SAMSON TECHNICAL BULLETIN

Vulcan: A Synthetic Emergency Tow-Off Pendant

Overview Emergency tow-off pendants (ETOPs), commonly referred to as "fire wires," provide a means of towing the ship away from the dock in the event of a fire. Wire rope is currently used in this application; however, the handling of these heavy wire ropes has resulted in many injuries to deckhands. Samson has developed a synthetic alternative named *Vulcan*,™ which is significantly lighter and eliminates "fish-hooks," broken wires that protrude from the wire rope that result in hand injuries. Maintenance costs are also reduced when using synthetic ropes in comparison with wire ropes.

Since no testing standards or high-heat performance requirements exist, Samson has developed a set of testing parameters by which to compare Vulcan to wire. Table 1 provides a comparison between wire and *Vulcan* with regard to the OCIMF minimum breaking strength requirements.

The patented synthetic ETOP *Vulcan* is made of aramid fiber in conjunction with a proprietary fire-resistant coating that meets the OCIMF required breaking strength after exposure to flames and a high-temperature environment (Chou, et al., 2007, 2008, 2010).

Meeting OCIMF Minimum Breaking Strength Requirements

Because some strength is lost when *Vulcan* is exposed to high temperatures, the user may chose to use a larger diameter so that its retained strength still meets the required break strengths even when operating under severe heat or flame conditions. Table 2 represents the rope sizes that meet the OCIMF strength requirements (Table 1). Ropes at these sizes were tested at 575°F (300°C) after being held at 20% of their break strengths for 30 minutes at the same temperature. Note that the wire sizes are larger here than in Table 1. This is due to the strength loss that is also observed in wire when exposed to the same high-temperature testing parameters as the synthetic rope.

Fiber Selection

Aramid fiber was chosen for this product due to its ability to retain certain properties at elevated temperatures, including strength retention when exposed to higher temperatures for extended periods of time.

Enhancing Flame Resistance

Although a rope made solely of aramid fiber can withstand high temperatures, it has a diminished ability to withstand direct contact with a flame.

Vulcan is designed to reduce the weight of ETOPS/fire wires and minimize the risk of handling injuries.

TABLE 1 VULCAN VS. WIRE: meeting OCIMF minimum breaking strength requirements prior to heat exposure.

VESSEL SIZE (DWT)	< 20,000	20,000–100,000	100,000–300,000	300,000+
MIN. BREAK STRENGTH REQUIREMENT METRIC TONS	30 *t*	55 *t*	100 *t*	120 *t*
WIRE DIAMETER INCHES	7/8″	1-1/8″	1-1/2″	1-5/8″
VULCAN DIAMETER INCHES	1″	1-5/16″	1-7/8″	2-1/8″
WIRE WEIGHT PER 100 FT.	142 lb	234 lb	416 lb	488 lb
VULCAN WEIGHT PER 100 FT.	30 lb	69 lb	125 lb	149 lb
WEIGHT SAVINGS OVER WIRE	**80%**	**70%**	**70%**	**70%**

TABLE 2 VULCAN: Rope sizes to meeting OCIMF strength requirements after heat exposure.

VESSEL SIZE (DWT)	< 20,000	20,000–100,000	100,000–300,000	300,000+
MIN. BREAK STRENGTH REQUIREMENT METRIC TONS	30 *t*	55 *t*	100 *t*	120 *t*
WIRE DIAMETER INCHES	7/8″	1-1/4″	1-5/8″	1-3/4″
VULCAN DIAMETER INCHES	1-1/4″	1-11/16″	2-1/4″	2-1/2″
WIRE WEIGHT PER 100 FT.	142 lb	289 lb	488 lb	567 lb
VULCAN WEIGHT PER 100 FT.	61.6 lb	107 lb	168 lb	192 lb
WEIGHT SAVINGS OVER WIRE	**57%**	**63%**	**65%**	**65%**

By utilizing a nonload-bearing jacket made of 100% aramid fiber and applying a proprietary fire-resistant coating to the core, resistance to the damage of direct flames is increased, the coating's special intumescent property provides maximum protection to the rope by expanding to form a high-density char that acts as insulation when it is exposed to fire or high heat. This allows the rope to retain more of its strength for a longer period of time.

