Chapter 1 – Tents & Terminology

For common temporary membrane structures (will call them tents) fall into three main categories:

• Pole – Where the top is held up by a series of poles inside are around the perimeter of the tent and the tent is held up by tension from the anchorage.

• Frame – Where a metal structure holds the top up and the anchorage keeps the tent in place.

• Clearspan – A heavy duty metal structure that, similar to frame but capable of larger spans.
Pole – where the fabric is held up by a series of poles around the perimeter and internally. Pole tent come in two style, Wind rated Tension Structures and non-wind rated Party Canopies (Canopy should not be confused with the code definition).

Frame – where a framework of pipes and fittings is freestanding and the fabric is applied over or into a framework. Frame tent also come in two basic types, wind rated and non-rated.

Clearspan – Similar to the frame tent but has a more robust structure, with box beams, requiring more precision in designing and installing.

Pole tent have main pole(s) and side poles. In addition a few have quarter poles as well. Poles must be mechanically attached to the tent using either jump ropes or other means preventing the pole from separating from the tent.

POLE TENTS
Integral to their structure is the anchoring system without which the pole tent would collapse. The anchoring provides the tension to the fabric which keeps all the poles vertical. Anchoring is normally achieved with ropes tied to stakes or web guys, also known as ratchets, and stakes.

POLE TENTS
A Tension pole tent requires a large amount of tensioning in order to be properly installed. The tent normally has a wind rating generally 70 mph or more in a Type “C” (IBC) location. These tents have reinforcement to qualify for wind ratings. They require more stakes and tension. You can generally identify them by the curved lines and catenary arches, either internal or external, in order to handle the tension in the structure.

Chapter 1 – Tents & Terminology

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POLE TENTS

The canopy or party canopy is an industry term not to be with the IBC and IFC. This however doesn't mean an installer will confuse the code or refer to a very large tent as a canopy based on the industry terminology. These tents generally haven't been designed with any wind ratings. They are normally installed with ropes and stakes since the ratchets will create too much tension and could tear the tent apart, therefore the tent will generally present with some slack. This type of tent doesn't have curved features or reinforcements. The ridge line between center poles will be very straight.

FRAME TENTS

Frame tents also are found with two main types; rated & unrated. Unlike pole tents however, frame tents are free standing and only require anchoring to prevent lifting and/or blowing away.

1st - Unrated frame tents, like party canopies, have no wind ratings. The framework consist of 2" diameter tube, sometime smaller, also referred to as “California Style”. Wider frame tents like 30-40’ require rafter cables.

2nd - Rated frame tents, as the term implies, have some engineering to achieve a wind rating under the IBC. These frame tents will have a beefed up structure with box beams and/or 2x4 pipes. They also might have a "keder" track to slide the fabric in. This method of fabric installation was borrowed from the last common type of tent – Clearspan. These frame tents could also have Gable or Hip type ends.

The two main differences between Rated & Unrated frame tent are the strength of the framework and the anchoring requirements, with the rated tents having a specific requirements from the manufacturer.

CLEARSPAN TENTS

Clearspan tents have a more robust structure than frame tents. Most common are the flat or “Gable” end to these tents. Unlike pole & frame tents, Clearspan tent are anchored through the base plates holding the rafters or arches in place. They don't require the out guying and staking like frame tents because of their more robust structure. They can resist wind pressure through the entire structure.

CHAPTER 2

HOLDING POWER OF STAKES AND BALLAST

SCOPE

To review the IFAI-TRD industry study concerning the holding power of stakes and ballast for anchoring of tents. To inform and guide the AHJ/CEO in field inspection of tents for compliance with IFC Chapter 24.

IFC 3103.9 (2012) states the following:

“Tents, canopies or membrane structures and their appurtenances shall be adequately roped, braced and anchored to withstand the elements of weather and prevent against collapsing.

As noted in Chapter 1 of this presentation, the most common method of anchoring is using a stake. IFAI-TRD conducted a study done by the University of Illinois to methodically determine the holding power of stakes. This study indicated some basic tenets that apply to stakes and staking. It also found some of the historical practices to be less effective than many people, including long time tent installers, believed. The baseline reference for the study was a 1” diameter x 36” long smooth stake vertical installed with 2 inches exposed above the ground.

We will review the IFAI-TRD staking study based on what was found to be the most effective and less effective practices. All stakes will resist being pulled out to some extent and will fail given enough force, the difference is how to get the most bang for the buck.
The items found by the study that maximize and minimize stake holding power were:

- How do you like your stake? Is there any difference between the types of stakes?
- Size matters – The length and diameter effect holding power.
- Deep Cover – How far should a stake be driven into the ground?
- The Right Angle – The effect the angle of installation has on holding power.
- All tied up – The placement of the anchor line on the holding power of stakes.
- Location, Location, Location – Where the stake is placed can increase or decrease a stake’s ability to resist being pulled out.
- What’ya holding – How soil types and conditions effect on holding power.
- Ganging Up – Using multiple stakes, stake bars and/or plates to increase holding power.

- Size Matters. The diameter of the stake when driven into the ground compresses the soils around it. The larger the diameter the more compression.
- Deep cover. The longer, and therefore deeper the stake is driven increases the amount of soil (the shaded triangle above) in front of the direction of force.

- Location, Location, Location: For Pole and frame tents the stake should be located at between 35-40° angle from the tent. A good rule of thumb for an installer is the stake should be located no closer than one foot (1 ft) less than the height of the side of the tent and no greater than the height of the side. Example: for an 8’ side height the minimum would be 7’, for a 7’ side height the minimum is 6’. Extending the stake location further from the tent increases the play (scope) in a line causing slack which will increase loss of tension and decreases down pressure on the side which, for a pole tent could cause the side pole to kick out especially when the tent is installed with sides or a frame to lift.

- What’ya holding: Soil conditions are highly variable. Factors such as soil composition and density, geological and water tables variations and man-made disturbances effect holding power of the soil. Even pavement will vary, fresh and decayed asphalt don’t hold as well as aged, but good condition, asphalt will.
  - Soils with less holding ability are: dry sand, gravel, organic and inorganic silt and loam (topsoil, mulch etc.).
  - Soils with good or higher abilities are: Stiff clay, soft (moldable) clay, naturally compacted soils and hard pan (soils that don’t soften when wet).

