

Rescue Knot Efficiencies Revisited, Again

ITRS 2023

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This presentation, as you can tell from the title, is a follow up to our earlier presentations in 2008 and 2014 at ITRS about knot efficiency for various sizes of kernmantle rescue rope.

With the wider acceptance of G rated 11mm ropes we have been getting questions from students in our classes about the knot efficiency using that rope and other smaller, meaning less than 12.5 mm (½”) diameter, ropes for rescue. Our previous testing was all done on what at that time was NFPA “G” rated rope nominally 12.5 mm in diameter.

We thought it would be simple. Run the tests with the new rope on the same knots, and be done with it. It didn’t turn out that way as you will see.

For reference this table is a summary of the results of our previous testing.

Knot	Rhino Rescue - 1987	Nylon Lifeline-2008	Polyester Lifeline-2014
Bowline	67%	75%	58%
Butterfly End to End		66%	60%
Butterfly Loop to End		77%	61%
Figure 8 End to End		74%	54%
Figure 8 Loop to End	80%	77%	70%
Double Loop Figure 8	82%	75%	66%
Figure 8 Bend	81%	57%	66%
Double Fisherman	79%	79%	80%
Inline 8 End to End		51%	49%
Inline 8 Loop to End		73%	63%
Scaffold Knot		81%	69%

The above tests were all conducted on 12.5mm (1/2”) samples

Cordage Institute CI-1800 test method (4” drums, 38-150mm/Minute pull rate etc.)

At least 5 samples for each knot in the Lifeline tests. Unknown for the 1987 tests.

Results were calculated by dividing the results of control samples (no knot) tests into the knot tests.

General Notes and Disclaimers

The data gathered over 15 years is incomplete and probably inconsistent, Different test machines and reporting methods were used. In the case of the 1987 data no information about the test method is available and it was before the current test methods were written or electronic load cells were used.

No one type of rope was sampled over the entire diameter range.

For the end to end tests with midline Figure 8, Butterfly and Inline 8 knots no load was applied to the loop. That might not be a real world condition but all knots were tested the same way for comparison. A carabiner was placed in the loop to insure that the loop did not collapse when force was applied.

Not all of the knots were tied by the same person and while all were pulled to be “hand tight” that might vary. It is unknown if that is a factor for knot strength.

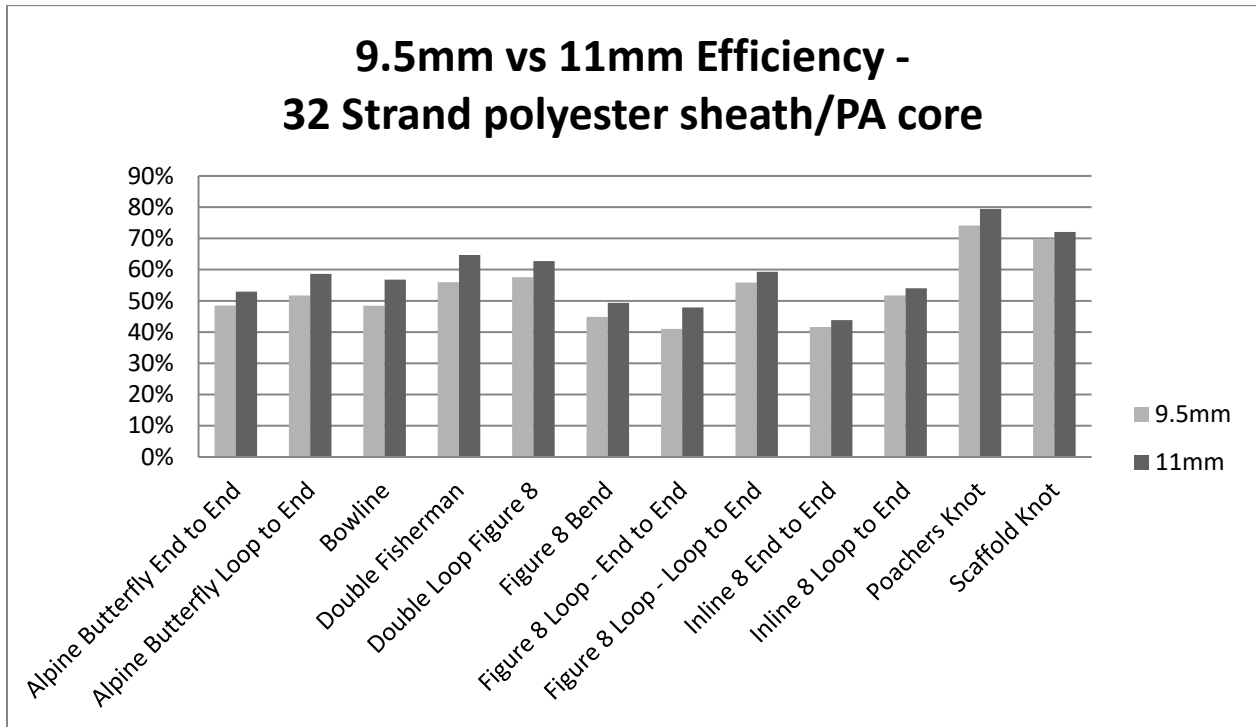
Because we had a mix of different ropes, in different sizes from different manufacturers we were limited in our ability to run a complete set of 5 tests each on the 12 knots. Therefore we scrapped our original plan and are reporting different comparisons based upon rope diameter, construction and materials. Our intent is to do further testing, including repeating the 2008 and 2014 tests to have a more complete data set. What follows is the result of 487 tests.

