Priority Subjects — **Establishment of Optimal Risk Management**

Development of Long-Term Storage Management Technologies for Spent Fuel

Background and Objective

The interim storage of spent fuels generated from nuclear power plants until they are reprocessed is necessary. Furthermore, it is important to prepare for an increase in storage amount and an extended storage period. Many dry interim storage facilities using metal casks exist in countries around the world, including Japan. It is also necessary to evaluate the safety of post-storage transport, taking into account aging of the components during the storage period. The early realization of interim storage facilities using concrete casks is demanded in Japan from an economical point of view.

In this project, we aim to develop an evaluation method for confinement of metal casks which takes aging into account. For the practical use of concrete cask technology, we aim to improve an evaluation technology for stress corrosion cracking (SCC) and an investigation method for welding of canisters*1. The objectives of this subject are to make use of these results for the safety of interim storage of spent nuclear fuel.

Main results

1 Performance validation of measurement device for sea salt in air by insitu measurement near the seashore

Because it is necessary to know the volume of sea salt in air at a storage site in order to evaluate the SCC of a canister, we developed a simple device to measure sea salt in air continuously and automatically over a long period. To validate the performance of our device, we compared the measurement results of our device with the results obtained simultaneously by another device based on a filter pack method at a marine exposure test field at CRIEPI's Yokosuka site. The device based on the filter pack method is one of the standard devices used. The comparison results show that the two devices have almost identical performance when measuring the volume of sea salt in air (Fig. 1).

2 Evaluation of relationship between sea salt in air and salt amount deposited on the canister surface

In our past studies, we measured the salt deposition amount in a laboratory and at an exposure test field located in Choshi at a distance of 4 km from the seashore. To add data of different environment conditions, we measured the salt deposition amount in a marine exposure test field carried out at CRIEPI's Yokosuka. In the test, we measured salt amount deposited on the test piece placed in the vertical wind tunnel in which outside air is introduced by a blower as well as in the horizontal wind tunnel. The chorine amounts deposited on the test piece in the vertical wind tunnel were less than 10 mg/m^2 within the test duration (Max: 6900 hours)(Fig. 2) (N14019). This value is similar to the results obtained at Choshi and much smaller than the values of salt deposition on the bridge and electrical equipment near the seashore and threshold value of SCC.

3 Development of a device for remote measurement of salt deposited on canisters

It is important to ensure the integrity of canisters by measuring the salt deposited on the canister surface and evaluating the occurrence of SCC. Remote measurement is an important issue as the radiation dose near the canister surface is very high and the space between the canister and concrete body is narrow. In this study, we clarified that the measurement method by laser-induced break down spectroscopy (LIBS)*2 is applicable and developed a compact device comprised of optics for LIBS and a drive unit for vertical movement in the space between the canister and a concrete body. We confirmed the measurement accuracy of our device using a miniature model simulating the narrow space between a canister and a concrete body. We moved the compact device up and down in the model and measured the salt deposits on the test piece placed on the side wall of the model (Fig. 3). The distance from the laser device to the measurement points was around 5 m and the space between the walls was 50 mm. As a result, the value obtained by LIBS (value calculated by intensity of chlorine fluorescence normalized by oxygen fluorescence) is in good agreement with the value obtained by ion chromatography within the measurement range of chlorine density between 0 to 100 mg/m^2 (Fig. 4). These results show that it is possible to measure the chlorine amount deposited on canisters stored in the concrete cask using our device for remote measurement which adopts LIBS technology (H14004).

*1 A cylindrical container made of stainless steel which contains spent nuclear fuel and is placed in a concrete cask.
*2 When the laser pulse irradiates to a target, the spectra of plasma emission is obtained. By analyzing the emission spectra, contained elements concentration on the target is evaluated.

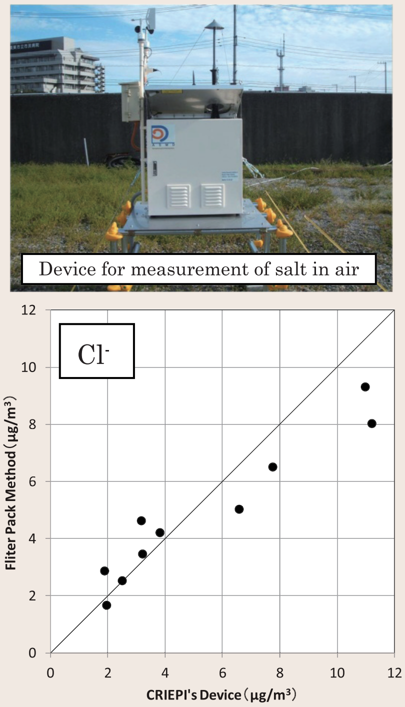

Fig. 1: Comparison of chlorine in air between the measurement values obtained by our device and existing device (Filter pack method)

To clarify the performance of our measurement device, we compared the measurement values obtained by our device with the values obtained by an existing standard device based on the filter method. As a result, it was confirmed that the performance of our device is equivalent to that of the existing device.

