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Sufficient sensitivity for detection of typical types of critical PD defects required

By application of an Online PD monitoring system (OPDM system), the user expects an improved reliability or availability and a reduction in maintenance costs, i.e. from the asset management point of view a better exploitation of the asset in question. This objective requires a high degree of efficiency and a reasonable application of the PDM system to support the risk assessment process sufficiently. In particular, the defect identification, which is most important among the technical impact parameters for determination of the failure probability, is often not satisfactory. I want to illustrate that with reference to an UHF PDM system applied on a gas-insulated system.

For defect identification three steps have to be carried out:

1. PD defect detection
2. Identification of type of PD defect
3. PD defect localisation

The PD defect detection needs a sufficient sensitivity, which is dependent on the type of defect. This means, both items, PD defect detection and identification of type of PD defect, are of major importance. In general, the sensitivity of a PDM installation in GIS or GIL is checked by means of Sensitivity Verification Step 2 onsite, based on the results of Sensitivity Verification Step 1 in the lab. Because of previous experience, mobile particle (MP) was initially used as the defect type and a PD magnitude equivalent to 5 pC. Due to the knowledge gained in the meantime that not only MP but also other defect types have caused dielectric failures, the Sensitivity Verification Step 1 with protrusion (PT) is now also recommended in the CIGRE TB 654. However, the UHF signal caused by a 5 pC PT is much smaller than that of a 5 pC MP, which also results in a much smaller artificial pulse to be injected in step 2.

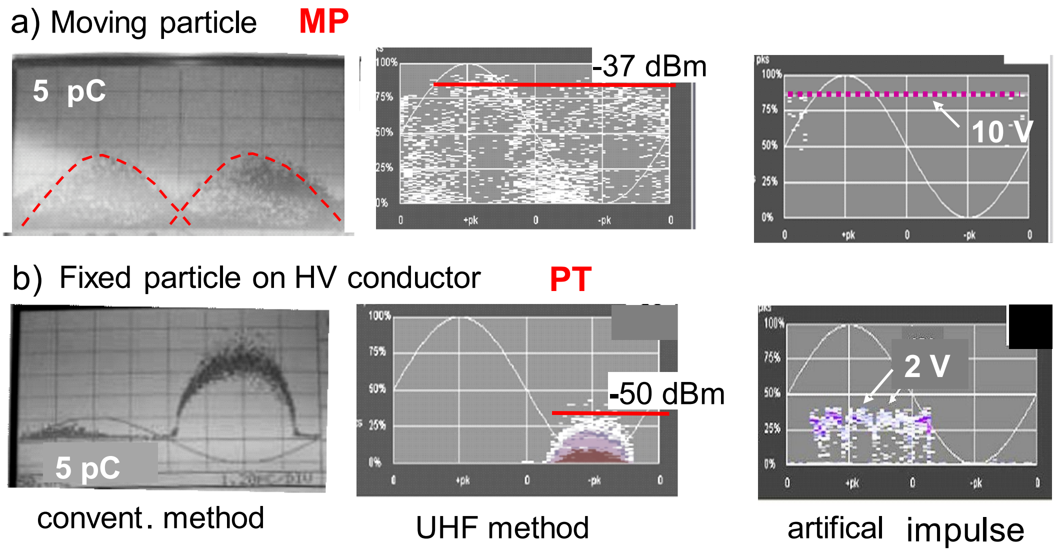

Figure 1 : Sensitivity verification step 1 for different types of PD defects

a) Moving particle *b) Protrusion, fixed particle on HV conductor*

The difference amounts to about 13 dB, as to be seen from the results of a sensitivity verification step1 shown in **Figure 1** and results in artificial pulse of 10 V and 2 V respectively. In consequence, the sensitivity of a section between two adjacent sensors might be sufficient for detection of a critical MP defect, but insufficient for detection of a critical PT defect.

