Antwerp Suscon

Rigging protocol

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FACTORS OF SAFETY

1. 1. MINIMUM BREAKING STRENGTH (MBS) is determined by 3-sigma testing, also known as the three-sigma rule. Three-sigma is a statistical tool used to calculate probability. Minimum break strength is very different from average break strength (abs), although abs is used in the calculation of mbs. The three-sigma value is determined by calculating the standard deviation (a complex and
   tedious calculation on its own) of a series of five breaks. Then multiply that value by three (hence three-sigma) and finally subtract that product from the average of the entire series. It is 99.73% probable any additional breaks will be at or above this final value. The three-sigma process:
   1.1. Carry out at least 5 breaks of the item to be rated
   1.2. Calculate the mean
   1.3. Calculate the standard deviation
   1.4. Multiply the standard deviation by 3
   1.5. Subtract the product in step 4 from the mean
2. FACTOR OF SAFETY is the ratio between the designated working load limit (WLL) or safe working load (SWL) and the load the equipment is expected to fail at. Below are examples and different terminologies.
3. DESIGN FACTOR (DF) is specified by a designer or manufacturer and this defines the factor applied to the minimum breaking strength (MBS) to determine the maximum load acceptable for a component.
4. WORKING LOAD LIMIT (WLL) is a term used by manufacturers to indicate the maximum force that should be applied to a component in normal use, regardless of industry. The ratio of MBS to WLL is referred to as the DF. Many manufacturers specify a df of 4, which implies a WLL of 25% of the mbs. Manufacturers state the WLL to ensure the item is not subjected to significant fatigue and remains in the range of normal elastic deformation.
5. SAFETY FACTOR (SF) or “factor of safety” is generally defined by industry rather than manufacturer. It may be significantly different to a manufacturer’s df. For example, a

particular connector may have a mbs of 50kn, a manufacturer specified a DF of 4, but an industry specified SF of 12 when used for a particular application.

6. SAFE WORKING LOAD (SWL) is typically determined by dividing the MBS of a component by the SF required for a particular use. As stated above, it's possible that an entertainment rigger may calculate a different SWL for a particular use of an item than the value determined by a rescue technician. The SWL should only be determined by a competent rigger.
   EXAMPLE: a particular steel connector has a MBS of 50kn. The manufacturer has specified a DF of 4 for this connector, regardless of use. This connector has a WLL of 12.5kn and this value should never be exceeded in normal use - regardless of industry and application. If this value is exceeded, it should not fail below the mbs however it should then be removed from service and destroyed. An entertainment rigger rigging in a certain country is required by the industry code-of-practice of that country to use a SF of 10 for flying performers, and thus determines the SWL of this connector is (50kn / 10) 5kn. A rescue technician in another country is supposed to apply a SF of 5 to hardware and thus determines a swl of (50kn / 5) 10kn for an identical connector.

ROLES & RESPONSIBILITIES

1. **HEAD RIGGER:** responsible for the overall rigging of the suspension event - all rigging is to be checked off by the head rigger prior to any suspension commencing. Any and all matters pertaining to rigging can be brought to the head rigger.
2. **TOP RIGGER:** responsible for the rigging of the hard point of the suspension and attaching all equipment of the load path from the ceiling to the bottom block.
3. **GROUND RIGGER:** responsible for spotting the top rigger on the ladder and must remain at the bottom as a support until the top rigger has concluded their work and is safely back on the ground. They are also responsible for identifying any hazards that may be present under and around the area to be rigged.
4. **GENERAL RIGGER:** responsible for the general checking and oversight of any rigging in place, being vigilant to ensure the safety of everyone involved with the suspension(s). It is the responsibility of all riggers to each have safety shears and a butane torch on their person in case of emergency. An LED torch should also be made available for checking of overhead rigging and/or hook shifting.

SETTING UP A LADDER

1. Secure the ladder at the top and the bottom to prevent it from slipping sideways or outwards.
2. You must wear a climbing helmet at all times when working at height.
3. Don’t overload yourself with equipment, anything being taken up must not exceed the safe working load of the ladder (150kgs).
4. Don’t overreach, stop at the third step from the top of the ladder.
5. Do not rest anything on the rungs.
6. Attach any tools/items to a harness or toolbelt.
7. Keep three points of contact on the ladder at all time
8. For every 4m the ladder is extended, it is to come out 1m (4:1 ratio).

