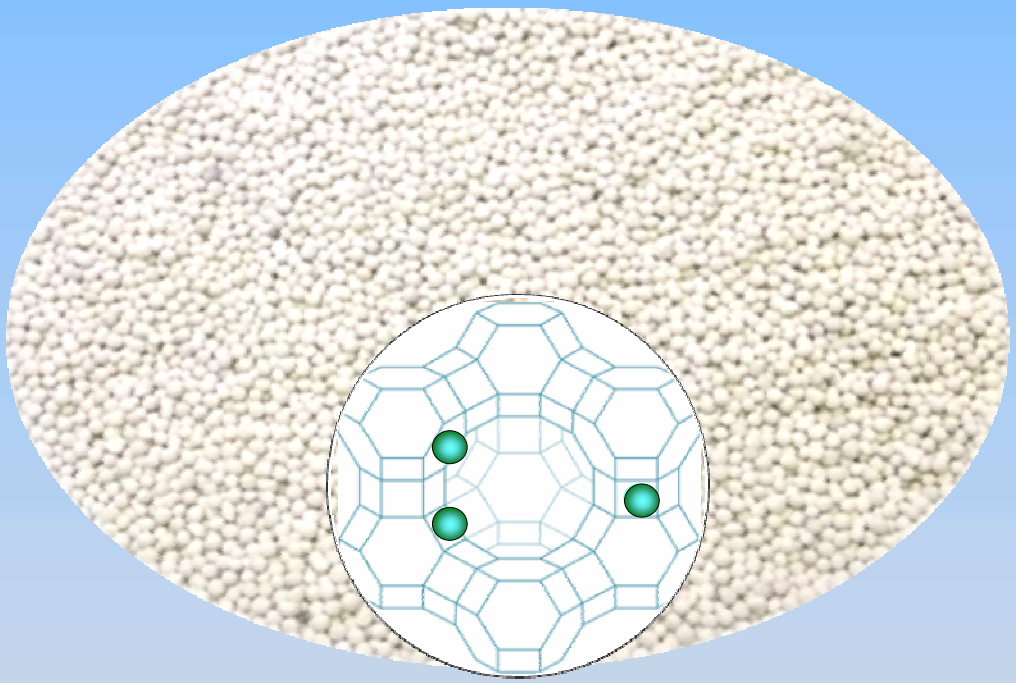
Radioiodine Adsorbent for Nuclear Power Plant

Silver Zeolite (AgX)



Rasa Industries, Ltd., Japan

PREFACE

Since the Fukushima-Daiichi nuclear accident, nuclear power plants in Japan start to improve safety countermeasures which are taken on the premise that an nuclear accident may happen. These countermeasures include installing and improving the filtered vents for preventing contamination of radioactive emission.

Rasa Industries, Ltd. has been providing the radioiodine absorbent since 1980, silver zeolite (AgX), which is highly efficient in removing radioactive iodine under the harsh conditions, especially organic iodine (CH_3I). Currently, some Japanese nuclear power plants are utilizing or intending to utilize AgX filters as the countermeasure of radioactive iodine in their vent systems.

ISSUES OF FILTERED VENT

1. Generation amount of organic iodine in radioactive emission was underestimated.
2. Hydrogen concentration in off-gas is high when vent starts to work.
3. Performances of adsorbent degrade due to the condensation of water vapor at the beginning of venting.
4. Traditional WET system cannot effectively remove radioactive organic iodine.
5. A high decontamination factor (DF) of 1000 should be achieved in eliminating organic iodine.

ISSUES OF SGTS AND ANNULUS

The Fukushima nuclear accident revealed a number of issues in SGTS performances, such as hydrogen generation and explosion, temperature rise, and operation break-down in the case of power loss. It is absolutely necessary to strengthen the safety measures against organic iodine and hydrogen.

