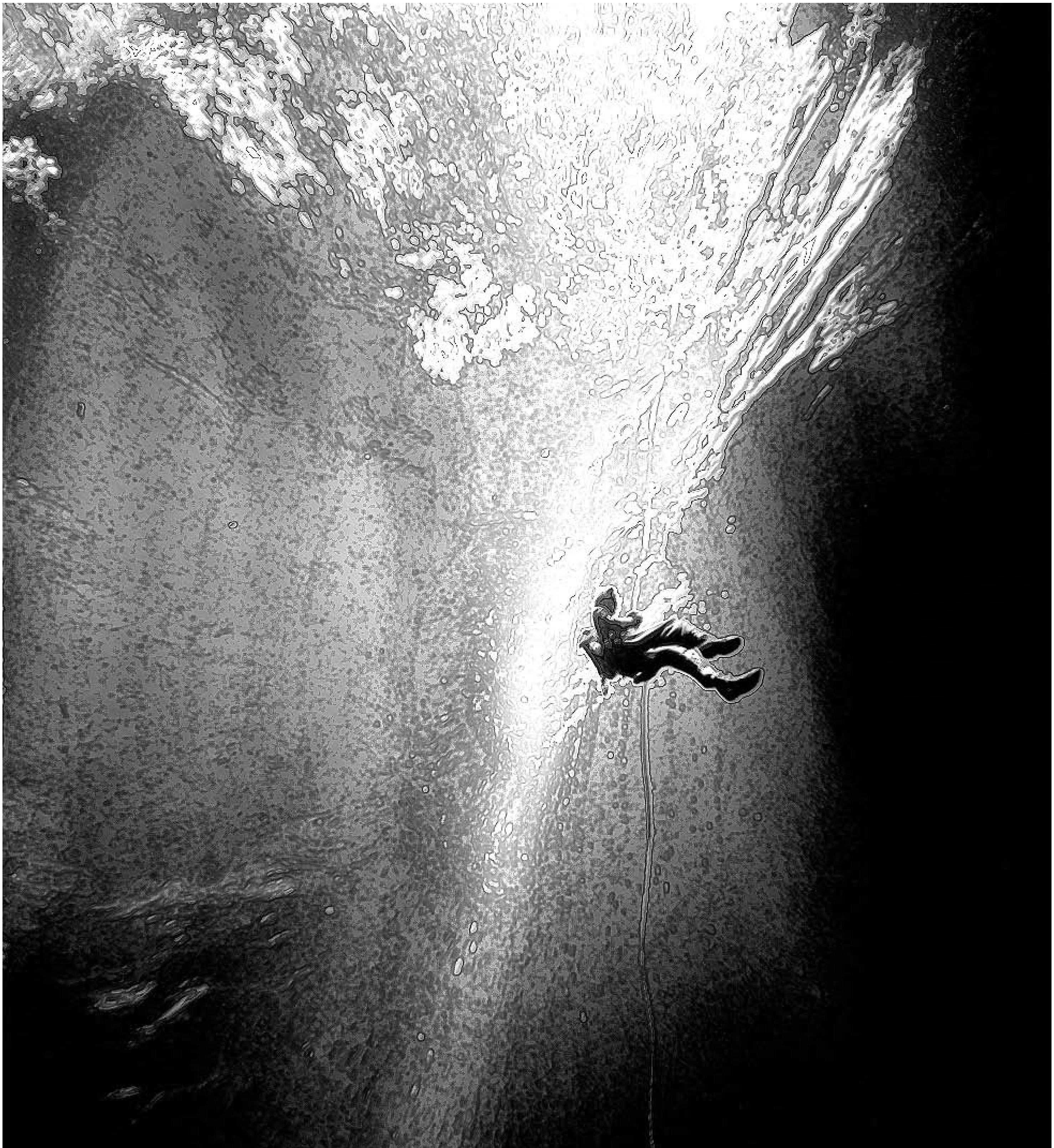
Nylon Highway

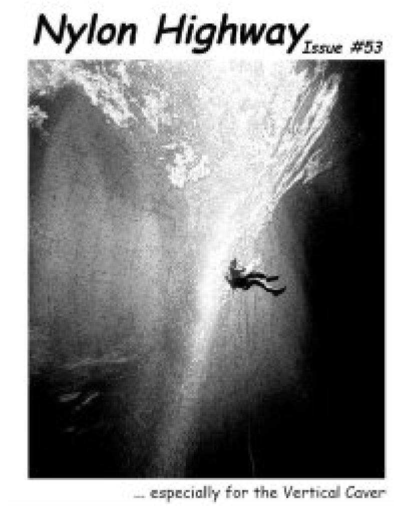
Issue #53



... especially for the Vertical Caver

#53

Contents



NH #43
NH #44
NH #45
NH #46
NH #47
NH #48
NH #49
NH #50
NH #51
NH #52
NH #53
NH #54
NH #55

Page Last Updated on June 17, 2009

Nylon Highway

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Series of tests on Cow's Tails used for progression on semi-static ropes

Chamonix

June 2006

Translated into English by D Weare

2008

Syndicat **F**rançais des **E**ntreprises de **T**ravaux en **H**auteur

École **F**rançaise de **S**péléologie

These tests were carried out by Sylvain Borie, Gérard Cazes, Nicolas Clément and José Mulot, from 26th-29th June 2006, in the laboratory of the National Ski and Mountaineering School (*l'École Nationale de Ski et d'Alpinisme*) in Chamonix.

The summary has been put together by Sylvain Borie.

Thanks :

To CAMP for providing several different types of Cow's Tails specially for this study.

To PETZL for also providing different types of Cow's Tails.

To BEAL for providing different types of rope.

To ENSA for making their laboratory facilities available.

To the companies MILLET and BACOU-DALLOZ for their involvement.

To Jean Franck Charlet for his comments and guidance on setting up the tests.

To Members of the DPMC's Technical Committee and the French Caving School's Committee for setting up the testing protocol.

Xavier Délalle for proof-reading this document.

Index :

The page sequence of the original report has been adhered to in this translation. Footnotes and Annexes have been added to the text in translation to help clarify various points.

Introduction

Work carried out by the DPMC Technical Committee (a committee bringing together representatives from different companies who work with ropes, and training centres as well as the manufacturers) and by the French Caving School highlighted significant differences both in the material currently used to move along semi-static ropes, and in the difficulty they have in recommending one material in particular.

Many companies, clubs and individuals looking to purchase Cow's Tails[1] currently use those which conform to EN 354[2]. However it has been proved that some of these products that conform to EN 354, and more specifically those made from sewn tape, seem to generate considerable shock loading when subjected to a Fall Factor 1.

Another option involved using Cow's Tails made from rope with sewn ends, attaching them to the harness with a knot (in the middle).

Finally many people continue to make their own Cow's Tails by using a dynamic rope and three knots, a very common practice among cavers.

The objective of this series of tests is to measure the shock loads generated by the different Cow's Tails in several configurations, so as to be able to identify those which can cause risks and therefore make recommendations regarding good practice with existing material.

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1 This translation uses the terms Cow's Tail(s) in place of the translation "speleological lanyard(s)" since this is the commonly known name in the UK for the item. It should be noted that some of the tests were undertaken on single lengths of rope with a loop at each end; which is known as a lanyard in the UK.

2 Equivalent to BS EN 354 : 2002

The protocol

All the knots were tied by the same person, following the standard rules and without any crossing of strands.

The knots were then preloaded with a slow pull[3] of 3 kN[4]. This value represents a typical force exerted on a Cow's Tail by a 80 kg person moving somewhat "brutally" (cf. tests carried out by the French Cave Rescue Team in 1994 and 1996).

Furthermore after several attempts we were able to confirm that this figure of 3 kN gave knots which most closely represented those knots that we could find on Cow's Tails in use.

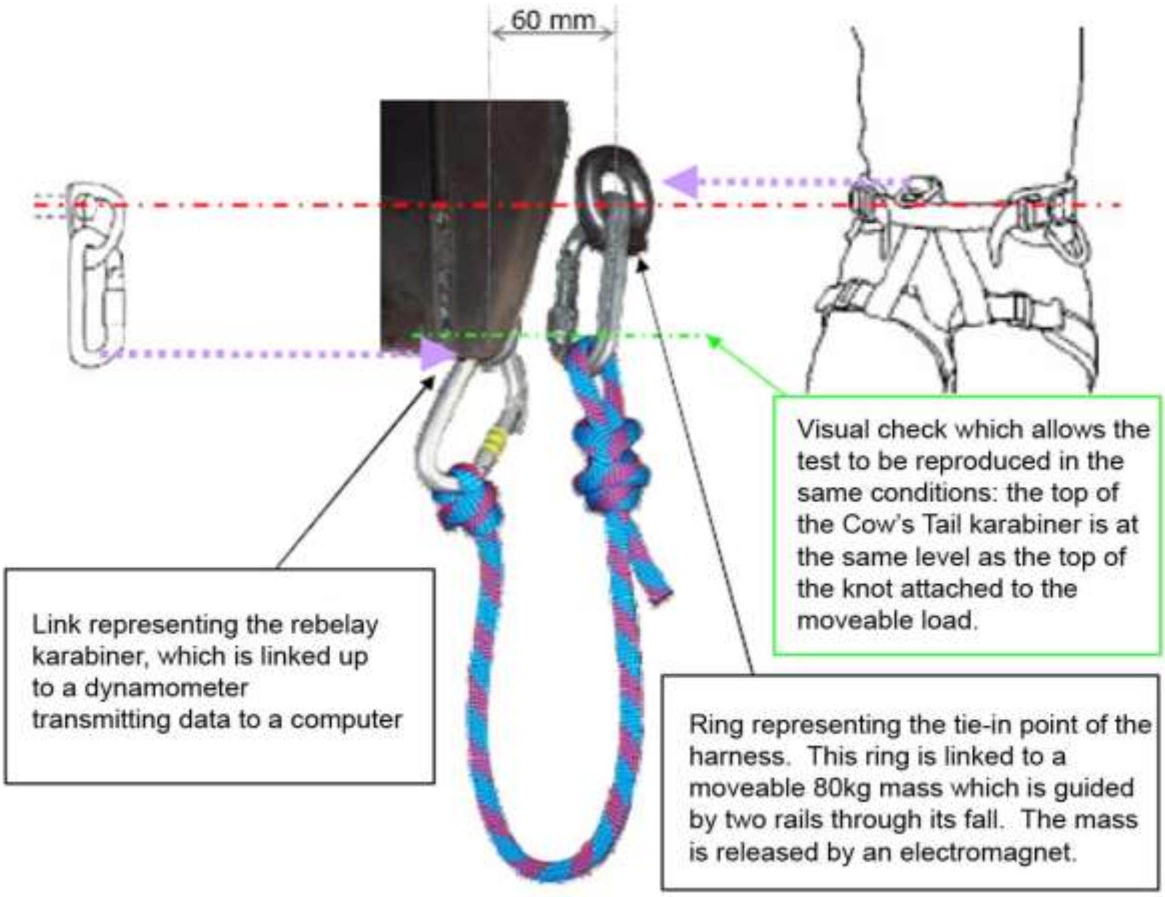
The Cow's Tails were then measured and marked.

3 Where the knot is "dressed" and then subject to a preload of 3 kN by a slowly applied "static" load (as opposed to a dynamic load such as would arise from a sudden fall).

4 The French document cites 300 daN. The deca newton (daN) is used as an approximation to the kilogram-force, being exactly rather than approximately 10 newtons. All forces quoted in this translation will be in kN using a conversion factor of 100 daN per kN.

The Fall-Factor 1 Test :

Here are the detail of the protocol for the Fall-Factor 1 tests which represented the vast majority of the tests that we carried out. The test rig, being used regularly for testing sporting equipment, was equipped with an 80kg load (and not 100kg as is the case for the standards for work equipment.)



Capturing the data and then classifying and storing the Cow's Tails.

Various Dynamic Tests :

The test described here is the one which will be referred to as a Fall Factor 1 in the whole of this document. It corresponds to the situation when the user is level with the anchor, that is to say when the tie-in point of the harness is level with the hanger. However, although you can effectively think of the Fall Factor in this exact case as close to 1 with a long length of rope, we are going to see that the Fall Factor in the case that we are interested in, that is in the case of Cow's Tails, is far from being a true Fall Factor 1[5].

In fact if we take the diagram from the previous page, we have in the case of one side of a Cow's Tail which is 36 cm long, a Fall Factor of:

The length of one side of the Cow's Tail = 36 cm

+

The length of the Cow's Tail karabiner = 9 cm

+

2 x the length of the harness karabiner[6] = 18 cm

=

63 cm

Which gives us a Fall Factor of : 63/36 = 1.75

For a Cow's Tail side which is 60cm long, this Fall Factor is : 87/60 = 1.45

The Fall Factor being equal to the height of the fall divided by the length of the rope able to absorb this fall[5].

This Factor would be slightly lower if the knot at the harness end were attached directly into the ring (representing the tie-in point of the harness). However, we should also take into account the turning of the tie-in point and the majority of Cow's Tail karabiners being more than 9cm long. Certain tests are titled "Real Fall Factor 1". In these cases we have measured the length of the Cow's Tails, have then suspended the load from it in the test rig and then raised the load to the length of the Cow's Tails. These tests then correspond correctly with a Fall Factor 1. For the tests titled "Real Fall Factor 2", we proceeded similarly but with the load raised to twice the length of the Cow's Tails.

Test 238

[5] An inherent presumption in defining a Fall Factor is that the whole length from anchor to suspension point of the person is energy absorbing rope. In practice there will be two karabiners and possibly other items not made of rope in this length. Thus the length of energy absorbing material is not quite the overall length. This presumption can be neglected when the overall length is large, but it is not valid for distances of less than 2 metres. In addition, the presence of a knot plus a loop, which could be considered as two lengths of rope, also undermines this presumption.

[6] It should be noted that according to the diagram on page 5, the harness attachment point is one karabiner's length above the actual attachment point of the test rig, hence this distance is doubled.

The tests entitled "Fall Factor 2" correspond to the situation that is commonly described as when the user finds himself above his anchor point with the Cow's Tails pulled between the anchor and his central tie-in point. As a point of reference for these tests, we used the position of the Cow's Tails karabiner. That is to say that we raised the load until this karabiner was vertical but without it lifting the karabiner at the anchor.

The length of fall for ones die of a Cow's Tail with a length of 36cm:

2 x the length of one side of the Cow's Tail = 72 cm

+

2 x the length of the Cow's Tail karabiner = 18 cm

+

2 x the length of the harness karabiner = 18 cm

=

108 cm

Which gives us a Fall Factor of : 108/36 = 3

For a Cow's Tail side which is 60cm long, this Fall Factor is : 156/60 = 2.6

The Static Tests:

These tests were carried out with a hydraulic ram extending at a speed of 720mm/min. The force is given by the deforming of a metal sensor. The test rig records the peak load, that is, the highest force held by the material being tested.

Averages and Standard Deviations :

The results table shows the mean value of these tests in kN for all the tests repeated a minimum of 6 times using the same protocol, together with the standard deviation, both in kN and as a % of the mean. The percentage corresponds to the coefficient of variation reflecting the relative variability of the results (it corresponds to the relationship between the standard deviation and the mean).

From a purely statistical point of view, this data in not relevant given such a low number of values. It does, however, give the reader some additional information.

The Knots

We do not think it is necessary to describe either the Figure of Eight Knot[7] or the Overhand Knot[8], but we will spend some time on a knot which is becoming increasingly used in caving. To our knowledge it does not yet have a name. The name which best fits this dynamic knot is "half a double fisherman's" (or Barrel Knot)[9] . It has the double advantage of being compact and of holding the karabiner in the correct position without needing to add an accessory. To our knowledge this knot does not feature in any publication. It therefore became important to study its behaviour, both from the point of view of a static and a dynamic force.


Stage 1


Stage 2


Stage 3

A situation can occur where the knot sticks under the gate of the karabiner (photo opposite) and this is particularly prevalent with people who permanently have either a handled or a basic ascender in their Cow's Tails karabiner.

One of the objectives of these tests will also be to determine whether or not this can create a problem during a fall.

7 It is considered that they mean the double figure of eight as can be deduced from some of the photographs used in the document, see Annex A.

8 It is considered that they mean the overhand knot on a bight, see Annex B.

9 This has been described in previous English publications as a Barrel Knot, see Annex C. The term Barrel Knot will be used in this translation.