CONNECTING THE LOAD PATH

1. Once the ladder is carefully secured against the steel beam, the top rigger is to climb the ladder with a protective layer (carpet) and round sling, while the bottom rigger secures the ladder.
2. The top rigger sets up a protective layer (carpet) over the beam checking first for any potential rough areas or abnormalities - specifically burrs or sharp edges, anything that may compromise the hardware. This layer can be taped down if needed.
3. A round sling is then wrapped around the beam by the top rigger over the protective layer using a girth hitch. Ensure this is secure.
4. The top rigger returns to the floor, collects remaining hardware (delta rapide, reeved pulley system) and climbs the ladder with the additional gear, while the bottom rigger secures the ladder.
5. The top rigger attaches delta to the round sling then attaches the pulley system to the delta. ensure there is no tension on the delta when threading the gate closed (remember to thread down).
6. Once all hardware is attached, have a competent rigger double check all the attachment points in the load path and attach a green tag.
7. It is the responsibility of the head rigger to ensure the load path is set up correctly. This checklist includes - but is not limited to:
    - PROTECTIVE MAT COVERING THE BEAM - make sure it is not moving around and is covering all of the edges
    - ROUND SLING - check it is evenly wrapped and not bunched
    - CONNECTOR - ensure the gate is closed properly
    - PULLEY SHACKLE - check pin is threaded properly and moused with a red cable tie

CORD USE

SINGLE USE CORD - when selecting an appropriate cord for use with body suspension, a safety factor of 10 needs to be employed. This safety factor takes into account dynamic forces and unknown variables but not terminations. The MBS of the cord needs to be derated by 50% to account for knots/terminations.

EXAMPLE 1: Cord with a mbs of 300 kgs (600 kg x 0.5 knots) has a swl of 30 kgs per line
Weight of person / # of hooks = swl per line. there are two lines per hook (up and down - essentially basketing).
80 kg (weight of person) / 4 hooks = 20 kg per hook / 2 lines (per hook) = 10 kg per working line (this means a cord with a minimum of 10 kg swl per line is required).
This means the 300 kg rope is suitable for this use.

EXAMPLE 2: cord with a mbs of 175 kg (350 kg x 0.5 knots) has a swl of 17 kgs per line.
Weight of person / # of hooks = swl per line. there are two lines per hook (up and down - essentially basketing).
80kg (weight of person) / 2 hooks = 40kg per hook / 2 lines = 20kg per working line (this means a cord with a minimum of 20kg swl per line is required)
Thus, the 175 kg cord is not suitable for this use.

Other factors that should be considered when selecting single use cord:

- What the cord is made from
- How well it holds knots, bends & hitches
- How well the cord cuts / melts
- How much friction the cord creates through eyelets
- How durable the cord is

TERMINATIONS

There are many knots/hitches/bends that can be utilized for body suspension. Below are the most
commonly used ones. As a general rule, it is widely agreed that knots derate rope by up to 50% - this
should be factored in when choosing a cord.

- **FIGURE 8 FOLLOW THROUGH:** This is one of the strongest terminations we use. Ideal for use on heavier dynamic loads with less attachments. This knot can also be used to terminate to the becket of the top block in a pulley system.
- **CLOVE HITCH:** Easily adjustable, perfect for use when a lot of points are being used and tension needs to be constantly adjusted. It is crucial however, that this kind of knot be backed up to avoid slipping.
- **DOUBLE FISHERMANS:** This can be used to attach two open lengths together and also as a barrel knot.
- **HALF HITCH**: This is primarily used to lock hitches/bends in place.
- **ALPINE BUTTERFLY:** Used to create an anchor on an existing line and can be loaded in multiple directions.
- **WATER KNOT:** Used to join two ends together to create a continuous loop.
- **MIDSHIPMAN'S HITCH:** Useful hitch for adjusting lines under tension.
- **ROUND TURN AND 2 HALF HITCHES:** Used generally only in static suspensions.
- **SCAFFOLD KNOT:** This is used primarily to terminate to the pulley becket (an alternative to the figure 8 follow through)

It is imperative a general rigger double checks all terminations prior to commencement of the suspension.

HARDWARE SELECTION & USE

When selecting hardware for suspension, it is important to take into special consideration its intended use and how it will work for your application. Certain hardware is designed for specific uses. Understand how they are designed and ensure their strength is suitable for your specific use. As a general rule of thumb - any single connector in the load path should have a MBS of at least 1500 kgs (15kN).

1. **ROUND SLINGS:** Round and synthetic generally - how it is used affects the strength so make sure you read the label and derate accordingly.
2. **CONNECTORS:** Popular connector options are aluminium carabiners, steel carabiners, maillon rapides and shackles.
3. **PULLEYS:** Many pulley systems are available. Marine styles are quite popular due to their high strength to weight ratio as well as their durability. Aluminium climbing pulleys are also a popular option as they too are lightweight and designed specifically with live loads in mind.
4. **MAINLINE ROPE:** Different applications may require different rope types. Commonly used are static or low-stretch ropes made from nylon or polyester. Common sizes are 10mm / 11mm / 12mm.
5. **SWIVELS:** These need to be at least 24 kn - check also the intended use of the swivel before purchasing.
6. **RIG PLATES:** Aluminium climbing plates are most suitable as these are rated for human load, are lightweight and are well finished. Custom steel and aluminium rigs can also be made to a suitable strength for human load.
7. **CUSTOM FABRICATION:** This is something that needs very careful consideration. All custom fabrication needs to be engineered by a professional who understands the intended use of the custom piece, therefore made in such a way to withstand the forces imposed on it.
8. **HOOKS:** Different hooks are available for different uses. The style of suspension will determine the desired hook type. Open gape hooks are primarily for static/semi-static suspensions; semi-locking hooks for multi directional static or dynamic loads; and locking hooks for dynamic loads.

