Efficiency Estimation of Toxicity Free Fire Resistance Cable

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In this paper, efficiency estimation of toxicity free fire resistance cable experiments was measured smoke density of toxicity free fire resistance polyolefin insulation material and electric field dependence of tree shape in low density polyethylene (LDPE). One of the most serious causes of failure in high-voltage cables, can be an electrical discharge across an internal gab or void in the insulating material. Treeing due to partial discharge is one of the main causes of breakdown in the insulating materials and reduction of the insulation life. Therefore the necessity for establishing a method to diagnose the aging of insulation materials and to predict the breakdown of insulation and research of the fire resistance character has become important. First, we have studied on electric field dependence of tree shape in LDPE about treeing phenomena occurring on the high electrical field. Second, the measurement method is the attenuation quantity of irradiation by smoke accumulating with in a closed chamber due to non-flaming heat decomposition and flaming combustion. A main cause of fire-growth and generating toxic gas when, it burns, should be dealt with great care in life safety design. The fire gases were occurred carbon monoxide and decomposition than in polyolefin due to incomplete combustion of PVC, which has high content of carbon in chemical compound.

Keywords : Toxicity free fire resistance, LDPE, Deterioration, Partial discharge, Polarization index

1. INTRODUCTION

Super high voltage, improvement of confidence of relative machinery and tools are accelerated. In spite of the fact that low-density polyethylene (LDPE) insulated cable has established an excellent service record, it had been once reported that some of LDPE cables failed in service over several years. Increasing demand for stable power and improving on confidence of relative machinery, and a study on the efficiency estimation of halogen free fire resistance cable was accelerated.

Halogen free fire resistance cable uses of automatic fire detection equipment, emergency equipment, sprinkler system, power system and such like. And so the development of insulation material that was equipped excellent insulation endurance and toxicity free fire resistance cable experiments was measured. A large amount of work has been done on the degradation of insulation materials caused by partial discharge occurring at various defects in the polymer insulator itself and interfaces between electrodes and the insulation materials. Treeing due to the high electrical field is one of the main causes of breakdown of the insulation materials.

First, we have studied on electric field dependence of tree shape in LDPE about treeing phenomena occurring on the high electrical field. Internal voids in insulators give rise to partial discharges, which cause local breakdown and even entire insulation breakdown.

Second, the measurement method is the attenuation quantity of irradiation by smoke accumulating with in a closed chamber due to non-flaming heat decomposition and flaming combustion. In particular, here in use of smoke density method, reference documents were ASTM E662 standard test method for specific density generated by solid materials [5].

2. SPECIMEN AND EXPERIMENT

Specimen used in this study was low density polyethylene supplied Han Yang Chemicals Company. First, samples were compressed at 120[℃] for 15min before inserting the needle and were then allowed to cool to enhance transparency of samples at water of 10[℃]. An electrode composition of specimen is shown in Figure 1. A stainless steel needle was molded in pellet. The distance of the tip of needle from bottom surface of the specimen was 2[㎜] and silver paste was used for the bottom electrode. The size of the LDPE specimen is 40 × 3.5× 30[㎣]. The needle tip was grounded to an angle of 30° , and a radius of curvature is 5[㎛][7].

The applied voltages were 8[kV], 10[kV], and 12[kV] for the needle plane electrode system. Schematic diagram of measurement system is shown in Figure 2. The system is composed of the treeing observation system [1,2]. The computer system consists of mainly IBM computer system, several data storage system and a data display system [3,4]. The growth and shape of tree observed on a display through an optical a microscope (× 30) and recorded using a CCD camera. The breakdown life of samples values resulting from stochastic distribution of sites can be often characterized by two-parameter Weibull function [6].

Accordingly, the expressions of the cumulative distribution and the probability density function are

$$F(t)=1-\exp[-(t/t_s)^n] \qquad (1)$$

where t_s and n are samples are measuring parameter and a measuring shape parameter (Accumulation breakdown probability is 63.2[%]). In order to find the shape parameter we must obtained by (1) formula

$$\ln\ln[1/(1-F(t)) = n\ln[(t/t_s)] \qquad (2)$$

Since prediction lifetime of time in measuring parameter, a measuring shape parameter are given by

$$M = t_s(\ln 2)^{1/n} \qquad (3)$$

where M is prediction lifetime of samples[8].

