Basic Model Design of Online Monitoring System for Mixed Radiation Field

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Abstract. With the wide application of nuclear technology, the radiation field shows more and more characteristics of hybrid, complexity and versatility. In order to ensure the safety and data transparency of radiation field, online radiation monitoring system is usually established for all important radiation fields. Its purpose is to monitor the parameters of radiation field in real-time and accurately, and evaluate the status of radiation safety scientifically and reliably. Therefore, a basic model of online monitoring system for mixed radiation field is established, which can be carried out proper expansion in accordance with the different scales and styles of radiation field.

Keywords: Mixed radiation field · Online monitoring system · Basic model · Evaluation

1 Preface

With the extensive and in-depth application of nuclear technology in national defense and civil fields, the radiation field shows more and more characteristics of hybrid, complexity and versatility. In order to ensure the safety and data transparency of radiation field, online radiation monitoring system is generally established for all important radiation fields. Its purpose is to monitor the parameters of radiation field in real-time and accurately, and evaluate the status of radiation safety scientifically and reliably. Therefore, a basic model of online monitoring system for mixed radiation field is established. The functional requirements, hardware composition, information exchange and data evaluation of the basic model are described in this paper.

2 Establishment of the Basic Model of On-Line Radiation Monitoring System

2.1 Functional Requirements

The system can monitor α, β, γ, neutron, ^{3}H, ^{222}Rn in real-time, continuously and accurately, and evaluate the monitoring data scientifically and reliably. Therefore, the system shall have the following functions: accurate measurement capability, comprehensive monitoring capability, real-time measurement capability, safety assessment capability and excessive alarm capability, etc.

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2.2 Index System

It is to provide infrastructure for different nuclear facilities and materials by establishing the index system of the monitoring system. These measurement functions and index relationship are shown in Fig. 1.

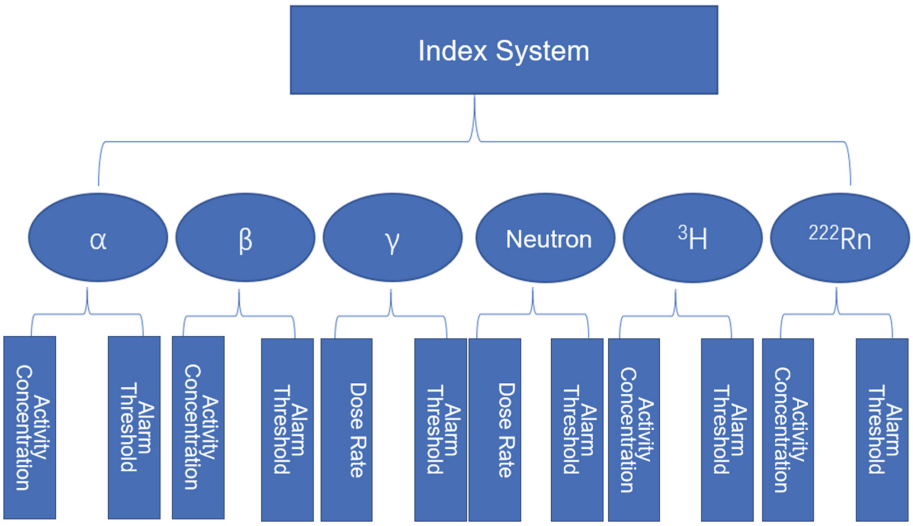

Fig. 1. Index of the measured quantity and alarm threshold

According to the specific conditions of nuclear facilities and nuclear materials, the measurement range, measurement lower limit, response time of relevant measurement equipment are given. The alarm threshold of each measured quantity is obtained through theoretical calculation or actual measurement.

2.3 Establishment Principles

In order to adapt to the online monitoring functions of different nuclear facilities and materials, and improve the adaptability of the basic model monitoring system. The following principles should be taken into consideration while establishing the basic model:

- The system expansion is simple
- Wire and wireless networking
- Supporting upward and downward data compatibility
- Supporting calibration-free in a long time
- Equipped with automatic data upload

2.4 Instrument Selection and Development Principle

Due to the special purpose of the system, stability, safety, reliability and other factors of the system shall be considered comprehensively. Therefore, the following principles shall be considered comprehensively in the selection or development of the instruments of the system:

- Try to use the domestic instruments
- Try to use mature and reliable instruments
- Key components shall be replaced by domestic ones as much as possible
- All instruments shall be tested for "six properties"

3 Key Technologies and Solutions

On-line monitoring system involves various detection instruments and collects multiple information, so there must be many problems about information fusion and integration. Therefore, we should focus on solving the following problems:

3.1 Various Types of Data Acquisition and Processing Technology

Under the framework of basic model, different nuclear facilities will be expanded, which will inevitably evolve into a huge system engineering, including multiple subsystems. In addition, there are different types of monitor terminals, and the sampling methods include online real-time fixed-point, patrol inspection, sampling detection and other means. At the same time, it is also compatible with the emergency decision-making system of nuclear accident, the radiation health protection system and the safety alert system of nuclear facility, and requires a large amount and variety of information.

Therefore, the three-layer network management structure of field monitoring, regional management and central management is adopted. TCP/IP communication protocol is used for central management, and RS-485 communication protocol is used for regional and field management, which is compatible with RS-232 communication protocol. In other words, output signals of all monitor terminals are converted into digital signals conforming to RS-485 communication protocol, and then transmitted by LAN. See Fig. 2.

