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Service Life of Synthetic Helicopter Longlines

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Abstract

This paper presents the results of a recent study undertaken by Barry. The objective was to determine the average residual strength of helicopter synthetic longlines which had been in service for various numbers of years. The purpose was to establish service life criteria for helicopter longlines and thereby provide guidelines and recommendations on retirement criteria for end users. The resulting data obtained was plotted and a graph was created to act as a reference guide found in the Barry helicopter longline User Instructions Manual.

> ***"The objective was to determine the average residual strength of helicopter synthetic longlines…"***

Introduction

The use of HMPE (High Modulus Polyethylene, such as Dyneema®, Spectra® or Plasma®) synthetic helicopter longlines for underslung external load transport is widespread and has been adopted for several decades by operators and regulatory helicopter agencies worldwide.

Synthetic longlines are lightweight and easy to handle. They do not corrode. New longline and jacket cover designs can compensate for the inferior wear properties of the synthetic fiber rope compared to steel cable, and take full advantage of the other fiber properties. They provide superior tension and bending fatigue performance compared to wire ropes. Thus, the new forms of synthetic longlines are ideal for many helicopter external load applications

Recently, there has been an increase in interest concerning the safety of materials used in the manufacturing of helicopter longlines, particularly since there were reported cases of failure of longlines resulting in significant loss of valuable goods. While the exact causes of these accidents are often nebulous and may be due to incorrect splicing methods, misuse or other factors, some are currently under investigation.

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One of the determining factors affecting longline integrity is prolonged exposure to cyclic loading. Information regarding the "service life" of longlines is either sketchy or contradictory, and altogether not well documented.

The present study was initiated by Barry as a result of discussions held at HAI and HAC meetings, whereby several operators and industry officials requested the undertaking of a pilot project to investigate the residual tensile strength of helicopter longlines for external load operations.

The purpose of this pilot project was to establish the service lifetime of helicopter longlines based on actual testing, and to document and establish an inspection criteria and methodology which may be easily adopted by the industry.

Use time and identification of existing longlines is often problematic since proper inspection forms and logbooks are generally not used even though they are available. The lack of proper inspection and logbooks, combined with the lack of control samples, namely new and unused material, make longline users unaware and misinformed about whether their longlines are still safe to use.

The Barry study intends to provide a guideline to users to assist in determining whether their longlines are still safe to use based on their age and in-service use.

Of course, pre-use and after-use inspections are and shall remain an essential part of a longline documentation process and as such will continue to prevail. The actual lifetime depends on the intensity and frequency of use, as well as the environment of use. One exceptional circumstance might limit the product lifetime to a single use.

Methodology

Barry obtained several used longlines from helicopter operators worldwide, that had been used for different periods of time under various environments in a multitude of missions, carrying loads ranging from 1000 lbs to 6000 lbs, thereby providing a cross section of uses throughout the industry.

The longlines received were between 1 and 11 years old and their diameter varied between 7/16" and 5/8". For this present study, the main focus is on 1/2" diameter longlines although data is also presented on the 5/8" for comparison purposes. All the tested longlines were made of HMPE fiber rope.

The samples were made by removing an end section from the worst looking side (usually the bottom end) of a longline. The cut end of the sample was re-spliced to perform the break test and obtain the tensile strength.

Figure 1 - Used longline spliced sample prior to break test

For some longlines, several segments of the same longline were cut and tested because there was no "worst looking" section. In those cases, only the minimum break test result was reported.

Initial (new) strength reference was taken from current published information by rope manufacturers.

Observations

The study demonstrates that as soon as longlines are put in service, they begin a gradual and irreversible loss of tensile strength over time.

> ***"as soon as longlines are put in service, they begin a gradual and irreversible loss of tensile strength over time."***

Some longlines, used intensively or incorrectly, had lost 40% of their initial strength after only 1 year of use.

At the other end of the spectrum, another longline that was never used (shelved) or maybe used once, had lost only 12% of its initial strength 4 years after its manufacturing date. This demonstrates that decay in the material properties must be expected even if the longline is never used.

