Radiation protection risk control method of nuclear power project based on sequence optimization

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Abstract. In order to protect the construction safety of nuclear power project and improve the radiation protection effect of nuclear power project, this paper introduces the sequence optimization algorithm to study the risk control method of nuclear power project radiation protection. The radiation risk level of nuclear power project is divided by sequential optimization algorithm, and the control structure of radiation protection risk of nuclear power project is optimized. In this paper, the radiation protection risk detection procedure is used to improve the radiation protection risk detection process of nuclear power engineering, so as to enhance the control effect of radiation protection risk of nuclear power engineering. In order to verify the protective effect of this method, a comparative experiment was designed. The results show that the radiation protection risk control method based on sequence optimization has high control accuracy in the practical application process, which fully meets the research requirements.

1. Introduction

Nuclear energy has many advantages. It is an important energy for human survival and development, and an indispensable part of the power industry. At present, the environmental problems at home and abroad are relatively serious. China is actively developing and utilizing new energy sources to promote the development of nuclear energy projects. The construction of nuclear power project is very complex. It is everyone's wish to effectively control the radiation risk of nuclear power project, protect the safety of construction related personnel, and realize the safe operation of the project. Therefore, risk management is very important[1]. At present, there is no standardized management mode. At present, the main problems existing in the management of radiation protection in China are: the concept of radiation protection is not mature enough, the organizational system of radiation protection is not perfect, the training and licensing system of radiation protection is not perfect, the management system of radiation work permit is not unified, the research on radiation source control is insufficient, the system of personal dose monitoring and management is not perfect, and the radiation protection facilities are not optimized[2]. Therefore, this paper proposes a risk control method of nuclear power project radiation protection based on sequence optimization. Combining foreign and domestic radiation protection risk control methods, according to national regulations and standards, the radiation protection risk control methods are optimized to further improve the radiation protection effect of nuclear power projects.
2. Radiation protection risk control of nuclear power project

2.1. Radiation risk measurement of nuclear power project based on sequence optimization

Risk assessment is mainly a comprehensive analysis of various risks that may occur, to measure the risks as a whole, and to evaluate whether the whole project can bear these risks. Through the comprehensive evaluation of the project risk, find out the relationship between the risk events, analyze the possible losses to the whole project, and then formulate a scientific and reasonable response plan to eliminate and reduce the project risk[3,4]. Again, it is necessary to measure whether the whole project can bear the possible risks, and finally determine whether the project can continue.

On the basis of risk assessment and analysis, this paper puts forward a series of risk response measures and methods, mainly aiming at various risks that may appear in the project to take positive measures to reduce or eliminate the impact of risks on the whole project[5]. According to the size and priority of risks and the progress of project objectives, it is very necessary to formulate feasible, scientific and reasonable risk countermeasures. It is necessary to cultivate the staff's risk awareness, so as to achieve effective ways to prevent, reduce, transfer, retain and utilize risks[6]. Based on this, the radiation anti-skid risk prevention and control structure of nuclear power project is optimized, as shown in the following figure:

![Radiation protection risk management structure](image)

Fig.1 Radiation protection risk management structure

Risk mainly refers to the active prevention of possible risks in the process of project implementation, the use of technology and various means to prevent the generation of risks, isolate various risk factors and avoid the accumulation of risks; the inevitable risks are taken to reduce the risks and reduce the occurrence of risks; taking transfer measures for risks is a more practical risk response strategy[7]. Try to transfer the risk to someone else, preferably to someone who can afford it. It is the most ideal to realize the win-win situation between the risk transferor and the risk receiver. First understand the possible risks in financial management. Other positive risk factors should also be included in the risk countermeasures. After the risk occurs, the wind can be compensated.

2.2. Optimization of radiation protection risk detection program

All nuclear power plant production activities must be based on strict management procedures. Radiation protection management is an important part of nuclear power plant safety management. To do a good job in radiation protection management, it is necessary to establish a sound program
In the process of management, we should first meet the requirements of national and industrial regulations, standards, norms and norms. According to the pre-set guidelines and risk levels, determine the risks to be dealt with, and classify the risks. Effectively eliminate or reduce radiation hazards to ensure safe production of source enterprises and occupational health of employees\textsuperscript{[9]}. The practicability of the evaluation method is analyzed, and the guiding significance of establishing the evaluation system for the application of radioactive sources in nuclear point engineering is discussed.

