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Nuclear Power

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# Preliminary Discussion of Potential Surface Contamination Risk Identification and Surface Contamination Control Method in Nuclear Power Plant

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一次把事情做好

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## Introduction

- At present, the risk management of radioactive surface contamination in international and domestic nuclear power plants is mainly "ex post facto" management, that is, the division of nuclear power plant contamination areas is only based on the actual measured surface contamination level.
- For the nuclear power plants with "EVEREST" mode, in order to avoid the occurrence of personnel contamination caused by equipment leakage, accidental contamination dispersion, etc., the potential surface contamination risk has to be considered.
- That is, the areas with high potential contamination risk are identified, and the contamination boundaries of these areas are controlled in advance. And the purpose is to decrease personal contamination and preventing contamination dispersion.



## What is “EVEREST” mode ?

What is “EVEREST” mode ?

- **EVEREST mode** is to access to the controlled area in common personal protection equipment on the basis of contamination classification of the controlled area.
- That means access to RCA with:





# Surface contamination zoning standard and principle

Surface contamination zoning standard and principle



Contamination Standard (Co-60 equivalent)

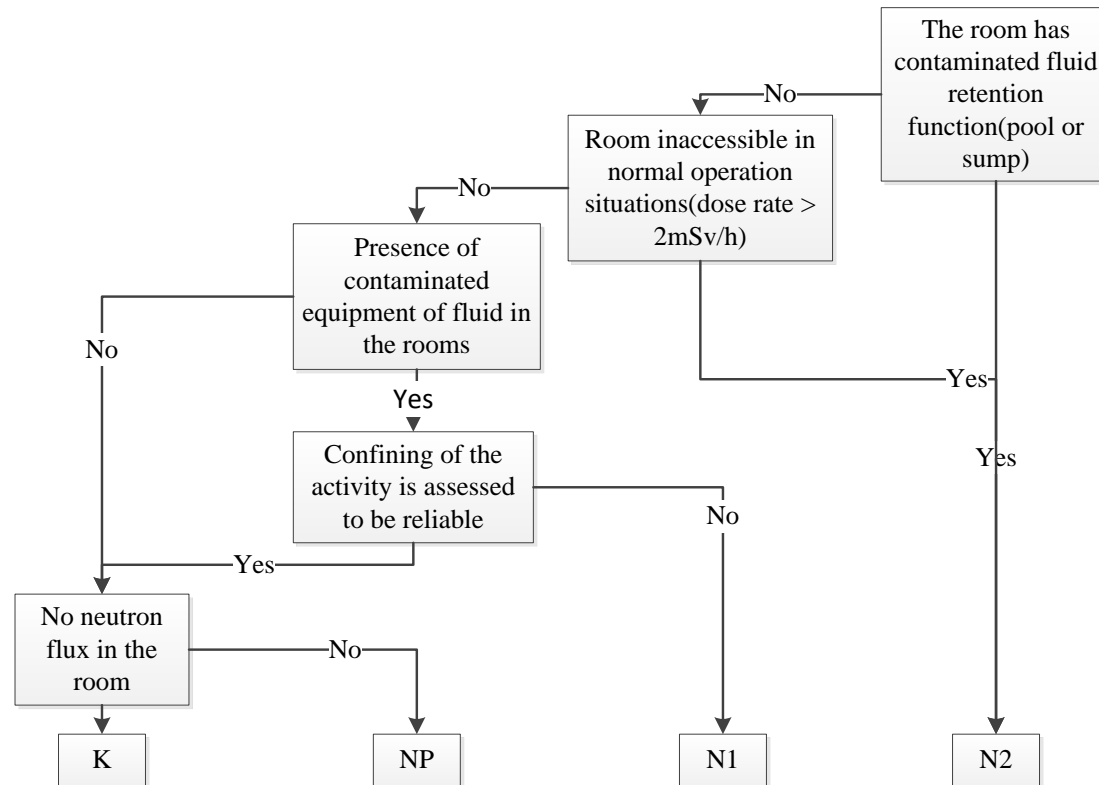
Conventional waste area	Radioactive waste area		
K	Np	N	
		N1	N2
Clean level	Clean level	Light contamination level	Contamination level
<0.4Bq/cm <sup>2</sup>	<0.4Bq/cm <sup>2</sup>	<4Bq/cm <sup>2</sup>	≥4Bq/cm <sup>2</sup>



