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NB

ENERGY INDUSTRY STANDARD OF THE PEOPLE'S REPUBLIC OF CHINA

NB/T 20487-2018

Methodology for performance of internal fire probabilistic safety assessment for nuclear power plants

核电厂内部火灾概率安全评价开发方法

Issued on: March 22, 2018 **Implemented on: September 1, 2018**

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Foreword

This document was issued on 22 March 2018 by the National Energy Administration of the PRC and takes effect on 1 September 2018.

It is a NB/T standard: recommended rather than compulsory, but it is the text a Chinese reviewer applies when assessing a submission.

It is classified under ICS 27.120.30, Chinese classification F 65.

This standard has been drafted in accordance with the rules given in GB/T 1.1-2009, Directives for standardization, Part 1: Structure and drafting of standards.

This standard has been developed mainly with reference to the internal fire PSA guidance of the United States Nuclear Regulatory Commission, NUREG/CR-6850, combined with the practical experience gained in the performance of internal fire probabilistic safety assessment at domestic nuclear power plants.

This standard was proposed by the Technical Committee for Nuclear Power Standardization of the energy industry.

This standard is under the jurisdiction of the Research Institute of Nuclear Industry Standardization.

The organizations that drafted this standard are: Suzhou Nuclear Power Research Institute Co., Ltd., Shanghai Nuclear Engineering Research and Design Institute Co., Ltd., and China Nuclear Power Engineering Co., Ltd.

The principal drafters of this standard are: Liu Xiang, Yang Zhichao, Li Zhaohua, Qiu Yongping, Zhao Qingnan, Huang Lihua, Zhu Yaoyao, Chen Yanzhu, He Jiandong and Yu Xinli.

Publication data

NB/T 20487-2018, Methodology for performance of internal fire probabilistic safety assessment for nuclear power plants, is an energy industry standard of the People's Republic of China issued by the National Energy Administration.

The standard carries the international classification ICS 27.120.30 (nuclear energy engineering, nuclear power plants and safety) and the Chinese standard classification code F 65. Its record number with the standardization authority is 62823-2018.

The standard was issued on 22 March 2018 and entered into force on 1 September 2018. The cover page carries no superseding note, so the document is an original issue and does not replace an earlier edition.

The Chinese title of the document is Hedianchang neibu huozai gailv anquan pingjia kaifa fangfa, literally the development methodology for internal fire probabilistic safety assessment of nuclear power plants. The English title printed on the cover reads Methodology for performance of internal fire probabilistic safety assessment for nuclear power plants.

The document contains four numbered clauses, one figure (the internal fire PSA development process), a series of tables supporting equipment and cable selection, and a bibliography. The body of the standard runs to 84 pages plus the bibliography.

Structure of the document

Clause 1 defines the scope of application of the standard; clause 2 lists the normative references; clause 3 gives the terms, definitions and abbreviations, split into 3.1 terms and definitions, with nineteen entries, and 3.2 abbreviations, with nine entries.

Clause 4 sets out the methodology for the development of the internal fire probabilistic safety assessment, and occupies the whole of the body of the standard from page 3 to page 83. It opens with 4.1, the overview of the methodology, which introduces the fifteen tasks and the two supporting tasks and presents Figure 1, the internal fire PSA development process.

The subclauses from 4.2 to 4.16 describe the fifteen tasks in order, each of them from the standpoint of objective, assumptions, task interfaces and steps: plant global analysis boundary and plant partitioning (4.2), internal fire PSA equipment selection (4.3), internal fire PSA cable selection (4.4), qualitative screening (4.5), fire-induced risk model (4.6), ignition frequency calculation (4.7), quantitative screening (4.8), determination of the scope of fire modelling (4.9).

The description of the tasks continues with detailed circuit failure analysis (4.10), circuit failure mode likelihood analysis (4.11), detailed fire modelling (4.12), post-fire human reliability analysis (4.13), fire risk quantification (4.14), uncertainty and sensitivity analysis (4.15) and internal fire PSA documentation (4.16).

The last two subclauses, 4.17 and 4.18, describe the two supporting tasks, namely supporting task A, the plant walkdown, and supporting task B, the internal fire PSA database. A bibliography closes the document at page 84.

The longest subclauses of the standard are those devoted to ignition frequency calculation, which runs from page 26 to page 37, to detailed fire modelling, from page 54 to page 64, and to post-fire human reliability analysis, from page 65 to page 73, which reflects the analytical weight of these three tasks within the overall method.

1 Scope

NB/T 20487-2018 sets out the method by which an internal fire probabilistic safety assessment is carried out for a nuclear power plant. Fire is treated separately from other internal events because it can defeat redundancy directly: a single fire in one room can damage several trains of a safety system at once, through cables that happen to share a route. A fire PSA quantifies that. The standard organises the work as a sequence of tasks. It begins with plant partitioning into fire compartments and zones, the identification of the equipment and cables in each, and the screening that removes compartments which cannot matter. It then covers the fire ignition frequency analysis using the plant and generic databases, the qualitative and quantitative screening steps, the fire scenario definition with

its ignition source and target set, fire growth and propagation modelling, the treatment of detection and suppression and their reliability, the circuit failure analysis including spurious operation, and the human reliability analysis for actions taken during a fire. The plant response model is then modified for each scenario and quantified to yield core damage frequency and large release frequency, with the uncertainty and sensitivity analysis and the importance measures that follow. Documentation and peer review close the method. Note that the Chinese title says development methodology, which the printed English renders only as methodology for performance.

This standard specifies the methodology for the development of a level 1 probabilistic safety assessment of internal fires (internal fire PSA) for nuclear power plants at power operation.

This standard applies to internal fire PSA for pressurized water reactor nuclear power plants at power operation. After the characteristics of shutdown conditions have been considered and appropriate corrections made, it also applies to internal fire PSA for shutdown conditions.

Nuclear power plants of other reactor types may take this standard as a reference.

2 Normative references

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

NB/T 20037.1, Level 1 probabilistic safety assessment applied to nuclear power plants, Part 1: General requirements.

NB/T 20037.4, Level 1 probabilistic safety assessment applied to nuclear power plants, Part 4: Internal fires at power operation.

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in NB/T 20037.1 and NB/T 20037.4 apply, together with the following.

3.1.1 ceiling jet. A layer of gas flowing along the surface beneath the ceiling, driven by the high temperature combustion products of the fire plume.

3.1.2 conductor-to-conductor short. An unintended electrical path between two or more conductors, such that the potential difference between those conductors becomes equal or close to zero.

3.1.3 fire area. An area made up of one or more rooms and enclosed by fire barriers whose fire resistance rating is at least equal to the duration of the design basis fire. A fire area shall ensure that a fire occurring inside the space does not spread outside it, and that a fire