Tall Ships America

Adventure and Education Under Sail®

Guidelines for Safety Aloft

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Table of Contents

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I. Overview and Scope

Tall Ships America member vessels represent a broad spectrum of vessel types, programs, and missions. The guidelines provided here attempt to cover a wide range of application and are necessarily general in nature. This document is aimed at providing a variety of options for implementation of a vessel-specific aloft safety regimen. This document offers some discussion and context for the provided options. It aims to provide resources for both training and equipment suitable for use in aloft work in sailing vessels, with emphasis placed on both training and safety. Effective training and practice are the primary means of ensuring safety aloft. Harnesses, lanyards, and related safety equipment provide protection in the event of the unexpected.

Sailing vessels, by nature of their design, require that personnel go aloft as part of the regular care and operation of the ship. Whether for routine rig inspections and maintenance or for the operation of the sailing rig, this aloft work carries with it a measure of risk. Although falls from aloft are rare, the implications of such a fall are dire. All sail training vessels must provide effective safety aloft training, gear, and operational protocols to their trainees and crew. All successful sail training operators place safety at the core of their program. Tall Ships America encourages a culture of safety and seeks to assist where it can in enhancing safety practices.

II. Operational Risk Assessment

Tall Ships America recommends a codified method to assess and mitigate operational risk. A risk assessment should be completed prior to every sailing evolution or other event that involves personnel aloft. Items that might be covered in a risk assessment include proper supervision, evolution planning, crew and trainee selection and job assignment, crew and trainee fatigue/fitness, environmental considerations, equipment needs, and the complexity of the evolution. A debrief of the assessment provides for explanation, questions, and discussion. A common-sense approach is to be encouraged, partnered with a structured process for assessing risk.

III. Physical and Medical Considerations

Fitness assessment and medical screening of all personnel intending to go aloft is critical to minimizing risk. Physical fitness for climbing must be assessed, either subjectively or by a structured evaluation, to ensure trainees and crew can meet the rigors of the task. Specific medical conditions or fitness level may call for additional safety measures, limitations, or restriction from going aloft. Physical and medical assessment is an ongoing process that extends past the medical practitioner's evaluation. Potential effects of fatigue, seasickness, illness, medications, etc. must be continuously monitored.

IV. Medications, Drugs and Alcohol

Some drugs taken for appropriate medical reasons (including some seasickness remedies), prescribed or otherwise, can have debilitating side-effects. Operators should assess whether to allow personnel to go aloft who are undergoing such treatment. No personnel known to be under the influence of recreational drugs or alcohol should be allowed aloft.

V. Equipment

No topic generates a more spirited discussion than the use of harnesses and other fall arrest equipment for safety aloft. First and foremost, it is imperative to recognize that any safety equipment must be considered secondary to proper training, sound judgment and alert climbing practices. Aloft safety harnesses must be worn when going aloft. The use of safety equipment has the potential to create complacency. The use of an aloft safety harness never takes away the need to think and act safely at all times. There remains the possibility of injury to personnel despite proper use of the aloft safety harness. When considering what safety equipment to use, it is important to understand the potential forces generated as that equipment arrests the fall of a sailor.

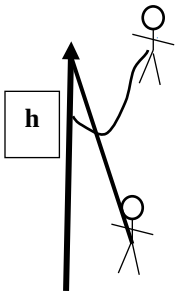
THE PHYSICS OF FALLING (AND STOPPING!)

If an object of a certain mass (in kilograms) is dropped a specific height (in meters) it will reach a determined velocity (meters/second) due to the acceleration of gravity (g), developing a kinetic energy (KE) just prior to impact or being arrested, as in falling tethered to a fixed anchor.

This alone does not inform us of the force generated until we factor in the distance (d) traveled after impact (coming up short on the tether).

Applying the work-energy principle it can be calculated that force (F) = work(W)/d

For the following, m = mass, g = acceleration due to gravity, h = height in meters, V = velocity in meters per second, and d = distance traveled during deceleration (i.e., lanyard stretch plus give in anchor point) in meters.



