

Using ANSI/TIA 222-G in TOWER and PLS-POLE

Introduction

TOWER and PLS-POLE have been tracking the evolution of ANSI/TIA 222-G for some years. 222-G represents an enormous change from 222-F in both the loading and strength philosophies employed. This document will briefly explain how TOWER and PLS-POLE can be used to meet some of the requirements of 222-G.

Revisions

July 2007: Addendum 1 incorporated into TOWER and PLS-POLE version 8.20 with the following changes:

Renamed design check to "ANSI/TIA 222-G-1" to make it clear that Addendum 1 is included.

- 2.6.5.1: Updated exposure category extent from 10 to 20 times structure height
- 2.6.7.5: Warnings that refer to this section now print the Grf should be 1.1 to 1.35
- 2.6.9.2: $K_a = \min(0.6, (1-\epsilon))$ now only applied when subcritical (so $K_a = 0.6$ for supercritical wind case may change to $K_a = 1$)
- 2.6.9.2 K_a is applied by the program so should not also be applied in 2.6.9.2.2 through 2.6.9.2.5 as per Note 3 in 2.6.9.2
- 2.8.2: The allowable horizontal displacement is now 3% of structure height instead of 5% in the Service Loads Check
- Table 2-2: TOWER does not automate the special case of "latticed structures with other than triangular or rectangular cross sections"
- 4.5.4.1 TOWER never suffered from this typo
- 4.5.4.2 Resistance factor for compression changed from 0.85 to 0.90 (Eqns. EIA-G-7 and EIA-G-8 in the TOWER manual)
- 4.8.2 Resistance factor for compression changed from 0.85 to 0.90.
- 4.9.6.2 One quarter of the bolt diameter is now added to dist1 and dist2 used for calculating R_{DIS} (Eqns. EIA-G-17 and EIA-G-18 in the TOWER manual)
- 4.9.6.2 The 0.75 factor has been changed to 0.80 for R_{DIS} , but R_{BSH} still uses 0.80 (Eqns. EIA-G-14 and EIA-G-15 in the TOWER manual)

February 2008, TOWER version 10.01:

- 4.6.3 Now exactly implement this section rather than using simpler, but more conservative ASCE 10-97 method for block shear
- 4.6.3.1 Now calculate $A_{net} = 0.75(A_{eff} - h \times t \times n_h)$ rather than the more conservative $A_{net} = (0.75 \times A_{eff}) - (h \times t \times n_h)$ which was introduced in July 2007 with Addendum 1

February 2008, TOWER version 10.02:

- Table 2.2 Now use less conservative Wind Direction Probability Factor (K_d) of 0.85 (previously 0.95) for appurtenances attached to a lattice tower. 0.95 came from the original balloted edition of the code. One can decide to use 0.85 based on the opaque language added in Addendum 1. Note that as a consequence you must design the appurtenance for a different (and larger) load than it supposedly transmits to the structure.

Notes for Users of 222-F

Models made in previous versions that used 222-F will open in the current version and produce the same results they did before. In addition, you will continue to be able to select 222-F as a strength check and a loading option. In fact, the 222-F support in TOWER and PLS-POLE has improved in version 7 as described in the *Notes on Version 7 for Telecommunications Users* section below (which was taken from the *Loading Methods Introduced in Version 7 of TOWER and PLS-POLE* technical note).

Getting Started With 222-G

The geometry of a TOWER or PLS-POLE model will not require any changes to be used with 222-G (except for bolts in TOWER – see 4.9.6.3 below). You can switch to the 222-G strength check simply by selecting it in *General/General Data*. Loads unfortunately are a completely different matter. Wind speeds in 222-F were fastest mile and in 222-G they are now based on a 3s gust. Therefore, a 222-F “.eia” file cannot be automatically converted to a 222-G “.eia” loads file by TOWER or PLS-POLE. Instead, you must create a new EIA loads file using *Loads/EIA Loads*. The type of file (F or G) created is based on the load type selection you made in *General/General Data* so you will want to switch to 222-G prior to doing this. Once you are in the *Loads/EIA Loads* table you will find that you need to input some additional information including: Structure Class, Topographic Category (and possibly Topographic Factor, K_{zt} and Crest Height, H), Exposure Category, design spectral response at short periods and at one second (SDS and SD1). Please refer to 222-G for a definition of these variables. In addition, for each load case you will need to select a type: *Regular*, *Service* or *Earthquake*. Service loadcases are used to calculate serviceability limit state deformations and selecting *Service* for Load Case Type will result in the following: the importance factor is set to 1, the directionality factor, K_d , to 0.85 (as per section 2.8.3) and an uncracked modulus of elasticity is used for concrete poles. No change is made to the topographic factor K_{zt} . The *Earthquake* Load Case Type implements the provisions of

section 2.7 as shown in Table 1 below. All load cases that are neither *Service* nor *Earthquake* should be input as *Regular*. The final piece of input that is required is the Mean Wind Start and Stop Elevations. Wind loads applied to a structure between these elevations will have the mean wind conversion factor m applied to them. This allows you to investigate the pattern wind requirements of section 3.6 for guyed masts.

