pour la spécification des systèmes de régulation des turbines hydrauliques

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

GUIDE TO SPECIFICATION OF HYDRAULIC TURBINE GOVERNING SYSTEMS

FOREWORD

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International Standard IEC 61362 has been prepared by IEC technical committee 4: Hydraulic turbines.

This second edition cancels and replaces the first edition published in 1998. It is a technical revision. It takes into account the experience with the guide during the last decade as well as the progress in the state of the art of the underlying technologies.

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

FDIS	Report on voting
4/270/FDIS	4/272/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

While a standard for the testing of hydraulic turbine governing systems had been existing for a very long time (IEC 60308 published in 1970)[1], a guide for the specification of hydraulic turbine governing systems was missing until 1998. The need for such a guide became more and more urgent with the fast development and the new possibilities especially of the digital components of the governor.

The current second edition of the guide takes into account the experience with the guide during the last decade as well as the progress in the state of the art of the underlying technologies.

While the first edition was written more or less as a supplement to the already existing guide for testing, the objective of the second edition is to be the leading guide with respect to turbine governing systems.

[1] IEC 60308:1970, *International code for testing of speed governing systems for hydraulic turbines*. This publication was withdrawn and replaced by IEC 60308:2005.

GUIDE TO SPECIFICATION OF HYDRAULIC TURBINE GOVERNING SYSTEMS

1 Scope

This International Standard includes relevant technical data necessary to describe hydraulic turbine governing systems and to define their performance. It is aimed at unifying and thus facilitating the selection of relevant parameters in bidding specifications and technical bids. It will also serve as a basis for setting up technical guarantees.

The scope of this standard is restricted to the turbine governing level. Additionally some remarks about the control loops of the plant level and about primary and secondary frequency control (see also Annex B) are made for better understanding without making a claim to be complete.

Important topics covered by the guide are:

– speed, power, water level, opening and flow (discharge) control for reaction and impulse-type turbines including double regulated machines;
– means of providing actuating energy;
– safety devices for emergency shutdown, etc.

To facilitate the setting up of specifications, this guide also includes data sheets, which are to be filled out by the customer and the supplier in the various stages of the project and the contract.

Acceptance tests, specific test procedures and guarantees are outside the scope of the guide; those topics are covered by IEC 60308.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-351:2006, *International Electrotechnical Vocabulary – Part 351: Control technology*

IEC 60068-2-6:2007, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-27:2008, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60308:2005, *Hydraulic turbines – Testing of control systems*

IEC 61000-4-1:2006, *Electromagnetic compatibility (EMC) – Part 4-1: Testing and measurement techniques – Overview of IEC 61000-4 series*

CISPR 11:2009, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*

ISO 3448:1992, *Industrial liquid lubricants – ISO viscosity classification*

3 Terms, definitions, symbols and units

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

NOTE This guide uses as far as possible the terms and definitions of IEC 60050-351. For clarification, the simplified differential equations and transfer functions of the idealized PID-controllers as used in this guide are given in Annex A. Additional reference is made to IEC 60308 for purposes of tests of governing systems.

3.1 General terms and definitions

3.1.1
turbine governing system
technical equipment governing the opening (guide vane, runner blade, needle, deflector position) of hydraulic turbines

Note 1 to entry At the present state of the art, the turbine governing system consists of an oil hydraulic and an electronic part, the "oil hydraulic governor" and the "electronic governor".

3.2 Terms and definitions related to control levels and control modes

3.2.1
turbine governing level
control functions directly related to the governing system of a single turbine

Note 1 to entry The following control modes are related to the turbine governing level:

- speed control;
- power output control;
- water level control;
- opening control;
- flow control (the term flow used in this guide has the same meaning as the term discharge).

Note 2 to entry The scope of this standard is restricted to the turbine governing level. Additionally some remarks about the control loops of the plant level and about primary and secondary frequency control (see Annex B) are made for better understanding without making a claim to be complete.

3.2.2
unit control level
control functions directly related to the overall control of a single unit (turbine, generator, unit auxiliaries) including turbine governing, voltage regulation, start-stop-sequencing etc.

3.2.3
plant control level
control functions related to the overall control of a whole plant including the control of several units

Note 1 to entry In automatic unit and plant control operation, the turbine governing system gets its modes and setpoints from the unit and plant control level.

3.2.4
grid control level
control functions related to the overall control of the grid as a whole

Note 1 to entry If required the turbine governing system participates in grid control over the primary and/or secondary frequency control mode (see Annex B).

