DAISY CHAINS AND OTHER LANYARDS:

Some Shocking Results when Shock Loaded

Presented to:
The International Technical Rescue Symposium
November 2005
Ft. Collins, CO
USA

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Introduction:

Over the years, organized rope rescue has evolved with respect to the techniques used as well as the equipment employed. Much of this evolution can be attributed to the borrowing of techniques, equipment and practices from similar disciplines. For example, many pieces of equipment originally designed for climbing or mountaineering have been adopted by rope rescue practitioners and incorporated into their systems.

The 'daisy chain' is one example of a piece of equipment originally popularized by aid climbers and later adopted for other uses. The daisy chain has largely become the lanyard-of-choice for climbers as a means of attaching themselves to an anchor point. Because the rope rescue community has such a strong contingency of climbers in its ranks, it is not surprising that the daisy chain is regularly used as a similar tool in rope rescue scenarios.

In two independent drop test series conducted in 2002 and 2005, we examined the effects of a shock load on to various commercially made and user-configured lanyards. This presentation offers a critical examination of daisy chains and other similar lanyards.

Background Information:

There are a vast number of different lanyards available in the marketplace for a variety of different applications. *Via ferrata,* for example, uses a lanyard with a Y-shaped double-tail connection system also incorporating an energy absorber. Because of the potential for extremely high fall factors (> 2) in *via ferrata,* lanyards used for this activity are manufactured to meet certain performance criteria based upon applicable CEN and/or UIAA standards addressing *energy absorbing systems.*

In the U.S., lanyards used within the scope of a *work positioning system* are regulated by OSHA. OSHA 29 CFR 1926.502(e) states: *Positioning device systems and their use shall conform to the following provisions:*

(1) Positioning devices shall be rigged such that an employee cannot free fall more than 2 feet (.6 m).

(2) Positioning devices shall be secured to an anchorage capable of supporting at least twice the potential impact load of an employee's fall or 3,000 pounds (13.3 kN), whichever is greater.

(5) Connecting assemblies shall have a minimum tensile strength of 5,000 pounds (22.2 kN).

The point of the brief background information on standards and regulations is simply to illustrate that there are existing benchmarks for both user application and performance criteria with respect to lanyards. Lanyards are designed and manufactured to meet certain criteria for specific application.

Daisy chains are multi-pocketed lengths of webbing. Commonly, the pockets are created by bar tacking the webbing loop on to itself at intervals along its length. Another method to create the pocket is to interweave the webbing. The webbing material is commonly either Nylon ® or a high modulus polyethylene (HMPE) such as Spectra ® or Dyneema ®. A review of any number of different equipment manufacturers/distributers websites show them marketed as a primary attachment lanyard for climbing activities as well as rope rescue applications such as litter attending.

Commonly, manufacturers rated breaking strength on daisy chains is around 22kN or approximately 5000 lbs force. Additionally, the individual rated pocket strength is regularly provided and the value is typically within a range of 2-5 kN. There are some hybrid products out there in the marketplace such as the Yates Adjustable Daisy Strap, which has a rated strength of only 1500 lbs force or around 6.6kN. While there exists a bandwidth of rated strengths amongst daisy chains and like products, the test method used to obtain those strengths is common – specifically, a slow pull style.

Test Method:

Rather than attempt to duplicate the test method of any particular standard or regulatory agency, we chose instead to test the various lanyards in a manner that:

(1) was representative of what could take place in the field of use.
(2) would provide some indications as to the capabilities and/or limitations.

The purpose of this study was twofold:

(1) to examine the magnitude of peak forces on certain lanyards and/or lanyard configurations in a dynamic event.
(2) to examine the integrity of the connections on certain commercially available as well as user-created lanyards in a dynamic event.

All of the drop tests conducted included a free fall of the test mass. This was done in order to simulate a climber or rescuer falling from a stance in which they had some slack in their primary lanyard attachment. Scenarios could include a climber standing up to adjust some rigging while at a belay station, a rescuer lanyard climbing a ladder on a tower rescue or a litter attendant scrambling up on to the side of the litter to adjust some rigging during a vertical lower/raise operation.