Heat and Flame Testing Procedures

To determine the effect that heat or flame exposure has on rope and wire in a potential real-world scenario, Samson developed specific heat and flame testing procedures.

HEAT TESTING Special equipment was fabricated to perform these tests, as shown in Fig. 1. A heated cylinder was installed in a test bed and the rope pulled through without direct contact of the rope and the heat source.

The heat test consisted of the following conditions:

1. A 575°F (300°C) temperature oven;
2. 30 minutes exposure of the rope to the heat source while loaded to 20% of break strength; and
3. the rope was broken while still at temperature (575°F, or 300°C).

In small-scale testing the results were as listed:

> The jacketed construction outperformed single braid ropes, which is a result of the increased insulation that protected the core (the strength member).

> The same jacketed rope construction with standard polyurethane (PUR) coatings actually lost more strength than an uncoated aramid single braid, indicating that PUR coatings may actually act as an accelerant, increasing the heat transfer through the rope.

> Wire rope also shows about a 12% reduction in strength due to heat exposure.

Retained Strength

The results shown in Fig. 2 are a "worst case scenario" since heat transfers more quickly through a smaller diameter rope than a larger diameter rope. As the diameter increases, the strength loss will be minimized. Based on actual test data and known fiber properties, we are able to model the strength loss under these specific heating conditions and provide ropes that will meet OCIMF strength requirements even after heat exposure.

TABLE 3 Time until failure, during 750°F (400°C) open flame testing on coated and uncoated ropes.

FIBER TYPE	UNCOATED	COATED
Aramid	**12 minutes**	**65 minutes**
Polyester	< 1 minutes	1.75 minutes
Nylon	< 1 minutes	1.5 minutes
HMPE	< 1 minutes	< 1 minutes

FIGURE 1 Special equipment for heat and flame testing.

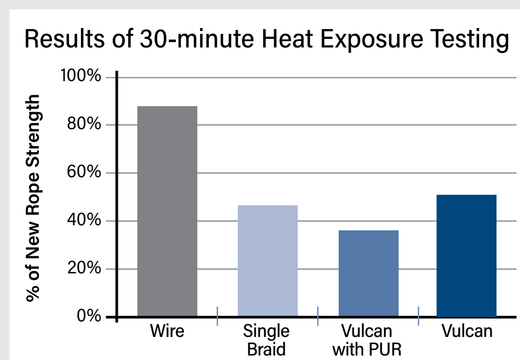

FIGURE 2 The retained strength of 1-inch diameter ropes of varying fibers and constructions after 30 minute exposure to 575°F (300°C) at 20% load.

Flame Testing

Specialized testing equipment was prepared for this test application as illustrated in Fig. 3. This equipment provided to the rope direct exposure to an open flame in a controlled setting. The flame test consists of the following conditions:

1. Direct exposure to a 1,100°F (600°C) open flame for 10 seconds, then
2. tested for tensile strength at room temperature (see Fig. 4).

The result demonstrated that there was no significant strength loss for wire or Vulcan.

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FIGURE 3 Open flame-test equipment.

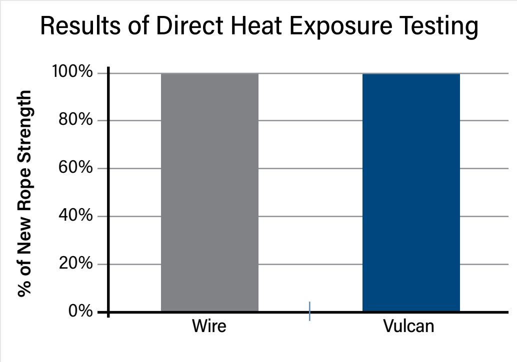

FIGURE 4 Retained strength of 1-inch diameter wire and Vulcan after 10-second direct exposure to a 1,110°F (660°C) flame.

Bibliography

Chou, C.-T., et al. *High Temperature Resistant Rope Systems and Methods.* United States Patent 7,168,231. January 30, 2007.

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