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Research paper

Corona Discharge Detection and Confirmation Method Using Ultraviolet Camera

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Abstract

Background/Objectives: It is very difficult to detect and identify insulation defects in high-voltage systems using ultraviolet (UV) corona cameras. This paper describes the effect of measurement distance and UV camera type and gain on photon count.
Methods/Statistical analysis: Experiments were carried out using two types of equipment (Superb and UVolle) manufactured by OFIL. As a result, we confirmed that the number of photons varies depending on the type, gain, and measurement distance of a UV camera.
Findings: It is difficult to judge corona count value and abnormality of electric equipment only with measurement of corona in the equipment. With consideration of various factors other than simple corona count value and visual inspection, it is possible to decide whether there is defect or not.
Improvements/Applications: In order to minimize errors in inspection and diagnosis in the field, we have proposed the UV corona determination criteria and implemented the applicable work process in the field.

Keywords: *Insulation fault, Ultraviolet camera, Corona discharge, Distance, gain*

1. Introduction

Corona Phenomenon is electrical discharge with low sound or light color glow when air insulation is partially destructed by applied voltage exceeding critical voltage near an electric line or an insulator. Corona causes adverse effects such as impaired transmission efficiency and inductive interference of communication line, along with negative impact on electric equipmentdue to electrical discharge. Therefore, early diagnosis of corona phenomenon and countermeasures are significantly important in securing integrity of electric equipment.

The number of corona stains and photons displayed in a UV camera was affected by measurement distance of the camera as well as gain and type. In addition, the air condition and observation angle have a slight impact on UV corona image and photon count[1, 2].

Diverse devices are used for corona measurement of electric equipment, and discharge quantity(count value) varies depending on measurement distance and gain of each device. The determination standard based on corona count, currently applied by our corporation, are as describedin the following table 1.

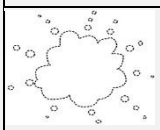
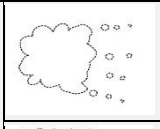
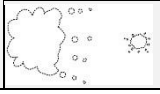
Table 1: Korea Electric Safety Corporation corona indication standard [3]

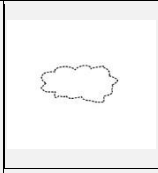
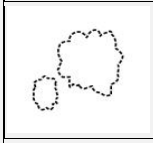
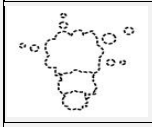
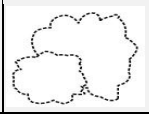
Classification	**UV corona(count/min)**		
Determination method	**Below 1,000**	**Over 1,000, below 5,000**	**Over 5,000**
	Good	**Attention**	**Inappropriate**

As shown in table 1,the current standard indicates good for below 1,000 of corona count, attention for over 1,000 and below 5,000, and inappropriate for over 5,000. However, as explained above, it is too much to apply such consistent determination standard since count value varies depending on gain, distance, temperature and humidity of each device.

In addition, according to KECS 1201-2011 in the determination standard annex of electric equipment technology standard, UV corona standard indicates attention when a measured pattern is abnormal as table 2, but the shapes of abnormal patterns suggested in the table are somewhat ambiguous considering characteristics of each device[4, 5, 6, 7, 8].

Table 2: KECS 1201-2011Table 12 [9]

Classification	Abnormal pattern (attention)	Equipment condition or characteristic
sunflower		. Size of diameter is within 10% . Generated at a point of insulating material . Early discharge phenomenon . Air or surface discharge
		. Electric field concentration . Imminent insulation destruction . Air discharge
jellyfish		. Electric field concentration . Direction of electric field(left→right) . Air discharge
		. Discharge path can be verified . Air discharge

amoeba		. Surface deterioration of insulating material . Size changes following progress stages . Amorphousness, most with oval . Surface discharge
		. Multiple generation . Assessed with the biggest size . If there is an adjoining one, assess the total of two
		. Gathered points where electric fields are focused . Air discharge
		. UV generation points are overlapped . Starting from surface and shift to air discharge

Therefore, we carried out a corona measurement test by using two types of corona measurement devices(Superb, Uvolle models by Ofil, CoroCAM model byUViRCAM). We repeatedly measured corona of an indoor transformer per gain and distance, and analyzed the secured data to come up with how to improve corona camera operation[10,11,12,13].

