中国辐射防护研究院
中核集团 CNNC
CHINA INSTITUTE FOR RADIATION PROTECTION

Radioactive Waste Management Solutions from China Institute for Radiation Protection

Radioactive Combustible Waste Incinerator

Treatment objects
Plastic, rubber, spent oil, resin, activated carbon, paper, cloth, wood, etc.

Treatment capacity
20-200kg/h

Application
Nuclear technology application, nuclear fuel processing, nuclear energy and nuclear power, post-treatment, decommissioning and radioactive waste treatment

Pyrolysis incinerator
Third-generation incineration technology
The incineration and tail gas purification technology is globally advanced.

Mobile incinerator
The whole set of incineration installation is integrated into a container car, realizing the automotive mobile of the device.
It can treat radioactive wastes in areas and be operated on behalf to reduce the operation and management load of waste generating units.

Compact incinerator
Meets the requirements for waste treatment by research and medical institutes.
Has a complete technological process and can operate inter-mittently, featuring a compact and small occupation, short construction period and simple operation.

Wet-oxidation Device for Radioactive Spent Resin

Treatment object
Radioactive spent resin

Technical principle
At low temperature (100°C) and atmospheric pressure, the spent resin is oxidized by H_2O_2 to CO_2 and low salt inorganic waste liquid, and all the radionuclides (except ^{14}C) are retained in the waste liquid.
The tail gas composition is simple and easy to treat, and the waste liquid can be treated by solidification / drying / radionuclide purification, with safety and economic advantages.

Technical parameters:

Treatment capacity	Oxidative decomposition rate	Volume reduction effect
10kg (14L)/ 4h	>99%	Waste liquid solidified, comprehensive volume reduction ratio >1.5 Waste liquid drying, comprehensive volume reduction ratio >7.5

Application
Spent resin treatment generated by nuclear fuel cycle production units, operation of nuclear facilities and nuclear technology utilization units.

Treatment Device of Radioactive Waste Oil

Treatment object
Radioactive waste oil from nuclear power plants

Technical principle
Radionuclide concentration and separation treatment are adopted. The radioactive (total γ) activity concentration of waste oil after treatment is less than 0.1Bq/g.

Technical parameters:

Treatment capacity	Activity concentration of waste oil after treatment	Secondary waste volume	Occupied area
200L/ batch (40h)	<0.1Bq/g	~90L/ $1m^3$ waste oil	~$30m^2$

Application
Radioactive waste oil from the operation of NPPs. It can be widely used in nuclear fuel cycle facilities.

Waste Oil Treatment Device

Waste Oil Treatment Site

Spent Radioactive Source Conditioning System

Treatment object
Spent radioactive source

Technical principle
Take the temporarily stored spent radioactive sources out of the original container with the conditioning system, seal multiple spent radioactive sources in one or several encapsulated tubes, and then load the encapsulated tubes into long-term storage containers for safe storage/disposal.

Technical parameters:

Conditioning capacity	Dose of conditioning personnel
3000ci (Co-60)	6mSv/a

High-activity Spent Radioactive Source Conditioning Device

Mobile Low-activity Spent Radioactive Source Conditioning Device

Solidification and Performance Characterization of Radioactive Wastes

Treatment object
Concentrated solution, spent resin, incineration ash, etc.

Technical parameters
concentrated solution ~50%, spent resin ~35%, incineration ash >100%

Free liquid
No free liquid on the upper/lower surface of the solidified object after 7 days' maintenance.

Mechanical property
Compressive strength of the solidified object≥7Mpa, without obvious fracture after free falling from 9m height.

Leaching resistance
The leaching rate of radionuclide on Day 42 is not lower than the standard limit.

Immersion resistance / freeze-thaw resistance / irradiation resistance
According to the test, it has no obvious cracks or fractures on the appearance, and the loss of compressive strength is not more than 25%.

