# Transport and Storage for Spent Nuclear Fuel

## Background and Objective

In Japan, spent nuclear fuel (SNF) exceeding the reprocessing capacity is being generated with progressive nuclear power generation, and the needs for interim storage of SNF are increasing. Although the use of metal casks for interim storage has been practically employed to date, the utilization of an alternative storage method, i.e. concrete casks, is also needed from the perspective of cask procurement risk management and economic benefit. In this project, to support promoting activities on interim storage and confirm the safety of the confinement components during future transport after long-term storage, we are executing study programs mainly related to metal cask and concrete cask storage technologies for the verification of the integrity of the components, such as canister and metal gasket, under long-term dry storage conditions.

## Main results

### 1. Prevention of chloride induced stress corrosion cracking for S30403 stainless steel canister

For the practical use of the concrete cask storage technology, remaining issues are preventive design (monitoring, inspection and countermeasures) and its demonstration in Stress Corrosion Cracking (SCC) on the canister surface. Scenarios to maintain the confinement function of the canister made of the conventional S30403 material during storage period were established by keeping the salt density on the canister surface within the critical value to initiate SCC or by controlling the crack propagation if the salt density exceeds the critical value. The feasibility of these scenarios (Fig.1) and methods of reducing welding residual stress to prevent SCC were demonstrated [N10035]. Furthermore, the possibility of the quantitative measurement of chlorine content on the canister by LIBS (Laser-induced breakdown spectroscopy) was proven for a periodical non-contact and remote inspection method (Fig.2).

### 2. Development of salt particle collection device for preventing canister SCC

At storage facilities with a natural ventilation system built near the seashore, mitigation of the salt particles will be a useful anti-SCC countermeasure. Here, we proposed a salt particle collection device with a low flow resistance which does not resist the air flow into the building, and confirmed its efficiency for the long-term usage in a field test [N10024].

### 3. Evaluation of long-term integrity of SNF by cover gas sampling inside metal cask

The integrity of SNF in metal cask stored in the Idaho National Laboratory (INL) in USA for 25 years was confirmed by mass spectra and $^{85}Kr$ gamma ray measurement technique (Fig. 3) [L10017].

### 4. Evaluation of long-term containment performance of metal cask

The containment function of the metal cask is secured by inserting metal gaskets. Here, we proposed a lifetime estimation method considering the influence of stress relaxation of the gaskets on the containment performance of the metallic gaskets for long-term usage, and estimated the aging condition of the metallic gaskets using the temperature profile that appeared during the realistic long-term storage (Fig. 4). Moreover, the importance of the lid-closure procedure to maintain the appropriate containment function was pointed out by the leak test with the full-scale lid model cask.

(These works have been carried out under the contract from NISA/METI.)

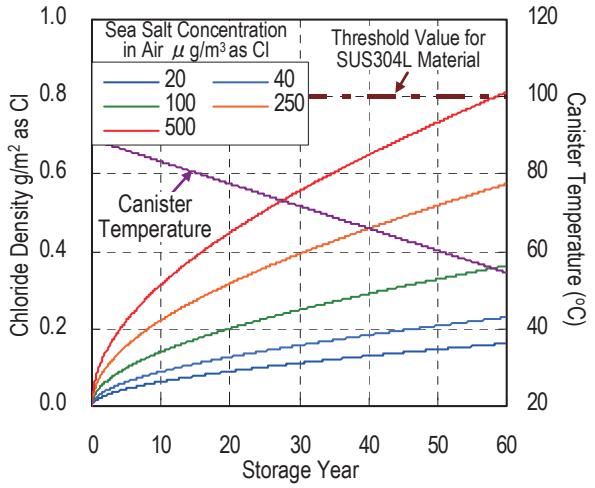
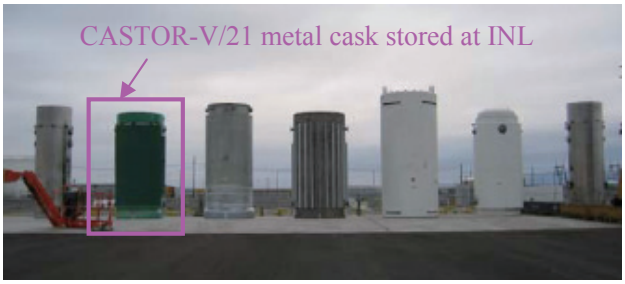



**Fig.1 Time to SCC initiation in salty air for the conventional stainless steel (S30403)**

The minimum amounts of salt for SCC initiation for the S30403 material should be set to 0.8g/m² as Cl. The SCC initiation of the canister with S30403 material will not occur for 60 years under an airborne salt concentration of 500 μ g/m³.