2. Materials and Methods

2.1 Construction of Corona Generation Experiment Equipment

The transformer used in corona measurement is a 3-phase mold transformer, and as shown in the below Figure1, measurement was carried out by contacting a pointed galvanized iron sheet to the outside of the transformer to artificially make corona generating device, and then applying power at the low voltage terminal to generate power of 13.2kV at the extra-high voltage terminal for measurement.

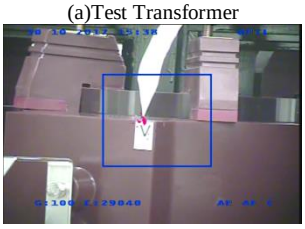
Figure 1: Transformer used for corona measurement

2.2 Corona Discharge Experiment

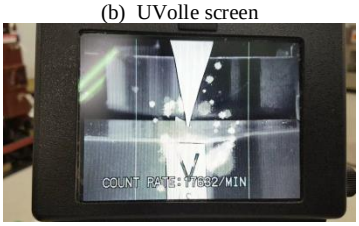
Experiment devices were Superb and Uvolle by OFIL, and corona discharge measurement values generated from the transformer were compared in testingas shown in the following Figure2. Corona discharge measurement values from the transformer were count values displayed per distance and gain. Distance was in the order of 1m, 2m, and 3m, and gain was 0 to 250 in Superb and 0 to 100 in Uvolle in tens, considering the characteristics of the two devices.

After ten times of measurement, average values were applied in implementing increase and decrease quantities per distance and gain.

(a)Test Transformer



(b) UVolle screen



(c) Superb screen

Figure 2: Experiment scene

3. Results and Discussion

3.1 Superb Device Measurement Result

The result of measuring the indoor transformer per distance by usingSuperbdevice is as shown in the following Figure3. There was not much difference from distance in between gain 60and100, but difference from distance was detected from gain 110, with consistent increase of gain depending on distance from gain 110 to 130 and somewhat significantly soared decrease rate. Increase ·decrease was measured in an inconsistent pattern from gain 140.

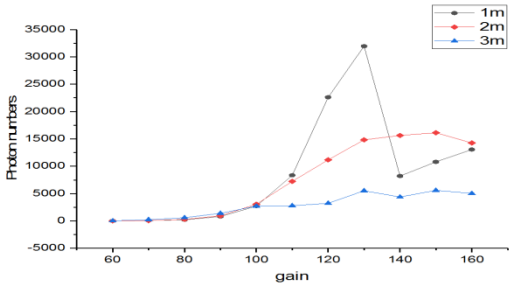


Figure 3: Superb equipment Corona measurement graph by distance (1, 2, 3m)

Table 3: Superb equipment Corona measurement graph by distance (1, 2, 3m)

gain / distance	60	70	80	90	100	110	120	130	140
1meter	**18.8**	**54**	**216.5**	**804**	**2723.1**	**8351.9**	**22613.4**	**31951.5**	**8211.5**
2 meters	**8.6**	**57.9**	**281.7**	**942.9**	**3063.4**	**7230.7**	**11171.9**	**14825.3**	**15637.7**
3meters	**19**	**202**	**639**	**1220**	**2255**	**2825**	**3189**	**5522**	**4387**

In the measurement values between gain 110 and 130 where the decrease pattern by distance is obvious, if distance is set as the x axis, there was a decreasing result as shown in the following Figure4.