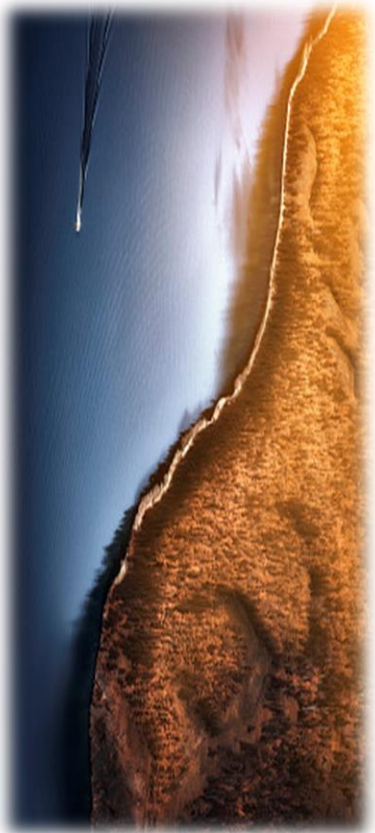


# Surface contamination zoning standard and principle

## Surface contamination zoning principle in a nuclear power plant



# ➤ Identification of potential contamination



Radioactive medium confinement reliability analysis  
of active equipment ( Pumps, Valves, Flanges,  
Containers, Pipelines)



Analysis of occurred contamination events



## Identification of potential contamination

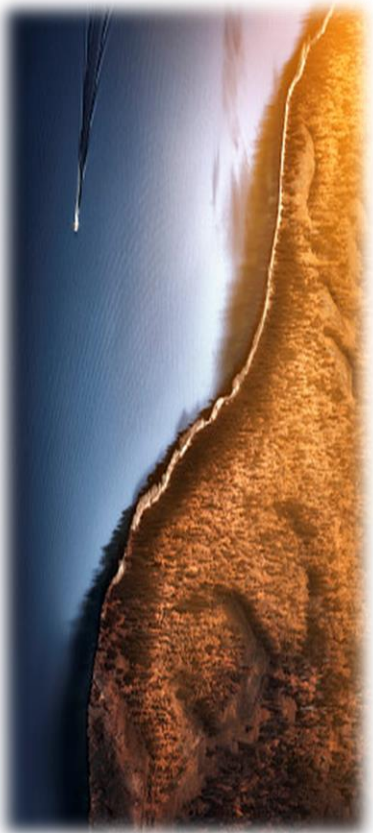
### Radioactive medium confinement reliability analysis of active equipment

#### ◆ Pumps

Many **sealing forms**: packing seal, oil seal, mechanical seal, and hydraulic seal and so on. Generally speaking, pumps are designed to allow for a certain leakage rate.

The base for collecting the leakage liquid normally is designed under the pump, and then the pedestal will be connected to the waste liquid collection sump through a guide pipe. However, the guide pipes are not always be designed, and sometimes the guide pipes are not always align with the collection sump.

Therefore, the pump body, pedestal, and even the area around the pedestal should be regarded as potential contamination area.