Second, the measurement method is the attenuation quantity of irradiation by smoke accumulating within a closed chamber due to non-flaming heat decomposition and flaming combustion. The test chamber shall be fabricated from laminated panels to provide inside dimensions 914 by 610 by 914[mm] for width, depth, and height, respectively. The furnace control system shall maintain the required irradiance level, under steady-state conditions with the chamber door closed, of 2.5[W/㎠] for 20[min]. For the flaming condition, a six-tube burner is used to apply a row of equidistant flame lets across the lower edge of the exposed specimen area and into the specimen holder through. The test specimens are exposed to the flaming and non-flaming conditions within a closed chamber. The smoke density is obtained at any given time as follows formula (4)

$$Ds = G[\log_{10}(100/T) \times F] \qquad (4)$$

where G = V/AL
V = Volume of the closed chamber, [m^3]
A = exposed area of the specimen, [m^2]
L = length of the light path through the Smoke, m
T = percent light transmittance as read from the light-sensing instrument
F = depends on the following

If the movable filter is in the light path at the time that T is measured, F=0 and T are the actual percent transmittance.

If the filter has been moved out of the light path at the time that T is measured, F is the known optical density of the filter, and T is an apparent percent transmittance [5].

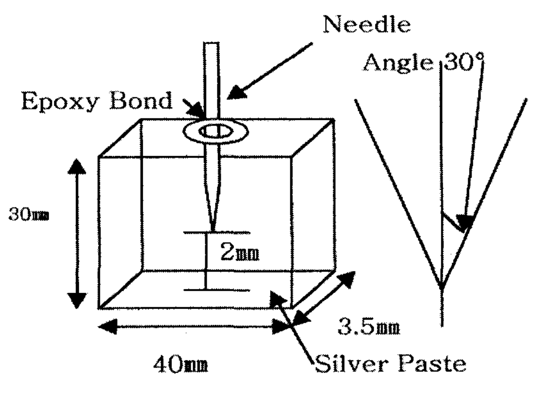

Fig. 1. An electrode specimen.

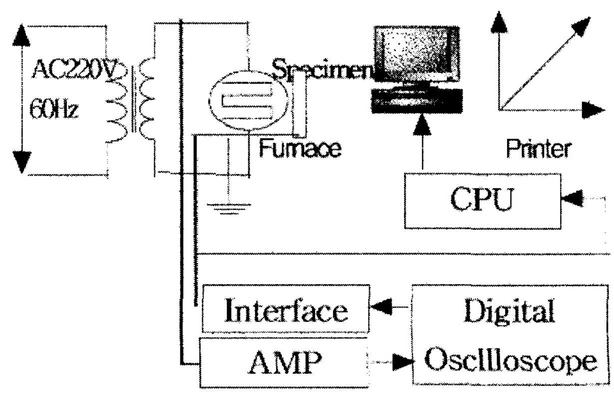

Fig. 2. An experimental device block diagram.

3. RESULTS AND DISCUSSION

3.1 Quantitative analysis of breakdown lifetime

The progress of the tree growth was observed and the images were obtained using equalizer filtering. During the initial stages the tree growth is rapid.

As breakdown condition approach, one important observation with branch-like formations was made in this study.

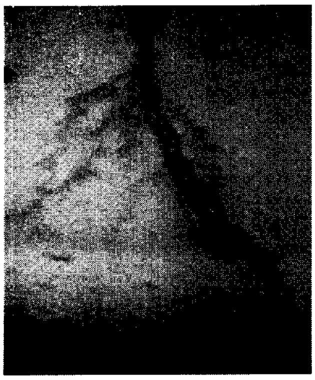

Fig. 3. Tree in applied voltage 8[kV].

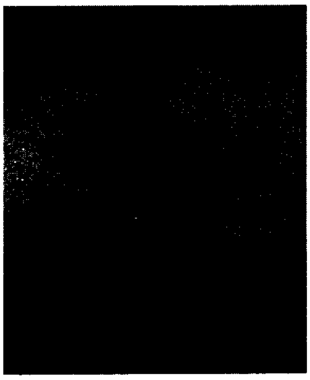

Fig. 4. Tree in applied voltage 10[kV].

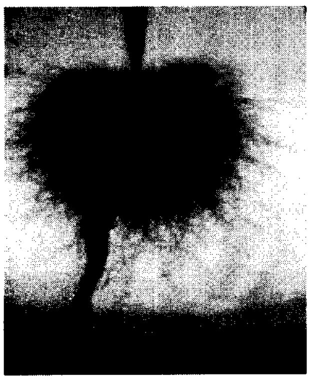

Fig. 5. Tree in applied voltage 12[kV].

