Performance study of iodine adsorbers used in an emergency fresh air system of main control room under severe accident conditions

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Content

Background

Severe nuclear accident

Inhabitability

Is personnel retention safe enough?

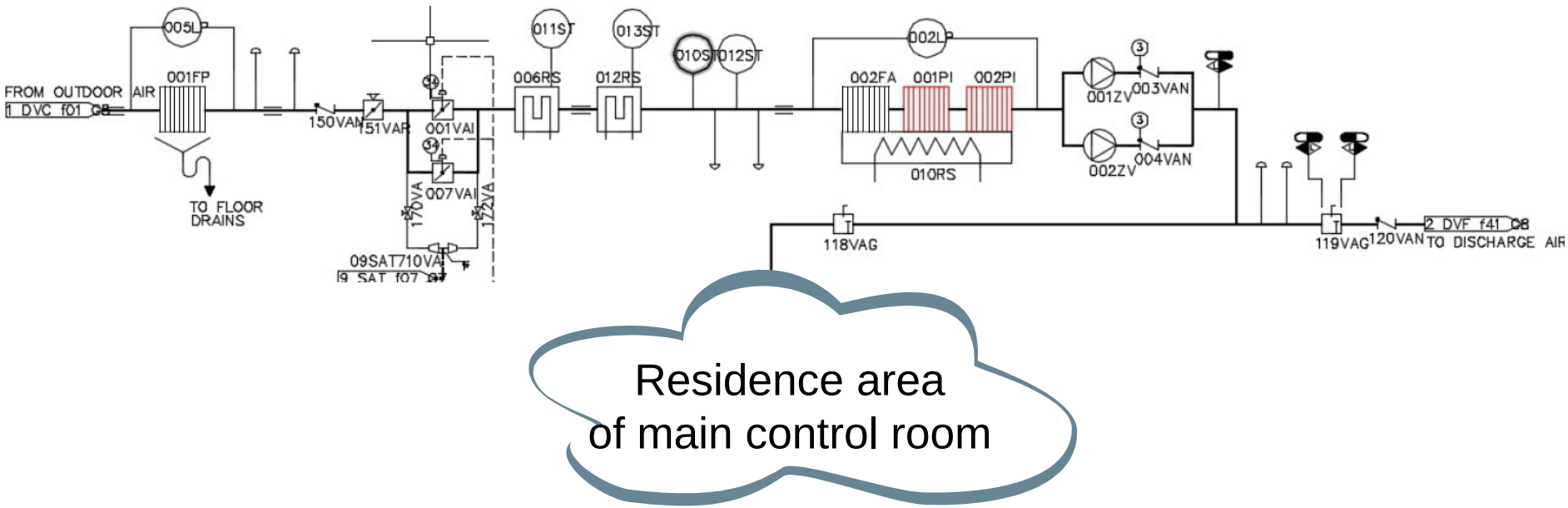
What criteria should be adopted to ensure the inhabitability?

