United States
Department of
Agriculture

Forest Service

Technology &
Development
Program

5700-Aviation
November 1992
9257 1207-SDTDC

Snap Back Tests of Nonmetallic Leadlines for External Helicopter Loads

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1E11P83
Helicopter Accessories

November 1992

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INTRODUCTION

For many years, experienced helicopter specialists in the field have indicated a desire for nonmetallic leadlines. Under current procedures, the General Services Administration (GSA) awards supply contracts for helicopter accessories such as leadlines. Forest Service standard No. 5100-500, *Accessories, External-Loading, Helicopter,* is used in this process and steel leadlines are currently the only lines specified.

In 1983 the Center evaluated a nylon leadline. This 10-foot line was tensioned to 2,500 pounds (considered the working load), and instantaneously released by tripping an electrically operated remote helicopter hook. The results were surprising and significant. The nylon leadline caused the helicopter hook to rebound 5 to 7 feet. This led to a recommendation that these nylon lines not be used until further development and testing was performed to ensure that hooks would not "snap back" into the airframe (or worse yet the main rotor), and that a broken line would not stream back into the tail rotor.

In 1991 the Center was asked to evaluate two leadlines containing Kevlar and polyethylene fibers. The Kevlar leadline, supplied by Versatile Helicopter, Inc., Prescott, Ariz., was made by braiding three 3/8-inch ropes together. The polyethlyene leadline was a single rope, 3/4-inch in diameter, supplied by Allied-Signal, Inc., Petersburg, Virg. Small loops had been spliced into both ends of each line. Properties of these materials revealed that they are less elastic than nylon, and specialists felt they could safely be used as leadlines. Tests were conducted during September of that year and are the subject of this report.

SCOPE AND OBJECTIVE

The test was limited to the evaluation of one sample of each line. The maximum vertical distance which the lower end of the line reached when the loop at that end was instantaneously released from the electrically operated hook was measured. (This is referred to as "snap back" in this report.)

The objective of this test was to measure the snap back of two different lines after tensioning them to 1,200 pounds. Snap back distances greater than one half the original length were considered excessive.

TEST PROCEDURE OUTLINE

Tests were conducted indoors at the San Dimas Technology and Development Center (SDTDC). Each test specimen was approximately 10 feet in length, with braided loops in each end. Plans called for each specimen to be tested four ways. In one configuration, the loop on one line end was placed in the hook of a ceiling mounted chain hoist, the other end was placed in a DH2000 Electric Release Hook. The body of the release hook was attached to a permanent eye in the concrete floor through a Dillon dynamometer.

In another configuration, the release hook was reversed so that the body of the release snapped back with the line and the hook released from the Dillon dynamometer, which was pinned to a eye mounted permanently in the concrete floor. The electric release hook was attached to the floor the first way and rode with the line the other way. The release was made both instantaneously and after a 30-second delay upon reaching a tension of 1,200 pounds.

> **NOTE:** Part way through the test, it was noted that the inner strands of the Kevlar line were showing near the end of the spliced section *(see fig. 1).* The decision was made to discontinue further testing of this sample.

A detailed description of the test procedure can be found in the appendix.

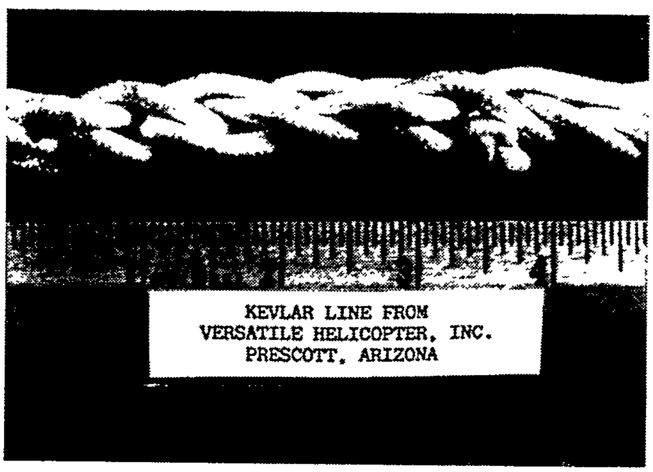

Figure 1. Kevlar outer rope cover ruptured during initial testing.