Table 1: Seismic Analysis Methods Implemented in PLS-POLE and TOWER

Structure Type	Analysis Procedure	Height Limit - No mass or stiffness irregularities	Height Limit - With mass or stiffness irregularities
Tubular Pole	Method 2	No Limit	200ft [61m]
Self Supporting Lattice	Method 2	No Limit	600ft [183m]
Guyed Mast	Method 1	No Limit	1500ft [457m]

Detailed Notes

Prior to making use of 222-G in PLS-POLE or TOWER you should read that code in detail along with these notes. The following notes correspond to section numbers in 222-G and will help you to understand the implementation of 222-G in PLS-POLE and TOWER.

- 2.3.2, 2.4: TOWER: Temperature effects are considered for guyed and self supporting structures. You enter the Guy Installation temperature in *General/EIA Options* (note that this temperature should be 60° F).
 PLS-POLE: Temperature effects are considered for steel poles and guys. The guy installation temperature is hard coded to 60° F.
 Guys will always have a dead load factor of 1 ($D_g = 1$) regardless of what is input in *Loads/EIA Loads* for the dead load factor.
 Concentrated loads input in the *Point Loads* subtable of *Loads/EIA Loads* are already assumed to be factored (the load factors in *Loads/EIA Loads* are not applied to them).
 You should input the load combinations from 2.3.2, any additional load combinations needed for wind pattern loading as per 3.6 and any additional load cases that are necessary in the *Loads/EIA Loads* table.
- 2.6.4: If you input an ice thickness in *Loads/EIA Loads* then the ice will be applied to your structure even if it is less than 0.25in (6mm) thick.
- 2.6.5.2: K_z is calculated automatically for you.
- 2.6.6.1: If any of these situations apply to your structure location you should adjust the input wind speed accordingly.
- 2.6.6.2: You must input the topographic category in *Loads/EIA Loads*.
- 2.6.6.3: TOWER: You input the building elevation in *General/EIA Options*.
 PLS-POLE: If your pole is placed on top of another structure, the Z coordinate entered in *Steel/Wood/Concrete Poles Geometry* must correspond to the elevation at the base of the pole.
- 2.6.6.4: If you select a topographic category of one in *Loads/EIA Loads* then K_{zt} will always equal one. For category two through four, K_{zt} will be calculated as per this section and you must input a Crest Height, H, greater than zero.

K_{zt} will be calculated at the appropriate height for all components (mid-height of sections, attachment height for equipment) except guys where a single uniform value of K_{zt} calculated at the mid-height of the structure will be used. For category five you must input a single K_{zt} which will be used for the entire structure.

2.6.7.1-3: G_h is calculated automatically for you.

2.6.7.4: If this situation applies to your structure you must account for it by inputting the ratio of the program calculated G_h and 1.35 (for tubular spine) or 1.1 (for latticed spine) in the Wind Load Factor column of the *Loads/EIA Loads* table.

2.6.8: t_{iz} is calculated automatically for you.

PLS-POLE: The Z in this equation equals the global Z at any point on your pole. So if the pole is mounted on top of a building, Z will need to reflect that.

TOWER: If number of angles is greater than one then the Wind Width from *Components/Angle* is used for D_c ; otherwise D_c is calculated as per Figure 2-2. Note that this differs from the 222-F methodology.

Guys always have a constant adjusted ice thickness applied which is calculated at the average elevation of each guy.

2.6.9: TOWER: Unless you know without a doubt that a face is the controlling face for wind loading you should create three separate TOWER models (one for each face) to make sure that all loading possibilities are considered. Neither TOWER nor PLS-POLE performs strength design of appurtenances or their connections.