Velocity of the fall, $V = \sqrt{2gh}$

Kinetic Energy, $KE = \frac{1}{2} mV^2$

KE = Work (W)

W = force (F) x d therefore, F = W/d

For example: A 170 lb (77 Kg) sailor climbing with a 40 inch (1 meter) lanyard falls 4' (1.2 m) (climber is one foot above their attachment point). As the sailor fetches up on the lanyard, it stretches 3 in (0.076 meters). As the fall is arrested the individual and equipment will be subject to about 2,700 lb. or 12 kN of force. This impact exceeds both the standards of OSHA and the margins of safety for recreational climbers.

The same 170 lb. sailor climbing with a 20 inch (0.5 meter) lanyard falling 0.5 meter (climber does not climb above their attachment point), and with a lanyard stretching the same 3 inches will experience less than 1,100 lb. or 5 kN of force.

In these examples, the equipment would likely stand up to the strain; however, the individual may be injured when impact forces exceed 8 kN. Minimizing the potential distance of a fall and using equipment specifically designed to arrest a fall is essential in the selection of equipment. Professionals who work at height, rock and ice climbers, use harnesses designed specifically for their activity. Tall Ships America recommends its member vessels use fall arrest equipment, certified to national standards and designed specifically for their intended usage. The use of two lanyards can be advantageous when

used properly. A lanyard one meter in length provides for a full arm's reach and will limit falling distances. A shorter lanyard in the pair further reduces falling distances and should be used when a climber is stationary in the rig. It is important to recognize that clipping the lanyard to the rig and then climbing to the full extent of the lanyard above that connection could result in a fall twice the length of the lanyard. Climbing above the attachment point should be discouraged. The lanyard(s) should be attached to the front of the harness for ease of use and facilitating self-rescue. The size of the clip or carabiner should be considered for ease of attachment to the standing rig. The ship's rig can be a harsh environment; UV exposure, salt, and solvents can take a toll on equipment. All equipment must be subject to regular inspection, testing and maintenance. Many harnesses have a useable life span, represented by an expiration date on the harness itself. This expiration date is independent of any use or wear that would further shorten the lifespan of the harness and is effective regardless of whether the equipment was ever used at all. This, and all other manufacturer's recommendations, should be carefully monitored and adhered to.

VI. Harnesses:

- Full-body (see Figure 1)

Extensively used as fall protection in industrial settings; construction, antenna maintenance, linemen's work, building maintenance, etc., the full-body harness is the recommended standard for fall arrest protection in these environments. It reduces two key risks: inversion with the possibility of falling out of the harness and back injury during fall arrest. Full-body harnesses are available with attachment points on back or front. The front, or sternal attachment point, should be used when aloft in a sailing rig. The sternal attachment point is easy to use and promotes self-rescue and simplifies assisted rescue. The back tether attachment is often used in industrial at-height environments where a sternal attachment would put safety lanyards in the work area and where rescue is possible in the event of a fall. Operators should consider the risks associated with a dorsal or back attachment harness and the difficulty of retrieving a swinging sailor from below a yard at sea.

Figure 1: Petzl Fall Arrest Newton Harness,
a full-body harness (Image courtesy of Petzl)

Figure 2: Petzl Avao Sit Harness
(Image courtesy of Petzl)

- Rock/Ice climber's "sit" harness (see Figure 2)

Designed for alpine, rock, and ice climbing environments where repeated falls are expected. They are available in a broad range of styles and are good candidates for aloft work but do not protect as well against inversion or back injury. With an appropriately short tether and safe working habits,
a sit harness is an acceptable option for aloft work in sailing vessels. Many options are available with a range of features, including attachment points for tools and padded waist belts and leg loops for greater comfort. Threading the waist belt of the sit harness properly through the buckle is critical. Threaded buckles should be inspected prior to laying aloft.

- Arborist harness

Available as full-body or "sit" harness, these are stoutly built, and have numerous additional attachment points for rigging. Additional padding provides a more comfortable seat. These are best suited for rigging work aloft in which the rigger must sit in the harness for extended periods or carry tools and gear along.

