V.N
PJM DESIGN & APPLICATION OF INSULATION COORDINATION AND SURGE PROTECTION

1.0 GENERAL REQUIREMENTS

1.1 Insulation coordination is the coordination of electrical insulation levels with overvoltage protection . It includes subjects of Shielding from lightning, Application of surge arresters, Insulator contamination, Switching surge mitigation, and temporary overvoltage control. The nominal voltage ratings of the effectively grounded transmission systems are 230 kV, 345 kV, and 500 kV. The 500 kV system frequently operates at 550 kV continuously. The 345 kV and 230 kV systems frequently, continuously operate at 362 kV and 242 kV respectively. All insulation shall be capable of operating at these continuous voltages, and withstanding the transient overvoltages allowed by the overvoltage protection. IEEE 1313.1 "Standard for Insulation Coordination Definitions practices and Rules", and IEEE 1313.2 "Guide for the Application of Insulation Coordination" should be followed when selecting surge arrester ratings and station and equipment insulation levels.

1.2 Shielding from Direct Lightning Strokes

All Facilities connected to the PJM system shall be shielded from direct lightning strokes to meet the design criteria in section II of these guides. IEEE standard 998 "IEEE Guide for Direct Lightning Stroke Shielding of Substations" should be used as guide in designing lightning shielding. Lightning Shielding may be accomplished through, masts, overhead ground wires, or other tall conducting structures. Overhead ground wires (static wires) crossing over busses and other circuits should be avoided.

1.3 Insulation Coordination Studies.

Detailed studies including lightning traveling wave analysis, switching surge analysis, TOV analysis, Harmonic resonance, etc., need to be conducted to balance the number and location of surge arresters with proposed insulation levels. EMTP and similar tools can be used in these studies.

Power Transformers will require surge arrester protection on all terminals. Additionally, line entrance arresters are often required, especially when line insulation level is higher than station or equipment insulation. Any frequently open position will be a positive reflection point for fast front transients and deserves special attention.

Generally, non-selfrestoring insulation is protected by a dedicated set of surge arresters at its terminals. In addition to power transformers this will include : underground cable, Gas Insulated Switchgear (GIS), and metalclad or metal enclosed switchgear. Exceptions may include: Instrument Transformers (column CTs, PTs , CCVTs, outdoor circuit breakers, and Capacitor Banks.

Compact line designs, may require use of line type arresters, or spill gaps. In any case, compact line designs require special insulation coordination studies to achieve desired transient overvoltage performance.

1.4 Selection of Surge Arrester Ratings.

The selection of a surge arrester rating is a balance between providing the lowest possible let through voltage (best protection), and the ability of the arrester to survive temporary overvoltages. Simplistically, the arrester is selected as the lowest available rating which will survive the expected temporary overvoltages under normal and abnormal system conditions.

2.0 SPECIFICATION of Surge Arresters

2.1 All surge arresters shall meet or exceed the latest applicable ANSI, IEEE, NEMA, NESC and OSHA Standards. In case of conflict, these standards shall govern in the order stated.

2.2 Surge Arresters shall be designed with adequate electrical and mechanical characteristics for the specific electrical system on which it is installed and for the application for which it is intended. These include but shall not be limited to: Maximum Continuous Operating Voltage (MCOV), Rated duty cycle voltage, energy discharge capability, Temporary Overvoltage capability, and environmental conditions.

2.3 Energy discharge capability must be sufficient to survive line or capacitor bank discharge from at least one maximum energy restrike of any switching device in the substation.

2.4 Studies for each Arrester application shall be performed and special consideration shall be given to all Temporary Overvoltage Duties.

2.5 Surge arresters shall be designed for an in service operating life, comparable to other electrical apparatus in the system to which it is applied.

2.6 Surge arresters, at a minimum, shall be designed to operate at ANSI required ambients of -30°C to +40°C (-22°F to +104°F). All surge arresters shall be designed to operate satisfactorily in the ambients required by their installed location. Some locations in PJM have required -40°C capability. When surge arresters are mounted on Transformers, their high temperature ambient may easily reach 50°C.

2.7 Typical surge arrester ratings are given in Section II Design Criteria.

2.8 Local environmental conditions should be considered when selecting creep requirements for Surge arresters.

3.0 APPLICATION & SPECIAL CONSIDERATIONS

3.1 Surge Arresters generally should be located as close as practical to the equipment they are primarily installed to protect. Both the lead length and the ground return length need to be kept as short and straight as possible.

For example, when possible, surge arresters protecting power transformers should be mounted on the transformer, and the grounded end solidly bonded to the transformer tank. Also, it is desirable for the incoming transformer lead to connect to the arrester BEFORE the transformer bushing.

4.0 SURGE ARRESTER MAINTENANCE

For maintenance requirements see section V.L.2.N