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

The Italian Alpine Club under the auspices of the UIAA organized this conference in Turin. While it was known that wet ropes lose much of their capacity, the rapid degradation of ropes in abseiling and top roping is surprising.

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.

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 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,
- 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
- 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,
- 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, - 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.

6. Safety Loss of Mountaineering Ropes by Lowering Cycles in Top-rope Climbing. This paper details the surprising loss of capacity in dynamic mountaineering ropes due to top roping. The translation is not of high quality. A better edited version can be found in www.alpineclubofcanada.ca/services/safety/index.html.

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 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.

8. 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) fibres. This will only happen, if there are other needs. Rope manufacturers use only a miniscule amount of the total nylon production in the world.

The complete proceedings of this conference may be obtained (on diskette) from

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