Nuclear Safety Authority

Designing Institute

Background

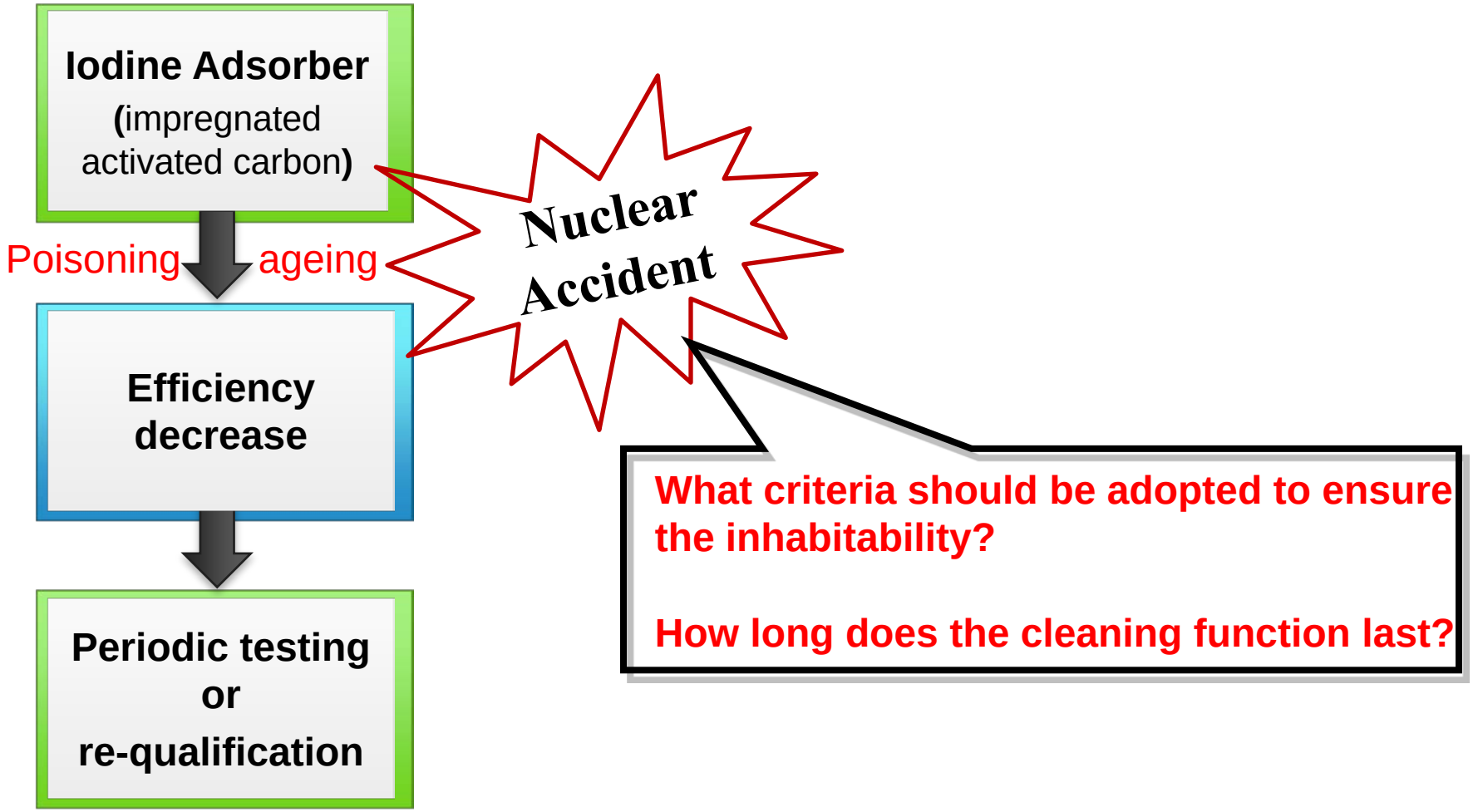
Importance of iodine adsorbers for inhabitability



