

HMPE ROPE COMPARISON – EFFECTS OF POST PRODUCTION PROCESS

The use of heat and moisture during the rope manufacturing process has been widely practiced for many years. In the case of nylon, the heat-setting process minimizes the amount of shrinkage the rope will exhibit when placed in an aqueous solution (i.e. water). Although this practice is widespread for traditional synthetic fibers, the practice of heat setting High Modulus fiber ropes is limited to a few rope companies.

Puget Sound Rope's patented Plasma recrystallization process starts with a single braid Spectra-900 fiber rope [1]. The rope is run through a high temperature bath under tension causing the fiber and the rope to change their physical characteristics. These changes generate large strength gains but may be at the expense of other mechanical properties (See Table 1).

Table 1: Strength Comparison for 1-5/16" (32 mm) diameter HMPE Ropes [1, 2]

Manufacturer	Rope	Fiber	Published MBS (lbs)
Puget Sound	Spectra 12	Spectra-900	114,300
Puget Sound	Plasma 12	Plasma	196,000
Samson	AmSteel	Dyneema SK-60	114,300
Samson	AmSteel-Blue	Dyneema SK-75	165,700

Although a Plasma rope starts with a lower strength fiber, Spectra 900, the Plasma process generates rope strengths on the order of AmSteel-Blue (manufactured using Dyneema SK-75, Table 2). As the rope is stretched under high temperatures the individual fibers are further drawn, creating a more crystalline polyethylene material. The increased crystallinity of the fiber increases the efficiency of the fiber and therefore creates a stronger rope, but the Plasma process can also produce negative effects to other mechanical properties. From laboratory tests the tensile fatigue and abrasion resistance appear to be compromised due to the Plasma process.

Table 2: Strength Comparison of HMPE Fibers [3, 4]

Manufacturer	Fiber	Measured Break Strength (grams/denier)
Honeywell	Spectra-900	27
DSM Dyneema	Dyneema SK-60	30
DSM Dyneema	Dyneema SK-75	40

The Thousand Cycle Load Level (TCLL) Test, an OCIMF standard test, was performed on Plasma 12 and AmSteel-Blue to determine the relative effects of the Plasma process. Size for size the Plasma 12 has a higher published minimum breaking strength than the AmSteel-Blue, so the Plasma 12 is being loaded at higher loads than the AmSteel Blue to maintain an equal percent loading. Based on the TCLL results, as shown in Figure 1, AmSteel Blue lasted longer and its residual strength at failure (90%) was significantly higher than the Plasma rope (70%). The test results show that Plasma 12 is more susceptible to tensile fatigue damage than the equivalent size AmSteel-Blue.

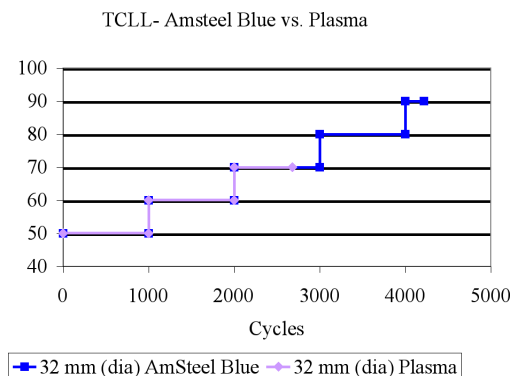


Figure 1. TCLL Chart for Plasma 12 and AmSteel-Blue.

However many companies are not substituting AmSteel-Blue for Plasma 12 on a size-for-size basis, rather they are matching the new rope's Minimum Breaking Strength. On a strength-for-strength comparison Plasma 12 will be even more susceptible to tensile fatigue damage, because of the decreased volume of fiber in the smaller diameter rope. Therefore the Plasma rope will fail at fewer fatigue cycles than the equivalent strength AmSteel-Blue.

On a strength for strength comparison, the 1-1/2" (36 mm) diameter AmSteel-Blue (MBL = 204,900 lbs) continues to get stronger with continued loading, whereas the Plasma 12 rope (MBL = 196,000 lbs) gains strength under modest loading, then loses strength as the load cycles increase. Figure 2 shows the effect of short term fatigue on rope strengths.

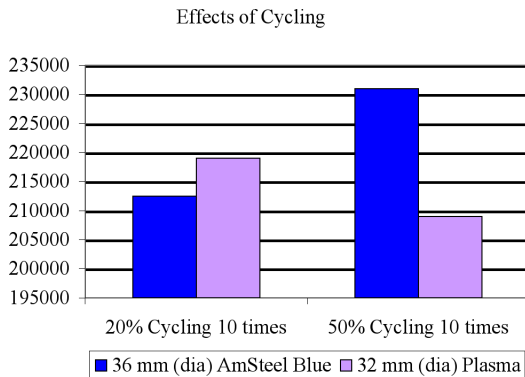


Figure 2. The effects of short term fatigue on Plasma 12 and AmSteel-Blue

Figure 3 depicts the strength change of AmSteel Blue due to fatigue. There is an initial strength increase of the rope followed by tensile strength decay. As the red arrow shows, the Plasma process basically enhances the rope strength by accelerating this initial strength improvement phenomenon. However, the overall fatigue life of the rope is compromised. For example, if a rope is treated to reach its highest initial strength, at the apex of the curve in Figure 3, the rope will be 25% stronger, but will only have 60% of fatigue life remaining (blue vs. purple arrows).

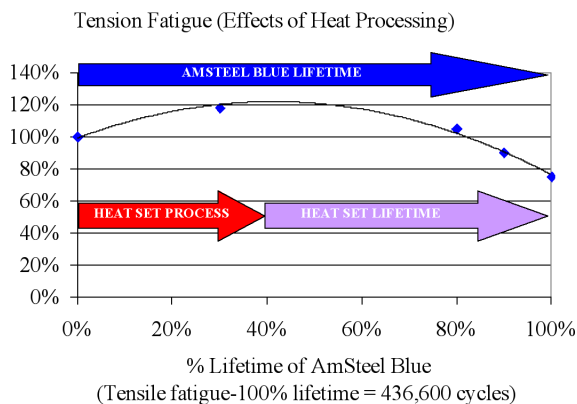


Figure 3. Fatigue lifetime comparison between Plasma 12 and AmSteel-Blue

Another important factor of rope performance is abrasion resistance. Table 3 compares the abrasion resistance between Plasma 12 and AmSteel-Blue, showing AmSteel-Blue has superior abrasion resistance, tested per Samson testing standards.

Table 3: Abrasion Resistance Comparison of HMPE Ropes – Higher cycles to failure show better abrasion resistance

Manufacturer	Rope	Fiber	Measured Cycles to Failure
Puget Sound	Plasma 12	Plasma	11,200
Samson	AmSteel-Blue	Dyneema SK-75	24,700

Conclusions: This study compares the different characteristics between Plasma 12 and AmSteel-Blue. While the patented Plasma process creates a stronger rope than AmSteel-Blue, the Plasma rope has shorter fatigue lifetime. Samson lab testing also shows that the Plasma rope has lower abrasion resistance as compared to AmSteel-Blue.

Depending on the application, one should consider all the performance factors to select the most appropriate product.

References:

- [1] Puget Sound Rope, Plasma 12 and 12x12 Strand Date Sheet, T3/T33 REV 010, 17 April 2003.
- [2] Puget Sound Rope, SPECTRA 12 and 12x12 Strand Data Sheet, S3/S33, REV 008, 17 April 2003.
- [3] Spectra Data Sheet.
- [4] Dyneema Data Sheet.