This information is being provided by Dominion Energy Virginia as a response to the DOE Request for Information (RFI) titled “Codes, Standards, Specifications and Other Guidance for Enhancing the Resilience of Electric Infrastructure Systems Against Severe Weather Events”.

The information has been divided into 2 categories. The first category lists the standards and best practices used for building and designing substations against severe weather. The second category lists the standards and best practices used for high voltage transmission lines.

For questions or comments regarding this information, please contact Francisco Velez – Manager of Electric Transmission Reliability at francisco.velez@dominionenergy.com.

1 Floods

1.1 Substations

- The Federal Emergency Management Agency (FEMA) Flood Map Service Center Maps are used to determine potential flood zone areas for substations. Floor elevations for buildings are placed a minimum of one foot above the 100 year flood elevation.

- Sea, Lake, and Overland Surges for Hurricanes (SLOSH), developed by the National Weather Service, is used to estimate impacts from storm tidal surges. Floor elevations for buildings are placed a minimum of one foot above the surge level for a category III hurricane event occurring at high tide.

- Both the FEMA and SLOSH analysis are considered to conclude that buildings are elevated a minimum of one foot above the highest expected water level. Rebuilt facilities will meet these requirements.

- Concrete and steel pedestals of 1, 2, 3ft-6in, and 5ft-6in are used to raise buildings above water level.

2 Extreme Wind / Windstorms

2.1 Substations

The following code references are used for Extreme Wind design:

- ASCE Manuals and Reports on Engineering Practice No. 113 Substation Structure Design Guide. Structures are designed to resist basic wind loads of 90 to 130 mph, three second gust.

- Substation Structure Design Guide and the Institute of Electronic Engineers, Inc. Standard 605 (IEEE 605): Guide for Bus Design in Air Insulated Substations.

- The National Electric Safety Code (NESC) Grade B Construction.

- American Society of Civil Engineers Standard No. 7 Minimum Design Loads for Buildings and Other Structures.

2.2 Transmission Lines

- Transmission Line Engineers are recommended to create designs such that the conductors remain in the transmission ROW during NESC extreme wind loading. This design guidance does not apply to spans over water or over valleys where terrain makes it unlikely for danger trees or other structures to be present.

- Structural Engineers design stronger foundations for locations where foundation replacement would be exceedingly difficult or time consuming. As a best practice, locations like in-water structures or structures in swamp locations are designed to meet or exceed the capacity of the structure. This practice is to reduce the chance of foundation damage if the structure were to fail in a storm and to improve the speed of replacing the structure and restoring the line.

3 Ice/Snow

3.1 Substations

The following code references are used for Ice loading:

- ASCE Manuals and Reports on Engineering Practice No. 113 Substation Structure Design Guide. Structures are designed to resist a combined three quarter inch conductor ice and 30 mph, three second gust, wind load for a majority of the service area.

- Substation Structure Design Guide and the Institute of Electronic Engineers, Inc. Standard 605 (IEEE 605): Guide for Bus Design in Air Insulated Substations.

- The National Electric Safety Code (NESC) Grade B Construction.

- American Society of Civil Engineers Standard No. 7 Minimum Design Loads for Buildings and Other Structures.

3.2 Transmission Lines

- Transmission Line Engineers are recommended to design using a maximum wire tension of 50% of the ultimate limit during NESC Heavy loading conditions. This is a lower tension than the 60% limit set by NESC and provides additional margin during heavy loading scenarios.

- Dominion’s experience has shown that suspension insulators are often a weak link in the hardware string supporting conductor. New designs are required to use a bundled insulator string for structures on either side of a critical crossing. Critical crossings are defined as major roads, water crossings longer than 500 feet, railroads, other transmission lines, or substations. The bundled insulators are for redundancy, not to meet mechanical strength requirements. The extra safety margin provided by the critical crossing insulator assemblies improves public safety during extreme loading events and reduces the possibility for conductors falling in areas where restoration would pose a significant challenge. This is a relatively new policy and has been in effect for approximately four years.

- Structural Engineers are required to follow the ASCE guidance on reducing cascading failures. Engineers must check for, and designs must meet, the Residual Static Load criteria. This is a requirement for all new line designs and is meant to reduce the possibility of cascading structural failures during icing events.

- Structural Engineers add additional loading factors for structures and foundations on critical crossing locations. This is a best practice and the details of how much additional loading to apply are left to the specifics of the design.

4 Earthquakes

4.1 Substations

- Dominion Energy uses USGS Seismic Hazard Maps that display ground motions and their probability of occurring. Dominion Energy uses this information to specify seismic rated battery racks for substation control houses. All battery racks are specified to withstand the highest PGA (Peak Ground Acceleration), found in the Dominion Energy service territory, in the 2% in 50 years map. IEEE 693 Standard and the NESC Code are also used for specifying and designing battery racks. In addition to battery racks, RIP bushings (Resin Impregnated Paper) are specified for equipment in substations that have a higher risk of experiencing a high PGA earthquake.

5 Other Standards

The following design codes are also referenced for substation design:

- ASCE 7-05 & 10, Minimum Design Loads for Buildings and Other Structures.
- IBC, International Building Code.
- OSHA 1926, Occupational Safety and Health Administration.
- ACI 318-14, American Concrete Institute.
- AISC 14th Edition, American Institute of Steel Construction.