

# V. Design, Application, Maintenance & Operation

## Technical Requirements

### V.C PJM Design & Application of Large Power Transformers

#### 1.0 General Requirements

1.1 The nominal voltage ratings of the effectively grounded transmission systems are 69 kV, 115 kV, 138 kV, 230 kV, 345 kV, 500 kV, and 765 kV. The above systems can operate up to 72.5 kV, 121 kV, 145 kV, 242 kV, 362 kV, 550 kV, and 803 kV continuously respectively. Refer to PJM Manual 03, Section 3.3.1 for detailed operational voltage limits.

#### 2.0 Specifications

2.1 All transformers shall meet or exceed the latest applicable ANSI, IEEE, NEMA, ASME, ASTM, NESC, and OSHA Standards and Loading Guides.

2.2 Transformers shall also 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: continuous current rating, short-circuit capability, operating voltage, BIL, and environmental conditions.

2.3 The following ratings apply to transformers installed at each voltage class:

| Voltage Class (kV) | Maximum Rated Voltage (kV) | BIL (kV)                 |
|--------------------|----------------------------|--------------------------|
| 69                 | 72.5                       | <b>350</b>               |
| 115                | 121                        | <b>450</b> , 550         |
| 138                | 145                        | <b>550</b> , 650         |
| 230                | 242                        | 750*, <b>825</b> , 900   |
| 345                | 362                        | <b>1050</b> , 1175       |
| 500                | 550                        | 1425, <b>1550</b> , 1675 |
| 765                | 803                        | <b>1950</b> , 2050       |

Numbers in **Bold** are preferred values. \* IEEE C57.12.00 Table suggested 750 kV for 230 kV.

Transformer BIL shall be carefully selected based on system studies, insulation coordination, and surge protection provided; higher than minimum BIL levels should be considered.

#### 3.0 Application and Special Considerations

3.1 All transformer terminals shall be equipped with surge arresters.

3.2 Transformer winding configurations and phase relationship shall be consistent with the connection point on the PJM system.

3.3 Local environmental conditions should be considered when selecting creep requirements for

transformer bushings such as altitude, proximity to the ocean, elevated highways, winter road treatment, dust, and chemical environments. Coordinate with the local transmission owner for creep requirements.

3.4 Transformers, at a minimum, shall be designed to operate at ANSI required ambient temperatures of  $-30^{\circ}\text{C}$  to  $+40^{\circ}\text{C}$  ( $-22^{\circ}\text{F}$  to  $+104^{\circ}\text{F}$ ). All transformers shall be designed to operate satisfactorily in the ambient temperatures dictated at their installed location. Start-up and operation of transformers with top oil less than  $-20^{\circ}\text{C}$  is considered an unusual service condition by ANSI, and must be specified by purchaser of equipment. Some locations in PJM have required  $-40^{\circ}\text{C}$  capability. Also refer to Chapter II, environmental design criteria table for details.

3.5 Firewalls shall be provided when required by the NFPA.

3.6 All environmental impacts of a transformer installation shall be considered, such as, sound, fire, leaks, security etc.

## **4.0 Maintenance**

4.1 If the transformer is to be turned over to the TO for ownership, then the transformer shall be designed for an in service operating life, considering normal routine maintenance, comparable to other electrical apparatus in the system to which it is applied. Coordinate with the local transmission owner to determine the transformer operating life used in a specific area. Refer to Section V.L.4.C for details.

## **5.0 Ratings**

5.1 Transformer capability shall not limit the load capability of the circuit or station facility into which it is connected.

5.2 Ratings of electrical system apparatus, including transformers, are critical to the reliable operation of the PJM system. Ratings of transformers applied to the PJM system should be determined using the PJM TSS guide "Guide for the Determination of Power Transformer Ratings" latest revision.