

## **SYNTHETIC FIBRE ROPES FOR FORESTRY USE - CRITERIA FOR THE REPLACEMENT OF FIBRE ROPES**

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**Abstract:** *Fibre ropes for forestry use are offered by several manufacturers. According to studies, fibre ropes offer a wide range of advantages in comparison to steel wire ropes: For example the low weight of fibre ropes facilitates forest operations and serious accidents through broken wires are avoided.*

*For safety reasons and to protect individuals who work with these types of ropes, clear decision-making aids are needed in order to assess the continued use or replacement state of a rope, as is in the working guidelines applying to steel cables.*

*The abrasion resistance of ropes, when pulled along rough ground has been found to be the most crucial factor affecting the continued usage of the rope, before it falls below the required minimum break force value (twofold pulling force in a winch wire). A secondary factor is the brand selection of the rope.*

*This paper presents first results of test series started by the Austrian Federal Research Centre for Forests, Natural Hazards and Landscape (BFW) provided initial indications to this question.*

### **1. Introduction**

The relatively new ropes from UHMPE-fibres (i.e. Dyneema) for skidding have so far no usable catalogue of criteria for timely detection of possible undershooting the prescribed coefficients of safety for the use on forest winches. On the Internet existing criteria catalogues from the field of nautical applications are not transferable or have only very limited transferable to forestall applications. Laboratory tests at the Oregon State University (GARLAND, J. et al, 2003) have shown that the tensile strength of a 12-stranded rope fell at cutting off 1.2 or 3 strands to 92%, 81% or 60% of the original tensile strength.

The aim of the ongoing project is the creation of simple detectable criteria for the replacement of winch ropes made from UHMPE-Fibres.

### **2. Experiences to date with synthetic ropes**

In the gliding area of the chokers the rope is heavily abraded. By improvements in the working method and innovative new developments of gliders the corresponding wear has already been significantly reduced.



**Figure 1.** Abraded area on a coated synthetic rope

It has also been proven that the spooling characteristics of synthetic ropes compared to steel ropes are very good, and this does not influence the durability of the ropes. The known influence of different drum design and the entry angle of the ropes as against the life of steel rope, could not be detected with synthetic ropes.

This means the rope's resistance to abrasion by pulling over rough ground is the most essential criterion towards the operational life of the rope, to avoid going below the required minimal tensile strength (2 times drag force of the winch). In contrast to stress through the choker gliders, which usually concerns only a few meters at the ropes end, heavy abrasion by pulling over rough ground takes place at one third of the used rope length.

We therefore focussed our investigation on specific work related abrasion of the ropes, utilising both photographic and written documentation of the ropes surface through continued wear and tear in working conditions. In combination with the remaining tensile strength, a growing data set will be established, to find out if there are indicators to determine the used and necessary replacement state of the synthetic rope, similar to existing replacement criteria for steel ropes.

### **3. Method of testing:**

No scientifically conducted investigations could be found concerning impact of abrasion under field conditions to help create the replacement criteria for UHMPE-fibre ropes in forestry applications. In a series of preliminary studies the method of analysis and the required test facility where developed and successfully utilised in the ensuing first trials.

#### **3.1 Considerations to the layout of the trials:**

The most essential criteria for planning and design of the investigation is the comparability and repeatability of results. In addition, the preferably actuality in exposure to abrasion of the tested ropes would be decisive for good interpretation of the results and the transfer to real conditions. To ensure these criteria, the abrasion would be simulated under the nearly natural conditions of stony ground.

#### **3.2 Design of the abrasion trial station:**

The test pulls were on an even, but abrasive surfaced 35 m track, closely duplicating extreme conditions in logging to simulate the expected fast wear of the rope samples. The necessary roughness was insured through application of limestone gravel (grain size 0/32) mixed with about 25 % humus. In order to simulate fixed

obstacles in extraction and to prevent the track from gradual depression, seven concrete sleepers were built diagonally into the track at a distance of about 3.5 m apart. The track was always levelled before starting a new test series. The test ropes were fastened with approx. 250 kg traction on wooden skids attached to a specially crafted carriage, drawn by a self propelled winch.



