

Rope Breakage



**Ref incident of May 20th, 2006
At Pipeworks Climbing Gym
Sacramento, California**

**Kolin Powick, Quality Assurance Manager
Black Diamond Equipment, Ltd
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THE INCIDENT (from posts on supertopo.com and rockclimbing.com)

Posted by a member of the gym

At approximately 1:15 pm, Saturday, May 20, 2006, at an indoor climbing gym in California, a climber was taking his "lead" test, which consisted of lead-climbing an indoor, slightly overhanging route of about 35 or so feet, clipping the pre-placed quickdraws, and then, taking a short fall from the top of the climb.

The climber, a young male, in the vicinity of 6 feet tall, of relatively thin build (weighing an estimated 155 lbs), had successfully climbed the route to its top, and had his hands on the top hold of the climb. His rope was clipped through a steel, key lock carabiner approximately 3.5 to 4 feet below his waist tie in point. The rope appeared to be properly clipped. The quick draw, and the clipped carabiner (that was about to take the load from his fall) hung out from the gently overhanging wall so that the carabiner did not come into contact with the wall. The climber, and his partner, were being observed by a gym staff-person who was evaluating the climber to determine whether the climber would pass his lead-test. In addition, several other climbers had gathered to observe the test.

Pursuant to the requirements of the lead test, the climber intentionally let go of his holds and proceeded to fall. It was not clear from my vantage point exactly how much slack the belayer had fed out at the time of the fall, but it appeared the climber fell perhaps 6-7 plus feet before the rope tightened and began to catch his fall. The climber had fallen approximately 2 clip points (perhaps approximately 10 or so feet) below the loaded carabiner, and his fall appeared to be substantially arrested, when the rope ruptured, and the climber plummeted to the deck. From a (very rough calculation), this appeared to be a very "low-load" fall. With the climber falling (including rope stretch before the break) about 10 feet (and perhaps up to 12 feet), before the break, it would appear that by an equally rough estimate that this 10-12 foot fall occurred on about 35 feet of rope (between the belay and climber). This fall would appear to produce a modest "fall factor" of say, around .333 (compared to the UIAA fall test of "fall factor" 2.)

I performed (an exceedingly) informal examination of the severed rope. According to the rope's owner, who was the partner, and belayer of the climber who fell, his rope was about three years old. He reported the rope had previously experienced several "light" falls, and, additionally, one 20 foot fall, which, according to the rope's owner, had occurred with much of the rope "out" to absorb the shock of the fall.

The rope appeared to be in good shape. The rope's sheath had almost no wear. I pulled the length of the rope through my hands: no obvious core irregularities were detectable. There were no detectable stains or other markings on the rope. In short, if the information reported from the rope owner was true, and there were no significant omissions, this appeared to be a rope that many climbers, including myself, would lead on, and indeed, had experienced less wear and tear than many gym lead ropes that I see employed on a daily basis. Of course, clearly, I am not in a position to know the whether the history of this rope was accurately reported.

Posted by the climber

I am the one that fell. It was at Pipeworks. The rope was flaked out twice before we began. The above story is correct. The rope was not caught in the gate of the carabiner. I saw it break as I fell. I was taken to UC Davis med center. After several test I was released. I am sore but ok. Link to a picture of the rope is below.

The rope belongs to my partner. I believe the history in the first post is correct. I will add that the rope was stored inside and he does not have pets that could have pissed on it. Furthermore, he has a lot of climbing experience, is a friend, and is someone I trust. The rope looks a lot better than most gym ropes. There is no damage anywhere to it except at the break. I believe it is going to be sent back to BD.

And I think they are going to make me take the test again.hahahaha.



posted by the climber

Hello everyone, I just joined the site. I have a question and I'll throw a couple more facts out.

When preparing the rope it somehow got pretty tangled. After untangling it the belayer/rope owner ran the entire thing through his hands, twice. I was not tied in while he was doing this. Once tied in the point where the rope would eventually fail was only ~5 ft from me. We are both human, but I think it is pretty unlikely we missed a cut in the rope.

