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Creep of Aged Rope

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Abstract

The creep properties of unaged and aged Kevlar© and Vectran© rope samples were studied while immersed in water. No significant difference in the creep properties of the rope were found 10 years of simulated aging

1 Introduction

The acrylic vessel used to contain the D_2O for the SNO experiment will be suspended from 10 loops of one inch diameter rope. In normal operation these ropes will support a load in excess of 100 tonnes for a period of at least 10 years. It is desirable that the creep of these ropes be minimal under these loads and be constant over the design life of the vessel. The requirements of low radioactivity restrict the choice of materials to, in practical terms, synthetic fiber ropes. Two ropes were studied, Kevlar© and Vectran©

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on the grounds of the low creep properties provided by their manufactures. Kevlar is a well established material and considerable long term data exists. This is not the case for Vectran which is a relatively new product. In order to simulate 10 years of service at 10°C rope samples were immersed in water at 60°C for 40 days. The creep properties for aged and unaged rope were then compared.

2 Apparatus

An apparatus was constructed which would allow the testing of two ropes simultaniously. One half of the apparatus is shown schematically in figure 1, the second half is identical. The rope was tensioned by a 4:1 lever loaded with 94 kg of lead, resulting in a load of 376 kg being applied to the rope. This represented approximately 10% of the ultimate load of the ropes tested. The rope then entered a water bath, was fed round a three inch diameter pully, exited the water bath and was attached to a fixed anchor point. Two surveying targets were attached to the rope, just above the water level in order to measure the extension of the rope. This measurement was carried out using a traveling microscope capable of measuring to 0.01mm, referenced to a fixed point on the laboratory floor. The temperature of the water bath and the laboratory environment was 23 ± 2°C. The length of the rope contained between the two surveying targets was 100cm, 4% of this was exposed to the air. Description of the two rope samples is given in Table 1. It should be noted that the rope tested were standard off-the-shelf samples[2]. The rope which would be used for SNO will probably require a special production run which would not use the typical organic lubricants used in rope manufacture.

The water bath in which the rope samples were aged was filled with 20 liters of 11 MΩ-cm water from a reverse osmosis supply. The bath temperature was stable to ± 1°C.