Results

Tape Cow's Tail :

The model tested is the Spelegyca Cow's Tail from PETZL[10] which has a long side of 60cm and a short one of 32cm.

No	Name	length	Fall Factor	Force
		cm		kN
1	Spelegyca short side	32	1	11.45
2	Spelegyca short side	32	1	11.63
3	Spelegyca long side	60	1	10.41
4	Spelegyca long side	60	1	10.47
5	Spelegyca with both sides connected		1	14.76
6	Spelegyca with both sides connected		1	15.79
7	Spelegyca	32	Real Fall Factor 1	10.03
8	Spelegyca	60	do	9.18
9	Spelegyca	32	0.5	5.57
10	Spelegyca	60	0.5	5.95

Manufacturer's Data: The SPELEGYCA is made of static webbing with stitching that is designed to rip to dissipate the energy of a fall. This dissipation system allows the SPELEGYCA to meet the same impact force requirements as a EN 892 dynamic rope. In our laboratory, a factor 2 fall on a SPELEGYCA with a mass of 80 kg yields a maximum impact force of 12 kN (EN892 dynamic rope requirement for a factor 2 fall with an 80 kg mass = Impact force less than 12 kN).

Schéma PETZL

For tests 1, 2, 3, 4, 7 and 8, the stitching in the unused side of the Cow's Tail ripped completely which must absorb part of the energy.

For tests 9 and 10 this stitching started to rip but only by a couple of centimetres.

For tests 5 & 6 the very high shock load measured is explained by the fact that, as the two sides are connected to the rebelay point, the dissipation of energy by the ripping can only take place for about 15 cms.

10 See Annex D

Sewn Cow's Tails :

We were able to test three models of entirely manufactured Cow's Tails :

- The Jane lanyard from PETZL[11], consisting of 11mm dynamic rope with sewn ends of about 4cm each.

Length 60 cm:

No	Name	length	Fall Factor	Force
		cm		kN
11	PETZL Jane 11 mm	63	1	8.30
12	PETZL Jane 11 mm	63	1	8.49
13	PETZL Jane 11 mm	63	Real Fall Factor 1	6.16
14	PETZL Jane 11 mm	63	2	11.09
15	PETZL Jane 11 mm	62	2	12.03
16	PETZL Jane 11 mm	62	2	11.40
17	PETZL Jane 11 mm	62	Real Fall Factor 2	9.73

- A CAMP prototype Cow's Tails made up of 11mm dynamic rope with sewn ends of about 8cm each.

Length 60 cm and 32 cm:

No	Name	length	Fall Factor	Force
18	CAMP 11 mm	59	1	8.67
19	CAMP 11 mm	59	1	8.95
20	CAMP 11 mm	33	1	9.54
21	CAMP 11 mm	33	1	10.03
22	CAMP 11 mm	60	2	12.73
23	CAMP 11 mm	60	2	12.67
24	CAMP 11 mm	35	2	13.37
25	CAMP 11 mm	35	2	12.98

The 5% difference that exists between tests 11-12 and 18-19 is to be explained by the difference in sewing between the two products. With the Jane there was about 80% of the rope free between the two sets of stitching, as against only 65% with the prototype made by CAMP for the occasion.

11 See Annex E

- A CAMP prototype Cow's Tails consisting of 9mm dynamic rope with about 10cm of stitching at each end.

Length 60 cm and 32 cm:

No	Name	length	Fall Factor	Force
		cm		kN
26	CAMP 9 mm	58	1	8.40
27	CAMP 9 mm	58	1	8.71
28	CAMP 9 mm	33	1	9.42
29	CAMP 9 mm	33	1	9.59
30	CAMP 9 mm	60	2	12.28
31	CAMP 9 mm	60	2	12.26
32	CAMP 9 mm	35	2	13.04
33	CAMP 9 mm	35	2	12.94

The difference between the 11 mm and the 9 mm (that is between tests 18 to 25 and 26 to 33) is, for these entirely sewn Cow's Tails, insignificant as it is only 2.6%

Mixed Cow's Tails (Sewn & Knotted) :

For these tests we used Cow's Tails made with one sewn end (identical to those described above) and the other with different knots:

- **Sewn – Figure of Eight Knot**

(Average of these 14 tests: 7.07 kN - Standard deviation: 0.26 kN or 4 %):

No	Name	length	Fall Factor	Force
		cm		kN
34	CAMP 11 mm	60	1	6.98
35	CAMP 11 mm	60	1	7.20
36	CAMP 11 mm	33	1	6.74
37	CAMP 11 mm	33	1	6.96
38	CAMP 9 mm	58	1	7.08
39	CAMP 9 mm	58	1	7.25
40	CAMP 9 mm	32	1	6.82
41	CAMP 9 mm	32	1	7.22
42	PETZL Jane 11 mm	61	1	7.11
43	PETZL Jane 11 mm	62	1	6.98
44	PETZL Jane 11 mm	36	1	6.62
45	PETZL Jane 11 mm	37	1	6.96
46	MILLET 11 mm	36	1	7.46
47	MILLET 11 mm	37	1	7.59
48	PETZL Jane 11 mm	60	2	9.29

- Sewn – Overhand Knot

(Average of these 14 tests: 7.50 kN - Standard deviation: 0.33 kN or 4%):

No	Name	length	Fall Factor	Force
49	CAMP 11 mm	60	1	7.37
50	CAMP 11 mm	60	1	7.02
51	CAMP 11 mm	33	1	7.43
52	CAMP 11 mm	33	1	7.41
53	CAMP 9 mm	57	1	7.63
54	CAMP 9 mm	57	1	7.77
55	CAMP 9 mm	32	1	8.03
56	CAMP 9 mm	32	1	7.59
57	PETZL Jane 11 mm	58	1	7.52
58	PETZL Jane 11 mm	62	1	7.43
59	PETZL Jane 11 mm	38	1	7.46
60	PETZL Jane 11 mm	37	1	6.73
61	MILLET 11 mm	33	1	7.83
62	MILLET 11 mm	33	1	7.82

(Average of these 7 tests: 10.27 kN - Standard deviation: 0.10 kN or 1%):

No	Name	length	Fall Factor	Force
		cm		kN
63	CAMP 11 mm	60	2	10.33
64	CAMP 11 mm	60	2	10.40
65	CAMP 9 mm	60	2	10.29
66	CAMP 9 mm	60	2	10.16
67	PETZL Jane 11 mm	60	2	10.12
68	PETZL Jane 11 mm	60	2	10.33
69	PETZL Jane 11 mm	57	2	10.28

- **Sewn – Clove Hitch**

(Average of these 12 tests: 6.87 kN - Standard deviation: 0.25 kN or 4 %):

No	Name	length	Fall Factor	Force
70	CAMP 11 mm	60	1	7.12
71	CAMP 11 mm	60	1	7.06
72	CAMP 11 mm	30	1	6.92
73	CAMP 11 mm	30	1	6.46
74	CAMP 9 mm	60	1	7.06
75	CAMP 9 mm	60	1	7.26
76	CAMP 9 mm	30	1	6.85
77	CAMP 9 mm	30	1	6.84
78	PETZL Jane 11 mm	52	1	6.82
79	PETZL Jane 11 mm	54	1	6.92
80	PETZL Jane 11 mm	29	1	6.40
81	PETZL Jane 11 mm	32	1	6.74

- **Sewn – Barrel Knot**

(Average of these 12 tests: 6.61 kN - Standard deviation: 0.24 kN or 4 %):

No	Name	length	Fall Factor	Force
82	CAMP 11 mm	60	1	6.65
83	CAMP 11 mm	60	1	6.44
84	CAMP 11 mm	33	1	6.50
85	CAMP 11 mm	33	1	6.29
86	CAMP 9 mm	57	1	6.90
87	CAMP 9 mm	57	1	6.80
88	CAMP 9 mm	32	1	6.62
89	CAMP 9 mm	32	1	6.87
90	PETZL Jane 11 mm	59	1	6.98
91	PETZL Jane 11 mm	56	1	6.58
92	PETZL Jane 11 mm	36	1	6.21
93	PETZL Jane 11 mm	36	1	6.51
94	PETZL Jane 11 mm	54	2	8.80

Knotted Cow's Tails:

For these tests we have used Cow's Tails knoted at both ends :

- **Figure of Eight – Figure of Eight**

(Average of these 18 tests: 5.83 kN - Standard deviation: 0.25 kN or 4 %):

No	Name	length	Fall Factor	Force
		cm		kN
95	CAMP 11 mm	53	1	5.90
96	CAMP 11 mm	53	1	5.93
97	CAMP 11 mm	43	1	5.61
98	CAMP 11 mm	43	1	5.54
99	CAMP 9 mm	62	1	6.27
100	CAMP 9 mm	62	1	6.29
101	CAMP 9 mm	38	1	5.87
102	CAMP 9 mm	38	1	5.97
103	PETZL Jane 11 mm	60	1	5.31
104	PETZL Jane 11 mm	59	1	5.96
105	BEAL Apollo II 11 mm	58	1	5.88
106	BEAL Apollo II 11 mm	58	1	5.89
107	BEAL Flyer II 10.2 mm	60	1	5.95
108	BEAL Flyer II 10.2 mm	60	1	5.79
109	BEAL Verdon II 9 mm	60	1	5.95
110	BEAL Verdon II 9 mm	60	1	5.56
111	BEAL Ice Line 8.1 mm	59	1	5.67
112	BEAL Ice Line 8.1 mm	59	1	5.51

The results of these tests are all very close to each other, the standard deviation is only 0.25 kN, while the ropes used are very different. It seems, therefore, that the tightening of the knots has a lot more influence on the shock load than the type of rope.

In order to confirm this hypothesis, we therefore, subsequently carried out the same test but with semi-static rope:

No	Name	length	Fall Factor	Force
113	BEAL Antipodes 9 mm new	50	1	8.46
114	BEAL Antipodes 9 mm new	50	1	7.56
115	BEAL Antipodes 9 mm used (first used: 2002)	61	1	7.06
116	BEAL Antipodes 9 mm used (first used: 2002)	65	1	6.23

The average of these 4 tests (7.33 kN) is logically higher than with the dynamic rope, but still reasonable (and well within the forces reached with the entirely manufactured Cow's Tails).

- **Overhand Knot – Overhand Knot**

(Average of these 18 tests: 6.35 kN - Standard deviation: 0.27 kN or 4 %):

No	Name	length	Fall Factor	Force
		cm		kN
117	CAMP 11 mm	58	1	6.43
118	CAMP 11 mm	58	1	6.77
119	CAMP 11 mm	35	1	6.33
120	CAMP 11 mm	35	1	6.42
121	CAMP 9 mm	62	1	6.51
122	CAMP 9 mm	62	1	6.67
123	CAMP 9 mm	38	1	6.52
124	CAMP 9 mm	38	1	6.64
125	PETZL Jane 11 mm	52	1	6.27
126	PETZL Jane 11 mm	54	1	6.78
127	BEAL Apollo II 11 mm	58	1	6.32
128	BEAL Apollo II 11 mm	58	1	6.19
129	BEAL Flyer II 10.2 mm	55	1	6.34
130	BEAL Flyer II 10.2 mm	55	1	6.16
131	BEAL Verdon II 9 mm	60	1	5.97
132	BEAL Verdon II 9 mm	60	1	5.95
133	BEAL Ice Line 8.1 mm	53	1	6.04
134	BEAL Ice Line 8.1 mm	53	1	5.99

The results of these tests are also very close to each other, the standard deviation is 0.27 kN.

The same test but with semi-static rope:

No	Name	length	Fall Factor	Force
135	BEAL Antipodes 9 mm new	49	1	9.40
136	BEAL Antipodes 9 mm new	51	1	9.24
137	BEAL Antipodes 9 mm used (first used : 2002)	57	1	7.05
138	BEAL Antipodes 9 mm used (first used : 2002)	63	1	7.12

The average of these 4 tests is 8.20 kN.

As with tests 113 to 116 there is a reduction of about 20% in the shock load with used rope. This is explained by the fact that, with time, there is damage to part of the rope's fibres, making it more dynamic (but weaker).

- **Figure of Eight Knot – Barrel Knot**

(Average of these 18 tests: 5.76 kN - Standard deviation: 0.28 kN or 5 %)

No	Name	length	Fall Factor	Force
		cm		kN
139	CAMP 11 mm	59	1	5.42
140	CAMP 11 mm	59	1	5.57
141	CAMP 11 mm	39	1	5.28
142	CAMP 11 mm	39	1	5.38
143	CAMP 9 mm	55	1	5.90
144	CAMP 9 mm	55	1	5.95
145	CAMP 9 mm	42	1	5.62
146	CAMP 9 mm	42	1	5.74
147	PETZL Jane 11 mm	66	1	6.02
148	PETZL Jane 11 mm	55	1	5.70
149	BEAL Apollo II 11 mm	58	1	5.85
150	BEAL Apollo II 11 mm	58	1	5.88
151	BEAL Flyer II 10.2 mm	60	1	5.84
152	BEAL Flyer II 10.2 mm	60	1	6.53
153	BEAL Verdon II 9 mm	60	1	5.66
154	BEAL Verdon II 9 mm	60	1	5.71
155	BEAL Ice Line 8.1 mm	55	1	5.88
156	BEAL Ice Line 8.1 mm	55	1	5.81
157	BEAL Verdon II 9 mm	60	2	7.25
158	BEAL Verdon II 9 mm	60	2	7.39

- **Overhand Knot – Barrel Knot**

(Average of these 18 tests: 5.97 kN - Standard deviation: 0.23 kN or 4 %):

No	Name	length	Fall Factor	Force
159	CAMP 11 mm	64	1	5.96
160	CAMP 11 mm	64	1	6.10
161	CAMP 11 mm	41	1	5.55
162	CAMP 11 mm	41	1	5.63
163	CAMP 9 mm	61	1	6.10
164	CAMP 9 mm	61	1	6.45
165	CAMP 9 mm	38	1	5.93
166	CAMP 9 mm	38	1	5.78
167	PETZL Jane 11 mm	48	1	6.05
168	PETZL Jane 11 mm	53	1	6.09
169	BEAL Apollo II 11 mm	58	1	6.07
170	BEAL Apollo II 11 mm	58	1	5.71
171	BEAL Flyer II 10.2 mm	60	1	6.05
172	BEAL Flyer II 10.2 mm	60	1	6.26
173	BEAL Verdon II 9 mm	60	1	5.90
174	BEAL Verdon II 9 mm	60	1	5.67
175	BEAL Ice Line 8.1 mm	54	1	6.16
176	BEAL Ice Line 8.1 mm	54	1	6.00

- **Figure of Eight Knot – Badly-positioned Barrel Knot**

One of the concerns with a Barrel Knot is that this self-tightening knot can often position itself, and even stick, under the gate of the karabiner (see photo p.8); a particularly likely occurrence among people who keep a handled or a basic jammer permanently in their Cow's Tail karabiner. A large force around this area of the karabiner could be critical, particularly when caving, where the snap-gate karabiners are used and where you can't prevent the gate opening at the point of shock loading.

Accordingly we carried out a series of tests for which, after preloading to 3 kN, we deliberately placed the knot just under the lower axis of the gate of the Cow's Tail karabiner (photo p.8)

(Average of these 8 tests: 5.70 kN - Standard deviation: 0.12 kN are 2 %):

No	Name	length	Fall Factor	Force
		cm		kN
177	BEAL Apollo II 11 mm	58	1	5.88
178	BEAL Apollo II 11 mm	58	1	5.68
179	BEAL Flyer II 10.2 mm	60	1	5.63
180	BEAL Flyer II 10.2 mm	60	1	5.81
181	BEAL Verdon II 9 mm	60	1	5.60
182	BEAL Verdon II 9 mm	60	1	5.50
183	BEAL Ice Line 8.1 mm	53	1	5.76
184	BEAL Ice Line 8.1 mm	53	1	5.75

The results are almost identical to those obtained for tests 139 to 156 (5.70 kN as against 5.76 kN). But it is important to note here that, during the shock, the knot moved to take up its normal position at the base of the karabiner.