- How do you like your stake? The IFAI-TRD study found no difference between rebar (smooth or rough) or smooth tent stakes. The only difference with 1” rebar was they structurally they failed at loads above 1600 lbs., therefore the maximum capacity is limited to 1600 lbs.
- The other factors to be discussed where by far more influential in determining a stakes final holding power.
Chapter 2 – Proper Staking

- Ganging Up: Using multiple stakes to increase holding power can be a good strategy. The distance between the stakes should be about 1/3 the length or 24" for a 40-42" long stake. The primary stake is providing the greater amount of resistance.
- Using mechanical means like bars and plates will also increase holding power, however, just like the old fashion gang staking above, the additional stakes only increase resistance by 60-85% of a single stake.

The IFAI-TRD study found the following for field/soil capacity. The baseline stake was:
- Stake was a 36" x 1".
- Stake side was smooth.
- Stake was driven vertically with only 2" exposed.
- The load was fastened at the surface, load was pulled at a 45° angle.

In order for installers to have a field reference for soil/pullout capacity the IFAI-TRD study correlated the amount a stake penetrated with the soil's hold power. A stake is embedded 24" and struck with a 16 lb sledge hammer using a normal swing. The amount of penetration is correlated in the table below.

Chapter 2 – Proper Staking

Estimating capacity for installation and conditions other than baseline uses the following formula:

\[ P = P_b \times C_e \times C_f \times C_i \times C_l \times C_d \]

- \( P_b \) = Pullout Capacity for a single stake
- \( C_e \) = Correction Factor for embedment depth
- \( C_f \) = Correction Factor for fastening height
- \( C_i \) = Correction Factor for stake inclination
- \( C_l \) = Correction Factor for load angle
- \( C_d \) = Correction Factor for stake diameter

Chapter 2 – Proper Staking

The most common soil condition is Medium. Using the baseline for a 1" diameter stake; medium soil type, holding and correction factors for typical stake installation methods; the following can be demonstrated for their holding power.

<table>
<thead>
<tr>
<th>Stake inches</th>
<th>40</th>
<th>36</th>
<th>30</th>
<th>24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>920</td>
<td>800</td>
<td>608</td>
<td>432</td>
</tr>
<tr>
<td>2/3 Embedment</td>
<td>561</td>
<td>432</td>
<td>352</td>
<td>112</td>
</tr>
<tr>
<td>% Fastening</td>
<td>%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top Fastening</td>
<td></td>
<td>533</td>
<td>415</td>
<td>236</td>
</tr>
<tr>
<td>2/3 Embedment</td>
<td>494</td>
<td>389</td>
<td>224</td>
<td>106</td>
</tr>
<tr>
<td>Stake Angle 30° - % Fastening</td>
<td>411</td>
<td>319</td>
<td>182</td>
<td>85</td>
</tr>
<tr>
<td>Stake Angle 30° - Top Fastening</td>
<td>360</td>
<td>299</td>
<td>172</td>
<td>81</td>
</tr>
<tr>
<td>53° Angle - Stake Angle 30° - % Fastening</td>
<td>349</td>
<td>271</td>
<td>154</td>
<td>72</td>
</tr>
</tbody>
</table>

Chapter 2 – Proper Staking

The IFAI-TRD study also covered Gang staking. As stated earlier, Gang staking does increase holding power but doesn’t achieve 100% baseline resistance. The following table and formula were developed by IFAI-TRD to calculate the amount of holding power for gang staking.

\[ P_g = P_b \times E_i \]

- \( P_g \) = Capacity of the stake group.
- \( P_b \) = Holding power of the baseline stake.
- \( E_i \) = Effectiveness coefficient for the group of stakes from the table.

Chapter 2 – Proper Staking

The IFAI-TRD study found the following for field/soil capacity. The baseline stake was:
- Stake was a 36" x 1".
- Stake side was smooth.
- Stake was driven vertically with only 2" exposed.
- The load was fastened at the surface, load was pulled at a 45° angle.

In order for installers to have a field reference for soil/pullout capacity the IFAI-TRD study correlated the amount a stake penetrated with the soil's hold power. A stake is embedded 24" and struck with a 16 lb sledge hammer using a normal swing. The amount of penetration is correlated in the table below.

Chapter 2 – Proper Staking

If the baseline stake was substituted to demonstrate loss of holding power.

\[ P_g = P_b \times E_i \]

- \( P_b \) = Pullout Capacity for a single stake
- \( E_i \) = Effectiveness coefficient for the group of stakes from the table.

Chapter 2 – Proper Staking

The IFAI-TRD study also covered Gang staking. As stated earlier, Gang staking does increase holding power but doesn’t achieve 100% baseline resistance. The following table and formula were developed by IFAI-TRD to calculate the amount of holding power for gang staking.

\[ P_g = P_b \times E_i \]

- \( P_g \) = Capacity of the stake group.
- \( P_b \) = Holding power of the baseline stake.
- \( E_i \) = Effectiveness coefficient for the group of stakes from the table.
The result of gang staking can be seen in the following table:

<table>
<thead>
<tr>
<th>STAKE</th>
<th>3 STAKES IN A BAR</th>
<th>6 STAKES</th>
<th>GANG PLATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>LENGTH</td>
<td>HOLDING</td>
<td>DOUBLE</td>
<td>VERTICAL</td>
</tr>
<tr>
<td>40</td>
<td>920</td>
<td>1122</td>
<td>2539</td>
</tr>
<tr>
<td>36</td>
<td>800</td>
<td>976</td>
<td>2208</td>
</tr>
<tr>
<td>30</td>
<td>608</td>
<td>742</td>
<td>1678</td>
</tr>
<tr>
<td>24</td>
<td>432</td>
<td>527</td>
<td>1192</td>
</tr>
</tbody>
</table>

Note: Stiff soil holding power assumed. All except 3 stake bar with greater than 15 degree installation use baseline condition.

