SAMSON TECHNICAL BULLETIN

Tanker Mooring with AmSteel®-Blue in High-Temperature Climates

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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. With the OCIMF's recent acceptance of synthetic mooring lines, Dyneema®-based mooring lines are now being considered for use, but the fiber's relatively low melting point and published critical temperature have raised concerns about the product viability in these climates. *We have determined that AmSteel®-Blue and other Samson Dyneema® fiber products 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. Although a few shipping companies using Dyneema® fiber mooring lines have been servicing these areas without incident, 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 TEMPERATURE:

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 Dyneema® fiber ropes moved from room temperature to a 100°C environment: one a 12-strand single braid, one 12-strand braid with a polyester jacket, and one a 12-strand braid with a Dyneema®/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].

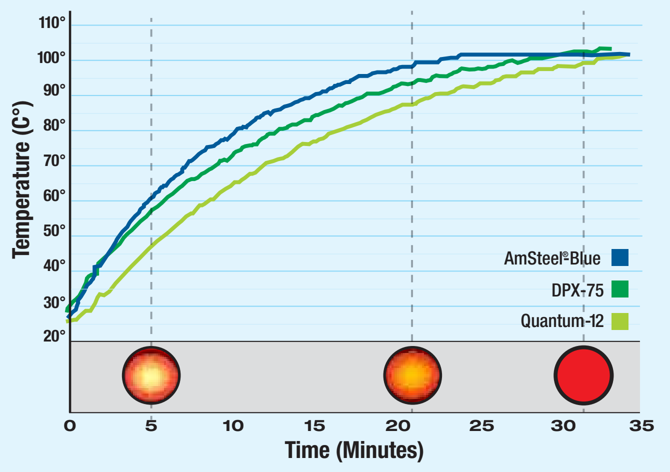

FIGURE 1 *Internal Rope Temperature Profiles*

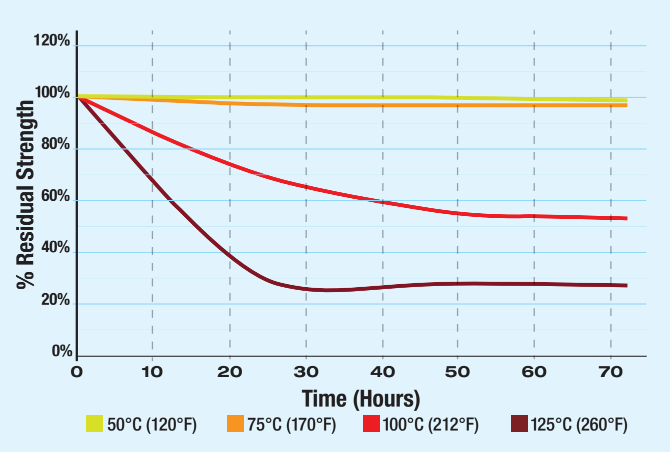

FIGURE 2 *Temperature Affect on Strength of 1/2" diameter AmSteel®-Blue*

While at elevated ambient temperatures, Dyneema® 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).

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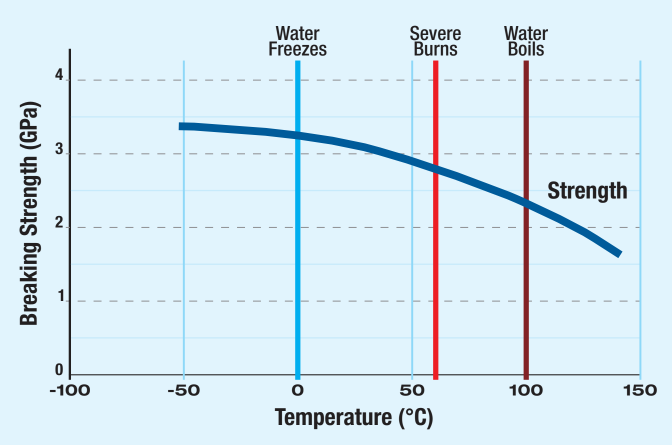

FIGURE 3 *Strength of Dyneema® fibers Influence of Testing Temperature*

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.

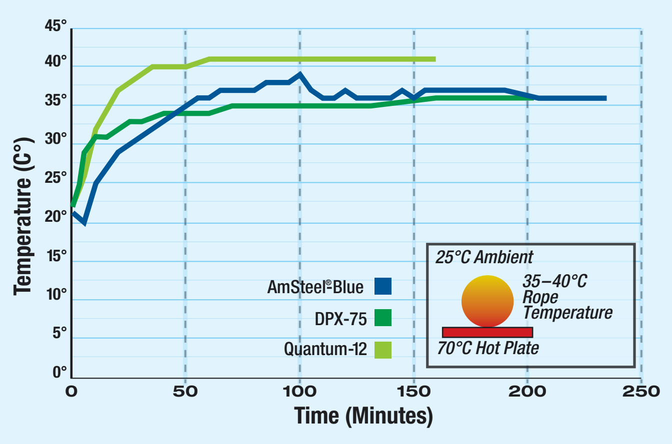

FIGURE 4 *1-5/8" Rope on 70°C Hot Plate*

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.

CREEP LIFE CALCULATIONS:

The combination of elevated temperature, load and time can accelerate a phenomenon known as creep.

Creep studies have been performed on Dyneema® 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 Dyneema® fiber mooring lines.

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

THE STRONGEST NAME IN ROPE