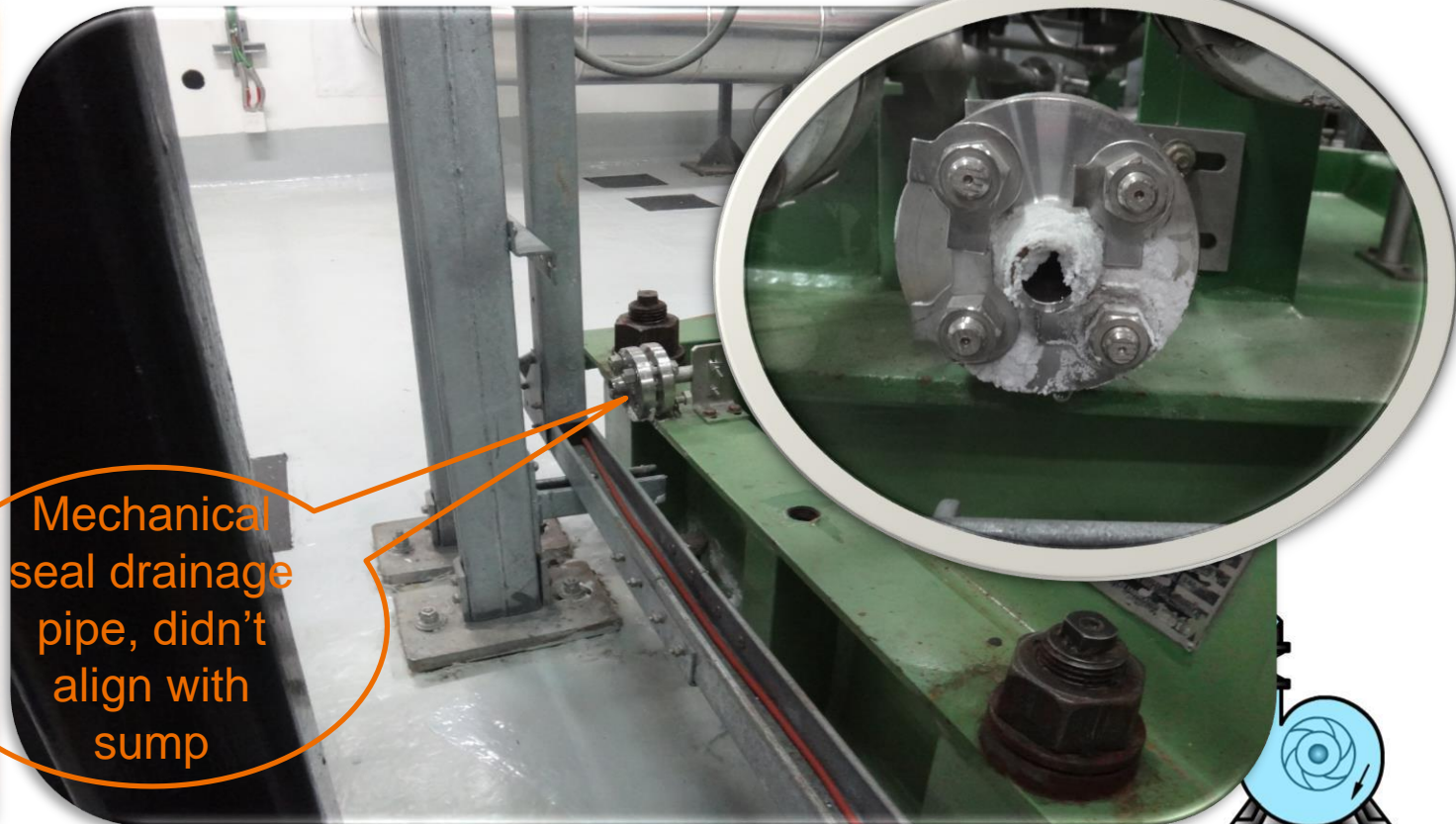


## Identification of potential contamination

Radioactive medium confinement reliability analysis of active equipment



Mechanical seal drainage pipe, didn't align with sump



## ➤ Identification of potential contamination

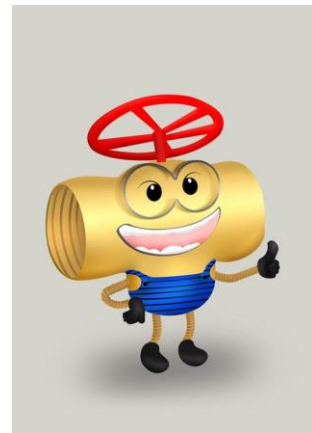
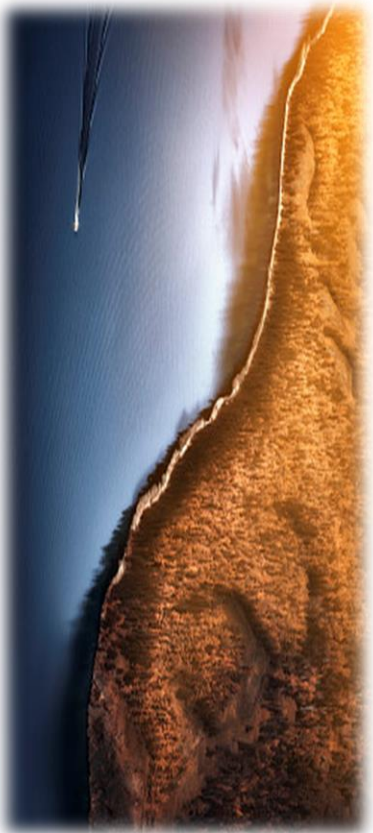
Radioactive medium confinement reliability analysis of active equipment

### ◆ Valves

Valve leakage is divided into **internal leakage** and **external leakage**.