- The ropes were divided into 5 Categories:
 - 9.5mm Polyester Sheath (KMIII)
 - 9.5mm Aramid Sheath (Canyontech and Tac Response)
 - 11mm T Polyester sheath (KMIII and Static Pro)
 - 11mm G Polyester sheath/Nylon core (G-11 2.0 and SYNC)
 - 12.5mm (Static Pro)
- Lifeline rope tests were not included. There was no other nylon over nylon rope for comparison.
- Only comparing knots with full data set
 - Alpine Butterfly – End to End
 - Alpine Butterfly – Loop to End
 - Bowline
 - Double Fisherman
 - Double Loop Figure 8
 - Figure 8 Bend
 - Figure 8 Loop
- With data cleanup, clear trend between 9.5, 11, 13mm ropes (poly sheaths).
 - 54% vs. 60 % vs. 65% respectively.
 - Larger diameter= larger bends= higher efficiency
- Aramid sheath ropes performed similar to poly sheath ropes on average.

Diameter Comparisons

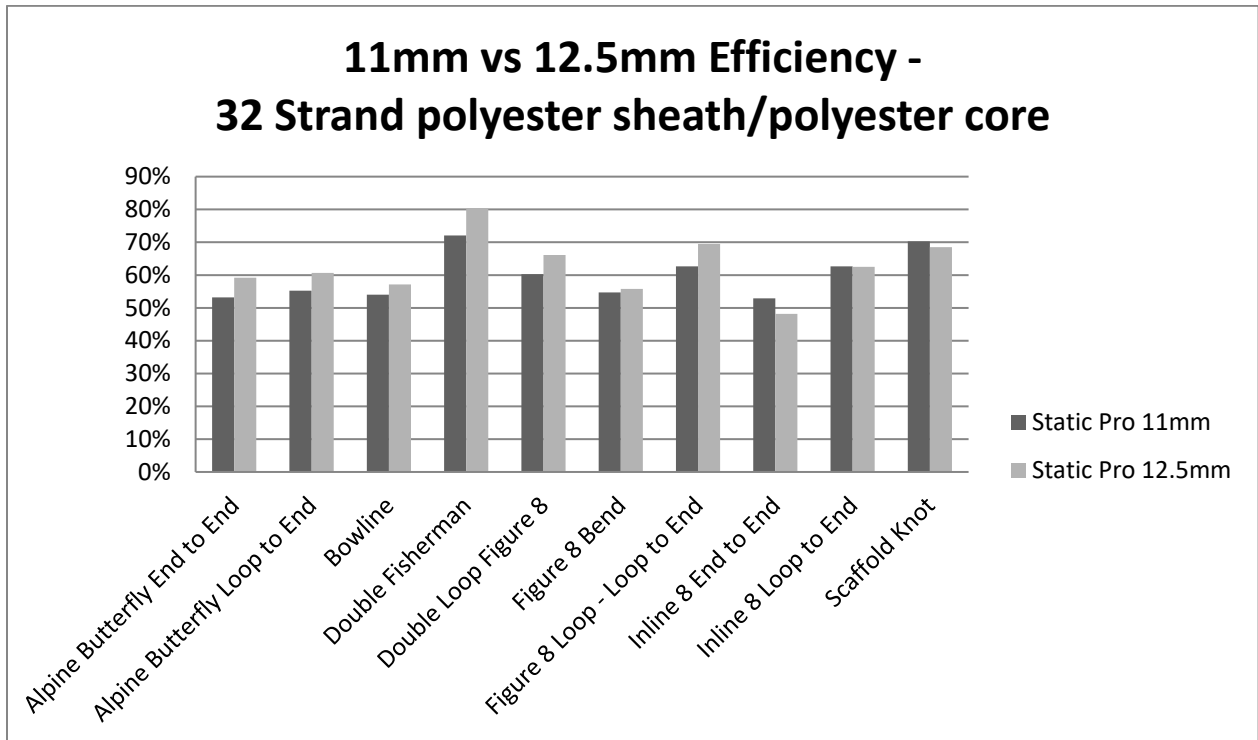
9.5mm vs. 11mm

- Comparing 32 strand polyester sheath/PA core across diameters (KM III).
- Complete knot set.
- Larger diameter had higher residual strength across the knot range.



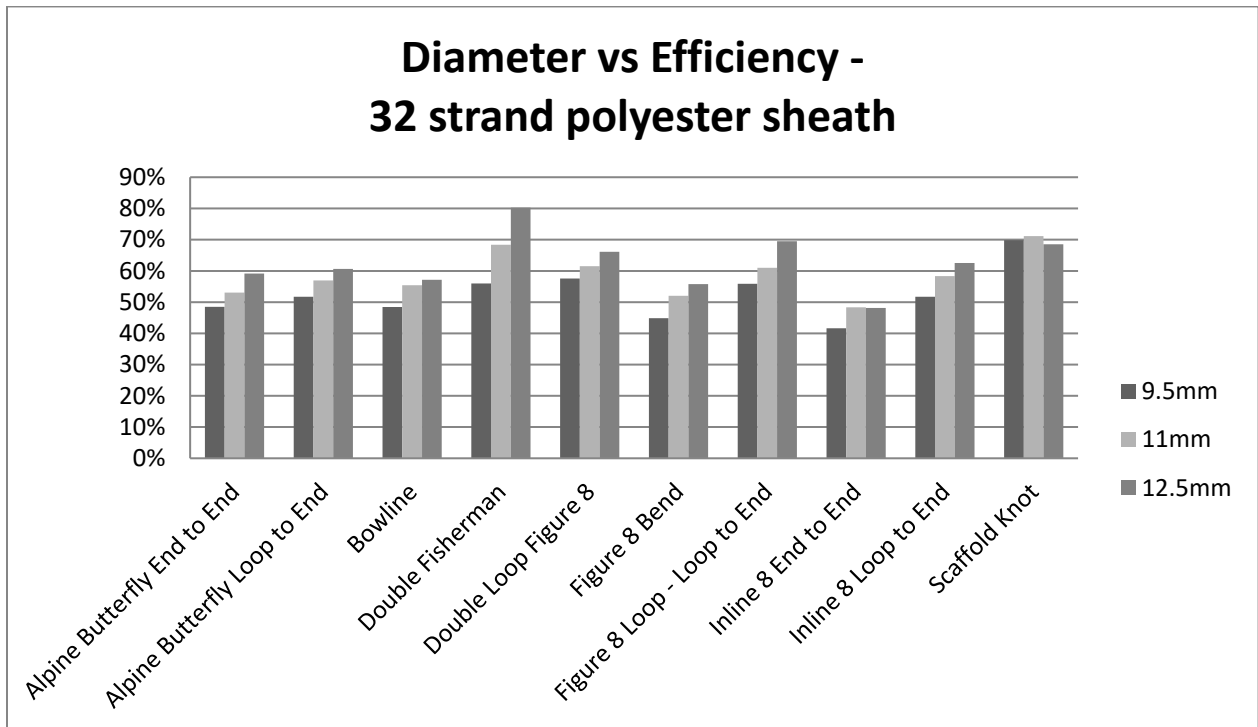
11mm vs. 12.5mm

- Comparing 32 strand polyester sheath/polyester core (Static Pro).
- Missing Fig 8 End to end, Poachers knot
- Larger diameter generally performed slightly better.