As for the biner. After I clipped it I made one move above it. Then I looked down at the draw, and realized I was not very far above it. I made another move up, then looked down at the draw again and then proceeded to take the intentional fall. Given that the route was slightly overhanging, the biner was in good shape, the biner was designed so that the rope would not get stuck in the gate, and the fact that I looked down at the draw twice after I clipped it leads me to believe the rope was not cut here. But again, I am human and it is certainly possible that I missed something. Also, there was some slack in the rope when I fell so a couple of feet of rope ran through the

biner, it seems like there would be damage elsewhere on the rope if it was indeed cut at this point.

Last thing, having had the rope on my desk for a couple days, I can say from a purely observational stand point, the rope looked cut. It looked cleanly sliced about half way through. The other half looked like it was ripped apart. This does not match the pictures of acid induced failures that I have seen. I am really interested in the testing results, I have no idea what they are going to be.

Take it easy everyone,

Brian Voyles

Posted by the Climber

The biner was removed from the draw and examined. I was told there was nothing at all wrong with it, no sharp edges, no deformation, etc. I never saw it after the incident and do not know if Pipeworks still has it or if it was sent elsewhere to be tested. I do not know the exact length of the draws, but they appear to be the standard length.

I think it is unlikely that the rope caught on the hanger or sharp holds. None of the holds were real large or sharp. It is only slightly overhanging, but enough that I think the rope would have just slipped off a hold. Also, when I fell I pushed away from the wall with my legs, so that should have helped pull the rope away and keep it from snagging something on the wall. While climbing up I never felt like the rope caught on anything. Because of the shape of the wall and the location of the draws I really do not see how it could have been cut by anything but the biner.

The break in the rope was about 5 feet from me while tied in. I was tied in with a figure eight with a roughly 6 inch tail. So I guess that puts it 8ish feet from the end of the rope. I had an atc and locker on my harness, but it was clipped to rear gear loop, so I'm sure it is innocent.

Brian Voyles

DISCUSSIONS WITH PARTICIPANTS/WITNESSES

Some general information after discussing the event with the belayer (Dan Sobieski)

- It was the belayer's (Sobieski's) rope
- It was their first climb of the day.
- When the climber fell, the belayer lost his balance but did not fall to the ground.
- The belayer was using an ATC.
- The belayer gave a slightly dynamic belay. He did not give a big 'jump' as many people do when climbing outside during a sport climbing fall.
- There was 'some' slack in the rope at the time the climber jumped.

Rope History

- Bought in 2002.
- Used fairly regularly (weekends and road trips) for a year.
- Then used periodically (odd weekends) for the next few years.
- Had not been used for a year prior to incident.
- Always stored in a rope bag.
- Washed two times with warm water in a tub (no soap, bleach or detergent), hanged to dry in a cool shaded environment.

INITIAL IMPRESSIONS

When I first heard of this incident, my initial reaction was that there had to be some outside circumstances that caused this rope to fail – because ropes just don't break. I've done a substantial amount of testing of very old weathered quickdraws and my own personal climbing ropes that have been beaten and abused, as well as new slings and ropes. Though I've learned that these nylon products definitely degrade with time, weathering and use, and I have seen some instances where rope products do start getting close to what I would call "the danger zone", I have yet to see a sample that would fail under the relatively low forces generated in a fall as in this case. My guess is that the rope was most likely cut somehow: on a sharp biner, sharp edge, a climbing hold, etc. I wasn't, however, ruling out some extremely peculiar manufacturer's defect, some form of contamination of the rope (improper care, exposure to chemicals, etc), or a pre-distressed area of the rope that finally saw its limit in this instance.

When I was first asked to look at this incident, I read the posts on Supertopo.com and Rockclimbing.com. Upon learning more about the circumstances, and once I saw the photos of the rope, I was more convinced that the rope had been cut. The core strands looked very different than a broken rope after typical drop tower testing. Some of the strands had very clean ends with little unraveling from the core strands, while others were more frayed and significantly unraveled. See photos below.

The belayer sent me the rope, I received it on May 25th.