- **Figure of Eight Knot – Badly-positioned Barrel Knot : Fall Factor 2**

(Average of these 11 tests: 7.65 kN - Standard deviation: 0.36 kN or 5 %):

No	Name	length	Fall Factor	Force
		cm		kN
185	CAMP 11 mm	55	2	7.80
186	CAMP 9 mm	55	2	8.14
187	CAMP 9 mm	55	2	7.87
188	BEAL Apollo II 11 mm	55	2	8.04
189	BEAL Apollo II 11 mm	55	2	7.75
190	BEAL Flyer II 10.2 mm	55	2	7.61
191	BEAL Flyer II 10.2 mm	55	2	7.90
192	BEAL Verdon II 9 mm	55	2	7.24
193	BEAL Verdon II 9 mm	55	2	6.95
194	BEAL Ice Line 8.1 mm	55	2	7.44
195	BEAL Ice Line 8.1 mm	55	2	7.43

As for tests 177 to 184, each time the knot moved to take up its normal position at the base of the karabiner during the shock.

Special Cases :

After covering the normal usage of Cow's Tails (Fall Factor 1) we tried to imagine the extreme or obscure situations that might be encountered.

Badly tied knots :

For these two series of tests the knots were intentionally badly made. That is to say the ropes crossed over each other in several sections of the knot. They were then preloaded in the same way as for other tests.

- **Figure of Eight Knot – Figure of Eight Knot**

(Average of these 6 tests: 5.69 kN - Standard deviation: 0.13 kN or 2 %):

No	Name	length	Fall Factor	Force
		cm		kN
196	BEAL Flyer II 10.2 mm	60	1	5.78
197	BEAL Flyer II 10.2 mm	60	1	5.91
198	BEAL Verdon II 9 mm	60	1	5.71
199	BEAL Verdon II 9 mm	60	1	5.59
200	BEAL Ice Line 8.1 mm	60	1	5.58
201	BEAL Ice Line 8.1 mm	60	1	5.58

- **Overhand Knot – Overhand Knot**

(Average of these 6 tests: 6.19 kN - Standard deviation: 0.20 kN or 3 %):

No	Name	length	Fall Factor	Force
202	BEAL Flyer II 10.2 mm	60	1	6.49
203	BEAL Flyer II 10.2 mm	60	1	6.33
204	BEAL Verdon II 9 mm	60	1	6.22
205	BEAL Verdon II 9 mm	60	1	6.13
206	BEAL Ice Line 8.1 mm	60	1	6.02
207	BEAL Ice Line 8.1 mm	60	1	5.97

If we compare the table of "Badly tied knots" with the table of the same tests for the "Well tied knots", that is to say 107 to 112 for the Figure of Eight and 129 to 134 for the Overhand, we can see that the differences are insignificant. So for the Figure of Eight the average is 5.74 kN for the well-tied knots as against 5.69 kN here, giving a difference of less than 1%. For the Overhand Knot we go from 6.08 kN to 6.19 kN, a difference of less than 2%. We can, therefore, say that the knots perform their shock absorbing role just as well when well-tied as when badly tied, that is with ropes crossing each other.

Knots which were not pre-tightened :

- **Sewn – Barrel Knot**

For the following two tests, the Barrel Knots were not pre-tightened, either by machine or by hand.

No	Name	length	Fall Factor	Force
		cm		kN
208	CAMP 11 mm	60	1	5.80
209	CAMP 9 mm	60	1	5.93

As could be anticipated, the shock loads registered are lower than those registered for the same tests with pre-tightening. 5.80 kN here, against 6.55 kN (average of tests 82-83) representing 11.5 % for 11mm and 5.93 kN versus 6.85 kN (average of tests 86 and 87) representing 13.5% for the 9mm. But what is particularly interesting to note is that the slippage of the tail end in the knot was not significant (between 1 and 1.5cm measured).

Two Cow's Tails connected :

It could well happen that, at the moment of the fall, the two ends of the Cow's Tail are connected and that they both help in stopping the fall, something which is more likely to occur with identical, or very similar Cow's Tail lengths.

No	Name	length	Fall Factor	Force
		cm		kN
210	CAMP 11 mm Sewn - Sewn	60	1	9.95
211	CAMP 11 mm Sewn - Sewn	60	1	9.92
212	PETZL Jane 11 mm Sewn - Overhand	60	1	8.05
213	PETZL Jane 11 mm Sewn - Overhand	60	1	8.30
214	BEAL Verdon II 9 mm Overhand - Overhand	54	1	6.80
215	BEAL Verdon II 9 mm Overhand	54	1	7.43
216	BEAL Verdon II 9 mm Overhand	49	1	6.66
217	BEAL Verdon II 9 mm Overhand	49	1	6.64
218	BEAL Verdon II 9 mm Overhand - Barrel	54	1	7.30
219	BEAL Verdon II 9 mm Overhand	54	1	7.40
220	BEAL Verdon II 9 mm Overhand	52	1	6.09

If we compare the tests with the 11 mm CAMP with tests 18 & 19, we can see an increase of 11 % in the shock loading, 9 % with the PETZL Jane, 13 % with the Verdon II overhand-overhand and 17 % for the Verdon II Overhand-Barrel Knot. The shock load therefore increases even if the fall is stopped simultaneously by the two Cow's Tails, although this increase is limited.

Fall Factor 2 Falls :

Although good practice excludes these situations, we wanted to know what would happen, knowing that it is very easy to encounter a Fall Factor 2, either voluntarily or involuntarily.

The following tables show tests appearing previously and thus keep the same numbers.

Sewn Cow's Tails

(Average of these 11 tests: 12.44 kN - Standard deviation: 0.71 kN or 5 %):

No	Name	length	Fall Factor	Force
		cm		kN
14	PETZL Jane 11 mm	63	2	11.09
15	PETZL Jane 11 mm	62	2	12.03
16	PETZL Jane 11 mm	62	2	11.40
22	CAMP 11 mm	60	2	12.73
23	CAMP 11 mm	60	2	12.67
24	CAMP 11 mm	35	2	13.37
25	CAMP 11 mm	35	2	12.98
30	CAMP 9 mm	60	2	12.28
31	CAMP 9 mm	60	2	12.26
32	CAMP 9 mm	35	2	13.04
33	CAMP 9 mm	35	2	12.94

Mixed Cow's Tails (sewn and knot)

No	Name	length	Fall Factor	Force
48	PETZL Jane 11 mm Sewn - Figure of Eight Knot	60	2	9.29

(Average of these 7 tests: 10.27 kN – standard deviation: 0.10 kN or 1%):

No	Name	length	Fall Factor	Force
63	CAMP 11 mm Sewn – Overhand Knot	60	2	10.33
64	CAMP 11 mm Sewn – Overhand Knot	60	2	10.40
65	CAMP 9 mm Sewn – Overhand Knot	60	2	10.29
66	CAMP 9 mm Sewn – Overhand Knot	60	2	10.16
67	PETZL Jane 11 mm Sewn – Overhand Knot	60	2	10.12
68	PETZL Jane 11 mm Sewn – Overhand Knot	60	2	10.33
69	PETZL Jane 11 mm Sewn – Overhand Knot	57	2	10.28
94	PETZL Jane 11 mm Sewn – Barrel Knot	54	2	8.80

Cow's Tails made entirely from knots :

- **Figure of Eight Knot – Barrel Knot**

No	Name	length	Fall Factor	Force
		cm		kN
157	BEAL Verdon II 9 mm	60	2	7.25
158	BEAL Verdon II 9 mm	60	2	7.39

Cow's Tails made entirely from knots - **Overhand Knot – Barrel Knot**

(Average of these 11 tests: 7.65 kN - Standard deviation: 0.36 kN or 5 %):

No	Name	length	Fall Factor	Force
185	CAMP 11 mm	55	2	7.80
186	CAMP 9 mm	55	2	8.14
187	CAMP 9 mm	55	2	7.87
188	BEAL Apollo II 11 mm	55	2	8.04
189	BEAL Apollo II 11 mm	55	2	7.75
190	BEAL Flyer II 10.2 mm	55	2	7.61
191	BEAL Flyer II 10.2 mm	55	2	7.90
192	BEAL Verdon II 9 mm	55	2	7.24
193	BEAL Verdon II 9 mm	55	2	6.95
194	BEAL Ice Line 8.1 mm	55	2	7.44
195	BEAL Ice Line 8.1 mm	55	2	7.43

Tests Repeated on the Same Cow's Tails :

In order to see what happened with a shock load when the Cow's Tail had already been used to hold a fall, we carried out certain tests on the same Cow's Tails. The second test was done after at least 24 hours during which the Cow's Tails were left alone. The third and fourth tests were carried out with only 10 minute intervals.

No	Name	length	Fall Factor	Force
		cm		kN
27	CAMP 9 mm Sewn - Sewn	58	1	8.71
221	Repeating the preceding test			10.40

Increase in shock loading: +19%

No	Name	length	Fall Factor	Force
96	CAMP 11 mm Figure of Eight – Figure of Eight	53	1	5.93
222	Repeating the preceding test			7.32

Increase in shock loading: +23%

No	Name	length	Fall Factor	Force
99	CAMP 9 mm Figure of Eight – Figure of Eight	62	1	6.27
223	Repeating the preceding test			7.58

Increase in shock loading: +21%

No	Name	length	Fall Factor	Force
140	CAMP 11 mm Figure of Eight – Barrel Knot	59	1	5.57
224	Repeating the preceding test			7.20

Increase in shock loading: +29%

No	Name	length	Fall Factor	Force
145	CAMP 9 mm Figure of Eight – Barrel Knot	42	1	5.62
225	Repeating the preceding test			7.19

Increase in shock loading: +28%

No	Name	length	Fall Factor	Force
163	CAMP 9 mm Overhand – Barrel Knot	61	1	6.10
226	Repeating the preceding test			8.31
227	Repeating the preceding test			9.11

Increase in shock loading between the 1st and 2nd test: +36%, between the 2nd and 3rd test: +10% (between the 1st and the 3rd: +49%)

No	Name	length	Fall Factor	Force
		cm		kN
182	BEAL Verdon II 9 mm Figure of Eight – Barrel	60	1	5.50
228	Repeating the preceding test			6.93
229	Repeating the preceding test			7.95
230	Repeating the preceding test			8.35

Increase in shock loading between the 1st and 2nd tests : +26%, between 2nd and 3rd test: + 15 % (between 1st and 3rd: 45 %), between 3rd and 4th test: + 5 % (between 1st and 4th: 52 %)

No	Name	length	Fall Factor	Force
169	BEAL Apollo II 11 mm Overhand – Barrel	58	1	6.07
231	Repeating the preceding test			7.08
232	Repeating the preceding test			7.88
233	Repeating the preceding test			8.17

Increase in shock loading between the 1st and 2nd tests: + 17 %, between 2nd and 3rd test: + 11 % (between 1st and 3rd: 30 %), between 3rd and 4th test: + 4 % (between 1st and 4th: 35 %)

No	Name	length	Fall Factor	Force
172	BEAL Flyer II 10.2 mm Overhand - Barrel	60	1	6.26
234	Repeating the preceding test			7.05
235	Repeating the preceding test			8.19
236	Repeating the preceding test			8.72

Increase in shock loading between the 1st and 2nd tests: + 13 %, between 2nd and 3rd test: + 16 % (between 1st and 3rd: 31 %), between 3rd and 4th test: + 6 % (between 1st and 4th: 39 %)

No	Name	length	Fall Factor	Force
176	BEAL Ice Line 8.1 mm Overhand - Barrel	54	1	6.00
237	Repeating the preceding test			7.43
238	Repeating the preceding test Sheath of the rope totally torn following this test[12]			7.25

Increase in shock loading between the 1st and 2nd test: + 24 %. The tearing of the sheath at the time of the 3rd test explains the fact that the recorded shock load is lower than during the previous test.

12 See page 6 for photograph of sample post test

For the Fall Factor 1 tests, the average increase in the shock load between the first and the second test is 23.5 %.

Repeating the Tests at Fall Factor 2

No	Name	length	Fall Factor	Force
		cm		kN
22	CAMP 11 mm Sewn - Sewn	60	2	12.73
239	Repeating the preceding test			15.31

Increase in shock loading: + 20 %

No	Name	length	Fall Factor	Force
23	CAMP 11 mm Sewn - Sewn	60	2	12.67
240	Repeating the preceding test			13.56

Increase in shock loading: +7%

No	Name	length	Fall Factor	Force
25	CAMP 11 mm Sewn - Sewn	35	2	12.98
241	Repeating the preceding test			16.03

Increase in shock loading: 23%

No	Name	length	Fall Factor	Force
30	CAMP 9 mm Sewn - Sewn	60	2	12.28
242	Repeating the preceding test : ripping of a sewn section			

No	Name	length	Fall Factor	Force
32	CAMP 9 mm Sewn - Sewn	35	2	13.04
243	Repeating the preceding test : ripping of a sewn section			

No	Name	length	Fall Factor	Force
		cm		kN
33	CAMP 9 mm Sewn - Sewn	35	2	12.94
244	Repeating the preceding test			15.00

Increase in shock loading: +16%

No	Name	length	Fall Factor	Force
		cm		kN
15	PETZL Jane 11 mm Sewn - Sewn	62	2	12.03
245	Repeating the preceding test			14.53

Increase in shock loading: 21%

No	Name	length	Fall Factor	Force
		cm		kN
16	PETZL Jane 11 mm Sewn - Sewn	62	2	11.40
246	Repeating the preceding test			13.25

Increase in shock loading: 16%

No	Name	length	Fall Factor	Force
63	CAMP 11 mm Sewn – Overhand Knot	60	2	10.33
247	Repeating the preceding test			13.47

Increase in shock loading: +30%

No	Name	length	Fall Factor	Force
64	CAMP 11 mm Sewn – Overhand Knot	60	2	10.40
248	Repeating the preceding test			13.55

Increase in shock loading: 30%

No	Name	length	Fall Factor	Force
65	CAMP 9 mm Sewn – Overhand Knot	60	2	10.29
249	Repeating the preceding test : rupture in the Overhand Knot			

No	Name	length	Fall Factor	Force
66	CAMP 9 mm Sewn – Overhand Knot	60	2	10.16
250	Repeating the preceding test : rupture in the Overhand Knot			

No	Name	length	Fall Factor	Force
67	PETZL Jane 11 mm Sewn – Overhand Knot	60	2	10.12
251	Repeating the preceding test			12.91

Increase in shock loading: 28%

No	Name	length	Fall Factor	Force
68	PETZL Jane 11 mm Sewn – Overhand Knot	60	2	10.33
252	Repeating the preceding test			12.80

Increase in shock loading: 24%

No	Name	length	Fall Factor	Force
186	CAMP 9 mm Overhand Knot – Barrel Knot	55	2	8.14
253	Repeating the preceding test : rupture in the Overhand Knot			

No	Name	length	Fall Factor	Force
		cm		kN
187	CAMP 9 mm Overhand Knot – Barrel Knot	55	2	7.87
254	Repeating the preceding test : rupture in the Overhand Knot			

No	Name	length	Fall Factor	Force
194	BEAL Ice Line 8.1 mm Overhand Knot – Barrel Knot	55	2	7.44
255	Repeating the preceding test : rupture in the Overhand Knot			

No	Name	length	Fall Factor	Force
195	BEAL Ice Line 8.1 mm Overhand Knot – Barrel Knot	55	2	7.43
256	Repeating the preceding test : rupture in the Overhand Knot			

No	Name	length	Fall Factor	Force
192	BEAL Verdon II 9 mm Overhand Knot – Barrel Knot	55	2	7.24
257	Repeating the preceding test			10.48

Increase in shock loading: 45%

No	Name	length	Fall Factor	Force
193	BEAL Verdon II 9 mm Overhand Knot – Barrel Knot	55	2	6.95
258	Repeating the preceding test : rupture in the Overhand Knot			

No	Name	length	Fall Factor	Force
191	BEAL Flyer II 10.2 mm Overhand - Barrel	55	2	7.90
259	Repeating the preceding test			9.74

Increase in shock loading: 23%

No	Name	length	Fall Factor	Force
189	BEAL Apollo II 11 mm Overhand - Barrel	55	2	7.75
260	Repeating the preceding test			10.31

Increase in shock loading: 45%

No	Name	length	Fall Factor	Force
157	BEAL Verdon II 9 mm Figure of Eight - Barrel	60	2	7.25
261	Repeating the preceding test			10.74

Increase in shock loading: 48%

All the ropes of diameters smaller than 10 mm suffered from ruptures during the second Fall Factor 2 tests, either in a knot or in a sewn section.

Static Tests :

- **Figure of Eight Knot– Barrel Knot**

In order to validate the use of a Barrel Knot we wanted to test its reaction to a static test involving a slow pull. For this we combined it with a Figure of Eight Knot. That is for the test we set up one Cow's Tail with a Figure of Eight at one end and a Barrel Knot at the other and pulled the combination until the rope broke.

