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Safety Test Planning for a Type B Packaging of Radioactive Waste

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Introduction

KHNP-NETEC has been developing a new Type B packaging for on-site transport of radioactive waste. The packaging is designed to meet the requirements of IAEA and Korean regulations[1][2][3]. Demonstration of compliance with the performance standards required in the regulations must be accomplished by analyses or safety tests or by a combination thereof. Analyses on the packaging for normal transport and accident conditions were completed using computer programs. In order to verify the analysis results and demonstrate the compliance with the regulatory requirements, a safety test planning was established and the safety tests on a prototype model will be carried out.

Type B Packaging of Radioactive Waste

The Type B packaging is designed to transport radioactive wastes exceeding specified quantity of radioactive material from the radioactive waste treatment facility of nuclear power plant to the interim storage building of radioactive waste, and is in compliance with the requirements of IAEA Safety Standards Series No.TS-R-1 and Korean Atomic Energy Act for the safe transport of radioactive material. The packaging provides containment, radiation shielding, thermal and structural integrity for normal conditions of transport and hypothetical accident conditions.

The packaging(Dia.960mmx1070mmH) consists of a forged thick-walled carbon steel cylindrical body with an integrally-welded carbon steel bottom and a lid made of carbon steel which is fastened to the packaging body by lid bolts and sealed by double elastomer O-rings. The steel thickness of the packaging body wall and of the lid is sufficient to meet the dose rate limits of the regulations. A cylindrical overpack(Dia.1520mmx1510mmH) to absorb the impact energy under 9m free drop condition and to maintain thermal integrity under fire condition is enclosed around the packaging. The overpack is filled with polyurethane foam and special heat-resistant mat is lined inside the casing. The total weight of the packaging including the overpack is about 4.5tons.

Safety Test Planning

For the Type B packaging safety tests will be carried out for only accident conditions and will demonstrate the verification of the numerical tools and methods used for its safety proof and the compliance with the regulatory requirements. The safety test planning describes the detailed methods and sequence of the safety tests, which include drop tests, thermal test and water immersion test. A prototype model including three overpacks for drop tests as shown in Fig.1 was fabricated to be used for the safety tests. The tests will be carried out at KAERI's test facility.

Fig. 1 Prototype model : packaging and overpack

To evaluate cumulative effect on the packaging in accordance with the regulations, drop, fire and water immersion tests will be applied to the same model sequentially. Safety tests will be carried out in the following order;

(1) Drops(Test 1-Test 2-Test 3)
(2) Drops(Test 4-Test 5)
(3) Drops(Test 6-Test 7)-fire-water immersion.

Prior to the safety tests, the test model will be examined by visual and dimensional inspections to identify and record faults or damage including divergences from design, defects in construction, corrosion or other deterioration and distortion of features. During all tests data such as acceleration, strain and temperature will be taken and recorded continuously at defined locations. Leak test, visual inspection and non-destructive examinations will be conducted before and after the tests.

Drop Tests

The packaging must withstand drop impact in a position causing maximum damage, but it is difficult to define the impact direction for which maximum damage is expected. The packaging will be tested at different drop positions on the rigid base and on a pin according to the regulations, that is, five drops from the height of 9m on the rigid

base as shown in Fig.2 and two drops from the height of 1m on a pin as shown in Fig.3.

(1) Drops from the height of 9m on the flat target;

- Test 1 Drop with vertical packaging axis, bottom directed downwards, overpack for bottom side
- Test 2 Drop with vertical packaging axis, lid directed downwards, overpack for lid side
- Test 4 Drop with horizontal packaging axis, the line of impact, overpack for side
- Test 5 Drop with sloping packaging axis(slap down drop), axis aligned at an angle of 20°, overpack for side
- Test 6 Drop with slopping packaging axis, center of gravity over the point of impact, overpack for lid side

(2) Drops from the height of 1m on the pin;

- Test 3 Drop with horizontal packaging axis, the line of impact, overpack for side
- Test 7 Drop with vertical packaging axis, lid directed downwards, overpack for lid side

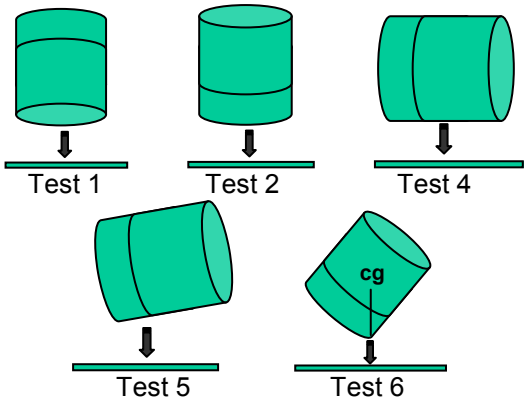

Fig.2 Positions for 9m drop tests

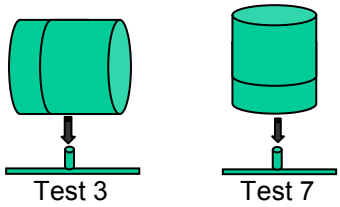

Fig. 3 Positions for 1m drop tests on a pin

Thermal Test

The thermal test will be an open pool fire test. The packaging will be in a position over the pool. It will be fully engulfed in a hydrocarbon fuel/air fire with an average flame temperature of at least 800°C and an average flame emissivity coefficient of at least 0.9 for a period of 30 minutes. The packaging shall not artificially cooled after thermal test, which means it has to be cooled down naturally in open air.

Because of conducting the open pool fire test using the open air fire test facility an ambient temperature of 38°C and solar insolation cannot be realized as initial conditions and during cool down phase. Pre-analysis will be done by using initial and boundary conditions, and differences in initial and boundary conditions between thermal test and pre-analysis will be considered.

Water Immersion Test

The packaging will be subjected to water pressure equivalent to immersion under a head of water of at least 200m for a period of not less than one hour in the attitude which will lead to maximum damage. For demonstration purposes, an external pressure of water of 2MPa will be considered to meet these conditions. The test will be conducted with the packaging without the overpack by using the pressure vessel.

Post-Examination for Tests

After conducting two drop tests(Test 6 followed by Test 7), fire test and water immersion test will be carried out sequentially, a leak test of the lid seal will be carried out, the releasing torques of the lid bolts will be determined when disassembling the lid, the outer and inner packaging body will be inspected visually and in case of visible damages by dye penetration tests as a suitable NDE method. The leak test for the lid seal is a pressure rise test, where the testing volume is mainly formed by the gap between lid and packaging body limited by the O-rings.

Conclusion

The safety test planning to demonstrate the compliance with the regulatory requirements for the Type B packaging of radioactive waste and to verify the analysis was established, and the safety tests on a prototype model will be carried out this year.

Reference

[1] IAEA, Regulation for the Safe Transport of Radioactive Material, Safety Standard Series No.TS-R-1(2005 Ed.)
[2] IAEA, Advisory Material for the IAEA Regulation for the Safe Transport of Radioactive Material, Safety Standard Series No.TS-G-1.1
[3] Korea MOST, Regulation for the Transport and Packaging of Radioactive Material, Notice No. 2001-23