The parameters we examined were:

(1) lanyard make, model & construction
(2) lanyard material & size
(3) mass of the 'climber / rescuer'
(4) inclusion / exclusion of an energy absorber
(5) fall factor

All of the drop tests were conducted using a rigid test mass and a rigid anchor beam. The lanyards tested were new and unused.

The drops were conducted with either a 80 kg or a 100 kg mass. The 80 kg amount was selected to represent a climber mass. This amount is equal to the mass used by UIAA in testing and standard-setting for climbing equipment. The 100 kg mass was selected to represent a rescuer. This amount is on par with that used in testing by the British Columbia Council of Technical Rescue to represent a 'mountain rescuer'. Tests were not conducted with a NFPA one-person mass of 300 pounds force (≈ 136 kg). Clearly, tests conducted with a 136 kg mass would likely produce lanyard failures and higher peak forces at smaller fall factors than those observed with the 100 kg mass.

The log sheets (included in this proceedings paper) from the two separate drop test series (2002 and 2005) outline the individual parameters and data points for each of the respective drop tests.

Data Highlights:

Some of the noteworthy drop tests were the ones that produced high MAF values or ones that resulted in a failure of the lanyard being tested.

Table 1 highlights some of the drops conducted with the Metolius PAS (personal anchor system), which is a lanyard constructed out of Dyneema ®. Fall factors of 1.25 and higher with a 100 kg test mass produced failures of the lanyard. Very high peak forces were observed on all of the drops conducted with this lanyard.

Table 1: Drop Test Data with 100 kg Test Mass

Lanyard:	**Fall Factor**	**MAF (kN)**	**Result**
Metolius PAS (2005 DT-4)	1.0	19.2	Catch (no apparent damage)
Metolius PAS (2005 DT-6)	1.25	20.9	Failure

Table 2 highlights some of the drops conducted with the Yates Spectra Daisy Chains. Using a 100 kg test mass, fall factors as low as 0.5 resulted in a failure of the lanyard.

Table 2: Drop Test Data with 100 kg Test Mass

Lanyard:	**Fall Factor**	**MAF (kN)**	**Result**
Yates Spectra Daisy (2005 DT-26)	0.25	9.0	Catch (fibers separating at bar tack)
Yates Spectra Daisy (2005 DT-25)	0.5	11.3	Failure

While the inclusion of an energy absorber will certainly reduce the MAF (all other parameters being equal), it still may not be enough to prevent catastrophic failure depending upon the lanyard. Table 3 highlights drops conducted with the Yates Spectra Daisy Chain girth-hitched to a Yates Shorty Screamer energy absorber. In each of the drops the energy absorber fully deployed and a fall factor of 1.25 and higher failed the lanyard.

Table 3: Drop Test Data with 100 kg Test Mass

Lanyard:	**Fall Factor**	**MAF (kN)**	**Result**
Yates Spectra Daisy with Yates Shorty Screamer (2005 DT-21)	1.0	11.1	Catch (Shorty Screamer fully deployed; fibers separating at bar tack on daisy chain – near failure)
Yates Spectra Daisy with Yates Shorty Screamer (2005 DT-23)	1.25	16.1	Failure (Shorty Screamer fully deployed)

Table 4 highlights some of the drops conducted with the Climb High 25mm Nylon Daisy Chains. While the MAF values were considerable, none of the tests failed the lanyard or resulted in any significant visible damage.

Table 4: Drop Test Data with 100 kg Test Mass

Lanyard:	**Fall Factor**	**MAF (kN)**	**Result**
Climb High 25mm Nylon Daisy (2005 DT-51)	1.0	12.8	Catch (no apparent damage)
Climb High 25mm Nylon Daisy (2005 DT-52)	1.5	17.0	Catch (moderate chafe at girth hitch)
Climb High 25mm Nylon Daisy (2005 DT-53)	2.0	19.9	Catch (moderate chafe at girth hitch)

Many of the drop tests in the 2005 series examined the Purcell Prusik being used as a lanyard. The Purcell Prusik originated in British Columbia in the 1970's and is used for a variety of different ropework applications including ascending a fixed line. The Purcell Prusik is commonly tied using either 6mm or 7mm nylon accessory cord and the nature of the design incorporates a prusik hitch on two strands of cord forming an adjustable closed-loop system. Depending upon a host of variables (# of wraps, diameter of cord, cord condition, snugness of prusik, etc.), the prusik hitch will exhibit a tendency to slip at a certain applied force. Used as a lanyard, it also offers a range of adjustability in length.

