Understanding Aerial Points

By Delbert L. Hall, PhD

A question that comes up a lot on aerial discussion groups is *"What is the minimum strength for an aerial point?"* The answer to this question is simple - *"Stronger than any force you will ever put on it."* While this is good answer to the question, it is one that is probably not going to satisfy many people hearing it; but then the original question probably did not please anyone who might be asked it. In this lesson I will begin by explaining what I mean by the point "aerial point" and then discuss factors that help determine its strength.

An aerial point should be thought of as having at least two parts: the anchor to the beam, and the hardware that connects the apparatus to that anchor. Anchors can be beam clamps, slings, or even hardware that is permanently attached to the beam (like an eyebolt). The beam, the anchor, and the attachment hardware all experience the force created by the aerialist, and all of these must have the same minimum breaking strength (MBS). A good aerial rigger should also understand terms such as load path, reaction force, shear force, and bending moments, and how they relate to the strength of the beam. While these terms are very important, they are subjects for another lesson on aerial rigging.

Back a couple of decades ago, a common answer to the question about the MBS of an aerial point would have been "10 times the weight of the performer and apparatus." However, back then most aerialists simply performed poses on the apparatus while suspended above the ground - performances were not very dynamic. Today, aerialists do rolls, flips, and drops that can generate huge dynamic forces on both the apparatus and the point supporting the apparatus. So, that "old" answer to this question is no longer adequate.

So, what was wrong with the question, *"What is the minimum strength for an aerial point?"* Actually, many things, especially if you are looking for a number as the answer to the question. As implied in my original answer, the strength of point should be based on the maximum force that the aerialist will be putting on the point. So, do you know the maximum dynamic force that will be exerted on this point? If not, you can measure the dynamic force you create by using a load cell. The dynamic force produced by an aerialist can depend on many factors, including the weight of the performer, the distance of drops executed, and the apparatus itself. If more than one aerialist is using this point, you need to know the maximum force of all the aerialists, then base the MBS on the greatest force. If you do not know the maximum force, you can estimate it by multiplying the weight of the aerialist(s) and their apparatus by a multiplying factor. For most aerial apparatus, a multiplying factor of 4-6 usually works well. If the aerialist does REALLY BIG drops, that number can be as high as 8 or 9. This calculates what is referred to as the "characteristic load." So, if the heaviest performer on the point weights 145 lb, and does moderate drops, then the characteristic load might be 145 x 5 or 725 pounds.

Next, you need to apply a design factor to the characteristic load. ANSI E1-43 recommends a Design Factor of 6 be applied to the characteristic load to find the Minimum Breaking Strength for a point and all of the hardware attached to it. Using our example above, the minimum breaking strength (MBS) for an aerial point for this aerialist is 725 x 6 or 4,350. Now that we have a number for our MBS, let's put it into some perspective before we move on.

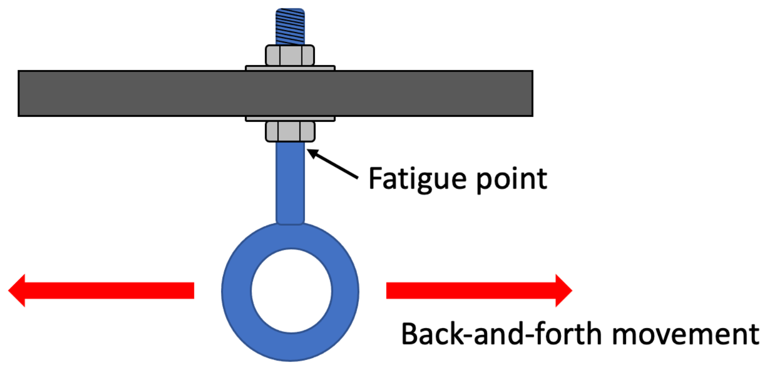
OSHA has a lot of numbers for fall arrest systems. First, it says that the MBS for a fall arrest system should be 5,000 pounds. OSHA also says that fall arrest system should limit the maximum allowable force of a fall to 1,800 pounds. This means that the system has a design factor of at least 2.77. While a design factor of 2.77 does not sound like a lot, there is one other number that might help put this into perspective - it is 2,500 pounds. This is the approximate amount of shock force that that a human body can take and survive. Put another way, an MBS of 5,000 pounds is twice the shock force needed to kill you. So, if the MBS of your aerial point is 5,000 (or 4,350 pounds) and you generate enough shock force to cause the point to fail, the shock force would kill you before the point fails.