200L Solidification Device

Leaching Resistance Test

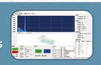
Clearance Process for Slightly Contaminated Material

Treatment object
Spent resin, spent filter frame and filter element, spent iodine absorber, technical waste, calcium fluoride residue, contaminated waste oil, etc.

Technical method
Separate radioactive wastes that conforming to the clearance process standard from radioactive wastes to be managed and controlled by means of source investigation, site sampling, radionuclide analysis and safety evaluation for general waste treatment or recycling.

Application
Safety management of slightly contaminated materials generated by nuclear power and related industries.

Measurement and Sampling Methods



Radionuclide Analysis Software

Waste Separation Measuring Device

Disassembly Device of Spent Iodine Absorber

Safety Assessment of Nuclear-related Facilities and Activities

Application
Safety prediction and assessment of nuclear-related facilities and activities, supporting management and decision-making.

Technical Features
Numerical simulation is used to predict and evaluate the safety of nuclear-related facilities and activities.

Established Models

- Radionuclide release model
- Water-gas migration model
- Temperature field model
- Radionuclide migration model
- Groundwater flow field model
- Mechanical model
- Fracture flow model
- THM coupling model

Numerical simulation capability

- Simulation theory
- Pre-processing/post-processing
- Secondary development
- Non-convergence solution
- Mesh generation
- Parameter optimization

Sampling Image of Inhaled Particle Size and Frequency

Temperature Field Distribution after Treatment Closetd for 20 Years

Temperature Field of HIC Treatment Facility after treatment closed for 4.6 years

Sensitivity Diagram

Series of Decontamination Detergents

Model
ZD series

Main Application
Used for the chemical tank decontamination for personnel, equipment and disassembled parts during the operation and decommissioning of nuclear facilities.

Features of detergents
Detergents of different formulas are available for facilities both in service or during decommissioning, and the detergents for in-service facilities passed through safety verification.
Detergents are free of halogen elements, safe and stable.

ZDB-1
hand sanitizer for radionuclide removal

ZDB-3
hand sanitizer for radionuclide removal

Before
After

ZDN series
ultrasonic detergents (acidic, alkaline and neutral)

ZDGN-1
high-elastic decontamination gel

Decontamination Practice of Haiyang NPP Steam Generator Side-pressure Plate

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Mobile Foam Decontamination Device

Model

ZXF-1

Main Application

Bubble filling of large volume cavity chemical tank and decontamination by foam spraying on surface of large tank, with high decontamination efficiency and effect, waste liquid volume can be reduced greatly. It can also be used for decontamination of radiation emergency vehicles and items.

Technical Features

High foam stability:
Foam half-life period≥80min
Liquid holdup half-life period ≥90min
Good decontamination effect:
comprehensive decontamination rate ≥90%
Three formula:acidic, alkaline and oxidized
Less secondary waste liquid:
Foaming ratio 8-10
Secondary waste liquid volume is about 20%

ZXF-1 Mobile Foam Decontamination Device

Foam Photomicrograph

Decontamination Site of Daya Bay NPP

Vacuum Dust Collection Device for Nuclear Industry

Product Features

- Multi-stage filtration, high efficiency, purification efficiency of the whole device ≥99.99%
- Automatic self-sealing after shutdown, and replacement process of dust bag is in the sealed device to prevent contamination diffusion
- Soft start equipped
- Strong suction, able to absorb metal particles
- Can be operated in pipe trenches and air ducts matching with a robot.