As another example, even though this is outside the scope of this study, a 1-1/2" diameter heavy-lift longline had lost 58% of its initial strength after only 2 years of use. This longline had been used intensively carrying very high loads.

With the break test results displayed on a graph (age versus residual break strength), an exponential curve was then drawn to visualize the average loss of strength over time (figure 2).

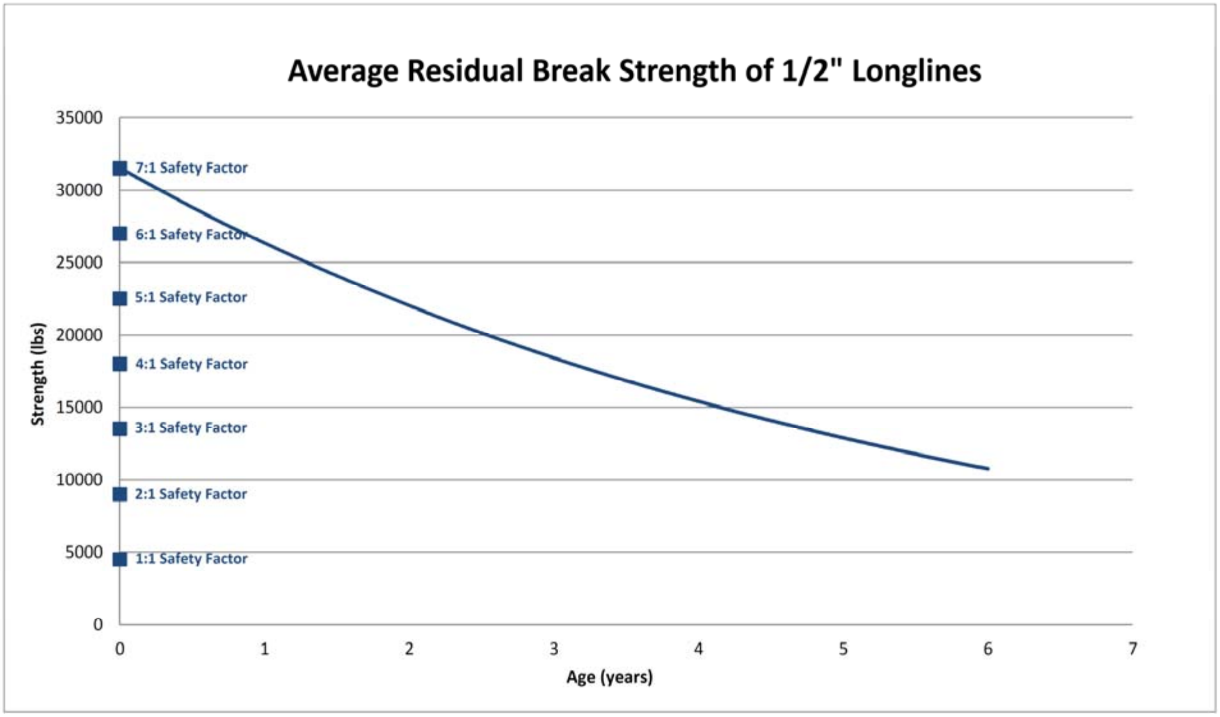

Figure 2 – Average residual break strength of 1/2" longlines

To better illustrate the spectrum of longline conditions that may be observed on the terrain, two average curves were made (figure 3) by taking the best residual strengths (top edge of red section) and the worst residual strengths (bottom edge of red section) from the tested longlines.