Table 5 highlights some of the drops conducted with the 7mm 3-wrap Purcell Prusik.

Table 5: Drop Test Data with 100 kg Test Mass

Lanyard:	**Fall Factor**	**MAF (kN)**	**Result**
Purcell Prusik made with 7mm PMI nylon cord and 3 wraps on prusik (2005 DT-8)	1.0	9.1	Catch (light to moderate chafe/glaze)
Purcell Prusik made with 7mm PMI nylon cord and 3 wraps on prusik (2005 DT-9)	1.5	12.7	Catch (light to moderate chafe/glaze)
Purcell Prusik made with 7mm PMI nylon cord and 3 wraps on prusik (2005 DT-10)	2.0	12.9	Catch (light to moderate chafe/glaze)

Recommendations:

The practice of effectuating technical rope rescues is often a somewhat improvisational activity. There are so many different variables to consider in processing the decisions to be made on the scene. In the end, it boils down to risk management and taking on acceptable levels of risk. And 'acceptable' level of risk varies organizationally, culturally and individually.

Subjecting rescuers to rigid standards and/or regulations with respect to the use and construction of primary attachment lanyards would possibly open up a Pandora's Box of trouble in an activity that relies heavily on judgment and flexibility in order to ensure its timely success. There are, however, some key principles that standard setting bodies and regulatory agencies addressing things like fall arrest, work positioning and via ferrata adhere to:

- limiting fall distance
- limiting MAF
- maintaining the integrity of the connection to the person

These principles are naturally designed to protect the person using the equipment. The rescue community should adopt these ideas in our use and selection of primary attachment lanyards.

At a minimum, a primary attachment lanyard should be able to withstand a fall factor of 1.0 with acceptable levels of peak force and stopping distance, while maintaining its functionality.

The introduction of high performance fibers into climbing and rope rescue equipment has some worthwhile applications. However, the use of HMPE like Spectra ® or Dyneema ® in the construction of daisy chains is simply a bad idea. The properties of HMPE include the benefits of high strength, the ability to float and excellent resistance to chemicals and U.V degradation. However, HMPE properties also include very low elongation at break and a low melting point. It is these last two properties that are likely the key contributing factors to:

(1) the high peak force values observed in our testing of lanyards constructed out of these materials.
(2) the breaking of these same lanyard types on certain drops.

A primary attachment lanyard in rescue work as well as climbing is an ubiquitous piece of equipment. The selection of that piece of gear should be made with careful consideration of the desirable characteristics for the activity {e.g. easily adjustable, lightweight, multi-function, etc.}.

When selecting a lanyard either to purchase or to construct:

(1) avoid the use of low-elongation high performance fibers.
(2) choose one that limits MAF to a reasonable level.
(3) keep in mind that a lanyard that reduces MAF, subjects the user to other hazards due to increased fall distance.
(4) select one that retains functionality even after a severe drop.

When using a lanyard as the only means of attachment to an anchor:

(1) keep unnecessary slack out of the lanyard, thereby keeping the potential fall factor low.

As rescuers and climbers we cannot eliminate all of the risks. However, we can reduce many of those risks to acceptable levels by appropriate selection and application of the equipment used in our respective activities.