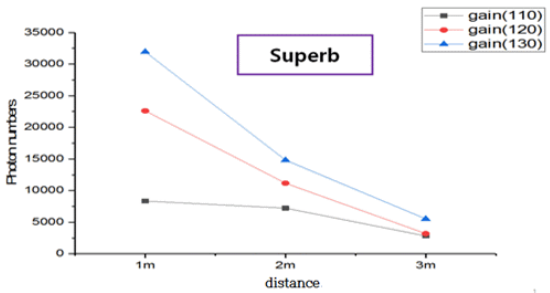


Figure 4: Reduction of photon numbers (gain 110 ~ 130)

Table 4: Reduction of photon numbers (gain 110 ~ 130)

gain / distance	110	120	130
1m - 2m	**13.42%**	**50.60%**	**53.60%**
2m - 3m	**61.50%**	**71.06%**	**62.69%**
1m - 3m	**66.67%**	**85.70%**	**82.69%**

3.2 Uvolle Device Measurement Result

The result of measuring the indoor transformer per distance by using Uvolle device is as shown in the below Figure5.Count values increased per distance from gain 20 to100 with a decreasing pattern by measurement distance. It was confirmed that the reason why the count value stopped at 32,760 when measured at 1 meter in gain 90 to 100 was that the limiting value of count that can be measured in the device was 32,760.

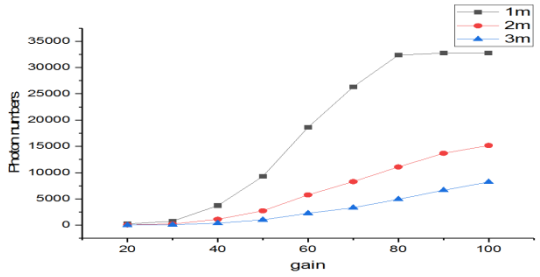


Figure 5: Uvolle equipment Corona measurement graph by distance (1, 2, 3m)

Table 5: Uvolle equipment Corona measurement graph by distance (1, 2, 3m)

gain / distance	20	30	40	50	60	70	80	90	100
1meter	**240.8**	**761.6**	**3729.6**	**9296**	**18636.8**	**26313.2**	**32373.6**	**32760**	**32760**
2meters	**61.6**	**229.6**	**1120**	**2732.8**	**5762.4**	**8288**	**11088**	**13669.6**	**15176**
3 meters	**11.2**	**95.2**	**369.6**	**1024.8**	**2268**	**3332**	**4939.2**	**6647.2**	**8220.8**

If distance is set as the x axis in gain 70 to 100 considering appropriate distance of the device (the initial gain value of the device is 100), measurement values display a decreasing pattern as shown in the below Figure6.

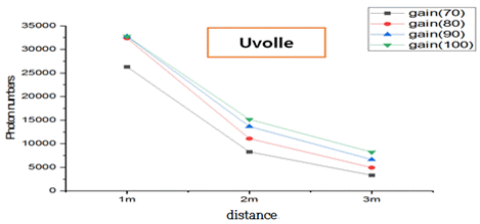


Figure 6: Uvolle measurement of photon numbers (gain 70 ~ 100)

Table 5: Uvolle equipment Corona measurement graph by distance (1, 2, 3m)

gain / distance	70	80	90	100
1m - 2m	**13.42%**	**65.75%**	**58.27%**	**53.68%**
2m - 3m	**59.80%**	**55.45%**	**51.37%**	**45.83%**
1m - 3m	**87.34%**	**84.74%**	**79.71%**	**74.91%**

4. Conclusion

As described above, various corona measurement devices are operated on the field, but values per gain and distance are different by device. Therefore, we chose two types of device (Superb and Uville by Ofil) and repeatedly measured corona of an indoor transformer to suggest UV corona camera operation method based on the data.