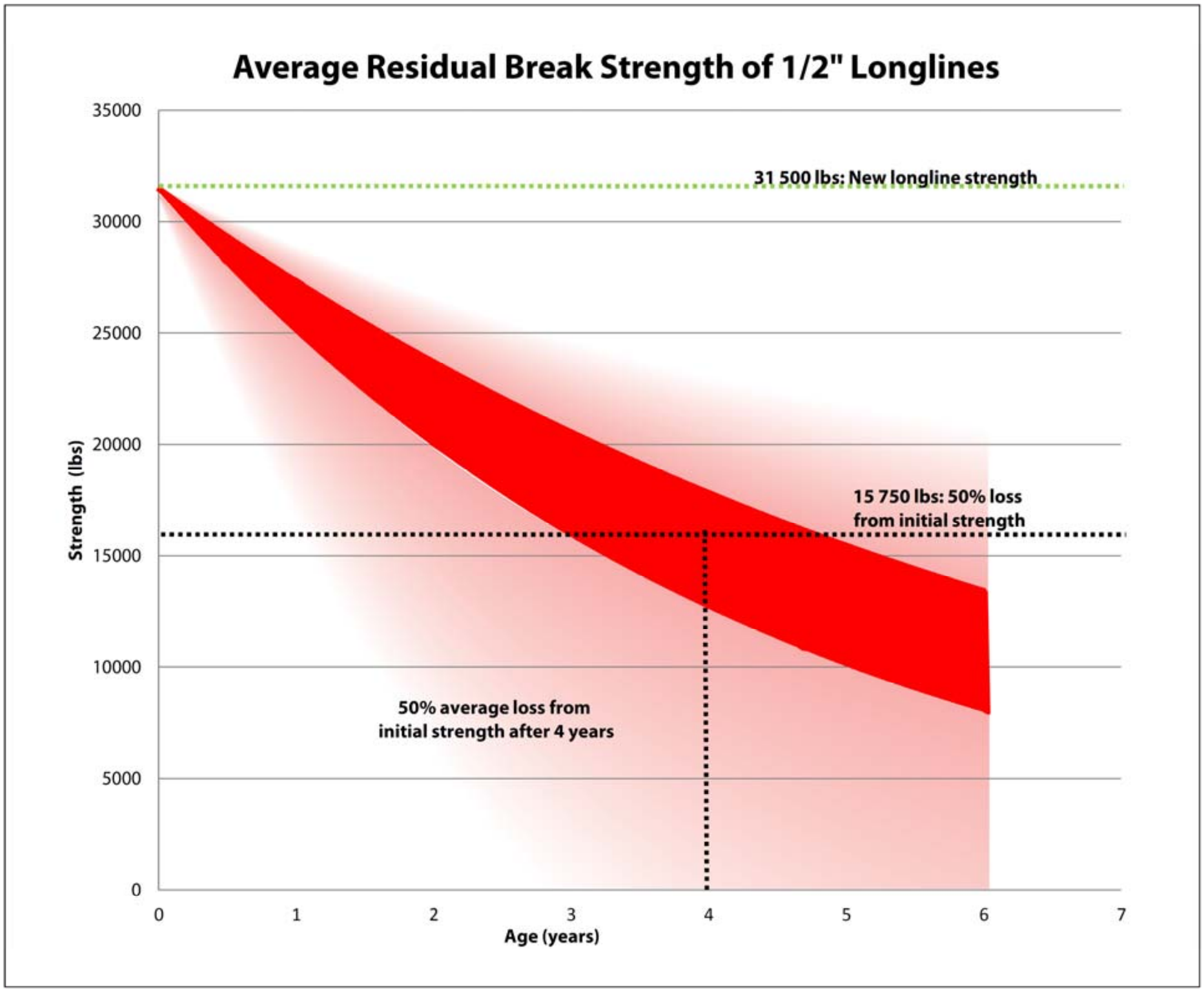

Figure 3 – Average span of residual break strength of 1/2" longlines

Those 2 curves show that the tested longlines have lost on average between 13%- 20% of their initial strength after the first year of service, and have reached the critical 50% loss of tensile strength after an average of 4 years (between 3 and 5 years).

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Result summary

Results indicate that on average, Dyneema® longlines have lost 50% of their original tensile strength after a period of 4 years from manufacturing date.