3.2 Multi-system Integrated Technology

The safety of nuclear facilities is of paramount importance. Therefore, the operation unit and Management Department of nuclear facilities will take various measures at all costs to ensure nuclear safety or mitigate the consequences of nuclear accidents. It must be considered the integration issues of nuclear security system, water and wind power system, environmental monitoring system and online radiation monitoring system. Therefore, it is necessary to carry out multi-level and multi spatial information complementation and optimized combination processing for various sensors. The ultimate goal of information fusion in this process is to derive more useful information

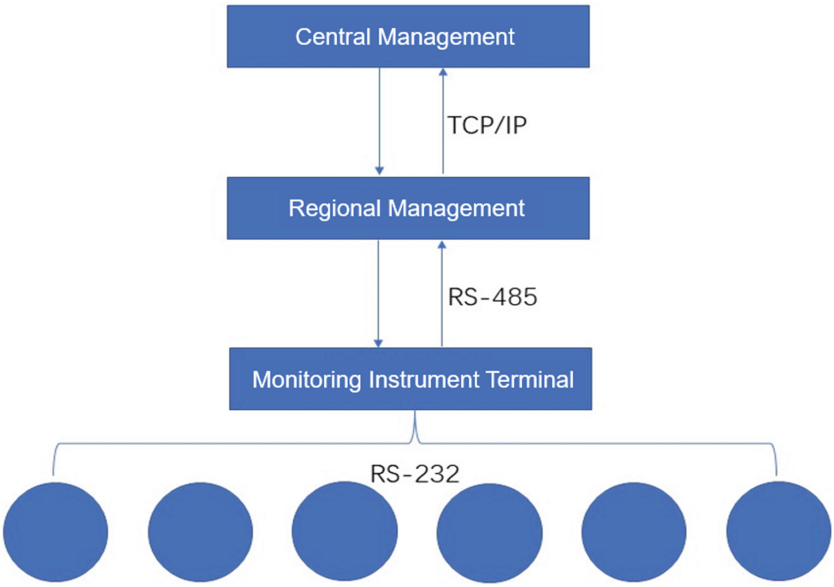

Fig. 2. Three level data transmission

through multi-level and multi-faceted combination of information based on the separated monitoring information obtained by each sensor, which not only makes use of the advantages of multi-sensor collaborative operation, but also integrates data from other information sources that are processed to improve the intelligence of the system. As a result, we should focus on the research of the following issues:

Firstly, the redundancy of information. For a feature of nuclear facilities, useful information can be obtained through multiple sensors, which are redundant and have different reliability. Therefore, more accurate and reliable information can be extracted through fusion processing. In addition, the redundancy of information can improve the overall stability of the system and avoid the paralysis of the whole system caused by the failure of a single sensor.

Secondly, the complementarity of information. Different kinds of sensors can provide different information for the system, because the objects described in this information are different features, so they are complementary to each other.

Thirdly, the timeliness of information processing. The processing of each sensor is relatively independent, and the whole processing can be processed in parallel, which makes the system have faster processing speed and provide more timely processing results.

In addition, the architecture of information fusion should be considered. Three structures are mainly considered by information fusion: centration, distribution and hybrid. Among them, the advantages of centration are real-time fusion, high accuracy and flexible algorithm of data processing. The disadvantages are high requirements for processor, low reliability, and large amount of data, that is difficult to achieve. The advantages of distributed system are low requirements for bandwidth, fast computing speed, better

reliability and continuity, but the tracking accuracy is not as high as centralized system. Generally, the hybrid is adopted, which integrates the advantages of centration and distribution to carry out the design.

4 Experimental Verification Design

Due to the special nuclear sites and equipment involved, it is necessary to take a variety of experiments to verify the basic model of online monitoring system. In view of the independence of the system, this paper presents but is not limited to the following tests:

4.1 Radiation Performance Test

The radiation performance test is based on industry standards or national standards, but it is basically carried out according to the following contents:

- Energy response
- Angle response
- Resolution
- Response time

4.2 Environmental Experiment

According to relevant standards, environmental experiments are carried out in accordance with the following contents:

- Temperature adaptability
- Electromagnetic compatibility
- Radiation environmental adaptability

4.3 Reliability Experiment

According to the requirements of the online monitoring system, the reliability index proposed by the design is evaluated experimentally.

- Reliability analysis and evaluation
- Reliability test

4.4 Maintainability Experiment

According to the requirements of the online monitoring system, the maintainability is tested.

5 Application Demonstration Design

It is necessary to carry out the application demonstration of typical scenarios to test its application effect after the mixed radiation filed online monitoring system is designed and manufactured. The following factors need to be considered in the application demonstration design:

5.1 Representative Application of Demonstration

The demonstration application scenario should be a typical mixed radiation field scenario, which can cover the measurement requirements of each functional module of the basic model of online monitoring system. Moreover, the application scenario has many parallel occasions, which can meet the conditions of mass promotion after the demonstration application.

5.2 Evaluability of Demonstration Application

During the demonstration application period, the basic model system should have evaluable conditions in operation state and various performance indexes, so as to be able to conduct a credible comprehensive evaluation on the basic model system of the demonstration application and provide data support for verifying its performance and subsequent promotion.

6 Conclusion

In order to meet the needs of online monitoring of mixed radiation field, this paper presents a basic model design of online monitoring system of mixed radiation field and its related technologies and verification approaches. This study provides a basic reference for the establishment of the basic model of online monitoring system for mixed radiation field and the design of a series of products.