TABLE OF RESULTS

Table—Leadline snap back

Test No.	Test specimen	Test setup	Release	Vertical travel distance (in)	Free length (%)
1	Kevlar	First	Instant	44	37
2	Kevlar	First	Instant	44 (1)	37 (1)
3	Kevlar	First	Delayed	- (2)	- (1)
4	Kevlar	First	Delayed	-	-
5	Poly	First	Instant	12	10
6	Poly	First	Instant	17	15
7	Poly	First	Delayed	5	4
8	Poly	First	Delayed (3)	8 (4)	7 (4)
9	Poly	First	Delayed	-	-
10	Poly	Second	Instant	5	4

> **NOTE: Important**—all tests were performed on one sample of each product. The values shown for delayed testing have broad tolerances, because the tension was dropping about 1-2/3 to 2 pounds per second.

(1) Snap-back value unknown, as the video camera did not record *(see the appendix).* Load dropped to 1,150 pounds before 30 seconds elapsed.

(2) Snap-back value unknown, as the video camera did not record. Load dropped to 1,160 pounds before 30 seconds elapsed.

(3) This specimen was released after 2 hours, 50 minutes. At that time the tension was below 680 pounds, but the exact value is unknown.

(4) Snap-back value unknown, as the video camera did not record.

DISCUSSION OF RESULTS

Observers noted that the Kevlar specimen snapped back approximately 36 to 44 inches after being tensioned for 30 seconds. This would indicate that the tension did not relax with time as dramatically for this material as for polyethlyene.

The observers also noted that the snap-back of the polyethylene sample after 2 hours, 50 minutes was only approximately 6 inches, but this is quite meaningless because of the dramatic decrease in line tension. A dynamometer reading was not taken at this point in time.

The 1,200 pounds of tension measured on the dynamometer decreased with time. The polyethylene line was tensioned to 1,200 pounds in the test fixture but, after only 30 seconds, the dynamometer read 680 pounds.

As a result of these tests, the samples tested should not be considered the optimum choice of materials and processes for leadlines. A market search (including Military Supply) was not performed nor followed up with an engineering approach to the selection of a leadline. An exercise of that nature may uncover better properties.

Although permanent set was not a test parameter, the lines were measured before and after testing. The Kevlar line was 107 inches *(8.9 feet)* long before the tests and 107-3/8 inches long after the test. The polyethylene line was 121 *(10.1 feet)* inches prior and 122-1/4 inches after. Leadlines used by helicopter specialists vary in length from 12 to as much as 150 feet.

Since leadlines like these are quite light, they stream back quite easily in forward flight. The down wash of the rotor alters this somewhat; however, the possibly of entanglement in the tail rotor may exist during forward flight. This was a SDTDC concern when testing the nylon lines and remains so today.

CONCLUSIONS

We reached the following conclusions:

1. This test demonstrated that the snap back of lines made with Kevlar or polyethylene fibers, when tensioned to 1,200 pounds, are acceptable; whereas those made from nylon tensioned to 2,500 pounds are not.

2. The snap back of a line varies with the magnitude of the mass attached to the end and tension just prior to release.

3. The jacket surrounding the 3/8-inch Kevlar rope failed in several places; this is unacceptable.

4. In future tests, the lines should be pre-stretched and measured before and after tests to ensure that the elastic limit has not been reached. There should be little if any change in the overall length. During periods where the line has been tensioned, the tension should not bleed off over periods of time as short as 30 seconds.

5. Nonmetallic leadlines are a promising technology, but further engineering work is needed before this type of line is considered for field use.

RECOMMENDATIONS

It is recommended that before field use, each type of line be tested for snap back, which should be limited to 40 percent of the original leadline length. Forest Service standard 5100-500 should be amended to include this recommendation.

Rejection of the triple-braided Kevlar specimen is also recommended; this because of the exposure of inner strands.

APPENDIX—Detailed Test Procedure

1. Scope
Because of the large amount of elasticity in most fiber ropes, the only leadlines currently approved for the use with USDA Forest Service helicopters are manufactured of steel wire rope. These tests are to determine whether two high-strength industrial fiber ropes—Kevlar and Spectra-900, a polyethlyene product—have a low enough elasticity and resistance to deformation to be used as an alternative to steel wire rope.

