Evaluation of Integrity against Stress Corrosion Cracking of Canister for Concrete Cask for Spent Nuclear Fuel Storage

Background

Application of the concrete cask system, a kind of interim spent nuclear fuel storage, to Japan has been discussed. As the concrete cask system utilizes external air to cool stainless steel canister that contains spent fuel, the canister may suffer from stress corrosion cracking (SCC) around weld if sea salt particles contained in air attached to the canister surface (Fig.1). Since SCC occurs above the relative humidity to deliquesce sea salt, SCC will not occur if the time in which sea salt gets wet (wet time) depending on surface temperature on canister and atmospheric conditions is shorter than the time required to initiate SCC (SCC initiation time).

Objectives

- To obtain a SCC initiation time and conditions to initiate SCC.
- To evaluate integrity of canister against SCC during 60 years of storage.

Principal Results

1. SCC initiation life

Constant load test was conducted at 80˚C and 35% of relative humidity while dosing sea salt on the specimen surface. In this experiment, we defined SCC initiation time on canister surface as a failure time of specimen in which thickness is 1/10 of canister wall thickness; 2mm. While S30403 stainless steel specimen ruptured at about 250 h, candidate canister materials did not fail for 46000 h (Fig.2).

2. Relative humidity for SCC initiation

Lower limit of relative humidity for deliquescent of sea salt, initiation of corrosion as a precursor of cracking and small crack initiation were investigated at lower than 100˚C where SCC is likely to occur. The limit of relative humidity becomes a low value when temperature is high (Fig.3). We defined limit value of relative humidity as 15% at 80˚C where crack initiation was observed.

3. Evaluation method and preliminary result

Relative humidity on canister surface changes in time was calculated for 60 years by utilizing hourly atmospheric temperature and humidity data and canister surface temperature obtained with model canister for decay heat test (Fig.4). The summated time above RH=15% is 15430 h, which is less than SCC initiation life of 46000 h. This method is useful for evaluation of integrity of the canister.

Future Developments

The SCC initiation test is going to be continued in order to obtain longer SCC initiation life data. The evaluation method will be modified refining factors that consist of the method.

Main Researcher: Jun-ichi Tani, Ph. D.,
Research Scientist, Material Science Research Laboratory

References

J. Tani, et.al., 2007, “Chloride induced stress corrosion cracking of candidate canister materials for concrete cask storage of spent fuel Vol.5,” CRIEPI Report Q06014 (in Japanese)
J. Tani, et.al., 2006, “Chloride induced stress corrosion cracking of candidate canister materials for concrete cask storage of spent fuel Vol.4,” CRIEPI Report Q06001 (in Japanese)

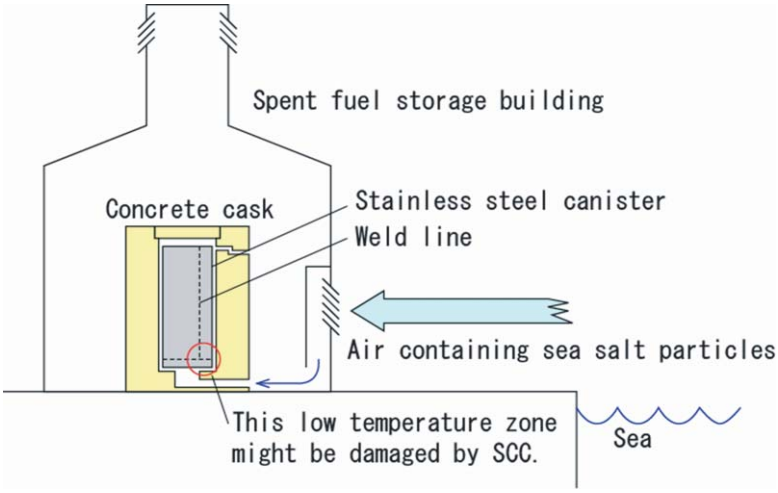

Fig.1 Expected SCC problem on concrete cask storage system in Japan.

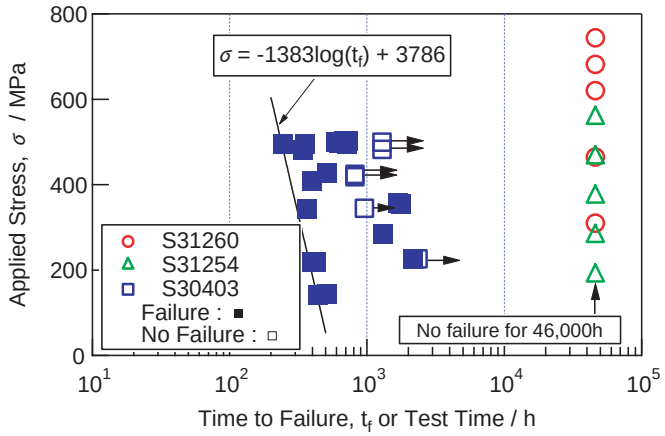

Fig.2 Measurement of SCC failure life by constant load test. Ranges of stress condition cover the ranges of residual stress induced by weld. Temperature, relative humidity and chloride density were determined to severe values.

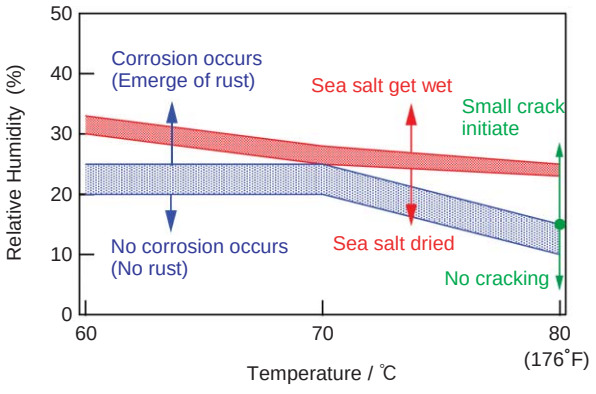

Fig.3 Lower limit of relative humidity for SCC initiation. We chose 15% as lower limit for SCC initiation.

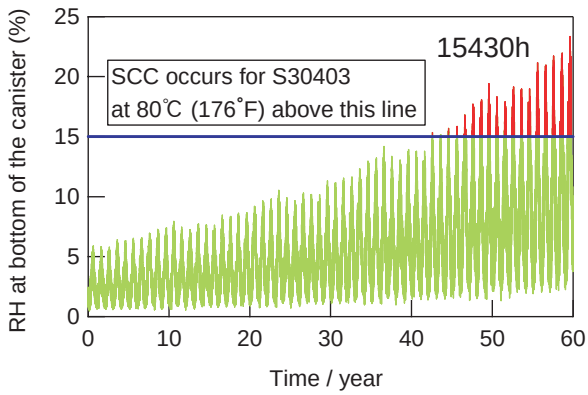

Fig.4 "Wet time" is calculated from Japanese meteorological data and the data of decay heat test of the canister. SCC initiation life on Fig.2 is sufficiently longer than the wet time. This preliminary calculation explains low possibility of occurrence of SCC.