RIGGING AND WEAK LINK ANALYSIS

It is important to understand that with the information supplied there are substantial safety risks if they are applied improperly or without suitably thorough knowledge and experience; furthermore, our understanding of aerial work is constantly evolving so it is important to refresh your understanding so information does not become out of date. I can accept no responsibility for any inaccuracy of information in my posts, or for any loss, damage or injury. Always carry out your own risk assessment to identify and mitigate potential risks. If in doubt, consult a suitably qualified and experienced professional.

Forces and Rigging

We need to be aware of all of the forces we could possibly put on the rigging. This includes the static load and the shock load.
We also need to be aware of the directions of those forces. A static load places forces on the mount point differently than does a swinging load, and both are different from a spinning load.
When it comes to aerial rigging, we are generally concerned with four classes of force:

- Static Load
- Shock Load
- Swinging Load
- Spinning Load

Shock Load: a load that does not change. Examples of static loads include

- Hoop
- Static Trapeze (Except major drops e.g. standing to ankles)
- Aerial Silks (except drops)

A Shock Load is the result load from the rapid change of movement, such as impacting or jerking, of a static load.
A Shock Load is generally significantly greater than the static load.
Examples of Shock loads include: Drops

Swinging Load: a load that is in motion horizontally. By definition, Swinging Loads cause side loading of the mount point. In a straight swing, the highest loads are at 4:30 and 7:30. Examples of swinging loads include:

- Swinging Trapeze
- Flying Trapeze
- Some Aerial Silks
- Swinging Hoop

Spinning Load: a load that is in constant rotation. By definition, Spinning Loads cause side loading of the mount point in all directions. Examples of swinging loads include

- Corde Lisse
- Spanish Web
- Some Silks Skills

Weights and Forces

One of the difficulties with rigging circus apparatus is that we end up using rigging components from many different industries, almost none actually designed for how we use them.
Some equipment uses the systems where weight is expressed in kilograms (a mass), newtons (a force) and kilonewtons (a force with mass).
When dealing with rigging components, it is often helpful to convert everything using one system or the other.

Whenever we set up rigging, we want to start by checking over the mount point, and follow the forces all the way down to the ground.

Terms/Acronyms:
Rated Strength: the strength the manufacturer has determined the equipment should take.

SWL = Safe Working Load: SWL is one way manufacturers use to rate strength. SWL is the load the manufacturer has guaranteed the equipment can be applied to the equipment without it failing and if the equipment is used as directed by manufacturer.
A safety factor is usually built into SWL figure, which varies across different types of equipment. Usually around x7 for textiles and x5 for metalwork (check manufacturers information as this can vary).

WLL = Work Load Limit: maximum amount of weight to be put onto a structure, it was bought in to replace the term Safe Working Load.

Safety Factor: a number that the breaking strength is divided by in order to determine the safe working load.

MBS = Minimum Breaking Strength: the average breaking strength the equipment is tested to (i.e amount of force required to break this object. Often referred to as tensile strength or breaking strength) measured in KN. *There is no safety factor in addition.*
MBL = Maximum Breaking Load: the load at which the equipment on average will fail. Measured in kg. *There is no safety factor in addition.*

The formula for computing the minimum shock load is: Shock Load = [(W x Df) / Ds] + W
Df = the freefall distance
Ds = the stopping distance
W = the weight of the falling object.

Example: an 80kg person (0.8kN) who does a 9 meters free fall and then suddenly stops over a 3 meters distance, would add up to a

Shock Load = [(W x Df)/Ds]+W 80kg=[(80kg x 9 m)/3 m]+ 80kg

So, this gives us a minimum shock load of 320kg (~3.2kN) of force on the rigging.

PLEASE CHECK CIRCUS RIGGING BY NOÉ ROBERT – pages 19 – 21

HOWEVER it is extremely difficult to accurately measure where deceleration starts and the distance over which the load is slowed. The formula is also skewed if the deceleration curve is not constant, but steeper at the end of deceleration than at the beginning, which is most often the case.
However as luck has it some of that work has already been done the hard work for you and we can abbreviate the calculation using standardise data for dynamic factors.
(Weight or User + apparatus) x dynamic factor = force

A useful internet resource that does the calculation for you and where you can find dynamic factor by equipment type: http://acrobaticrigging.com/index.php/home/tools-info/calculator.

Force you put on equipment must be less than breaking load / safety factor of use or WLL.

WLA = Weak Link Analysis: the process of systematically examining each and every component of a rigging setup to find the weakest link. Once identified, rigging is designed and built with the weakest link in mind, and with the desired safety factor.