Jacklines, Clip-in Points and Tethers

Improved designs and approaches

By Evans Starzinger

Offshore boats typically carry (and are required by the Offshore Special Regulations to carry) jacklines, tethers and harnesses in their safety equipment. These systems have two objectives: (1) to keep the crew attached to the boat if they go overboard, and (2) to minimize the possibility they will in fact go over the side.

The majority of offshore boats use a "typical system" that incorporates polyester webbing jacklines that run up the sidedecks from near the stern to the bow, and 2-meter long tethers (or tethers with two legs of 1 meter and 2 meters) to connect each crewmember's harness to the jackline. This "typical system" does an adequate job of keeping crew attached to the boat, but a less adequate job at keeping crew on deck. There are several potential improvements to this "typical system" that can improve results for both objectives.

System design

Work Stations

The majority (very roughly 8 out of 10) of MOBs (from offshore sail boats) are in situations where the person was stationary, working with both hands (not holding on to the boat), and usually (about 7 out of 10) standing up. Relatively few MOBs occur when people are simply moving up and down the deck, which is unfortunately the situation the "typical system" is principally focused on.

So, the first improvement priority is to focus on the "work stations" (helm, winches, mast, innerstay, headstay). Fixed clip-in attachment points at each workstation where people are working with both hands can go a long way toward reducing the risk of MOB. Traditionally, through-bolted padeyes have been used as attachment points, but Spectra loops through already existing strong points (existing padeyes, blocks bases, strong hand grips, etc.) are at least as strong, lighter, and eliminate the need for holes through the deck. Going one step further, as is recommended by the OSRs, and attaching tethers that are the "perfect length," that is just long enough to allow you do work but no longer, means a tether is always available even if the crew forgets to bring theirs. Though not ideal, these tethers can even be hooked to a belt if the crew does not happen to have either tether or harness with them.

These fixed tethers can be made from webbing, as most typical crew tethers are, but ¼" spectra cord is stronger than the OSR requirement and will coil much more compactly. Spectra cord tethers also use very easy to make and reliable splices and do not require any machine sewing. The shackle that clips to the crew should be a "release under load" type. "Trigger shackles" (as made by Tylaska and Wichard) are typically considered the best design for this.

If the crew is spending a lot of time sitting on the rail, it is advisable to also organize a secure "perfect length" solution for that "work station." If there are strong hand grips along the coach roof edge, one convenient solution is to have the crew tethers be just long enough to loop to the handgrips while hiking, but no longer.

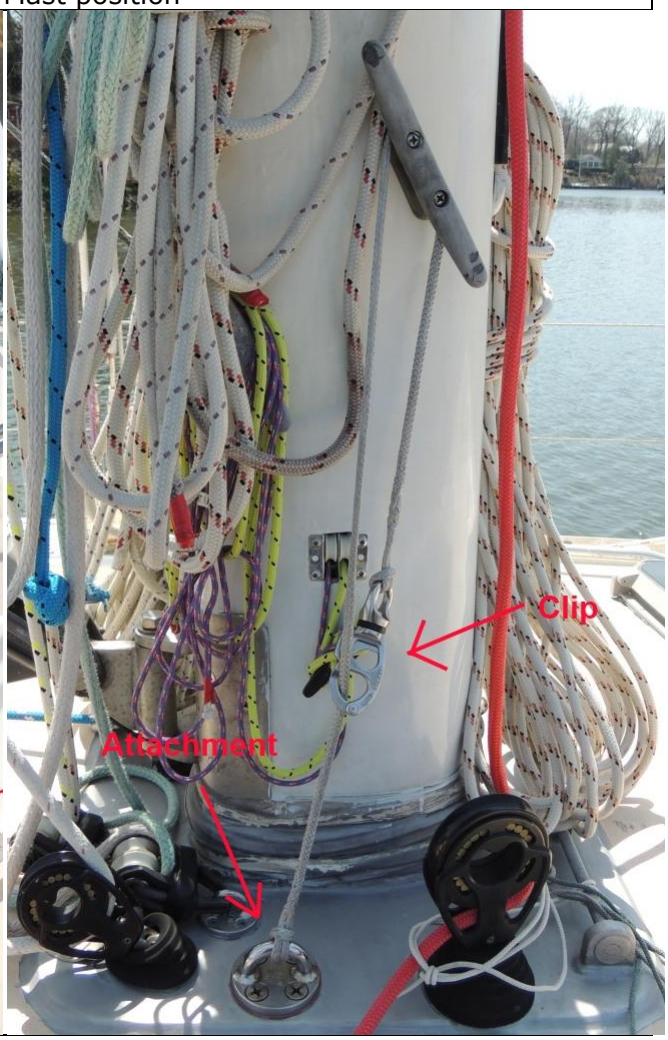
On some Volvo boats, the jacklines have webbing loops sewn into them near the work stations. Crew clip around the whole jackline to move up the deck, and the loops are designed to be low profile enough to allow the tether clip to slide over them. To work at a work station, crew clip to the closest loop. This would prevent a crewmmber from being washed back down the whole jackline if hit by a wave.

