TREE-RETARDANT CROSSLINKED (TRXLPE) REDUCED INSULATION WALL ACCELERATED CABLE LIFE TEST (ACLT) RESULTS

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ABSTRACT

The IEEE P1407 Draft Guide for Accelerated Aging Tests for Medium-Voltage (5 kV – 35 kV) Extruded Electric Power Cables Using Water-Filled Tanks recommends that maximum conductor shield test stresses be limited to 12 kV/mm (300V/mil). This presentation will show historical and current Accelerated Cable Life Test (ACLT) results of reduced insulation wall test specimens that were wet-aged in the 8kV/mm (200 V/mil) – 25kV/mm (500 V/mil) test stress range. Test results will show that for several commercially-available conductor shields and TRXLPE insulation systems that were wet-aged in this test stress range, characteristic life and testing times are ≥ 2X that for full-size (4.45mm, 175mil) 15kV-rated insulation wall cables at the recommended maximum conductor shield test stress of 12kV/mm(300V/mil). This result is demonstrated in two (2) different ACLT protocols, and for two (2) different reduced insulation design thicknesses. ACLT results at higher aging test stresses (>16kV/mm (400V/mil) show significant reductions in characteristic life and testing times. Thermal preconditioning of the reduced wall test specimens to remove all crosslinking by-products (acetophenone, dimethylbenzylalcohol, alpha-methylstyrene) also contributes to a reduction in characteristic life and testing times. This also provides an estimation of the "true" dielectric life of the insulation system. Implications of these results on insulation wall cable design are discussed.

KEYWORDS

TRXLPE, ACLT, Water-Filled tanks, Reduced Insulation Wall, Characteristic Life, Medium Voltage Power Cable, IEEE Std 1407-2007

INTRODUCTION

Accelerated Cable Life Testing (ACLT) in water-filled tanks using full-size test cables, has been used in North America since the late 1970's/early 1980's to evaluate insulation materials for medium voltage (MV) underground distribution power cables [1]. In the late 1980's, the ACLT also began to be successfully used to evaluate performance differences of semi conductive conductor shield materials. "Full-size" cables used in ACLT evaluations (as opposed to insulated wires) are defined as cables having an aluminum or copper stranded conductor, covered with successive layers of a semiconductive shield material, insulation thicknesses in compliance with the 100% insulation level prescribed in Association of Edison Illuminating Companies (AEIC) cable specifications (CS), No. 5 through No. 8. , a semiconductive insulation shield material and a concentric copper wire metallic shield [2]. For 15kV-rated MV cables, the 100% insulation level over the conductor size range is defined such that the maximum stress at the conductor shield/insulation interface is limited to 2kV/mm (51V/mil). Typically, in ACLT evaluations, the test cable's insulation level is prescribed at 4.45mm (0.175"), and the cables tested at stresses in the 6 – 8kV/mm (150 – 200V/mil) range. Since the early 1990's, interest in reduced insulation wall MV cables has grown, and AEIC has published a document, which provides guidelines for insulation thicknesses that are less than 100% insulation levels [3]. Research efforts at cable manufacturers and testing laboratories have focused on wet-aged testing of cables with reduced insulation wall thicknesses [4,5]. However, other researchers and IEEE Std 1407™-2007 caution against testing cables at maximum conductor shield stress > 12kV/mm (300V/mil), under dry or wet aging conditions [6,7]. This paper will present ACLT results for reduced insulation wall tree retardant crosslinked polyethylene (TRXLPE) insulations, with two (2) different types of conductor shield materials, using two (2) different ACLT protocols. One (1) conductor shield type commonly known as "conventional" (CCS) and another known as "supersmooth" (SSCS) are evaluated with the TRXLPE materials. The test protocols recommended by IEEE STD 1407™-2007 are followed, with the exception that some test stresses do exceed the maximum recommended 12kV/mm wet-aging test stress.

ACLT Details

The details of the ACLT protocols are shown below in Table 1.

Table 1

ACLT Protocol Details

IEEE 1407 Std Test Element			
Tank Type	#1	#2	#3
Tank Materials of Construction	Stainless Steel	High Density Polyethylene	Stainless Steel
Tank Thermal Insulation	Redwood	Fiberglass	Redwood
Water Quality	Deionized	Deionized	Deionized
Conductor Metal	Aluminum	Aluminum	Aluminum
Conductor Size, (mm^2)	28, 53	53	53
Insulation Wall, (mm)	1.6, 3.18, 4.45	1.6, 4.45	1.6, 4.45
Test Voltage, (Multiple of U_0^*)	4, 3	3, 2, 1	4, 3, 1
Preconditioning	"B", "J"	"B", "J"	"B", "J"
Conductor Temperature Control/Location	90 ± 2°C in air	75 ± 2°C Mid-Sample in Water	75 ± 2°C Mid-Sample in Water
Conductor Temperature Load-Cycle	8 hrs. On/16 hrs. Off	8 hrs. On/16 hrs. Off	8 hrs. On/16 hrs. Off
Tank Room Temperature,(°C)	35 ± 2°C	25 ± 3°C	25 ± 3°C
Tank Water Temperature Control	No	Yes	Yes

*U_0 – rated voltage to ground

Tank Types #1, #2 and #3 of IEEE 1407 were used in this testing, with Type #1 and Type #3 accommodating a maximum of twelve (12) specimens, and Type #2 a