A critical defect is a defect, which reduces the insulation withstand level of the GIS below the coordination withstand level (U_{cw}) and which might lead to dielectric failures. A critical defect of the PT type shows a PD magnitude in the range of 1…2 pC at service voltage, whereas a critical defect of the MP type shows a PD magnitude in the range of 5…10 pC.

By means of the step 1 and step 2 sensitivity verification measurements, an attenuation profile between the adjacent sensors A and B can be established assuming that the attenuation follows a linear profile along the propagation path. This is an approximation only, but it can be used for assessment of the sensitivity performance between two adjacent sensors A and B. As to be seen from the attenuation profile presented in **Figure 2**, the sensitivity in the section between sensor A and B would be sufficient for detection of a PD defect equivalent to 5 pC caused by a MP (**Figure 2 a**), but is at the limit for a PD defect equivalent to 5 pC caused by a PF (**Figure 2 b**). This attenuation profile can be established by means of the results of sensitivity verification step 1 and step 2.

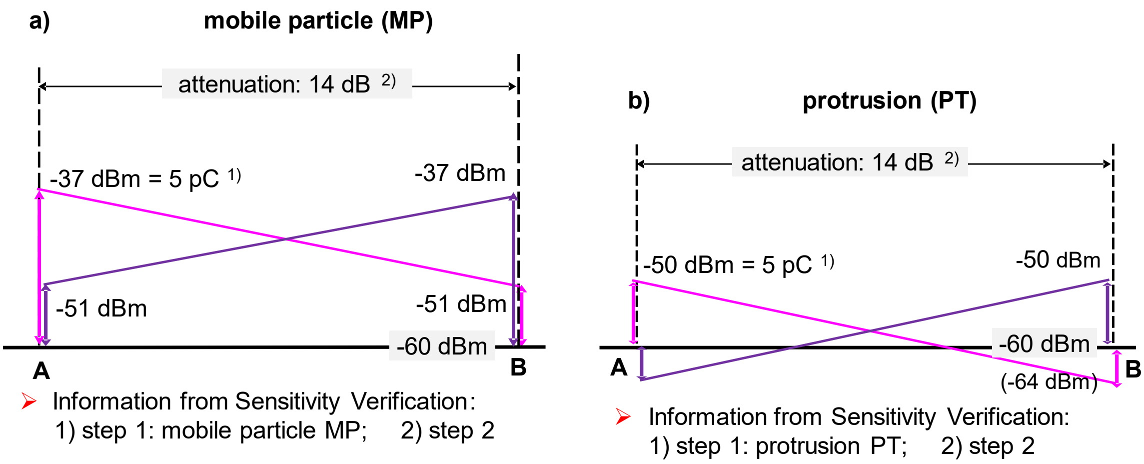

Figure 2 : Attenuation profile established by means of the results in Sensitivity Verification Step 1 in the lab and Sensitivity Verification Step 2 onsite

a) Defect type: mobile particle (MP) ***b) Defect type: protrusion (PT)***

That means, a critical defect of MP type can be detected, but a critical defect of PT type would need a much higher sensitivity. In particular, a critical PD defect of the PT type in the middle third between sensor A and B can't be detected. PD defects due to PT are critical under fast front overvoltages (FFO), i.e. under lightning overvoltages (LIO) and very fast transient overvoltages (VFTO) caused by disconnector switching. Due to disconnector switching, fast front overvoltage of up to 2.5 p.u. can be exited. Thus, some dielectric failures, which have become known in the past in connection with disconnector switching at locations far away from the relevant disconnector, can be explained, although the substation was equipped with a PDM system. However, the sensitivity of the system was more oriented to detection of MP type PD defects and not to PD defects of PT type, which would have required a higher sensitivity. This deficiency is not caused by insufficient ability of the measuring device itself, but of an inadequate sensor arrangement.

To overcome this deficiency, both types of PD defects, MP and PT, should be taken into account in the sensitivity consideration of future PDM systems in GIS/GIL. Existing PDM systems should be reconsidered with this regard. Probably, an improvement can only be achieved by the installation of additional UHF sensors.