2.6.9.1.1: TOWER: A_g is based on the horizontal distance between the axes of the members in the model (not on the outside dimensions) unless you have a mast with round legs in which case you can select the *General/EIA Options* "Member face width based on out-to-out dimensions" option. TOWER does not automatically account for connection plates. You must manually account for them by increasing the factors A_f and/or A_r in *Geometry/Sections/Define*.

2.6.9.1.1: The only round structural component recognized by TOWER is a round "angle member" (i.e. an entry in *Components/Angles* with $w/t = 1$).

2.6.9.1.1 (Note 5): TOWER does not calculate or account for R_a . If R_a is more than 0.1 you should account for it by modifying the factor A_r in *Geometry/Sections/Define*.

2.6.9.1.1.1 TOWER does not support loading of structures with latticed legs according to this section. Instead, you can either calculate the properties of an equivalent round member and input that as the leg (with the appropriate factors to obtain loading according to 2.6.9.1.1.1) or you can model the lattice leg work directly and manually calculate the factors necessary to obtain loads equal to or greater than the provisions of this section.

2.6.9.1.2 When calculating C_f , PLS-POLE will calculate R_a as the ratio of the area of linear appurtenances mounted outside the pole to the area of the pole for each section. Only the linear appurtenances are considered in the calculation of R_a and all of the appurtenances outside the pole are considered exposed to wind.

Linear appurtenances are always considered to contribute to the wind load

if they are mounted outside the pole regardless of the value of R_a . Brackets or other discrete, but repeating appurtenances should be modeled as equivalent linear appurtenances if you want them included in the calculation of R_a .

PLS-POLE does not automate the provisions of the note in this section regarding the minimum diameter of a pole structure.

- 2.6.9.1.3 PLS-POLE requires the Maximum Pole Segment Length input in *General/General Data* be 4 ft or less in order to guarantee that the requirements of 3.4 2.6.9.1.3 that a section does not exceed 20ft and the requirements of 3.4 that a section have at least 5 beams are met. For loading purposes PLS-POLE treats each beam as its own section.
- 2.6.9.2 Discrete Appurtenances (including Microwave Antennas) should be input in Table 2-8 *Geometry/Equipment*
- Linear appurtenances always have C_a calculated from table 2-8 (they are not treated as being mounted in clusters or blocks as per 2.6.9.5). Linear appurtenances should be input in *Geometry/Linear Appurtenances*
- TOWER: If you select "Yes" for *In Face Zone* in *Geometry/Linear Appurtenances* then K_a will automatically be calculated as $\min(0.6, \{1-\epsilon\})$ where ϵ is the solidity ratio of the face.
- The full projected area of the appurtenance is always used (the program always uses $(EPA)_A$).
- The loads from a linear appurtenance are distributed evenly over all joints in the section along with the loads from angle members. The loads from a discrete appurtenance are applied directly to whatever joint that appurtenance is connected to in *Geometry/Equipment*.
- The aspect ratio of a linear appurtenance is always assumed to be greater than or equal to 25 for C_a from table 2-8.
- If R_a is more than 0.1 you should account for it by modifying the Width input in *Geometry/Linear Appurtenances*.
- 2.6.9.2.1 - 2.6.9.2.5 The provisions of these sections are not automated and the loads must be manually calculated and input in the point loads table of *Loads/EIA Loads* for each load case or equipment with an area calculated to yield an equivalent load input in *Geometry/Equipment*.
- 2.6.9.3 A drag coefficient of 1.2 is always used internally overriding whatever you input in *Components/Cable*.
- If you need to account for attachments such as spoilers or markers then create a new guy property in *Components/Cable* and input an effective diameter that accounts for the attachments.
- A uniform wind pressure and ice thickness is applied to each guy calculated at the mid elevation of the guy.
- 2.6.9.4 Shielding is never considered except through the use of K_a .
- 2.6.9.5 Transmission lines mounted in clusters should be input as an equivalent single linear appurtenance. Linear appurtenances use the drag coefficients specified in table 2-8, not those specified in this section.
- 2.7 TOWER and PLS-POLE provide the methods shown in Table 1 above. They assume the structure does not have any stiffness or mass irregularities. It is your responsibility to determine if the structure has such an irregularity and the applicability of the provided methods to your situation.
- The weight of equipment, linear appurtenances and/or concentrated loads

entered in *Loads/EIA Loads* is included in the calculation of the lateral seismic force.