[2]Supplied by Samson Ocean Systems Inc., 2090 Thornton Road, Ferndale, WA 98248

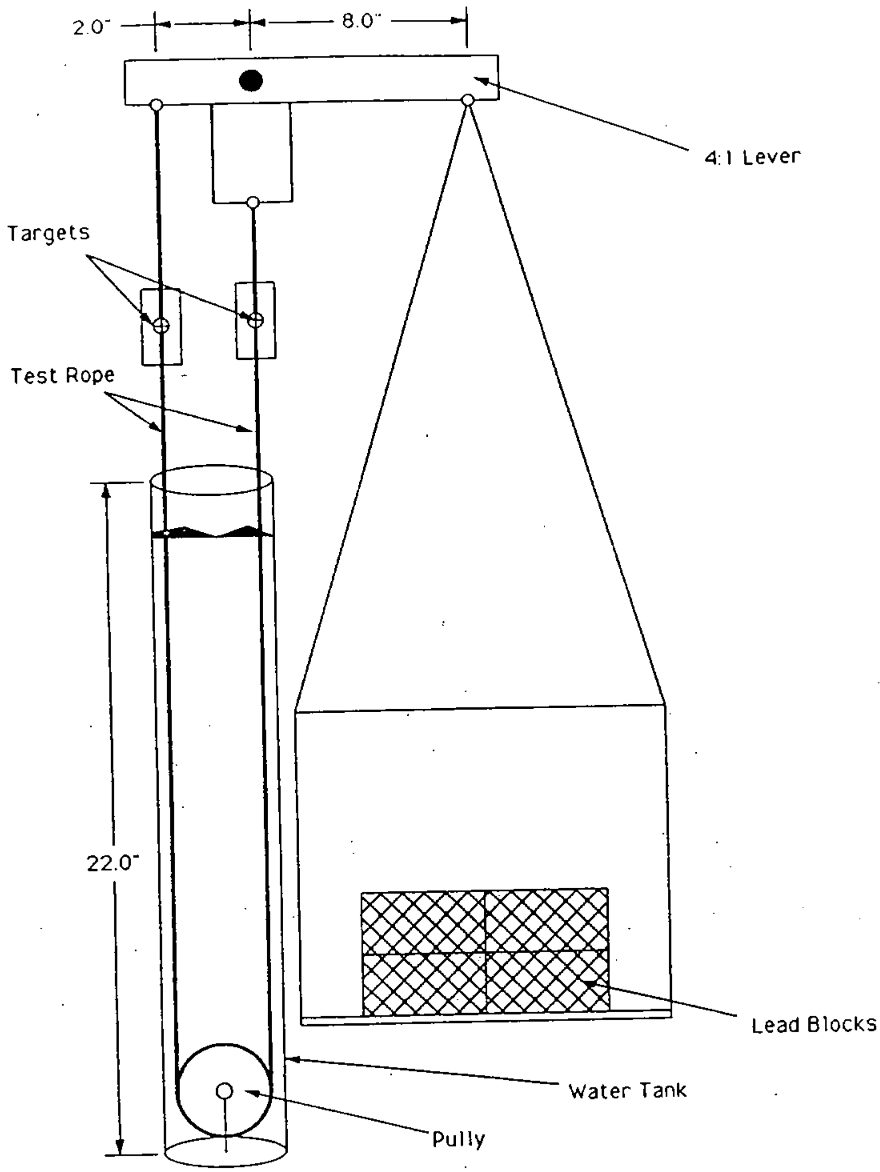


Figure 1: Schematic showing the principal elements of the rope creep apparatus

Product Name	**Vectran Braid**	**Kevlar 29 type 960**
Product Code	393-081	503-080
Nominal Dia.	0.25in	0.25in
Actual Breaking Strength	8,900 lbs	7,180 lbs
	(Avg. of 9 tests 1990)	(Avg. 2 tests 1988-1990)
Number of Strands in Rope	12	12
Number of Yarns per Strand	14 12	
Yarn Size	1500 denier	1500 denier
Weave Type	Twill	Twill

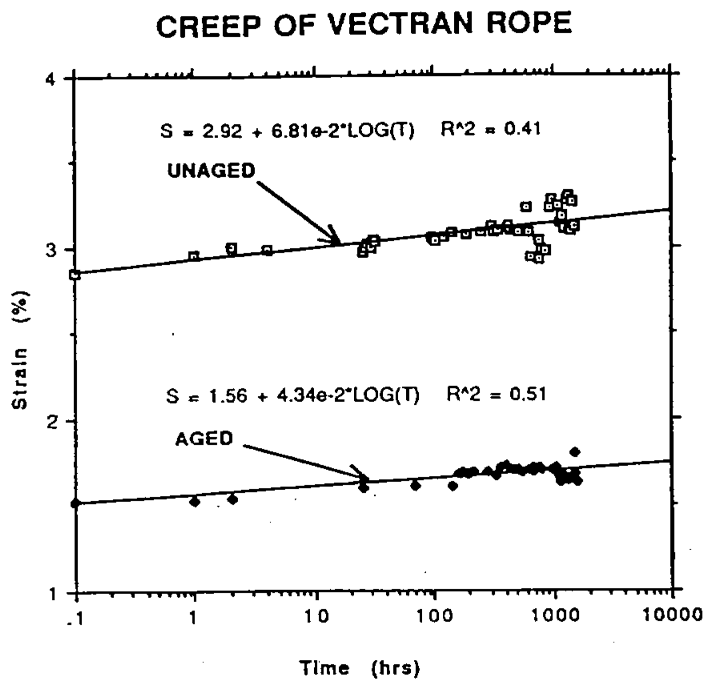
Table 1: Description of rope supplied by Samson Ocean Systems Inc.

