Talk on "Energy Delivery System- Understanding Power Cables and Connections (Part 2: Topic 6 to 8)

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When it comes to cable commissioning, there are several tests involved. In the context of field testing of underground cables, there are commissioning tests, re-commissioning tests, fault location, preventive testing and diagnostic tests. Commissioning test is done to confirm the integrity of cable system after installation while re-commissioning test is done to ensure cable system reliability after failure and repair. Preventive testing is basically done to locate major problem areas in cable system while diagnostic test is to provide information on the remaining life of cable insulation. The ideal test equipment for field testing of underground cables should be portable and simple to operate. Some of the existing test methods include DC Hipot testing (PILC cable), AC/Power frequency testing (Factory routine test), VLF testing 0.1Hz (XLPE on site test), Time Domain Reflectometry (fault pre-location) and thumping (surge voltage). More advance methods include partial discharge mapping, VLF tangent delta measurement and dielectric spectroscopy. The IEEE Std 400 series are good reference for such tests.

A cable can fail due to several reasons. It may be the result of flashover between the two dielectrics in the cable or joint or termination section and aging. Aging can happen as the bulk dielectric material degrades. Other mechanisms which accelerates the aging process includes thermal, mechanical and chemical. Thermal effects may be due to excessive load, proximity to other cable circuits, soil thermal resistivity issue and laying conditions which may result in derating. Mechanical issues on the other hand may arise from damage during transportation, excessive pulling tensions, excessive bending radius and damage from digging. Chemical or environmental effects may be in the form of vented water trees, bowtie trees, high rate of neutral corrosion, chemical attack and surface contamination. Manufacturing defects which include voids, contaminants in insulations, protrusions on the shields, poor application of jackets and shield materials may also cause cable failure. In addition to that, issues with workmanship which include cuts, contamination, missing applied components and misalignment of accessories are other possible causes.

The final topic of the talk is on failure analysis of cables. IEEE Std 1511.1-2010 is recommended as guide for investigating and analyzing power cable, joint and termination failures on systems rated 5kV through 46kV. Factors affecting the performance of in service cables such as electrical aging and presence of water in conductor stand need to be understood. Electrical aging comes in the form of partial discharges, electrical trees and water trees. Partial discharge is simply the breakdown of gas in cavity which could be formed due to manufacturing defect, morphological changes or loss of adhesion at the interface. This erosion of cavity surface may result in formation of pit and channel, electrical trees and ultimately cable failure. Electrical trees reduce the breakdown strength of insulation resulting in degradation with time, electrical stress, frequency and water pressure. The two common types of electrical tree are bow ties and vented trees. Bow ties arise within insulation due to voids and contaminants. Vented trees are usually formed due to screen interface protrusions and imperfections and is more dangerous because they decrease the dielectric resistance of the insulator up to a point at which catastrophic breakdown happens. There are four stages involved in the formation of water tree namely migration of water into insulation, condensation of water to form droplets or water filled cavities, filling of cavities with water and final breakdown of insulation. Inhibiting ingression of water will prolong the lifespan of cables by preventing the four stages. Detection of water trees in service cable can be done by measuring DC leakage current, AC leakage current, DC absorption current/residual voltage, capacitance as well as evaluating tan δ. Elimination of contaminants, voids, protrusions, reduction of moisture ingression with strand block materials, jackets and moisture barriers, improvement of surge protection and incorporation of tree retardant materials are some of the countermeasures to water treeing.

Throughout the talk, many questions were asked by the participants and the event concluded with the presentation of a token of appreciation by Ir. Yau Chau Fong as the chairman of IEM Electrical Engineering Technical Division to both of the speakers.

Figure 1: EETD Chairman and Ir. Tan Chow Heang

Figure 2: EETD Chairman and Mr. Ng Choon Guan

Figure 3: The participants (from the back view)

Figure 4: The participants (from the front view)