VLF TAN-DELTA MEASUREMENT ON SUBMARINE CABLES IN KEPCO

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ABSTRACT

Since 2007, KEPCO has taken the VLF(Very Low Frequency) tanδ measurement to detect the aged submarine cables. Our field experience shows that the values of VLF tanδ are influenced by the leaking current on terminations of submarine cables. By replacing terminations of submarine cables assessed as degraded, the result of re-diagnosis is turned to "Good" from "Seriously aged". External factors such as terminations need to be considered on the VLF tanδ measurement; the trend or historic analysis of VLF tanδ measurement is also recommended to assess degradation of submarine cables because the cost of construction of submarine cables can be considerably reduced.

KEYWORDS

VLF tanδ, Submarine cable, Diagnostic, Termination

INTRODUCTION

The submarine cables of medium voltage have been installed to supply electricity to islands since 1979. The voltage rating of submarine cables is the same as in the common distribution system in Korea: 22.9 kV in phase-to-phase voltage and 13.2 kV in phase-to-ground. The insulation is XLPE. The submarine cables have had 4 failures. However, no diagnostic system and equipment for measuring degradation of submarine cables has been used. Since 2007, KEPCO has done the research on the VLF tanδ measurement to detect the aged submarine cables. In this paper, we present the results from diagnostic experiences in the field and instructions when VLF tanδ measurement is carried out.

INSTALLATION OF SUBMARINE CABLE

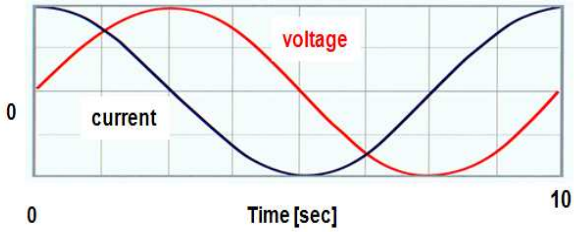
The installations of the medium voltage submarine cables have been increasing to supply electricity to islands as shown in Table 1. There have been 4 failures on submarine cables, in which 3 of them were failures from external damage and the other was from insulation breakdown. It occasioned huge expenses for the restoration work and temporary power supplies. There were 10 sites that have been used more than 30 years. For the reason, there is a strong possibility of degradation failure. Therefore, we need to assess the aging condition of the submarine cables exactly to plan to new construction or replacement of them. Accordingly, we began to diagnose it using VLF tanδ system from 2008.

Table 1: Installation of submarine cables by year

Year	~'80	~'90	~'00	~'05	'05~	Total
Number of sites	10	5	2	4	7	28
Length[km]	25.3	33.2	7.8	26.3	24.9	1175

VLF TAN-DELTA MEASUREMENT

VLF tanδ measurement is a method that measure voltage and current at cables by utilizing AC signals in 0.1 Hz and then calculates the dissipation factor (tanδ). As voltage increases, magnitude and rate of tanδ can change. Tanδ is the most important factor to assess the ageing condition of cable insulation. (Fig. 1)



$$Dissipation\ Factor = \tan\delta = \frac{true\ power}{reactive\ power} = \frac{U^2/R}{U^2\omega C} = \frac{1}{\omega CR}$$

Fig. 1: Principle of VLF tanδ measurement

The IEEE Std. 400 had been used as a degradation assessment criterion until 2009 in KEPCO. However, we found that IEEE criterion was not suitable for the distribution system in Korea and suggested the new degradation assessment criterion through study and experiences in the field. The new criterion has applied in underground distribution cables and submarine cables since 2010.

Criterion of IEEE

The degradation assessment criterion of IEEE Std. 400 established in 2001 is as shown in Table 2. In this Criterion, degradation is decided by tanδ measurement while testing voltage is raised up to 2 times of Uo. The criterion will be revised in several years.

Table 2: Criterion of IEEE 400-2004

tanδ at 2Uo*	Differential of tanδ tanδ2Uo- tanδ Uo	Assessment
Less than 1.2×10^{-3}	Less than 0.6×10^{-3}	Good
Greater than or $=1.2\times10^{-3}$	Greater than or $=0.6\times10^{-3}$	Aged
Greater than or $=2.2\times10^{-3}$	Greater than or $=1.0\times10^{-3}$	Highly degraded

* Uo : phase-to-ground
※NOTE: It has been found that copolymer dielectric materials such as TR-XLPE or silicon fluid treated insulations exhibit different tanδ characteristics; therefore, other criteria are valid.