ISOE-International-Symposium 2025, Rongcheng

Surface Contamination Control and CRCA Precise Management in Taishan Nuclear Power Plant

Author: 任学明 REN Xueming

Taishan Nuclear Power Joint Venture, ltd

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01

Overview of Surface Contamination Control in Nuclear Power Plant

Importance of contamination control

Nuclear safety is an important pillar of the national strategy

Radioactive contamination control is directly related to the implementation of the national nuclear energy development strategy, and is the key security factor to ensure the realization of the goal of "carbon peak and carbon neutralization".

The Value of the Model for Clean Radiological Control Areas

CRCA mode（**enter RCA without changing clothes**）significantly reduces the contamination rate of personnel protective equipment through the whole process contamination provention and control system, and provides innovative solutions for the long-term safe operation of the unit.

Surface contamination control is a difficult point in the industry

Compared with external irradiation and airborne contamination, surface contamination involves complex physical and chemical processes and personnel behavior management, which restricts the improvement of safety level of nuclear power plants for a long time.

Double promotion of economic and decommissioning benefits

Fine contamination control can reduce the production of technical waste, reduce the cost of operation and maintenance, and accumulate important management experience and technical reserves for future decommissioning of nuclear facilities.

Innovation of CRCA model

1

Core Concept Innovation of CRCA Model

CRCA model breaks through the traditional "post-processing" thinking, and upgrades the cleanliness standard to the international leading level by establishing a forward-looking provention and control of potential contaminated area to control contamination risk.

2

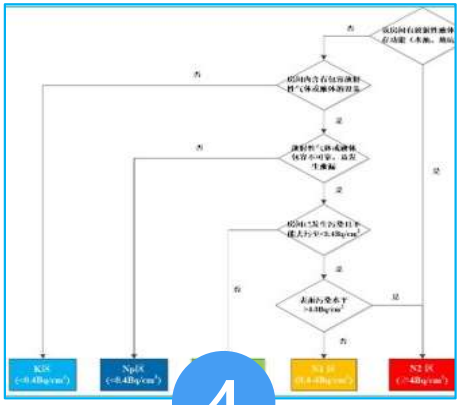
Innovation of contamination Zoning Management System

Initiate K/NP/N0/N1/N2 five sub zoning system, combined with dynamic radioactive working zone management, to achieve accurate identification and hierarchical management of contamination risk.

3

Two-dimensional innovation of "technical barrier + human factor measures"

It integrates seven technical means, such as contamination barrier monitoring and environmental optimization, and supports human factor management tools such as " Three-Forms-One-Signage " to build a closed-loop provention and control network.



4

Innovation of contamination control mechanism in the whole process

From design and construction to operation and maintenance, a closed-loop management system covering contamination prevention, process control and emergency disposal is established to realize the whole life cycle control.

02

Preventive Control Management System

Zoning in the design phase

The Importance of Zoning in the Design Phase

Scientific zoning in the design phase is the basis for provention and control of radioactive contamination in nuclear power plants, and the risk of contamination diffusion is reduced from the source through functional division and risk prediction.

Hierarchical management and control strategy for potential risk areas

In view of the medium leakage risk areas such as pipeline valves, differentiated protective barriers and monitoring equipment are set up to realize dynamic risk management and control.

Special Design Standard for High Radioactive Area

Special building structures and quarantine measures are adopted in high-risk areas such as reactor buildings to ensure strict closure of radioactive substances and avoid cross-contamination.

Functional Zoning and Personnel Movement Line Optimization

Through cleaning area, physical separation of contaminated area and one-way traffic design, the working path of personnel is optimized and the probability of contamination transmission is reduced.

Reliability Analysis of Equipment Sealing

Importance of Reliability Analysis of Equipment Sealing

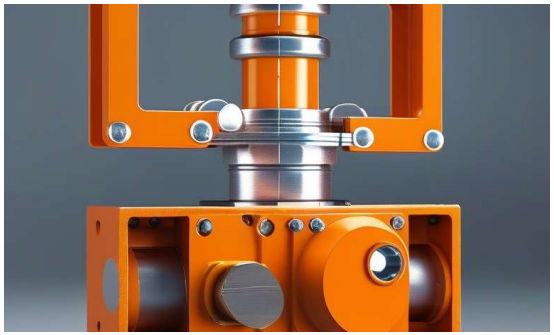
The sealing reliability of equipment is the core part of radioactive contamination control in NPP, which directly affects the safety of operation and the health of personnel, and needs systematic evaluation to ensure long-term stability.

