

## **V.B**

# **PJM DESIGN AND APPLICATION OF UNDERGROUND TRANSMISSION CABLES**

### **1.0 GENERAL REQUIREMENTS**

- 1.1 All new underground transmission lines (500 kV, 345 kV, 230 kV, 138kV, 115kV and 69kV) shall, as a minimum, meet the technical requirements of this document and Section II (Transmission System Design Criteria).
- 1.2 Shunt reactive compensation must be considered and provided, when system conditions dictate. The need for shunt reactive compensation will depend on the overall cable capacitance and the system source impedance under all cable system operating conditions.
- 1.3 The latest edition of the Association of Edison Illuminating Companies AEIC CS - 2, "Specifications for Impregnated Paper and Laminated Paper Polypropylene Insulated High Pressure Pipe Type Cable" should be referenced when specifying pipe type cable.
- 1.4 The latest edition of the Association of Edison Illuminating Companies AEIC CS - 4 , "Specifications for Impregnated Paper Insulated Low and Medium Pressure Self Contained Liquid Filled Cable" should be referenced when specifying SCFF cable. Note that although PPP insulation can be used on SCFF cables, the AEIC Specification does not include PPP insulation in this specification. This is because pipe type systems make up the majority of transmission applications in the US and SCFF designs using PPP have not been installed to date.
- 1.5 The latest edition of the Association of Edison Illuminating Companies AEIC CS7, "Specifications for Crosslinked Polyethylene Insulated Shielded Power Cables" should be referenced when specifying solid dielectric cable. Note: this AEIC specification is limited to voltages 138kV and below. For Higher voltages, the principles of the document should be followed along with good engineering practices from appropriate IEC Standards.

### **2.0 CONDUCTORS**

- 2.1 Underground transmission lines 230kV and above should generally be pipe.type. Pipe type systems are preferred due to their extremely high reliability. Solid Dielectric Cables and self contained fluid filled cables may also be used .
- 2.2 Solid dielectric cable may be preferred over pipe type for circuit lengths under 600m, and for circuits 138kV and below.

### **3.0 ROUTING**

- 3.1 Route length should be minimized. Factors such as existing underground utilities, changes in elevation, sources of thermal energy such as steam mains, rock, and the ability to obtain ownership or easement rights should be considered in the selection of an underground route.

- 3.2 Construction in public rights of way such as streets is not recommended for circuits 230kV and above unless easement terminology addresses potential line relocation. Easements for occupation of these rights of way usually require the owner of the cable system to pay for the entire cost of relocation of the line, should work on the highway require relocation of the facility. This can be costly and also interrupt service for extended periods of time during the relocation.

#### 4.0 GENERAL CONSIDERATIONS

- 4.1 The rating or ampacity of the cable system is the fundamental design requirement that determines the conductor size and the overall cable design. The thermal resistance of the soil along the cable route will also impact the rating of the cable system. Load factor, depth of burial and other sources of heat such as existing ducts, steam mains and other underground facilities have an effect on the rating of the cable. A thermal evaluation to determine the soil resistance, known as the thermal rho of the soil must be performed in areas where this data is unknown.
- 4.2 The load factor of the cable is critical especially for generator leads which often have a 100 percent load factor. Corrective thermal backfill materials should be used for transmission cable systems. These can be a graded sand that is compacted or an engineered fluidized thermal backfill made from a weak concrete solution.
- 4.3 The pipe size or conduit diameter is usually determined as part of the rating calculation. Pulling calculations must be made to determine splice locations.
- 4.4 Surge arresters should be installed at all termination locations to protect the underground cable system from transients caused by lightning or switching.

#### **5.0 Pipe Type Cable Considerations**

- 5.1 Pumping plants are required and the design and siting of these systems must factor in the risk of leaks into the environment.
- 5.2 Modern cathodic protection systems are required to minimize the risk of leaks and an active maintenance program can reduce this risk to very low levels.
- 5.3 Pumping plant alarms and control systems must be designed to minimize the loss of dielectric fluids should a leak occur and assure that improper operation and abnormal conditions are reported for immediate corrective action. The ability to monitor the plant remotely is highly suggested.
- 5.4 There is a great deal of experience in the design of pipe type cable systems and; consequently, splices and terminals can be purchased separately from the pipe cable system, i.e. from other specialty vendors who produce these accessories. In all cases, the cable manufacturer should be consulted and dimensional data, as well as design details such as the lay of the outer paper tapes, should be provided to the accessory suppliers by the cable supplier in order to ensure that the accessories fit the pipe type cable.
- 5.5 The use of a pipe type cable system requires at least one pumping plant and possibly two or more depending on reliability criteria and the length of the pipe type system.
- 5.6 The reliability of the cable is no higher than the reliability of the pumping plant. Therefore two independent sources of power to the pumping plant are recommended so that outages to the distribution system or interruptions to station service and power do not interrupt the pipe type cable system.

- 5.7 Long underground cables may need pumping plants along the cable route because the plants must be able to maintain cable pressure as the dielectric fluid expands and contracts with load i.e. operating temperature. Only very long cable systems would require intermediate pumping plants.
- 5.8 Energy storage or on site generation is required for pumping plants to allow for black start of the cable system. The fluid MUST be at rated pressure prior to energizing the cable.

## 6..0 MAINTENANCE

For maintenance see section V.L.2.B