3.3 Terms and definitions from control theory

3.3.1
differential equation
equation describing the dynamic system behavior in the time-domain, as shown in Annex A

3.3.2
transient response
system response (output) to a step change of the input

3.3.3
frequency response
dynamic response of the linearized system to a sinusoidal change of the input signal derived from the differential equation by applying the Fourier transformation

3.3.4
transfer function
dynamic response of the linearized system to an arbitrary variation of the input signal derived from the differential equation by applying the Laplace transformation

3.4 Subscripts and prefixes

Sub-clause	Term	Definition	Symbol	Unit
3.4.1	**rated**	subscript indicating the rated operation point of the system	r	–
3.4.2	**maximum minimum**	subscript indicating maximum or minimum values of any term	max. min.	–
3.4.3	**deviation**	deviation of any term from a steady-state value	Δ	–
3.4.4	**guide vanes**	subscript associating a quantity to guide vane position	ga	–
3.4.5	**runner**	subscript associating a quantity to runner blade position	ru	–
3.4.6	**nozzle**	subscript associating a quantity to needle position	ne	–
3.4.7	**Deflector**	subscript associating a quantity to deflector position	de	–

3.5 Terms and definitions related to the plant and the machines

Sub-clause	Term	Definition	Symbol	Unit
3.5.1	**specific energy of machine**	specific energy of hydraulic water available between the high- and low-pressure side sections of the machine	E	$J \cdot kg^{-1}$
3.5.2	**turbine head**	$H = E/g$ definition of E, see 3.5.1 g = acceleration due to gravity = 9,81 $m \cdot s^{-2}$ (at sea level)	H	m
3.5.3	**flow**	volume of water per unit time flowing through any section in the system	Q	$m^3 \cdot s^{-1}$
3.5.4	**rotational speed**	number of revolutions per unit time	n	s^{-1} [a]
3.5.5	**frequency**	cycles per second	f	Hz
3.5.6	**generator power output**	generator power measured at generator terminals	P_G	W
3.5.7	**moment of inertia of mass**	moment of inertia for calculation of fly-wheel effect. $I = M D^2/4 = MR^2$ (M = mass, D = diameter of gyration, R = radius of gyration)	I	$kg \cdot m^2$

[a] The unit rpm is frequently used.

3.6 Terms and definitions relating to the governing system

Sub-clause	Term	Definition	Symbol	Unit
3.6.1	**controlled variable**	variable which has to be controlled as speed n, output P_G, water level h, servoposition opening y, flow Q:		
		– absolute, dimensional value	X	var.
		– relative deviation from a steady-state value, $x = \Delta X/X_r$	x	–
		rotational speed	x_n	–
		power output	x_p	–
		water level	x_h	–
		opening	x_y	–
		flow	x_q	–
3.6.2	**command signal**	a signal which can be set by an external adjustment:		
		– absolute, dimensional value	C	var.
		– relative deviation from a steady-state value, $c = \Delta C/C_r$	c	–
		rotational speed	c_n	–
		power output	c_p	–
		water level	c_h	–
		opening	c_y	–
		flow	c_q	–
3.6.3	**servomotor stroke**	stroke of the main servomotor which moves the guide vane/runner blades/needles/deflectors		
		– absolute value	Y	m
		– relative deviation from a steady-state value, $y = \Delta Y/Y_{max}$	y	–
		Note 1 to entry: The effective max. servomotor stroke Y_{max} has to be defined between customer and supplier.		
3.6.4	**controlled variable range**	adjusting range for the setting of a controlled variable (rotational speed in speed control, or water level in level control) with an average setting of the permanent droop, if applicable (see 3.6.8 and 5.3.2):		
		– maximum value of the controlled variable for $Y/Y_{max} = 0$	X_{max}	–
		– minimum value of the controlled variable for $Y/Y_{max} = 1{,}0$	X_{min}	–
		SEE: Figure 1		