Keeping in mind that Manufacturer’s instructions for installation trump the following there is some common threads for staking pole and frame tents that can help guide an installer and AHJ to determine if these types of tents have been anchored sufficiently.

For non-rated pole tents 5-10 lbs/ sqft for holding power is required. For rated tents this will increase to 15-20 lbs/ sqft for holding power or higher to achieve certification.

Example and 40x60 pole (2400 sq ft) party canopy tent would require a minimum of 12,000 lbs. of holding power. If we used the base line stake; 36” x 1”, at medium soil consistency; the tent would require 15 stakes for installation. If this same tent were a tension structure the calculation would increase to a minimum 36,000 lbs and 45 stakes required. If the length of the stake was 40” x 1” this would reduce the necessary amount of stakes to 13 for non-rated and 39 for a rated tent.
Keeping in mind that Manufacturer’s instructions for installation trump the following there is some common threads for staking pole and frame tents that can help guide an installer and AHJ to determine if these types of tents have been anchored sufficiently.

Frame tents follow along the same line as pole tents. Although tension is used for holding the tent up, since the frame does that, they require anchorage to prevent them from lifting, being pushed or torqueing from the wind. For non-rated frame tents, using a minimum of 5-10 lbs is still best. The State of Kentucky has just modified their codes calling for a minimum of 5 lbs/ sqft.

Remember this is using the “maximum” provide by the baseline for the soil conditions. If stakes are not installed for pole and frame tents in the baseline method, more stakes will be required.

IFAI-TRD commissioned a study on how to ballast a tent. This study was conducted by Clemson University. The results were far more complex than the staking study and required a “tool” be used to since the “math” is more complex than most installers or AHJ’s would be able to accomplish. The tool is available to members of IFAI-TRD and they are able to print out the result of each calculation. As the AHJ, if a tent is being ballasted, you should require proof of a calculation based on the non-rated 5-10 lbs/ sqft or manufacturer’s certified loads for the tent as entered into the tool.

The study revealed an number of general facts about ballasting:
- 1 lb or weight never equals 1 lb of ballast.
- The tent type effect how the tent can be ballasted.
- The surface and whether its wet or dry can effect the required ballast.
- The type of ballast, like concrete or a plastic drum effects the ballast’s ability to hold a load.
- The physical profile and placement also are considered when ballasting. Multiple formulas are used to determined which condition is the most severe.

The study identified four ballasting methods referred to as configurations.

Configuration A is generally used for Clearspan tent where the ballast plate is attached to tent upright. The Fx is the lateral force to be resisted according to the Manufacturer and the Fy is the uplift. The weight, width and location of the center of the ballast is need to calculate part of the formula. The modifier is a rubber or plywood used to increase the surface friction.
Configuration B is similar to A in that a plate is attached to the upright of the tent. B is generally to be used on a frame tent where both \( F_y \) & \( F_x \) and the "T" tension also needs to be resisted by the ballast. The "T" is the outguy that would normally have to be stake but instead is attached to the ballast. The formulas take into account the ballast sliding on the plate and require more weight.

Configuration C places the ballast directly on a surface. Water barrels and concrete blocks are commonly used this way for frame and pole tents. The formulas take into account sliding, lifting and tipping of the ballast.

Configuration D would be used on Pole or Frame tents that require a large amount of ballast. The rope or guy would be attached to a plate that the weight would be sitting on top of.

<table>
<thead>
<tr>
<th>INPUT</th>
<th>CONFIGURATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configuration</td>
<td>A</td>
</tr>
<tr>
<td>Surface</td>
<td>Required</td>
</tr>
<tr>
<td>Horizontal - ( F_x )</td>
<td>Required</td>
</tr>
<tr>
<td>Vertical - ( F_y )</td>
<td>Required</td>
</tr>
<tr>
<td>Tension - ( T )</td>
<td>---</td>
</tr>
<tr>
<td>Modifier</td>
<td>Option</td>
</tr>
<tr>
<td>Ballast Type</td>
<td>---</td>
</tr>
<tr>
<td>Ballast Secured</td>
<td>---</td>
</tr>
<tr>
<td>Ballast width - ( w )</td>
<td>Required</td>
</tr>
<tr>
<td>Ballast locate - ( x )</td>
<td>Center</td>
</tr>
<tr>
<td>Ballast height - ( h )</td>
<td>---</td>
</tr>
<tr>
<td>Guy height - ( g )</td>
<td>---</td>
</tr>
<tr>
<td>Guy Angle Calculated</td>
<td>---</td>
</tr>
</tbody>
</table>

Ballasts

- Concrete blocks
- Plastic barrel (blue) with concrete
- Plastic barrel (white) with concrete
- Special plastic barrel with water
- Steel drum with concrete
- Plastic barrel with water

Ground Surfaces

- Smooth Concrete (Dry & Wet)
- Rough Concrete (Dry & Wet)
- Asphalt (Dry & Wet)
- Gravel (Dry & Wet)
- Dirt (Dry & Wet)
- Grass (Dry & Wet)
Selected Results