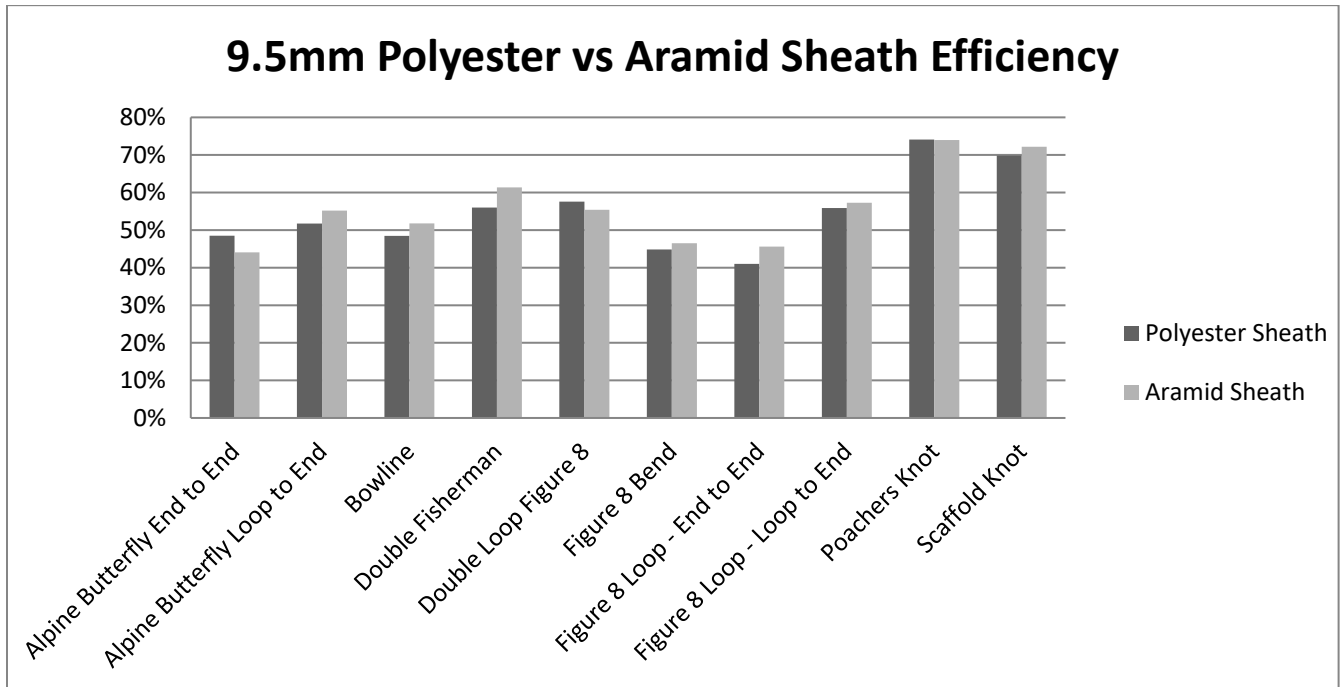
9.5 vs. 11mm vs. 12.5mm

- Comparing KMIII, Average of 11mm Static Pro and 11mm KMIII, 12.5mm Static Pro.
- Different cores, similar 32 strand poly sheath. We suspect sheath construction influences efficiency based on 11mm g rated rope testing.
- Missing Figure 8 loop end to end, poachers knot.
- Consistent pattern of increasing efficiency as diameter increases.