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Results also indicate that following normal use and exposure to conditions met during helicopters operations, the residual tensile strength of the longlines is often reduced in a uniform and predictable manner. This suggests that a retirement criteria may be defined. In fact, the used longlines residual strengths demonstrate that longline strength is often overestimated significantly by users as several of the longlines received were still in service prior to being tested in this study. There may be isolated cases where the longline may need to be retired from service sooner than 4 years after its manufacturing date, in the case of an exceptional event or series of events which have made it age prematurely (i.e. shock-loading or overloading).

Commentary

It is generally accepted in various safety-related industries that materials which have lost more than 50% of their original tensile strength properties are considered to have been seriously affected by a number of factors such as UV exposure, abrasion, cyclic load, overload, material fatigue, or other environmental factors, and should be removed from service as they will no longer be able to provide optimum performance and reliability.

Barry endorses the applied criteria of removing from service the longlines which have lost more than 50% of their initial strength. This rationale is further supported by analyzing the safety factor requirements from the following regulatory agencies:

- *US Department of the Interior ARA: Safety factor of 7 for synthetic rope longlines*
- *European Commission Machinery Directive 2006/42/EC: Safety factor of 7 for synthetic rope longlines*
- *FAA CFR14 Parts 27.865 and 29.865: Safety factor of 3.75 (2.5 multiplied by 1.5)*
- *EASA CS 27.865 and CS 29.865: Safety factor of 3.75 (2.5 multiplied by 1.5)*

It should be noted that none of these standards specifically address the strength loss phenomenon characteristic to synthetic fibers, nor do they specify whether the required safety factor is only valid for new longlines or whether it should be valid for the entire service life of longlines. Perhaps a review of these standards may be useful to clarify the safety factor issue.

Barry has taken a conservative (but realistic) approach by using the most and the least stringent safety factor requirements from the above cited normative references. By applying a safety factor of 7 for new longlines and a safety factor of 3.75 as a retirement criteria, this minimum safety factor (3.75) is thus attained when the longline has reached approximately 50% of its initial break strength.

Some users may have stricter internal guidelines and rules which may limit the useful life of the longlines to maintain a higher minimum safety factor (i.e. a safety factor of 5 at all times) thus limiting the useful life of the longline for an even shorter period of time.