**Figure 2.** The testing track and the special carriage with 4 wooden skids



**Figure 3.** The test rope is fastened on the skid

### 3.3 Test – Design

Each rope will be tested with five different frequencies of repetition (0, 10, 20.30, 40) with a speed of approx. 1 m/sec in both directions on the track. The highest frequency is chosen for consistent wear to occur and achieving the state of worn out for replacement. To compensate difference in the track and eventual rope material, each rope in each frequency will be repeated four times rotationally around the four positions on the carriage. At each run a constant reference rope will be carried to observe and also compensate the expected differences in abrasion with temperature and humidity.

### 3.4 Documentation of the test ropes:

After the abrasion test each rope will be systematically documented through photography, and the changes to the ropes surface and the condition of the filaments strands respectively described. The determined and respective worn state of a rope, combined with the remaining breaking strength, yielded initial indicators towards determining the necessary replacement state of a rope. Further tests will predictably increase the accuracy.

### 3.5 Collecting test material of ropes used in forest practise:

Further sample material for adjusting and verification of the artificial abrasion tests, will be collected from ropes which had been used for forest skidding operations. After comparison and documenting the state of wear with the results of the test series, the tensile strength would be measured too. Further documentation

through telephone interviews about the users experiences with fibre ropes, assisted in the analysis of data and descriptions towards the worn state and replacement of ropes.

#### 4. Criteria for replacement:

It was already evident in the first results that the derivative clearly identifiable criteria would be the biggest challenge. Therefore to create such a list of criterion, for the safety of the growing number of users, to be able to observe the advancement in the worn state of ropes (state of replacement) and conform to the coefficient of safety (Ropes strength = 2-fold max. pulling force of the winch) prescribed in the standard for forest winches (EN 14492-1) would be a major step forward. However, the results of the project also could show differences in abrasion resistance between the various products and new developments could accordingly be accompanied through comparative testing.

#### 5. Results of tests carried out to date:

Up to the deadline for this report, 5 ropes were tested from different product lines for use with 8 tonne winches with according minimum breaking forces of more than a 160 kN, but there has been only one rope, the reference rope, tested till now at all frequencies (0, 10, 20, 30.40 trips).