The length of tree is taken as the perpendicular distance from the tip of the electrode to the tip of the longest discharge path. The applied voltage shown in Figure 1 is 8[kV]. The progress of the tree grew rapidly, and the breakdown of tree was short. Figure 1, 2 and 3 demonstrates shape of tree in applied voltage, respectively. Figure 1 and 2 demonstrate a branch type after 30[min]. While the applied voltages are 8[kV] and 10[kV], the length of tree was 1.3[㎜] and 1.1[㎜]. One of the most serious causes of breakdown can be an electrical discharge across an internal gab in the insulating material. The partial discharges will repeat every cycle, causing gradual erosion and chemical deterioration. The tree emanated from the needle edge point and increased with time. Figure 3 demonstrates a similar-bush type with little branch after 85min, in applied 12[kV], length of tree was 1.2[㎜]. voltage 8[kV] was similar to are in applied voltage 10[kV], with the passage of time, it was shown in a few thicken channel like the applied voltage of 10[kV] from 20 to 30 min. After 40, 51, and 120[min] from the applied voltage of 8, 10 and 12[kV], the tree leads to breakdown, respectively. Comparative breakdown life of samples specimen are summarized in Table. 1

Figure 6, 7 and 8 show the experimental results relating the accumulative breakdown probability to the breakdown lifetime in the applied voltages of 8, 10 and 12[kV], respectively. Measurement parameter (t_s) of no void sample by quantitative assessment according to Weibull probability distribution is increased at 126.6→ 138.3→ 188.5 in according with increasing applied voltage. Shape parameter (n) is increased at 2.03→ 2.36 → 5.21. Consequently, n>1 treeing breakdown is abrasive type. In Table.2, resulting values of 9 statistical parameters describing the shapes of the distributions in fig. 6, 7, and 8[7~9].

Table. 1 Breakdown life of samples.

Number	**8[kV]**	**10[kV]**	**12[kV]**	**Accumulative Breakdown probability**
Average	106.1 [min]	116.0 [min]	169.5 [min]	
1	40	51	120	9.09[%]
2	60	72	132	18.18[%]
3	74	86	145	27.27[%]
4	87	94	154	36.36[%]
5	96	104	165	45.45[%]
6	99	119	172	54.54[%]
7	125	135	184	63.63[%]
8	145	147	195	72.72[%]
9	160	172	208	81.81[%]
10	175	180	220	90.91[%]

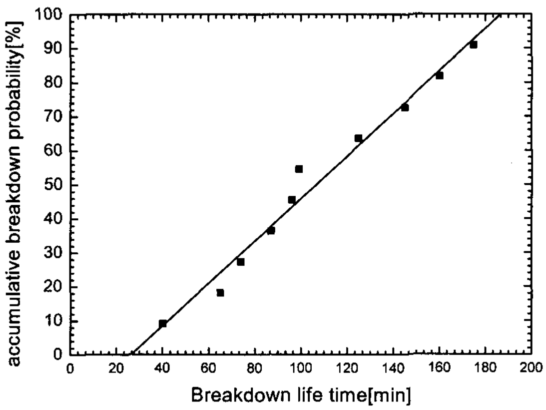

Fig. 6. Weibull analysis of the times for trees to propagate across the point-plane gab for materials at 8[kV].

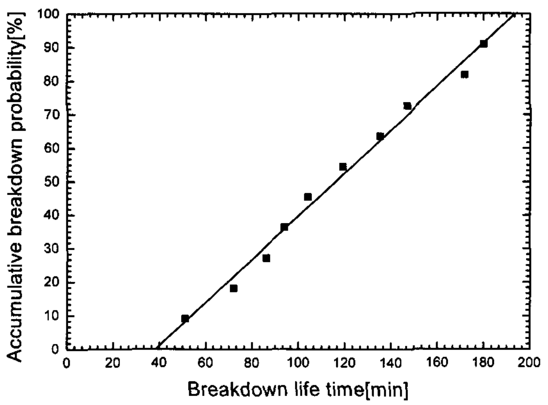

Fig. 7. Weibull analysis of the times for trees to propagate across the point-plane gab for materials at 10[kV].

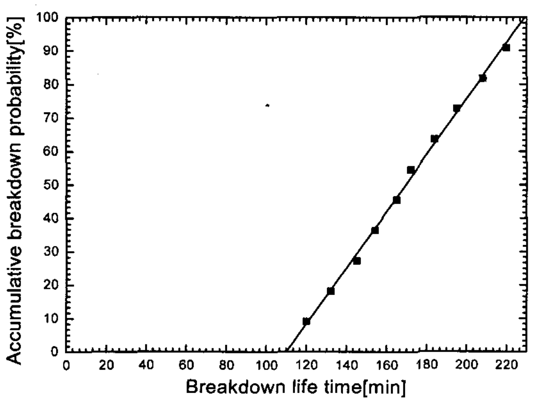

Fig. 8. Weibull analysis of the times for trees to propagate across the point-plane gab for materials at 12[kV].

Table. 2 Statistics parameter data.

Applied voltage	8[kV]	10[kV]	12[kV]
Measuring parameter	t_s=126.6	t_s=138.3	t_s=188.5
Shape parameter	n=2.03	n=2.36	n=5.21
Prediction Life time	M=105.6	M=118.4	M=175.7

3.2 Smoke density analysis

The behavior displayed by Figure 9 and 10 were explained by the appearance of a smoke density properties NFR-8. Figure 9 and 10 show the smoke density of the times for NFR-9 cables under non-flaming and flaming method.

