

Research Status on Long-term Performance of Seals for Spent Fuel Transport and Storage Casks

Yun-young Yang*, Jongmin Lim, and Woo-seok Choi

Korea Atomic Energy Research Institute, 111, Daedeok-daero 989beon-gil, Yuseong-gu, Daejeon, Republic of Korea

*Yang0124@kaeri.re.kr

1. Introduction

Seals are often used as a main component for the containment of cask for spent fuel transport and storage. Accordingly, various projects have been performed to evaluate the containment performance of seals in the world's leading nuclear power advanced countries.

Therefore, this paper describes the technology trends related to the research on the containment integrity of the seal in Korea and abroad.

2. Research Status

2.1 Domestic

In the "Securement of comprehensive safety verification technology of spent fuel storage and transportation system" project, which was completed in 2016, the proof test was conducted on the metal seal through development of the spent fuel transportation and storage system [1]. In this test, the accelerated method using the Larson-Miller parameter was used to evaluate the containment integrity of the KORAD-21 dual purpose metal cask through two accelerated tests. Accelerated test results have shown that the containment integrity is maintained for 50 years [2].

2.2 United States

In the United States, various tests have been carried out on spent fuel transportation/storage technology since the late 1970s. Recently, R&Ds related to long-term storage have been invested intensively. There has been a growing demand for public interests and regulatory issues on the beyond-design-basis accidents of spent fuel transport and storage systems since 9/11.

The NIST researchers conducted various tests to evaluate the containment integrity of metal and

polymer seals under heat exposure conditions that could occur during the beyond-design-basis fire accident, and found that leakages occurred in the metal and polymeric seals under some conditions [3].

SRNL researchers have investigated the aging behavior of elastomer-based Viton GLT and GLT-S O-rings for the purpose of supporting 9975 transport cask for the transportation and storage of Plutonium, and developed a lifetime predictive model [4]. The predictive model based on the compressive stress relaxation test data expected that seals have a life expectancy of about 8 years at a maximum expected temperature of 93°C and decades at a practical operating temperature of 66°C or less. After six years of testing, the package showed only a small compression effect on the O-ring and no significant performance degradation was found.

2.3 Japan

Japan conducted researches on the safety test and the containment integrity evaluation of the transportation cask with the original scale test facility. To evaluate the containment integrity of metal gaskets in the long-term storage, prototype test models including two types of cask lids were developed and used for tests during 19 years [5]. The containment performance proved that the silver jacket gasket showed better results than the aluminum jacket gasket and had a very stable containment performance over 19 years.

In Japan, CRIEP also worked with CEA, TECHNETICS in France and GNS in Germany to study metallic seals. Surface inspection of the metal seal after 100,000 hours at several temperature ranges was carried out, and the behavior of the metallic seal according to change in load were investigated by an analytical method [6,7].

2.4 Germany

Germany conducted a safety evaluation test at

original scale on the transport and storage casks from the end of the 1970s. Various tests have been carried out to show the adequacy of containment evaluation using the reduced model and to obtain the safety factor. The BAM researcher conducted tests to evaluate the behavior of the metallic seal under normal conditions and accident conditions during cask transportation, and evaluated the performance degradation factors of metallic seal for long - term storage under various parameters [8]. Tests of the containment integrity of the seal were carried out to evaluate the effects of axial and radial impact loads and the effects of particles on the seal and flange surface, chemical resistance and corrosion.

In recent years, research has been carried out on elastomeric seals at low and high temperature [9]. In the metallic seals, stress relaxation with respect to time has been researched. In the elastomeric seals, design life has been evaluated by determining the compressibility of the seal with respect to temperature and time.

3. Conclusion

The trends of three countries that study the containment integrity including domestic and abroad are described in this paper. Major advanced countries have already reached leading position by conducting precedent research. Korea needs to make efforts to secure the technology for evaluating the containment performance of the seals. It is also necessary to consider the interaction of flange, bolt, and seal with creep in addition to the study of seal performance.

ACKNOWLEDGMENTS

This work was supported by the KETEP and the MOTIE of the Republic of Korea (no. 2018710201770).

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