V.B PJM DESIGN AND APPLICATION OF UNDERGROUND TRANSMISSION CABLES

1.0 GENERAL REQUIREMENTS

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).

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.

3. The latest edition of the Association of Edison Illuminating Companies AEIC CS2, "Specifications for Impregnated Paper and Laminated Paper Polypropylene Insulated High Pressure Pipe Type Cable" should be referenced when specifying pipe type cable.

4. The latest edition of the Association of Edison Illuminating Companies AEIC CS4, "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.

5. The latest edition of the Association of Edison Illuminating Companies AEIC CS9, "Specification for Extruded Insulation Power Cables and their Accessories Rated Above 46 kV through 345 kV AC" should be referenced when specifying solid dielectric cable.

6. If the cable system is to be turned over to the TO for ownership, cable type and cross section should be chosen from those used by the TO. This provides the ability to quickly repair a section of cable with utility stock material should an emergency arise. Contact PJM to determine the types of cable used in a specific Transmission Owner area.

2.0 CONDUCTORS

2.1 Underground transmission lines 100 kV and above can be solid dielectric, self-contained fluid filled, or pipe type cables.

2.2 Solid dielectric cable may be preferred over pipe type for short length circuits without splices.

3.0 ROUTING

3.1 Route length should be minimized. Factors such as existing underground utilities, changes in elevation, and 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 preferred for circuits 100 kV and above. Permits for occupation in these corridors 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. If not in a duct bank, corrective thermal backfill materials should be considered for transmission cable systems. These can be engineered graded sand that is compacted or fluidized thermal backfill. In all cases, the engineered backfill shall be tested to demonstrate expected thermal resistivity.

4.2 The load factor of the cable is critical, especially for generator leads which often have a 100 percent load factor.

4.3 The pipe size or conduit diameter is usually determined as part of the rating calculation. Pulling calculations and maximum reel lengths must be evaluated to determine splice locations and feasibility of construction.

4.4 Surge arresters are recommended be installed at all termination locations to protect the underground cable system from transients caused by lightning or switching. However, a switching surge analysis should be performed for cable insulation coordination and protection.

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 Pumping plant alarms and control systems must be designed and utilized to minimize the loss of dielectric fluids. Improper operation and abnormal conditions shall be reported remotely for immediate corrective action.

5.3 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.

5.4 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.

5.5 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. Additional issues that must be addressed are environmental risk and hotspot mitigation. Management of these issues may require intermediate pumping plants, multiple hydraulic sections, special valve and pipe schemes, circulating oil, forced cooling systems, etc.

5.6 The fluid must be at rated pressure prior to energizing the cable. Therefore, energy storage or on site generation is required for pumping plants to allow for black start of the cable system.

5.7 Cathodic protection systems are required to protect the integrity of steel pipes and minimize the risk of leaks. Resistor rectifier circuits shall be discouraged for new installations.

5.8 There is a great deal of experience in the design of pipe type cable systems. Consequently, splices and terminals can be purchased separately from the pipe cable, 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.

6.0 MAINTENANCE

For maintenance see section V.L.2.B