Evaluation of Sealing Performance of Pumps

The Pump bodies, bases, and surrounding areas for transporting radioactive liquids, due to the possibility of leakage, need to be classified as contaminated areas or potential contaminated areas.

Valve seal failure mode and provention and control

Valve internal and external leakage is the main form of failure, which requires the use of high-specification packing and welding sealing technology, especially for high temperature(≥80℃) medium system. Related areas need to be classified as potential contaminated area.



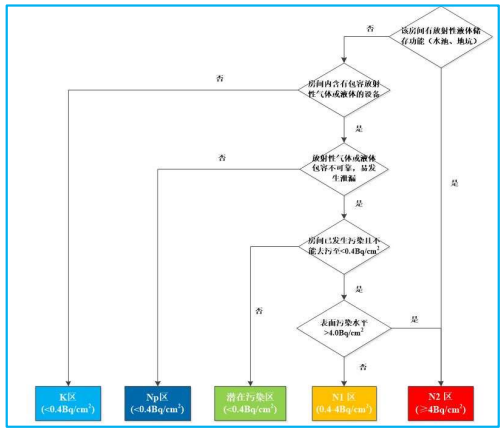
High Temperature and High Pressure Sealing Challenges for Flanged Connections

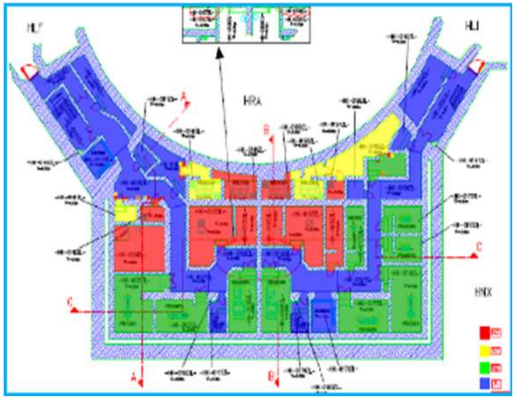
The flange is easy to leak due to material creep under high temperature and high pressure, so it is necessary to evaluate the risk level and classify the potential contaminated area based on the medium temperature and lip welding process.

Contamination Zoning Control and Management

Establish contamination zoning principal

According to the differences in surface contamination levels and potential surface contamination risks, the controlled area is divided into five sub-areas: K, NP, N0, N1, and N2.





Development of Zoning map

Develop zoning maps for the buildings in RCA according to the requirements of nuclear power plant.

Setting up (potential) contamination barrier

(Potential) Contamination barriers are set up between clean areas (K/NP) and potential contamination areas (N0) or contamination areas (N1/N2).

污染分区	分区标准 (Bq/cm²)	基本劳保用品	附加防护用品			
			头部	躯干	手	脚
K区	〈0.4	安全帽 + 劳保服 + 劳保鞋 + 防尘鞋套	\	\	\	\
NP区	〈0.4		\	\	\	\
潜在污染区	〈0.4		帽套	\	棉纱手套	橡胶鞋套
N1区	0.4-4		帽套	薄连体服/N1纸衣	棉纱手套	橡胶鞋套
N2区	≥4		帽套	N2纸衣	棉纱手套 乳胶手套	橡胶鞋套 塑料鞋套

Different PPEs required for the sub-zonings

Different PPEs are required for different sub areas.

03

Radioactive activities contamination control

Seven-step operation process

01

Marked opening operations

For the operation with high risk of contamination diffusion, eye-catching signs shall be set in the scheme document to remind engineers and operators to pay attention to the contamination risk and take protective measures.

02

Declaration mechanism of radioactive operation

Before radioactive activities, it is necessary to declare the work type, time and personnel information of the operation, so as to ensure that the management department fully grasps the operation dynamics and realizes effective supervision.

03

Preparation of radiation work permit(RWP)

The license specifies the task steps, safety requirements and emergency measures, standardizes the operation process, and ensures the compliance of the operation.

04

Radiological risk interview system

Operators and radiation protection personnel communicate risk points face to face, strengthen protection awareness, and collect improvement suggestions to optimize measures.

Seven-step operation process

05

System registration

Relevant operation information is registered in a specific management system, including operation declaration, risk interview records, and collection of protective equipment, so as to realize digital management of the operations.