THE FACTS

- Rope – the rope is a 10.5mm Black Diamond rope – circa 2001. It appears to be a "Cirque" – at this time Black Diamond ropes were manufactured by PMI, with Nylon supplied by Beal.
- Carabiner – Kong steel key-lock carabiner
- Quickdraw – was a Petzl 'logo-ed' draw with Petzl rubber "keeper" – attached to the bolt with a Quicklink
- The climber was approx 4ft above the last quickdraw when he jumped falling approximately 10 feet. There was approximately 35 ft of rope out at this time – equaling a fall factor of about .29. The rope came tight, then broke sending the climber another 20ft to the padded floor where luckily he was not seriously injured.

ANALYSIS

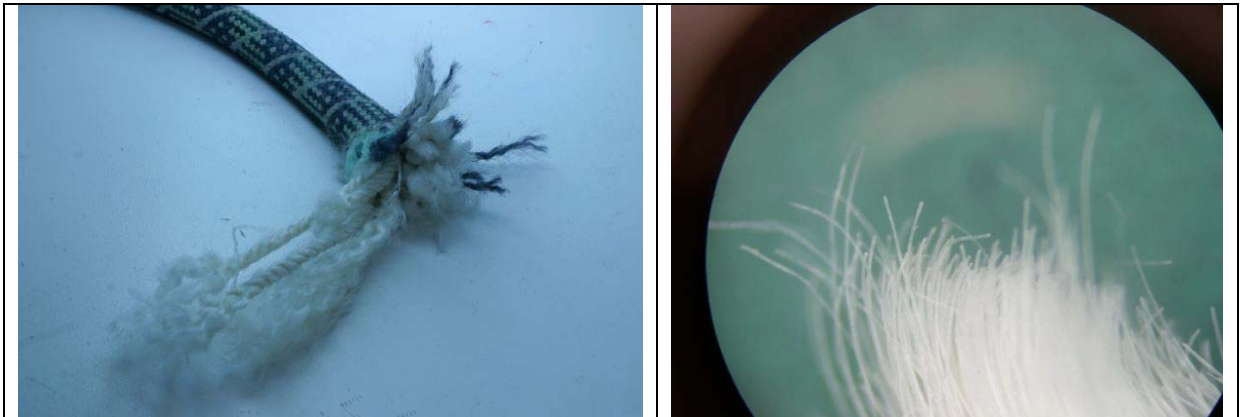
Carabiner

- The carabiner is a steel keylock. It is not worn significantly. (note: it's steel). There are no sharp edges.



Rope

- The rope broke 8ft from the end at which the climber was tied in. Using a figure eight with a back-up knot, this would equate to approximately 5ft from the climber's harness.
- Some of the strands at the point of breakage had clean ends, others were unraveled and frayed.



Comparative Rope Testing

Background

- Typical sport climbing falls, with a dynamic belay, generate forces at the top piece of protection anywhere from 1-4kN.

Lab Testing

- Several sections of the Sobieski rope were pulled to ultimate strength in a tensile testing machine. All failure loads and modes were consistent with a rope of this diameter. There was nothing unusual discovered in the sections of the ropes tested.
- Severe drop tower tests were performed on the remaining sections of the Sobieski rope, as well as a comparable new 10.5mm dynamic rope. These tests included factor 2 falls generating upwards of 10kN. Test configurations included the rope with falls:
 - over standard carabiners
 - pinched in the gate of a similar steel carabiner
 - running across the back edge of the gate of similar steel carabiners
 - over the edge of an extremely sharp and worn carabiner
 - through a bolt hanger (simulating a very sharp edge)
 - over the sharp back edge of a climbing hold
- The summary of the results is that the remaining sections of the Sobieski rope did not cut even under these extreme circumstances until multiple severe falls in the same location occurred. Even then, the failure mode was not consistent with the failed rope in this case. (ie. There was substantial melting of the strands in the drop tested ropes).
- The remaining portions of the Sobieski rope fared only slightly worse than the brand new rope in the same tests.
- Based on the results of this testing it was obvious that the entire rope was not suspect and the likelihood of a 'normal' rope being cut under the circumstances given in this case was very low.

On Site Re-creation of the Fall

The staff at Pipeworks, a representative from PMI ropes and I visited Pipeworks to examine the route and try to re-create the fall. The staff at Pipeworks had kept the route intact, changed nothing and were there to answer questions and assist in the analysis. As well, the climber and the belayer were there to answer questions and help in the investigation and analysis.