Key References:

www.yatesgear.com

Chapter XVII OSHA, Department of Labor
Regulations (Standards - 29 CFR)
PART 1926 – Safety and Health Regulations for Construction,
Subpart M – Fall Protection,
§1926.502 Fall protection systems criteria and practices

Lanyard Testing

Drop Test Log Sheet

Date: 3-4-05

Test #	Lanyard Type: make, model, color	Lanyard Type: size, material & construction	Initial Unit Length (cm)	Mass (kg)	Drop Height (cm)	Fall Factor	Slide Distance (cm)	Final Unit Length (cm)	Maximum Arrest Force (N)
1	Yates Heavy Duty Daisy Chain; Black	70" x 1"; Nylon (suspect Spec 18)	173	100	173	1	NA	MNT	13327
Comments: No apparent damage.									
2	Yates Heavy Duty Daisy Chain; Black	70" x 1"; Nylon (suspect Spec 18)	173	100	259.5	1.5	NA	198	16523
Comments: Four bar tacks blown apart (proximal to anchor side).									
3	Yates Heavy Duty Daisy Chain; Black	70" x 1"; Nylon (suspect Spec 18)	173	100	303	1.75	NA	200	17294
Comments: Four bar tacks blown apart (anchor side). One bar tack torn on load side. Heavy fusing at girth hitch.									
4	Metolius PAS	Dyneema; sewn	99	100	99	1	NA	116	19257
Comments: Rigged per manufacturers instructions. Minor chafe at girth hitch. No other apparent damage.									
5	Metolius PAS	Dyneema; sewn	99	100	148.5	1.5	NA	**Failed**	20661
Comments: Failed in first link after the girth hitch at the load end. Failed in the webbing link - not the stitching.									
6	Metolius PAS	Dyneema; sewn	99	100	123.8	1.25	NA	**Failed**	20900
Comments: Same failure location as in drop test #5.									
7	Metolius PAS	Dyneema; sewn	99	100	99	1	NA	116	18251
Comments: No apparent damage.									
8	Purcell Prusik w/ 3-wrap prusik	7mm PMI Cord; tied	66.5	100	66.5	1	13	91	9135
Comments: Purcell adjusted to its shortest configuration. Prusik "appropriately snug" (e.g. hear the friction). Light chafe at girth hitch. Moderate chafe at figure 8. Light chafe/glaze at prusik location.									
9	Purcell Prusik w/ 3-wrap prusik	7mm PMI Cord; tied	71	100	106.5	1.5	12	93.5	12707
Comments: Light chafe at girth hitch. Light to moderate chafe at figure 8. Light to moderate chafe/glaze at prusik.									
10	Purcell Prusik w/ 3-wrap prusik	7mm PMI Cord; tied	68	100	136	2	15.5	95.5	12987
Comments: Moderate chafe at girth hitch. Light to moderate chafe at figure 8. Light to moderate chafe/glaze at prusik.									
11	Purcell Prusik w/ 2-wrap prusik	7mm PMI Cord; tied	72	100	72	1	21.5	98	9731
Comments: Same set up as drops 8-10 except 2-wrap prusik (shortest configuration, snug prusik, etc.) Light chafe at girth hitch. Light chafe at figure 8. Light to moderate chafe/glaze at prusik.									