06

“Three-Forms-One-Signage” mechanism

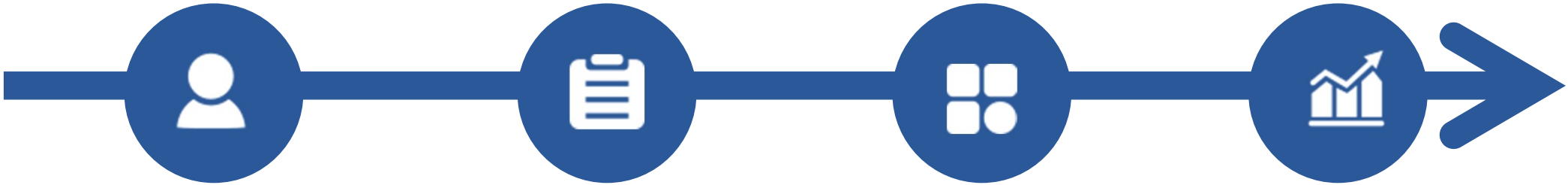
Which is mainly referred to the independent verification of start conditions and permission release by full-time safety officers before the start of radioactive opening operations, so as to ensure the effective implementation of contamination protection measures.

07

Post-operation site acceptance

When the operation is completed, strict acceptance of the operation site is carried out, including requirements for site contamination monitoring and cleaning.

Contamination survey and control



Contamination survey and monitoring

- All rooms except high radiation rooms and unachievable rooms are measured at least once a month.
- All contamination barriers and RCA barrier are setup equipment to monitor surface contamination of workers.

Protection for Transportation of Radioactive Substances

- Clean bags fully cover the transported packages;
- Specific and well protected trolley are used;
- All package ties are facing upwards;
- Related logistic workers should be protected with gloves and long gown.

Site Paving and Personnel Protection

- Impermeable plastic sheets and absorbent cotton is paved on site for risks with fluid leakage maintenance;
- PPEs are used according to different risks of the activities.

Site Management Responsibility System

- Regional grid management，each grid area is assigned a dedicated person；
- Contaminated site responsibility management，work leader responsible for his work site.

04

Contamination Incident Handling Mechanism

Contamination Incident Handling Mechanism

Contamination Monitoring and Response

- Specific logistic work group for quick response(during outage)
- More frequent contamination survey during outage
- Response: isolate, warning signs, investigate, decontamination…

Decontamination technology

- Chemical decontamination(acids, alkalis, or oxidizers…)
- mechanical decontamination(wiping, high-pressure water washing, rinsing,…)
- Ultrasonic decontamination

Resolved

Contamination Source Investigation and Tracing

- On-site survey
- Path tracing
- Review of work records
- Review monitoring equipment data
- Human error analysis…

Experience Feedback

- Summarize and record the handling process
- Cause analysis
- Adopted measures, and results
- Improvements, review contamination zoning
- Feedback, training….

05

Management effectiveness

Management effectiveness

Overview of rad-waste reduction effectiveness data

Comparing with changing clothes mode, the amount of PPE washing liquid waste decreased about 43%, scrapped PPE solid waste decreased about 38%, which verified the effectiveness of the management mode of the clean controlled area.

Comparative Analysis of C2 Measurement Alarm Rate

The surface contamination alarm rate of C2 access control points is continuously lower than 0.2%, which is better than average level of 1.2% of international counterparts, reflecting the advantages of hierarchical control.

Surface contamination of ground mostly occurred in potential contamination area

Surface contamination of ground due to equipment leakage happened mostly in potential contamination area, which about takes part of 95%. By setting the potential contamination area effectively controlled the surface contamination diffusion.

Change in rate of personal surface contamination

By using the seven-step operation process(interview with work leader, Three-Forms-One-Signage mechanism ...) , the contamination of PPE and body surface are much decreased, total number is less than 10 for each outage, better than the average number 20 of international counterparts.

06

R & D management

R & D management

Innovative Design of Area Adaptive Protective Equipment

According to the regional and activity characteristics, specific protective equipment could be developed to adapt the risks and should be easily used, such as long sleeves for some single and small work site, reusable shoe covers for potential contamination area, etc.

1

Integrated Application of Intelligent Monitoring Equipment

Intelligent surface contamination self-detector are deployed at the contamination boundary to transmit data to the central system in real time, so as to improve the timeliness and management efficiency of contamination diffusion.

2

Develop New Decontamination Technology

Research and development of advanced technologies such as ultrasonic cleaning and chemical detergents, implement differentiated treatment for surface contamination of different materials, and improve the decontamination efficiency.

3

Practice of Human Factors Engineering Optimization Design

Through lightweight materials and simplified wearing process (such as magnetic sealing interface), the burden of protective equipment on personnel can be reduced, and the tolerance of high contaminated section for long-term operation can be improved.

4

THANKS!

Q&A?