No	Name	Fall Factor	Force
			kN
262	BEAL Apollo II 11 mm	Static Test	17.78
263	BEAL Apollo II 11 mm	Static Test	17.23
264	CAMP 9 mm	Static Test	12.96
265	CAMP 9 mm	Static Test	13.35
266	BEAL Ice Line 8.1 mm	Static Test	9.45
267	BEAL Ice Line 8.1 mm	Static Test	9.80

During these 6 tests the break occurred in the Figure of Eight Knot. The strength of the Cow's Tail (and more generally of a rope) is therefore better with a Barrel Knot than with a Figure of Eight Knot.

- **Cow's Tails subjected to shock loading 2 days earlier**

No	Name	Fall Factor	Force
268	CAMP 11 mm Overhand Knot- Overhand Knot	Static Test	16.38
269	CAMP 11 mm Overhand Knot- Overhand Knot	Static Test	16.31
270	CAMP 9 mm Overhand Knot- Overhand Knot	Static Test	11.50
271	CAMP 9 mm Overhand Knot- Overhand Knot	Static Test	11.70
272	BEAL Apollo II 11 mm Overhand Knot- Overhand Knot	Static Test	15.38
273	BEAL Apollo II 11 mm Overhand Knot- Overhand Knot	Static Test	15.69
274	BEAL Flyer II 10.2 mm Overhand Knot- Overhand Knot	Static Test	13.26
275	BEAL Flyer II 10.2 mm Overhand Knot- Overhand Knot	Static Test	13.15
276	BEAL Verdon II 9 mm Overhand Knot- Overhand Knot	Static Test	10.35
277	BEAL Verdon II 9 mm Overhand Knot- Overhand Knot	Static Test	10.52
278	BEAL Ice Line 8.1 mm Overhand Knot- Overhand Knot	Static Test	8.24
279	BEAL Ice Line 8.1 mm Overhand Knot- Overhand Knot	Static Test	8.01
280	PETZL Jane 11 mm Overhand Knot- Overhand Knot	Static Test	18.01
281	PETZL Jane 11 mm Overhand Knot- Overhand Knot	Static Test	17.81

Used Cow's Tails :

Numerous caving Cow's Tails had been collected for these tests and we thank all those who responded to our request. However, faced with an inability to interpret the results, we soon stopped these tests. These lasts tests seemed inconsistent since those Cow's Tails that had been used for several seasons and appeared quite badly worn gave much better dynamic results than those Cow's Tails that had only been used for a few trips. The opposite results occurred when the Cow's Tails were subject to the static tests. It appears that this can be explained quite simply by the fact that with time and repeated usage the fibres of the rope had broken making the rope more elastic but weaker. A more in-depth study with more precise histories (number of trips, type of trips, weight of the user…) could perhaps answer this question on the ageing of Cow's Tails.

The results below will therefore not be commented on.

- Cow's Tails used for one season of caving (2004) used by CREPS of Chalain

No	Name	length	Fall Factor	Force
		cm		kN
282	BEAL Stinger 9.4 mm Overhand Knot – Barrel Knot	34	1	5.16
283	BEAL Stinger 9.4 mm Overhand Knot – Barrel Knot	37	1	5.15
284	BEAL Stinger 9.4 mm Overhand Knot – Barrel Knot	50	1	5.32
285	BEAL Stinger 9.4 mm Overhand Knot – Barrel Knot	48	1	5.07
286	BEAL Stinger 9.4 mm Overhand Knot – Barrel Knot	39	2	6.74
287	BEAL Stinger 9.4 mm Overhand Knot – Barrel Knot	38	2	6.85
288	BEAL Stinger 9.4 mm Overhand Knot – Barrel Knot	58	2	7.32
289	BEAL Stinger 9.4 mm Overhand Knot – Barrel Knot	58	2	7.32
290	BEAL Stinger 9.4 mm Overhand Knot – Barrel Knot	38	Static Test	10.22
291	BEAL Stinger 9.4 mm Overhand Knot – Barrel Knot	58	Static Test	9.90

- **Cow's Tails used for three seasons of canyoning by professionals (2004)**

No	Name	length	Fall Factor	Force
292	BEAL Stinger 9.4 mm Overhand Knot – Overhand Knot	46	1	5.80
293	BEAL Stinger 9.4 mm Overhand Knot – Overhand Knot	42	1	5.96
294	BEAL Stinger 9.4 mm Overhand Knot – Overhand Knot	60	1	5.50
295	BEAL Stinger 9.4 mm Overhand Knot – Overhand Knot	72	1	5.37
296	BEAL Stinger 9.4 mm Overhand Knot – Overhand Knot	45	2	7.50
297	BEAL Stinger 9.4 mm Overhand Knot – Overhand Knot	42	2	7.67
298	BEAL Stinger 9.4 mm Overhand Knot – Overhand Knot	68	2	7.47
299	BEAL Stinger 9.4 mm Overhand Knot – Overhand Knot	64	2	739
300	Repetition of the previous test: rope broke in the middle of the Cow's Tail			
301	BEAL Stinger 9.4 mm Overhand Knot – Overhand Knot	48	Static Test	7.50
302	BEAL Stinger 9.4 mm Overhand Knot – Overhand Knot	54	Static Test	7.70

- **Cow's Tails used for a year (2003) by Secondary School Pupils**

No	Name	length	Fall Factor	Force
		cm		kN
303	PMI 10.2 mm Figure of Eight Knot - Figure of Eight Knot	40	1	5.16
304	PMI 10.2 mm Figure of Eight Knot - Figure of Eight Knot	40	1	5.26
305	A Static test on the Cow's Tail used for test 303			11.78
306	A Static test on the Cow's Tail used for test 304			13.63
307	PMI 10.2 mm Figure of Eight Knot - Figure of Eight Knot	55	1	5.24
308	PMI 10.2 mm Figure of Eight Knot - Figure of Eight Knot	50	1	5.61
309	PMI 10.2 mm Figure of Eight Knot - Figure of Eight Knot	40	2	7.72
310	PMI 10.2 mm Figure of Eight Knot - Figure of Eight Knot	40	2	7.53
311	Repetition of the previous test			10.07
312	PMI 10.2 mm Figure of Eight Knot - Figure of Eight Knot	45	2	6.36
313	PMI 10.2 mm Figure of Eight Knot - Figure of Eight Knot	50	2	7.13
314	Repetition of the previous test			9.94

- **Cow's Tails used for caving and canyoning (professional environment)**

No	Name	length	Fall Factor	Force
315	Single canyon Cow's Tail rope Overhand Knot– Overhand Knot	50	Static Test	8.04
316	Single canyon Cow's Tail rope Overhand Knot– Overhand Knot	50	Static Test	8.06
317	Cow's Tail 9 mm Figure of Eight Knot - Figure of Eight Knot	35	Static Test	8.24
318	Cow's Tail 9 mm Figure of Eight Knot - Figure of Eight Knot	50	Static Test	9.53
319	Cow's Tail 9 mm Figure of Eight Knot - Figure of Eight Knot	70	2	8.47
320	Cow's Tail 9 mm Figure of Eight Knot - Figure of Eight Knot	70	2	8.47
321	Repetition of previous test : Cow's Tail broke			

- **Cow's Tails used for a year in rope work**

No	Name	length	Fall Factor	Force
322	PETZL Jane 11 mm Sewn - Overhand Knot	37	1	6.91

Summary

Comparison of different Cow's Tail ends:

In order to compare only the ends, we have created averages from the results of the tests on the Cow's Tails made from 11 mm rope (CAMP 11 mm, PETZL Jane and Beal Apollo II), excluding of course the Spelegyca Cow's Tail which is made from tape. The results are ranked from the best performer to the poorest performer and only for Fall Factor 1 falls.

		k N
1	Figure of Eight Knot Knot – Barrel Knot	5.64
2	Figure of Eight Knot – Figure of Eight Knot	5.75
3	Overhand Knot Knot – Barrel Knot	5.90
4	Overhand Knot – Overhand Knot	6.44
5	Sewn – Barrel Knot	6.52
6	Sewn – Clove Hitch	6.81
7	Sewn – Figure of Eight Knot	7.30
8	Sewn – Overhand Knot	7.34
9	Sewn – Sewn	9.00
10	Spelegyca tape Cow's Tail (long)	10.99

Ranking by the type of Cow's Tail is quite easy as the 4 best results correspond to the Cow's Tails made entirely out of knots, the next 4 corresponding to those made from one knot at one end and a sewn end at the other, the penultimate category corresponds to Cow's Tails made entirely from rope (with sewn ends at both ends) and the poorest are those Cow's Tails made from tape.

Only the Cow's Tails made from knots at both ends achieve values below the level of 6 kN.

We have not collected enough tests at Fall Factor 2 to rank all the ends, however the results we do have correspond to the previous ranking.

- 12.32 kN on average for the entirely sewn Cow's Tails
- 9.94 kN on average for the mixed Cow's Tails
- 7.86 kN on average for the Cow's Tails made entirely from knots

Comparison of different types of ropes:

In order to compare only the types and diameters of rope, we have produced averages of the results for each type of rope. These come from the tests on the 60 cm Cow's Tails knotted at both ends (taking exactly the same tests for all the Cow's Tails), except of course for the Spelegyca Cow's Tail, which is made from tape.

The results are ranked from the best performer to the poorest performer and only for Fall Factor 1 falls.

		kN
1	BEAL Verdon II 9 mm	5.80
2	BEAL Ice Line 8.1 mm	5.88
3	BEAL Apollo II 11 mm	5.97
4	CAMP 11 mm	6.01
5	PETZL Jane 11 mm	6.02
6	BEAL Flyer II 10.2 mm	6.12
7	CAMP 9 mm	6.27

The results are very close (average of 6.01 kN and standard deviation of only 0.15 kN or 2,5 %) although these ropes display very different characteristics and have varied diameters.

Comparison of different lengths of Cow's Tails :

These results all relate to Fall Factor 1 tests.

	kN
Spelegyca long (60 cm)	10.44
Spelegyca short (32 cm)	11.54
CAMP Cow's Tail sewn - sewn long (59 cm)	8.68
CAMP Cow's Tail sewn - sewn short (33 cm)	9.64
Mixed Cow's Tails long	6.82
Mixed Cow's Tails short	6.88
CAMP Cow's Tails with 2 knots long	6.61
CAMP Cow's Tails with 2 knots short	5.86

The differences between the short and the long Cow's Tails are not very significant. However, it is interesting to note that for the manufactured Cow's Tails (either in tape or with sewn ends) the shock load is lower with the long side of the Cow's Tail, whereas it's the opposite with those Cow's Tails made with 2 knots. For the mixed Cow's Tails, the average values are almost identical.

Thus, the concept of Fall Factor does not apply to the Cow's Tails made with one or several knots. In fact, we have seen (p. 5) that a Fall Factor 1 more accurately corresponds to a Fall Factor 1.75 for a short Cow's Tail and to a fall Factor 1.45 for a long Cow's Tail. We note that in all the tests on Cow's Tails with knots, the shock load is lower with the short side of the Cow's Tail than with the long side of the Cow's Tail. Therefore in this specific circumstance there is a lower shock load for a higher Fall Factor.

This is explained by the fact that, with such small distances, knots play a greater shock absorbing role than the stretch of the rope. This shock absorption by the knots is similar on either side of a Cow's Tail. Therefore it can be assumed that the shock load is lower with the short side of a Cow's Tail simply because the energy to be absorbed is less since the fall distance is less.

Conclusion

Cow's Tails currently on the market that are entirely manufactured, whether they be single or double, symmetrical or non-symmetrical, are not appropriate for either caving or work on ropes. In particular, Cow's Tails made from sewn tapes, in widespread use by cavers and rope workers, can pose a real risk. The tests have, in effect, shown that a Fall Factor 1 shock load could exceed 15 kN (test 6) when the recognised maximum for work equipment according to the European Standards is set at 6 kN.

However, it is possible to use manufactured goods by linking them to the harness with a knot to specifically perform a shock absorbing role and thereby serving to keep the shock load for a Fall Factor 1 fall within acceptable bounds. Different manufacturers offer lengths of dynamic rope with pre sewn ends. With a 150cm Cow’s Tail, it is therefore quite easy to make a pair of non-symmetrical Cow's Tail, which is ideal for both caving and rope work. It can be joined directly to the harness tie-in point with a Figure of Eight Knot, an Overhand Knot or a Clove Hitch.

From the point of view of shock absorption, Cow's Tails made from dynamic rope and knots at both ends achieve the best results. The effect of the diameter and of the weave of the rope on this shock load is not significant. Furthermore, the results are similar for knots that are well tied and knots that are badly tied, that is when the ropes cross over each other, and also whether they have been pre-tightened or not. This method also allows the lengths of the Cow's Tails to be adapted to the size of the user. Figures of Eight Knots, Overhand Knots or Clove Hitches can be used at the harness end. At the other end, a Figure of Eight Knot or an Overhand Knot and also a Barrel Knot can be connected to the karabiner. The Barrel Knot is being increasingly used by cavers and has the advantage of holding the karabiner in place. It is, in effect, completely secure and furthermore is the knot that provides the best results in both the static and dynamic tests.

One of the lessons from this series of tests is that the theory behind Fall Factors inadequately explains how shock loads are absorbed by Cow' Tails. In particular it is the knots that absorb the greater part of the energy from a fall and in various identical set-ups, it has been demonstrated that the shock loads are inversely proportional to the fall factors (see p. 32[13]). Despite this we should continue to teach that cavers should not position themselves above their anchor point when using Cow's tails; fortunately this is a situation which is quite easy to identify. The tests carried out in less favourable conditions gave shock loads well in excess of those that can be sustained by the human body. Tests also showed that heavily used Cow's tails can break on the first fall.

Finally it is regrettable that the most recent laws and particularly article R 233-13-20 of the Fair Labour Standards Act (added by decree on 1st September 2004) are not based on shock loads and the limit of 6 kN. It requires that "[…] the protection of workers must be assured by means of an appropriate Fall Protection system which does not allow a free fall of more than one metre or limiting in the same way the effects of a fall from a greater height."; Yet these tests indicate that a fall of less than one metre can create a shock load above 15 kN.

13 The original text said p33 but from the context it is clear it should be p 32.

Annex A Figure of Eight Knot

A (single) Figure of Eight Knot is shown in Figure A.1 and a Figure of Eight Knot tied on a Bight is shown in Figure A.2. This translation adopts the convention of using the term "Figure of Eight Knot" to mean a Figure of Eight Knot tied on a Bight.

Figure of Eight Knot

Figure A.1

Figure of Eight Knot
tied on a Bight
Figure A.2

Annex B Single and Double Overhand Knots

A (single) Overhand Knot is shown in Figure B.1 and a Double Overhand Knot is shown in Figure B.2. An Overhand Knot tied on a Bight is shown in Figure B.3. This translation adopts the convention of using the term "Overhand Knot" to mean an Overhand Knot tied on a Bight.

Overhand Knot

Figure B.1

Double Overhand Knot

Figure B.2

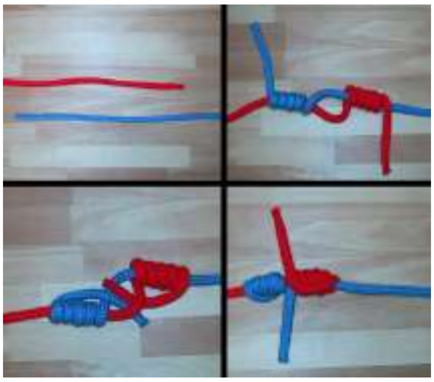
Overhand Knot
tied on a Bight
Figure B.3

Annex C Half a Double Fisherman's or Barrel Knot

The name Barrel Knot was given in an English publication[14] in 2001, see Figure C.1, to the knot shown on page 8, see Figure C.2. The description of a Barrel Knot[15] however, is one which applies to a number of turns, perhaps as many as 8 and is used to join two lengths of line, see Figure C.3. Variations in usage of the Barrel Knot within a Cow's Tail in the United Kingdom include using three turns. This translation adopts the convention of using the term "Barrel Knot" in place of the French name "Half a Double Fisherman's Knot" [Demi pêcheur double].