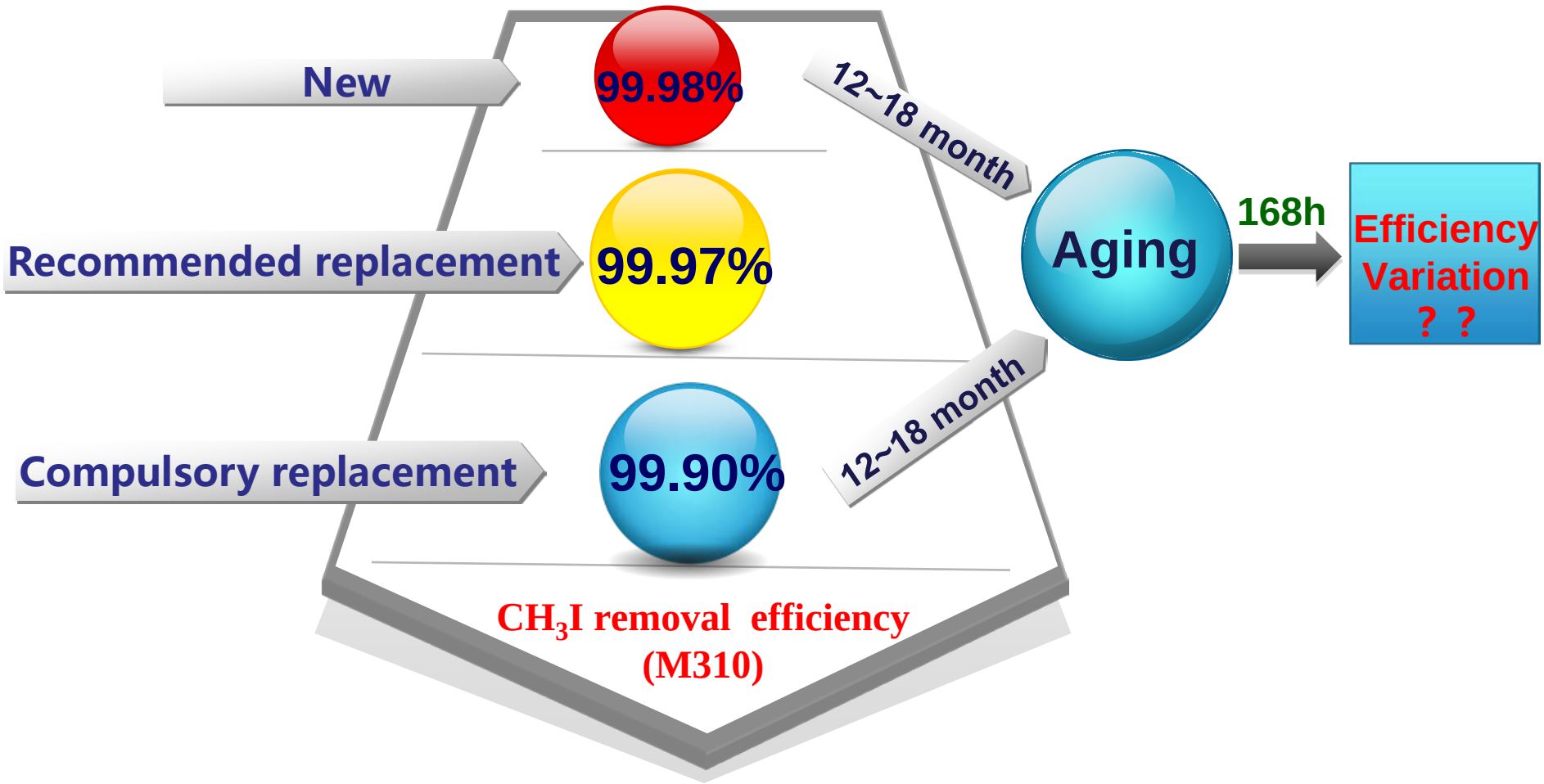
Flowchart for emergency fresh air system of main control room under accident conditions (M310)

