Rigging Loads and Forces

Rigging activities are one of the most critical activities in telecommunications construction. Rigging commonly involves the lifting or lowering of a load, which regularly occurs during customer installations, structural modifications, maintenance and many other construction tasks in a scope of work (SOW). The focal point of this PAN is to ensure proper planning is conducted in accordance with the ANSI/ASSP A10.48 and other standards or regulations that may apply. A fundamental part of that planning and execution involves determination of the Gross Load and the forces it can generate throughout the rigging system onto both the rigging components as well as the structure.

Throughout this article, you will learn what components are included in the gross load, how the gross load relates to rigging forces, and how gross load(s) influence lift planning.

This understanding ensures proper planning to address gross loads and forces, and modifications to the plan or proper procedures when field changes to the original plan are required. The calculations and tabular information presented in this article are intended to be illustrative of best practices and compliance with the ANSI/ASSP A10.48 and may not cover or consider all factors for all applicable scopes. Site specific scopes of work and site conditions shall be assessed rigorously by the responsible person(s).

Throughout this PAN we discuss the ANSI/ASSP A10.48. Currently the standard is published as the ANSI/ASSE A10.48. In 2019, the American Society of Safety Engineers changed their name to the American Society of Safety Professionals. The authors

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encourage all to reference the most current revisions of the standards as a part of their planning.

What Makes Up a Gross Load?

A Gross Load is defined as the total weight of a lifted load. This includes all components such as, but not limited to, mounts, antennas, radios, structural steel, as well as rigging components including overhaul ball, rigging slings and hardware, load lines and tag lines. When determining the Gross Load, the key concept is totaling all lifted components supported by the top block and located on the load side of the top block. The following examples detail some of the things to consider with the Gross Loads for different SOW's.

Scope of Work:	Rigging System:	Gross Load Considerations:
Carrier Maintenance: Radio Replacement	Top Block with Self Trolley System	Load => Radio weight Load Line => Rope weight on load side of top block Rigging Hardware => Trolley Block Weight, Rigging Slings and Rigging Hardware Weight used to attach the load to the load line as well as the trolley block to load
Structural Modification: Diagonal Replacement	Straight Tag with Top and Heel Blocks	Load => Diagonal Weight Load Line => Rope Weight on load side of top block Tag Line => Rope Weight Rigging Hardware => Rigging Slings and Rigging Hardware Weight used to attach the load to the load line as well as the tag line to the load
New Colocation: Flying a Mount with 1 antenna and 1 radio **Reference the example titled "Gross Load Calculation" in this PAN for an illustration of this.*	Straight Tag with Top Block Only	Load => Sector Weight, Antenna Weight, Radio Weight Load Line => Rope Weight on load side of top block Rigging Components => Rigging Slings and Rigging Hardware Weight used to attach the load to the load line as well as the tag line to the load

Key Concept *– When calculating the weight of any rigging ropes, consider the weight of all rope in the air at any given moment being supported by the top block and located on the load side of the top block. As the load moves from ground level to the desired location, there will be different lengths of load rope in the air and tag rope in the air at those given times. Consider this with the unit weight of the ropes (lbs/foot) to calculate the total weight of all rope as part of the gross load consideration.*

How Do Gross Loads Turn Into Forces?

A force is an interaction that causes an affected object to be pushed or pulled in a certain direction. With a rigging system utilizing ropes and blocks, the load moves from one level to the desired elevation as a result of forces transferring through the rigging system. The Gross Load and the configuration of the rigging system will determine how large that force needs to be in order to move the load with the rigging system. The Gross Load and configuration will also influence how much force is applied to each rigging rope and rigging component in the rigging system.

Reference the image of the man holding two buckets. On the far left side, the man as able to hold the buckets with ease. In the two images on the right, the man is struggling to hold the buckets. Each configuration has the same man and the same weight buckets, but the forces generated based on the way he's holding the buckets is different. In the rigging systems, the following factors will influence the amount of forces generated by the gross load; sling angles, block angles, load line angles, tag line angles, tag method, line parting, and friction. Friction is not a main point of interest in this PAN; however, it can directly influence forces generated by gross loads in the form of wraps on a capstan, type of block sheaves, and number of block sheaves in a rigging system.

