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Indenter aging test on the field cables of Kori Unit 4 NPP

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1. Introduction

Most of cables currently used in nuclear power plant were licensed to use during 40 years of plant design life. Since these cables were tested for the qualification of 40 years only, we have to replace the cables with new cables to extend the plant life beyond 40 years. It is inconceivable to replace all of them since the cables spread over all of the plant area. Another way to extend the cable life is proving that the design life is too conservative compared with actual aging. If we know aging condition at the end of cable life, plant cables can be used until the aging condition of the cables reach the failure point. Periodic measurement of cable aging condition is required to apply this methodology. We call it 'condition monitoring'[1]. Condition monitoring is getting prevalent since it uses a non-destructive methodology for evaluating an aging condition of cable.

KEPRI developed portable cable indenter which can be used for condition monitoring of cable aging. Condition monitoring results for same cable materials installed in different plant environments are described herein.

2. Methods and Results

2.1 Principle of Cable Condition Monitoring

Cables exposed to a harsh environment in a nuclear power plant tend to show signs of aging degradation. One of these symptoms is the hardening of the cable jacket and insulation. In 1991, EPRI developed the first cable indenter which can measure the hardness of the cable jacket[2]. In 2001, KEPRI developed computer equipped cable indenter which uses same methodology of EPRI[3]. This device is very convenient for condition monitoring of nuclear cables since it use a non-destructive method for diagnosing the extent of cable aging. Modulus value, the aging level of cable jacket, is calculated by dividing the indenting force with the indent depth. Figure 1 shows a picture of a portable cable indenter developed by KEPRI[4]. Figure 2 shows "Force-depth" curve of the portable cable indenter.

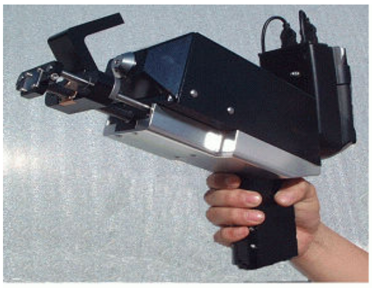

Figure 1. Portable Cable Indenter

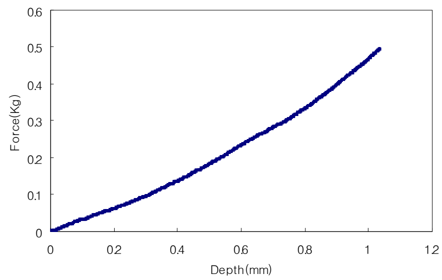

Figure 2. Force-Depth Curve of Cable Indenter

2.2 Indenter Test for Nuclear Plant Cables

2.2.1 Cable information

The cables for indenter test were CRDM(Control Rod Drive Mechanism) cables which have been installed for 20 years in the Kori Unit 4. These cables were supplied from the USA cable manufacturer named Okonite. This cable consist of 0.45 inch Okonite insulation, 0.3 inch Okolon jacket and 6 core conductors which allows 600V power supply. We chose 3 cables which were installed in different environmental conditions of Kori Unit 4. The first cable was installed in the mild environment condition which was not influenced by a high temperature and radiation. The second cable was installed in the vertical cable tray of containment building which had a high temperature and radiation during normal operation. The third cable was installed in the same area as the second cable but was installed in the horizontal type cable tray located in the 18 feet higher level of the second cable.

2.2.2 Indenter test result of the cables

Table 1 shows data of indenter test results for the Kori-4 CRDM cables[5]. Figure 3 shows comparison graph for the indenter test result of 3 cables. As shown on the graph of figure 3, the modulus value of cable installed in the mild condition is relatively low compared with the cables installed in the containment building. This result was almost same as we expected since we found that Okolon cable jacket was a series of Hypalon cable material which had hardening character when it was aged.

It was proved that the indenter modulus value of Okolon cable jacket went higher when it was aged in a higher temperature and radiation area. It was new to me to see that the horizontal cable had a higher modulus value compared with the vertical cable even they are installed in similar environments.

Table 1. Indenter test result for Kori-4 CRDM Cable

Cable Location	Material	Meas. Point	Modulus Value	Oper. Temp.	Rad. (RAD)	Modulus Average
Auxiliary building Control Cabinet	OKOLON	1-1	68.740	20℃	N/A	64.54
		1-2	66.941	20℃	N/A	
		1-3	64.308	20℃	N/A	
		1-4	61.780	20℃	N/A	
		1-5	62.389	20℃	N/A	
Containment building 148ft Vertical Cable Tray	OKOLON	2-1	73.183	26℃	1.5	72.98
		2-2	73.435	26℃	1.5	
		2-3	78.509	26℃	1.5	
		2-4	70.839	26℃	1.5	
		2-5	72.395	26℃	1.5	
		2-6	72.930	26℃	1.5	
Containment building 166ft Horizontal Cable Tray	OKOLON	3-1	95.373	26℃	1.5	81.39
		3-2	79.965	26℃	1.5	
		3-3	89.202	26℃	1.5	
		3-4	81.505	26℃	1.5	
		3-5	80.508	26℃	1.5	
		3-6	90.294	26℃	1.5	
		3-7	76.126	26℃	1.5	
		3-8	81.074	26℃	1.5	
		3-9	77.565	26℃	1.5	
		3-10	74.620	26℃	1.5	

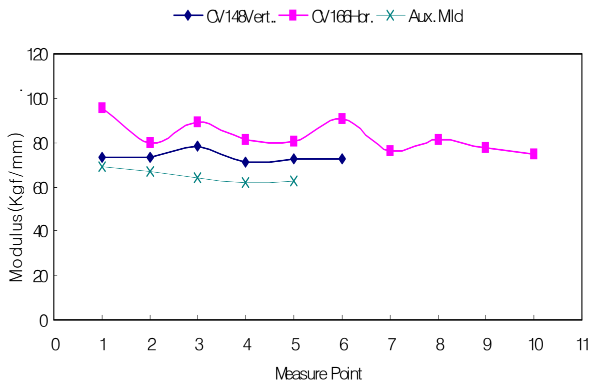

Figure 3. Comparison graph for test result of 3 cables

3. Conclusion

Field indenter test on the Kori-4 CRDM control cables was implemented. Cable jacket installed in the harsh area showed more hardening character compared with cable jacket installed in relatively mild area. It was found that the cables installed in the horizontal cable tray getting more aged compared with cables installed in the vertical cable tray. As result of this test, it was proved that the hardening level of cable jacket changes depend on the environmental condition of cable.

If we can get an indenter modulus value of cable failure point through laboratory test, plant cable is expected to be used until the indenter modulus value reach the failure point of cable if only the periodic field indenter test can be implemented.

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