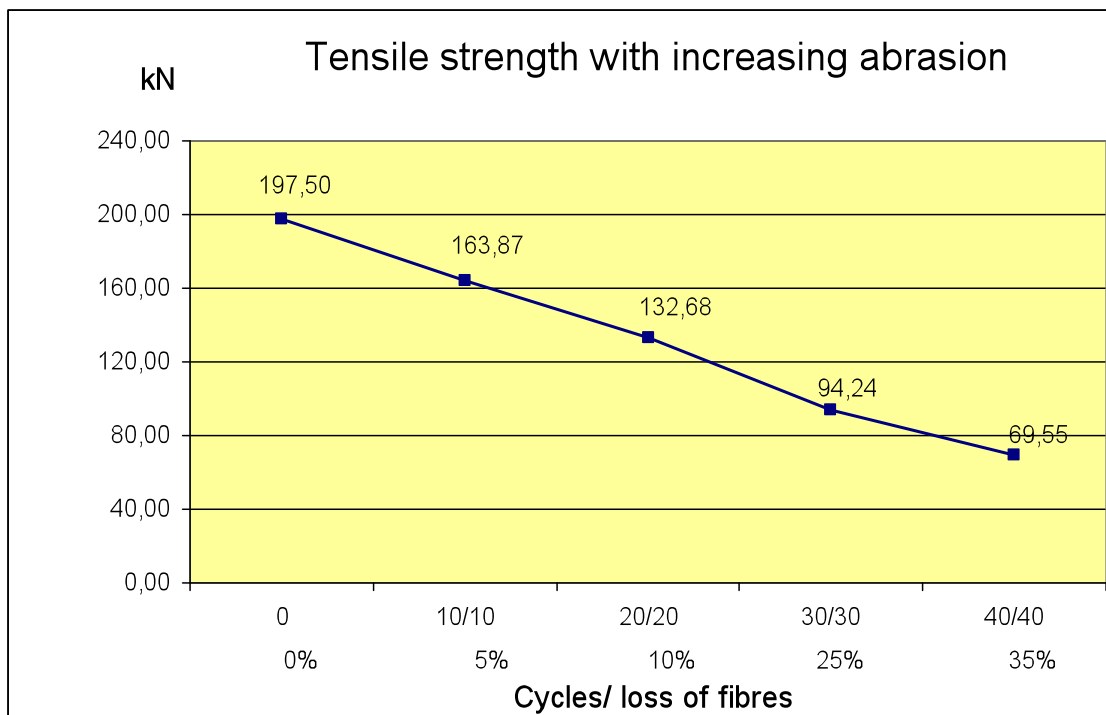


Figure 4. Results from the reference test rope



**Figures 5.** The reference rope after 10 trips



**Figure 6.** The reference rope after 20 trips



**Figures 7.** The reference rope after 30 trips



**Figure 8.** The reference rope after 40 trips

The other 4 types of ropes have only been tested in the highest frequency (40 trips) to determine whether the proposed abrasion frequencies with the Maximum 40 rides cause a reduction of strength significantly below the 2 fold value of the maximum winch pulling force.

This condition was more than clearly met!

The results of the tensile strength check after 40 trips with not more than 20% to 35% loss of individual fibres were that the ropes had lost 55 % to almost 73% of their original minimal breaking force.



**Figures 9.** The surface of two test ropes after 40 trips



This was very surprising, because the superficial check of the worn ropes showed only minor damage comparable to the surface of similar ropes after a few weeks of usage, presuming a high tensile strength.



**Figure 11.** Harvester hanging in a steep slope on a rope in condition similar to the test ropes on figure 9

It seems, that the determination could only be successful by precise evaluation of the loss of fibres in each individual yarn, as done for estimating the loss of fibres for the reference rope (Figure 4). The increasing data base will show the trueness of this method to constitute a executable way to check the intact rope



**Figure 12.** Strands from 4 differently worn ropes



**Figure 13.** The loss of fibres could be estimated at the individual yarns of the strand

## 6. Conclusion:

The tests carried out have shown, that a reduction of the tensile strength is already present at a relatively marginally loss of fibres, resulting in critical values and the prescribed required safety factor 2, in most cases, clearly being surpassed after initial use. This underlines the urgent need for a criteria catalogue for timely detection of the state determining replacement of the rope

Considering the growing number of users and the necessary observance of the safety factor to avoid accidents by unexpectedly breaking ropes, the establishment of a replacement criteria catalogue, and the training of users is of paramount importance.

In addition, the delivery of data to the manufacturing industry with valuable information on their products abrasive resistance compared to the products of competitors and could be of interest in further product development.

## **7. Acknowledgements**

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## **References**

Garland, J.J. et al (2002), “Using Synthetic Rope to Reduce Workloads in Logging”, Final Report, Worksite Design Program, Oregon Occupational Safety and Health Administration, Oregon, US

Garland, J.J. et al (2003), “Synthetic Rope to Replace Wire Rope in Mountain Logging Operations”, Proceedings of Austro 2003 – High tech Forest Operations for Mountaineous Terrain, Schlägl, Austria

Kirth, R. et al (2007), “Further Developments of Synthetic Ropes for Logging Applications in Forestry”, Proceedings of Austro 2007/Formec 2007 – Meeting the Needs of Tomorrows’ Forests – New Developments in Forest Engineering, Vienna, Austria