PRODUCT FEATURES, ADVANTAGES and BENEFITS

1. AgX exhibits high adsorption efficiency of radioiodine, especially organic iodine even under high temperature, high humidity, and high pressure (please refer Tables 2). Furthermore, it also exhibits excellent adsorption characteristics in different gas compositions and temperatures (please refer Table 5). In the range of examined temperature, the higher the temperature, the higher the absorption efficiency.
2. Adsorption capacity for radioactive organic iodine is in the range of 85-200 mg/g. Using AgX filters can enhance the adsorption capability and reduce the waste.
3. High adsorption efficiencies can be kept under following conditions.

   1) within 0.06 sec. in residence time; 2) after heat treatment at 500 ºC for over 10 days; 3) after high temperature steam exposure (over 100 ºC) for over 10 days; 4) in gas mixtures containing hydrogen.
4. A compacted design of filter vent is possible. This is thought to be useful in anti-earthquake and preventing terrorism activities.
5. AgX has the effect of removing hydrogen (please refer to Table 6). This behavior can reduce the risk of hydrogen explosion.
6. Retention is over 99.9%. Adsorbed radioiodine can be retained almost completely.
7. Long product life cycle. There is hardly any aging deterioration under refrigeration or inert gas condition.
8. AgX is very stable in water. Even if it gets wet or is immersed in water, its adsorption performance can be recovered by drying it.
9. AgX filters can work without power supply.
10. Non-flammability. Secondary disasters such as fire will not occur.

PRODUCT APPLICATIONS

1. As radioiodine collection filters used in WET and DRY systems.
2. As a substitute for activated carbon in SGTS of BWR-type reactor (please refer to the evaluation results in Tables 3 and 4).
3. As a substitute for activated carbon in annulus of PWR-type reactor.
4. As a radioiodine filter used in the central control room for reducing the risk of occupational exposures. Also it can be utilized together with HEPA and metal filters.
5. As radioiodine filters utilized in other nuclear facilities such as reprocessing plants, place of fuel handling and storage of nuclear fuel.

PRODUCT EVALUATIONS

Table 1 Dependences of absorption efficiency of CH_3I on the temperature of superheated steam. The evaluation was performed by TÜV SÜD.

Bed depth (mm)	Residence time (sec.)	Absorption efficiency (%)				
		99 ºC (DPD* 0 K)	101 ºC (DPD 2 K)	104 ºC (DPD 5 K)	109 ºC (DPD 10 K)	114 ºC (DPD 15 K)
50.8	0.16	99.860	99.922	99.913	99.964	99.990
76.2	0.24	99.988	99.995	99.974	99.990	99.998
101.6	0.32	99.997	99.999	99.989	99.999	99.999

*DPD: Dew Point Distance.
Other test conditions. Radioiodine: CH_3I (I-131); gas comp.: steam/air=95/5 (super heated gas); P=0.98 bar.

Table 2 Relationships between absorption efficiency of CH_3I and bed depth at the high temperature, relative humidity (RH) and pressure. The evaluation was performed by NUCON International Inc.

Bed depth (mm)	Residence time (sec.)	Absorption efficiency of CH_3I (%)
T=130 ºC; RH=95 %; P=399 kPa		
50.8	0.246	99.967
76.2	0.369	> 99.999
101.6	0.492	> 99.999

Other test conditions. Linear velocity (LV)=20 cm/sec.; Radioiodine: CH_3I (I-131).

Table 3 Absorption efficiencies of CH_3I on AgX at different temperatures and relative humidity. The evaluation was performed by NUCON International Inc.

Bed depth (mm)	Residence time (sec.)	Absorption efficiency of CH_3I (%)			
		RH 95%			RH 70%
		30 ºC	60 ºC	90 ºC	66 ºC
50.8	0.250	98.738	99.685	99.970	> 99.999
76.2	0.375	99.850	99.950	99.983	> 99.999
101.6	0.500	99.962	99.987	99.995	> 99.999

Other test conditions. P=103 kPa; LV=20.3 cm/sec.; Radioiodine: CH_3I (I-131).