The internal leakage refers to the sealing degree of the medium between the valve seat and the closing part, and the external leakage refers to the leakage of the **packing part of the valve stem**, the leakage of the **flange gasket** and the leakage of the **valve body caused by casting defects** .

Unlike the pumps, the leakage of valves is not allowed at all.



## Identification of potential contamination

Radioactive medium confinement reliability analysis of active equipment

### ◆ Valves

In order to prevent valve leakage, the sealing of valve stem can be realized by **compression packing**, and the sealing of flange gasket can be realized by **sealing and welding** the connecting flange between valve cover and valve body. In addition, different connections between valves and pipelines may also result in external leakage, such as threaded connections and flanged connections; therefore, **welding end connections**, such as socket welding or casing welding, or sealing welding are usually used to avoid leakage.

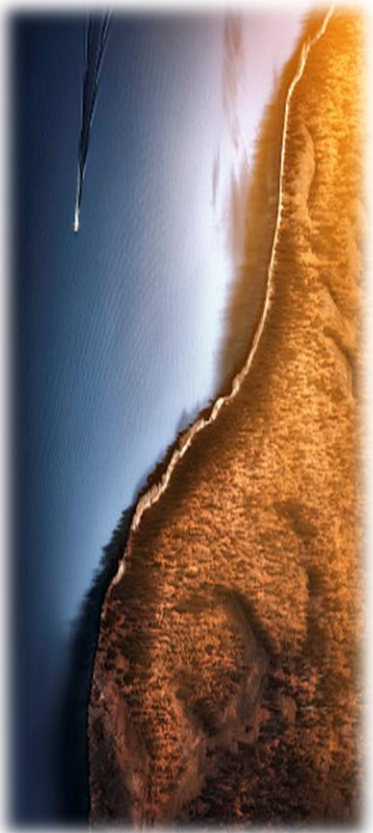


## ➤ Identification of potential contamination

### Radioactive medium confinement reliability analysis of active equipment

#### ◆ Valves

Different kinds of valves have different working medium temperature and pressure. Although the leakage of valve is not allowed in design, in practice, the leakage of valve exists. According to the experience feedback, the probability of leakage is higher occurs when the temperature of the medium exceeds **80 °C**, such as valves of RCV (chemical and volume control system), TEP (coolant storage and treatment system), TEG (waste gas treatment system) systems, rooms of those valves situated will be identified as potential contamination area. The rooms with valves of other systems are mainly identified as clean area.

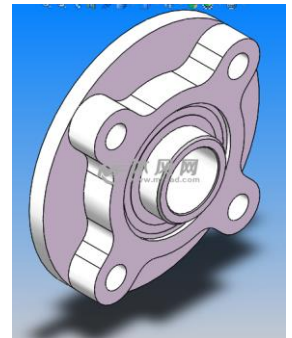
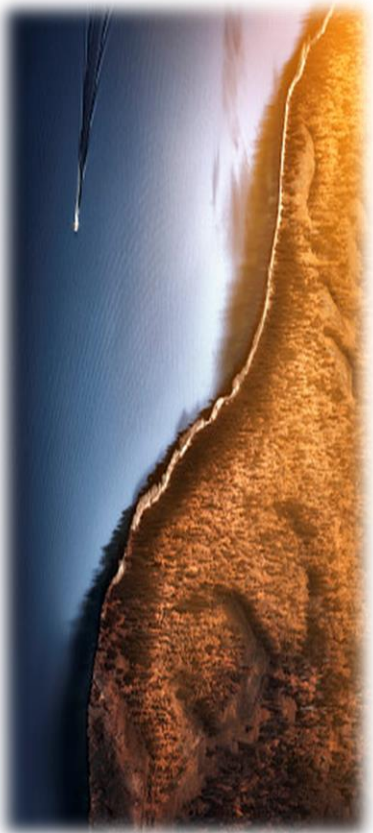


## Identification of potential contamination

Radioactive medium confinement reliability analysis of active equipment

### ◆ Flanges

In the case of high temperature and pressure, the sealing gasket of flange will almost inevitably leak. Many cases induce the decrease of gasket stress, including the **high temperature and long-term stress of gasket**, the **different thermal expansion** caused by different connecting material between connector and fastener, and **the creep of fastener at high temperature**.