Center Line clipping
The second improvement priority is to move the jacklines as far inboard as practical. This obviously will keep crew as far from the deck edge as possible. Crew do need to be able to reach and clip/unclip to the jackline from the side deck. On boats with a wide beam this will place the jackline about ½ meter in from the cabin trunk edge. Further inboard is obviously 'safer' but also tends to be more awkward and less likely to actually be used by the crew.

Ease of Use
Of course, this whole centerline clipping/jackline/tether system will be of no value unless it is actually used when conditions warrant it. Today a significant fraction of racers consider their systems to be too clumsy, too slow, and too ineffective to use except in the direst situations.

So, to get crew to use the system, the final improvement priority is to make every part of the system (a) easy and smooth to use, (b) not a major hindrance to working the boat, and (c) stow well so it does not get in the way and the clips will not damage the gelcoat. The objective is to make it one quick motion for the crew to clip/unclip, reach, rehang/reclip.

The fixed tethers of ¼-inch Spectra with trigger shackles are recommended as the most compact, fastest and easiest systems to use. Each of the fixed work station tethers need a specific convenient place to coil, clip or hang. How best to do this will depend on the nearby deck hardware and lay out, but the tether might clip to a little hook, or to the base padeye or Spectra loop. Here are photos of solutions at the helm and the mast which seem to work well. The helm tether is sized so that it just allows the helmsman to sit and steer from the coaming, while the mast tether just allows a crewmember to work winches on both sides of the mast.

Helm position	Mast position
	

Jackline Elasticity

The OSRs set a minimum 4,500 lbs breaking strength for the jacklines. Webbing, Spectra line, and wire are all allowed. The jacklines need to be constructed to have 'just enough, but no more' stretch. A little stretch (say 3-6 inches) will absorb shock loads, which can impose quite high loads on the ends of the jackline and on the attachment points because the low angle geometry of a tight jackline means there is A LOT of leverage on the ends.

One way to set the perfect amount of stretch is to use hollow polyester webbing (which is more UV resistant than nylon or polypropylene) with a ¼-inch Spectra cord (5mm, 3/16 inch is the minimum diameter required by the OSRs for jacklines) threaded down the center and adjusted to be slightly slack. This arrangement will allow the polyester to stretch before taking up. The webbing protects the Spectra cord from UV and chafe, while the Spectra acts as a secure backup to the webbing. Compared to the alternatives, the webbing plus Spectra cord approach to jacklines combines high strength, UV and chafe protection, and the capability to adjust and fine tune the stretch/elasticity.

Jackline Attachment Points
The attachment points need to be as strong as the jackline itself, and as mentioned above, the OSRs require a minimum breaking strength for jacklines of 4500 lbs. The attachment points should be through-bolted or welded padeyes, cleats or other strong anchor points. On a fiberglass boat, the hardware will have to be fastened through the deck with at least four ¼-inch stainless steel machine screws with a substantial backing plate under the deck. Stanchions and stanchion bases should not be used for two reasons. First, they can be pulled from the deck in a hard roll or when a mast comes down, leaving the jackline loose (the same is true of stays and chainplates). Second, some stanchion bases are strong enough but most are not.

Because it is easier to retrieve someone from the side of the boat than from the back, the aft end of the jackline should be attached at least 2 meters forward of the transom. That way, if someone who is clipped in is washed over the lifelines, the crewmember will not end up behind the boat but alongside.

The jackline can be attached to the strong points in a variety of acceptable ways: (a) the jackline can be cleated around a cleat; (b) a loop in the end of the jackline can be cowhitched to the hardware; (c) a loop in the jackline can be lashed to the hardware (the lashing will need to be as strong as the jackline); or (d) the jackline can be tied to the hardware – the figure 8 and water knot are useful webbing knots for this.

