Safe Storage of Zeolite Adsorbents used for Treatment of Accident-generated Water at Fukushima Daiichi Power Station

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Safe storage of radioactive zeolites

Circulating Water Cooling at Fukushima-1 NPS

Oil separator

Spent adsorbents
※Cs removal >99%, high activity

Removal of radioactive materials

- Cs adsorption (KURION)
- 2nd Cs adsorption (SARRY)
- Decontamination by precipitation (AREVA)

Desalination

- Reverse Osmosis
- Evaporative Concentration

Saline waste

AREVA sludge
※low activity

ALPS

- Characterization of spent KURION media
  ➢ Radioactivity, thermal conductivity, etc.
- Verification of its safe storage
  ➢ Hydrogen by water radiolysis, corrosion, etc.

Seawater
Hydrogen production from zeolite mixtures

**Dose dependence of H₂ production**

*1 Kumagai et al., Transactions of the AESJ, 10(4), 235 (2011).

Air-sat., R.T., dose rate 1-4 kGy/h

\[ P \text{ [mol/g]} = G \text{ [mol/J]} \times D \text{ [J/g]} \]

**Formation of H₂ in aqueous phase and emission up to gas phase**

- **primary yield**, \( g(H₂) \)
- **observed yield**, \( G(H₂) \)

- **ionizing radiations**
- **diffusion, equilibrium**
- **oxidation by radiolysis products**
- **H₂O + H**
- **OH**

- **H₂**

- **gas phase**

- **aqueous phase**

- **Absorbed dose by mixture [kGy (= J/g)]**

- **seawater only**
- **pure water only**
- **seawater + zeolite (50 wt%)**

- **seawater**
- **zeolite addition**
- **50% of seawater only**

**H₂ production**:
- seawater(100 wt%) > seawater(50) + zeolite(50) > pure water(100).
  - Because H₂ is oxidized to H₂O in pure water but not in seawater.
  - Desalination & Dehydration are important for safe storage.
Estimation of temperature and hydrogen in vessel

Thermal-hydraulic analysis

- Model, code: 3D full structure, FLUENT
- Zeolite: dried Herschelite loading Cs 0.07wt%

Hydrogen concentration less than 4% (under the lower explosive limit)

- The maximum temperature of zeolite bed (153°C) became lower than the self-ignition temperature of hydrogen (about 560°C).
- Opening end lines of water inlet/outlet and vent tubes, a kind of siphon effect occurred by buoyancy and difference of mixed gas density. \( \text{H}_2 \) concentration in a vessel is kept lower than 4% (the under explosive limit).

⇒ Opening of the tubes is effective for decreasing of \( \text{H}_2 \) concentration
Stress Corrosion Cracking (SCC) was not observed on the surface of U-bend coupons after the 1000-hour test (Cl- 20,000 ppm) and 2000-hour tests (Cl- 2,000 and 6,000 ppm) at 80 °C.
Estimation of Cs in zeolite by ZAC code

ZAC (Zeolite-Adsorption Column) code

- Distribution of Cs in a vessel is a primary input for more precise evaluation.
- Improved code will be applied to the analysis of an actual vessel.

The results essential to the safe storage will be summarized by the end of FY 2013.