- Chest (sailboat cockpit/deck) harness

Chest harnesses are designed for use on deck only, where they are designed to keep sailors on board the vessel during heavy weather. Rigged to jack lines or other attachment points, their purpose is lateral restraint, never fall arrest. These types of harnesses are wholly unsuitable for work aloft or fall arrest and should not be used aloft under any circumstances.

- Lineman's belt

Lineman's belts are designed for climbing poles along with boot spikes and have no practical application aboard a sailing vessel. These or any other type of belt are wholly unsuitable for fall arrest and should not be used aloft under any circumstances.

VII. Lanyards and Clips/Shackles/Carabiners:

Lanyards are the essential linkage between the harness and the rig. Minimizing any fall distance and avoiding loading the gear unnecessarily are critical to minimizing the risk of serious injury in a fall. Lanyards should be only as long as can be extended with an arm, (1 meter is a common length) and should ideally be clipped at or above the climber's harness attachment point. An attachment point below the climber increases fall length and fall factor, dramatically increasing the forces experienced by the climber.

All harnesses should have two lanyards, each with a carabiner suitable for the rig of the ship in which they are to be used. Two lanyards are preferred, one shorter than the other. The short one should be used once in position. The use of different lengths also eliminates the risk of having the climber's neck captured between two secured lanyards.

A ship with large gear and large attachments might require an oversized pear-shaped carabiner with large gate opening. Vessels with smaller gear might allow for the use of conventional climbing gear. Carabiners or clips that do not screw lock or auto-lock may be subject to 'unclipping' unintentionally in some circumstances. Choice of materials is important. Aluminum carabiners, used for their low cost and extremely low weight, are readily available because they are the choice of the recreational climbing community. But aluminum is harder to inspect, more prone to invisible cracking, and more susceptible to corrosion. A more practical, reliable, and long-lasting choice may be the steel carabiners found in industrial applications.

VIII. Shock absorption devices

Many at-height industrial safety rigs use a shock absorption device. One example of this is a length of webbing stitched back and forth, accordion style, so the stitching tears out during a fall, slowly decelerating the climber. While these are excellent at reducing the effects of a fall, they may have other negative repercussions at sea. For example, they might result in a fallen sailor swinging below a yard and unable to reach anything to self-rescue. These devices may be appropriate for some training vessel applications and should be considered in the context of these benefits and drawbacks.

IX. Rig

The condition of both standing and running rigging play a critical role in working safely aloft. A rigorous formal inspection and preventative maintenance program for all components of the rig is strongly advised. [For additional resources on this topic, see Tall Ships America's Rig Inspection Checklist and Self-Inspection Protocol.]

Running rigging should always be properly secured. Prior to any sail evolution, all personnel aloft must be alerted and readied for the executed change. When complete, running rigging should again be made fast.

Differing types of rigs can create different areas where the potential for a fall is greater. A square-rigged vessel presents different challenges than those found on a fore-and-aft-rigged schooner. The futtock shrouds, the transition over crosstrees, and the yards are locations in the rig that have been the site of multiple incidents. Vessels have modified their rigging to create alternative means for climbing in these locations and/or added rigging specifically designed as anchor points for harness lanyards. Truss cranelines from shrouds to yards assist when laying out on the yards. The addition of safety jackstays provides an attachment point for harness lanyards but must be fitted with forethought. A vertical jackstay at the futtock shrouds may potentially add a significant distance that a sailor could fall before being arrested by their equipment. The forces generated by a long fall may exceed the breaking strain of equipment and/or cause critical or fatal injury to the climber. The horizontal (Jarvis) jackstay or back rope on the yard has been used to provide an attachment point for harness lanyards, allowing the sailor to traverse out to the end of the yard while remaining attached to the wire. However, when a downward load is placed on a horizontal wire, the strain is increased up to six times the force created by the fall alone. With multiple sailors on a yard, if one falls while attached to a wire jackstay, there is potential to create a chain reaction of falls. Attachment points along the yard jackstay require clipping and unclipping as one moves out on the yard but, with a two-lanyard system, can still provide continuous safety while making the traverse and eliminating the dangers of the horizontal wire.

