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Flashover Tests Under Wet Conditions on Full and Sectioned UHV Insulators

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SUMMARY

This paper aims to be a contribution to the current discussion about dielectric test procedures for full UHV insulators under wet conditions. It presents results of wet power frequency flashover voltage tests performed on 800 kV porcelain multicone type post insulators, composed by two sections with metal fittings between them.

UV images were used to observe the differences among the profiles of discharge activities when testing each section at a time in a separated test arrangement and in a full insulator test arrangement with one section short-circuited, compared to the case of testing the complete insulator. It was observed that none of the simplified test arrangement considered was able to represent or to be useful to replace the test on full insulators under artificial rain.

It was also verified that the extrapolation of flashover test results on insulator sections may lead to values greater the values obtained for full insulators.

KEYWORDS

UHV Dielectric tests, UHV Insulator, UHV insulator wet test techniques

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INTRODUCTION

There is a current technical discussion about dielectric test procedures for full UHV insulators under wet conditions [1]. Some aspects that have given rise to this discussion are:

- limited dimensions of indoor UHV test facilities,
- test reproducibility and repeatability and test feasibility regarding the required uniformity of the artificial rain along the insulator.

Considering the height and number of sections of UHV porcelain multicone type post insulators, for instance, one point under consideration is the possibility of testing the complete insulator fully assembled, as it is used in service, or each section at a time separately or by short-circuiting one section in the complete insulator test arrangement. This paper presents results of tests on insulator sections compared to results of tests on full insulators, as used at the substation busbar, taking into account not only the voltage values but UV images related to discharge formation along its sheds during a wet test with precipitation rate ranging from 1 mm/min to 5 mm/min. Originally, some of the tests presented here were not done with the purpose of this paper but their results served as examples for this discussion [2].

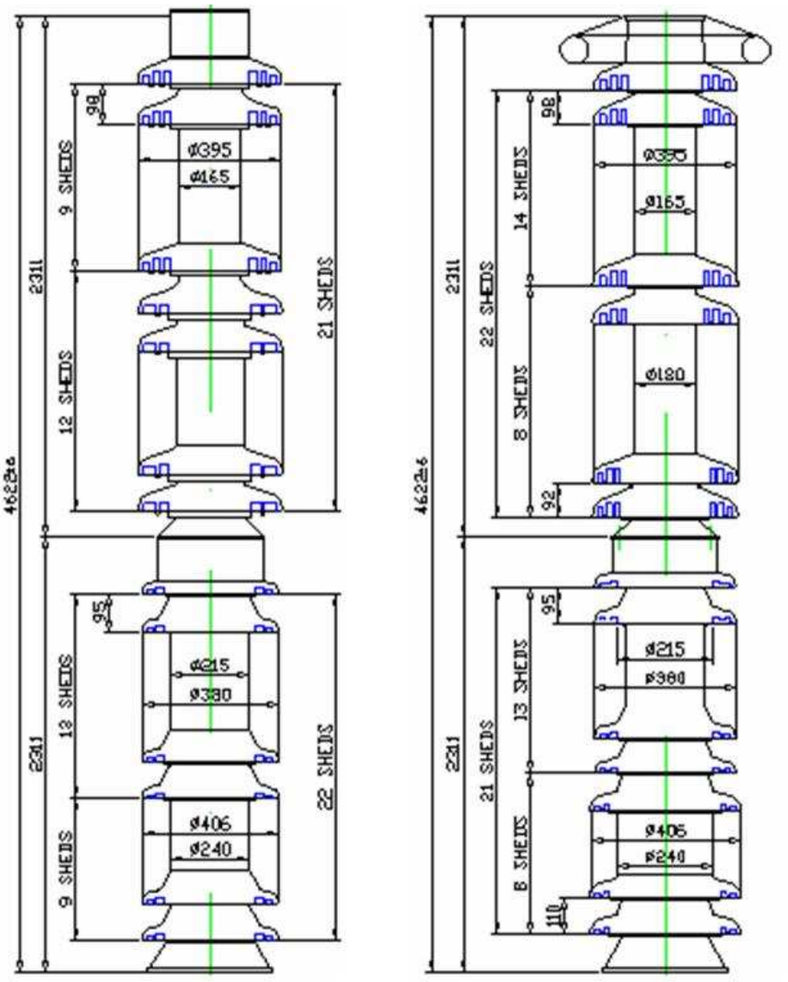
CHARACTERISTICS OF THE SAMPLES UNDER TEST