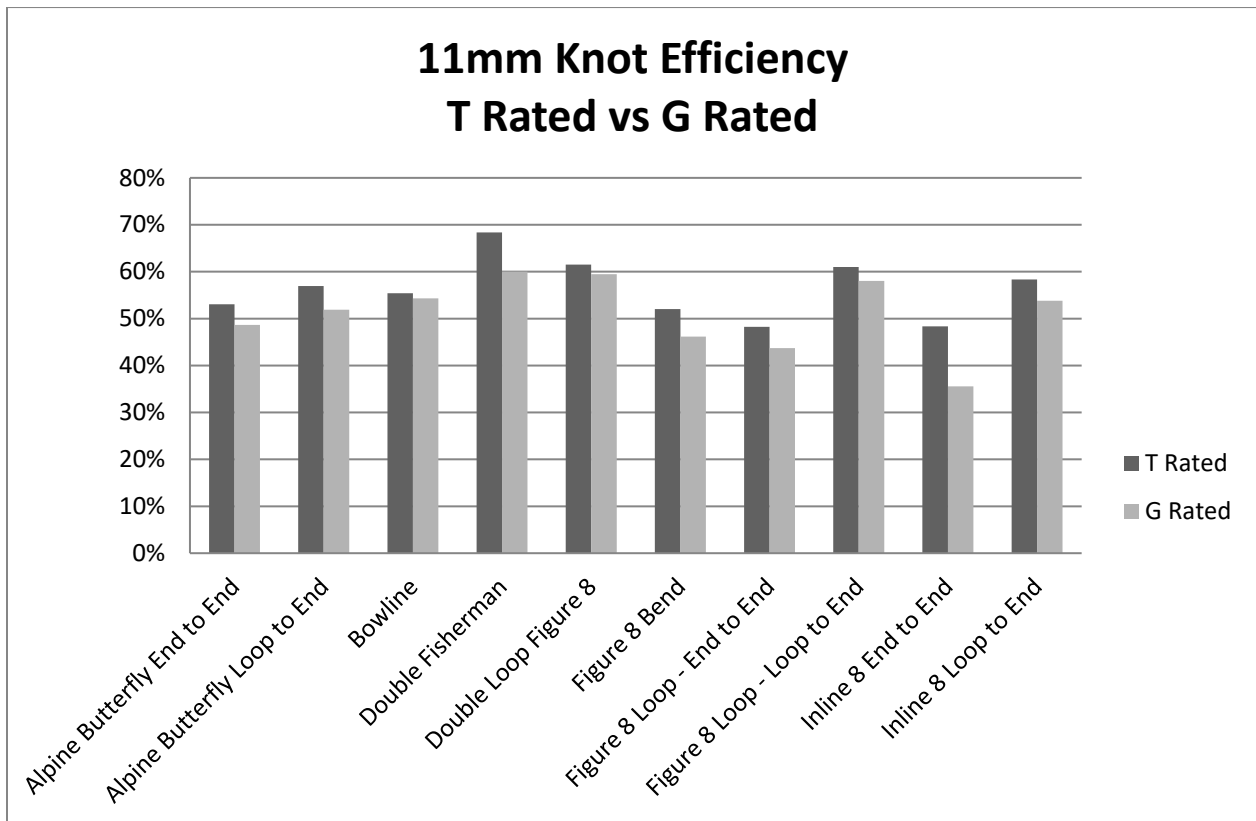
9.5mm Aramid vs. Polyester Sheath

- Missing Inline 8 data (both)
- KMIII vs. average of Canyon tech and tactical response
- Performance was similar across both constructions.