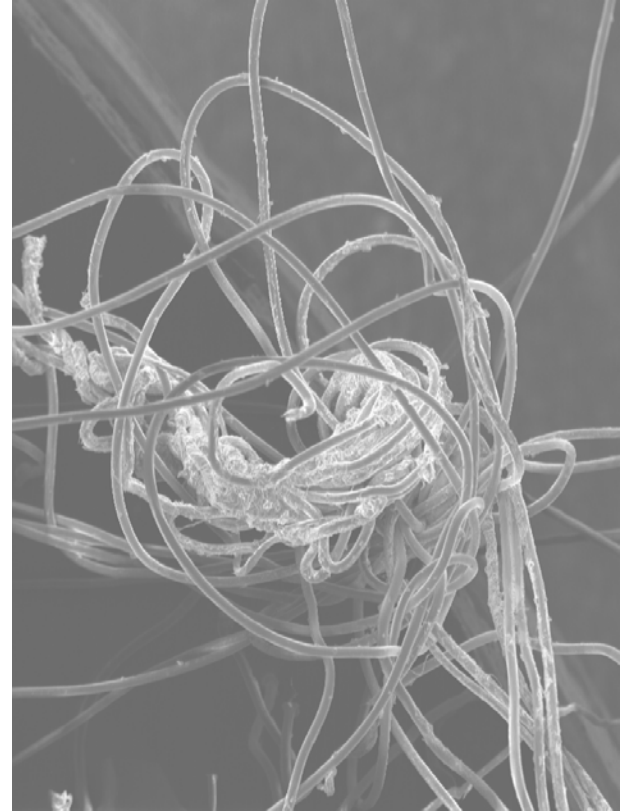
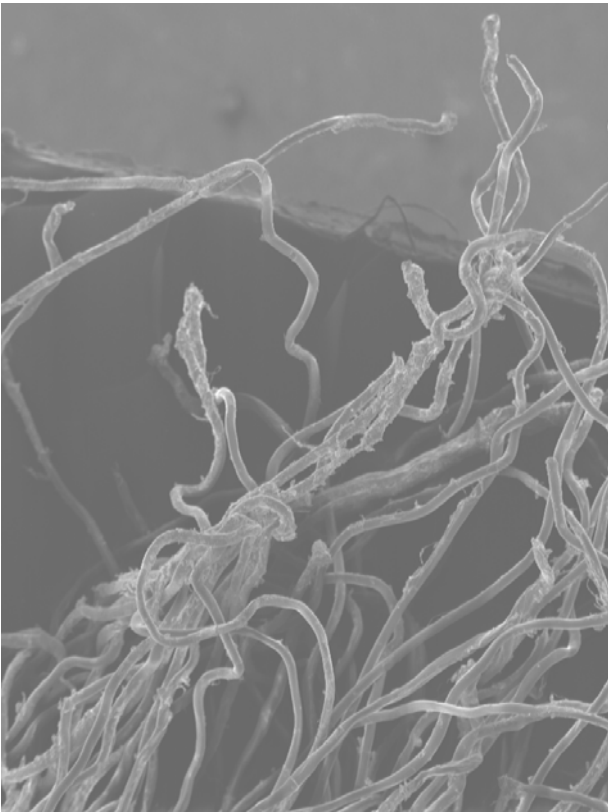
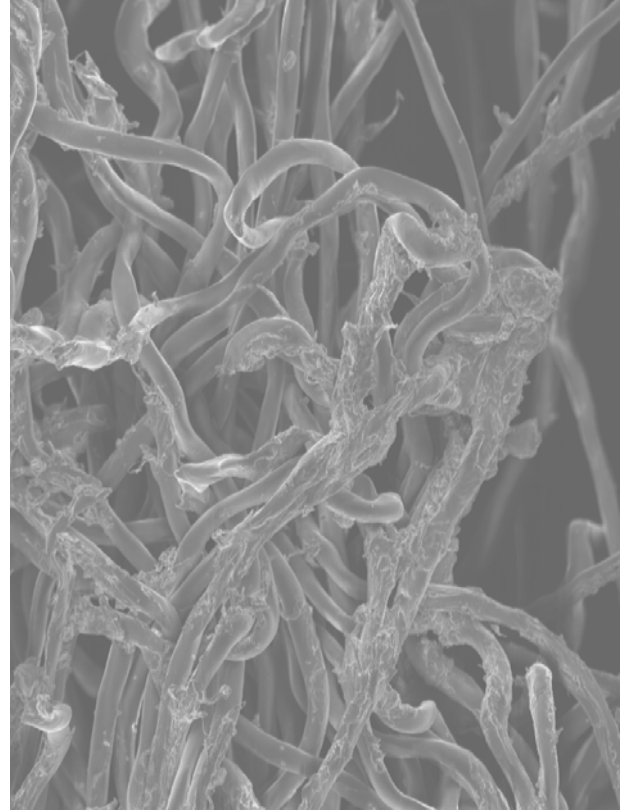
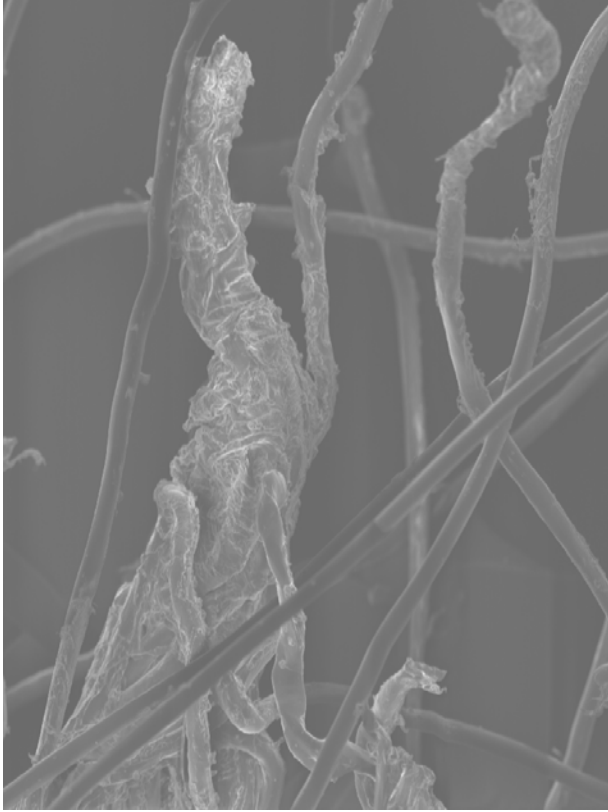
We climbed the actual route which the incident occurred, taking the identical fall using remaining sections of the Sobieski rope. We attempted to have the rope cut by forcing it behind nearby climbing holds, behind bolt hangers, being pinched in the carabiner gate, etc. The results from this test were that we could not get the rope to even come close to cutting in the terrain where the incident occurred.