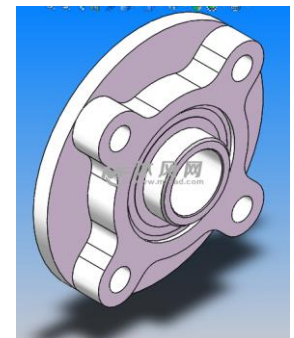
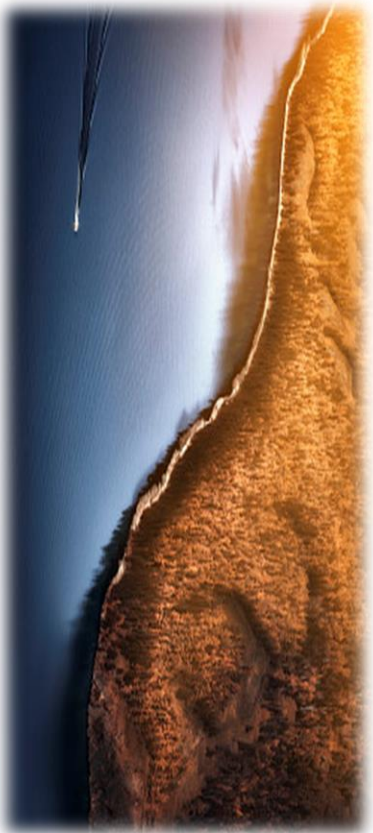
## Identification of potential contamination

Radioactive medium confinement reliability analysis of active equipment

### ◆ Flanges

The gaskets used in nuclear power plants include graphite gaskets with metal reinforcements and silver-plated metal gaskets, such as Helicoflex. In order to avoid leakage, **lip welding** can be carried out on the connecting flange.

Therefore, the potential contamination of flange system and rooms should also be identified according to the temperature of the medium and whether the lip welding is used or not.



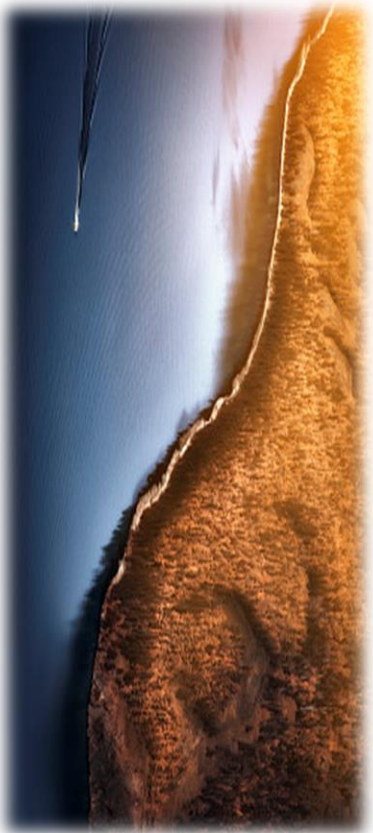
## Identification of potential contamination

### Radioactive medium confinement reliability analysis of active equipment

#### ◆ Containers

Containers containing radioactive media, heat exchanger, sump and so on are generally considered as containers. In the analysis, the container can be divided into open and closed. For open containers, because of the risk of liquid overflow when operation is wrong or abnormal, the room in which open containers containing radioactive media is located can generally be considered as a potential contamination area.

Although the closed container has a more reliable confinement of radioactive medium, the container is usually accompanied by the connection with valves, flanges and so on in the system, so the room in which the closed container is located should also pay attention to it.