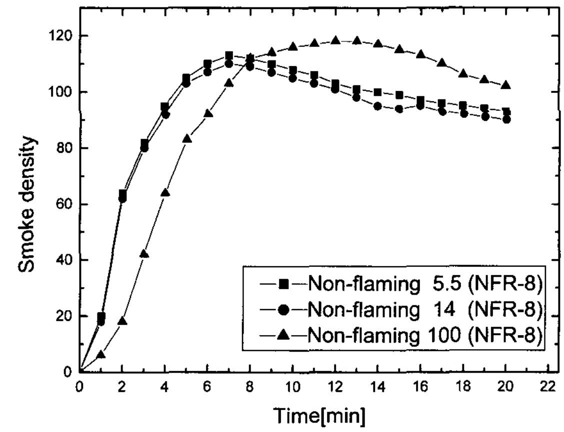

Fig. 9 Smoke density of the times for different types of fire resistance cables under non-flaming conditions.

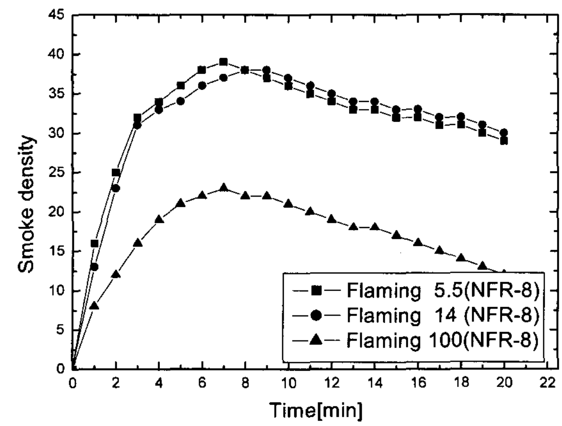

Fig. 10 Smoke density of the times for different types of fire resistance cables under flaming conditions.

The non-flaming method samples are increased above maximum density value 113, 110 and 118, whereas flaming method samples are maximum density value 38, 36 and 23. These results of reference documents were ASTM E662 method by solid materials [5].

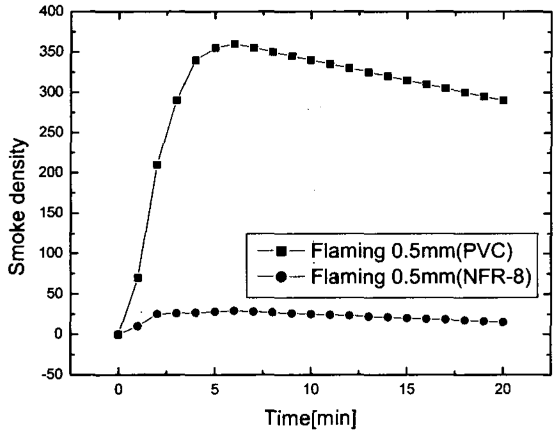

Fig. 11. Smoke density of the times for different type cable under flaming conditions.

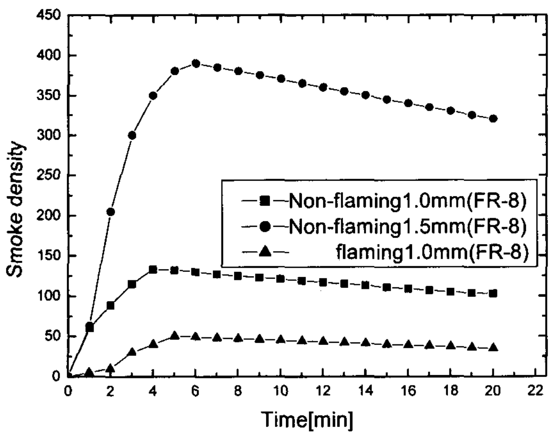

Fig. 12. Smoke density of the times for different specimen thickness under non-flaming and flaming condition.

Figure 11, 12 shows the smoke density versus time relation ships of each sample at PVC 0.5[mm], NFR-8 0.5[mm], FR-8 (1.0[mm], 1.5[mm]).

4. CONCLUSION

The characterization of the toxicity free fire resistance cable, which are classified into smoke density and insulation breakdown time, was conducted by non-flaming, flaming method and quantitative analysis of breakdown lifetime. The obtained results are summarized as follows.

1. The parameter of the probability function is connected with the insulation breakdown phenomena involved, thus they are useful for quantitative analysis of breakdown lifetime recognition.
2. There are cases where diagnosis deterioration classify-ing lifetime can be separated and independently studied as functions of deterioration and test voltage as shown in Figure 6~8.
3. The conclusion for the investigation of the proposed toxicity free fire resistance cable is far less small smoke density than PVC.

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