BELAY - ASCENT / DESCENT

1. The purpose of the belay (or in the case of body suspension, modified belay) is to be able to raise and lower the suspendee in a safe and controlled manner.
2. The belayer should have an attachment point on their person, usually a well fitted harness, fit for purpose. Alternatively, utilizing a fixed point may also be appropriate (this is usually venue and situation dependent).
3. A suitable descent device should be used. Ensure the rigger/belay is trained in its use.
4. Riggers gloves should be worn to ensure hand safety.
5. The belayer is to keep their attention on the suspendee throughout the whole duration of the suspension.

MAINLINE

1. Care should always be taken with the mainline.
2. Follow the mainline inspection guide prior to use.
3. Unravel the mainline in such a way that it is free from any kinks or unnecessary twists.
4. Never stand on the mainline at any time, this can damage the rope.

GEAR INSPECTION

TO BE VISUALLY CARRIED OUT BEFORE, DURING AND AFTER USE.

1. ROUND SLINGS:

   Inspect for any damage, irregularities, or signs of wear and tear, specifically nicks & cuts. check the stitching also.
   - Check to make sure the safety tag is readable and intact

2. PULLEYS:

   - Check the sheaves are free moving
   - Check the body is free from any deformities
   - Check the swivel shackle head is moving freely
   - Ensure the shackle is in working order
   - Ensure the becket pin is secure

3. MAINLINE:

   - Rope should be inspected by passing through hands, meter by meter, feeling for any changes in the flex/shape.
   - Check for any bunching of the sheath
   - Check for any pulls in the sheath
   - Ensure there are no cuts or abrasions
   - Ensure the core is not exposed

4. CARABINERS:

   - The gate mechanism should operate freely
   - The gate should close straight so that it cleanly engages
   - The body of the carabiner should be free of any cracks, marks and deep scratches
   - There should be no corrosion evident
   - Locking mechanisms should operate freely

- Wear should be no more than 10%

5. SWIVELS:

   - Check all parts are moving and spinning freely
   - Check for any cracks, deformation, wear and corrosion
   - Ensure there are no unusual noises when spinning
   - Check the axle screw has not loosened
6. RIG PLATES:
   - Check for any burrs, scratches and wear
   - Eyelets should be free from any nicks that may damage cord
   - Ensure there is no deformation of the plate
   - Wear on the anchor points should be no more than 10%
7. BELAY / DESCENT DEVICES:
   - These can be prone to excessive wear given the friction from rope
   - Ensure the device is functioning properly
   - Check the rope surface is free from any nicks, burrs or abrasions
8. SHACKLES:
   - Check for wear on the surface
   - Check the pin is still straight and threads into the body freely
   - Check there are no signs of the body opening
   - Ensure the pin is well seated
9. HOOKS:
   - Ensure hooks are not deformed in any way
   - Check hooks for any signs of damage
   - Locking hook parts should all still align and bolts should thread freely
10. HARNESSES / RESTRAINT BELT:
    - Check all stitching, buckles and attachments for any sign of damage or wear
    - Ensure harness webbing is dressed and not twisted

GENERAL RIGGING GUIDELINES

1. All cord is single use and disposable.
2. Inverted suspensions are to be fitted with a harness with a reusable mainline attached or alternatively, a crash mat can be used.
3. All knots and connections are to be double checked by another rigger.
4. A visual check of all hardware should be carried out before and after each use.
5. Full hardware inspections are to be carried out and recorded at least every 12 months.
6. Only approved people are allowed to change, add or remove equipment and/or apparatus at our events/workshops. These people may not appoint another person to change, adjust or modify any piece of rigging gear unless competent to do so.
7. An approved person may allow a volunteer to clip gear onto the eyelet end of the pulleys however you must double check their work.
8. Wherever possible when you have attached anything onto the pulley, get another person to double check your work.
9. Only trained riggers may modify, move, adjust any rigging that directly connects to the structure.

SOURCES / CREDITS:

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- Safe Rigging Practices for the Entertainment Industry in New Zealand
- Circus Safe New Zealand
- Physics for roping technicians 2020 - Richard Delaney
- Nick Creech
- IE PROTOCOL