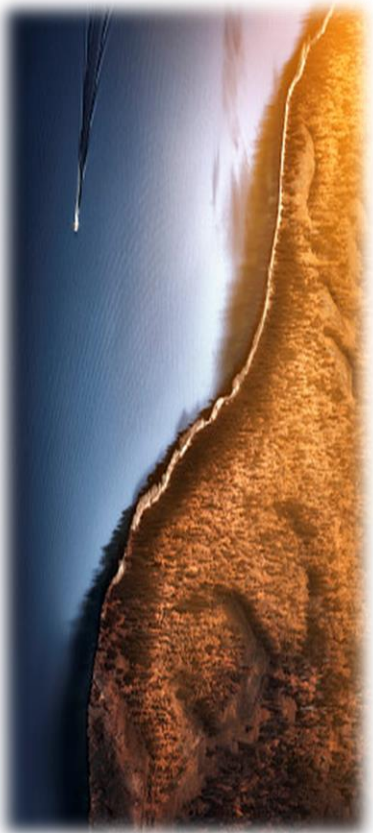
## Identification of potential contamination

Radioactive medium confinement reliability analysis of active equipment

### ◆ Containers

The room in which the heat exchanger containing radioactive medium is located is generally identified as a potentially contaminated area, and the probability of leakage of the heat exchanger is also relatively high from the point of view of practical feedback.

For the sumps, such as RPE (nuclear island vent and drain system) system in nuclear power plants, there are a large number of tanks or sumps specially used to collect radioactive waste liquid and non-radioactive waste liquid, which can be directly divided into clean area or N2 area according to the medium.





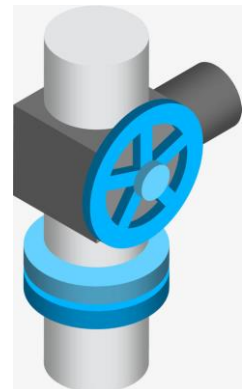
## ➤ Identification of potential contamination

### Radioactive medium confinement reliability analysis of active equipment

#### ◆ Pipelines

Pipelines usually has good confinement and reliability to the radioactive medium, and the pipe connection is mostly welded, which has good sealing and is generally not identified as a potential contamination area. However, the medium with high temperature and high velocity in the pipeline will lead to a degradation of the welding zone of pipelines, and the possibility of leakage will not be ruled out.

The above covers the main machinery and equipment of nuclear power plant, and its analytical principles are also basically applicable to other machinery and equipment.



## ➤ Identification of potential contamination

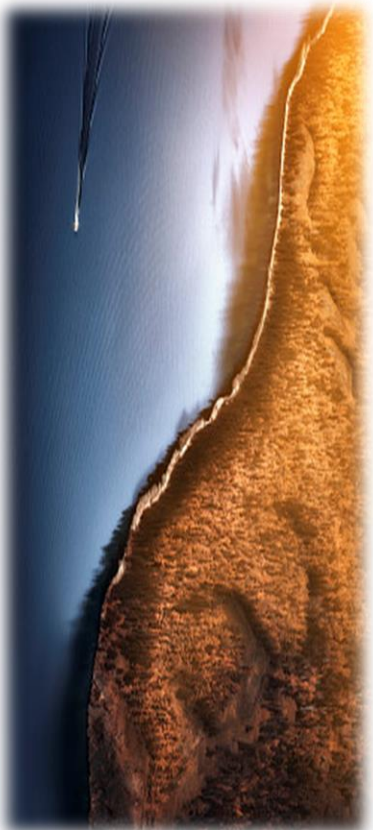
### Analysis of occurred contamination events

This part mainly has the equipment design defect, the installation deviation or the human factor error and so on.