Backropes may be employed as an additional safety measure for sailors on footropes on the yards. Properly employed, they may be effective at offering an additional measure of protection against a "backflap" of canvas over the yard. As with all gear, backropes must be properly rigged, inspected, and

maintained. Particular care should be taken if backropes are used as clip-in points when traversing the yard. Due regard should be paid to potential strains generated by multiple sailors falling at once and to the lateral travel possible on a backrope in a seaway.

All equipment designed to prevent or arrest falls should take into account the specific rig of the vessel and the anticipated maximum strain the gear may experience.

Safety aloft regimes should explicitly include the bowsprit and areas near headsail standing and running rigging.

X. Working Aloft While Being Belayed

Hoisting an individual aloft on halyards or belaying this person from deck using a gantline necessitates additional training, skills, and supervision. The climber's safety is dependent on a crewmember on deck. The line must be attended at all times by a crewmember experienced in these skills. The gantline often uses the friction of a belaying pin to adjust the line and secure the worker aloft. The crew member on deck and at the belaying pin controls the safety of the climber and must be an expert at this skill. Clear communications between deck and aloft are essential. Whenever practical, a redundant safety system should be employed. Possible backup safety systems could include a camming self-arrest device riding on a suitable line or a prusik hitch on a safety line or stay. As with all safety gear, these devices and techniques require professional training, supervision, and practice to be effective. An improperly employed technique or piece of gear can create a feeling of safety where none exists and may be worth less than no gear at all. A sailor lowered down a stay must ensure that a shackle pin is moused and the pin is not riding on the stay to prevent an unexpected failure (backing out) of the pin.

It is possible to safely self-belay down a stay or mast in a bosun's chair or padded harness. Several methods may be employed and the climber should be thoroughly trained and practiced in the chosen technique. It is strongly recommended that a separate and redundant system be utilized to ensure safety.

XI. Training and Best Practices

Tall Ships America recommends all personnel (professional crew, participants, trainees, and/or students) receive formal training on proper procedures and techniques before climbing aloft. Participation in this training should be required prior to going aloft and should be documented in writing. Permanent crew should participate in refresher training, preferably no less frequently than annually, including a refresher on the sailing organization's aloft policy and/or Safety Management System. Training with external companies or organizations may be appropriate where little or no experience exists, as in the case of a new vessel or organization.

A suggested list of training topics include but are not limited to:

- Proper dress for laying aloft and for weather conditions. Full-fingered gloves should be discouraged.
- Explanation of vessel-specific harness, proper donning, care and storage, and proper use of carabiners and lanyards.
- Use only a properly fitted at-height safety harness in good condition. Inspect prior to donning. Personnel "buddy-check" each other's harness.
- Receive permission and final inspection of harness/attire from the appropriate designated authority (master, mate, bosun or designated observer on deck) prior to laying aloft and report in when back on deck.