Background

Importance of iodine adsorbers for nuclear safety

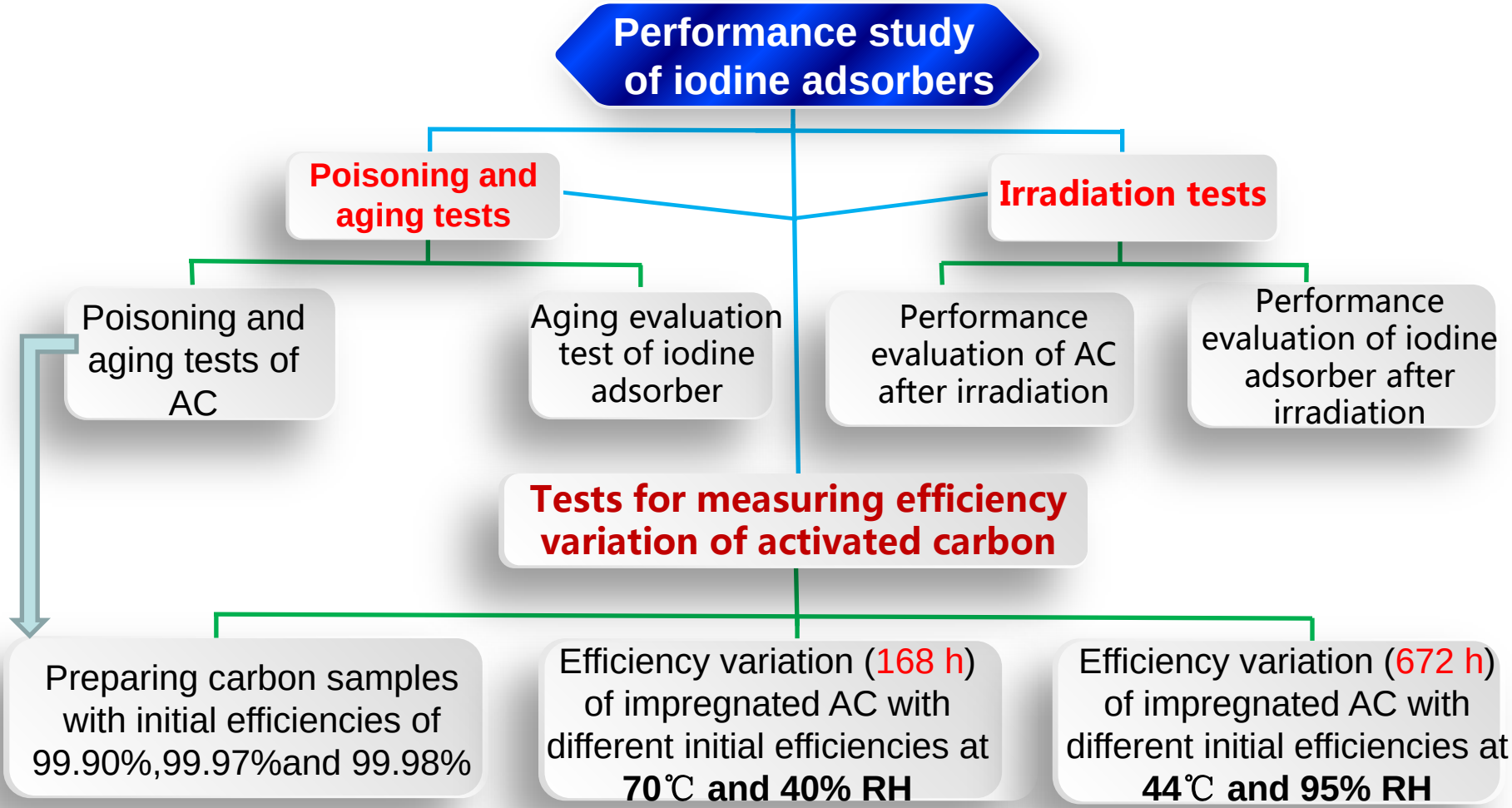


Background


New
99.98%
12~18 month
Recommended replacement
99.97%
Aging
168h
Efficiency Variation ? ?
Compulsory replacement
99.90%
12~18 month
CH_3I removal efficiency (M310)

Research Contents

2.1 Research Scheme



Research Contents

2.2 Test Conditions

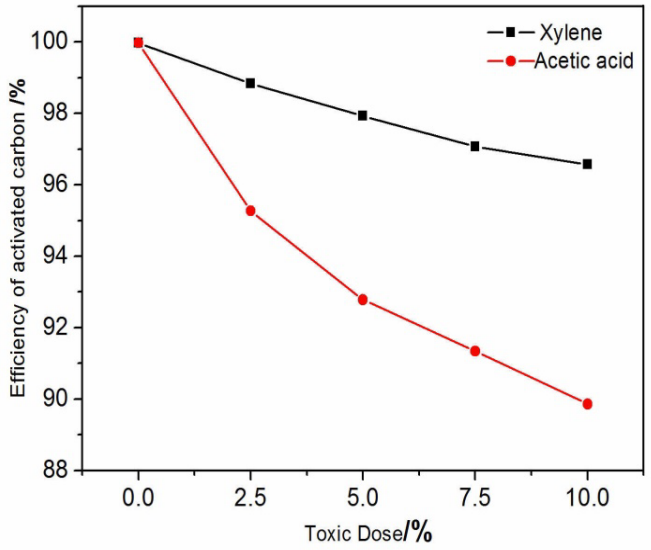
Test conditions based on source term at fresh air entrance

Test Items	Test Conditions
Challenge	$CH_3{}^{127}I + CH_3{}^{125}I$
Temperature（℃）	70.0±1.0(a)、44.0±1.0(b)
Relative Humidity（%）	40.0±2.0(a)、95.0±1.5(b)
Velocity（m/min）	11.3±0.2
Pressure（kPa）	101±2
CH_3I Concentration（mg/m^3）	$(8.3\pm0.42)\times10^{-2}$
Carbon Bed Depth（mm）	100±2
Challenging duration of CH_3I（h）	≥168
Irradiation Dose Rate（Gy/h）	1×10^3
Cumulative dose from irradiation（Gy）	1×10^5

Research Contents

3.1 Poisoning and aging tests of activated carbon

(1) Accelerated poisoning and natural aging tests of impregnated AC



Efficiency variation of impregnated AC poisoned by toxic reagents

At 30℃ and 95% RH according to D3803-91

Efficiencies of AC before and after natural aging

code	Initial efficiencies (%)	Aging time (M)	Efficiencies after aging (%)	Aging conditions
JZM201301	98.759	33	98.638	Bag storage
JZM201202	99.988	42	99.835	Bag storage
JZM201202	99.988	42	99.424	Open storage
JZM201202	99.988	54	98.873	Open storage