ZXZ-3 Vacuum Dust Collection Device

ZXZ-R Vacuum Dust Collection Device (for NPPs)

Robot Equipped (360° rotation, elevated, minimum access size 280×220mm)

Trapping and Immobilization Device for Aerosol with Atomization Method

- Applicable to the contamination suppression in confined and inaccessible spaces
- Aerosol collection efficiency 99%, immobilization period ≥14 days
- Atomized particle size 2~10μm, strong atomization ability

ZXU-1 Immobilization Device for Aerosol with Atomization Method

Application Practice

Surface Contamination Suppression Device

- Applicable to contamination suppression of internal contaminated surfaces, such as pipe trenches, air ducts and chimneys.
- Applicable to suppression of aerosol generation during cutting and removal
- Suppression coverage ratio ≥90%
- Resuspension rate of suppression ≤3%

ZXR-1 Main Unit of Contamination Suppression Device

Spray Robot Platform Equipped

Simulation and Characterization of Material Performance Evolution under Radiative/ Thermal Conditions

Application

Prediction of material performance, providing technical support for design, management and decision making.

Technical Features

According to the specific characteristics of materials used in nuclear-related sites or activities, accelerated simulation experiments and characterization are carried out to deduce the evolution process of performances.

Built Capacity

- Experiment design and implementation
- Gas generation/consumption monitoring
- Expansion stress monitoring
- Radionuclide migration/diffusion characterization

Related equipment

- Expansion stress testing system
- Mossbauer spectrum
- Raman spectrum

Raman spectrometer

ICP-OES

GC-MS (ppb)

- The China Institute for Radiation Protection (CIRP), established in 1962, is the only comprehensive research establishment solely dedicated to radiation protection research and application in China.

- CIRP acts as the Secretariat of China Society of Radiation Protection-the only state-level academic association in China's radiation protection field, and the Editorial Department of Radiation Protection-the solely professional core journal of radiation protection in China.

- The Department of Radioactive Waste Management of CIRP, as a dedicated department regarding this field is mainly engaged in the technology and product development as well as technical service support related to decommissioning of nuclear facilities and radioactive waste management.

- It is one of the earliest research units dedicated to this field in China and once took the lead in completing the decommissioning project of Qinghai 221 plant, China's first large-scale nuclear facility.

Nuclear facilities decommissioning and environmental remediation

- Source item investigation, decontamination, demolition and disassembly, environmental remediation

Waste treatment

- Incineration, wet oxidation of spent resin, drying of resin and concentrated solutions, and treatment of waste oil

Waste conditioning

- Waste safety characterization (cement solidification, clearance), radioactive source conditioning

Waste disposal

- Safety assessment of medium and low level radioactive waste disposal, study on medium-depth radioactive waste disposal, safety assessment of high level radioactive waste disposal

Research on new materials

- Neutron shield absorbing material
- Silicon carbide continuous fibre

Policies and regulations
Technologies development
Technical service
Technical support

Decontamination Gel

ZDG series gel

Peelable decontamination gel ZDG-P-3
Self-embrittlement oxidized gel ZDG-D-1
Water-washing acidic, alkaline and oxidized gels

Product Features

Peelable gel is applicable to the surface decontamination of various materials, such as metal, glass and cement.
Additionally, it can be collected in the form of film, which has good performance and high tensile strength (up to 30Mpa).

Oxidized gel is applicable to the deep decontamination of heavy contaminated chambers and hot cells of nuclear facilities.
It can realize the decontamination and degradation, with decontamination factor ≥100.
Additionally, it can be collected after self-embrittlement in dry condition, and the whole process does not produce liquid waste.

Peelable Decontamination Gel

Practice of Oxidized Gel

Mobile Electrochemical Decontamination Device

Model

ZXE-1 mobile electrochemical decontamination device
ZXEA-1 autocontrol mobile electrochemical decontamination device

Main Application

Used for rapid decontamination of local hot spots during the operation and decommissioning of nuclear facilities, and match for various decontamination applicators for all kinds of surfaces.

Technical Features

High decontamination speed, with corrosion rate of 0.5μm/h
High decontamination factor ≥100, able to achieve clearance
Applicable to contamination hot spots on conductive parts surface

ZXEA-1

ZXE-1

Application Site of Daya Bay NPP

Decontamination Applicators of Different Types