Man holding two buckets.

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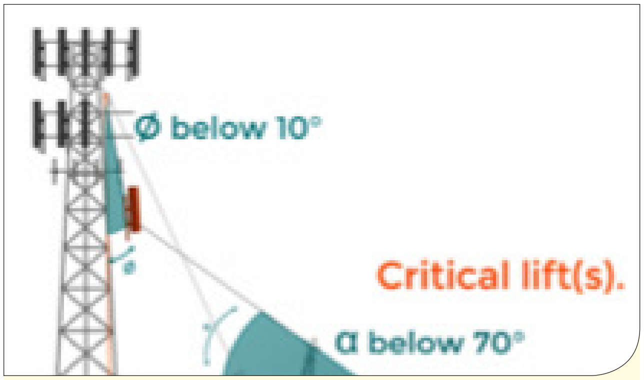

Load and Tag Angle Illustration: To minimize rigging forces in straight tag configurations, it is best practice to plan your critical lift(s) so that your load line angle (Ø) is less than 10 degrees and your tag line angle (α) is less than 70 degrees. As those two angles increase, the forces throughout the rigging system escalate rapidly without any change to the gross load weight.

How Does the Gross Load Influence my Planning?

Proper rigging planning in accordance with the ANSI/ASSP A10.48 requires specifying the construction classification of the rigging plan. Either the **scope of work (SOW), the procedures, impact to the structure or the gross load** can dictate the construction classification for a project. There are several factors that contribute to determine the proper classification, one of the several being gross loads. For construction classifications dictated by the gross load, the limitations are as follows; Class I limited to 350 lbs. or less, Class II limited to 500 lbs. or less, Class III limited to 2000 lbs. or less and requires involvement of a Qualified Person, and anything greater than 2000 lbs. requires a Class IV rigging plan with involvement of both a Qualified Person and a Qualified Engineer. A designated Competent Rigger is required for all construction classes and are typically involved in determining gross loads; however, they should always have access to a Qualified Person in accordance with the ANSI/ASSP A10.48 to ensure they are considering all the requirements necessary to properly establish construction class. Keep in mind that some SOW's may require multiple lifting system configurations to complete the work. Gross Load should be determined for each lifting system utilized to complete work.

How Do I Get My Loads in the Planning Phase?

Planning the Gross Load means understanding the weights of everything which will be hoisted and/or attached to the structure as part of the rigging system. Considering all items down to the exact weight is very important since just one lb. will make the difference between each of the classes. As mentioned in the example from the *What is a Gross Load?* section, the **load consideration** will be the exact weights of all equipment to be hoisted. NOTE: Weight alone is not the only consideration to define rigging class -example - you may have a 350 lbs. Gross Load that is Class IV construction due to other factors in the SOW. For more information refer to the PAN on ANSI/TIA 322 and ANSI/ASSP A10.48. Reference the *Gross Load Calculation* Example within this PAN.

Weight of equipment or steel to be hoisted can typically be found in construction drawings, engineering documents or manufacturer product sheets. For customer equipment, the weights of all equipment are typically contained within a construction drawing package. The individual equipment specifications can also be obtained through a simple internet search – key in the manufacturer and model name. Most if not all manufacturers will have product specifications on their website. For structural modifications, the weights of all steel will be found with the structural design drawing package. In situations where the information is not readily available, weight estimations followed by physical onsite measurements in accordance with the ANSI/ASSP A10.48 must be completed.

Conversely, rigging equipment and ropes are not included in construction drawing packages. It is the contractor's responsibility to dictate means, methods, and equipment used. Therefore, it is important for contractors and their crews to maintain records and product specifications for all the components utilized in a rigging configuration as well as ensuring proper inspections and maintenance of these components. The product specifications typically state the weight of the rigging equipment.

Rigging ropes must have special consideration when calculating the Gross Load. When a crew is implementing a lift with the top block installed at 230 feet, they may have a 600-foot rope for the load line. However, all 600 feet does not need to be included as part of the Gross Load. The plan will only need to consider the maximum length rope which will be supported by the top block and located on the load side of the top block at any given time. That length of rope will be used with the rope's unit weight (lb/ft) to determine the total rope weight to include in the Gross Load. Therefore, based on the hoist location, load staging area, and tag location, approximately 230 feet of load rope and 150 feet of tag rope will need to be included in the Gross Load. Reference the "Rigging Rope's Weight Consideration Example" for an illustration of this concept.