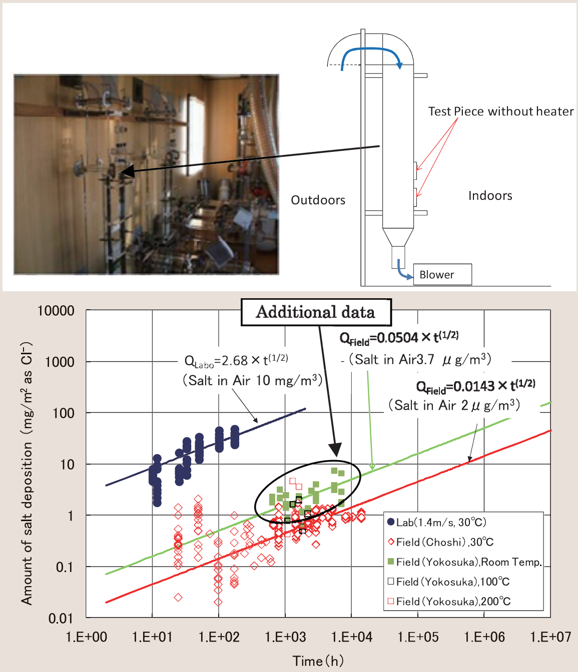

Fig. 2: Relationship between the amount of salt deposition and time in the tests using vertical wind tunnel

We measured the amount of salt deposition attached to the test piece using a vertical simplified wind tunnel simulating the flow area of a concrete cask. Outside air was introduced to the wind tunnel using a blower. We obtained additional data regarding salt deposition with different environment conditions from the existing data. The relationship between the amount of salt deposition and time obtained in additional tests are similar to the existing data. The dispersion of data in additional tests is relatively small.

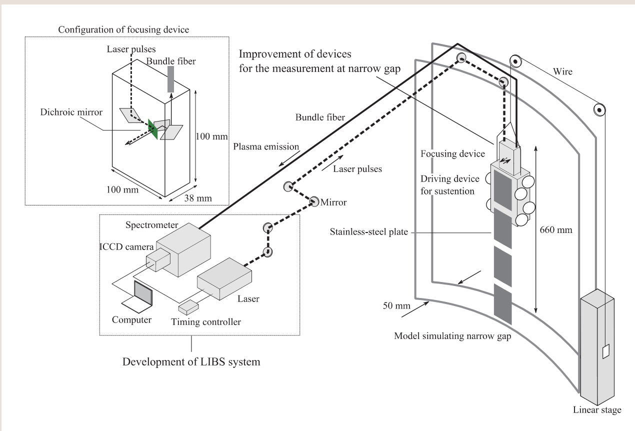

Fig. 3: Outline of miniature model simulating the narrow space between a canister and a concrete body

We developed an LIBS device for measurement of salt deposit on canisters and modified a compact device comprised of optics for LIBS and a drive unit for vertical movement in the narrow space. In the tests, using a miniature model simulating the narrow space between a canister and a concrete body with curvature, we measured the salt deposit on test pieces made of stainless steel placed on the side wall of the model. Artificial sea water was sprayed on the test pieces before measurement. One of the test parameters was the salt deposit on the test pieces.

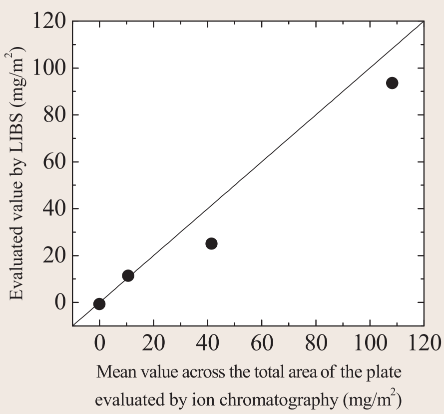

Fig. 4: Validation of measurement method based on the LIBS technology

We compared the results of the chlorine amount deposited on the test piece obtained by LIBS with the results obtained by ion chromatography. It is clear that each result is in good agreement. The applicability of the measurement method using LIBS was confirmed.