<table>
<thead>
<tr>
<th>Ballast type</th>
<th>Surface type</th>
<th>Surface condition</th>
<th>Ballast weight (lbs)</th>
<th>Average friction coefficient</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic barrel w/water</td>
<td>Smooth concrete</td>
<td>Dry</td>
<td>460</td>
<td>0.318</td>
<td>0.013</td>
</tr>
<tr>
<td>Plastic barrel w/water</td>
<td>Smooth concrete</td>
<td>Wet</td>
<td>460</td>
<td>0.263</td>
<td>0.021</td>
</tr>
<tr>
<td>Plastic barrel w/water</td>
<td>Rough concrete</td>
<td>Dry</td>
<td>460</td>
<td>0.416</td>
<td>0.019</td>
</tr>
<tr>
<td>Plastic barrel w/water</td>
<td>Rough concrete</td>
<td>Wet</td>
<td>460</td>
<td>0.403</td>
<td>0.022</td>
</tr>
<tr>
<td>Plastic barrel w/water</td>
<td>Asphalt</td>
<td>Dry</td>
<td>460</td>
<td>0.449</td>
<td>0.004</td>
</tr>
<tr>
<td>Plastic barrel w/water</td>
<td>Asphalt</td>
<td>Wet</td>
<td>460</td>
<td>0.431</td>
<td>0.003</td>
</tr>
<tr>
<td>Plastic barrel w/water</td>
<td>Dirt</td>
<td>Dry</td>
<td>441</td>
<td>0.428</td>
<td>0.019</td>
</tr>
<tr>
<td>Plastic barrel w/water</td>
<td>Dirt</td>
<td>Wet</td>
<td>441</td>
<td>0.420</td>
<td>0.049</td>
</tr>
<tr>
<td>Plastic barrel w/water</td>
<td>Gravel</td>
<td>Dry</td>
<td>441</td>
<td>0.386</td>
<td>0.028</td>
</tr>
<tr>
<td>Plastic barrel w/water</td>
<td>Gravel</td>
<td>Wet</td>
<td>441</td>
<td>0.522</td>
<td>0.030</td>
</tr>
<tr>
<td>Plastic barrel w/water</td>
<td>Grass</td>
<td>Dry</td>
<td>441</td>
<td>0.450</td>
<td>0.030</td>
</tr>
<tr>
<td>Plastic barrel w/water</td>
<td>Grass</td>
<td>Wet</td>
<td>441</td>
<td>0.462</td>
<td>0.010</td>
</tr>
</tbody>
</table>

Plastic Barrel vs. Steel Drum

Chapter 2 – Ballasting

Whether staking or ballasting a tent proper methods, staking and weight must be used. This becomes part of your inspection of the installation.

We all know there are good, average and not so good contractors in every facet of the economy and the same is true for tent rental. Keeping the public safe is the job, but some rental companies don’t see it that way, and you stand as the last resort for keeping the public safe.

Chapter 3 – Inspections

**SCOPE**

To educate AHJ/CEO with items that should be inspected based on the type of tent installed for compliance in their role of Public Safety.

**Anchorage Inspection**

One of the most important aspects for inspection on any tent is anchorage, whether by stake or ballast should be inspected. This is a public safety concern and one place where many installers don’t perform to best practices in order to save labor and money.

We will apply information in Chapter 2 for anchorage inspection for the three types of tents; pole, frame and clearspan.

**IBC – Installation locations:**

Type A – Urban, building or other structures taller than tent, little additional space.

Type B – Suburban, building or other structures same or lower in height than tent, gaps or space around tent.

Type C – Rural, little or no structures or trees within 500 feet of then and not as tall. Possible for straight line winds to develop. Most “engineered and/or certified” tents use this category.

Type D – Open water, Tent is within 1500’ of open water that is, at least 1500’ of open water. Worst case in the code for straight line winds.
Fire Retardant Certification

Fire retardancy is common to all tents. The Barnum fire of 1945 was a result of a canvas tent with paraffin used to waterproof the tent, can you say "candle"! Fire resistance back then was provided by coating the canvas with a chemical, this chemical would wear and wash away after time, therefore proof of its yearly application and field testing was necessary.

However most modern tents are manufactured with vinyl materials that are inherently fire resistant so it doesn’t wash or wear away. The label on the tent and the documentation provide by the installer should match. Also a label should be on the sides provided for the tent.

Chapter 3 – Inspection

POLE TENTS - INSPECTION

When inspecting this type of tent, in addition to anchoring, there are other facets to the construction of a tent to prevent injury and collapse.

The side and internal poles should be of good quality. Aluminum poles should be made from schedule 40 pipe. Wood poles should be used only on smaller widths (20’ or less) this includes using 2” x 4”.

Tension structure pole tents cannot achieve their ratings utilizing any wood poles and center pole diameters will increase with the increase in width of tent. Generally 30’- 40’ wide tents use 4” diameter aluminum poles; 60’- 80’ wide tents use 6” diameter and so on.

Depending on where it’s located a tear the fabric can threaten the tents structure.
Chapter 3 – Inspection

Tying two tents – guys to one stake – failure

2 tents – 1 stake – Failure
Guy tension removed stake

What’s wrong with this picture:
• Angle
• Stake diameter
• Guy location
• Knot

Pull out less than 15 MPH
Pull out/bulge failure

Trench failure
Another key requirement for pole tents are “jump ropes”. These rope attach to the tent fabric near a point adjacent to where the pole is inserted. A properly attached rope keeps the pole from falling out, especially critical for side poles, and keeps the fabric attached to center and, if any, quarter poles should some tension be lost in the pole tent. For these taller poles their should be at least one “hitch” higher up on the pole in addition to being tied off lower down.

One practice that shouldn’t be allowed is looping over the side pole pin. The rope or guy is not attached to the fabric of the tent and if the pole should dislodge the rope or guy will disconnect from the tent.

Lastly inspecting for any of the following:

- Tears or other signs of weaknesses in the fabric, other than in the valance of the perimeter.
- Frayed ropes or web (ratchet) straps.
- Properly tied knots, located near or at ground level. Should not use “dog bones” for anything but a camping tent.
Chapter 3 – Inspection

Tying to other objects like Tree & fences not allowed

Note: both side poles have fallen out.

Any tent should be in reasonable shape or “good repair”. Special attention should be paid to where the tents, especially pole tents, have the guy attached.

Guy plate Not attached
Rain flap Torn – not critical
Frayed rope

Chapter 3 – Inspection

Rain flap Torn – not critical
Guy plate Not attached

Chapter 3 – Inspection

Rain flap Torn – not critical
Guy plate Not attached

Chapter 3 – Inspection

Rain flap Torn – not critical
Guy plate Not attached
Inspecting a frame tent is different than a pole tent in many ways. Since the structure is free standing a tear in the fabric may only cause a leak but not a public danger from collapse. The real key is to look for proper assembly of the fittings and pipes or beams. Nails, undersize bolts or empty holes without pins or bolts between interlocking pieces can alert a CEO/AHJ to an improper and dangerous assembly.

Mix and don’t match. Generally the lower part of a frame tent can be more substantial than the upper part. For example the legs and perimeter pipes are 2”x4” and the upper pipe are 2” could be a proper assembly. But if the upper pipes were 2”x4” and the legs and/or perimeter beams were only 2” then undue stress would be place on these lower structural members, and with the addition of wind and/or precipitation, could become overwhelmed and collapse.