Personal/portable tethers
The various minimum requirements for the tethers which the crew carry with them are spelled out in detail in the Offshore Safety Regulations. But a short summary is:
(a) Each crew member shall have a harness, and a tether which is not more than 2m in length.
(b) At least 30% of the crew shall in addition to the above be provided with either a second safety line not more than 1m long, or a mid-point snaphook on the 2m safety line.
(c) A coloured flag shall be embedded in the tether stitching, to indicate an overload has occurred.
(d) The use of snaphooks with positive locking devices is strongly recommended. At least 30% of the crew shall each

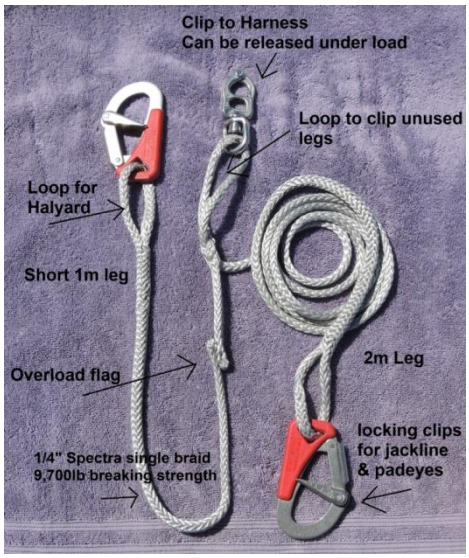
A picture is below showing the various features.

When using a '2 leg' tether, it is important to clip the unused leg back to the tether itself and NOT clip the unused leg directly to your harness (as many people do without thinking about it). The reason is that if you clip it to your harness you are now attached by a not-releasable-under load clip and have defeated the purpose of the 'releasable under load' clip. So, the tether should have a ring or loop near the harness clip where you can clip the unused legs.

The only feature we would add is a 'halyard loop' in the tether near the jackline clip. Then, in the case of a tethered MOB, a halyard can be clipped to this loop quite easily, the tether can be unclipped from the jackline, and the halyard can be used to start hoisting the MOB immediately. The MOB is always attached to the boat, and there is no wasted time trying to figure out how to lift them.

Note: there is no official specification for what load the 'overload flag' is suppose to break open at. So, if you make your own tethers, you can pick whatever loading you feel is sensible. I use 10% of the breaking strength of the tether material, which translates into 900lbs the ¼" spectra single braid (9,700lb breaking strength).

An example 'two leg' tether showing the various features:



System Use

Prevention

It is of course best to simply prevent/avoid crew being unstable. It may not be macho, but kneeling or sitting at the work stations when working with both hands is much more stable than standing and should be encouraged by the skipper and watch captains. The deck should be truly non-skid. It is useful to do an inspection and identify slick spots such as Lexan hatch covers, bare gelcoat on coach roof sides, and worn down nonskid in high-traffic areas. These can be easily improved with nonskid tape or paint. Toe rails and bulwarks are not popular with some racers but they do give crew a secure place to put their feet when the boat is heeled. Strong handgrips positioned to provide secure handholds from the cockpit to the bow area allow the crew to keep "one hand for themselves" all the way forward and can be used as strong clip-in points, particularly for sitting on the rail. Finally, deck layout often can be improved to remove tripping hazards in the form of lines and hardware in or across traffic areas.

When to Use

Skippers and watch captains must be clear about when the crew will be clipped in and securely tethered. There are four obvious situations where clipping in would be recommended: (1) When there is the possibility of solid green water on deck that can wash off someone with a firm grip on the boat. (2) When there is the possibility of more than a 40 degree knockdown as would be the case, for instance, when encountering unusually shaped waves, as is typical in a current or over shallow water; or breaking waves on the beam; or in particularly squally or gusty conditions; or when pushing a chute very hard in a big breeze and waves downwind. (3) When working in a particularly unstable and vulnerable position, for instance, when working out on the pulpit with a moving spinnaker pole. (4) When recovery of a MOB might be particularly slow or difficult – for instance at night with a minimal 'delivery' crew on board. The key skill is to recognize that a particular situation will make the crew vulnerable and clip-in well in advance, and not just react after the fact.

Beyond that it's a skipper and crew judgment call. Some skippers have hard and fast rules about when to clip in, such as at night and whenever the boat is reefed. Others make more situation-dependant calls, such as while the crew is finding their sea legs, when the waves are unusually unpredictable and uneven, or when the deck is unusually slippery or has particular 'trip hazard' in its layout. But with a properly-designed system, as described

above, the crew should feel comfortable and not constrained by clipping in whenever they are stationary at a work station.

Recovery

It someone goes over the side while tethered, it turns out to be quite difficult for many crews to lift the MOB back on board. Quite a number of tethered MOB have drowned quickly and/or gotten knocked unconscious on the hull side while the crew was trying to figure how to get them back on board. So speed is of the essence.

First the boat should be stopped IMMEDIATELY. This will greatly reduce the possibility of drowning and bashing. It also reduces water pressure on the MOB and makes them easier to recover.

Second, unless you have some true NFL linebacker types on board, skip trying to pull the MOB up by hand. This is much harder than it initially seems it should be because it is so difficult to get a good angle that allows any leverage. It's best to go directly to lifting with a halyard. It is not an ISAF requirement but, as mentioned above, it is convenient to have a loop in the tether about a foot from the jackline clip end. If you have one of these, you can clip the halyard to this (over the lifelines), tighten up the halyard, and then unclip the tether from the jackline (so the MOB is always attached), and then hoist away with the halyard. If you do not have this sort of loop, then clip the halyard to the tether just behind the jackline clip, so that when you lift the jackline clip will jam in the halyard shackle. Take up on the halyard and then release the whole jackline from one end (cut the lashing if its lashed, uncleat it if its cleated, etc.), and then lift away.