- 2.7.4 Seismic forces occur in the Wind Direction entered in *Loads/EIA Loads*.
- 2.7.7.1 The primary equation for total seismic shear, V_s , is always used.
- 2.7.7.2 k_e is determined by linear interpolation between 1 and 2.
- 2.7.11 The fundamental frequency of a structure, f_1 , is determined in accordance with this section.
 - 2.7.11.3 The alternate simplified equation is used.
- 2.7.12 No special provision is made for considering earthquake loads on structures supported by a building.
- 2.8.3 If you select a Load Case Type of Service in *Loads/EIA Loads* then the provisions of this section are used for that load case.
- 3.4.1 The horizontal design wind force on linear appurtenances, F_A , is distributed in the same manner as F_{ST} (equally over all joints in the section).
TOWER does not perform any local bending checks for members that support appurtenances.
- 3.6 All wind loading patterns can be considered by inputting the Mean Wind Start and Stop Elevations for any load case that requires a mean wind in *Loads/EIA Loads*. Wind pressures within this elevation range will have the mean wind conversion factor, m , applied to them.
- 3.7 TOWER does not automatically check this, but you may be able to meet these requirements by making sure no diagonal in a span has a capacity less than 40% of the diagonal with the maximum capacity.
- 4.4 The strength checks implemented by TOWER are described in detail in section 3.1.3 of the TOWER manual.
The strength check implemented by PLS-POLE for steel poles is described in section 3.1.1.3.3 of the PLS-POLE manual.
- 4.5.2 TOWER does not automate the calculation of K , as per table 4-5 for round members welded directly to leg members. For these members you should calculate the compression capacity manually and input it in *Geometry/Member Capacities and Overrides*.
 - 4.5.2.1 If you select ANSI/TIA 222-G for the Crossing Diagonal check in *General/General Data* and place any crossing diagonals in a "Crossing Diagonal" group then TOWER will check that the force in the tension member is at least 20% of that in the compression member. If it is not then the alternate RL value will be used. For more information see the Crossing Diagonal Check Technical Note at <http://www.powline.com/products/tower-crossing-diagonal-check.pdf>
 - 4.5.4.1 In order to guarantee correct capacity calculations for round members you must be sure to input them with the long leg equal to the outer diameter,

the short leg equal to the inner diameter and the thickness equal to zero. For solid rounds you should make that both the short leg and the thickness are input as zero.

4.9.6.3 You must create a new ".blt" Bolt Component file where you have calculated the Ultimate Shear Capacity as per this section. Note that you cannot simply reuse your ".blt" file from a 222-F model. Nor can you use bolts where the Ultimate Shear Capacity has been calculated as per ASCE 10-97 section 4.3.2. You will also need separate bolts to handle the case where the threads are included in the shear plane.

Annex C The calculation of wind loads on microwave antennas is automated provided you select one of the EIA Microwave Antenna Types in *Components/Equipment* and then install the antenna in *Geometry/Equipment*. If you do not yet know what the orientation of your antenna will be, you can select a "MaxCA" type which will override the wind incidence angle with the angle that produces the maximum C_A for that particular antenna type according to Annex C.

As you can see from these notes 222-G is vastly more complex than 222-F. When using 222-G you should carefully review the output from the program and compare it to hand calculated values to make sure that you have properly understood and accounted for all the assumptions, approximations and factors involved in the modeling.

Notes on Version 7 for Telecommunications Users

(Excerpt taken from http://www.powline.com/products/version7_loads.pdf these notes apply to users upgrading from version 6)

TOWER and PLS-POLE version 7 offer a number of modeling improvements. In PLS-POLE, you can leave the drag coefficients blank and the program will calculate them for you as per TIA/EIA 222-F. You can inspect these drag coefficients as well as the loads that were placed on your pole by reviewing the **EIA Load Case Information** table which is printed for every load case. This table is the EIA analogue of the **Detailed Pole Loading Data** that is used for transmission codes. In TOWER, you can use the new **Force Solid Face** option to force the longitudinal face to be solid for any section. You will also note that the *Structure Type* input has migrated from the *General/EIA Options* dialog to *General/General Data* and been renamed *Structure Shape*. Another new TOWER option is the *Allow separate faces for each section* setting in *General/General Data* to automate wind loading for complex structures (such as multi-masted structures) that previously had to be done manually. When selected, no section is allowed to shield another section which allows for more than one face at any given elevation. Joints can now belong to more than one section which results in a more even distribution of load in the tower. Finally, you can now override the automatic calculation of face for every member in the structure using the new *Geometry/Graphical Member/Face Override* and *Geometry/Graphical Member/Fence Override Face* commands. This enables you to control the face and wind loading for previously tricky situations like outriggers.