Data Acquisition Rate: 2000 Hz

Lanyard Testing
Drop Test Log Sheet
Date: 3-4-05

Test #	Lanyard Type: make, model, color	Lanyard Type: size, material & construction	Initial Unit Length (cm)	Mass (kg)	Drop Height (cm)	Fall Factor	Slide Distance (cm)	Final Unit Length (cm)	Maximum Arrest Force (N)
12	Purcell Prusik w/ 2-wrap prusik	7mm PMI Cord; tied	73	100	109.5	1.5	38.5	108.5	10073
Comments: Light chafe at girth hitch. Light chafe at figure 8. Light to moderate chafe/glaze at prusik.									
13	Purcell Prusik w/ 2-wrap prusik	7mm PMI Cord; tied	69.5	100	139	2	48	111.5	11918
Comments: Moderate chafe at girth hitch. Moderate chafe at figure 8. Moderate chafe/glaze at prusik.									
14	Purcell Prusik w/ 2-wrap prusik	7mm PMI Cord; tied	52.5	100	78.75	1.5	0	61	15057
Comments: The test included a carabiner-clip from the primary attachment loop back to the girth hitch location. This configuration resulted in a shorter lanyard length and no slippage of the prusik hitch. Moderate chafe at girth hitch. Moderate chafe at figure 8. Moderate chafe/glaze at prusik. Some sheath damage at girth hitch.									
15	Purcell Prusik w/ 3-wrap prusik	6mm PMI Cord; tied	74	100	74	1	12	97	8947
Comments: Light chafe at girth hitch. Moderate chafe at figure 8. Moderate chafe/glaze at prusik.									
16	Purcell Prusik w/ 3-wrap prusik	6mm PMI Cord; tied	66.5	100	99.75	1.5	16.5	93	11151
Comments: Light chafe at girth hitch. Moderate chafe at figure 8. Moderate chafe/glaze at prusik.									
17	Purcell Prusik w/ 3-wrap prusik	6mm PMI Cord; tied	67.5	100	135	2	21	95.5	11491
Comments: Light to moderate chafe at girth hitch. Moderate chafe at figure 8. Moderate chafe/glaze at prusik.									
18	Purcell Prusik w/ 2-wrap prusik	6mm PMI Cord; tied	74	100	74	1	24.5	101	9753
Comments: Light chafe at girth hitch. Light chafe at figure 8. Moderate chafe/glaze at prusik.									
19	Purcell Prusik w/ 2-wrap prusik	6mm PMI Cord; tied	75	100	112.5	1.5	31.5	109.5	11112
Comments: Moderate chafe at girth hitch. Sheath stripped on one strand at figure 8. Moderate chafe/glaze at prusik.									
20	Purcell Prusik w/ 2-wrap prusik	6mm PMI Cord; tied	74	100	148	2	54	119.5	11673
Comments: Moderate chafe at girth hitch. Moderate chafe at figure 8. Moderate to heavy chafe/glaze at prusik.									
21	Yates Daisy Chain w/ Shorty Screamer	13mm; Spectra; sewn	125	100	125	1	NA	178.5	11140
Comments: Shorty Screamer fully deployed. Girth hitch easy to undo. Daisy stitching coming apart at anchor end.									
22	Yates Daisy Chain w/ Shorty Screamer	13mm; Spectra; sewn	125	100	187.5	1.5	NA	**Failed**	12539
Comments: Shorty Screamer fully deployed. Daisy failed in strand near Screamer girth hitch connection. Only the stub of bar tacking that wedged itself into the Screamer girth hitch connection prevented the load from grounding.									

Data Acquisition Rate: 2000 Hz

Lanyard Testing
Drop Test Log Sheet
Date: 3-4-05 and 3-5-05

Test #	Lanyard Type: make, model, color	Lanyard Type: size, material & construction	Initial Unit Length (cm)	Mass (kg)	Drop Height (cm)	Fall Factor	Slide Distance (cm)	Final Unit Length (cm)	Maximum Arrest Force (N)
23	Yates Daisy Chain w/ Shorty Screamer	13mm; Spectra; sewn	125	100	156.25	1.25	NA	**Failed**	16110
Comments: Same results as drop test #22.									
24	Yates Daisy Chain {no Shorty Screamer}	13mm; Spectra; sewn	115	100	86.5	0.75	NA	**Failed**	10800
Comments: Failed in a bar tacked location.									
25	Yates Daisy Chain {no Shorty Screamer}	13mm; Spectra; sewn	115	100	57.5	0.5	NA	**Failed**	11307
Comments: Failed.									
26	Yates Daisy Chain {no Shorty Screamer}	13mm; Spectra; sewn	115	100	28.75	0.25	NA	MNT	9096
Comments: Near failure. Fibers separating at first bar tack.									
27	Yates Daisy Chain	11/16"; Nylon; sewn	MNT	100	0	0	NA	MNT	2651
Comments: Clipped two pockets side by side. Demonstrating an incorrect attachment method, but one that is commonly observed to be used in the field. No apparent damage.									
28	Yates Daisy Chain	11/16"; Nylon; sewn	100	100	25	0.25	NA	MNT	4698
Comments: Same set up as drop test #27. No failure.									
29	Yates Daisy Chain	11/16"; Nylon; sewn	94	100	31.3	0.33	NA	MNT	5949
Comments: Same set up as drop tests #27 & 28. Tore through one and a half of three bar tacks.									
30	Yates Daisy Chain	11/16"; Nylon; sewn	87	100	43.5	0.5	NA	**Failed**	6434
Comments: Same set up as drop tests #27 - 29. Failed.									
31	Yates Adjustable Daisy w/ Shorty Screamer	1" Nylon Webbing w/ adjustable cam buckle	100	100	100	1	NA	MNT	6663
Comments: Full deployment of Shorty Screamer. Deformation of buckle. Moderate damage to webbing under the cam.									
32	Yates Daisy Chain {frozen overnight}	11/16"; Nylon; sewn	130	80	130	1	NA	151	9020
Comments: Soaked in water for 5 minutes and left outside overnight (-2° C). Stiff prior to drop test.									
33	Climb High Daisy Chain	11/16"; Spectra; sewn	130	80	65	0.5	NA	153.5	9949
Comments: One pocket blown out at anchor end.									

