A SUMMARY OF THE CONFERENCE ON NYLON AND ROPES TURIN, MARCH 8/9, 2002

Several scientific papers were presented, including mathematical modeling of belay techniques and analytical models for the analysis of textile ropes. Water absorption in polymers is much better understood now than over 30 years ago, when tests established that a wet rope loses much of its dynamic performance. Today it is known that water causes the nylon to plasticize, drastically changing its mechanical and physical properties. Work on this subject, while presented at the conference, can be found elsewhere on this site.

1. Material facts about polymers (nylon) of interest to rope users:
    - polymers consist of macromolecules, where crystal parts, perfectly ordered chain structures, alternate with amorphous parts, disorderly structures with tangled chains,
    - the temperature at which the amorphous parts are modified is called the glass transition temperature (Tg), because the material behaves similar to glass.
    - the addition of water lowers the Tg of the material and has the same effect as heating the material,
    - thus the mechanical and physical properties of nylon change with, among others, temperature and moisture,
    - with increasing temperature the material goes from very hard (glassy) to flowing (rubbery), the material is similarly plasticized when it is wetted,
    - testing a wet rope is similar to testing a dry rope at a temperature of 70 - 80 ° C.

2. Rope making facts:
    - energy capacity is principally given by the core (multiple twisted strands),
    - to improve dynamic performance increase core and reduce sheath
    - sheaths are constructed with 32, 36, 40, 48 bobbins (spindles) and, generally, two-on-two construction,
    - abrasion resistance is more or less proportional to the amount of sheath,
    - a thicker sheath resists abrasion better than a thin one, all things being equal,
    - increase bobbins, diminish thickness of yarn (twine) and get a thinner sheath,
    - for a 10.5 mm rope 48 bobbins are used for a sport rope and 32 for a gym rope,
    - tight sheath vs. loose sheath. A tight sheath produces a rope, which is more rigid, has more resistance to abrasion and cutting, kinks more, has a higher elongation, is less supple and has less resistance in the knot than one with a loose sheath.

3. Why ropes have gone thinner and hold more falls.

- fifty years ago an 11 mm diameter rope barely held two falls. Now we get a rope with 9.5 mm diameter holding eight falls,
- yarns: improved raw materials, production methods and quality control,
- twine: better methods of twisting of yarn and of shrinkage and dying process,
- proper selection (and setting up) of braiding machines and yarn-count,
- better knowledge of balancing core and sheath construction,
- years of experimentation, research and experience.

4. Influence of sunlight on the dynamic performance of multi-fall mountaineering ropes:

- some colours in the sheath fade, while others do not,
- there is a correlation between decolourisation of the filaments and the mechanical properties: the higher the loss of colour, the higher the degradation of the mechanical properties. It seems to affect more the brilliant and "stylish" colours,
- the mechanical properties of the core degrade in a markedly more uniform way and much less than the sheath,
- a relatively low degradation of the mechanical properties of the filaments (approx. 10 % reduction in breaking strength and elongation) corresponds to a notable reduction in the number of falls held (up to 50 %). The ropes were exposed for three months at an elevation of 2550 m in the Dolomites,
- as expected, degradation at a lower elevation (1834 m) was considerably less (up to 25 % reduction in the number of falls held),
- the value of the impact force is not affected.

5. When to retire a rope; a study of rope wear:

- it is hardly any news that the principal factors of rope wear are the combined effects of rubbing against rock, mechanical reduction (rappelling and belaying devices), dust and microcrystals that penetrate the sheath and the number of meters climbed (not the time used),
- the enemy of rope wear is friction - most intense in abseiling and top roping, made worse by dirt, and the inevitable rubbing against rock,
- to weaken the sheath means to seriously compromise the dynamic performance of the rope,
- the sheath of a sport rope is about 30 % of the weight of the rope. The core alone, of such an 8 - 9 fall rope, holds only one fall,
- some abseiling devices produce much more wear damage than others,
- after only 50 descents with a figure-eight, the dynamic resistance of a rope is reduced by one third (number of drops). The descents were undertaken with extreme care - slowly and without impact,
- rappelling with a Robot (a multi-use device manufactured by Kong) does not appear to compromise the dynamic resistance of the rope. The device functions like a carabiner brake,
- not surprisingly rope wear is much more severe on granite than on limestone,
- rope degradation is approximately proportional to the number of broken textile yarns of the sheath,

- current work confirms previously published information. After climbing approximately 5000 meters, the dynamic resistance of the rope is reduced to half and after an additional 6000 meters it is down to 30 % (UIAA Bulletin # 146, June 1994, in German),
- see also The Journal of the UIAA #3, 2000, pp. 12 - 13, available on the Internet under www.uiaa.ch.

6. Safety Loss of Mountaineering Ropes by Lowering Cycles in Toprope Climbing.
   This paper is of sufficient importance that it can be found in its entirety elsewhere on this site. The logical conclusion to this presentation is the use of a heavy sheath (top) rope for toproping. If the pitch has to be led to the toprope anchor, then a sport rope should be used for the lead and a different (top) rope for the lowering and subsequent toproping.
   A note of caution regarding the use of the Grigri in this study: the device acts statically and should not be used to belay a lead climber. It was developed for toproping and should only be used for this purpose.

7. Claims abound about the benefits of dry coating of ropes (durably waterproof, improved handling, abrasion resistance and durability, etc.). First of all, there are no standard procedures. Manufacturers can do as much or as little as they feel like. Furthermore, there are no tests **specifically** for climbing ropes, which measure durability, abrasion resistance or waterproofing. No valid comparisons can, therefore, be made.

   However, there is no doubt that treatments and finishing processes are known, which reduce water absorption. The aging behaviour of this treatment is supposedly good over the rope's lifetime, but it is also accepted that the dry proofing deteriorates with rope use.

   A study of dry proofed ropes from thirteen different manufacturers, using a variety of test methods, shows that only a very few ropes do indeed repel water well. The rest are bunched together with much higher absorption rates. One may say that many of the claims hold no water, but the ropes do.

   One of the presenters felt that climbers do not want ropes with water resistance treatment, because they only climb when it is sunny and are unwilling to pay for the added cost. Until there is an accepted standard, it may indeed not be worth the money to buy a dry treated rope.

8. Sharp edge testing: the aim is to find a suitable test method. An attempt to differentiate between edge-proof ropes (based on a sharp-edge test in the UIAA drop test) and others, which make no such claims, by measuring the energy absorption of the rope, failed. The results were nearly the same for all ropes. The suggestion was made to go away from the drop test and approach the problem from cutting the rope under tension (sideway action), which also reflect reality more closely.

9. New directions:

- find ways to maintain strength in a high humidity or wet environment,
- better resistance to sharp edges (a modern rope can only fail by being cut on a sharp edge),
- develop new (polyamide) fibers. This will only happen, if there are other needs. Rope manufacturers use only a miniscule amount of the total nylon production in the world.