Kelly-Peterson 44 / Formosa 46

R.M. (lbs) @ 30 deg	72000	Righting Moment
Beam (Ft)	11.2	
Shroud Load (Lbs)	19286	Shroud Load = R.M 30 * 1.5 / (Beam / 2)

Safety Factor	2.5	
Design Load	48214	

Formulas from Riggers Apprentice by Brion Toss

Strength Factor	1.2	Difference from standard tables
Wire Threshold	45%	Use Wire High if Delta > Threshold

IMPERIAL WIRE SIZE	% of Load	1x19 Load (Lbs)	Min BL (Lbs)	Wire Low	Wire High	Delta
Lowers D1	25%	4821	12054	9/32	5/16	90%
V1	50%	9643	24107	7/16	1/2	12%
Intermediates D2	29%	5593	13982	5/16	3/8	32%
Uppers D3/V2	30%	5786	14464	5/16	3/8	42%
Jibstay	30%	5786	14464	5/16	3/8	42%
Backstay	25%	4821	12054	9/32	5/16	90%
Forestay (Staysail)	25%	4821	12054	9/32	5/16	90%

METRIC WIRE SIZE	% of Load	1x19 Load (Lbs)	Min BL (Lbs)	Wire Low	Wire High	Delta
Lowers D1	25%	4821	12054	7	8	90%
V1	50%	9643	24107	11	12	12%
Intermediates D2	29%	5593	13982	8	10	32%
Uppers D3/V2	30%	5786	14464	8	10	42%
Jibstay	30%	5786	14464	8	10	42%
Backstay	25%	4821	12054	7	8	90%
Forestay (Staysail)	25%	4821	12054	7	8	90%

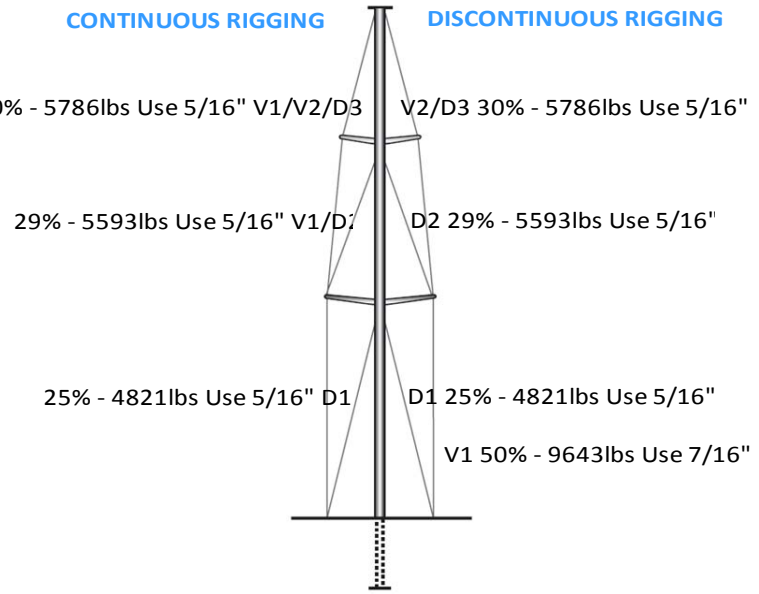
Note 1. Wire Factors are based on 1x19 316SS tables (see Wire worksheet).
Note 2. Delta = percent of load difference from Lower Wire Size to Higher Wire Size.
Note 3. Righting moment is always given in foot-pounds.
Note 4. % of load values and formulas as specified in The Rigger's Apprentice, Brion Toss, pgs. 137-138. 1998

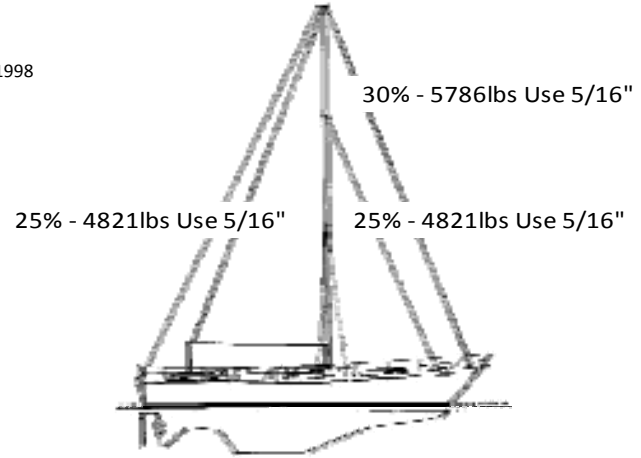
Brion RECOMMENDS	METRIC	IMPERIAL	ORIGINAL	FINAL	
Lowers D1	8mm	5/16	5/16	8mm	
V1	~~11mm~~	7/16	3/8	11mm*	
Intermediates D2	8mm	5/16	5/16	8mm	
Uppers D3/V2	8mm	5/16	3/8	10mm	
Jibstay	10mm	3/8	3/8	10mm	
Backstay	11mm Dux	11mm Dux	3/8	11mm Dux	$610
Forestay (Staysail)	8mm	5/16	5/16	8mm	

