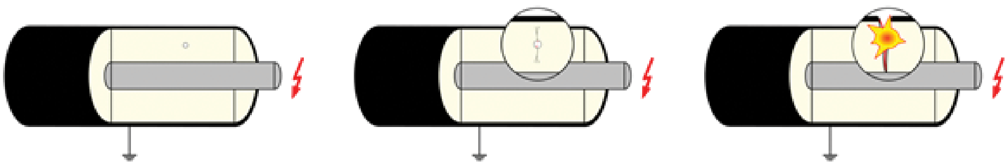
What is Partial Discharge?

Partial discharge (PD) is a localized dielectric breakdown of a small portion of a dielectrical insulation system under high-voltage stress.

The definition of partial discharge in the IEC 60270-2000 standard is “a localized electrical discharge that only partially bridges the insulation between conductors and which can or cannot occur adjacent to a conductor“, and it may cause irreversible damage to liquid and solid insulation systems.

Figure 1



The development of a void to breakdrown over time in a cable insulation system

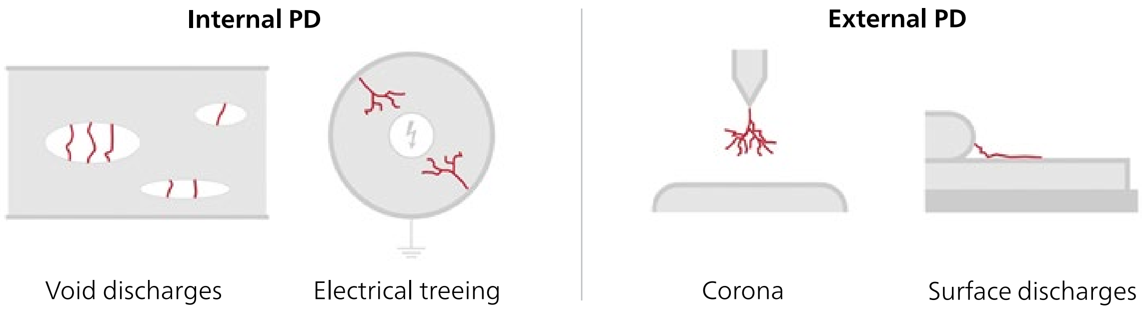
Partial discharge occurs as a consequence of:

- Increased electric field strength (weak design or over stress)
- Local over-heating (creation of voids and bubbles)
- Defects or weakness in the insulation material
- Delamination of cast resin
- Abrasion
- Mechanical stress (vibration)
- Water treeing

PD analysis allows us to detect critical defects and assess a condition of the insulation systems. In many cases, PD phenomena are the preliminary stage of a complete insulation breakdown, and as a result, power transformers, generators, instrument transformers, cable systems, and switchgear have been checked for PD for many years.

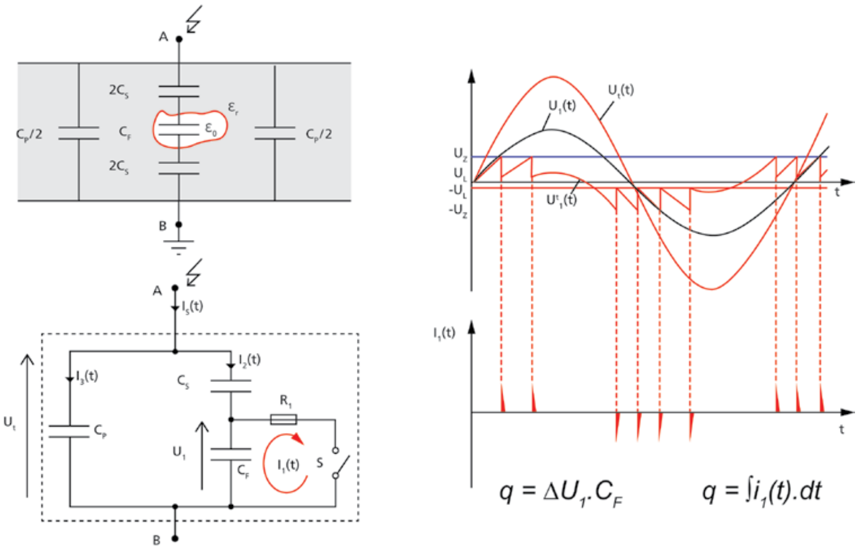
In general, partial discharge can be broken down into two categories, one is *internal* partial discharge and the other is *external* partial discharge.

Figure 2



The void discharge and treeing are the most dangerous types of partial discharge for an assets' insulation system. The following example of a simplified solid insulation system shows how localized electrical discharges develop in a void (capacitor C_F) after the terminal A is energized. The "healthy" dielectics are shown as the parallel capacitance C_p and serial capacitance C_s.

Figure 3



Example of a PD source (upper left), its equivalent circuit (lower left) and the charge and discharge processes by PD and applying AC voltage (right)

The dielectric of a capacitor includes a gas void (upper left figure) and the equivalent circuit diagram of this dielectric (lower left figure). The capacitors C_S and C_F form a capacitive divider. Thus, the U_1 drop voltage on C_F is lower than the applied voltage U_t (figure on the right).

If the electric field strength in the void of the insulation becomes higher than the dielectric strength of the gas inside, the discharge – a small arc – will appear inside the void. This moment is reflected in the equivalent circuit as the switch "S" is closed and the voltage "U_1" across the void capacitance (C_F) drops.

The arc discharges the capacity of the failure C_F and leads to the current $I_1(t)$. Further, a certain amount of charge from the parallel capacitance C_P (and potentially other capacitances, such as C_K connected at terminal A) are discharged via C_S and the arc (Switch S shown in the lower left figure).

When the discharge is completed, the dialectical strength of the gas inside of the void returns and the capacitance of failure C_F starts to recharge due to the gradient of the applied voltage U_t.

The PD process shown in this example (a void in a solid insulation) appears around the phase position of the zero crosses of U_t due to the comparable high-voltage gradient. The phase correlation of the discharges is displayed in a so-called Phase-Resolved Partial Discharge (PRPD) pattern.

Dependent on the failure type, insulation system and asset design respectively, the discharges versus the test (or grid) voltage phase position are different and provide you with an indication of the type of PD source. According to the IEC 60270 standard, partial discharge is indicated as charge Q[Coulomb] and is measured as apparent charge at the terminals of the devices under test (see A or B in Figure 3 above).