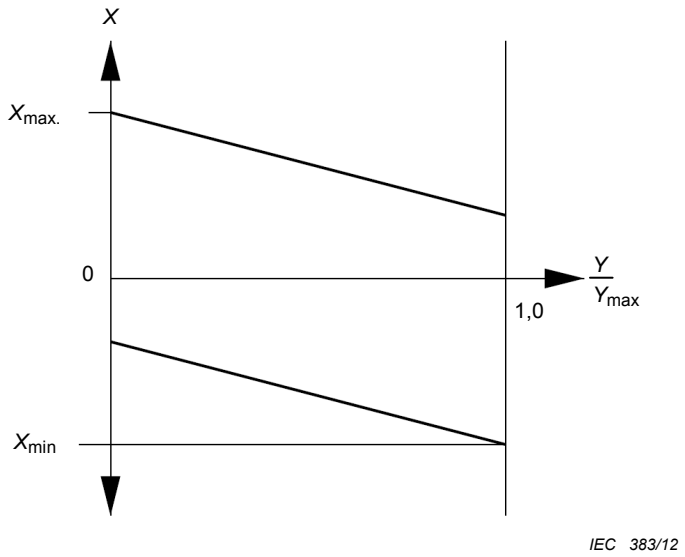

Figure 1 – Controlled variable range

Sub-clause	Term	Definition	Symbol	Unit
3.6.5	**electronic governor output signal**	output signal at the electronic governor = input signal of the following servo-positioner Relative deviation from a steady-state value	s	–
3.6.6	**output signal of a pilot servo-positioner**	output signal of a pilot servo-positioner = input signal of the following main servo-positioner Relative deviation from a steady-state value	s_v	–
3.6.7	**droop graph**	a graph showing the relationship between a relative controlled variable (speed n/n_r, or in some cases water level H/H_r) as a function of the relative servomotor stroke or the relative power output under steady-state conditions SEE: Figure 2		

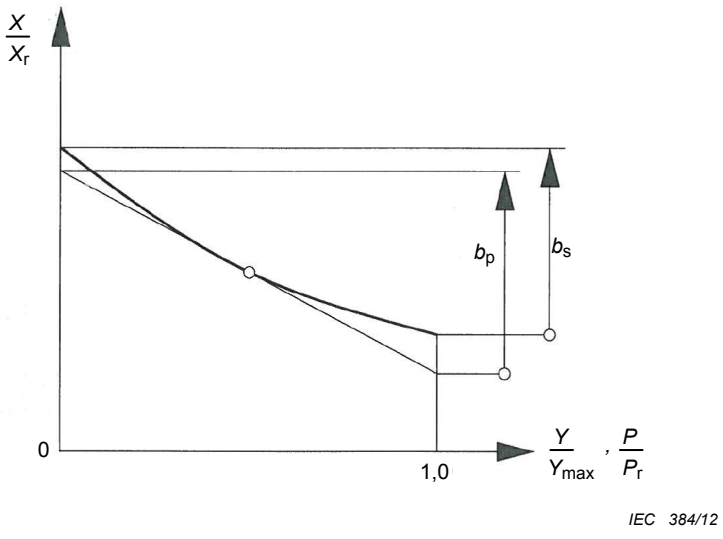

Figure 2 – Permanent droop

Sub-clause	Term	Definition	Symbol	Unit
3.6.8	**permanent droop**	slope of the droop graph (see Figure 2): – at a specific point of operation, – defined by the end values of the droop graph	 b_p b_s	 % %
3.6.9	**proportional action coefficient**[a]	proportional amplification, defined by the step response of an idealized PID-controller with $b_p = 0$, $K_D = 0$ and input signal $x = 1$ SEE: Figure 3	K_p	–
[a] In accordance with IEC 60050-351.				

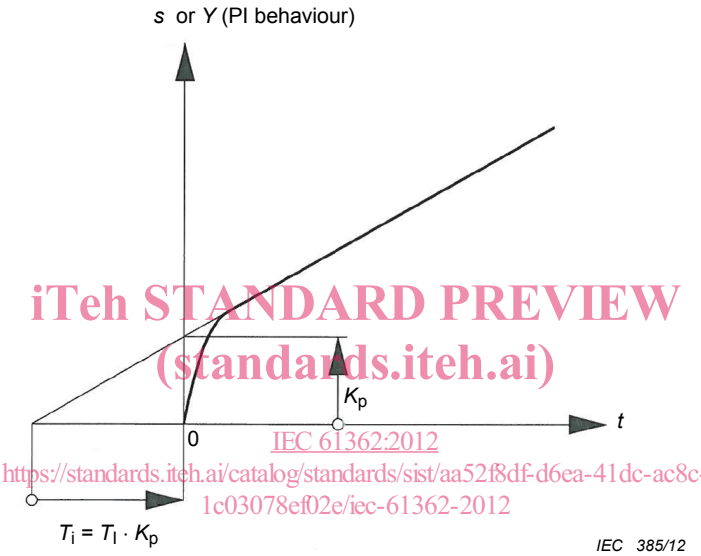

Figure 3 – Proportional action coefficient and integral action time