* 11mm not available. Use 10mm Powerflex (Dyform) instead.

	kg	lbs
10mm Powerflex (Dyform) is	9800	21605
7/16" is available	10700	23589
10mm 1x19	8415	18552
8mm 1x19	5745	12665

Righting Moment	ft-lbs	kNm
Selden Calculated Righting Momer	48237	65.4
Brion Toss Riggers Apprentice	72000	





KOS Stainless strain testing appears to be about 20% more than what is listed in standard tables

BT (Brion Toss) Final Recommendations:

7/16" V1, 5/16" V2/D3, 9/32" or 5/16" D2, 5/16" lowers and forestay, 3/8" jibstay or metric equivalents of any of these. 1/2" V1's are too big and would also require very large pins.

We recently had Brion Toss replace the standing rigging on Tango (KP44 #115). Here are his comments.

Dennis

Rig sizes should of course not be arbitrary; they should reflect the loads that are imposed on each piece. In the case of this vessel there was an apparent anomaly, in that the 3/8" V1's which extend from the chainplates to the lower spreaders, were quite a bit weaker than the combined strengths of the 3/8" V2's, which go to the masthead, and the 5/16" D2's, which go from the lower spreader to just under the upper spreader. If the upper two wires were the right size, then the V1's were too small, and vice versa. It was also possible that all of them were the wrong size, having no relationship to the vessel's righting moment. So it was clear that we had to start by determining the loads that the vessel put onto those wires, before we chose new wires for a rerig.

There are several ways to do this. The simplest one is to consult "Skene's Elements of Yacht Design" for a chart showing typical loads for a vessel of a given waterline. This is a remarkably reliable chart, in my experience. For a KP44, with a waterline of 38'8", we can derive a load on the shrouds of in the neighborhood of **33,750lbs**, once we have taken the vessel beam and safety factor into account. About 60% of this load can be expected to land on the V1's, which means about 20,000lbs, and this translates either to 7/16" 1x19 or 3/8" compact strand. For more on this process, see my book, "The Rigger's Apprentice."

To double-check the accuracy of those chart-derived figures, the owners arranged for a direct incline test. Because righting moment increases in approximately a straight line through at least 30 degrees of heel for monohulls, even a small amount of heel, from a small load, can be extrapolated for loads at large angles of heel. My favorite method for such a test is to have as many people as will fit lined up along the rail of the boat. Their weight, times their distance from the centerline, gives the foot-pounds of force heeling the boat. The resulting angle of heel can be measured old-school, using a pendulum and square, or new-school, using an inclinometer on a smart phone.

In the event, a sufficiently large group of friends wasn't available, so the owners placed a weight at the end of the boom, swung the boom out to the side, measured the heel, and repeated the exercise on the other side. The results were consistent side-to-side, and the extrapolation showed righting moment fairly close to that derived from the chart, just a bit higher, but resulting in the same wire sizes.

Based on these results, we installed 3/8" compact strand V1's, 5/16" 1x19 V2's, and 9/32" D2's. These sizes reflect typical distribution of load, and the V1's are no longer overwhelmed by the upper two wires.

Note that this wasn't the only KP44 with anomalous wire sizes. Also note that the rigs aren't collapsing all over the place. But the dimensional changes on this boat accomplished two important things:

First, we achieved a consistent, desirable factor of safety for all components. Previously the V1's were weak relative to the combined strengths of the wires they supported, meaning they were more /likely/ to fail. That hazard was now gone.

Second, we were able to reduce weight aloft, so that the boat will sail better, have less weather helm, need reefing less often, etc.

--Brion Toss

Continuous rigging allows all shrouds to pass over the spreader tips without termination, therefore making continuous rigging popular due to the ease of spreader design, installation, and straightforward tuning adjustment all at deck level. It also is less expensive and thus favored by many builders of production boats.

Discontinuous rigging is based on the principle of one stay in between each span, linked by tip cups tip cups or special links. Each span is fitted with the correct size wire or rod to accept the loads, so the stays can be reduced in section progressively up the spar. The center of gravity is lowered, windage is less and often the total rig weight is lowered. Tuning, although done at deck and spreader levels, is easier due to the shorter span lengths, therefore less stretch in each stay.

On BEATRIX we have discontious rigging, which I believe is the preferred design.