2. Applicable Documents, Current Issue
USDA Forest Service *Standard for Accessories, External-Loading, Helicopter, 5100-500e.*

3. Definitions

3.1 Kevlar is a woven, manmade material.

3.2 Spectra-900 was patented by Allied Corporation in 1983 as a high-tenacity, high-modulus polyethylene and polypropylene fiber. Spectra-900 is woven by Allied-Signal, Inc., into rope material.

4. Apparatus

4.1 Yale pulleys system, spur-geared block, 4,000-pound capacity, equipped in the Indoor Test room 14 at SDTDC.

4.2 DH2000 Electric Release Hook, borrowed from the Forest Service Arcadia Fire Cache.

4.3 Dillon dynamometer, 4,000-pound capacity gauge.

4.4 Fixed steel eye in floor of Indoor Test room 14 at SDTDC.

4.5 Video camera.

4.6 Measurement rod, incremented in inches, placed behind the test setup to allow the video camera to record the snap-back height when the rope is released.

5. Environmental Conditions

5.1Testing Room *(not environmentally controlled)*:
Temperature: Ambient.
Humidity: Ambient.

6. Test Equipment Calibration
Test equipment must be calibrated annually. A label with date of calibration shall be on the Dillon dynamometer.

6.1 Dillon dynamometer
Power Module calibration due date: 9-23-92.
Load Cell calibration due date: 9-23-92.

Dynamometer was also manually calibrated by pull test on the calibrated Tinius Olsen machine by SDTDC personnel.

7. Test Specimen

7.1 Specimen are of two ropes of approximately 10-foot lengths of high-strength industrial fiber rope with nonthimbled eyelets on both ends. The Kevlar specimen type is white, 3/16-inch diameter woven cord, with three 3/16-inch diameter woven together to form one 3/8-inch overall diameter cord configuration. Kevlar specimen is provided by Versatile Helicopters, Inc., Prescott, AZ. The other specimen type is orange 3/4-inch diameter Spectra-900 single-woven cord, provided by Allied-Signal, Inc., Petersburg, VA.

8. Preparation

8.1 **Setup:** Two test setup positions will be utilized. The difference is the attachment of the DH2000 Electric Release Hook. In the first setup it is hook end up; in the second it is fixed end up. This is planned because it is unknown if it will make a difference.

8.1.1 **First setup:** Yale pulley system at the top with one eye of the test rope attached to the pulley hook. The bottom eye of the test rope shall be attached to the hook end of the DH2000 Electric Release Hook. The fixed end of the release hook shall be attached to the Dillon dynamometer. The dynamometer shall be attached to a fixed wheel steel eye, which is located within the floor of the Indoor Test room 14.

8.1.2 **Second setup:** Yale pulley system at the top with one eye of the test rope attached to the pulley hook. The bottom eye of the test rope shall be attached to the fixed end of the DH2000 Electric Release Hook. The hook end of the release hook shall be attached to the Dillon dynamometer. The dynamometer shall be attached to a fixed wheel steel eye, which is located within the floor of the Indoor Test room 14.

8.2 Tests will be conducted in the Indoor Test room No. 14 at San Dimas Technology and Development Center, San Dimas, CA 91773.

8.3 Number each specimen with masking tape.

9. Test Procedure

9.1 All test instrumentation and test specimens shall be in ready to operate and test modes.

9.2 Testing and test results will be recorded with the video camera so that "stop action" can be used when viewing the video to determine more accurately how much snap back occurs with each rope. The approximate snap back distance shall be recorded for each test.

9.3 For the first setup, place the rope on the pulley and the hook of the DH2000 Electric Release Hook. Tighten the pulley until the dynamometer indicates 1,200 pounds. For the first two hooks, the hook will then be immediately released. For the next two tests, the pulley will be tightened until the dynamometer reads 1,200 pounds. The hook not be released immediately, but delayed 30 seconds. The purpose is to determine if the load is reduced due to the rope stretching or elongation. Dismount specimen.

9.4 For the second setup, place the rope on the pulley and the hook of the DH2000 Electric Release Hook. Tighten the pulley until the dynamometer indicates 1,200 pounds. For the first two hooks, the hook will then be immediately released. For the next two tests, the pulley will be tightened until the dynamometer reads 1,200 pounds. The hook not be released immediately, but delayed 30 seconds. The purpose is to determine if the load is reduced due to the rope stretching or elongating. Dismount specimen.

10. Report

10.1 The report will include test results, an explanation of any anomalies experienced during the testing, an analysis of the data, and possible conclusions.