Looking for consistency of parts and connections; a steel pipe for a leg where others are aluminum, some nails or bolts in some fittings when others have pins or clips. The problem for the CEO is that manufacturers used different methods and parts to achieve assembly of their frame.
Another good one. The leg in not pinned but resting on top of the bolt, therefore its not attached. The pipe on the eave is not a 2” tube but a EMT electrical conduit. It is also not connected to the fitting, stopped by the bolt.
Chapter 3 – Inspection

Tent is on water barrels.
No pins in legs.
Leg removed per customer request.

Chapter 3 – Inspection

Crown fitting no pins

Chapter 3 – Inspection

No out guy staking

Chapter 3 – Inspection

20 x 20 frame push pole tent. Note the staking.
Chapter 3 – Inspection

Besides the fire extinguisher, this type of tent and fitting has push button. This type will never have a high wind rating.

Only 2 stakes instead of 4 – tent can flip

Note the water level

How many things can you find wrong here
Clearspan or structure tents are engineered to be wind rated. If staked through the base plate it is the opposite side that resists wind uplift and pressure. If ballasted it’s the windward side.

Like frame tent they need to be bolted properly.

Unlike frame tents they don’t rely on out-guying for structural stability.

This type of tent can be multi story. It can also be assembled or anchored wrong.

Clearspan drawings
Note: holes for staking in the base plates.
Cross bracing of the bay. Clearspan’s should have every 3 bay braced, minimum of 2 bays per tent.


Purlins can only handle about 100 lbs. of load, here the purlin is holding up the floor.
Only 3/8" plywood being used – code requires maybe ½” or 1” for residential load – 50 lbs./sqft – commercial is 100 lbs., meet neither.

Emergency stair case – exit. What’s wrong with this?
Chapter 3 – Inspection

Proper anchoring of clearspans in necessary like any tent. When staked, the clearspan will resist, unlike a frame tent, on the leeward side by transferring the load through the framework.

However, when you ballast a clearspan, it’s the windward side that resists the wind loads. Plates are normally attached to the base plate or integrated into a ballast plate as covered in Chapter 2. The manufacturer will specify the amount of ballast required to prevent lift and horizontal movement. Using the IFAI-TRD ballast study the installer can calculate the amount of weight need, however under ballasted and improper techniques can cause a engineered/certified clearspan to fail.

Note: This location would be considered a Type A or B.

Chapter 4 – Code Requirements

Since the Hartford Connecticut Barnum and Bailey Brothers tent fire (July 6, 1944) a major focus has been fire protection of tents. It is not the only focus, however, the constructions methods, limiting use and occupancy have also been included in code requirements. An AHJ/CEO today solely focusing on fire retardant materials fail to accomplish their job in securing public safety. Although fire is a hazard, it is not the sole threat to the public.

This presentation will cover only tents and not Air Supported structures that are pressurized for the purpose of supporting the membrane covering.

We will review some of the critical code requirements for tents, which will include fire retardant materials, but also requirements on construction, location of services, occupancy and so on. Some of these requirements need to be met in the pre-permit and permit process then carried through to the actual installation.

However, whether there is a permit required or not, code must be followed. The question is, do you only stop at a stop sign or light if the cop is there to give you a ticket?

Chapter 4 – Code Requirements

For the purpose of this presentation code requirements for tents, not air support structures will be reviewed. Code sections will be paraphrased (…) eliminating references such as tents, canopies and membrane structures for brevity.

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<tr>
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<td>107 IBC – Administration</td>
<td>Authorizes permits for temporary structures and then defines temporary as 180 or less. An applicant must specify a time period not to exceed 180 days. This section doesn't regulate temporary structures which is the scope of Section 3103.</td>
</tr>
<tr>
<td>107.1 IBC – Permits authorized with 180 day time limit unless extension approved by AHJ.</td>
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<tr>
<td>107.2 IBC – Requires conformance to requirements of Structural Strength, Fire Safety, Egress and ADA.</td>
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<tr>
<td>107.3 IBC – Temporary Power must conform to Electrical Code (NEC).</td>
<td></td>
</tr>
<tr>
<td>3103 IBC – Temporary Structures</td>
<td>Construction documents as defined in IBC Chapter 2 include written, graphic, pictorial documents. Also pertinent information on location, seating capacity, construction and all mechanical and electrical equipment. This should be part of the permit process.</td>
</tr>
<tr>
<td>3103.1 IBC – Restates the 180 day limit and requires compliance with the IPC</td>
<td>Construction documents as defined in IBC Chapter 2 include written, graphic, pictorial documents. Also pertinent information on location, seating capacity, construction and all mechanical and electrical equipment. This should be part of the permit process.</td>
</tr>
<tr>
<td>3103.2 IBC – Construction Documents require to include site plan with location of tent(s), egresses delineated and occupant load(s). Most other requirement of 3103 are further outlined in the IPC.</td>
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</tr>
</tbody>
</table>

Note: This location would be considered a Type A or B.
Chapter 4 – Code Requirements

**CODE SECTION**

2403.3 IFC – Place of Assembly

**COMMENTARY**

A detailed site & floor plan for tents, canopies or other membrane structures shall indicate details of the means of egress facilities, seating capacity, arrangement of the seating and location and type of heating and electrical equipment. A floor plan shall indicate details of the means of egress facilities, seating capacity, arrangement of the seating and location and type of heating and electrical equipment.

2403.4 IFC – Permits shall be required as set forth in Section 105.6 & 105.7

**COMMENTARY**

These sections are similar to IBC 107 requiring permits and defining what is a “temporary tent”. The only addition to “temporary” in 2403.5 is the 12 month period at a location.

2403.6 IFC – Construction Documents

**COMMENTARY**

This section is more detailed than the IBC 3103.2 with the requirements starting at occupancy loads of 50 people. This places the designer, applicant and inspector on the “same page” helping to reduce conflicts in the field during an inspection.

