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The improved residual-charge measurement to diagnose the water-tree deteriorated power cable

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It is well known that water trees affect the dielectric characteristics such as the breakdown strength. Therefore, it is important to diagnose the degree of water-tree deterioration of power cable for the stable power supply. From this point of view, we have been investigating the residual charge method for diagnosing the water-tree deterioration. The residual charge method is based on detecting the current due to the accumulated charges on the water trees under the alternative voltage application after DC voltage application. Accumulated charges on water trees under DC voltage application remains for a long time even after short-circuiting, but those are easily released under alternative voltage application. Generally, the amount of residual charges is used as an index to determine the degree of water-tree deterioration.

The breakdown strength of power cable deteriorated by water trees strongly correlates with the longest water tree, but not the number of water trees, it means that it is important to detect not how many water trees but how long water trees exist in insulation of power cable for highly reliable diagnosis. However, the conventional method can not obtain the information about the water-trees length, because the conventional one diagnoses the degree of water-tree deterioration by using the amount of residual charges. The amount of residual charges seem to correlates with number of water trees in insulation of power cable, that is, it depends on the length of cable. Therefore, the result of diagnosis also depends on it, even if the degrees of water-tree deterioration are the same of the two, for example.

To realize the highly reliable diagnosis, we have investigated the dependence of residual charges on the alternative voltage, and found that the residual charges due to the accumulated charges on longer water trees need higher alternative voltage. On the basis of this phenomenon, we developed the new residual charge method that is just carried out by measuring the current under the application of the alternative voltage from V_1 to V_n ($n=1,2,...m$ $V_n > V_1$, V_n is a voltage in service) after DC voltage application. Assuming that two kinds of samples (A and B) are measured by applying the alternative voltage of V_1 and V_2 after DC voltage application, and the obtained results are as follows; sample A: residual charges are detected under V_2 after those are detected under V_1, sample B: residual charges are detected only under V_1 and not detected under V_2. These results lead to a conclusion that sample A is more deteriorated due to water trees than sample B, because the residual charges are detected under higher applied voltage in sample A.

In the new residual-charge method, the used index to determine the degree of water-tree deterioration is a voltage that residual charges are detected, which does not correlate with amount of water trees, that is, it is independence of the cable length. Therefore, the highly reliable diagnosis can be realized. We confirmed the effectiveness by some experiments and also by measurements in field.