Research Contents

3.1 Poisoning and aging tests of activated carbon

(2) Preparation of impregnated AC samples by poisoning and aging

Code	Carbon substrates	Aging time (M)	Toxic reagents* (%)	Depth of carbon bed（cm）	efficiencies （%）
LZ10-1	JZM201202	54	5.0	10 cm	99.909
LZ10-2	JZM201202	54	1.5	10 cm	99.968
LZ10-3	JZM201301	33	0.0	10 cm	99.984

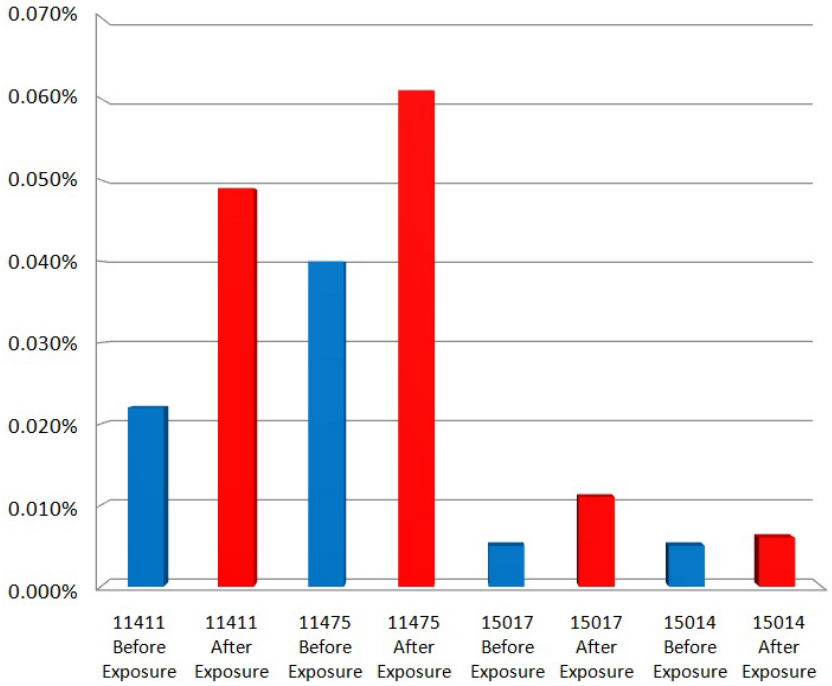
* - Acetic acid is the poisoning agent

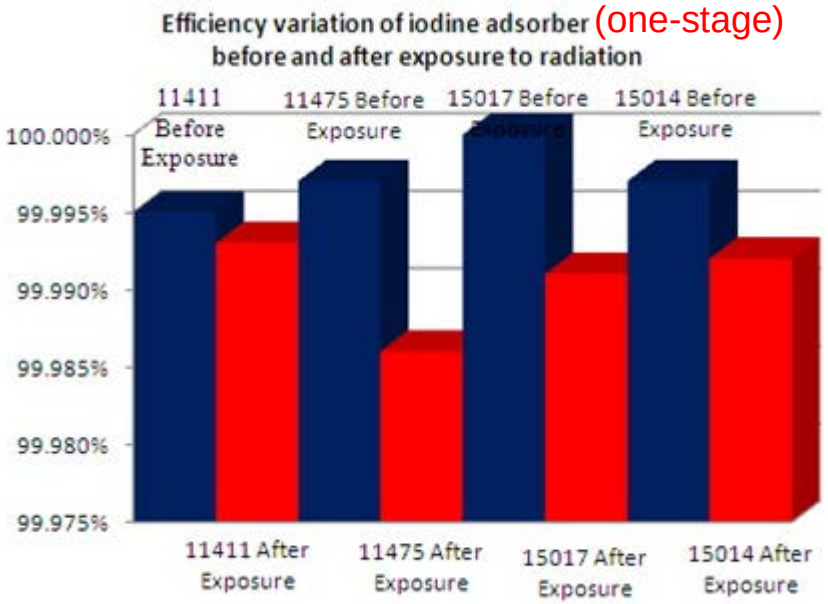
The final impregnated AC samples are labeled as LZ10-1, LZ10-2 and LZ10-3 respectively, which will be used in subsequent tests.