The summary of experimental results by the two devices is as follows. First, appropriate gains for corona measurement are different as their detailed operation methods are not same. Appropriate gain of each device is gain 110 to 130 in the case of Superb(default 120) and gain 70 to 100(default 100) as for Uvolle as deducted in the experimental result of each device on the same sample. The above gains are suggested as appropriate values since increasing and decreasing patterns were most consistent in the ranges. Second, theoretically, it is reasonable that corona count values decrease as measurement distance increases in the same gain, but in some experiments, count values did not decrease although distance is farther. It is assumed that the reason is difference in recommended corona measurement distance per device suggested by device manufacturer. (Superb 3m, Uvolle 1.5m)

Thus, it is difficult to judge abnormality of electric equipment only with corona count values displayed when measuring corona, which is evident in experimental result. Therefore, various factors should be considered along with visual inspection, instead of simple corona count, in deciding if there is defect in electric equipment. The following Figure7 describes UV corona determination standard (proposal) suggested in this study.

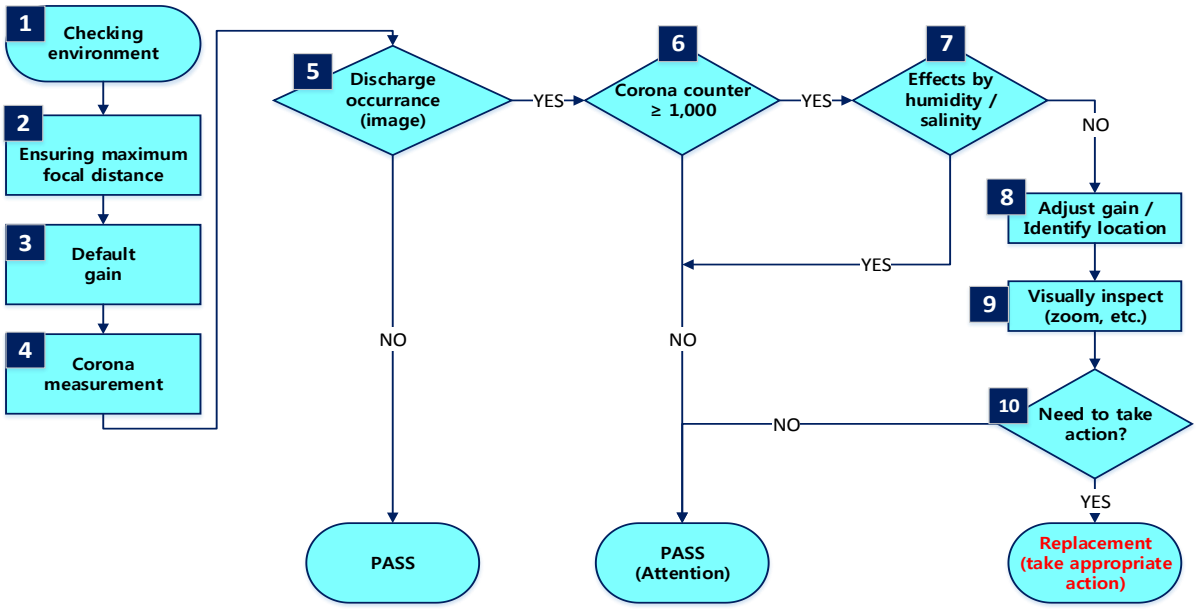


Figure 7: Ultraviolet corona determination criteria (plan)

According to the experimental result, it is very difficult to assume insulation level of electric equipment based on the size and shape of corona image, and the number of photons. UV corona camera should aim to accurately locate corona discharge at the time of electric equipment diagnosis.

First, set gain of each device as a default value, and check if corona image is generated. If there is no corona image detected, it passes the test, and if there is any, see if the count value is over 1,000. If the value does not surpass the standard value, it is considered attention, but if it does, adjust gain to locate corona generation. Check temperature and humidity as they affect corona measurement, and then carry out visual inspection on corona generated equipment. In most cases, visual inspection is difficult considering the location of electric equipment, so abnormality of equipment would be checked with zooming function of a measurement device. If any equipment defect is found, it should be judged as inappropriate and necessary actions such as replacement should be taken. If there is no defect found, it should be judged as attention, which requires regular equipment inspection.

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