4.3. Structural Design Load~~ing~~ ~~Conditions~~ Cases

All transmission line facilities shall be designed to withstand the load cases defined in Sections 4.3.1 through 4.3.7. The effects of gravity, wind, ice, conductor tension, construction, and maintenance loads shall be included as applicable. For the purposes of this standard, transmission line facilities include structures, insulators, hardware, and foundations. Structure types include, but are not limited to dead-end, strain, and tangent.

4.3.1. Legislated Loads

4.3.1.1 Transmission line facilities shall be designed to the loading conditions defined in Rules 250B, 250C, and 250D of the NESC. For Rule 250B, use Grade B construction and the Heavy loading district. ~~The provisions of the NESC Heavy Loading District, Class B Construction shall apply to all structure types.~~ The provision permitting exclusion of structures
less than 60 ft in height from Rule 250C shall not apply.
~~All wires intact. The latest NESC edition in effect at the time of line design shall apply. For informational purposes, the 1997 edition of NESC specifies the following requirements. Wind pressure – 4psf. Radial Ice – 0.5in. Temperature - 0F.~~
~~For the purpose of calculating conductor or static wire tensions, a load constant of 0.3lbs shall be added to the resultant of the per linear foot weight, wind, and ice loads on the conductor or static wire.~~
~~For steel structures, the load factor for wind load is 2.50; the load factor for vertical loads (dead weight and ice) is 1.50; and the load factor for conductor and static wire tension is 1.65.~~
~~The associated factors for wooden transmission line structures shall be obtained from the TO.~~
4.3.1.2 The Designated Entity shall design to all additional legislated requirements as adopted by local jurisdictions.

4.3.2. Extreme Wind ~~Loading Conditio~~

Transmission line facilities shall be designed to resist the wind loads associated with a 100 year mean return period. Wind maps are found in ASCE 7-16. ~~n – Applies to all structure types.~~ All wires shall be assumed intact. The load factor ~~is~~shall be a minimum of 1.0~~0~~.

Wind loads shall be applied both 90 degrees and 45 degrees to the structure and conductor.

~~4.3.2.2. Line voltage less than 230kV. The provisions of the NESC Extreme Wind loading shall be applied, subject to a minimum wind pressure of 17psf. The load factor is 1.00. The provision in NESC permitting exclusion of structures less than 60ft in height from extreme wind criteria shall not apply.~~

4.3.3. Concurrent Ice with Wind

Transmission line facilities shall be designed to resist the ice with concurrent wind loads associated with a 100 year mean return period. Ice with concurrent wind maps and associated temperature maps are found in ASCE 7-16. All wires shall be assumed intact. The weight of ice shall be considered 57 pcf. The temperature used shall be either the values shown in the maps or 32 degrees F, whichever results in the worst loading effect. The load factor shall be a minimum of 1.0.

4.3.4 Heavy Ice ~~Loading Condition~~

Transmission line facilities shall be designed to resist a minimum radial ice loading equivalent to 1.25 inches. All wires shall be assumed intact. The weight of ice shall be considered 57pcf, the temperature 0 degrees F, and the wind speed 0 mph. The load factor shall be a minimum of 1.0.

In mountainous regions at higher elevations, and other areas know to accumulate greater amounts of ice, the ice loading used in design shall be based on weather studies.
~~– Applies to all structure types. All wires intact.~~

~~4.3.3.1. Line voltage 230kV and greater. Radial ice thickness on the wires only is to be 1.50in. No wind pressure. Temperature is 32F. Load factor is 1.00.~~

~~4.3.3.2. Line voltage less than 230kV. Heavy ice loading (if any) shall be as specified by the TO. Ice loading will not be more severe than that required for voltages 230kV or greater.~~

4.3.5. Longitudinal Load Cases ~~for Suspension Structures (line voltage 230kV or greater) – The TO will specify one or more of the following loading conditions for design of Suspension Structures.~~

Comment [TDP1]: Seems like we should have the same loading for any structure type.

Transmission line facilities shall be designed to resist longitudinal loads due to broken wire conditions and differential ice.

4.3.5.1. Broken Wire Loading

Comment [TDP2]: Descriptions need help for clarity.

Transmission line facilities shall be designed to resist the forces due to broken wires as described below.

