Talk on "Energy Delivery System- Understanding Power Cables and Connections (Part 1: Topic 1 to 5)

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A talk on "Energy Delivery System- Understanding Power Cables and Connections" was organized by IEM Electrical Engineering Technical Division at Wisma IEM on 13th August 2016. The talk was actually divided into 2 parts due to the wide scope to be covered by the two speakers namely Ir. Tan Chow Heang and Mr. Ng Choon Guan. The first part of the talk centered around electrical power cable while the second part focused on connections of power cables. This report will also be divided into two parts due to the immense amount of information and knowledge shared by both experts.

A total of 8 topics were covered namely cable design and construction, cable application, underground cable installation, cable ampacity ratings, jointing and termination standards and practices, commissioning and in service maintenance testing, cable failure modes and faults analysis on cables. Cables can be categorized into aerial, underground or submarine type. They are applied in power distribution and transmission either for AC or DC at various voltage levels. Aluminum and copper are the two dominant types of cables in Malaysia with the former being superior in terms of conductivity while the latter is lower in density. The basic design elements of a cable include the conductor which is determined by the base current ratings, insulation which is determined by the voltage stress level, and protection which is determined by the installation conditions. Common types of insulation include PVC (Polyvinyl Chloride), PE (Polyethylene), XLPE (Cross linked PE), Rubber, and PILC (Paper Insulated Lead Covered). PVC cables are operable up to 3.3kV while XLPE cables are operable up to 500kV. Protection-wise, external damages which could be mechanical in nature as well as ingression of moisture and other contaminants and even pest attacks are some of the factors to be considered. As for the construction of cables, IEC 60228 is the main reference for conductors of insulated cables. The main difference between LV and MV/HV cable is that no conductor screen is required in the former.

In the selection of cables, factors to be considered are:

1) Installation type → indoors, outdoors, underground, underwater
2) Thermal withstand→fire resistant, high temperature
3) Ratings→steady state (continuous), cyclic and short circuit
4) Accessories→joints and terminations

Would there be flora and fauna damage? Any digging and excavation issue? Does the physical protection needs armoring? Is water treeing an issue? What about chemical attack? There are more questions that need to be answered in selecting cable. To decide on single or three cores, current carrying capacity, short circuit current forces, voltage drop consideration, accessories consideration, sheath current management, cable lengths on drums and pulling force requirements are guiding factors. Good installation practices encompass careful handling of cables, adequate clearance from other underground services, separation between cables of different voltages and avoidance of over-bending.

Meanwhile for underground cable installations, cable transportation, site preparation and cable installation are vital factors which will decide the reliability and performance of such cables. Cable should not be laid flat on flanges when being stored as cable drums. Methods of installation of underground cables include direct burial, or being laid in ducts, dedicated concrete trench and utility tunnels. For laying in ducts, the Horizontal Directional Drilling (HDD) method is widely practiced today. The IEEE Guide for the Design and Installation of Cable Systems in Substations (IEEE Std 525-2007) is a comprehensive reference.

For calculation of cable ampacity rating, the IEC 60287 series is a good standard as reference. Factors which influence the cable ampacity are soil thermal resistivity, depth of cable laying, ambient temperatures, bonding types, cable sizing and dimensions, soil drying out, geometry of installation, methods of installation, cable grouping and cable physical properties.

The delivery of the fifth topic on jointing and termination started by defining what are joints and terminations by which both are actually electrical connections. Joints function to combine several lengths of cable sections together to form a long feeder cable with associated insulation reconstruction. A cable drum is usually a roll of 250m. On the other hand, terminations are required to either end of the cable to equipment such as switchgear or transformer. Jointing is performed using conductor connectors or ferrules while termination is done with lugs. Good workmanship is vital to ensure that the joint or termination at least last as long as the cable's operating lifespan. Ideal requirements of joints include low contact resistance to limit connector heating, reconstruction of the main insulation integrity, proper sealing against moisture ingression, maintenance of continuity of semicon screens and metallic screen connection. Proper crimping tool and dies should be used to ensure good connection.

Stress control methods are paramount to mitigate the issue of high local voltage stresses in joints and terminations by redistributing the electric stress in the cable insulation. Examples of such methods include geometric method with low permittivity, capacitive method using capacitive grading, zinc oxide non-linear, resistance grading and high permittivity method with high dielectric constant materials.