SAMSON TECHNICAL BULLETIN

Mooring in High-Temperature Climates

Overview Many areas of new oil and gas reserve development and production are occurring in the Middle East, the Northwest Shelf, Western Africa, or other regions that have extremely high climatic temperatures and utilize ocean-going vessels to transport this cargo to their ultimate destination. High modulus synthetic fiber-based mooring lines relatively low melting point and published critical temperature have raised concerns about the product viability in these climates. *We have determined that Samson HMPE lines will have negligible degradation due to high temperature ports.*

The climates of the Middle East, Northern Africa, and the Northwest Shelf can have high daily temperatures. Samson conducted three experiments to better understand the effects of heat:

1. **Effects of Ambient Heat**
2. **Effects of Conducted Heat**
3. **Effects of Temperature, Load and Time**

Effects of Ambient Heat

Ambient Temperature is the temperature measured for a given environment. This ambient temperature will cause all objects in the environment to be heated to the environment's temperature [1]. Fig. 1 shows the temperature profile of three Samson HMPE fiber ropes moved from room temperature to a 100°C environment: one 12-strand single braid, one 12-strand braid with a polyester jacket, and one 12-strand braid with a Samson HMPE/polyester fiber hybrid jacket. All the ropes in the experiment ultimately reached 100°C regardless of the insulating properties of their jackets.

Exposing the ropes to temperatures between 25°C and 75°C does not have a significant effect on the residual strength of *AmSteel®-Blue,* as shown in Fig. 2 [2]. Similarly thermal cycling, for example, cycles of 8 hours at 65°C followed by 16 hours at 20°C did not result any significant strength loss over a period of 60 days [2].

At elevated ambient temperatures, HMPE fibers will soften, which results in a reduction of strength. However for realistic environmental temperatures, between 20°C and 50°C, the fiber loses less than 8% of its breaking strength (Fig. 3).

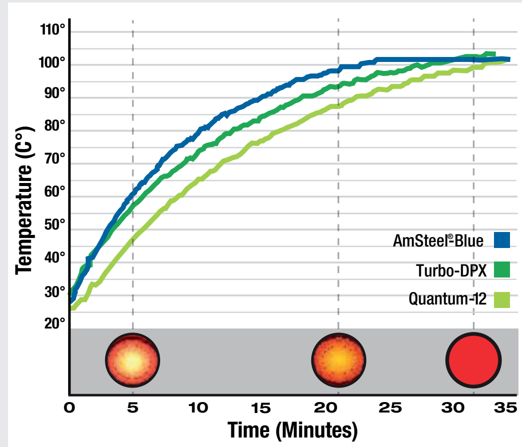

FIGURE 1 Internal Rope Temperature Profiles

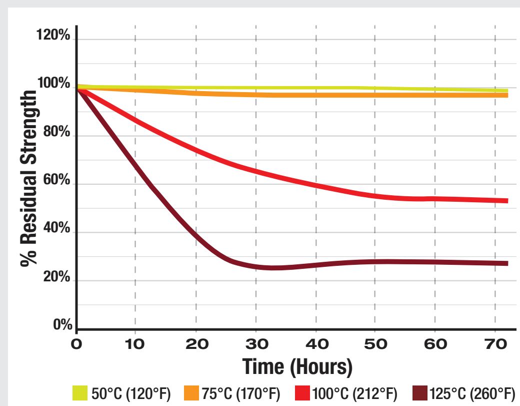

FIGURE 2 Temperature Affect on Strength of 1/2" diameter AmSteel®-Blue

Samson customers have been working in the Middle East, Northern Africa, and the Southeast Asia and Australia with HMSF mooring lines without incident.

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Effects of Conducted Heat

When a rope comes in contact with a hot surface, the heat is conducted into the rope. However, unlike the effects of ambient heat, the conducted heat may not increase the entire rope's temperature to the same temperature as the contact surface [3]. Lab tests placing ropes on a 70°C constant heat source shows the temperature increase with time, as shown in Fig. 4. Interestingly, the rope's upper surface never reaches the heat source temperature, showing a steady-state heat equalization with the environment. Since not all the fibers are heated to the temperature of the hot surface, it is expected that most of the strength of the rope is still maintained.

Effects of Temperature, Load and Time

The combination of elevated temperature, load and time can accelerate a phenomenon known as creep. Creep studies have been performed on HMPE fiber ropes to identify how it influences other rope properties such as strength [4]. We can use this predictive model to determine the length of time before reaching rupture for a rope that is loaded under different conditions.

For an LNG tanker trading in Qatar to Europe, the effective creep life for an *AmSteel®-Blue* mooring line would exceed 40 years, which far exceeds the actual lifetime of a mooring line. At the effective creep life, the *AmSteel®-Blue's* residual strength would exceed 80% minimum breaking strength (MBS) assuming the following conditions [5]:

1. Load:
- a. *Initial Tie-up = 30% MBS*
- b. *Mooring Load = 18% MBS*

2. Time:
- a. *Initial Tie-up = 2 hours/mooring*
- b. *Mooring = 46 hours/mooring*
- c. *13 moorings in Qatar per year*
- d. *26 mooring total per year (13-Qatar) (13-Europe)*

3. Temperature:
- a. *Initial load always occurs at the maximum daily temperature*

Even under the extreme case, e.g., every time it moored in Qatar the temperature exceeded 50°C and the strain on the lines is 18% MBS, an *AmSteel®-Blue* LNG tanker mooring line still has a residual strength of 80% MBS after 10 years.

Conclusions

In summary, climatic temperature is not a factor affecting the lifetime of HMPE mooring lines.

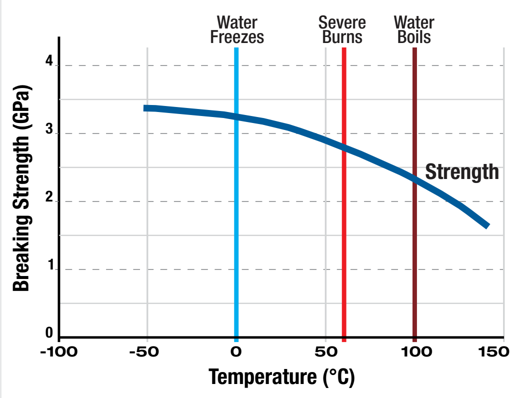

FIGURE 3 Strength of HMPE fibers Influence of Testing Temperature

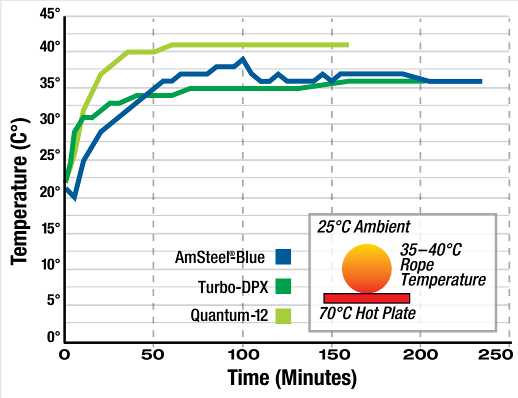

FIGURE 4 1-5/8" Rope on 70°C Hot Plate

REFERENCES

[1] TR-037-2004-FDL., Samson 2004
[2] TR-036-2004-FDL., Samson 2004
[3] TR-038-2004-FDL., Samson 2004
[4] Smeets, P., et. al, *Creep as a Design Tool for HMPE Ropes in Long Term Marine and Offshore Applications,* Samson 2004
[5] TR-040-2004-FDL., Samson 2004

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