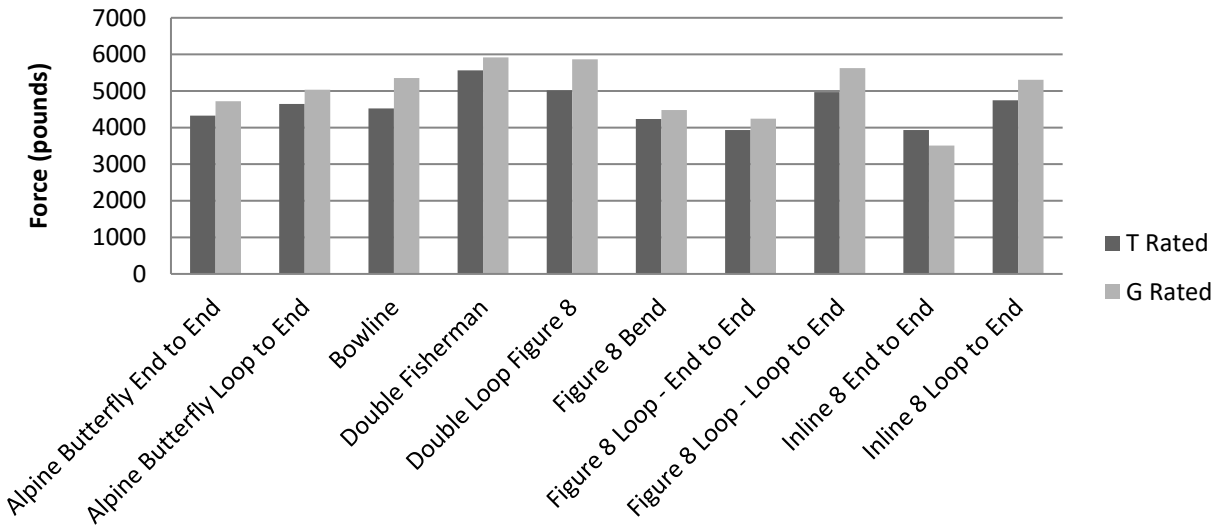


Traditional 11mm vs. G rated 11mm

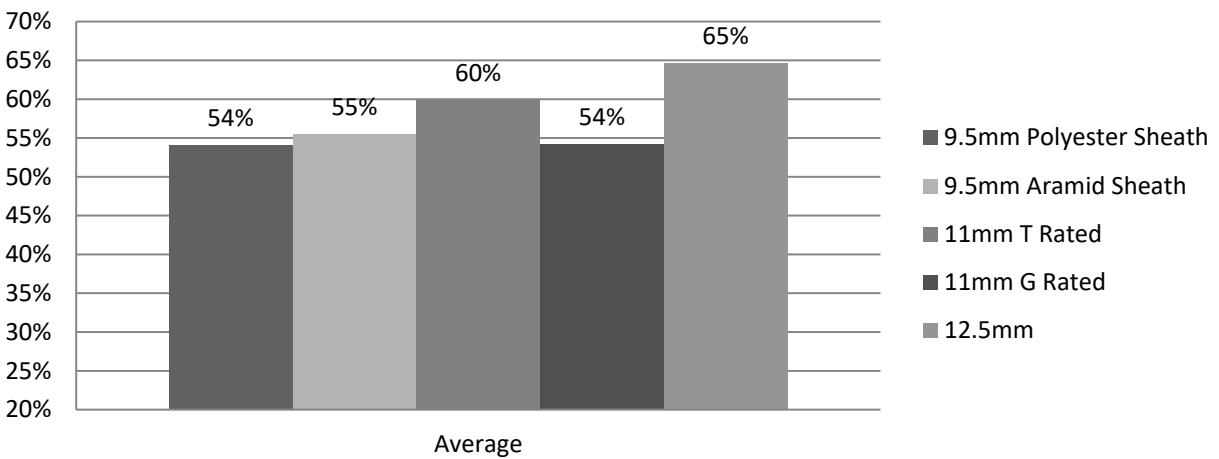
- T rated: KMIII and Static Pro, G Rated: G-11 2.0 and SYNC
- Missing Poachers and Scaffold knots. G-11 data not following trends, likely testing differences vs. other ropes.
- Partial set of SYNC data.
- Showing both efficiency and residual strength
 - Even though lower %, average breaking strength is higher.
- G rated construction is different – more core/ less sheath.



11mm Knot Residual Strength T Rated vs G Rated



Average Efficiency per Rope Type



Conclusions and Acknowledgements

Based upon this testing you might want to consider using a lower knot efficiency when doing system safety factor calculations.

As stated earlier it is our intention to continue this project by repeating the tests done in 2008 and 2014 and by including additional rope types and knots as we receive sample material from other manufacturers.

The authors are very grateful for the assistance and encouragement of the CMC Engineering staff led by Tyler Mayer. We especially want to thank Conner Warren for making sense of the test results and for creating the graphs included in this paper.

We would also like to thank Matt Hunt from Sterling Rope, Loui McCurley from PMI and the management of CMC Rescue for providing rope samples for testing.