How Do I Get My Forces in the Planning Phase?

When planning the rigging configuration and equipment to be used, the general contractor must be able to use the Gross Load in order to determine

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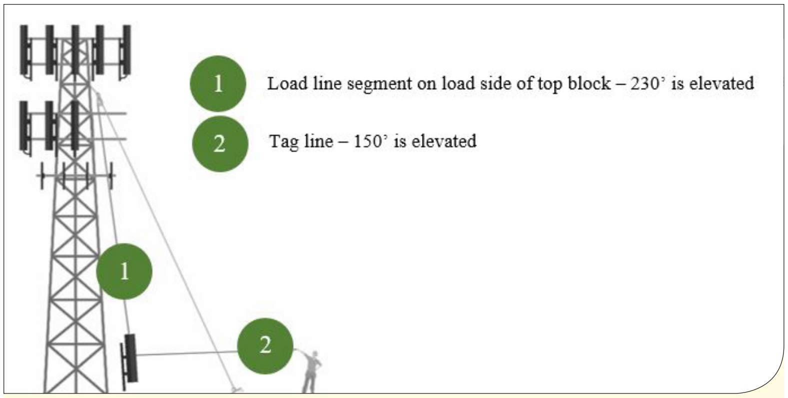
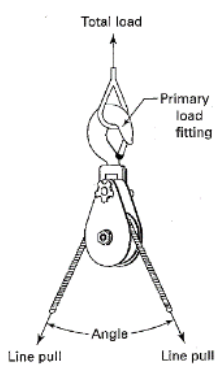


Rigging Rope's Weight Consideration Example.

the force demands on each piece of equipment and the underlying structure. A fundamental knowledge of trigonometry is essential in understanding how to perform these calculations by hand. There are also standardized charts and industry tools, which can streamline these efforts.

Standardized Charts: The ANSI/ASSP A10.48, Appendix A-13(f) Load and Tag Line Multipliers for Straight Tag Lift Arrangements is a chart with example calculations, which illustrate line multipliers that are to determine load line and tag line forces based upon the Gross Load, load line angle and tag line angle for straight tag configurations. Another example resides in the ASME B30.26, Figure 26-5.3-1 Block Load Factor Multipliers which provides a chart with example calculations that illustrate force multipliers that can be used to determine forces exerted on a block based upon the line pull (load line force) and the angle of the rope moving through the block. Understanding these charts, and others contained in standard rigging handbooks, will serve as the fundamentals for calculating forces developed based upon a Gross Load.

Industry Tools: There are few industry tools that can provide assistance in rigging planning and rigging force calculations specifically for the telecommunications industry. Research and reach out to your industry experts to learn more about what tools are available for your needs.



Tackle Block Angles

What Happens When Field Conditions Require Changes to Plan?

A plan is a plan until it needs to change. A rigging plan should be developed prior to arriving on the job site. This aids for the proper planning as well as the proper tools that are required before arriving at the job site. However, not all jobs go according to plan. Plans often change as part of a job, and if the plans do change the right course of action is Stop, Assess, Understand, Communicate and Execute. Revaluating and maintaining the plan prior to execution will tell the crew important information concerning their individual roles for safe and successful work. For instance, the crew develops the rigging plan prior to arriving at site, when performing an initial inspection to ensure the plan can be executed the crew notices a new shelter was added inside the compound, but the construction drawings were never updated to

Multipliers

Angle, deg	Factor	Angle, deg	Factor
0	2.00	100	1.29
10	1.99	110	1.15
20	1.97	120	1.00
30	1.93	130	0.84
40	1.87	135	0.76
45	1.84	140	0.68
50	1.81	150	0.52
60	1.73	160	0.35
70	1.64	170	0.17
80	1.53	180	0.00
90	1.41	...	...