| classification | Quantity (copies) | \begin{itemize} 
  \item Integrated management of radiation protection
  \item Entrance and exit management of radiation control area
  \item Fire safety supervision
  \item Boundary management of radiation control area
  \item Operation management of radiation monitoring system
  \item Radioactive source management of radioactive materials
  \item Portable instrument and material management
  \item Management of electronic dosimeter system
  \item Refuelling outage radiation protection action guide
  \item Implementation plan of radiation protection for refueling overhaul
  \item Refuelling overhaul radiation protection control point
  \item Refuelling outage radiation protection measurement chart
\end{itemize} |
|-----------------|-----------------|
| Guidelines for preparation of radiation protection investigation report |
| Guide for filling in radiation protection duty log |
| Guidelines for access to the reactor building after criticality |
| Radiation control area boundary door opening and closing |
| Work guide radiation monitoring system operation card |
| Operation guide for radiation safety supervision of radiographic inspection |
| Introduction of portable radiation instrument |
| Guide for daily maintenance of electronic dosimeter system |
| Refuelling outage radiation protection action guide |
| Radiation protection implementation plan for the 10th overhaul of unit 1 |
| Radiation protection scheme for pressure vessel operation |
| Visual inspection of radiation protection control points of pressure vessel flange |
| Measurement drawing of steam generator primary side manhole after opening |

When repairing equipment with serious radioactive contamination, a permanent negative pressure shed should be connected to the inlet of the pollution source. If the opening of radioactive equipment or system may cause air pollution, a vacuum cleaner should be installed at the opening of the system or equipment to suck out the leaked radioactive air, and filter the radioactive aerosol with a filter, so as to prevent workers from directly inhaling after opening the system. Staff can wear personal respiratory protective devices and use aerosol monitor to continuously monitor the air pollution on site according to the pollution of the system and equipment. Generally, direct acting seal can be used to maintain pressurizer, open pump body and valve, replace various packing and filter radioactive equipment. Based on this, the radiation protection risk detection process of nuclear power project is optimized, as shown in the following figure:
2.3. **Realization of nuclear radiation protection risk control**

Sequence optimization technology is used to control radiation protection, and the maintenance work on site is transferred to computer instruments. The potential radiation hazards of computer radiation to nuclear power plant buildings. In the sequence optimization scenario of nuclear power plant buildings, maintenance personnel can interact with each other through friendly interactive interface in a repeatable roaming environment. Through repeated practice, maintenance personnel can It can help the maintenance personnel to intuitively judge where the radiation high-risk area is and determine the maintenance path under zero risk state, so as to replace the traditional desktop negotiation scheme determination method. Good guidance on site maintenance. Some operations will change the distribution of dose field in the optimization environment of main program sequence during maintenance. The program changes the user's dose calculation scenario, then triggers recalculation and outputs the results to the output file. In the data conversion interface, the conversion results are returned to the main program to update the dose display effect.

Nuclear protection risk control mainly includes three-dimensional sequence optimization main program, database file system and post-processing module. Furthermore, it simulates the roaming and maintenance of the workshop in charge of front order optimization, and maps the dose data from background calculation to optical attribute map, which makes background calculation more realistic. The main program of 3D order optimization and the back-end dose calculation module need data conversion. As mentioned above, the database file system is the link between the 3D sequence optimization main program and the background dose calculation module. In order to convert the read-write data into the dynamic link library of the database file system, this paper designs a general data conversion interface. In the future, it is not necessary to modify the main program, but to extend the algorithm to the existing data conversion interface. Similarly, the back-end calculation module also adopts the form of dynamic link library.
After the nuclear power radiation dynamic link library structure is configured with functions, the risk prevention and control system model is established. Combined with the engineering practice of Jilin Jingyu nuclear power plant, the maintenance scheme of operation unit and competent department is put forward. Digital and distributed instrument control systems are used. Human factors are fully considered in the design of main control room.

Fig. 3 structure of nuclear radiation dynamic link library

Based on the above methods, the research objectives of reasonable protection and control of nuclear power project radiation and scientific avoidance of nuclear radiation risk can be achieved effectively.

