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Design requirements for the passive containment heat removal of pressurized water reactor nuclear power plants

压水堆核电厂非能动安全壳热量导出设计要求

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Foreword

This document complies with the provisions of GB/T 1.1-2020 "Standardization Work Guidelines Part

1.Structure and Drafting Rules of Standardization Documents". Drafting. Please note that some content in this document may involve patents. The issuing organization of this document assumes no responsibility for identifying patents. This document was proposed and is under the jurisdiction of the National Nuclear Energy Standardization Technical Committee (SAC/TC58). This document was drafted by: China Nuclear Power Engineering Co., Ltd., Nuclear and Radiation Safety Center of the Ministry of Ecology and Environment, Harbin Engineering University, and China National Nuclear Corporation. Formerly, China International Engineering Co., Ltd., Hualong International Nuclear Power Technology Co., Ltd., Shanghai Nuclear Engineering Research & Design Institute Co., Ltd., and CGN Engineering. Limited Liability Company, Nuclear Industry Standardization Research Institute. The main drafters of this document are. Hu Zongwen, Huang Weifeng, Gao Li, Jiang Huixia, Mao Yawei, Li Li, Yu Yong, Yuan Xia, Li Jingyan, Li Lijuan, and Zheng Yuntao. Wang Xiangyi, Dou Chaozong, Zeng Qingzhu, Li Chun, Zhao Danni, Sun Zhongning, Ding Ming, Zhang Nan, Zhao Guanghui, Pan Xinxin, Huang Jingyu, Zhou Shaofei, Gu Mingzhou Wang Zhichao. Heat removal from the passive containment of pressurized water reactor nuclear power plants Design Requirements

1.Scope This document specifies the overall design requirements for passive containment heat removal in pressurized water reactor nuclear power plants, including containment heat

removal and safety distribution. Levels, single failure criteria, internal and external events, and testing and maintenance, etc. This document applies to the design of passive containment heat removal functions and systems in pressurized water reactor nuclear power plants.

2 Normative references

This document has no normative references.

4 System and Functions

4.1 Passive containment heat removal system To achieve the heat dissipation function of passive containment structures, considering the characteristics of concrete and steel containment structures, different passive containment structures can be designed. The entire containment heat removal system is achieved through water cooling or air cooling. A typical passive containment heat removal system is shown in Appendix A.

4.2 Main Functions

4.2.1 Passive containment heat removal system is used to remove heat from the containment under accident conditions to prevent the containment pressure and temperature from exceeding the specified limits. Set limits to maintain the integrity of the containment structure.

4.2.2 The portion of this system that forms the boundary of the containment structure shall meet the requirements for containing radioactive materials.

5.1 Heat Dissipation from the Containment

5.1.1 When performing the containment heat removal function after an accident, the system will reduce and maintain the containment temperature and pressure within the design limits.

5.1.2 When performing the containment heat removal function after a design-based accident, the system should reduce the containment pressure to the design level within 24 hours after the accident. Below 50% of the pressure (gauge pressure). If analysis indicates that the calculated containment pressure cannot be reduced to 50% of the design pressure within 24 hours, then... The impact of stress on radiological consequences needs to be assessed.

5.1.3 When the cooling water tank is used as a heat sink for heat removal from the containment, its water volume should be sufficient to meet the cooling requirements for a certain period of time after an accident. When performing the design-based containment heat removal function after a disaster, the cooling water tank capacity should be sufficient to meet cooling requirements for 72 hours after the accident. After this, water replenishment can be used to keep the system running continuously.

5.1.4 For extreme environments at the plant site, measures should be taken to prevent the cooling water from freezing.

5.1.5 The water quality in the cooling water tank should be within an acceptable range.

5.1.6 Pipelines and equipment located within the containment and forming a closed loop in the system shall be considered as containment boundaries.

5.2 Safety Classification

5.2.1 Containment heat removal is an important safety function. The classification of passive containment heat removal systems and equipment shall be in accordance with nuclear safety regulations. The relevant provisions of HAF102-2016 and its guidelines shall be followed.

5.2.2 The portion used for performing containment heat removal under design-baseline accident conditions shall be of safety grade. It shall only be used for extended design conditions. The portion of the containment that performs heat dissipation function may be non-safety grade.

5.2.3 Equipment and piping that serve as containment boundaries shall be of a safety class.

5.3 Single Failure Criterion

5.3.1 If a passive component is not affected by the assumed initiating event, then in a single failure analysis, it does not need to be assumed to fail, and its design, Manufacturing, in-service inspection, and maintenance should all reach a high level of quality.

5.3.2 Active equipment used for design baseline accidents and requiring a change in state shall meet the active single fault requirement.

5.4 Internal and external events

5.4.1 The design shall provide protection against internal events such as fire, explosion, internal flooding, internal projectiles, pipe swaying, and jet stream impact. Require.

5.4.2 For design-based accidents, the design shall meet requirements such as earthquakes, design-based aircraft impacts, floods, strong winds, tornadoes, and tsunamis (tidal waves). Protection requirements for external events such as extreme weather conditions. These protection requirements can be referenced when designing for extended operating conditions.

5.5 Operating Guidelines

5.5.1 For design baseline accidents, the system should be able to start automatically without human intervention.

5.5.2 For designing extended operating conditions, the system can be put into operation automatically without human intervention.

5.6 Layout Guidelines The layout of system equipment and components should meet the following requirements.

a) Natural heat extraction;

b) Reduce the adverse effects of uneven temperature distribution within the containment body, including unevenness between the interior and exterior of the containment body and in the concrete structure. Heat transfer;

c) Facilitates operation and maintenance, in-service inspection, periodic testing, and radiation protection.

5.7 Power Supply Active equipment intended to respond to design-baseline accidents should be powered by a safety-grade power supply.

5.8 Instrumentation and Control

5.8.1 The system should be able to be monitored and controlled from the main control room during normal operation and accidents at the nuclear power plant.

5.8.2 In the event of a severe accident, the system should be able to monitor critical information at the emergency control center.

6 Testing and Maintenance

6.1 The ability to conduct testing and maintenance to ensure system operation should be provided.

6.2 Measures should be taken to ensure that the passive containment heat removal system is adequately inspected.

6.3 Appropriate venting and drainage measures should be provided to allow for equipment maintenance.

6.4 Maintenance accessibility should be ensured in accordance with maintenance requirements.