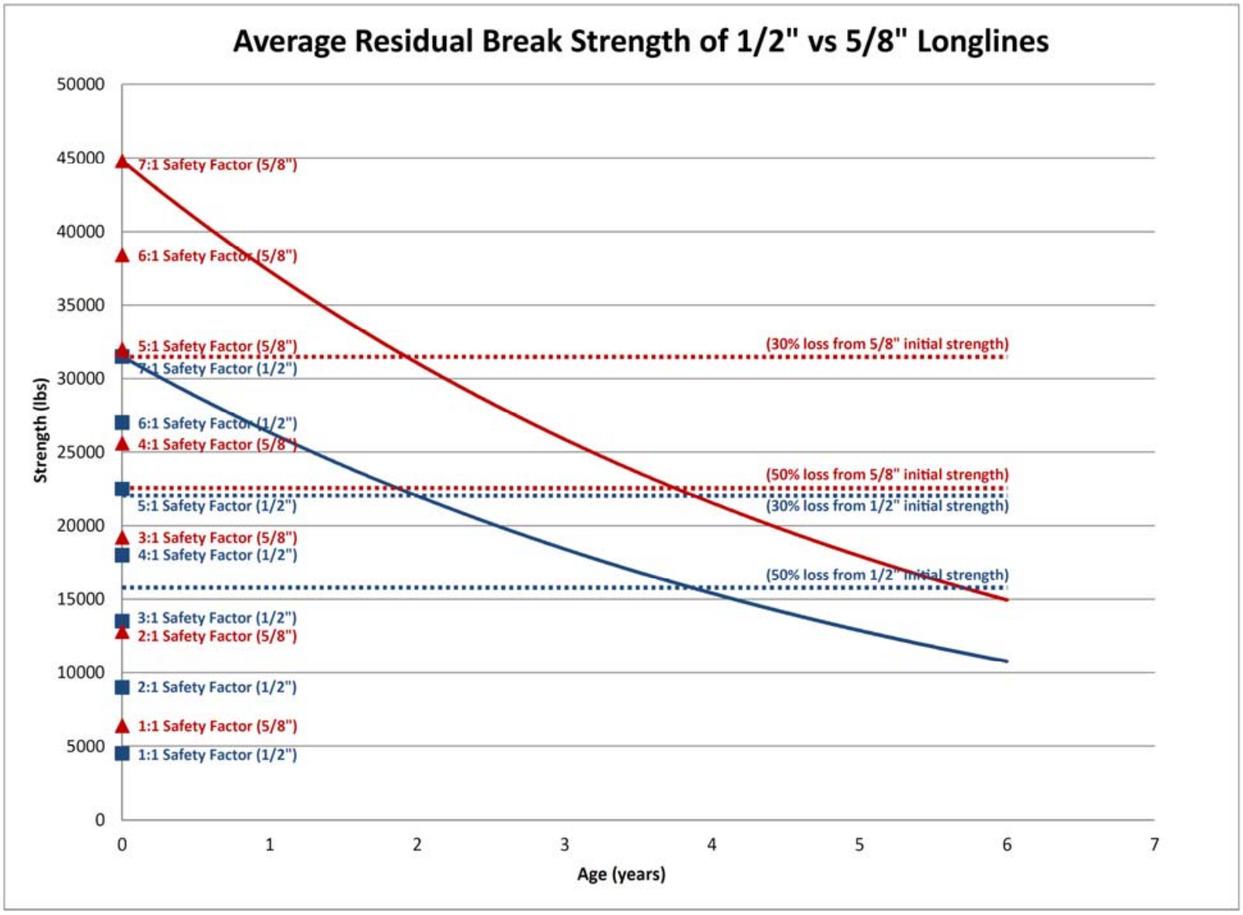

Figure 4 – Average residual break strength of 1/2″ longlines compared to 5/8″ longlines

It should be noted that the breaking point determined by these tests does not necessarily give an exact indication of the force at which longlines can break in certain circumstances.

For example, factors such as the speed and intensity at which the fibers are loaded, previous conditioning or previous shock loading of the materials can influence significantly the residual tensile strength of the longline. Abrasion, cuts, sharp bends, etc. can decrease the tensile properties of the rope. Additionally, knots, torsion or other distortion of the longlines can also have an effect on the residual tensile strength.

Conclusion

The study provides documented proof from a representative cross-section of users and reveals that a more conservative approach must be taken with regards to the service life of helicopter longlines.

> ***"Barry has reviewed its User Instructions Manual and now limits the service life of its helicopter longlines to 4 years"***

Accordingly, Barry has reviewed its User Instructions Manual and now limits the service life of its helicopter longlines to 4 years, unless for exceptional cases where actual break testing is being performed by Barry to determine a used longline residual tensile strength and whereby the working load limit may be reduced as well. In certain cases, the lifetime of a longline may be reduced or extended, but this decision must always be left to the manufacturer who will analyze all aspects of the longline's condition and history of usage.

References:
- McKenna H.A., Hearle J.W.S., O Hear N., "Handbook of Fibre Rope Technology", CRC Press, 2004
- Cordage Institute International Guideline CI 1401-06 – Safer Use of Fiber Rope, 2006
- Cordage Institute International Guideline CI 2001-04 – Fiber Rope Inspection and Retirement Criteria, 2004
- DSM Dyneema® CIS YA103, "Outdoor use of ropes made with Dyneema® fibers", 2008
- DSM Dyneema® CIS YA101, "Chemical resistance of Dyneema® fibers", 2008
- DSM Dyneema® CIS YA100, "Ultra High Molecular Weight Polyethylene fiber from DSM Dyneema", 2010
- Barry Publication, "High Strength Synthetic Fiber Rope Compared to Wire Rope for Helicopter Longline Applications", 2010

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