Barrel Knot
Figure C.1

Half a Double Fisherman's Knot
Figure C.2



Barrel or Blood Knot
Figure C.3[16]

[14] Page 15, "Industrial rope access – Investigation into items of Personal Protective Equipment" by Lyon Equipment Limited, a Contract Reseach Report for the UK Health and Safety Executive, No 364/2001, see http://www.hse.gov.uk/research/crr_pdf/2001/crr01364.pdf as on 9 February 2008

[15] See http://en.wikipedia.org/wiki/Blood_knot as on 9 February 2008

[16] *This Wikipedia and Wikimedia Commons image is from the user Chris 73 and is freely available at http://commons.wikimedia.org/wiki/Image:BloodKnot_HowTo.jpg under the creative commons cc-by-sa 2.5 license.*

Annex D SPELEGYCA Asymmetrical Y-shaped Cow's Tail

The SPELEGYCA Asymmetrical Y-shaped Cow's Tail, see Figure D.1, is made by PETZL from flat sewn webbing and is stated as not being an energy absorber[17].

Figure D.1[18]

17 See http://en.petzl.com/petzl/ProProduits?Produit=524 as on 9 February 2008

18 Taken from 19 above

Annex E Jane Non-adjustable Dynamic rope lanyard

The Jane non-adjustable dynamic rope lanyard, see Figure E.1, is made by PETZL from 11 mm dynamic rope and comes with two sewn loop terminations[19].

Figure E.1

The literature which accompanies the lanyard specifies that the lanyard has a strength of 22 kN which is reduced to 18 kN if used with a knot termination. It also claims a shock load of 7 kN for a Fall Factor 1 drop of 0.6 m and 9 kN for a Fall Factor 2 drop of 1.2 m by a 80 kg mass.

19 See http://en.petzl.com/petzl/ProProduits?Produit=310 as on 9 February 2008

DAISY CHAINS AND OTHER LANYARDS:
Some Shocking Results when Shock Loaded

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

Presented by:
Mike Gibbs
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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

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.									

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.									

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

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.									

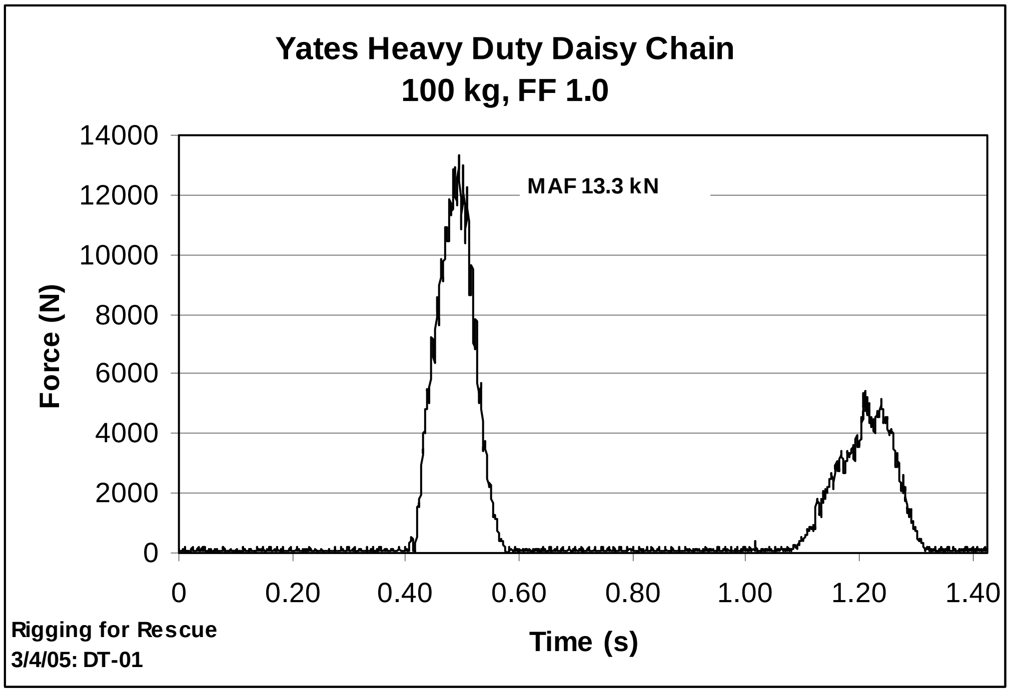
Test #	Lanyard Type: make, model, color	Lanyard Type: size, material & construction	Initial Unit Length (cm)	Mass (kg)	Drop Height (cm)	Fall Factor	Slide Distance (cm)	Final Unit Length (cm)	Maximum Arrest Force (N)
23	Yates Daisy Chain w/ Shorty Screamer	13mm; Spectra; sewn	125	100	156.25	1.25	NA	Failed	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.									

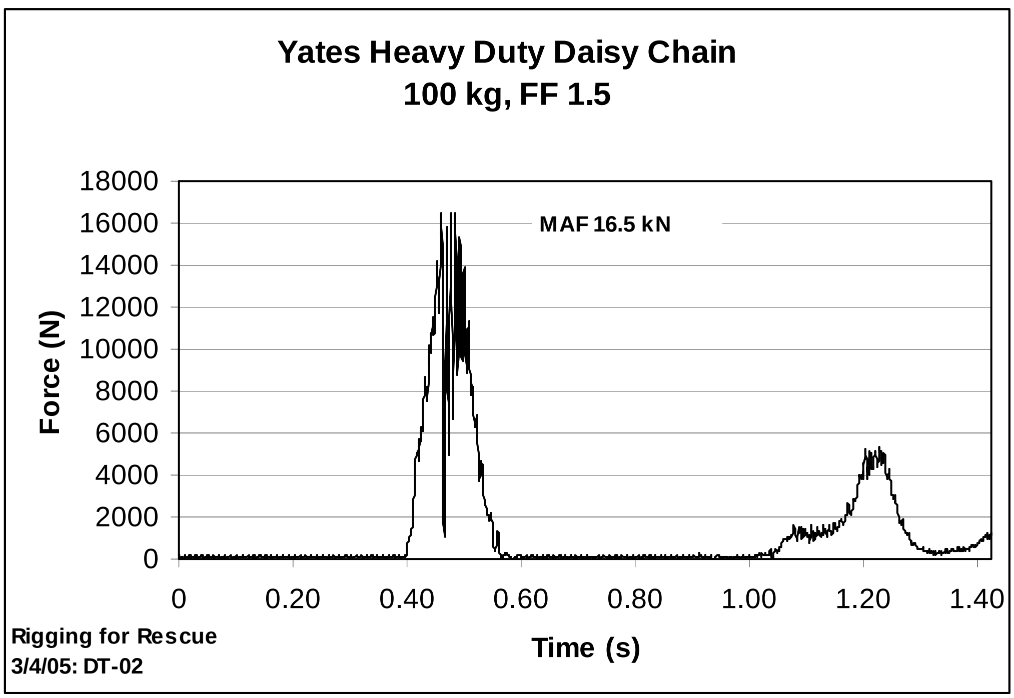
Test #	Lanyard Type: make, model, color	Lanyard Type: size, material & construction	Initial Unit Length (cm)	Mass (kg)	Drop Height (cm)	Fall Factor	Slide Distance (cm)	Final Unit Length (cm)	Maximum Arrest Force (N)
34	Climb High Daisy Chain	11/16"; Spectra; sewn	130	80	97.5	0.75	NA	154	14685
Comments: 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.									

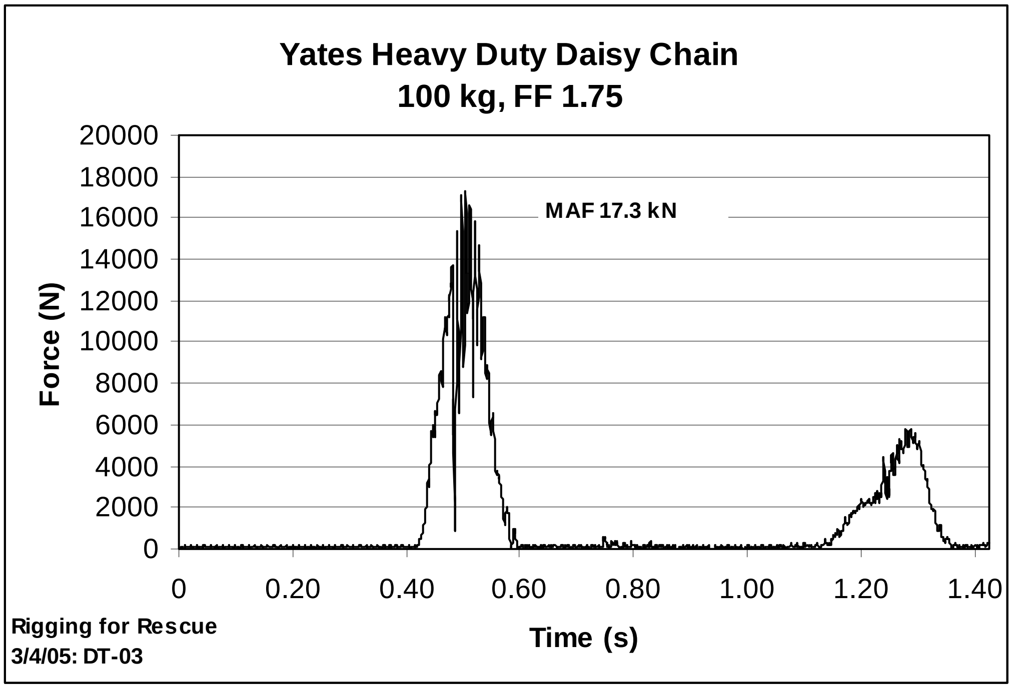
Test #	Lanyard Type: make, model, color	Lanyard Type: size, material & construction	Initial Unit Length (cm)	Mass (kg)	Drop Height (cm)	Fall Factor	Slide Distance (cm)	Final Unit Length (cm)	Maximum Arrest Force (N)
45	Purcell Prusik w/ 3-wrap prusik	6mm PMI Cord; tied	73	80	146	2	14.5	97.5	11307
Comments: 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.									

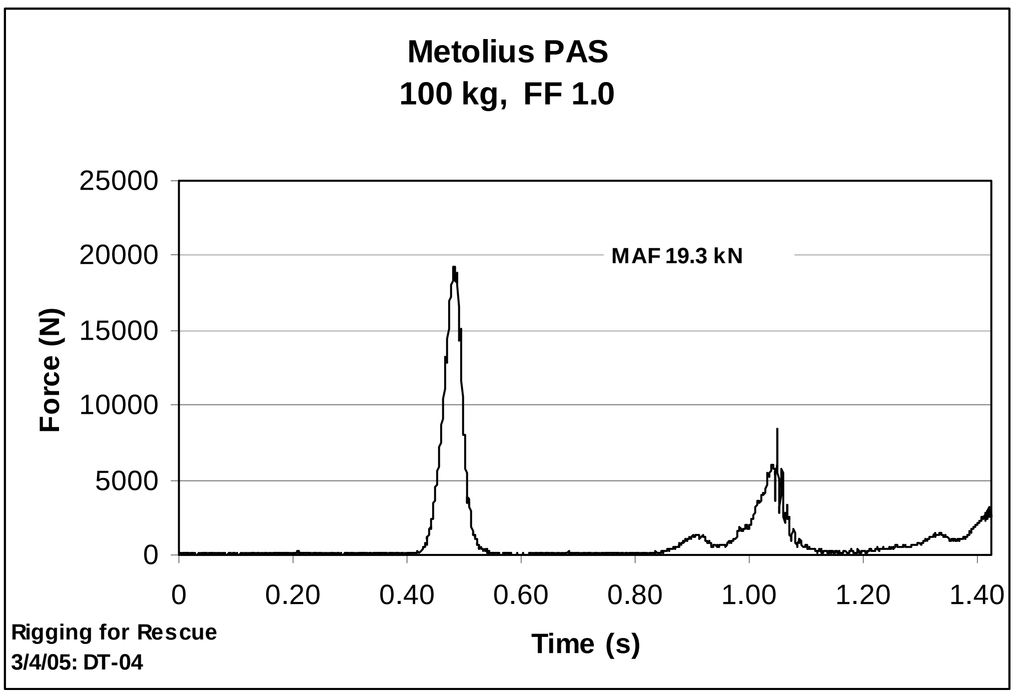
Key to Acronyms and Abbreviations

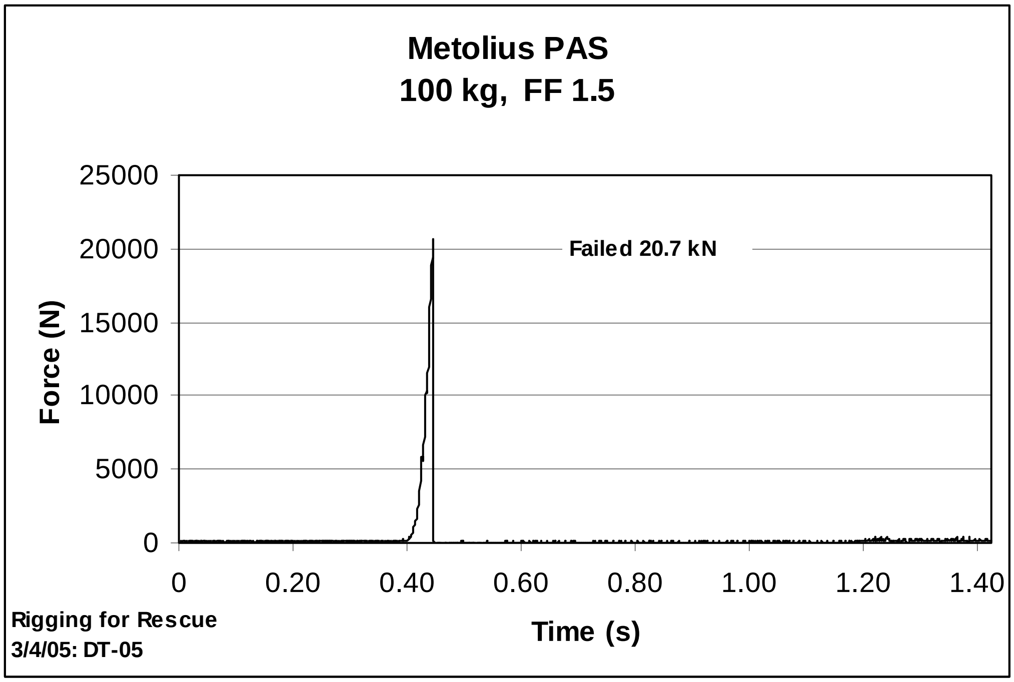
Item	Description
cm	centimetre
mm	millimetre
kg	kilogram
N	Newton
MNT	Measurement Not Taken
PAS	Personal Anchor System
NA	Not Applicable
PMI	Pigeon Mountain Industries

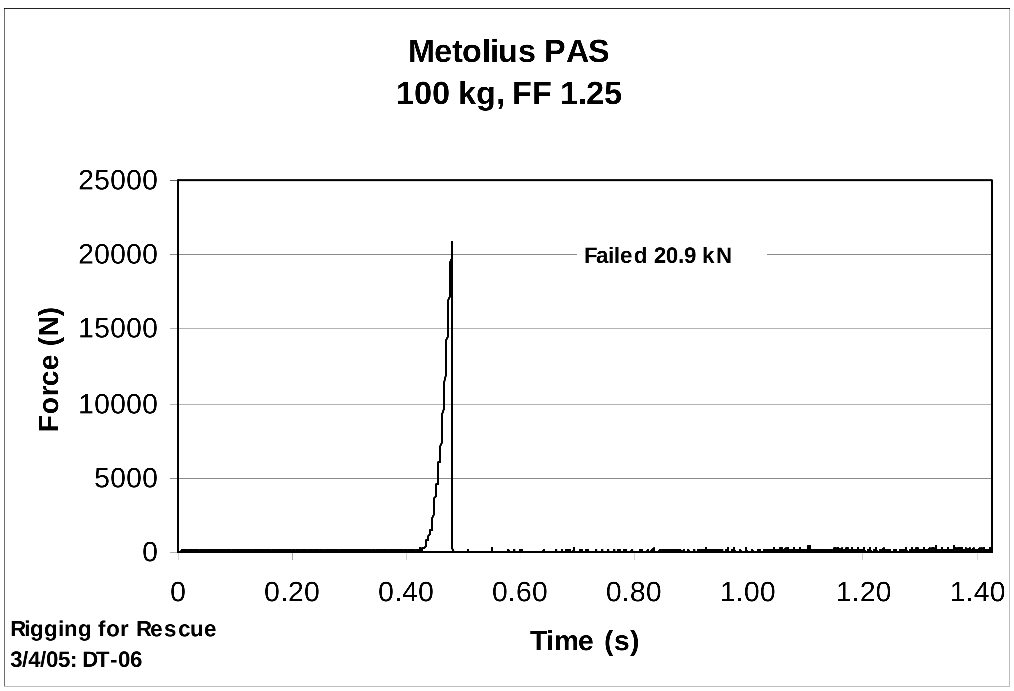

Yates Heavy Duty Daisy Chain
100 kg, FF 1.0
MAF 13.3 kN
Force (N)
0
2000
4000
6000
8000
10000
12000
14000
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-01