3. Analysis of experimental results

In order to verify the practical application effect of the radiation protection risk control method based on sequence optimization for nuclear power engineering, a reasonable design of multiple function integration functions of nuclear power project is carried out. By reducing equipment, total production and building area, the construction period and total cost are minimized. In the process of use, 2e battery pack, DC switch and comprehensive protection are required. The installation of protection system and main control room reduces the distribution of cables in PWR nuclear power plant; the use of passive safety system replaces or cancels many conventional mechanical safety measures in some seismic buildings of PWR nuclear power station. The experimental environment and parameters are further standardized as follows:

| Classification | name               | describe                                                                 |
|----------------|--------------------|--------------------------------------------------------------------------|
| Class A        | High risk radiation device | In the event of an accident, serious radiation damage, even death, or serious impact on the environment can be caused to the exposed personnel in a short time. |
Class B  Medium risk radiation device
In case of accident, the exposed personnel may suffer from serious radiation damage, and even lead to death.

Class C  Low risk radiation device
Generally, radiation damage to the exposed personnel will not be caused during the accident.

Class D  Extremely dangerous source
Without protection, exposure to such sources can cause death in minutes to one hour.

Class E  High risk source
Without protection, exposure to these sources for hours and days can cause death.

Class F  Dangerous sources
Without protection, exposure to such sources can cause permanent damage to people for a few hours, and can cause death for several days and weeks.

Class G  Low risk source
It will not cause long-term damage to man-made, but it may cause temporary damage that can be quickly recovered to people who have long-term and close contact with these radioactive sources.

Class H  Very low risk source
It will not cause permanent damage to people.

Based on the information in the above table, the traditional control method and the method in this paper are further compared for detection, and the actual control accuracy of the two methods is recorded. The specific test results are shown in the following figure:

![Comparison of test results](image)

Based on the above inspection results, it is not difficult to find that, compared with the traditional methods, the control effect of the radiation protection risk control method based on sequence optimization proposed in this paper is obviously better than the traditional method in the actual application process, and the risk control effect is still stable in the case of large risk, which fully meets the research requirements.

4. Conclusion
In view of the problems existing in radiation protection management in China, this paper proposes a risk control method of nuclear power project radiation protection based on sequence optimization. By dividing the radiation risk level of nuclear power project, designing the radiation protection risk detection procedure, improving the radiation protection risk detection process of nuclear power project, the radiation protection risk control of nuclear power project is realized. Experiments show that the proposed method still has high control accuracy under a large risk level, which indicates that this method has good protection effectiveness.

Reference
[1] Zhu F, Pu Z, Chen P, et al. Investigation on Hold-down Force Calculation Model of Fuel Assembly Based on Monte Carlo Algorithm[J]. Hedongli Gongcheng/Nuclear Power
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[2] Wang J, Zan Y, Huang Y. Experimental Study on Flow and Heat Transfer during Reflooding Process in a Vertical Annual Channel[J]. Hedongli Gongcheng/Nuclear Power Engineering, 2018, 39(4):22-32.

[3] Cai Y, Zhang Z, Li Q, et al. Application of Diagonally Implicit Runge Kutta with Exponential Transformation on Point Kinetic Equations[J]. Hedongli Gongcheng/Nuclear Power Engineering, 2018, 39(8):24-27.

[4] Zhao D, Chen X, Wang X, et al. Causal Analysis and Resolution of Main Feedwater Pump Frequency-Doubled Vibration of Tianwan NPP Units 3 and 4[J]. Hedongli Gongcheng/Nuclear Power Engineering, 2018, 39(6):79-80.

[5] He T, Liu X. Research on Fuel Loading Operation Scheme for Annual Refueling Core of M310 Advanced Nuclear Power Plant[J]. Hedongli Gongcheng/Nuclear Power Engineering, 2019, 40(1):37-41.

[6] Zeng J, Peng C, He P, et al. Research on Current Monitoring and Fault Diagnosis Technology for Control Rod Drive Mechanism[J]. Hedongli Gongcheng/Nuclear Power Engineering, 2019, 40(1):172-175.

[7] Yan W, Liu J. Research and Application of the Blowdown Cave Hydraulic Flushing Device of the Horizontal Steam Generator[J]. Hedongli Gongcheng/Nuclear Power Engineering, 2019, 40(1):101-104.

[8] Liu Y, Huo M, Lan L, et al. Experimental Study on Separating Efficiency of Heat Pump Evaporating System in Nuclear Power Plant[J]. Hedongli Gongcheng/Nuclear Power Engineering, 2018, 39(4):141-143.

[9] Hou J, Xia Y. Optimal Analysis of Mixing Performance of In-Containment Refueling Water Storage Tank in a Nuclear Power Plant[J]. Hedongli Gongcheng/Nuclear Power Engineering, 2018, 39(4):137-140.