Chemical Analysis

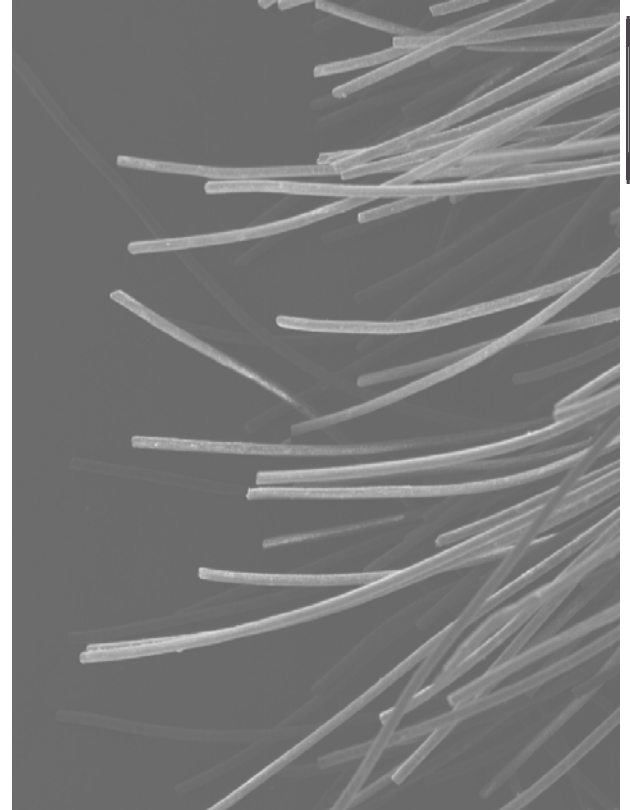
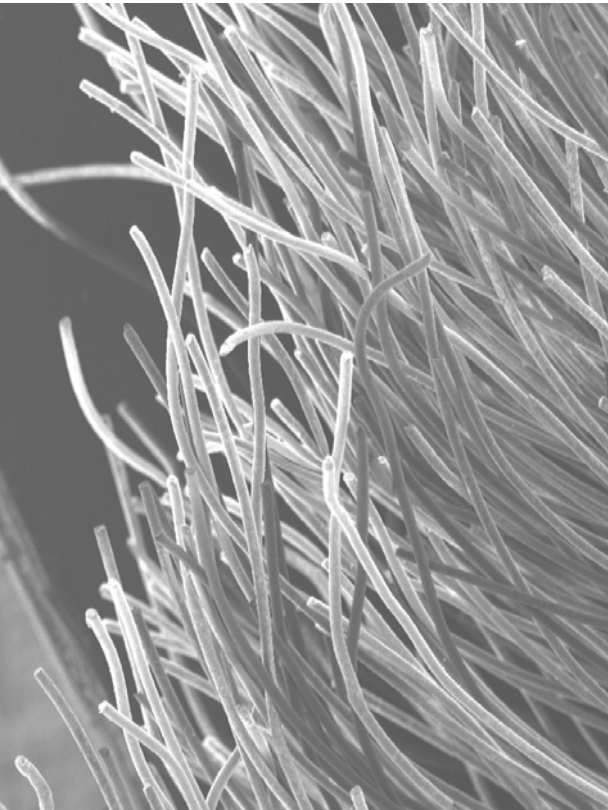
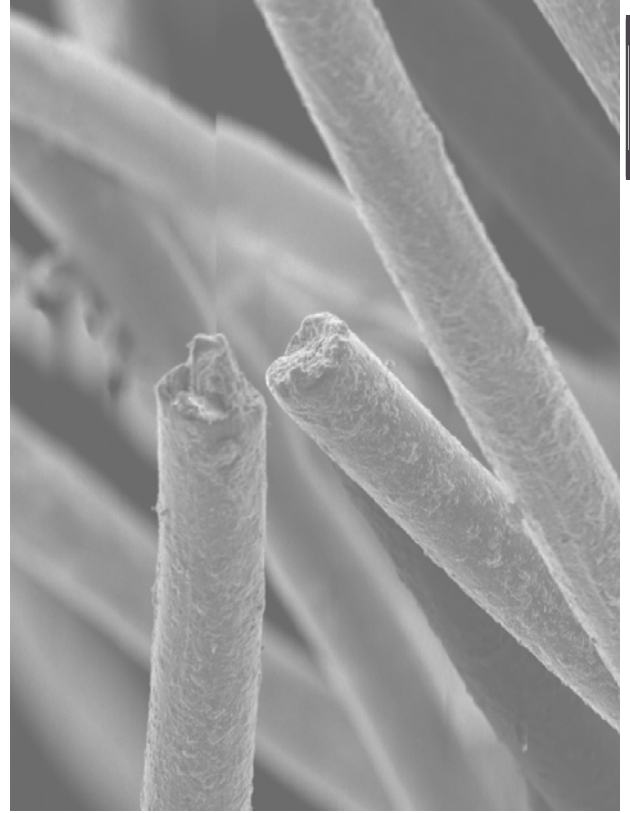
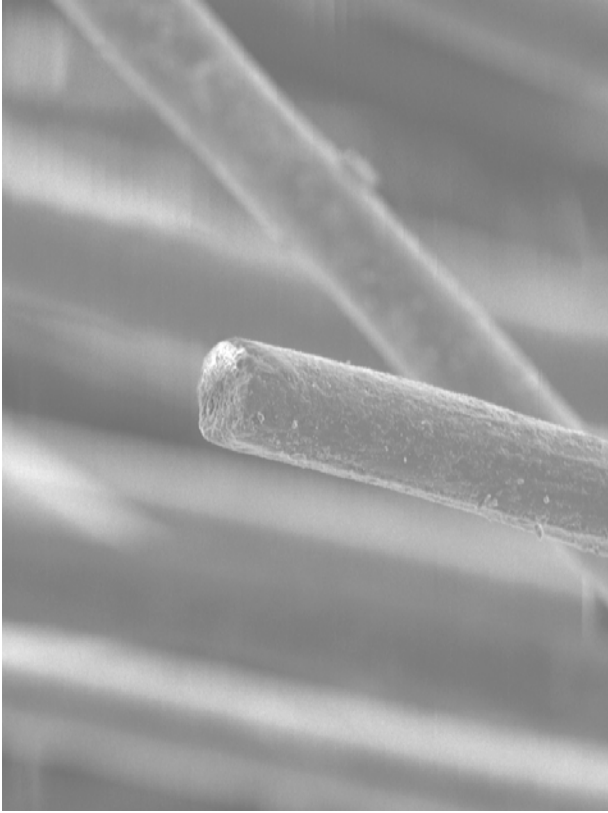
The section of the rope where the original failure occurred was sent to a Nylon manufacturer and chemical laboratory for analysis. **The results came back showing traces of sulfuric acid on the rope in the location of the rupture.** The photos on the following pages show the strands from the Sobieski rope (clean ends) compared to photos of a comparative rope when tested to ultimate failure in a UIAA drop test.