Chapter 4 – Code Requirements

**CODE SECTION**

2403.8.2 IFC – Location – Exceptions Con’t

**COMMENTARY**

In addition to 2.3, if the means of egress must flow between tents a minimum of 10’ or more plus any ropes, guy’s and stakes would be added to the separation required. As an example two pole tents were next to each other and staked 7’ from the tent perimeter, the space between stakes would be minimum of 10’ for egress and distance between the perimeters of the actual tent would be 24.

2403.8.3 IFC – Location of tents in excess of 15,000 sq ft.

**COMMENTARY**

The larger spacing recognizes the increased hazards for the larger structure. Exception for structures connected by corridors considers the smaller hazard posed by the covering of the corridor. Corridors shouldn’t contain any combustible materials. Although specifically for air-supported structures large tents like clearspan also are included.

Chapter 4 – Code Requirements

**CODE SECTION**

2403.2 IFC – Approval required

**COMMENTARY**

A tent is a free standing structure, either temporary or permanent. See IFC Figure 2403.1/4)

This section sets the minimum size of a structure that requires approval.

Chapter 4 – Code Requirements

**CODE SECTION**

2402.1 IFC – Definitions

**COMMENTARY**

Tents, Canopies and other Membrane Structures shall not be used for a period of not more than 180 days within a 12 month period on a single premise. 

Chapter 4 – Code Requirements

**CODE SECTION**

3102 IBC

**COMMENTARY**

These materials must comply with either Section 703.4 of the IBC for noncombustible or NFPA 701 for fire resistant materials.

Chapter 4 – Code Requirements

**CODE SECTION**

2402.3 IFC – Inspections

**COMMENTARY**

The fire inspector or building code official must inform the permit holder if they require a written report. Although it covers maintenance, anchors and fabric, the report format is left to the permit holder, owner or tent installer as agent.

Chapter 4 – Code Requirements

**CODE SECTION**

3103.2 with the requirements starting at occupancy loads of 50 people. This places the designer, applicant and inspector on the “same page” helping to reduce conflicts in the field during an inspection.

Chapter 4 – Code Requirements

**CODE SECTION**

2403.8.3 IFC – Location of tents in excess of 15,000 sq ft.

**COMMENTARY**

The larger spacing recognizes the increased hazards for the larger structure. Exception for structures connected by corridors considers the smaller hazard posed by the covering of the corridor. Corridors shouldn’t contain any combustible materials. Although specifically for air-supported structures large tents like clearspan also are included.
Chapter 4 – Code Requirements

2403.8 IFC – Connecting Corridors

Tents or membrane structures are allowed to be joined together by means of corridors. Exit doors shall be provided at each end of such corridor. On each side of such corridor and approximately opposite each other, there shall be provided opening not less than 12' wide.

2403.8.4 IFC – Connecting Corridors

Larger Tents are connected by small tents generally referred to as Marquees. They are mostly framed in nature and therefore have set increments for length. Doors should be installed in the larger structure and not in these Marquee tents unless additional doors are installed to provide egress away from and out of the Marquee from a larger structure while providing entry for emergency responders.

Chapter 4 – Code Requirements

CODE SECTION

2403.8.4 IFC – Connecting Corridors

COMMENTARY

Larger Tents are connected by small tents generally referred to as Marquees. They are mostly framed in nature and therefore have set increments for length. Doors should be installed in the larger structure and not in these Marquee tents unless additional doors are installed to provide egress away from and out of the Marquee from a larger structure while providing entry for emergency responders.

Chapter 4 – Code Requirements

CODE SECTION

2403.8.5 IFC – Fire Break

Tents or membrane structures are connected by small tents generally referred to as Marquees. They are mostly framed in nature and therefore have set increments for length. Doors should be installed in the larger structure and not in these Marquee tents unless additional doors are installed to provide egress away from and out of the Marquee from a larger structure while providing entry for emergency responders.

Chapter 4 – Code Requirements

CODE SECTION

2403.12 IFC – Means of Egress

Tents, canopies or membrane structures & their appurtenances shall be adequately anchored. Documentation of structural stability shall be furnished to the fire code official on request.

Chapter 4 – Code Requirements

CODE SECTION

2403.12.5 IFC – Exit opening from tents.

2403.12.5 Exit opening from tents.

Exit openings from tent shall remain open unless
...
Chapter 4 – Code Requirements

**CODE SECTION** | **COMMENTARY**
--- | ---
2403.12.6 | Exit signs shall be of an approved self-luminous type or shall be internally or externally illuminated by fixtures supplied in the following manner:
1. Two separate circuits, one of which shall be separate from all other circuits, for occupant loads of 300 or less; or
2. Two separate sources of power, one of which shall be an approved emergency power source, shall be provided when the occupant load exceeds 300. Emergency systems shall be supplied from storage batteries or from the on-site generator set, & shall be installed in accordance with the ICC Electrical Code.

**Chapter 4 – Code Requirements**

2404.2 Flame-resistant treatment
- Before a permit is granted, the owner or agent shall file with the fire code official a certificate, executed by an approved testing laboratory, certifying that the tent...and their appurtenances, sidewalls, drops & tarpaulins, floor coverings, bunting...shall be composed of flame-resistant material or treated with flame retardant in an approved manner in accordance with NFPA 701. & that such flame resistance is effective for the period specified by the permit.

2404.3 Label
- This label gives the fire code official important information about the fabric, the design size of the structure & the manufacturer. This label does not identify the installer. Currently there is no standardization as to the format, size or presentation of information.

Chapter 4 – Code Requirements

2403.12.6.1 Exit Sign Illumination – Additional Commentary

Many different requirements are covered for exit signs in this section. Additional codes calling for and covering exit and egress lighting are: IBC Chapter 10 (1011.4), IFC Chapter 10 (1011 & 1010), NEC, NFPA 1, 7 & 101.

UL Standard 2404 covers design & performance criteria for exit signs and lighting based on the above codes.

Additional commentary about sign illumination follows.

Chapter 4 – Code Requirements

2403.12.7 Means of egress illumination – Additional Commentary

Battery operated exit signs with lights generally will suffice to meet this requirement. The exit signs require a the same specifications for a dedicated source of energy including: non-GFCI power source, & 90 minute time duration.

