4.0 LOADING AND STRENGTH REQUIREMENTS

Transmission Line Facilities shall have sufficient strength to resist the individual effects of all load cases defined in Section 4.2, including all subsections. Loads shall be adjusted by the Load Factors defined in the subsections of Section 4.2, and the strengths shall be adjusted by the material strength reduction factors specified by the applicable governing industry body referenced in Section 4.3.

4.1 Definitions

Comment [TDP1]: Review definitions; revise for clarity as needed. – TDP & All

Do we have everything? Do we need everything? - All

The following definitions apply to this section.

4.1.1 Load Factor

A value by which calculated loads are multiplied in order to provide increased structural reliability. For the purpose of structural design, Overload Capacity Factors as specified by the NESC shall be considered Load Factors.

4.1.2 Longitudinal load

Forces or pressures acting parallel to the direction of the line. For angle structures, the longitudinal direction is perpendicular to the bisector of the angle of the transmission centerline.

4.1.3 Structure, Dead-End and Line Termination

Structures where the phase conductors and shield wires are attached to the structure by use of dead-end insulators and hardware and where the ability of the structure to resist a condition where all wires are broken on one side under full loading is required or desired under all-loading combinations.

4.1.4 Structure, Strain

A structure where the phase conductors and shield wires are attached to the structure by use of dead-end insulators and hardware but where the ability of the structure to resist a condition where all wires are broken on one side under full loading is **not** required or desired.

4.1.5 Structure, Suspension

A structure where the phase conductors and shield wires are attached through the use of suspension insulators and hardware or, in the case of the shield wire, with a clamp not capable of resisting the full design tension of the wire.

4.1.6 Transmission Line Facilities

Transmission Line Facilities include all supporting structures, insulators, hardware, and foundations.

4.1.7 Transverse Load

Forces or pressures acting perpendicular to the direction of the line. For angle structures, the transverse direction is parallel to the bisector of the angle of the transmission centerline.

4.1.8 Wires

Includes all conductors and shield wires.

4.2. Design Load Requirements

All Transmission Line Facilities shall be designed to withstand the independent load cases defined in Sections 4.2.1 through 4.2.7. The effects of gravity, wind, ice, wire tension, construction, and maintenance loads shall be included as applicable.

4.2.1. Legislated Loads

4.2.1.1 Transmission Line Facilities shall be designed to resist the loading conditions defined in Rules 250B, 250C, and 250D of the NESC. For Rule 250B, the provisions of Grade B construction and the Heavy loading district shall be applied. The Rule permitting exclusion of structures less than 60 feet in height from complying with Rules 250C and 250D shall not apply.

4.2.1.2 The Designated Entity shall identify and design to all additional legislated requirements as adopted by state and local jurisdictions.

4.2.2. Extreme Wind

Transmission Line Facilities shall be designed to resist the wind loads corresponding to a 100 year mean recurrence interval (MRI).

Wind pressures shall be calculated in accordance with the procedures of the latest edition of ASCE Manual of Practice 74, properly adjusted for structure shape, gust, and height. The Load Factor applied shall be a minimum of 1.0.

Wind loads shall be applied in the direction producing the maximum loading effect.

All wires shall be assumed intact.

4.2.3. Concurrent Ice with Wind

Transmission Line Facilities shall be designed to resist the ice loads resulting from freezing rain along with the associated concurrent wind loads corresponding to a 100 MRI.

Wind pressures shall be calculated in accordance with the procedures of the latest edition of the ASCE Manual of Practice 74, properly adjusted for structure shape, gust, and height. The Load Factor shall be a minimum of 1.0.

Wind loads shall be applied in the direction producing the maximum loading effect.

The weight of ice shall be considered 57 pounds per cubic foot. The temperature used shall be either the values specified or 32°F.

All wires shall be assumed intact.

4.2.4 Heavy Ice

Transmission Line Facilities shall be designed to resist ice loads resulting from freezing rain, snow, and in-cloud icing as defined in Sections 4.2.4.1 through 4.2.4.4.

In each case, the weight of ice shall be considered 57 pounds per cubic foot, the temperature 0°F, and the wind speed 0 mph. The Load Factor shall be a minimum of 1.0. All wires shall be assumed intact.

4.2.4.1 Transmission Line Facilities shall be designed to resist the effects of a minimum of 1.0 inch radial ice resulting from freezing rain applied to the wires, except as defined in Sections 4.2.4.2, 4.2.4.3, and 4.2.4.4.

4.2.4.2 Transmission Line Facilities constructed in the District of Columbia, and in the states of Delaware, Maryland within approximately 75 miles of the Atlantic coast, and New Jersey shall be designed to resist the effects of a minimum of 1.5 inches radial ice resulting from freezing rain applied to the wires.

