Chapter 13
Electrical and Water Treeing of Cable Insulation

ABSTRACT

Partial discharges (PD) have been recognized as a harmful ageing process for electrical insulation at the last century when the high voltage technology was introduced for the generation and transmission of electrical power. Since that time numerous papers and books appeared, dealing with the physics and recognition of partial discharges. First industrial PD tests of HV apparatus were introduced at the beginning of 1940. The method applied was based on NEMA 107, which specifies the measurement of ratio influence voltages (RIV) expressed in terms of μV. One disadvantage of this method is, however, that the RIV level is weighted according to the acoustical noise impression of the human ear, which is not correlated to the PD activity. Therefore, the IEC Technical Committee No.42 decided the issue of a separate standard on electrical PD measurement associated with the PD quantity apparent charge, which is expressed in terms of pC.

13.1 INTRODUCTION

The first and second editions of the IEC Publication 60270 appeared in 1968, IEC 60270 (High-voltage test techniques-Partial discharge measurements, third edition), published in December 2000, covers besides classical analogue instruments also requirements for digital measuring systems. Moreover, the maintaining of specific characteristics of PD measuring systems by the user in record of performance is recommended. In the last ten years the use of digital PD measuring techniques for quality assurance in the works, during on-site testing as well as for monitoring purposes during service life of HV XLPE cables has got increasing attention.

13.2 PARTIAL DISCHARGES OCCURRENCE

Partial discharges are defined in IEC 60270 (2000) as: “Localized electrical discharges that only partially bridge the insulation between conductors and which can or cannot occur adjacent to a conductor”. Partial

DOI: 10.4018/978-1-4666-6509-5.ch013

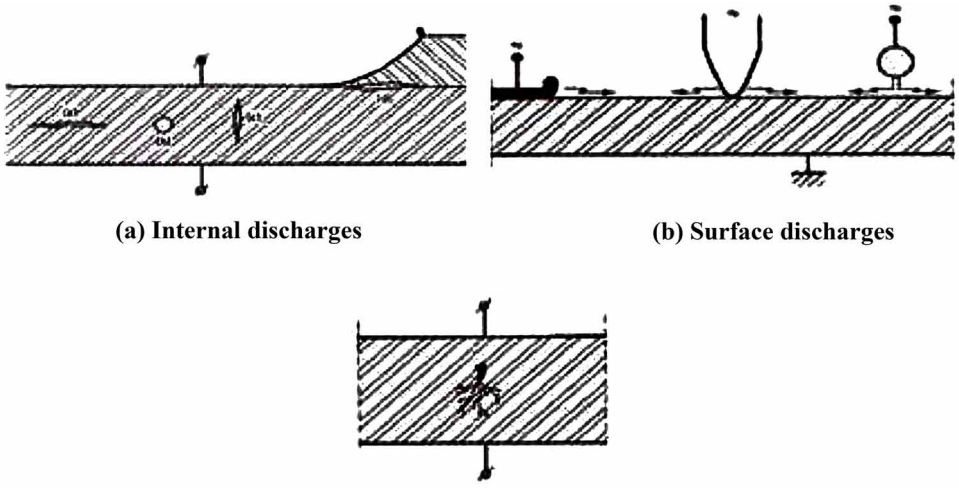
discharges are in general a consequence of local stress concentrations in the insulation or on the surface of the insulation. Generally, such discharges appear as pulses having duration of much less than 1 μs. From a physical point of view self-sustaining electron avalanches may happen only in gaseous dielectrics. Consequently, typical discharge types occurring in ambient air, such as glow, streamer and leader discharges, may also happen in gaseous inclusions due to imperfections in solid and liquid dielectrics. The pulse charge of glow discharges is in the order of few pC. Streamer discharges may create pulse charges ranging from about 10 pC up to some 100 pC. A transition from streamer to leader discharges may occur if the pulse charge exceeds few 1000 pC. In principle, there are three types of PD-related failure that can occur in power cable system. These partial discharges can be classified depend on the origin or location that result in field enhancement situation and produce partial discharge activities in cable systems. These types of PD are:

- Discharge result from internal cavity in the insulation media.
- Surface discharge along interfaces.
- Discharge in the form of electrical treeing in insulation.

(Figure 1) shows the three types of condition in power cable system that can result in discharge activities.

A partial discharge occurs often within gas filled voids in solid or impregnated insulation or from sharp protrusions giving a field enhancement in gaseous, liquid or solid insulation systems of high voltage equipment. If the local field exceeds a certain limit determining the onset voltage and a seeding electron are present, and then an electron avalanche will result. This avalanche will for a partial discharge stop, either from the barrier effect of the cavity walls or from space charge effects when propagating in a gas or liquid. This process is very localized and transient in nature, with a typical duration of microseconds or less.

Figure 1. Types of PD-related failures that can occur in power cable system



(a) Internal discharges **(b) Surface discharges**

(c) Electrical tree