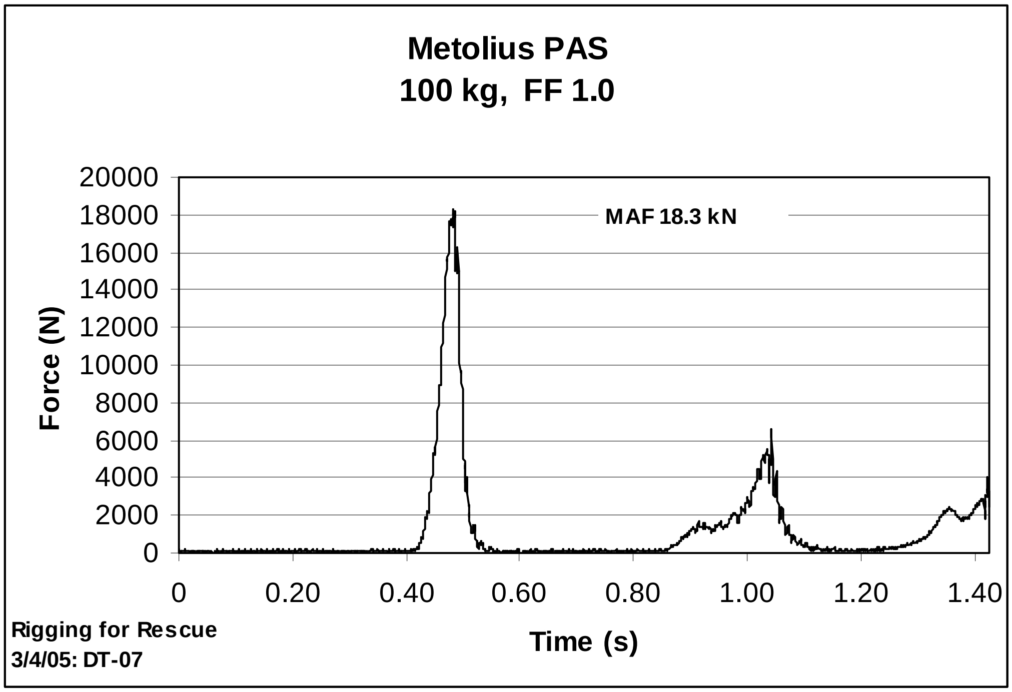

Yates Heavy Duty Daisy Chain
100 kg, FF 1.5
MAF 16.5 kN
Force (N)
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-02

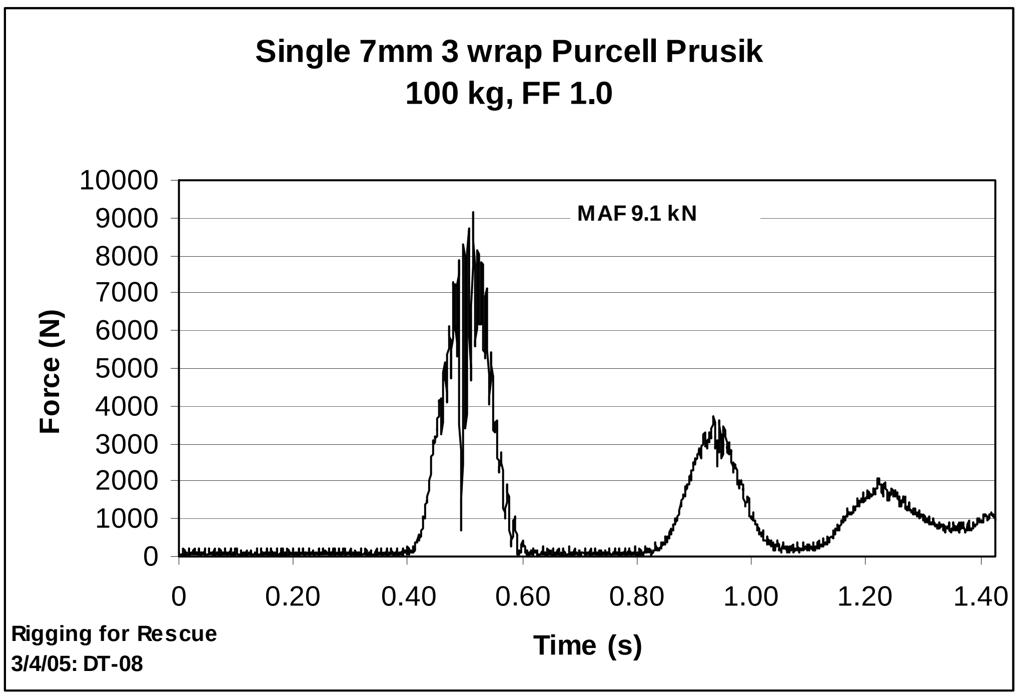

Yates Heavy Duty Daisy Chain
100 kg, FF 1.75
MAF 17.3 kN
Force (N)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-03

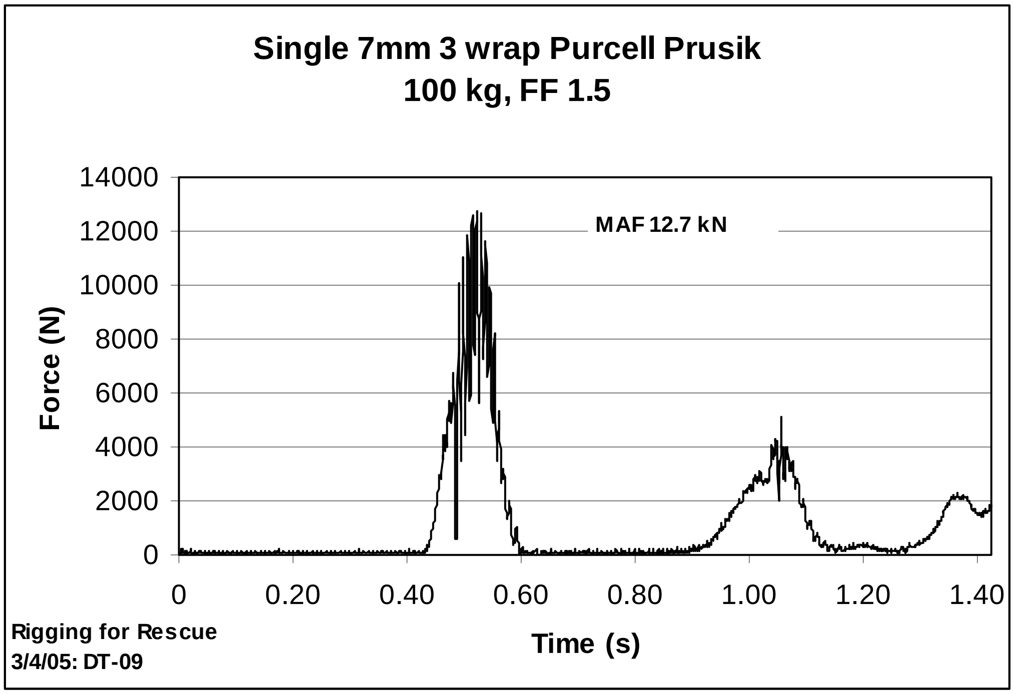

Metolius PAS
100 kg, FF 1.0
MAF 19.3 kN
Force (N)
25000
20000
15000
10000
5000
0
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-04

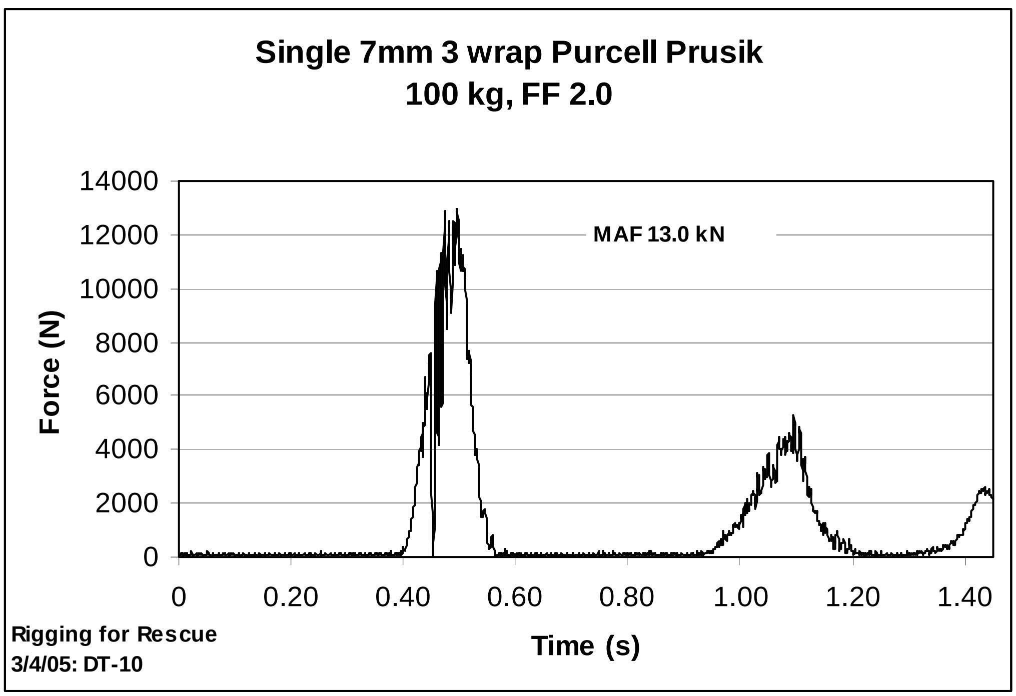

Metolius PAS
100 kg, FF 1.5
25000
20000
15000
10000
5000
0
Force (N)
Failed 20.7 kN
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-05

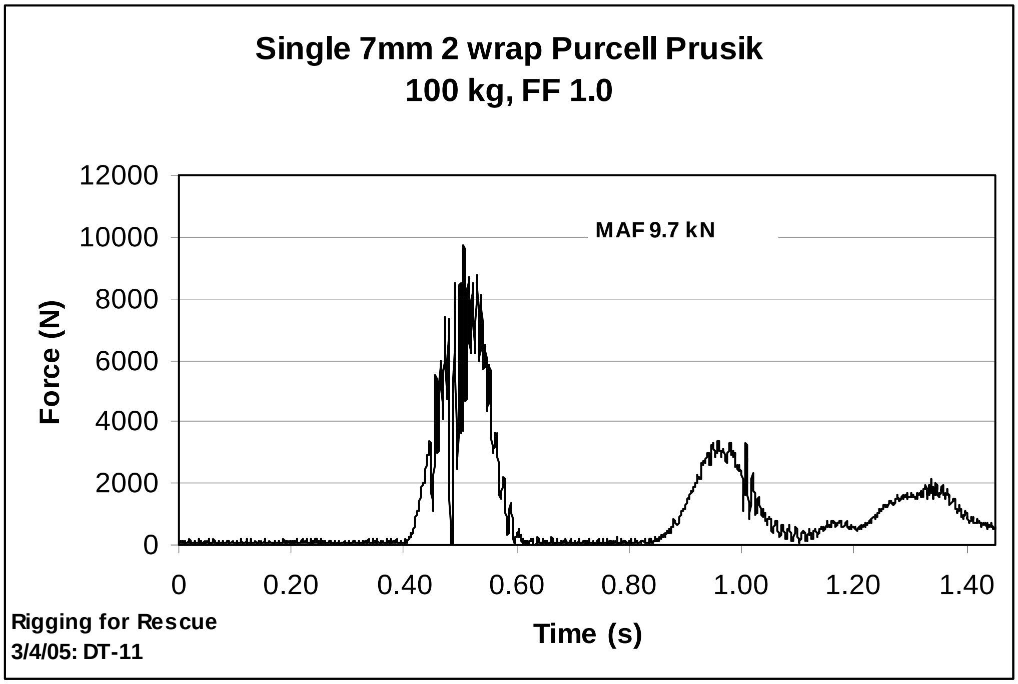

Metolius PAS
100 kg, FF 1.25
25000
20000
15000
10000
5000
0
Force (N)
Failed 20.9 kN
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-06

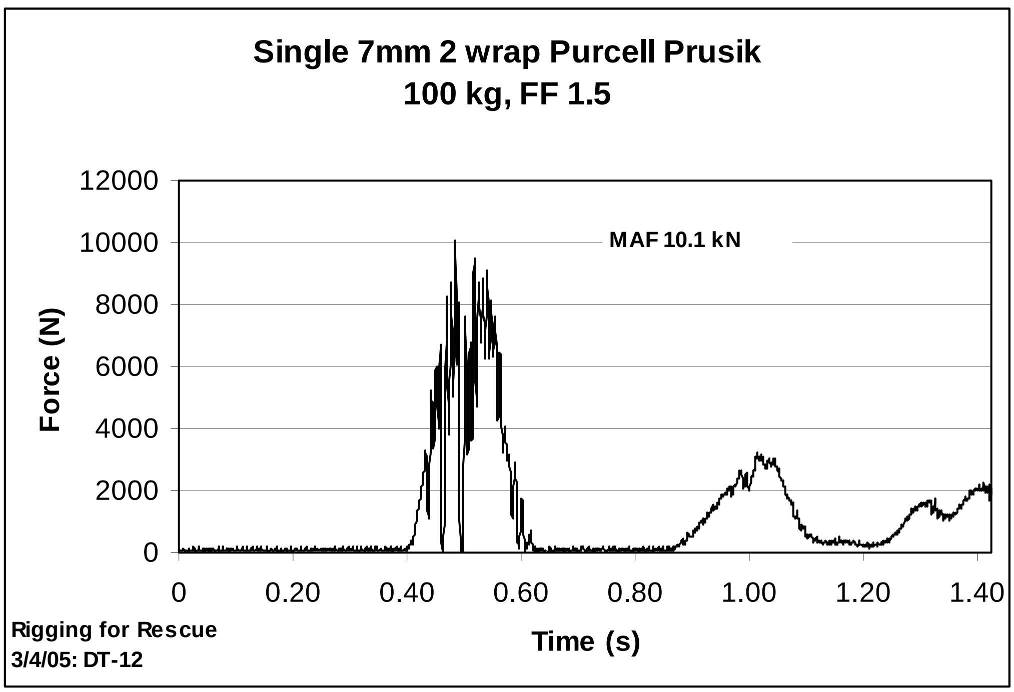

Metolius PAS
100 kg, FF 1.0
MAF 18.3 kN
Force (N)
Time (s)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Rigging for Rescue
3/4/05: DT-07

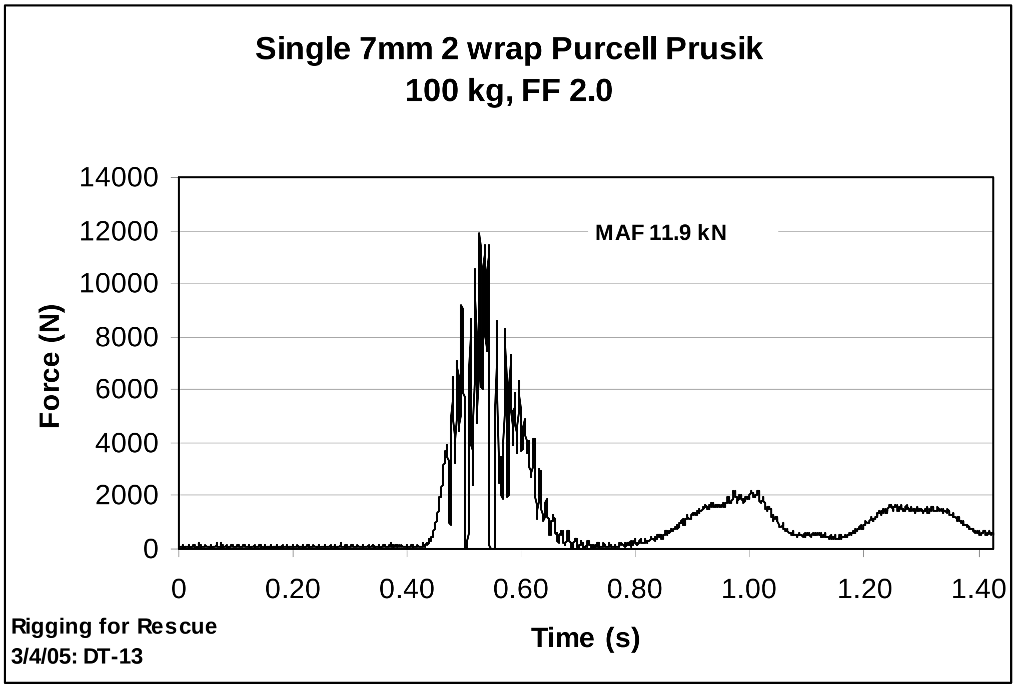

Single 7mm 3 wrap Purcell Prusik
100 kg, FF 1.0
MAF 9.1 kN
Force (N)
Time (s)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Rigging for Rescue
3/4/05: DT-08