For single conductor phase configurations, 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, 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 environmenta l~~One broken conductor or static wire. Any one phase conductor or static wire~~
~~is assumed broken. For construction using bundled phase conductors, one subconductor of any one phase bundle shall be assumed broken, the other subconductor(s) of that phase shall be assumed intact. All other conductors and static wires are intact. L~~oad~~ing~~ condition ~~is NESC Heavy~~shall be X inches of ice, Y mph wind, and Z degrees F.~~. The longitudinal load shall be the tension of the broken static wire or broken conductor or subconductor.~~ . The conductor tensions ~~shall not~~may be reduced by ~~assumed~~ the calculated insulator swing. ~~For the intact phases and static wires, the wind on the structure, and the structure dead weight, the NESC load factors shall apply. For the broken static wire or the phase with the broken conductor or broken subconductor, t~~The load factor shall be a minimum of 1.0~~10~~.

4.3.5.2. Differential Ice Loading

Transmission line facilities shall be designed to resist the forces due to unbalanced ice as described below.
With all wires assumed intact, each ~~. No Wind. Temperature 32F. All~~ conductor and static wire on one side of the structure shall be ~~assumed to have 1.0in~~loaded with X inches of radial ice with Y mph wind at Z degrees F. All conductors and static wires on the other side of the ~~tower~~ structure shall be assumed to have no ice. The determination of differential tension may include the calculated insulator swing ~~of suspension insulator or static wire assemblies~~. The load factor shall be a minimum of 1.0.

~~4.3.4.3. Bound stringing block – All wires intact. 2psf wind. No ice. 30F. Any one static wire or phase conductor (or all subconductors of any one phase) are assumed to bind in a running block during installation. The block is assumed to swing 45 in-line. This swing will result in a longitudinal load equal to the calculated vertical load of the static wire or phase conductor(s) under this loading condition. Load factor is 2.00.~~

~~4.3.5. Longitudinal Loading Conditions for Strain Structures – The TO will specify one or more of the following loading conditions for design of Strain Structures.~~

~~4.3.5.1. One broken conductor or static wire. Any one phase conductor or static wire is assumed broken. For construction using bundled phase conductors, one subconductor of any one phase bundle shall be assumed broken, the other subconductor(s) of that phase shall be assumed intact. All other conductors and static wires are intact. Loading condition is NESC Heavy. The longitudinal load shall be the tension of the broken static wire or broken conductor or subconductor. For the intact phases and static wires, the wind on the structure, and the structure dead weight, the NESC load factors shall apply. For the broken static wire or the phase with the broken conductor or broken subconductor, the load factor shall be 1.10.~~
~~OR~~

Comment [TDP3]: We'll need to discuss the level of prescriptiveness.

Comment [TDP4]: Discuss prescriptiveness.

~~4.3.5.2. All conductors and static wires broken. Loading condition is NESC Heavy. Load factor is 1.00.~~

~~4.3.6. Longitudinal Loading Condition for Dead End Structures – All conductors and static wires are to be intact on one side of the structure only. Loading condition is NESC Heavy. Load factors are those specified by NESC.~~

~~4.3.7. Longitudinal Loading Condition for Line Termination Structures – Conductors and static wires are to be intact on one side of the structure only. All loading conditions and load factors set forth by Section 4.3.1, 4.3.2, and 4.3.3 shall apply.~~

~~4.3.8. Foundation Loading – The ultimate strength of overturning moment and uplift foundations shall be not less than 1.25 times the design factored load reactions of the structure. The ultimate strength of foundations subjected to primarily to compression load shall be not less than 1.10 times the design factored load reactions of the structure. Overturning moment foundations designed by rotation or pier deflection performance criteria shall use unfactored structure reactions for determination of the foundation performance, but shall use factored reactions for the 1.25 time ultimate strength check.~~

4.3.6. ~~Personnel Support Loading~~Construction and Maintenance Loads

Construction and maintenance loads shall be applied based on the recommendations of ASCE Manual of Practice 74 and OSHA.~~Structures shall be designed to support a point load of 350 lb at any point where a construction or maintenance person could stand or otherwise be supported.~~

4.3.7. Foundation Loading

Foundation reactions shall be determined from the load cases presented in Section 4.3. Overload factors shall be a minimum of 1.0

X.X Structure and Foundation Design

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. 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. 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. Total foundation deflection and rotation shall be limited to W inches/X degrees. Recoverable deflection and rotation shall be limited to Y inches/Z degrees. Deflection and rotation shall be calculated using ultimate, factored loads. Deflections shall be measured at the top of the foundation.

Comment [TDP5]: Copied from SPP MDS. Should we add the NESC? It's not a design code.