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The corrosion behavior of one-fifth scale lid models of transport cask submerged in sea bottom

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Abstract

Corrosion tests have been performed for one-fifth scale lid models of typical transport cask for radioactive materials and for other crevice corrosion test specimens at a sea bottom for maximum 6 years. The effect of corrosion on the performance of the cask was evaluated based on the test results. The dissolved oxygen (DO) value measured at the test site was about 5–14 mg/l. These values were higher than DO values at the sea bottom of 200 m to 3000 m depth in the shipping route, and hence the corrosive condition was more severe than that for the actual cask. No leak was found for models with rubber gasket after immersion at the sea bottom for about 6 years. The crevice between cask body and cask lid was unchanged after immersion for about 700 days, that is, 1.4–2.8 μm. Therefore, even if the rubber gasket were deteriorated, the crevice seemed to be narrower than 10 μm, that have been regarded as the safety opening for sunken transport cask assumed in the environmental impact assessment. The maximum penetration depth at contact surfaces of lid models after immersion for 700 days was about 200 μm which was significantly lower than that of creviced specimens of type 316 stainless steel. This might be due to galvanic effect of carbon steel bolts on the corrosion of stainless steel body.
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Keywords: Transport cask; Crevice corrosion rate; Seawater corrosion; Leak rate

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1. Introduction

Radioactive materials packed in casks have been so far transported safely by the sea. The dose assessment has been carried out on the assumption of transport casks sunken into the sea by unexpected reasons. If a transport cask sinks into the sea, corrosion through the small gap between cask body and cask lid will lead to a release of nuclides. However, the corrosion behavior of cask and corrosion damage between cask body and cask lid are not well known [1].

Central Research Institute of Electric Power Industry, Japan (CRIEPI) conducted corrosion tests in a sea bottom using small lid models of transport cask and evaluated the corrosion behavior. This paper presents these test results.

2. Environmental factors of test site [2]

According to Levitus data base [3,4], the maximum dissolved oxygen (DO) value at the sea bottom of 200–3000 m depth in the actual shipping route of transport cask is about 5 mg/l, which is relatively low in spite of relatively lower water temperature.

The test site of this study was chosen so as to be more corrosive than the actual shipping route because of higher DO values.

The environmental factors, that is, DO value, water temperature, NaCl concentration and pH of test site were measured. The DO value and water temperature were measured directly in the sea, and NaCl concentration and pH were measured after sampling seawater. Fig. 1 shows changes in these values for a year. Table 1 summarizes these data. Fig. 2 shows the relation between DO and water temperature. The DO value decreases almost linearly with water temperature, but NaCl concentration and pH are almost constant throughout the year.

Test models and crevice corrosion test specimens were submerged to the about 4.2 m deep sea bottom from the sea surface. The DO value measured at the test site was about 5–14 mg/l, and higher than that at the sea bottom of 200–3000 m depth in the shipping route [3,4]. Thus, the corrosive condition at the test site seemed more severe than that of the shipping route.

3. Corrosion test by cask-lid models [2]

3.1. Test lid models and test method

The several one-fifth scale cask-lid models were submerged to the sea bottom for about 6 years and salvaged periodically. Leakage test was conducted and crevice between cask and lid was measured on the mechanically cut cross-section.

Table 2 shows test periods of individual models. Figs. 3 and 4 exhibit the configuration of test model and bolt. Type A model was for corrosion test with gasket for short period, Type B model was for corrosion test for long period assuming the case

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