Research Contents

3.2 Irradiation tests of iodine adsorbers and activated carbon samples

(1) Irradiation tests of iodine adsorbers





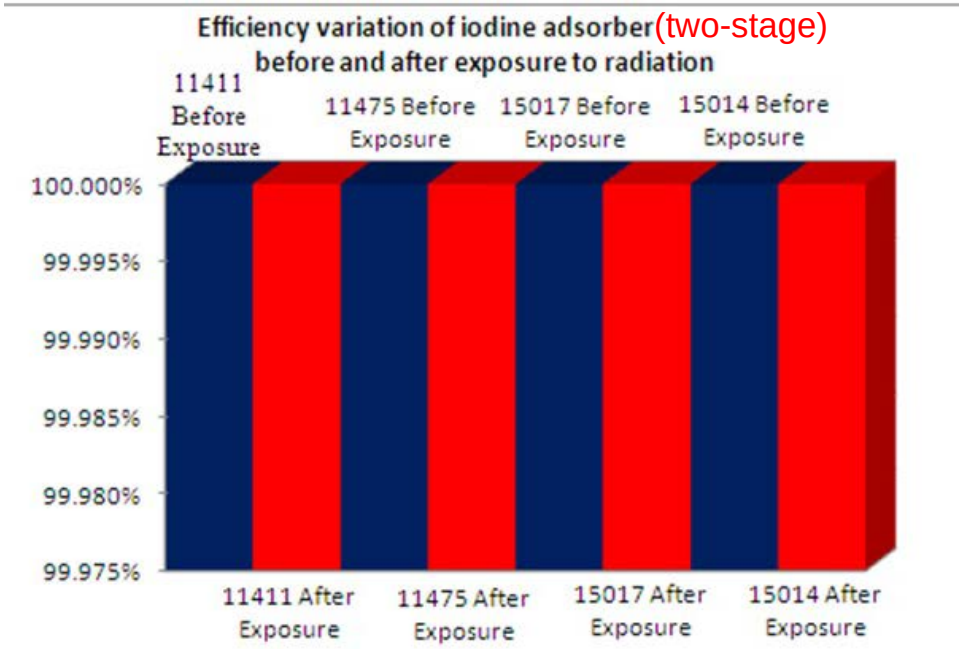
Mechanical leakage of individual iodine adsorbers before and after exposure to irradiation

Efficiencies of individual iodine adsorbers before and after exposure to irradiation

Research Contents

3.2 Irradiation tests of iodine adsorbers and activated carbon samples

(1) Irradiation tests of iodine adsorbers



Total efficiencies of two-stage iodine adsorbers before and after exposure to irradiation

It can be seen that, the efficiencies of individual iodine adsorber slightly decreased after irradiation, while the effect of irradiation on iodine adsorbers can be ignored for two stages .

Research Contents

3.2 Irradiation tests of iodine adsorber s and activated carbon samples

(2) Irradiation tests of impregnated AC

Efficiencies of impregnated AC before and after exposure to irradiation

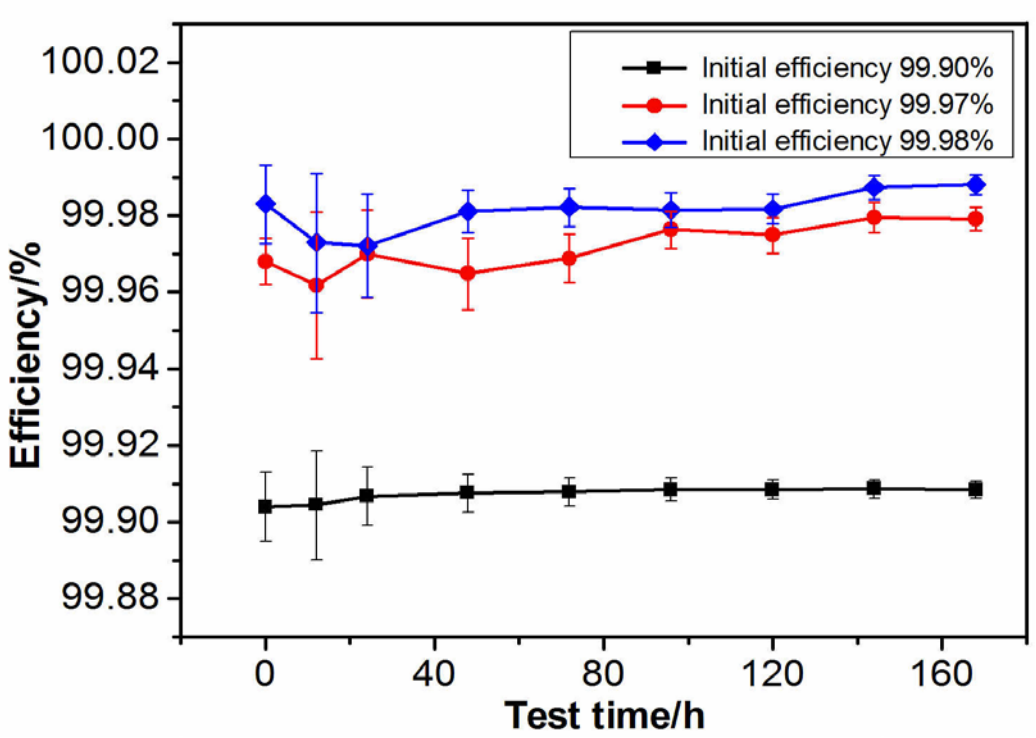
Code	Depth of carbon bed (cm)	Irradiation	Efficiency （%）
LZ10-1	10	Before	99.909
		After	99.911
LZ10-2	10	Before	99.968
		After	99.966
LZ10-3	10	Before	99.984
		After	99.983