The tests were performed on 800 kV porcelain post insulators, multicone type, composed by two sections with metal fittings between them of two different manufacturers, as shown in Figure 1. Both insulators have dry withstand ac voltage of 960 kV_{rms}, wet withstand voltage of 885 kV_{rms} (1mm/min) and dry arcing distance of 4400 mm. The total height of the insulator column is 4622 mm, being 2311 mm for each section. The number of sheds for manufacturer “A” insulator is 21 at the upper section and 22 at the lower section. For manufacturer “B” it is 22 and 21, respectively. The test arrangements used are shown in Figure 2. The height to the laboratory floor and the dimensions of the base metallic structures used were as in accordance as possible to the actual insulator installation at a 765 kV substation busbar. The artificial rain structure dimensions are 5 x 5.7 m.

Initially, three sections of two insulators made by manufacturer “A” were tested one at a time separately: Upper section A1, Lower A2 and Upper A2. Tests on complete insulators were done on one insulator of manufacturer “A” (Column A3) and on another insulator of manufacturer “B” (Column B1). The insulators from manufacturer “A”, designed without top corona ring, were removed from service after 20 years under operation and the one from manufacturer “B”, designed with top corona ring, had been stored since 1982 on site and was never put into operation.

TEST PROCEDURES

The test procedure for the complete insulator was simplified in comparison to the standardized one. At first, each insulator was energized under an assured withstand voltage level, during one minute, and the voltage was increased step by step, being applied during 1 minute at each step, up to the level that caused one flashover or up to 900 kVrms, that is the highest level possible with the test transformer used. For the test with the sections alone or with short-circuited sections, the flashover voltage was obtained as the average value of 5 voltage applications that caused disruptive discharges on the insulator under test. In this case, the time interval between each voltage application was 1 minute.



(a) Manufacturer A (b) Manufacturer B

Figure 1 – Drawings of insulators under test

The artificial rain was adjusted to the desired precipitation rate in mm/min, with rain vertical and horizontal components as equal as possible to each other and with a uniform precipitation rate along the insulator height, according to standardized methods. For sake of simplicity, the water resistivity was 100 Ω.m even for 5 mm/min. The rain remained applied for fifteen minutes and the high voltage was applied during the last minute of rain. The time interval between each voltage step was thirty minutes for the test on the complete insulator.

Images of the discharge activities along the insulator were recorded by a daylight UV camera during the tests (see Figure 3). The UV images were valuable to compare details of the discharge mechanism along the insulator column and along each insulator section.

(i) One section under dry test (ii) Full column under wet test

(a) artificial rain structure; (b) HV test transformer; (c) voltage divider; (d) insulator under test

Figure 2 – Test arrangements

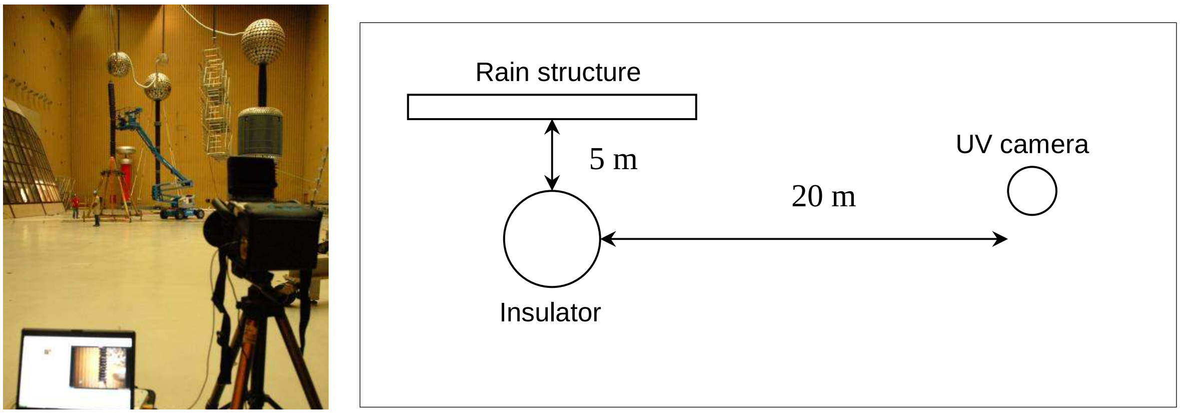


Figure 3 – Test layout, including the position of the daylight UV camera

TEST RESULTS

The flashover voltage results are summarized in Table I, for the complete insulators, in Table II, for each section separately and in Table III for tests with short-circuited sections.