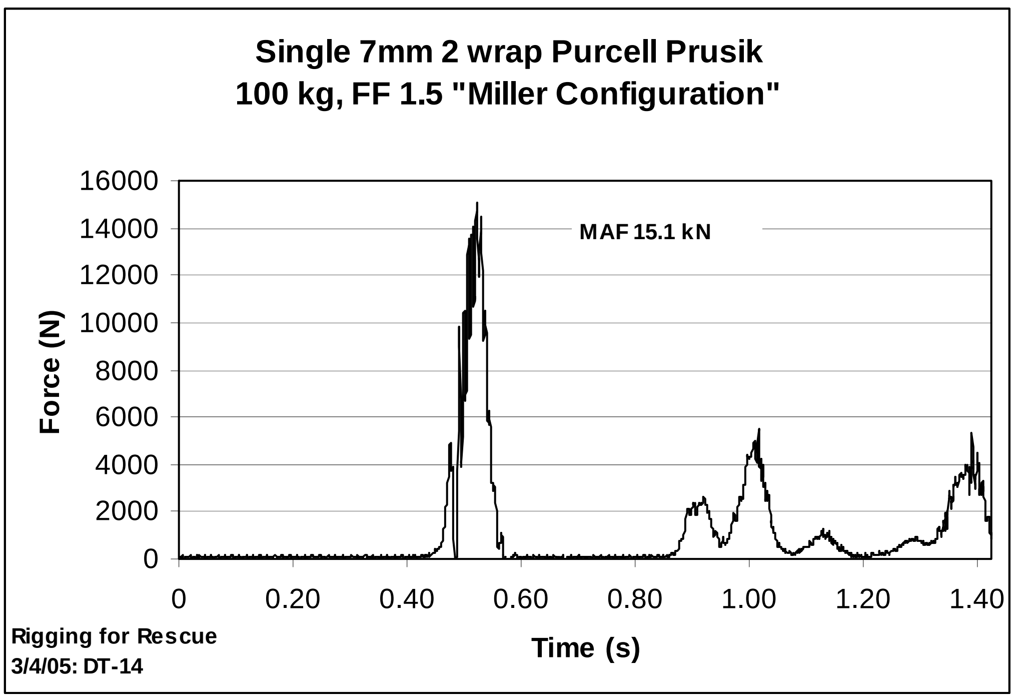

Single 7mm 3 wrap Purcell Prusik
100 kg, FF 1.5
14000
12000
10000
8000
6000
4000
2000
0
Force (N)
MAF 12.7 kN
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-09

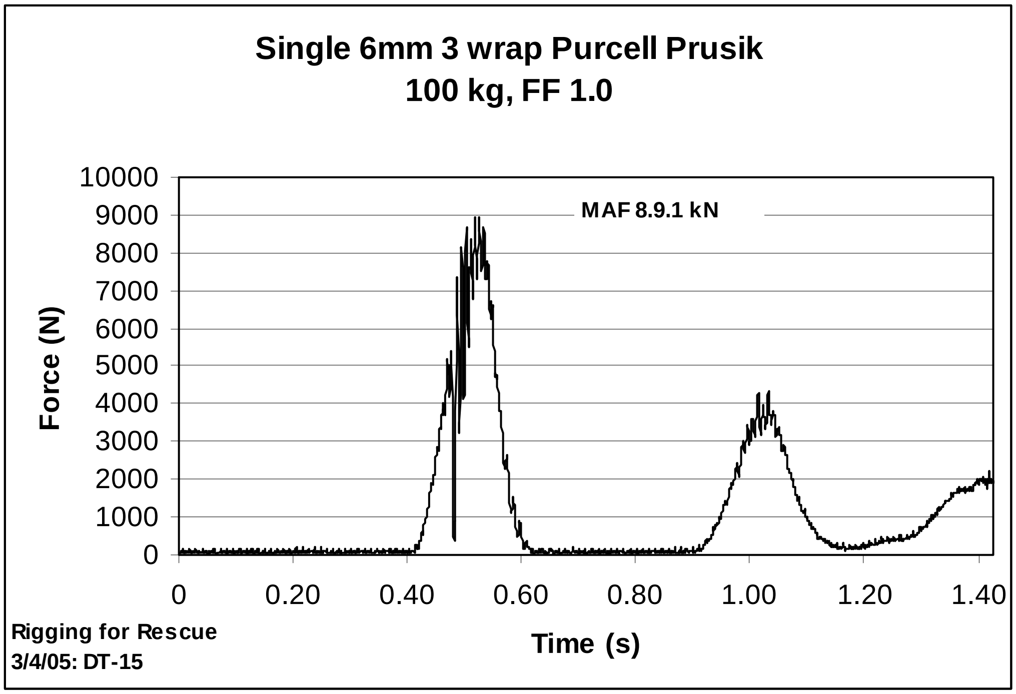

Single 7mm 3 wrap Purcell Prusik
100 kg, FF 2.0
14000
12000
10000
8000
6000
4000
2000
0
Force (N)
MAF 13.0 kN
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-10

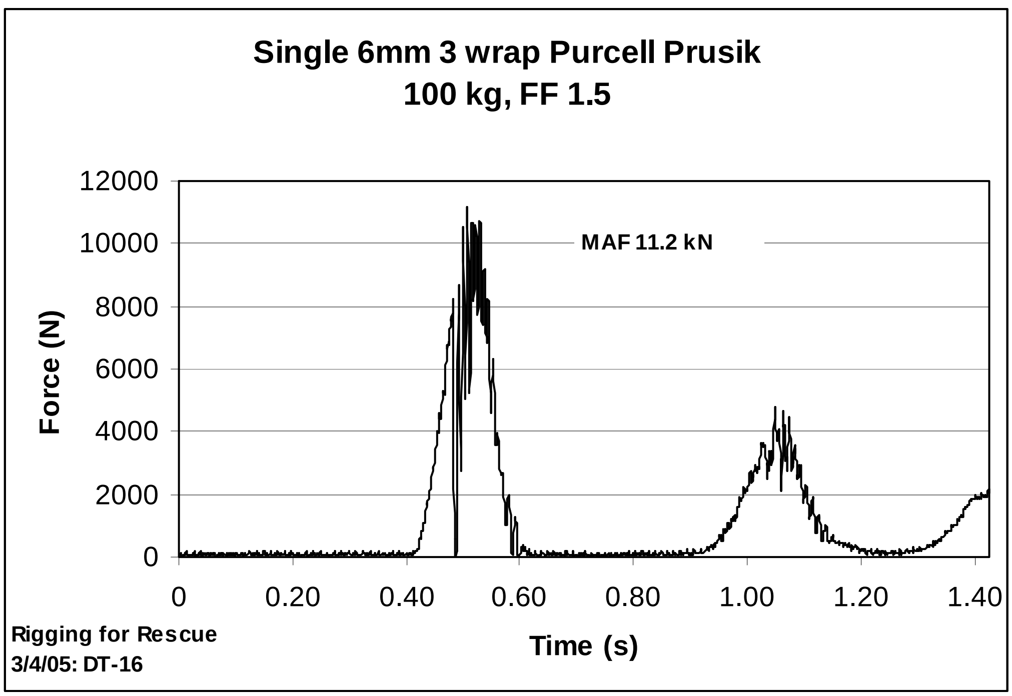

Single 7mm 2 wrap Purcell Prusik
100 kg, FF 1.0
MAF 9.7 kN
Force (N)
12000
10000
8000
6000
4000
2000
0
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-11

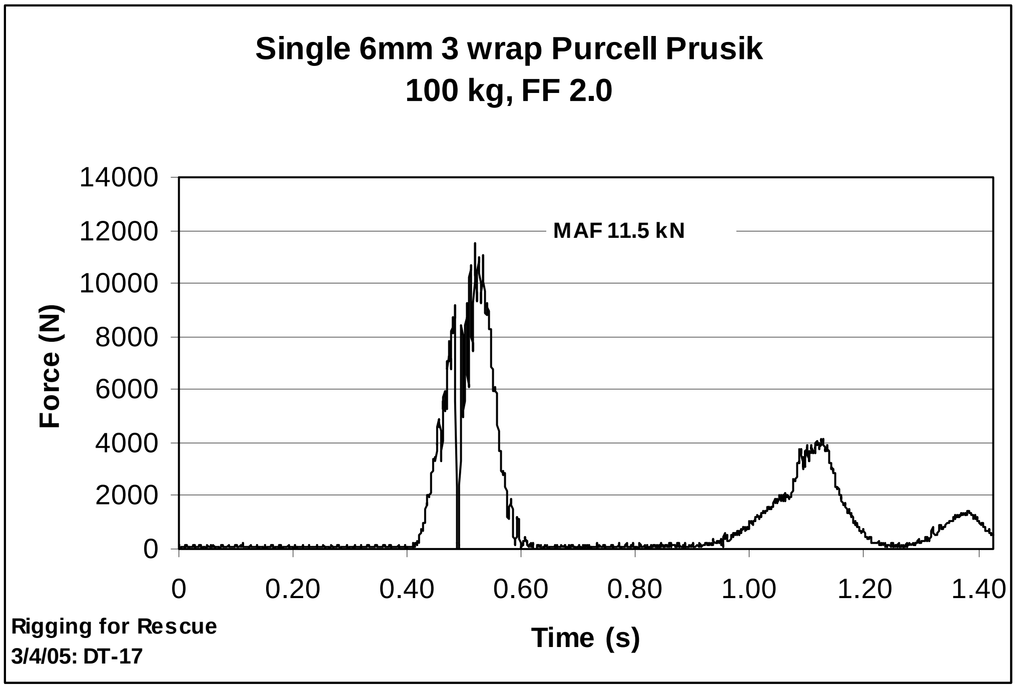

Single 7mm 2 wrap Purcell Prusik
100 kg, FF 1.5
MAF 10.1 kN
Force (N)
12000
10000
8000
6000
4000
2000
0
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-12

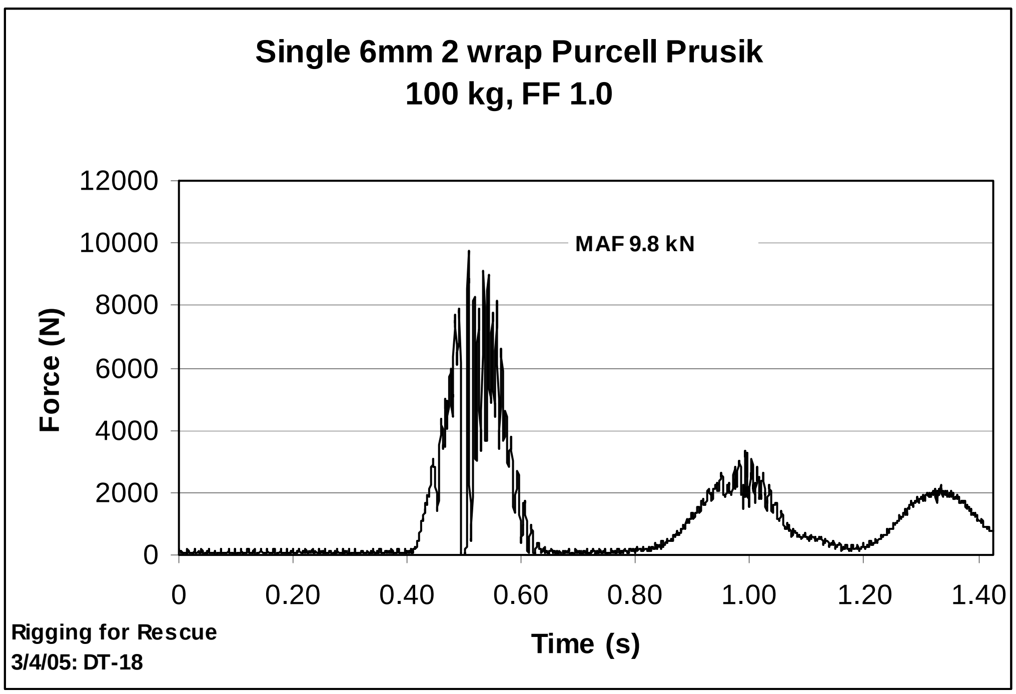

Single 7mm 2 wrap Purcell Prusik
100 kg, FF 2.0
MAF 11.9 kN
Force (N)
14000
12000
10000
8000
6000
4000
2000
0
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-13


Single 7mm 2 wrap Purcell Prusik
100 kg, FF 1.5 "Miller Configuration"
MAF 15.1 kN
Force (N)
16000
14000
12000
10000
8000
6000
4000
2000
0
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-14


Single 6mm 3 wrap Purcell Prusik
100 kg, FF 1.0
MAF 8.9.1 kN
Force (N)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-15


Single 6mm 3 wrap Purcell Prusik
100 kg, FF 1.5
MAF 11.2 kN
Force (N)
12000
10000
8000
6000
4000
2000
0
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-16


Single 6mm 3 wrap Purcell Prusik
100 kg, FF 2.0
14000
12000
10000
8000
6000
4000
2000
0
MAF 11.5 kN
Force (N)
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-17