Data Acquisition Rate: 2000 Hz

Lanyard Testing
Drop Test Log Sheet
Date: 3-5-05

Test #	Lanyard Type: make, model, color	Lanyard Type: size, material & construction	Initial Unit Length (cm)	Mass (kg)	Drop Height (cm)	Fall Factor	Slide Distance (cm)	Final Unit Length (cm)	Maximum Arrest Force (N)
34	Climb High Daisy Chain	11/16"; Spectra; sewn	130	80	97.5	0.75	NA	154	14685
Comments: Two bar tacks blown out at anchor end.									
35	Climb High Daisy Chain w/Yates Shorty Screamer	11/16"; Spectra; sewn	139	80	173.75	1.25	NA	198	10492
Comments: Screamer fully deployed. No bar tacks blown out on daisy.									
36	Climb High Daisy Chain; Red	25 mm; Nylon tubular; sewn	125	80	125	1	NA	137	10854
Comments: No apparent damage.									
37	Climb High Daisy Chain; Green	25 mm; Nylon tubular; sewn	125	80	187.5	1.5	NA	137	15093
Comments: No apparent damage. Light chafing at girth hitch.									
38	Climb High Daisy Chain; Yellow	25 mm; Nylon tubular; sewn	125	80	250	2	NA	139	19429
Comments: No pockets blown. Light chafing at girth hitch.									
39	Purcell Prusik w/ 3-wrap prusik	7mm PMI Cord; tied	72	80	72	1	6	89	8096
Comments: Light chafe at girth hitch. Light chafe at figure 8. Light chafe/glaze at prusik.									
40	Purcell Prusik w/ 3-wrap prusik	7mm PMI Cord; tied	67.5	80	101.25	1.5	24.5	96.5	11314
Comments: Light chafe at girth hitch. Light chafe at figure 8. Light to moderate chafe/glaze at prusik.									
41	Purcell Prusik w/ 3-wrap prusik	7mm PMI Cord; tied	73	80	146	2	13	96	11773
Comments: Moderate chafe at girth hitch. Light to moderate chafe at figure 8. Light to moderate chafe/glaze at prusik.									
42	Purcell Prusik w/ 3-wrap prusik	7mm PMI Cord; tied	32	80	32	1	MNT	39	8512
Comments: The test included a carabiner-clip from the primary attachment loop back to the girth hitch location. Similar to the test set up in drop #14. Primary difference was that the prusik hitch was set midway along its adjustable length to allow for some slippage.									
43	Purcell Prusik w/ 3-wrap prusik	6mm PMI Cord; tied	70	80	70	1	7	90.5	7235
Comments: Light chafe at girth hitch. Very light chafe at figure 8. Negligible chafe/glaze at prusik.									
44	Purcell Prusik w/ 3-wrap prusik	6mm PMI Cord; tied	72	80	108	1.5	14	96.5	9646
Comments: Light chafe at girth hitch. Light chafe at figure 8. Light chafe/glaze at prusik.									