- Remove and leave all unnecessary gear on deck. Knives, marlinespikes, pliers, cameras, etc. must be secured to the person by a lanyard.
- Know the status of all radio/RADAR transmitters before going aloft and avoid restricted areas.
- Whenever possible, lay aloft on the windward side only.
- Safe movement through the rig, including maintaining consistent three-point contact with the rig (move only one hand or foot at a time).
- Description and identification of standing and running rigging.
- Suitable and unsuitable attachments. Clip directly to standing rigging or loop around or through standing rigging and clip back to harness attachment point. Avoid looping around and clipping to lanyard, this may place improper strain on the clip/carabiner.
- Location and use of vessel-specific clip-in points.
- Grasp, stand on, or clip in to standing rigging or fixed gear only; never use running rigging or ratlines to hold onto or clip in to. Do not clip in to backstays. Do not use the carabiner as a hand hold.
- No unnecessary risks.
- No skylarking, acrobatics, grandstanding, haste, or competitions in the rig. Cloud walking on sails, descents or ascents other than by approved paths through the rig should be forbidden. An example is a descent via a backstay.
- No unnecessary noise.
- As soon as a person aloft stops moving or needs to work, clip in immediately unless already attached to a fall arrest device, safety stay, or other such equipment. A secondary point of clip-in is recommended with the shortest possible lanyard length.
- When aloft, work sails from the windward side. While on the bowsprit, stay on the windward side of the headsails.
- Stay well clear of all headsail and staysail sheets.
- Do not lay out onto a yard until it is secured (ie., all braces are taut and, if the sail is not set, it is in its fixed lifts). Where fall arrest systems or designated clip-in points allow, clip in before transferring to or from the yard.
- Announce the fact that you are laying out on the yard before doing so. Likewise, when laying off.
- Avoid straddling shrouds and running rigging; do not sit or stand on yards.
- While working on deck, never cast off or move running rigging while personnel are moving or unclipped in the rig.
- Take extra care bracing yards when personnel are aloft. Do not brace yards when personnel are on the yards. Ensure that no personnel (in the shrouds) will become trapped as the yards are braced sharp up to the (lee) rigging.
- Take extra care to ensure that sails are kept under control whenever personnel are in the vicinity, aloft or on the bowsprit.
- The officer supervising the helm should ensure that the sails are not luffed up when personnel are on the head rig or in the vicinity of sheet blocks/sheets.
- When on the fo’c’sle or foredeck of the vessel, be aware of flying sheet blocks.
- Professional crew engaged in work aloft should understand the additional risk of conducting maintenance aloft. Additional training should be given to crewmembers working aloft for the first time and should be overseen by authorized personnel.
- When work is to be done aloft with a crewmember on belay (attached to running rigging in bosun's chair or sit-harness); explain and demonstrate belaying a person on a pin. Verify the skill level of the crewmember tending the line on the pin and limit distractions. Confirm that the

crewmember on belay and the crewmember on deck have a set of commands that they both understand. Use a locking hitch or other method to communicate to all crew that the line must not be cast off.

- On vessels where it may be necessary for watch standers to lay aloft quickly, harnesses should be worn throughout the watch.
- Rescuing a fallen climber: Training should include the rescue of a fallen climber who is injured, unresponsive or cannot self-rescue. A special rescue kit will facilitate a quicker response. This gear should be purpose specific; lightweight, compact and preferably different from ship's running rigging. (Note: Rescue practice is a high-risk activity. Experienced personnel should lead this training.)
- Review of previous incidents, accidents, and "near-misses" aloft, their causes, and the organization's response to prevent the accident in the future.

XII. Summary

Climbing aloft on a sail-training vessel is required for rig inspection, maintenance, and sail handling. It also provides trainees with a unique challenge and experience found only aboard these sailing ships. Properly conducted with appropriate gear, training, and skill, it can be done routinely and safely. It is critical that best practices be employed to minimize risk. Sail-training organizations are encouraged to use the principles in this document, the resources listed below, and to consult experts in evaluating their own operation's risks and in preparing and implementing a safety aloft program.

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RESOURCES

Definitions:

1. Fall Factor - The fall factor is the ratio of the height a climber falls before the rope begins to arrest the fall and the rope length. Ex. Climbing aloft with a 3 ft. tether, the climber is 2 ft. above the attachment point of the tether. A fall will result in 5 ft. of free fall. The fall factor ratio is 5:3, or a fall factor of 1 2/3. Minimizing fall factor reduces the forces generated by a fall and the forces that people and equipment must tolerate.
2. Prusik - The term prusik is used to describe a loop of cord and the knot or hitch created with that loop around another rope. The prusik hitch is similar to a rolling hitch or icicle hitch in its ability to grab onto a rope while tensioned or weighted. The prusik hitch may be moved when the load is removed from the cord.
3. Ascender - An ascender is a mechanical climbing tool that can grab a rope, similar to the friction knots described above. It employs a cam that allows the device to slide along a rope in one direction but grabs the rope when weighted in the opposite direction.
4. Fall Arrest Device - Similar to an Ascender but allows travel in either direction along a fixed rope, but grabs the rope using a centrifugal camming device in the event of a fall.
5. Carabiner - A carabiner is a "spring hook"; a metal loop with a spring-loaded gate used to quickly and reversibly connect components. Carabiners are available in different shapes, sizes, and materials. The gates, when closed, are a critical part of the strength of the equipment. There are non-locking gates or locking gates. The screw gate must be manually turned to screw the lock into place. A twist lock automatically locks when the gate closes.
   Note: Many aluminum carabiners are made for recreational climbing. Industrial carabiners are commonly made of steel.