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|---|---|
| Fuel Type | 15×15 Array for PWR |
| Loading | 21 PWR spent fuel assemblies |
| Burn-up | 30 ~ 36 GWd/tHM |
| Cooling Time | 2.2 ~ 3.8years |
| Enrichment | 2.9 ~ 3.1 wt% |
| Mean Residual Heat | 28.4 kW |

**Fig.3 The CATOR-V/21 metal cask stored at INL for cover gas sampling analysis, and its specification of SNF**

The CASTOR-V/21 metal cask which stores 21 PWR spent fuel assemblies served to cover gas sampling analysis. $^{85}$Kr concentration in the gas sample data measured during storage period from 1985 to 2010 showed an extremely low value. Moreover, there were no signs for degradation or damage by the visual inspection of SNF executed in 1999. Thus, the integrity of SNF is kept up to the present.

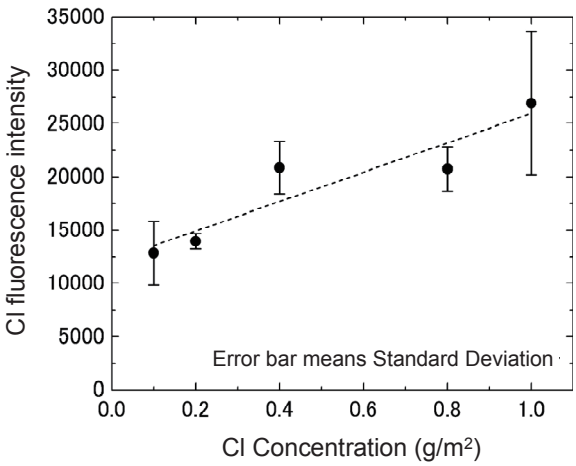


**Fig.2 Cl content dependence of Cl fluorescence intensity in double pulse measurement by LIBS**

Using stainless steel plates (S30403) sprayed with synthetic seawater, laser beam was focused onto the plate with chlorine concentration from 0.1 to 1.0 g/m² and the chlorine spectra were measured by use of double pulse method. As the intensity of the chlorine fluorescence was increased linearly versus chlorine concentration, the possibility of the quantitative measurement of chlorine content on the canister by LIBS was verified.

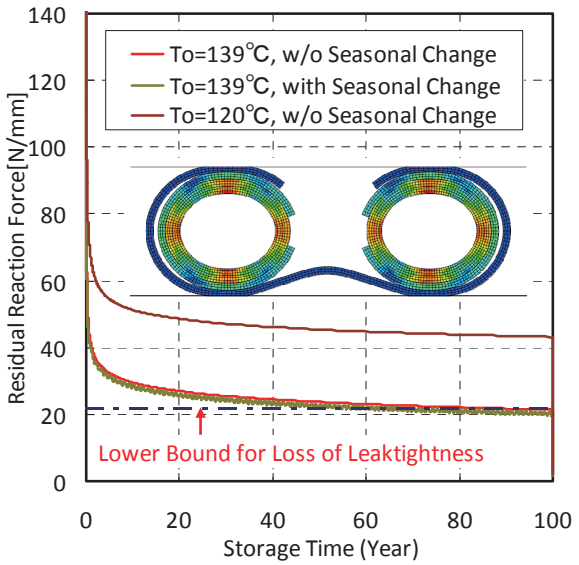


**Fig.4 Relaxation analysis of the full-scale metal gasket covered by aluminum layer**

Creep constitutive formulae for the gasket cover layer to use in FEM tools were proposed by tensile creep tests at high temperature with the A1050-O aluminum material. As the relaxation analysis showed that the residual reaction force of the metal gasket was kept over the limit value (22N/mm) under the realistic condition (139℃ x 60 years), the long-term reliability of metal gasket was confirmed.