Data Acquisition Rate: 2000 Hz

Test #	Lanyard Type: make, model, color	Lanyard Type: size, material & construction	Initial Unit Length (cm)	Mass (kg)	Drop Height (cm)	Fall Factor	Slide Distance (cm)	Final Unit Length (cm)	Maximum Arrest Force (N)
45	Purcell Prusik w/ 3-wrap prusik	6mm PMI Cord; tied	73	80	146	2	14.5	97.5	11307
Comments: Light to moderate chafe at girth hitch. Light to moderate chafe at figure 8. Light chafe/glaze at prusik.									
46	Purcell Prusik w/ 2-wrap prusik	6mm PMI Cord; tied	74	80	74	1	24	101.5	7939
Comments: Negligible chafe at girth hitch. Negligible chafe at figure 8. Light chafe/glaze at prusik.									
47	Purcell Prusik w/ 2-wrap prusik	6mm PMI Cord; tied	76	80	114	1.5	42.5	114.5	9696
Comments: Light chafe at girth hitch. Moderate chafe at figure 8. Moderate chafe/glaze at prusik.									
48	Purcell Prusik w/ 2-wrap prusik	6mm PMI Cord; tied	74	80	148	2	46	116.5	11409
Comments: Moderate chafe at girth hitch. Moderate chafe at figure 8. Moderate chafe/glaze at prusik.									
49	Metolius PAS	Dyneema; sewn	100	80	125	1.25	NA	115	20130
Comments: Some light webbing cutting noted where girth hitch loop links to adjacent sewn link.									
50	Metolius PAS	Dyneema; sewn	100	80	150	1.5	NA	115.5	19864
Comments: Some light webbing cutting noted where girth hitch loop links to adjacent sewn link.									
51	Climb High Daisy Chain; Black	25 mm; Nylon tubular; sewn	125	100	125	1	NA	139.5	12802
Comments: No apparent damage.									
52	Climb High Daisy Chain; Yellow	25 mm; Nylon tubular; sewn	125	100	187.5	1.5	NA	140	17084
Comments: No apparent damage except moderate chafe at girth hitch.									
53	Climb High Daisy Chain; Red	25 mm; Nylon tubular; sewn	125	100	250	2	NA	144	19945
Comments: Moderate chafe at girth hitch.									

Key to Acronyms and Abbreviations

Item	Description
cm	centimetre
mm	millimetre
kg	kilogram
N	Newton
MNT	Measurement Not Taken
PAS	Personal Anchor System
NA	Not Applicable
PMI	Pigeon Mountain Industries

Data Acquisition Rate: 2000 Hz

Lanyard Testing

Drop Test Log Sheet

Date: 7-19-02

Test #	Lanyard Type: make, model, color	Lanyard Type: size, material & construction	Initial Unit Length (cm)	Mass (kg)	Drop Height (cm)	Fall Factor	Slide Distance (cm)	Final Unit Length (cm)	Maximum Arrest Force (N)
1 to 26									
TESTS NOT GERMANE TO THE SUBJECT MATTER									
27	Black Diamond; Daisy Chain; Purple	11/16 " x 55"; Nylon; sewn	132	80	33	0.25	NA	143	3628
Comments: No apparent damage to the daisy chain. All bar tacks intact.									
28	Black Diamond; Daisy Chain; Yellow	11/16 " x 55"; Nylon; sewn	133	80	66.5	0.5	NA	146.5	5094
Comments: No apparent damage to the daisy chain. All bar tacks intact.									
29	Black Diamond; Daisy Chain; Purple	11/16 " x 55"; Nylon; sewn	133	80	99	0.75	NA	147.5	6962
Comments: No apparent damage to the daisy chain. All bar tacks intact.									
30	Black Diamond; Daisy Chain; Yellow	11/16 " x 55"; Nylon; sewn	133	80	132	1	NA	151	8211
Comments: Visible damage - first bar tack proximal to the load totally blown out. Girth hitch of the test unit to the shackle extremely difficult to release; nylon welding noted inside of girth hitch.									
31	Black Diamond; Daisy Chain	11/16 " x 55"; Nylon; sewn	133	80	165	1.25	NA	153	9155
Comments: Girth hitch easy to remove. Three sets of bar tacks blown out from anchor side of test unit.									
32	Yates Adjustable Daisy w/ Shorty Screamer	1" Nylon Webbing w/ adjustable cam buckle	122.5	80	122.5	1	NA	164.5	4866
Comments: Unit was pre-set with ≈20cm of available tail prior to drop. Shorty Screamer completely deployed. Girth hitch easy to remove. Slight deformation of cam buckle noted.									
33	Yates Adjustable Daisy w/ Shorty Screamer	1" Nylon Webbing w/ adjustable cam buckle	120.5	80	180.75	1.5	NA	**Failed**	6592
Comments: Unit was pre-set with ≈20cm of available tail prior to drop. Shorty Screamer completely deployed. Daisy appeared to have failed at the cam buckle location.									
34	Yates Adjustable Daisy *{No Shorty Screamer}*	1" Nylon Webbing w/ adjustable cam buckle	105	80	105	1	NA	**Failed**	6983
Comments: Unit was pre-set with ≈20cm of available tail prior to drop. Failure noted at cam buckle location.									
35	Purcell Prusik w/ 2-wrap prusik	7mm Mammut Cord; tied	88	80	88	1	6	105	7103
Comments: No apparent damage.									