3 proceedure

Each rope sample was divided into two equal pieces. One piece of each sample was inserted in the water bath at $60°C$ for 40 days in order to simulate 10 years in water at 10°C. The remaining two unaged pieces were installed in the creep machine. Within five minutes of the load being applied to the rope, the position of the two survey Targets were recorded and subsequently at intervals of one hour for the first six hours, then every 24 hours until approximately 1,200 hours had passed. The aged ropes, which after aging had been stored in water at 23°C for approximately 30 days, were then inserted in the creep machine and the creep recorded as before for approximately 1,200 hours.

4 Results

The creep (% strain vs. time) of the two rope samples, is given in figure 2. Plotted using log-linear axies, the data are expected to fall on a straight line. Within the experimental errors, the gradients of the unaged and aged samples are the same and that the performance is in general agreement with the specifications of the manufactures for rope of this type of construction.



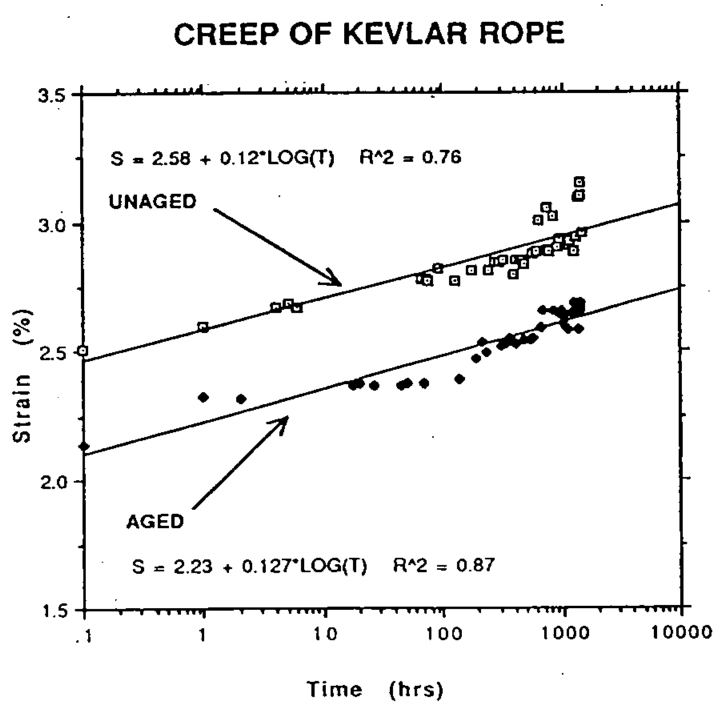


Figure 2: Creep of the unaged and aged rope samples

5 Discussion and Recommendations

The above results suggest that there will be no significant difference in the creep properties of the two ropes after 10 years service in SNO. However there are a number of shortcoming associated with this work. The principal one is the question of whether the accelerated aging bears any relationship to reality. In addition, when the rope was aged, it was not subject to loading. This is not the case for ropes used in SNO, which will be under load as they age naturaly. Fortunately, for Kevlar, (the rope chosen to support the vessel), there exists considerable long term data, so these tests are largely redundant. Another shortcoming of the test concerns the purity of the water. Although high purity water was used for the aging process, it soon deteriorated due to contaminants on the surface of the rope. This will not be the case for SNO where the mass of the rope is small compared to the 7,000 tonnes of light water, which will be constantly purified. Therefore, although the elevated temperature of the aging bath probably enhanced any leaching and deterioration of the rope, the test did not directly simulate the SNO conditions.

Since data does not exist on the long-term properties of Kevlar in ultra pure water,it is recommended that samples of the actual rope be immersed under load in the SNO detector and periodicaly tested to determine its properties.

Since the data suggest that the creep properties of the suspension rope will be predictable and managable over the operating life of it is suggested that the spring constant of the rope is another useful selection criteria, since this may effect the seismic response of the vessel.