Table 4 Absorption efficiencies of elemental iodine (I_2) on AgX at different bed depth/residence time. The evaluation was performed by NUCON International Inc.

Bed depth (mm)	Residence time (sec.)	Absorption efficiency of I_2 (%)
50.8	0.250	> 99.999
76.2	0.375	> 99.999
101.6	0.500	> 99.999

Other test conditions. T=66 ºC; P=103 kPa; LV=20.3 cm/sec.; Radioiodine: I_2 (I-131).

Table 5 Adsorption efficiencies of CH_3I on AgX in different periods and gas compositions. These conditions are corresponding to the beginning of a vent in BWR. The evaluation was performed by Rasa Industries, Ltd.

Time (min.)	Gas composition (Vol. %)			AgX temp. (°C)	Adsorption efficiency (%)*
	H_2	N_2	Steam		
0 - 3	28	60	12	22 - 70	> 99.6
3 - 6	28	60	12	70 - 75	> 99.6
6 - 9	28	60	12	75 - 75	> 99.6
15 -18	23	53	24	105 - 115	> 99.6
35 - 38	5	12	83	140 - 145	> 99.8

* Detection limit.
Other test conditions. Gas temp.=150 °C; residence time=0.18-0.21 sec.

Table 6 Variations of hydrogen content before and after the gas mixture (air + H_2) flows through AgX. The evaluation was performed by Rasa Industries, Ltd.

Air+H_2 conditions				AgX temp. (ºC)	Results	
Humid air* flow (ml/min.)	H_2 flow (ml/min.)	Residence time (sec.)	Inlet H_2 content (vol. %)		Rising of temp. (ºC)	Outlet H_2 content (vol. %)
6600	205	0.87	3.0	75	1	> 1.5
				120	15	< 0.5
				136	17	< 0.5

*Humid air: air was bubbled in water at room temperature.

PRODUCT SPECIFICATIONS

No.	Items	Specifications	Remarks
1	Composition	Synthesized zeolite	
2	Metal cation of exchange	Silver (Ag)	
3	Exchange rate	> 97 %	
4	Silver content	> 36 %	Dry base
5	Particle size	10 × 20 mesh	JIS K 1474
6	Bulk density	1.2 g/ml (as is)	JIS K 1474
7	Attrition	< 3.0 %	ASTM D-4058
8	Moisture content	< wt 12 %	150 ºC/3h dried
9	Pressure loss	0.15 kPa	Thickness: 50 mm LV: 20 cm/sec.

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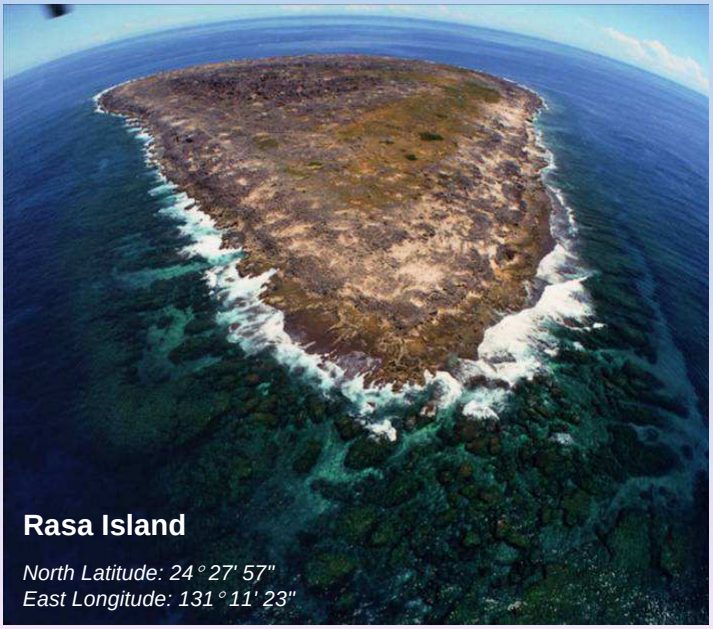

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