4.2.4.3 Transmission Line Facilities constructed in mountainous regions with a ground elevation greater than 1200 feet above mean sea level and less than 3000 feet shall be designed to resist the effects of a minimum of 1.25 inch radial ice resulting from freezing rain applied to the wires. Greater values shall be used in areas know to accumulate greater amounts of ice resulting from freezing rain, or are prone to in-cloud icing or accumulation of snow; and when indicated by historical weather data or site-specific ice studies.

4.2.4.4 Transmission Line Facilities constructed in mountainous regions with a ground elevation greater than 3000 feet above mean sea level shall be designed to resist the effects of a minimum of 1.5 inch radial ice resulting from freezing rain applied to the wires. Greater values shall be used in areas know to accumulate greater amounts of ice resulting from freezing rain, or are prone to in-cloud icing or accumulation of snow; and when indicated by historical weather data or site-specific ice studies.

4.2.5. Unbalanced Longitudinal Load Cases

Comment [TDP2]: Provide a comparison of design longitudinal tensions for comparison. – TDP

Carefully review wording for preciseness.

Transmission Line Facilities designed for voltages 230kV and greater shall be designed to resist longitudinal loads due to broken wire and differential ice conditions as described in Sections 4.2.5.1 and 4.2.5.2.

Transmission Line Facilities designed for voltages less than 230kV may be designed to resist longitudinal loads due to broken wire and differential ice conditions as described in Sections 4.2.5.1 and 4.2.5.2.

4.2.5.1. Broken Wire Loading

For single conductor phase configurations of both single and multiple circuit structures, only one conductor or the shield wire shall be considered broken in each load case considered. Each wire shall be broken individually to ensure the maximum loading effect is determined for each component.

For phase configurations with more than one sub-conductor of both single and multiple circuit structures, a minimum of one sub-conductor, or the ground wire shall be considered broken in each load case considered. The conductor bundle with the sub-conductor(s) broken shall be considered individually to ensure the maximum loading effect is determined for each component.

The minimum environmental load condition shall be 0.5 inches of ice, 40 mph wind, and 32°F. The Load Factor shall be a minimum of 1.0.

For the design of suspension structures, the conductor tensions may be reduced by the effects of longitudinal insulator displacement.

4.2.5.2. Differential Ice Loading

With all wires assumed intact, each conductor and shield wire on one side of the structure shall be loaded with 0.5 inch of radial ice and 40 mph wind at 32°F. All conductors and shield wires on the other side of the structure shall be loaded with the specified wind only. The Load Factor shall be a minimum of 1.0.

For the design of suspension structures, the conductor tensions may be reduced by the effects of longitudinal insulator displacement.

4.2.6. Construction and Maintenance Loads

Transmission Line Facilities shall be designed to meet all applicable OSHA requirements related to climbing and fall protection, and the provisions of this section.

4.2.6.1 Bound Stringing Block

Transmission Line Facilities designed for voltages greater than 230kV shall be designed to resist longitudinal loads simulating a bound stringing block.

Transmission Line Facilities designed for voltages less than 230kV may be designed to resist longitudinal loads simulating a bound stringing block.

With all wires assumed intact, any one shield wire or phase conductor (or all sub-conductors of any one phase) shall be assumed to bind in a stringing block during installation. The block is assumed to swing 45°in-line. Apply 2 pounds per square foot of wind loading and no ice at a temperature of 30°F. The Load Factor shall be a minimum of 1.5.

4.2.6.2 Climbing and Working Loads

Structures shall be designed to support a point load of 350 pounds at all areas where personnel performing construction or maintenance activities may be present.

4.2.7. Foundation Loading

Foundation reactions shall be determined from the load cases presented in Section 4.2. Load Factors shall be a minimum of 1.0.

4.3 Strength Requirements

Structures and foundations shall be designed to the requirements of the applicable publications:

- *ASCE Standard No. 10, Design of Latticed Steel Transmission Structures*
- *ASCE Standard No. 48, Design of Steel Transmission Pole Structures*
- *ASCE Manual No. 91, Design of Guyed Electrical Transmission Structures*
- *ASCE Manual No. 74, Guidelines for Electric Transmission Structural Loading*
- *ASCE Manual No. 104*, *Recommended Practice for Fiber-Reinforced Polymer Products for Overhead Utility Line Structures*
- *ASCE Manual No. 123, Prestressed Concrete Transmission Pole Structures*
- *ANSI 05-1, Specifications and Dimensions for Wood Poles*
- *IEEE Std. 691, Guide for Transmission Structure Foundation Design and Testing*
- *IEEE Std. 751, Trial-Use Design Guide for Wood Transmission Structures*
- *ACI 318 Building Code Requirements for Structural Concrete and Commentary*

A geotechnical study shall be the basis of the final foundation design parameters.