Data Acquisition Rate: 2000 Hz

Lanyard Testing

Drop Test Log Sheet

Date: 7-19-02

Test #	Lanyard Type: make, model, color	Lanyard Type: size, material & construction	Initial Unit Length (cm)	Mass (kg)	Drop Height (cm)	Fall Factor	Slide Distance (cm)	Final Unit Length (cm)	Maximum Arrest Force (N)
36	Purcell Prusik w/ 2-wrap prusik	7mm Mammut Cord; tied	85	80	127.5	1.5	10	102.5	8870
Comments: No apparent damage.									
37	Black Diamond; Daisy Chain; Yellow	11/16 " x 45"; Nylon; sewn	110	80	110	1	NA	125.5	7592
Comments: Three bar tacks blown apart (proximal to anchor side).									
38	Black Diamond; Daisy Chain; Green	11/16 " x 45"; Nylon; sewn	110	80	110	1	NA	123.5	8287
Comments: Three bar tacks blown apart.									
39	Black Diamond; Daisy Chain w/Yates Shorty Screamer	11/16 " x 45"; Nylon; sewn	118	80	118	1	NA	159	5821
Comments: Shorty Screamer fully deployed. No apparent damage to daisy chain.									
40	Climb High; Daisy Chain	11/16 " x 48"; Spectra; sewn	129	80	129	1	NA	**Failed**	10958
Comments: Daisy chain failed at first pocket proximal to the anchor side.									
41	Climb High; Daisy Chain	11/16 " x 48"; Spectra; sewn	130	80	130	1	NA	**Failed**	11371
Comments: Daisy chain failed at girth hitch attachment to the test mass.									
42	Climb High; Daisy Chain w/Yates Shorty Screamer	11/16 " x 48"; Spectra; sewn	139	80	139	1	NA	193	7070
Comments: Shorty Screamer completely deployed. No apparent damage to the daisy chain.									
43	Black Diamond; Daisy Chain	11/16 " x 45"; Nylon; sewn	109	80	163.5	1.5	NA	128	14716
Comments: Significant difficulty removing girth hitch; nylon welding noted at girth hitch. Eight bar tacks blown out.									
44	Black Diamond; Daisy Chain	11/16 " x 45"; Nylon; sewn	111	80	166.5	1.5	NA	130.5	12859
Comments: No difficulty removing girth hitch; no nylon welding noted at girth hitch. Seven bar tacks blown out.									
45	Black Diamond; Daisy Chain w/Yates Shorty Screamer	11/16 " x 45"; Nylon; sewn	118	80	177	1.5	NA	166	7038
Comments: Shorty Screamer completely deployed. No apparent damage to the daisy chain.									
46	Climb High; Daisy Chain	11/16 " x 48"; Spectra; sewn	130.5	80	195.75	1.5	NA	**Failed**	17007
Comments: Four bar tacks blown apart before complete failure.									
47	Climb High; Daisy Chain w/Yates Shorty Screamer	11/16 " x 48"; Spectra; sewn	139	80	208.5	1.5	NA	206.5	13141
Comments: Shorty Screamer completely deployed. Fibers separating. Near failure of daisy chain.									

Data Acquisition Rate: 2000 Hz