Third, when you have gotten to the 'lift away' part, and if you have spare crew, cut the lashings on the lifelines so you only have to lift to the deck edge and not over the lifelines. Wait as long as possible before doing this to make sure everyone else stays on deck.

It is very helpful if the the person in the water has crotch straps hooked up, otherwise the MOB needs to keep both arms firmly down to prevent slipping out of the harness/PFD. However, current crotch strap designs are far from perfect. They are primarily designed to hold the PFD floatation bladder down, and not to lift or tow a person. Most crotch straps are clumsy and uncomfortable, so many sailors tuck them out of the way and do not use them even when they come attached to the PFD. We hope harness manufacturers are working on improving the designs.

Construction Details

Hollow Webbing with Spectra Cord Jacklines

The Spectra cord can either be sewn at the ends of the webbing, particularly if there are also sewn loops in the webbing ends, or knotted (or both). Knotting works and is easy . . . just bring the cord out the end of the webbing and tie it into around the webbing loop. However, sewing is preferred, because it keeps the cord inside the webbing and protected from chafe and UV and it is neater with less to snag on deck.

There are several techniques for sewing spectra cord into webbing. A sewing machine with the special cord sewing foot is the simplest; it will guide the stitching right down the cord. However, a neater and stronger technique is this: (a) unbraid the cord for about a foot; (2) cut two pieces of Dacron sail cloth about a foot long and wide enough to fit neatly into the hollow webbing when folded in half or third; (3) spray one side of the sail cloth with high strength contact adhesive (3M); (4) fan the unbraided Spectra fibers out on the adhesive on the Dacron, and then fold it to the size to fit in the webbing and clamp until the adhesive is set; (5) pull it back into the hollow webbing; (6) sew a 5-inch "X box" (described below)

through the webbing and Dacron, and add several extra bar tacks at each end for good measure.

Sewn loops on the end of the webbing (and for the spectra cord) require a surprising number of stitches to match the OSR required webbing strength (4,500 lb breaking strength). V92 polyester thread is a common 'heavy duty' thread used for this application. It has a 14 lb breaking strength. So, at 10 stitches per inch, you need a total of 32 inches of stitching to reach 4,500 lbs and that assumes that all the stitches are exactly evenly loaded. 60 inches would adequately account for some uneven tension and some UV damage. So, just as an example, if you are using 1-inch wide webbing, and you stitch an "X box" pattern (see below), the box needs to be 5 inches long, with each edge and the X sewn 3 times (at 10 stitches/inch), to get 60 inches of stitching.

This is a professional "X Bar" stitch. However, there is not enough stitching here for a 4,500 lb jackline application. It should be a 5-inch long rectangle rather than a square, every leg should be triple-stitched, and it should be 10 stitches/inch (it looks instead to be about 5).	

The sewing should be done with a contrasting color thread, to more quickly spot chafe and popped stitches, and triple-stitched using 'machine lockstitches' (the most common sewing machine stitch) so that the stitches are as even as possible in tension and will not quickly unravel if one stitch breaks.

Splicing

For single braids, there are two splices in common usage: the locked Brummel and the Bury Splice. Both splices are acceptable, but the Bury splice is simpler and more resistant to improper construction, so it is generally used.

The single braid Bury is perhaps the simplest of all splices in all types of line. After making it once with instructions, most people can make it again without instructions. This splice must absolutely be lock stitched or it may slip under low load. With lock stitching it is absolutely secure.

The locked Brummel is more complex and many people will require instructions each time they make it. In return for this complexity, the locked Brummel is more secure (without lock stitching) against low load slipping. However, if the buried tail is too short on a locked Brummel, the whole load can come off the 'knot like' locking portion and it will break at much lower than expected load. Recent testing indicates the buried tail must be 72 times the diameter of the line, which is longer than previously recommended and typically used in practice.

In double braid line you can strip the cover off the ends of the line and use either of the above two splices on the core just as if the core was a single braid line. However, that exposes the core to UV and chafe at the splices. To avoid this you can either cover the splice carefully with tape, or use a more complex splice (called a Core to Core splice, or Core to

Core 2) which covers the core. These splices are more difficult that the single braid splice, particularly getting the necessary long bury driven home. But do not skimp on the bury as it is critical to the strength of the splice in these very slippery fibers.

One key to proper construction for both splices is a long smooth taper on the buried tail. If the tail is not tapered it will create a stress riser at its end and the splice will fail at that point.