Table I - Power frequency flashover voltage tests: Complete insulators.
W=Withstand, F = FLASHOVER.
(*) Manufacturer data, (**) Limit voltage level of test transformer

Insulator	**Dry**	**1 mm/min**	**3 mm/min**	**5 mm/min**
Column A3	W 960 kV(*)	W 900 kV(**)	F 800 kV	F 780 kV
Column B1	W 960 kV(*)	F 900 kV	F 850 kV	F 900 kV

Table II - Power frequency flashover voltage tests: Sections.

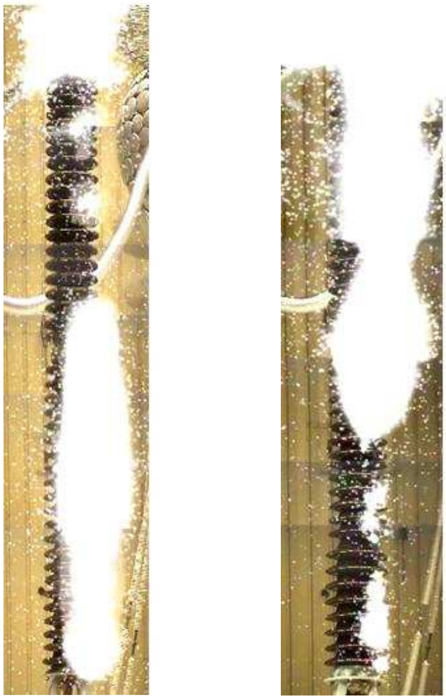
Section	Dry	1 mm/min	3 mm/min	5 mm/min
Lower A1	648 kV	575 kV	483 kV	460 kV
Lower A2	659 kV	506 kV	460 kV	437 kV
Upper A2	662 kV	529 kV	506 kV	483 kV

Table III - Power frequency flashover voltages: Short-circuited sections.

Short circuited section	5 mm/min
Lower A1	473 kV
Upper B1	513 kV

Based on the UV camera images it was possible to see that when testing the complete insulator column, the discharge activities were much more concentrated along the lower section for manufacturer A and along the upper sections for manufacturer B, as shown by the composed frames in Figures 4.

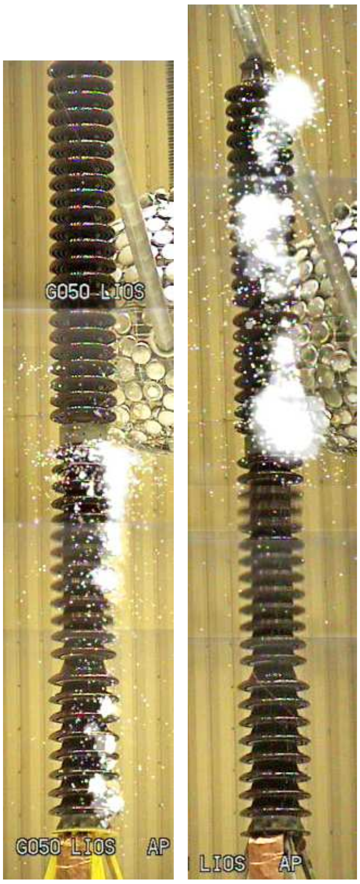
When insulator sections were tested separately or on complete insulator with one section short-circuited, the profiles of discharge activities were different as can be seen in Figures 5 and 6



(a) Manufacturer A, 750 kV   Manufacturer B 885 kV

Figure 4 – UV composed frames of images taken with the same camera set up during flashover test on full insulators, under 5 mm/min and the same test arrangement.

Figure 5 – Flashover test, Lower A1 section, V = 500 kV_{rms}, 5 mm/min



(a) (b)

Figure 6 – Flashover tests on complete insulator Manufacturer A, 450 kV, 5 mm/min. (a) Upper section short-circuited; (b) Lower section short-circuited.

CONCLUSIONS

Based on UV images, taken during flashover tests under wet conditions on 800 kV multicone post insulator, it can be concluded that the discharge activities along the insulator in case of testing the complete insulator is much different compared to the case of testing each section at a time. It leads also to the conclusion that none of the simplified test arrangement considered: one section at a time or one section short-circuited on the complete insulator test arrangement was able to represent or to be useful to replace the flashover test on full insulators under artificial rain.

It can be also verified that the extrapolation of flashover test results on insulator sections or even the sum of the results for each section may lead to values greater the values obtained for full insulators.

In case of 800 kV porcelain multicone type post insulators, with height of about 5000 mm, test facilities for wet tests on complete insulator test arrangement seem to be feasible, as well as to keep the required uniformity of the artificial rain along the insulator column.

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