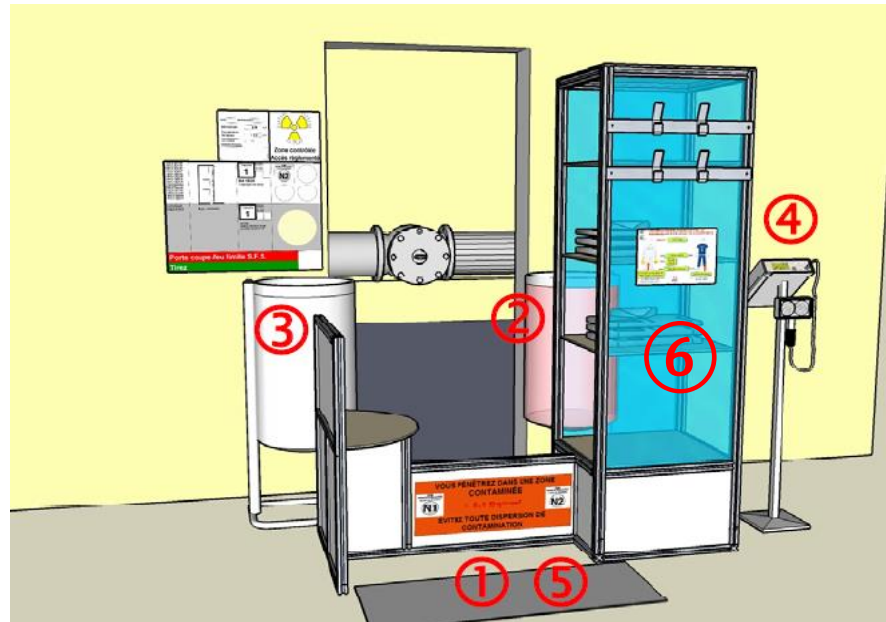
For example:

- ◆ The mechanical sealed drainage pipe the pumps containing radioactive fluid is designed to discharge directly into the air;
- ◆ The misalignment of the outlet of the drainage pipe of pumps or drain valves;
- ◆ The leakage of the downstream plug caused by the human operation error, due to the isolation valve as the pressure boundary is not closed, resulting in the leakage of the downstream plug, and so on.

In view of the above design defects or deviation, before completing the transformation, it is necessary to set the relevant area or rooms as a potential contamination area (N1 area) or contamination area (N2 area). For the contamination dispersion caused by personnel error, it is necessary to analyze the type and frequency of personnel operation, and the operation area which is easy to cause contamination dispersion and has high operation frequency is generally managed as a potential contamination area.



## Contamination zoning management



For the identified potential contamination area and contaminated area, it is necessary to set up isolation boundary. The boundaries mainly include protective equipment cabinets, barrier, dust pad and surface contamination monitoring instrument, radioactive waste collect bin and protection equipment collet bin.



## Surface contamination control

SURFACE CONTAMINATION CONTROL


- ◆ Contamination Zoning, Setting up boundaries
- ◆ Surface contamination surveys and monitoring
- ◆ Protection during activated materials transportation
- ◆ Working site protection and person protection
- ◆ Tools used separately
- ◆ Training for personnel authorization
- ◆ Site management responsibility system





## Surface contamination control

### Site management responsibility system



Site management can be divided into "regional grid management" and "contamination site responsibility system management". The former refers to the division of grid format of the plant in controlled area (such as the reactor building), which specifies the responsible person for each grid area, and the responsible person manages the area to ensure that there is no contamination dispersion incident; the latter is the person who is in charge of the work shall carry out contamination control and monitoring for the site. Through the implementation of these management systems, the contamination dispersion is under controlled. In recent years, these two systems have been applied in practice, and the practice has been proved feasible.





## Summary



### Benefits

- ◆ Identifying potential contamination benefits to control contamination at its source;
- ◆ Reducing the probability of the spread of contamination.
- ◆ Reducing the probability of personnel clothing contamination. Especially for the NPP with EVEREST mode. And the treating for the personnel clothing contamination is quite complicated.

### Costs

- ◆ Real contaminated area and potential contamination area co-exist on site, may lead to confusion and lack of vigilance for the workers.
- ◆ Potential contamination area consumes more PPEs and maintain the potential contamination boundaries need more human resources and workload.





## Summary

### Practical feedback

- ◆ According to the practical feedback, most of the areas where the contamination of personnel protective equipment occurs are in the identified potential contamination areas, such as the rooms with the pumps or valves of the main nuclear loop systems.
- ◆ At present, the management of potential contamination is effective. With the prolongation of operation time of nuclear power plant, the probability of equipment degradation or leakage will be gradually increased. By continuing to analyze and summarize the causes and commonness of contamination dispersion incidents, it is helpful to improve the identification method of potential contamination risk.
- ◆ The management method of potential contamination risk can also be used as a reference for other nuclear power plants in contamination risk management, especially in the nuclear power plant which is going to use the "EVEREST mode".
- ◆ In addition, the identification method of potential contamination risk also has reference value for the radiation protection design of nuclear power plant, such as the arrangement of radioactive equipment and the design of ventilation systems.



Thanks for your attention!



