# Performance Test on Polymer Waste Form

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## 1. Introduction

Boric acid wastewater and spent ion exchange resins are generated as a low- and medium- level radioactive wastes from pressurized light water reactors (PWRs). In Korea, boric acid wastewater is concentrated and dried in the form of granules (boric acid bead), and finally solidified by using paraffin wax. Spent ion exchange resins are dewatered and stored in high integrity container (HIC). Recently, however, waste solidified using paraffin wax has been deemed suspect in meeting the acceptance criteria for permanent disposal. Also the use of HIC is limited due to its high cost.

In this study, polymer solidification was attempted to produce the stable waste form for the boric acid concentrates and the dewatered spent ion exchange resins. The polymer mixture which consists of epoxy resin, amine compounds and antimony trioxide was used to solidify the boric acid concentrates and the dewatered spent ion exchange resins. To evaluate the stability of polymer waste forms, a series of standardized performance tests was conducted. Also, by the requirement of the regulatory institute in Korea, an additional test was performed to estimate fire resistance and gas generation of the waste forms.

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## 2. Body

### 2.1 POLYMER

A polymer mixture consisted of two compounds, epoxy resin and polyamine hardener, was used to solidify the boric acid concentrates and the spent ion exchange resins. To improve the fire resistance, a small amount of antimony trioxide was added in the polymer mixture. The viscosity of epoxy resin is 12~22 poise and that of the hardener is 0.05~0.37 poise at temperature of 25 °C. The viscosity varies with the season. In winter, the viscosity of epoxy resin was 70~100 poise and that of hardener was 0.2~0.6 poise. Meanwhile, the viscosity of epoxy resin in summer was 2.1~7.1 poise and that of the hardener was 0.05~0.3 poise. The specific gravity of the epoxy resin was about 1.44 and that of the hardener was about 0.97 at temperature of 25 °C. The specific gravity of the epoxy resin also varies with the season. However, the difference of specific gravity with the season was not higher than that of viscosity. In winter, specific gravity of the epoxy resin was about 1.44 and that of the harden was 0.99 poise. In summer, specific gravity of the epoxy resin was about 1.43 and that of the hardener was 0.96 respectively. It is recommended that the polymer mixture should be cured under the ambient condition of 15~30 °C. The Curing may be retarded at ambient temperature of less than 10 °C.

### 2.2 Compressive Strength

Compressive strength test was performed in accordance with ASTM C39 standard. The test results are shown in Table II for lab scale waste forms as cured, a mean compressive strength of the waste form containing surrogate of boric acid concentrates was 53.14 MPa (7,707 psi) and that of waste forms containing surrogate of dewatered spent ion exchange resins, 30.73 MPa (4,457 psi). For full scale waste forms as cured, a mean compressive strength of the specimens containing surrogate of boric acid concentrates was 39.70 MPa (5,758 psi) and that of the specimens containing surrogate of dewatered spent ion exchange resins, 26.97 MPa (3,912 psi). From the results of compressive strength test on waste forms, all the waste forms prepared for the tests were exhibited excellent structural integrity.

### 2.3 Thermal Stability

A thermal stability test was performed on the lab scale waste forms in accordance with ASTM B553 standard. By visual observation after testing, there was no significant change on the appearance of waste form. After thermal stability testing, compressive strengths of waste forms were measured and the results are shown in Table II. All the waste forms were turned out to have been retained their compressive strength after the testing.

**Table 1. Performance tests and method on polymer waste forms.**

| Test | Method |
|---|---|
| Compressive strength | -ASTM C39 [1], ASTM D5731 [2] |
| Thermal stability | - ASTM B553 [3] |
| Irradiation stability | - Exposure to total accumulated dose of $10^9$rad |
| Biodegradation stability | - ASTM G21[4] and ASTM G22[5] |
| Water immersion | - 90 day immersion in water<br>- ASTM C39 |
| Leaching | - ANS 16.1 [6] |
| Free water | - ANSI 55.1 [7] |
| Burning resistance | - KS M 3015(A) [8] |

### 2.4 Irradiation Stability

Irradiation stability test was performed on the lab scale waste forms under the exposure of total accumulated dose of $10^9$rad.

Usually, irradiation stability testing on the waste forms is performed under the exposure of an accumulated dose of $10^8$rad. However, in this study, under more severe condition, the effect of irradiation on the polymer waste form was observed.

By visual observation after the test, there was no significant change on the appearance of waste form. No cracks or fractures were observed on the surface of waste forms. The compressive strength of irradiated waste forms were measured and the test results are shown in Table II. After irradiation, compressive strengths of the waste forms have exhibited a decrease of about 50% of the original strength in the case of waste form containing surrogate of boric acid concentrations, to about 75% in the case of waste form containing surrogate of spent ion exchange resins. However, because the compressive strength values of all the waste forms were more than 20.69 MPa (3,000 psi) after irradiation, it could be estimated that the waste forms still have enough structural integrity.

### 2.5 Biodegradation Stability

Biodegradation stability was performed on the waste forms in accordance with ASTM G21 standard(for determining the resistance of synthetic materials to fungi) and ASTM G22 standard(for determining the resistance of synthetic materials to bacteria). From the results of tests, no indication of culture growth was found on the polymer waste forms.

After a biodegradation stability test, compressive strengths of waste forms were measured in accordance with the ASTM D5731 because the waste form for the biodegradation stability test had a disc shape. The test results are shown in Table III. Polymer waste forms had still exhibited high compressive strength after the biodegradation stability test.

## 3. Conclusion

A series of performance tests was conducted including compressive strength test, thermal stability test, irradiation stability test and biodegradation stability test, water immersion test, leach test, and free standing water for the polymer waste forms. In addition, a fire resistance test and an analysis of gas generation were performed on the waste forms by the requirement of the regulatory institute in Korea.

From the results of the performance tests, it is believed that the polymer waste form is very stable and can satisfy the acceptance criteria for permanent disposal.

## 4. Reference

[1] ASTM, “Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens,”. American Society for Testing.