ICS 27.120.20
CCS F 65

NB

ENERGY INDUSTRY GUIDING TECHNICAL DOCUMENT OF THE PEOPLE'S REPUBLIC OF CHINA

NB/Z 20326-2014

Analysis methodology for uncertainty of setpoints for instrumentation of safety system in nuclear power plants

核电厂安全系统仪表触发整定值不确定度的分析方法

Issued on: October 15, 2014 **Implemented on: March 1, 2015**

Issued by: National Energy Administration of the PRC

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Foreword

This document was issued on 15 October 2014 by the National Energy Administration of the PRC and takes effect on 1 March 2015.

It is a NB/Z guiding technical document: it does not oblige, it guides.

It is classified under ICS 27.120.20, Chinese classification F 65.

This guiding technical document was drafted in accordance with the rules given in GB/T 1.1-2009.

This guiding technical document was prepared with reference to ISA-RP67.04.02-2000 Methodologies for the Determination of Setpoints for Nuclear Safety-Related Instrumentation.

This guiding technical document was proposed by the Nuclear Power Standardization Technical Committee of the Energy Industry.

This guiding technical document is under the administration of the Nuclear Industry Standardization Research Institute.

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Introduction

The main subject of this guiding technical document is the use of generally accepted methods to calculate the setpoint of a single instrument channel. The use of these methods is of great importance in guaranteeing the normal operation of the plant, in enveloping the accident analysis, and in guaranteeing the integrity of the fission product boundary.

The purpose of this guiding technical document is to give the person performing the calculation a definition of the various areas that have to be considered during the calculation of instrument channel uncertainty, and to offer some recommendations on the method of determining the setpoint.

Many concepts drawn from probability theory and mathematical statistics are used in this guiding technical document. Since those subjects are not the object of this document, the reader is advised to read first some material on the terms used here and on the related basic concepts of mathematical statistics, in order to establish a grounding in those areas.

In addition, this guiding technical document recognises that some of the safety-related setpoints defined by a plant are not closely related to the safety analysis, and that from a

system point of view there may be no clearly defined limiting value at all. In such cases a graded approach may be used to classify the safety-related setpoints of the plant, the grading being based on the contribution made to plant safety. On the basis of such a classification it is then possible to give guidance on the determination of channel uncertainty. How the specific criteria for the grading are established, and the method of dividing the levels used for the analysis, are not discussed in this guiding technical document.

1 Scope

NB/Z 20326-2014 is the Chinese guiding technical document that sets out how to calculate the uncertainty of a trip setpoint in the safety instrumentation of a nuclear power plant. It exists because a reactor trip setpoint is not a number an engineer chooses: it is the end of an arithmetic chain that begins with the safety limit the plant must never cross. The safety analysis fixes an analytical limit below that safety limit, and the trip has to be set far enough below the analytical limit that the protection still acts in time even when every instrument in the chain is at the unfavourable end of its tolerance at once. Set the trip too close to the analytical limit and the plant can cross the limit while the instrumentation still reads normal; set it too far away and the reactor trips on noise and the plant is unavailable. Everything therefore turns on knowing honestly how wrong the instrument channel can be. This document builds that number step by step: it defines the twenty-nine terms the calculation uses, from as-found and as-left state through bias, drift, span and reference accuracy to channel uncertainty itself; it requires the channel to be drawn as a configuration diagram from the process interface to the bistable, with the environmental conditions each part experiences; it enumerates the sources of uncertainty part by part, separating process measurement effects such as impulse line temperature and fluid density from instrument effects such as temperature, pressure, drift and power supply variation; it classifies each contribution as random, bias or abnormally distributed, which decides whether it may be combined by the square root of the sum of the squares or must be added arithmetically; and it then derives the trip setpoint and the allowable value used during periodic testing. Nine informative annexes carry the worked detail, covering differential pressure level measurement, flow accuracy, pipe head loss, RTD accuracy, insulation resistance, statistical analysis, digital signal conditioning and plant-specific calibration data. The document was prepared with reference to ISA-RP67.04.02-2000, and is the companion to NB/T 20072-2012, which governs the determination and maintenance of the setpoints themselves. It was issued on 15 October 2014 by the National Energy Administration and took effect on 1 March 2015.

This guiding technical document specifies the methodology for analysing the uncertainty of the trip setpoints of safety system instrumentation in nuclear power plants.

This document applies to the analysis of the uncertainty of the trip setpoints of safety

system instrumentation in nuclear power plants.

2 Normative references

The following document is indispensable for the application of this document. For dated references, only the edition cited applies to this document. For undated references, the latest edition, including all amendments, applies to this document.

NB/T 20072-2012 Determination and maintenance of trip setpoints for safety system instrumentation in nuclear power plants

3 Terms and definitions

The following terms and definitions apply to this document.

3.1 allowable value

A limiting value that the trip setpoint may take during periodic testing; if this limit is exceeded, appropriate measures are taken. [NB/T 20072-2012, definition 3.1]

3.2 analytical limit (of setpoint)

A limiting value of a measurable or calculable variable, determined by the safety analysis, that ensures the safety limit is not exceeded. The margin between the analytical limit of the setpoint and the safety limit shall take account of: the response time of the instrument channel; and the transient range of the postulated accident. [NB/T 20072-2012, definition 3.2]

3.3 abnormally distributed uncertainty

An uncertainty that does not have the characteristics of a normal distribution.

3.4 as found

The state of an instrument channel, or of part of a channel, after one operating cycle and before recalibration, if recalibration is necessary. [NB/T 20072-2012, definition 3.3]

3.5 as left

The state of an instrument channel, or of part of a channel, after calibration or verification of the setpoint of the terminal setpoint device. [NB/T 20072-2012, definition 3.4]

3.6 bias

A component of uncertainty that always carries the same algebraic sign, positive or negative, and is expressed as a bounded error of a given magnitude.

3.7 bistable

A device or component whose output state changes as soon as the signal reaches the set