2403.12.8 Maintenance of means of egress
- The required width of exits, aisles & passageways shall be maintained at all times to a public way. Guy wires, guy ropes & other support members shall not cross a means of egress at a height of less than 8 ft. The surface means of egress shall be maintained in an approved manner.

The intent of this section is to cover both temporary and permanent tents regardless of the length of use; that is should be soundly designed so as not to present a hazard to personnel or the structure.

Chapter 4 – Code Requirements

2404.4 Certification
- An affidavit or affirmation shall be submitted to the fire code official and a copy retained on the premises on which the tent...structure is located.
- 1. Name & address of the owners of the tent...structure.
- 2. Date the fabric was last treated with flame resistant solution.
- 3. Trade name or kind of chemical used in treatment.
- 4. Name of person or firm treating the material.
- 5. Name of the testing agency & tent standard by which the fabric was tested.

Again most of this was developed after the Barnum circus fire when tent were constructed of natural fabric. Fire retardant material was only accomplished through the use of chemical treatment which had to be reapplicated at intervals to maintain its fire-retarding properties.

Most tents are now manufactured using some form of vinyl that meet NFPA 701 large scale standards. Documentation is provided by the tent manufacturing in the label affixed to the tent and certification documentation provided at sale from the manufacturer.
Chapter 4 – Code Requirements

**CODE SECTION**

2404.5 Combustible materials

**COMMENTARY**

Hey, straw, shavings or similar combustible materials shall not be located within any tent… structure containing an assembly occupancy, except for materials necessary for the daily feeding and care of animals. Sawdust & shavings utilized for a public performance or exhibit shall not be prohibited provided the sawdust & are kept damp. Combustible materials shall not be permitted under stands or seats at any time. The areas within & adjacent to the tent…structure shall be maintained clear of all combustibles or vegetation that could cause a fire hazard within 20 feet of the structure. Combustible trash shall be removed at least once a day from the structure during the period the structure is occupied by the public.

The section contains a “laundry list” of unacceptable practices. Readily ignitable materials should not be used in tent, including for displays unless they can be made fire-retardant. Keeping areas under seating free of combustibles removes a significant fire hazard from these areas of high occupant density. Maintaining a clear 20 ft buffer zone around & outside of the tent removes a potential fuel source from the area & minimizes the possibility of a wind-blown fire causing the structure to ignite. However, not all vegetation is a hazard. Well keep gardens, trees etc will not readily ignite. The fire official should consider this & ask about conditions during he process. Keeping trash cleaned both inside & out also removes potential fuel source from the area.

**CODE SECTION**

2404.9 Spot Lighting

**COMMENTARY**

Although incandescent lighting can generate considerable heat, new form of theatrical lighting that are based on LED (light emitting diode) or general lighting using CFL (compact fluorescent) are considerably cooler & don’t pose the same hazard as incandescent fixtures. The 12 spacing between flues & membrane is intended to give clearance to the fighters for immobile contents stored in a tent and prevent the stored contents from igniting the membrane, however if proper distance have been maintained between tables & tent sides fire fighters will still have avenues for movement & access with movable seating.

Sections 2404.15 states that extinguishers are required in Group A occupancies or areas designated by the fire code official. Section 906 also refers to NFPA 10 & 101 requirements. A basic rule of thumb taught to the fire code official. Section 906 also refers to NFPA 10 & 101 requirements. The areas within & adjacent to the tent…structure shall be maintained clear of all combustibles or vegetation that could cause a fire hazard within 20 feet of the structure. Combustible trash shall be removed at least once a day from the structure during the period the structure is occupied by the public.

Chapter 4 – Code Requirements

**CODE SECTION**

2404.7 Open or exposed flame

**COMMENTARY**

Open flame or other devices emitting flame, fire or heat or any flammable combustible liquids, gas, charcoal or other cooking device or any other unapproved devices shall not be permitted inside or located within 20 feet of the tent….structures while open to the public unless approved by the fire code official.

Because no specification exist for standard signs, each jurisdiction having authority is responsible for establishing its own criteria. To be approved, signs must be large enough to be read from a distance & be worded simply & clearly.

Chapter 4 – Code Requirements

**CODE SECTION**

2404.15.5 Location (Cooking & Heating Equipment)

**COMMENTARY**

Cooking & heating equipment shall not be located within 10 ft of tent….structures. This section establishes the requirements for this type of equipment and the fire authorities ability to approve to the equipment & installation.

This represents clearance required from exits & other combustibles, for this type of equipment, and not the required clearances from the membrane structure being heated or one being used as dedicated for cooking.

Approved “No Smoking” signs, each jurisdiction having authority is responsible for establishing its own criteria. To be approved, signs must be large enough to be read from a distance & be worded simply & clearly.

Chapter 4 – Code Requirements

**CODE SECTION**

2404.11 Clearance

**COMMENTARY**

There shall be a minimum clearance of at least 3 ft between the fabric envelope and all contents located inside the tent…structure. Intended to give clearance to the fighters for immobile contents stored in a tent and prevent the stored contents from igniting the membrane, however if proper distance have been maintained between tables & tent sides fire fighters will still have avenues for movement & access with movable seating.

Although these operations have authorization the fire code official should make certain they meet the requirements of other subsections within this section. This separation is consistent with 2404.7 covering open or exposed flames and combustible materials.

Chapter 4 – Code Requirements

**CODE SECTION**

2404.15 LP-gas

**COMMENTARY**

The storage, handling & use of LP-gas & LP-gas equipment shall be in accordance with Section 310. The storage, handling & use of LP-gas & LP-gas equipment shall be in accordance with the general requirements of Chapter 38 for LP-gas regulation.

Because of the nature of membrane structures & possible sources of ignition, this section adds to the general requirements of Chapter 38 for LP-gas regulation.

Chapter 4 – Code Requirements

**CODE SECTION**

2404.15.4 Operations

**COMMENTARY**

Operations such as warming of foods, cooking demonstrations & similar operations that use solid flammables, butane or similar devices which do not pose an ignition hazard, shall be approved.

