Evaluation on degradation of cable in nuclear power plant by boric acid

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1. Introduction

Cable is one of the major nuclear power plant components and there are various environmental stressors that can influence the aging rate of cable, such as elevated temperatures, high radiation fields, and humid conditions. Exposures to these conditions for long periods of times can cause a degradation of cable [1].

Borated water is used in the primary systems of PWR plants to control the reactivity during normal plant operation and refueling, and under potential accident conditions [2]. If borated water leaks from primary and secondary systems, significant corrosion problems can develop. However, little research has been carried out on the effects of cable degradation by borated water. In this experiment, TGA, indenting test, and FT-IR were performed to evaluate the degradation of cable by borated water.

2. Methods and Results

In this experiment, we used the same kinds of cables, such as those used in a nuclear power plant, to evaluate the effects of borated water. The EPR (ethylene propylene rubber) and CSP (chlorosulfonated polyethylene) sprayed with borated water were used as the specimen. The solutions for this experiment are listed in Table 1, such as those used in power plants.

Table 1. The composition of solutions of borated water

Temp.(°C)	B (ppm)	ppm			Periods
		F	Cl	S	
R.T.	170000	140	30	180	30 days

2.1 Cable degradation experimental methods (TGA)

The activation energy after a degradation of cables in nuclear power plant insulation and sheath materials by borated water was calculated with TGA (thermogravimetric analysis) according to the procedures in ASTM E1641 [3]. The activation energy was measured by varying the heating rate up to 800°C. The degradation was assessed by comparing the specimen which has not been sprayed with boric acid, with the specimens of the cables sprayed with boric acid by comparing the activation energy.

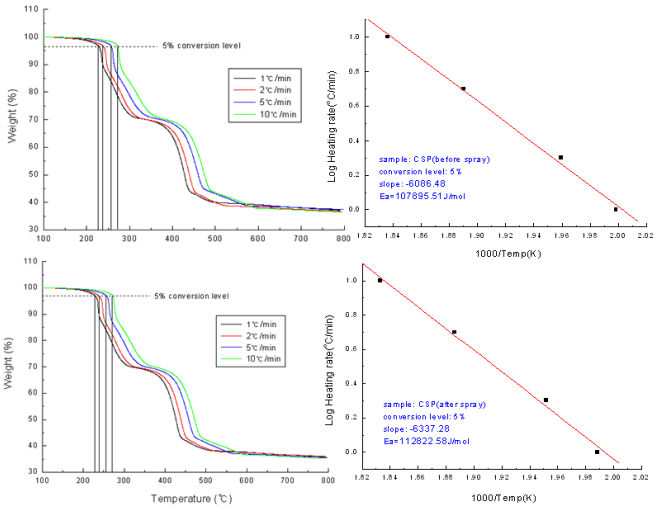

Fig. 1. TGA results of CSP (upper : before spray, lower : after spray).

The TGA results of CSP are shown in figure 1. The 5% conversion level of the specimen before spray with boric acid was 227.4, 237.4, 256.05, and 271.58°C, respectively, according to the heating rates. The 5% conversion level of the specimen after spraying with boric acid was 229.88, 239.4, 257.22, and 272.58°C, respectively, according to the heating rates, and the results before and after spraying with boric acid were similar. The activation energy before and after spraying with boric acid was 108 kcal and 113 kcal, respectively, and the effects of degradation by borated water were found to be insignificant.

2.2 Indenting test

An mechanical property evaluation was used to compare the hardness using the indenting robot, from which the KHNP Central Institute developed [4]. The indenter test results for a degradation evaluation are shown in figure 2. The specimen, 0216LCP8, with the largest changes in modulus value before and after spraying with boric acid, showed a 20% rate of increase. There have been 2 ~ 3 fold differences when a serious degradation occurs. The mechanical property evaluation showed no serious degradation of cable by spraying with boric acid.

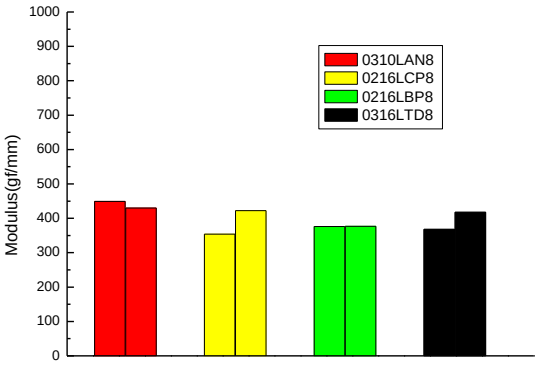

Fig. 2. Results of indenter test of NPP cables (the left of each group with same colors is before spraying and the right of each group with same colors is after spraying, respectively).

2.3 Degradation test for cable (Fourier Transform Infrared, FT-IR analysis)

An FT-IR analysis was performed to examine an EPR and CSP. An FT-IR is a useful method for a quantitative and qualitative analysis for organic substances, and was performed to evaluate the degradation degree of insulation and sheath before and after spraying with boric acid [5]. Figure 3 shows that there are no significant changes between cables experiencing high concentrations of spray with boric acid and severe stress conditions, and those experienced without spraying with boric acid. Therefore, no degradation is considered to occur in an ERP and CSP.

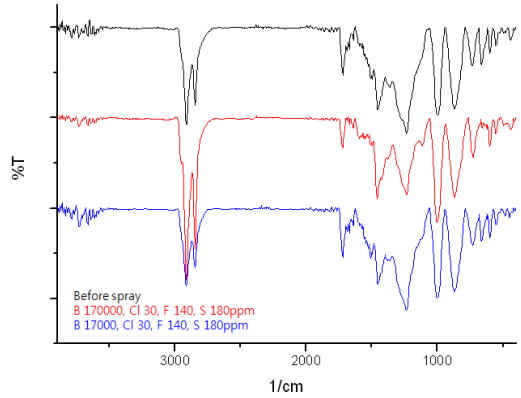

Fig. 3. FT-IR analysis of CSP.

3. Conclusions

An evaluation of cable degradation by borated water was carried out. A TGA analysis, the measurement of cable microhardness and an FT-IR analysis before and after spraying with boric acid (B:170,000ppm). It is considered that there is no significant degradation of cables due to spraying with boric acid. More studies on long-term experiments for severe conditions are now progressing.

REFERENCES

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