It is found that irradiation has no effect on the efficiencies of impregnated AC under an accident dose .

Research Contents

3.3 Tests of efficiency variation of activated carbon samples

（1） Efficiency variation of AC at 70 ℃ and 40% RH



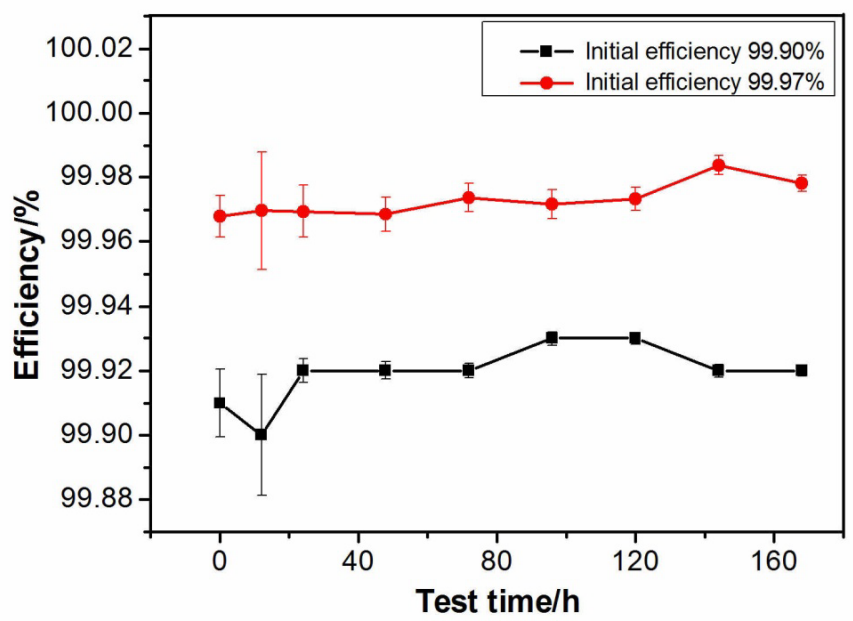
Under such conditions, the efficiency of activated carbon samples kept on unchanged.

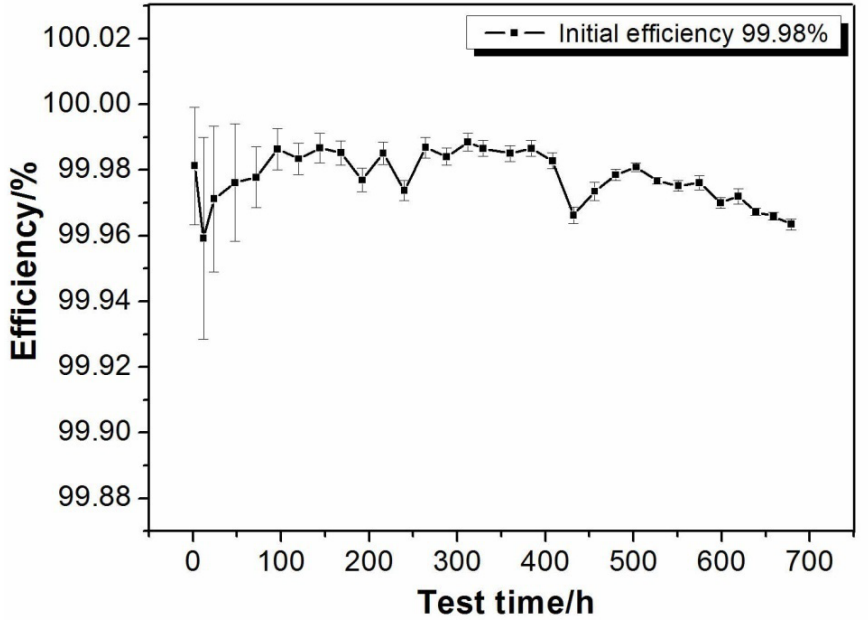
Efficiency variation of samples with time under high temperature