As can be seen in the photos, the strands of a standard tested rope are extremely melted whereas in the Sobieski rope in this case, there are very clean-cut strands. Note that there is no 'bulb' of melted section on the fiber ends. This too is consistent with nylon affected by acid. The acid weakens the nylon and even under low load the strands pull apart easily rather than generating heat while being pulled apart which exhibits signs of melting.

Comparative Rope



Failed Rope



CONCLUSIONS

Based on the following:

- Typical ultimate strength of other sections of rope in tensile tests.
- Typical behavior of other sections of the Sobieski rope during extremely aggressive drop tests over biners, sharp edges, etc.
- Inability to recreate the breakage in the drop tower.
- Inability to recreate the failure on the exact route (human testing).
- Findings of the chemical analysis showing traces of sulfuric acid on the section of the rope where failure occurred.

It is apparent that **the rope was locally contaminated by sulfuric acid**. This contamination led to a weak location in the rope which ultimately failed when loaded even to a low load during the mild fall of the lead test.

FURTHER THOUGHTS

What is unknown:

- 1) How did the rope get contaminated with sulfuric acid?
- 2) How did ONLY the location in question get contaminated?

Sulfuric acid is the electrolyte found in lead-acid batteries (ie. Car batteries). It is also found in fertilizer, high powered drain cleaner, glue and some other household products. Even the vapors alone can destroy nylon.

There have been at least three other cases of ropes breaking due to sulfuric acid contamination. Details can be found in the German Language book by Pit Schubert *Sicherheit und Risiko*, as well as a short article written here: <http://www.uiaa.ch/article.aspx?c=231&a=147>

After discussions with the owner of the rope (belayer Dan Sobieski), it is still uncertain how the rope could have possibly come in contact with sulfuric acid. He reports that it never came in contact with a car battery and was always stored in a rope bag away from any of the other possible sources of sulfuric acid. He recalls during one of the ropes last usages prior to the incident, laying it coiled in a parking lot while racking-up – could a car battery have leaked there? Would it have been enough to cause this rope failure? And how did only the section of rope which would run over the carabiner in this particular fall get contaminated? These are answers which may never be known.

FINAL COMMENTS

I'm still a firm believer of the age old climbing adage that 'ropes just don't break'. Proper care and storage of your rope is paramount. Always use a clean rope bag and never let your rope get in contact with items which may contain sulphuric acid or other chemicals which may harm nylon. Be conscious of where you put your rope. Never throw it in the back of a pickup truck or trunk of a car that may have been used to transport old batteries or other potentially harmful chemicals.

ACKNOWLEDGEMENTS

Thanks to those who assisted in the investigation and analysis:

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- Beal Ropes
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- Rhodia
- Dan Sobieski (belay/rope owner)
- Brian Voyles (climber)