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Guide for the nuclear power plant control room human factors engineering integrated system validation

核电厂控制室人因工程集成系统确认指南

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Foreword

This document was issued on 7 January 2021 by the National Energy Administration of the PRC and takes effect on 1 July 2021.

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 document was drafted in accordance with the rules given in GB/T 1.1-2020 Directives for standardization - Part 1: Rules for the structure and drafting of standardizing documents.

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

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1 Scope

NB/Z 20598-2021 is the Chinese guiding technical document for integrated system validation of human factors engineering in a nuclear power plant control room. It exists because verification and validation answer two different questions, and only one of them can be answered by inspection. Verification checks each element of the control room against its criteria - is this display legible, is that control reachable, does the alarm meet the

guideline - and a well built control room can pass every one of those checks and still fail the operator. Validation is the step that puts the whole thing together: real licensed operators, the real procedures and the complete human-system interface, working a demanding scenario in real time on a full-scope simulator, to see whether the crew actually keeps the plant safe. That distinction is the lesson the industry took from accidents where the equipment behaved as designed and the control room still did not tell the crew what was happening. This document sets out how that test is run: how the validation team is put together and why it has to stay independent of the designers, how faithful the simulator has to be in physical form, function, data content and dynamic response, who may sit in the operator seats - licensed operators of that plant, not hand picked high performers and not anyone who worked on the design or on an earlier assessment - which plant conditions have to be sampled, from normal start-up and refuelling through faults and design basis accidents to design extension conditions such as station blackout, and how the resulting data is turned into a defensible conclusion. Being an NB/Z document it guides rather than obliges, but it is the text a Chinese reviewer works from when assessing the human factors engineering file for a control room. It was issued on 7 January 2021 by the National Energy Administration and took effect on 1 July 2021.

This document specifies the requirements for every aspect of carrying out integrated system validation of human factors engineering for nuclear power plant control rooms, including the composition of the validation team, the test objective requirements, the test platform requirements, the requirements on the test participants, the selection of operating conditions, performance measurement, test design and personnel training, data analysis, and the validation conclusion.

This document applies to the guidance of integrated system validation activities for human factors engineering of nuclear power plant control rooms.

2 Normative references

The following document contains provisions which, through normative reference in this text, constitute indispensable provisions of this document. For dated references, only the edition corresponding to that date applies to this document. For undated references, the latest edition (including all amendments) applies to this document.

GB/T 13630-2015 Design of nuclear power plant control rooms

3 Terms, definitions and abbreviations

3.1 Terms and definitions

The following terms and definitions apply to this document.

3.1.1 human factors verification

The process of determining whether each component satisfies the specified requirements, that is, a series of analytical examinations of the human-machine interfaces - measuring instruments, controllers, displays and other equipment - carried out against the specified technical specifications, the human factors engineering criteria, and the operating and functional objectives.

3.1.2 human factors validation

The tests carried out to ensure that the integrated whole formed by the personnel, the procedures and the human-system interfaces within the control room system is able to guarantee the safe and reliable operation of the plant.

3.1.3 simulator

A physical human-system interface facility that represents the configuration of the actual nuclear power plant control room and is able to reproduce dynamically the operating characteristics and the real-time response of the plant.

3.2 Abbreviations

The following abbreviations apply to this document.

HSI: Human System Interface

PSA: Probabilistic Safety Assessment

SPDS: Safety Parameter Display System

4 General principles

Clause 8.3.1 of GB/T 13630-2015 states that the control room system as an integrated whole shall be validated in order to demonstrate that it can achieve the intended performance, and that particular attention shall be paid to the time-dependent dynamic characteristics of the integrated control room system.

Integrated system validation of human factors engineering in a nuclear power plant is an essential part of human factors verification and validation. It examines the human factors engineering design of the control room system as a whole and supports an effective assessment of the HSI design, of training and of procedure development, so that the nuclear power plant can be operated safely and effectively.

Integrated system validation activities shall be organised and planned in advance, the test activities shall be carried out in accordance with the established test procedure, and the validation conclusion shall finally be reached through analysis of the test data. The following principles shall be given full consideration in the course of the activity:

a) the validation team shall be made up of personnel from several disciplines and/or specialities, and shall remain independent of the design personnel concerned;

b) the test platform shall be highly consistent with the real unit;

c) the test participants shall be licensed operators of the plant concerned; the staffing of the test participants shall be consistent with the actual staffing of the unit control room; and the sample of participants shall be large enough to represent the overall level of the plant;

d) the operating conditions selected shall be representative;

e) a detailed test procedure shall be prepared, and both the test participants and the test execution personnel shall receive the corresponding training;

f) in order to ensure the quality of the test, a pre-test shall be carried out before the formal test activity;

g) all problems found during the whole activity shall be recorded, tracked and resolved;

h) the analysis of the validation test data shall combine qualitative and quantitative methods; the relationship between the observed performance data and the existing performance criteria shall be clear and shall be supported by the results of the data analysis;

i) the validation conclusion shall rest on a clear basis of data and logic.

5 Integrated system validation

5.1 Team composition

The validation team shall be made up of personnel from several disciplines (specialities), assembled according to the professional characteristics of the validation work, and the qualification requirements for the personnel shall be clearly stated. Personnel from the relevant specialities shall jointly take part in the test design, the development of the test procedure, the performance measurement and the data analysis.

The members of the validation team shall maintain a degree of independence from the design personnel concerned, so as to guarantee the objectivity and impartiality of the assessment. Independence also helps to prevent expectation bias on the part of the test personnel, a bias that would affect the validity of the test. Before conducting the system test, the independent validation team shall understand the assumptions and constraints of the design stage, and shall avoid problems arising during the test from exceeding those assumptions and constraints.

The validation team shall be able to consult all documents relating to human factors engineering and to have access to all members of the human factors engineering team.

The post responsibilities within the team and the corresponding disciplines (specialities) are given in Table 1.

Table 1 - Post responsibilities and corresponding specialities