Chapter 4 – Code Requirements

**CODE SECTION**

2404.15.1 General

**COMMENTARY**

LP-gas equipment & associated components shall comply with the International Fuel Gas Code. LP-gas installation must meet the minimum standards for conventional installation & inspection requirements.

Because of the nature of membrane structures & possible sources of ignition, this section adds to the general requirements of Chapter 38 for LP-gas regulation.

Chapter 4 – Code Requirements

**CODE SECTION**

2404.15.2 Venting

**COMMENTARY**

Where vents or flues are used, all portions of the tent…structure shall not be less than 12 inches from the flue or vent. Where vents or flues are used, all portions of the tent…structure shall not be less than 12 inches from the flue or vent.

The 12 spacing between flues & membrane is intended to prevent possible point of ignition to the membrane.

Chapter 4 – Code Requirements

**CODE SECTION**

2404.15.3 Location (Cooking & Heating Equipment)

**COMMENTARY**

Cooking & heating equipment shall not be located within 10 ft of exits or combustible materials.

This section establishes the requirements for this type of equipment and the fire authorities ability to approve to the equipment & installation.

Consistent with codes covering conventional structures.

Chapter 4 – Code Requirements

**CODE SECTION**

2404.15.6 Outdoor Cooking

**COMMENTARY**

Outdoor cooking that produces sparks or grease-laden vapors shall not be performed within 20 ft from a tent…structure. This section establishes the requirements for this type of equipment and the fire authorities ability to approve to the equipment & installation.

Chapter 4 – Code Requirements

**CODE SECTION**

2404.15.7 Electrical Heating & Cooking Equipment

**COMMENTARY**

Electrical cooking & heating equipment shall comply with the ICC Electrical Code. This section establishes the requirements for this type of equipment and the fire authorities ability to approve to the equipment & installation.

Chapter 4 – Code Requirements

**CODE SECTION**

2404.16.2 Location of Containers

**COMMENTARY**

LP-gas containers & associated components shall comply with the International Fuel Gas Code. LP-gas equipment & associated components shall comply with the International Fuel Gas Code.

Chapter 4 – Code Requirements

**CODE SECTION**

2404.16.2 Container(s)

**COMMENTARY**

Containers 500 gallon or less Portable LP-gas containers with a capacity of 500 gallons or less shall have a minimum separation between the container & structure not less than 10 ft.

Cylinders greater than 1lb would have to be located well away from the wall of the structure are examples of appliances that a code official can allow for use inside a tent.

Chapter 4 – Code Requirements

**CODE SECTION**

2404.14 Occupant Load Factors

**COMMENTARY**

Whether permanent or temporary, a membrane structure is treated the same as conventional construction with the additional consideration of the guy ropes or anchoring would cause blockage of egress & therefore the code official need to review plans to insure proper egress from a membrane structure.

Chapter 4 – Code Requirements

**CODE SECTION**

2404.12 Portable Fire Extinguishers

**COMMENTARY**

Portable fire extinguishers shall be provided as required by Section 906. Section 906 states that extinguishers are required in Group A occupancies or areas designated by the fire code official. Section 906 also refers to NFPA 10 & 101 for guidance on selection & placements of extinguishers. A basic rule of thumb taught to the tent industry is an approved ABC type of every required exit, which generally address to Section 906 & NFPA 10 & 101 requirements.
Chapter 4 – Code Requirements

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<td>Containers more than 500 gal. Portable LP-gas containers with a capacity of more than 500 gallons (1901L) shall have a minimum separation between the container &amp; structures not less than 25 ft.</td>
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| 2404.20      | Standby Personnel – Con’t  
approved, to remain on duty during the times such places are open to the public, or hen such activity is being conducted.  
Before each performance or the start of such activity, standby personnel shall keep diligent watch for fires  
during the time such place is open to the public or such activity is being conducted & take prompt measures for  
extinguishment of fires that occur & assist in the evacuation of the public from the structure.  
There shall be trained crowd managers or crowd manager supervisors at a ratio of one crowd  
manager/supervisor for every 250 occupants, as approved. |
| 2404.21      | Vegetation removal  
Combustible vegetation shall be removed from the area occupied by a tent…structure, & from areas  
within 30ft of such structures.  
Not all vegetation is readily combustible so preplanning, pre installing site visitation should be conducted to  
determine if the tent will be located in an area that would contain combustible vegetation. Since weather  
conditions could change over time, previously acceptable vegetation might with a lack of  
precipitation; pose a risk at installation. Grasses, gardens might be acceptable but wood chips or hay  
covering landscaping might pose a risk and would need to be removed. |
| 2404.22      | Waste material  
The floor surface inside tents…structures & the grounds outside & within a 30ft perimeter shall be kept clear of combustible  
wa...
Now for wind, the single biggest threat to any tent. Although the minimum IBC rating in Chapter 16 for a tent is 70 MPH or 5 min. and 90 MPH for 3 sec., most tent don’t and can’t meet that criteria. Mother Nature has a way of finding the weakest link and wind is very often the method used. A squall of a short duration or microburst can cause a tent to fail very quickly. This is why proper installation and egress are necessary for setup.

Let’s look a wind ranges and average frequency:
- 0-15 MPH Any time any day
- 15-25 MPH 7-10 days
- 25-35 MPH 10-25 days
- 35-45 MPH 25-45 days
- 45-60 MPH 45-120 days
- 60-75 MPH 120-365 days

This doesn’t mean that when you had a 45 MPH wind you won’t have another for 45 days, could have another the very next, these are just averages.

So it really doesn’t matter if the tent is up for a day or 179, eventually you will have one up for a wind event.

Too review, it’s everyone’s job to work for the safety of the public and employees, however not everyone does this as we’ve seen. Although we have directly related the presented material to emergency preparedness and event contingency planning it certainly is part of the whole picture. Preventing a tent collapse in minor winds or because of improper assembly and/or installation and being prepared for other, more serious weather events or other incidents is part of the picture.

You as the AHJ are becoming a more important part of all special events. Whether a private party or wedding to a large public events, from a bar in Kansas City to an air show in Huntsville, AL, each with a fatality, the importance of the material presented should help with your obligations to public safety.