A-13(f) Load and Tag Line Multipliers for Straight Tag Lift Arrangements

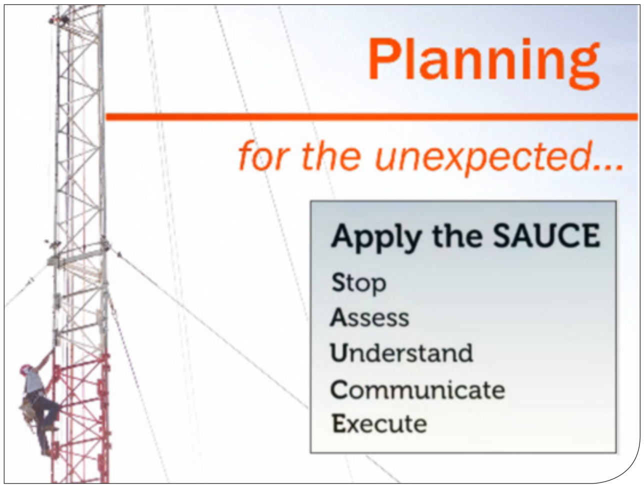
This chart and example calculation illustrates line multipliers that can be used to determine load line and tag line forces based upon the gross load, load angle and tag angle for straight tag configurations.

LOAD ANGLE, θ	LINE MULT.	TAG ANGLE, α						
		45	50	55	60	65	70	75 and Up
3	PM	1.057	1.068	1.082	1.101	1.128	1.170	Not Recommended (See Note 2)
	TM	0.078	0.087	0.099	0.115	0.140	0.179	
4	PM	1.078	1.094	1.114	1.141	1.179	1.241	
	TM	0.106	0.119	0.135	0.159	0.195	0.253	
5	PM	1.100	1.121	1.147	1.183	1.236	1.321	
	TM	0.136	0.152	0.174	0.206	0.255	0.337	
6	PM	1.124	1.149	1.183	1.229	1.298	1.414	
	TM	0.166	0.187	0.216	0.257	0.321	0.432	
7	PM	1.149	1.180	1.222	1.280	1.368	1.520	
	TM	0.198	0.224	0.260	0.312	0.394	0.542	
8	PM	1.175	1.213	1.263	1.335	1.445	1.645	
	TM	0.231	0.263	0.307	0.372	0.476	0.669	
9	PM	1.203	1.248	1.308	1.395	1.533	1.792	
	TM	0.266	0.304	0.357	0.437	0.568	0.820	
10	PM	1.233	1.286	1.357	1.462	1.633	1.970	
	TM	0.303	0.347	0.411	0.508	0.671	1.000	
11 and Up	PM	Not Recommended (See Note 2)						
	TM							

Load Line Multiplier, $PM = \frac{1}{\cos(\theta) - \sin(\theta)\cdot\tan(\alpha)}$ Tag Line Multiplier, $TM = \frac{PM\cdot\sin(\theta)}{\cos(\alpha)}$

reflect this. This will affect the tag operators working area and initial set up distance. The proper course of action is to Stop, Assess the limitations, Understand the options that exist, Communicate the planned changes both in the rigging plan document and to all involved personnel, and Execute the changed operations according to the revised plan.

Other examples of changed conditions may include; increasing the gross load lifted, changing the lifting system configuration, adding a transition block, increasing the load line angle or tag angle for needed lifted load path. There are many variables in construction and not all field conditions can be anticipated; expect that the need for change will come and be prepared to apply the SAUCE - **Stop, Assess, Understand, Communicate,** and **Execute**.



As a reminder, if the plan involves Class III construction, the Qualified Person must be engaged with the change, and likewise both the Qualified Person and Qualified Engineer need to be directly included with changes impacting Class IV construction.

In conclusion, rigging activities are a necessity in the telecommunications construction arena. When proper planning occurs the crew, rigging system, structure, and equipment all work together in a manner that safely completes the SOW and prevents dropped loads. There should always be a rigging plan that addresses each lift's means and methods including the gross load and the forces generated based on rigging system configurations. Therefore, it is important for workers to understand the following:

1. Components which make up a gross load;
2. How resulting rigging forces are then determined based on the gross load and rigging configuration;
3. Impacts the gross load will have on rigging planning;
4. How to obtain loads and forces in planning phases; and
5. Process to manage changes to rigging plans. ■