SAMSON TECHNICAL BULLETIN

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HMPE Rope—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.

The heat-setting process often starts with a single braid HMPE fiber rope. 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 are 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]

FIBER	TYPICAL MIN. BREAK STRENGTH
Spectra®900	114,300 lbs
Heat-Set Spectra®900	196,000 lbs
Dyneema® SK75	166,000 lbs

Although a heat-set HMPE rope usually starts with a lower strength HMPE fiber, the heat-setting process can generate rope strengths on the order of AmSteel®-Blue (manufactured using Dyneema® SK75, 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 heat-set 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 heat-setting process.

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

MANUFACTURER	FIBER	MEASURED BREAK STRENGTH
Honeywell	Spectra-900	27 grams/denier
DSM Dyneema®	Dyneema® SK75	40 grams/denier

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

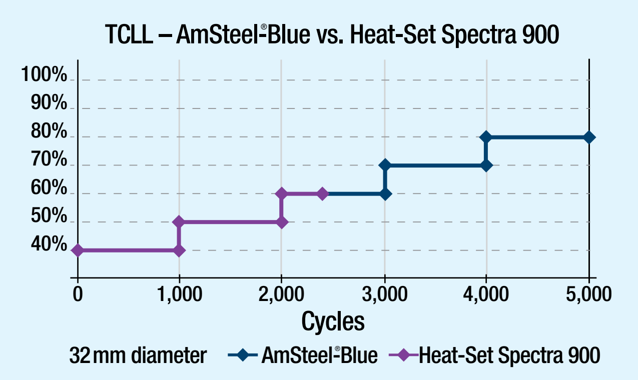

FIGURE 1 TCLL Chart for AmSteel®-Blue and Heat-Set Spectra 900.

However many companies are not substituting AmSteel®-Blue for heat-set ropes on a size-for-size basis, rather they are matching the new rope's Minimum Breaking Strength (MBS). On a strength-for-strength comparison, the heat-set samples will be even more susceptible to tensile fatigue damage because of the decreased volume of fiber in the smaller diameter rope. Therefore, the heat-set 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 (MBS = 205,000 lbs) continues to get stronger with continued loading, whereas the heat-set rope (MBS = 196,000 lbs) gains strength under modest loading, then loses strength as the load cycles increase. Fig. 2 shows the effect of short term fatigue on rope strengths.

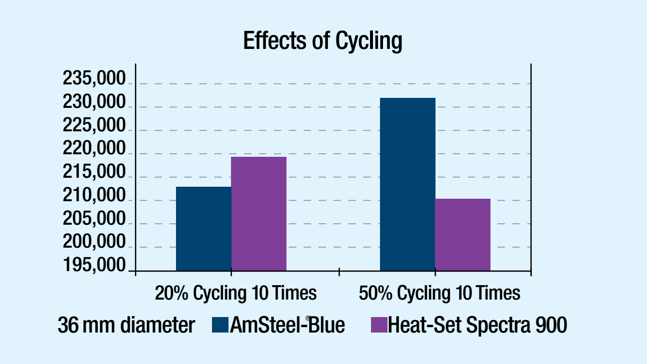

FIGURE 2 The effects of short term fatigue on AmSteel®-Blue and Heat-Set Spectra 900.

Fig. 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 heat-setting 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 Fig. 3, the rope will be 25% stronger, but will only have 60% of fatigue life remaining (blue vs. purple arrows).

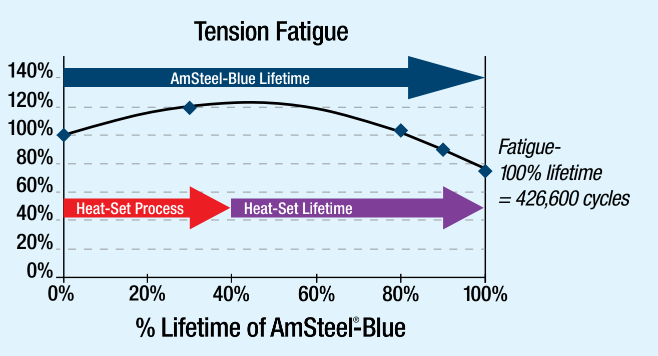

FIGURE 3 Fatigue lifetime comparison between AmSteel®-Blue and Post-Processed Rope

Another important factor of rope performance is abrasion resistance. Table 3 compares the abrasion resistance between heat-set HMPE fiber ropes 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

FIBER	MEASURED CYCLES TO FAILURE
Heat-set Spectra®900	11,200 cycles
Dyneema® SK75	24,700 cycles

CONCLUSIONS

This study compares the different characteristics between heat-set HMPE fiber ropes and AmSteel®-Blue. While the heat-setting process creates an initially stronger rope than AmSteel®-Blue, the heat-set rope has shorter fatigue lifetime. Samson lab testing also shows that the heat-set 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 Data 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.