Research Contents

3.3 Tests of efficiency variation of activated carbon samples

（2） Efficiency variation of AC at 44 ℃ and 95% RH



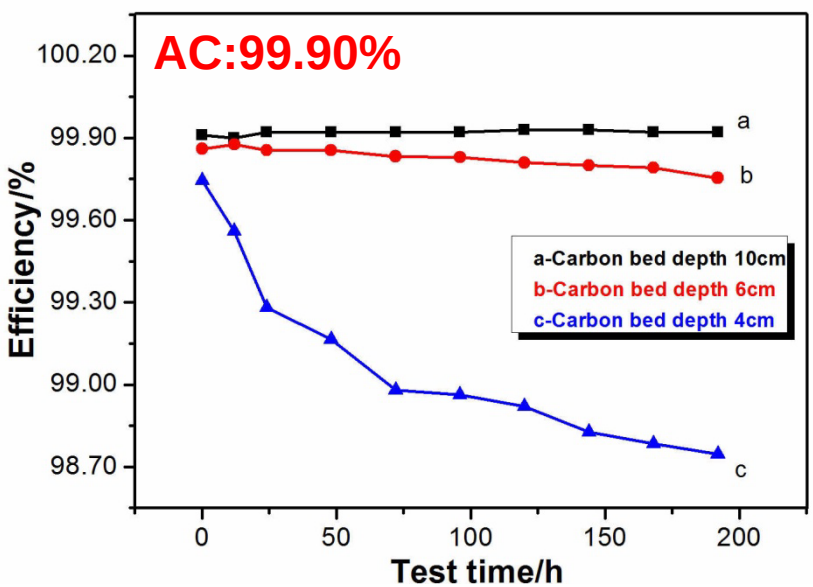


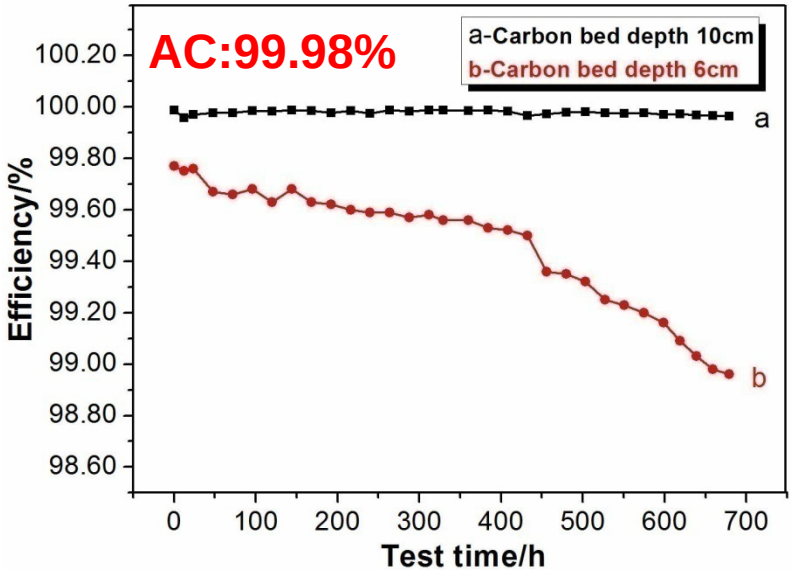
Efficiency variation of impregnated activated carbon samples with time under high humidity

Research Contents

3.3 Tests of efficiency variation of activated carbon

（3） Efficiency variation of AC at 44 ℃ and 95% RH





Efficiency variation of samples with the initial efficiencies of 99.90% (left) and 99.98% (right) **at different carbon bed depths**

Remarks: Efficiencies of two-stage iodine adsorbers can meet design requirements, while a single-stage design can not.

Conclusions

(1) The efficiency of impregnated AC suffers considerable decrease over three years. Once the required indicators can not be met, the adsorbers must be replaced timely.

(2) The overall efficiency of two-stage iodine adsorbers with a total bed depth of 10cm can meet design requirements for protecting operators, even after 168 hours of operation under the most severe accident. However, only one stage of iodine adsorbers can no longer meet above requirements, which proves that 10cm bed depth is adequate for control room iodine adsorbers.

THANKS FOR YOUR ATTENTION!