Publications:

1. Further reading: Mountaineering: Freedom of the Hills, 8th edition. The Mountaineers and Ronal C. Eng. (2010). ASIN: 159485138.

This reference is referred to as the mountaineer's and rock climber's bible. It is the American Practical Navigator (Bowditch) of the climbing world. Freedom of the Hills has detailed information about equipment, ropes, and their use. The reference has been updated eight times reflecting the latest in equipment and techniques. The relevant sections of this book would be very helpful to those exploring options for equipment as well as the use of this equipment. Rope techniques and the use of specialized knots are discussed and illustrated.

2. The Complete Caving Manual. Andy Sparrow. (2010). Cornwood Press. ISBN: 1847971466.

The equipment and techniques used in caving have relevancy to some practices used while climbing aloft. Chapters on equipment, horizontal and vertical techniques, and single rope technique may provide useful information for safe practices aloft.

Web Links:

Petzl USA

Petzl is a leading manufacturer of climbing gear/equipment. Their web site is split between Sport and Professional sections. The Professional site provides a multitude of information on equipment and its use. The link below is for verticality:
http://www.petzl.com/en/Professional/Verticality?l=US#.VMvu6mjF-So
There are numerous topics relevant to safe working practices aloft. Navigate through this section for a variety of applications.

This link accesses Petzl's Rope Access section.
http://www.petzl.com/en/Professional/Rope-access-and-confined-space?l=US#.VMvtymjF-So
: www.petzl.com

Wespur
Wespur is an arborist's site for equipment and training. The gear used by arborists is similar to climbing equipment but more industrial in design and materials. The gear is also specific to the needs of tree work. This may be helpful when selecting the best equipment for a vessels rig. Wespur contracts Ascension Group Northwest for training (see training).
http://www.wesspur.com

NFPA (National Fire Protection Association)
NFPA 1983: STANDARD ON LIFE SAFETY ROPE AND EQUIPMENT FOR EMERGENCY SERVICES
http://www.nfpa.org/codes-and-standards/document-information-pages?mode=code&code=1983
: www.wesspur.com

OSHA
OSHA regulates and provides information for safe work practices in the US. The link below offers numerous articles regarding fall protection and work in the marine environment.
https://www.osha.gov/SLTC/fallprotection/standards.html

Training:

Ascension Group Northwest
This organization offers a variety of high angle training courses and will also customize a training course to fit the needs of their client.
http://www.ascensiongroupnw.com/html/custom-training-courses.html

Ropes that Rescue: Training in the Vertical Realm
The Rope Access Skills Workshop 1 is an intensive six-day, open enrollment workshop intended specifically for those who work on rope at elevation. Rope access is used around the world to support or place workers in various environments for the purpose of performing their jobs. This may include, but is not limited to:

- Bridge, dam or structural inspectors
- High scalers
- Construction personnel
- Sea platform inspection and construction
- Tower workers

http://www.ropesthatrescue.com/rope-access

American Alpine Institute
Technical Self-Rescue for Climbers
The Technical Self-Rescue for Climbers program is an intensive one to two-day seminar on improvised multi-pitch rock rescue techniques. Participants study a series of haul, lower, rappel and rope-climbing systems and then apply them to a variety of practical scenarios. Individuals who complete this rock-rescue program should be able to apply these skills to a wide array of complex high-angle problems.
http://www.alpineinstitute.com/catalog/technical-self-rescue-for-climbers/
http://www.osha.gov/SLTC/fallprotection/