So, does this mean that an MBS of 2,500 pounds, plus the weight of the apparatus, is enough? Not really. First, that 2,500-pound figure is just an approximation - some people might survive it, but some will not. So, the MBS needs to be greater than 2,500 pounds. Second, whatever the original MSB of the point you rig, it does not mean that it will remain at that strength - the strength of the point/hardware can easily be reduced over time, so always making the point stronger than the calculated MBS is a good idea. To understand this better, let's look at a few things that can cause a point to lose strength.

Metal components can lose strength dues to a couple of factors, including wear and metal fatigue. Aluminum components are especially susceptible to wear, especially when they are connected to steel components. Inspecting hardware is VERY important for this reason.
See the photo below.

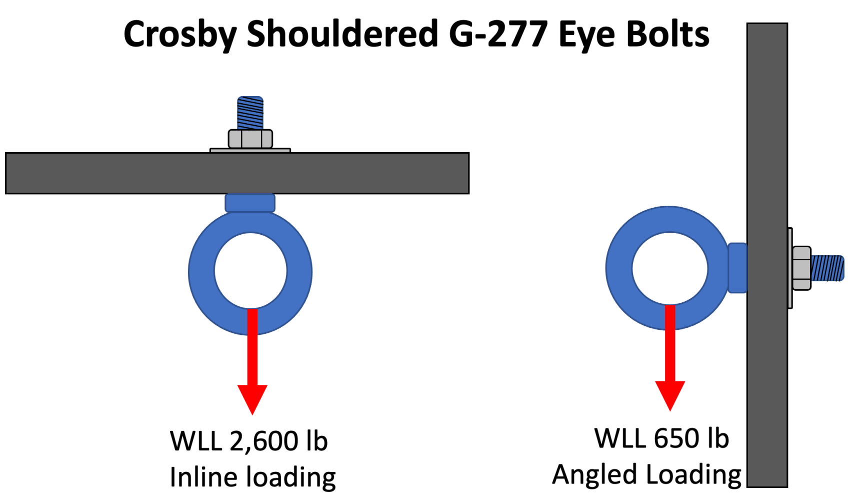
Metal components should be replaced if more than 10 percent of the metal has been worn away. Components made of fabrics, such as slings, are also susceptible to wear and should be inspected regularly and replaced if there is significant wear.

Metal components are also suspectable to fatigue. For example, below is a diagram of a long non-shouldered eyebolt being used for an aerial point. The back-and-forth swinging of an apparatus, such as a Lyra or trapeze, can cause the bolt to bend, which can cause fatigue of the metal at the nut. Fatigue can result in the metal component failing.



It could take months or years, but the metal will fatigue over time. The longer the shaft, the greater the level, the greater the force at the stress point, and the faster fatigue occurs. For this reason, shouldered eyebolts are recommended for many aerial points.

The strength of components can sometimes depend on how they are used. Since I mentioned shouldered eyebolts earlier, let’s use a shouldered eyebolt as an example. The diagrams below show two ways to that you can attach a load to eyebolts, inline loading and angled loading (in relation to the shaft), and their specified WLLs for an eyebolt with ½” dia. shaft.



As you can see, the specified WLLs are considerably different, based on how the hardware is loaded. If you do not know how the angle of the force on the hardware you are use affects its WLL, then your aerial point may not be as strong as you believe it is.

To conclude, just knowing how strong an aerial point needs be is a good start, but you must also know how strong the point actually is. Many factors must be taken into consideration in making this determination, including the strength of components, how they are used, wear, and fatigue. Also understand the beam the strength of the beam, especially how the location of the aerial point on the beam affects the strength (the bending moment).

To learn more about beams and aerial rigging, you can take my Aerial Rigging Safety course. You can find out more about this course and purchase it at
http://hallriggingacademy.thinkific.com