Single 6mm 2 wrap Purcell Prusik
100 kg, FF 1.0
12000
10000
8000
6000
4000
2000
0
MAF 9.8 kN
Force (N)
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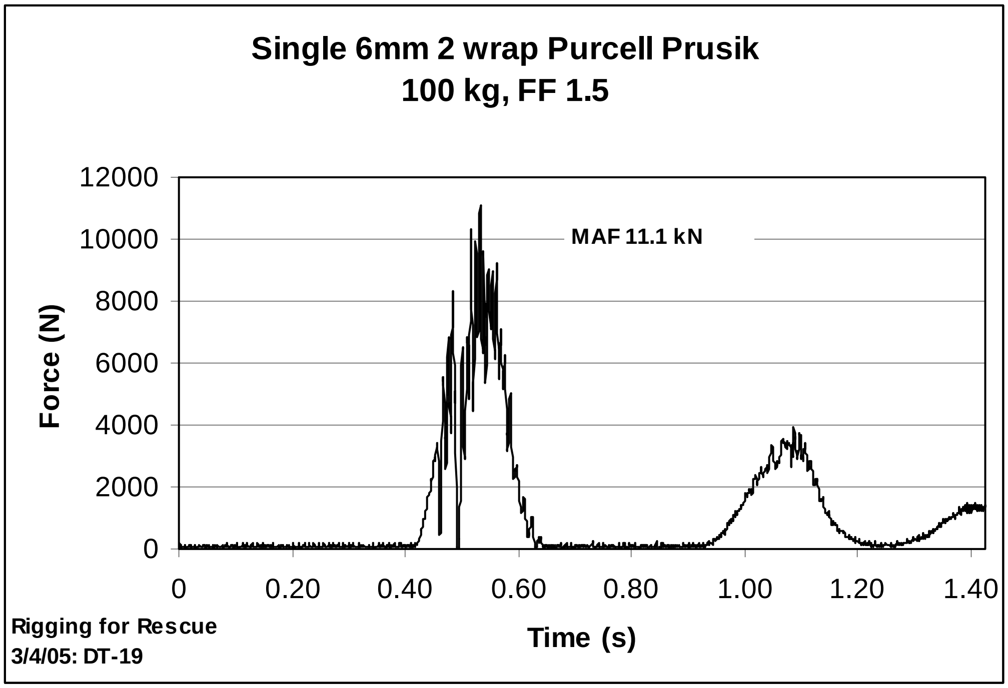
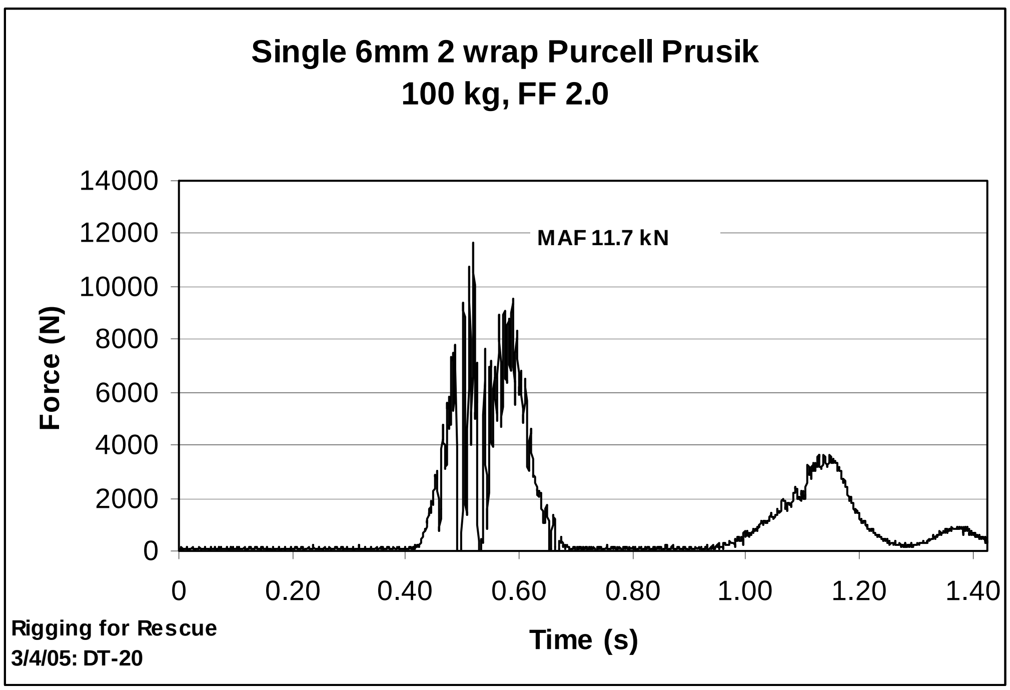
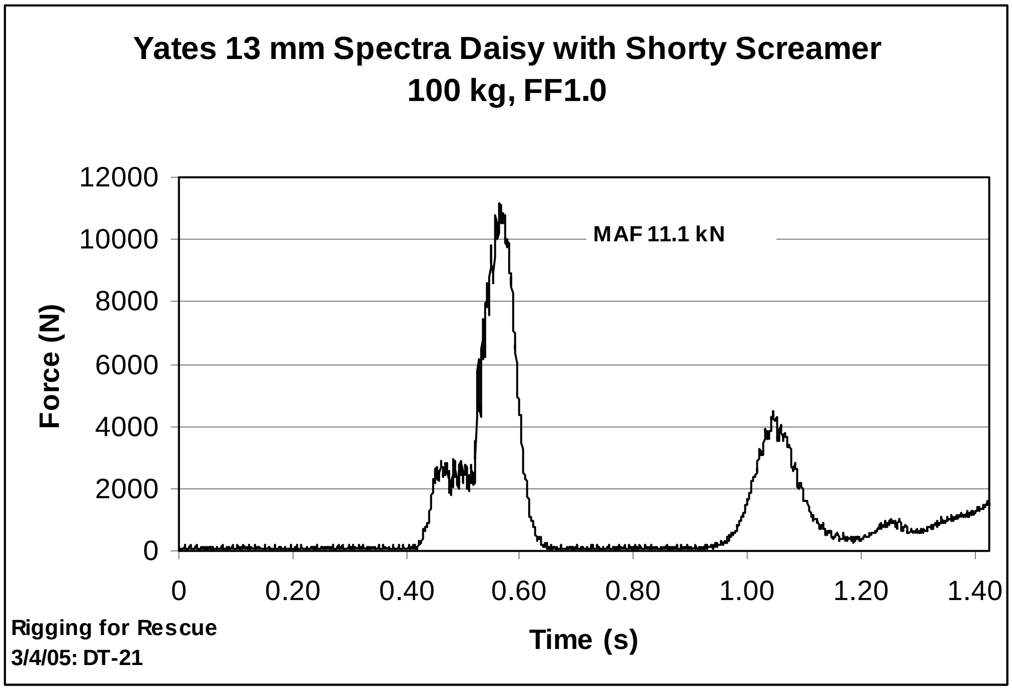
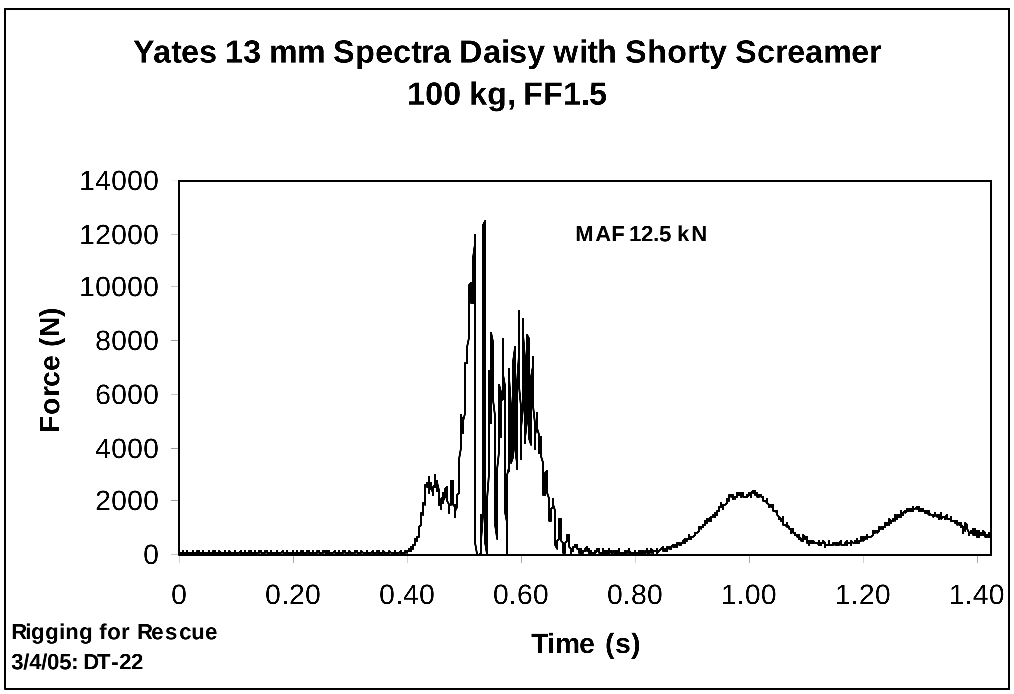
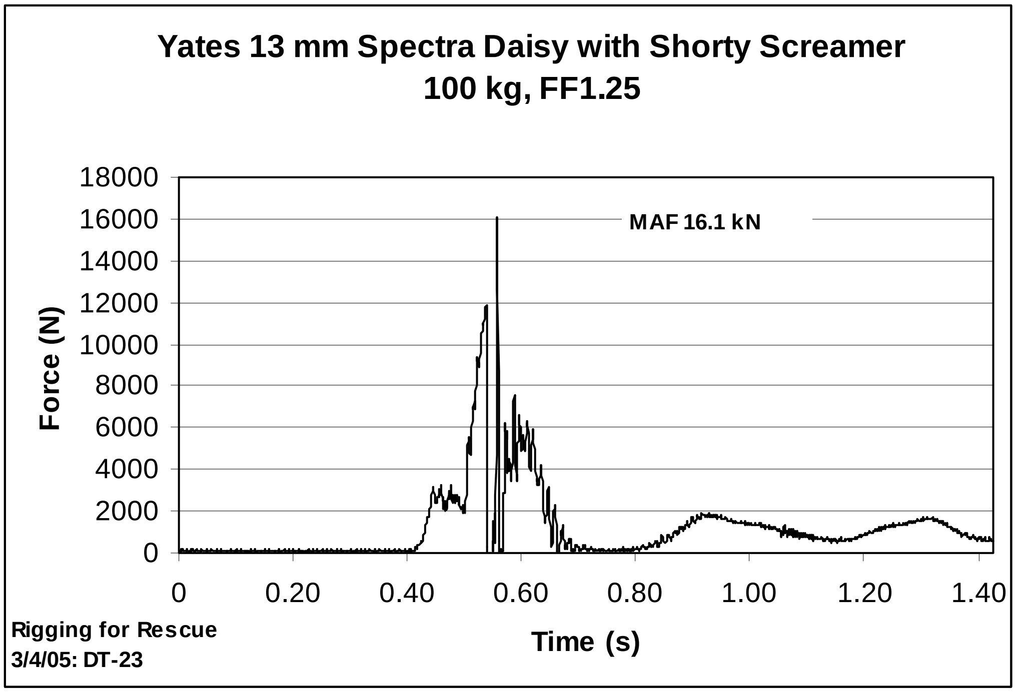
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-18

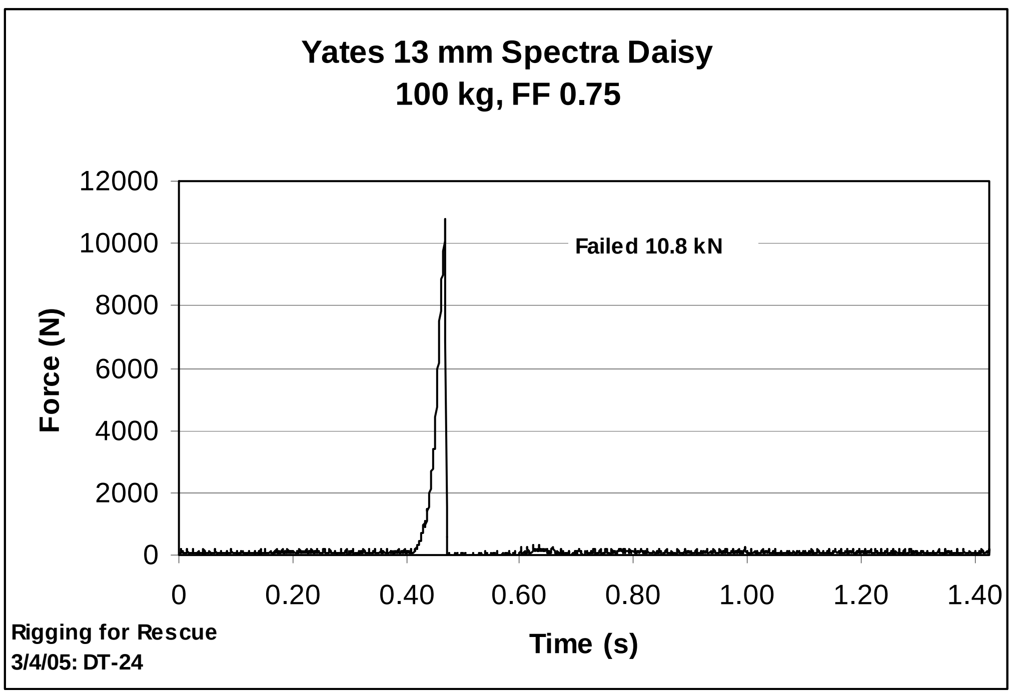

Single 6mm 2 wrap Purcell Prusik
100 kg, FF 1.5
12000
10000
8000
6000
4000
2000
0
Force (N)
MAF 11.1 kN
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-19

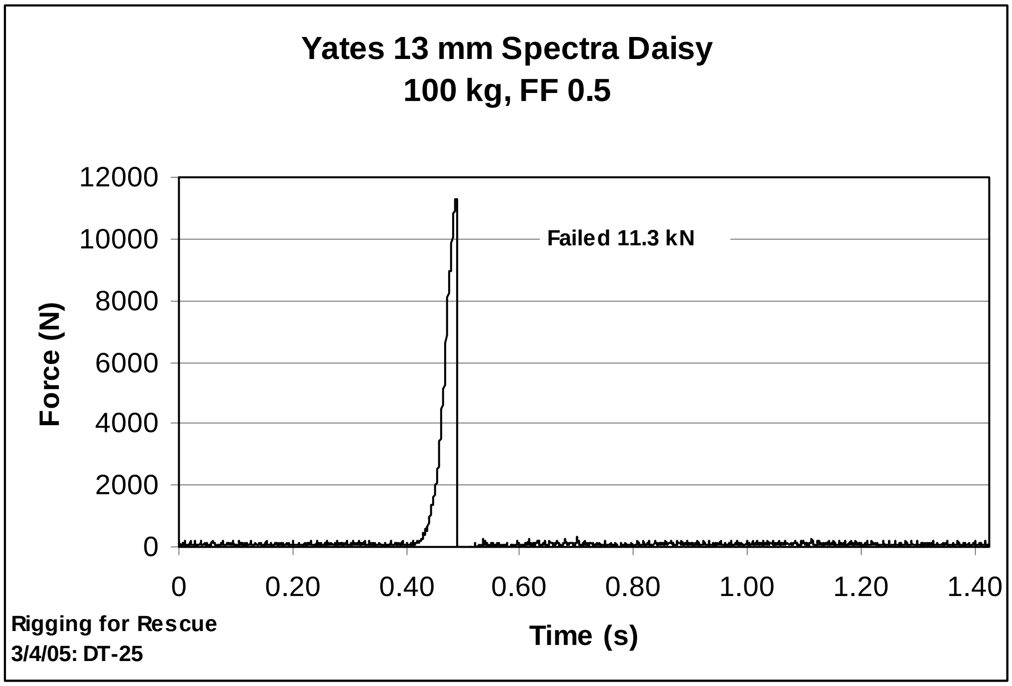

Single 6mm 2 wrap Purcell Prusik
100 kg, FF 2.0
14000
12000
10000
8000
6000
4000
2000
0
Force (N)
MAF 11.7 kN
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-20

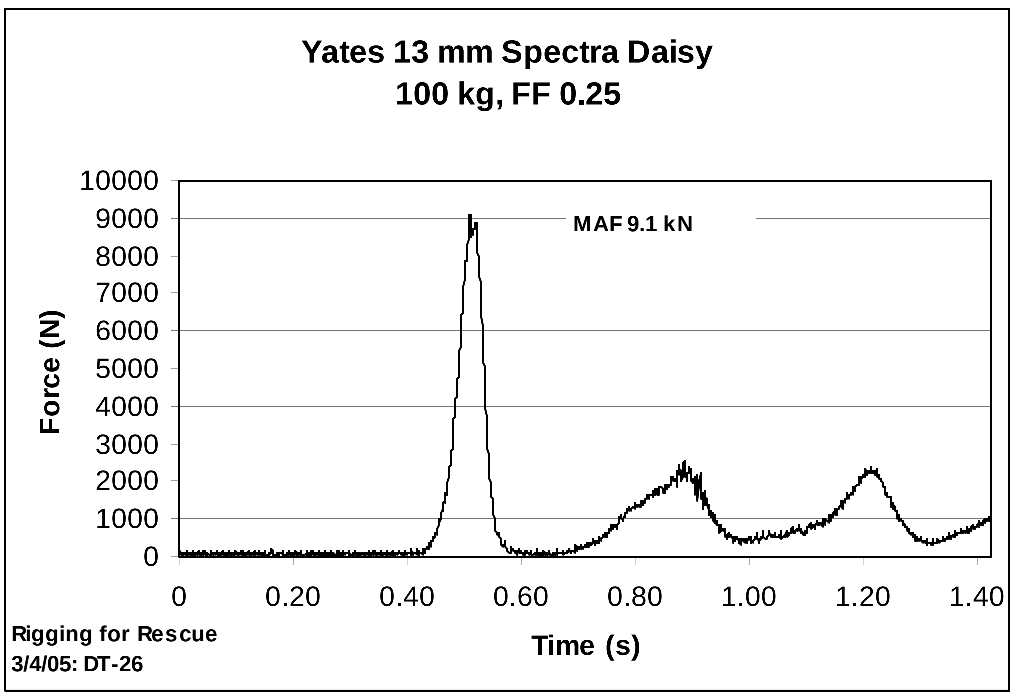

Yates 13 mm Spectra Daisy with Shorty Screamer
100 kg, FF1.0
MAF 11.1 kN
Force (N)
12000
10000
8000
6000
4000
2000
0
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-21

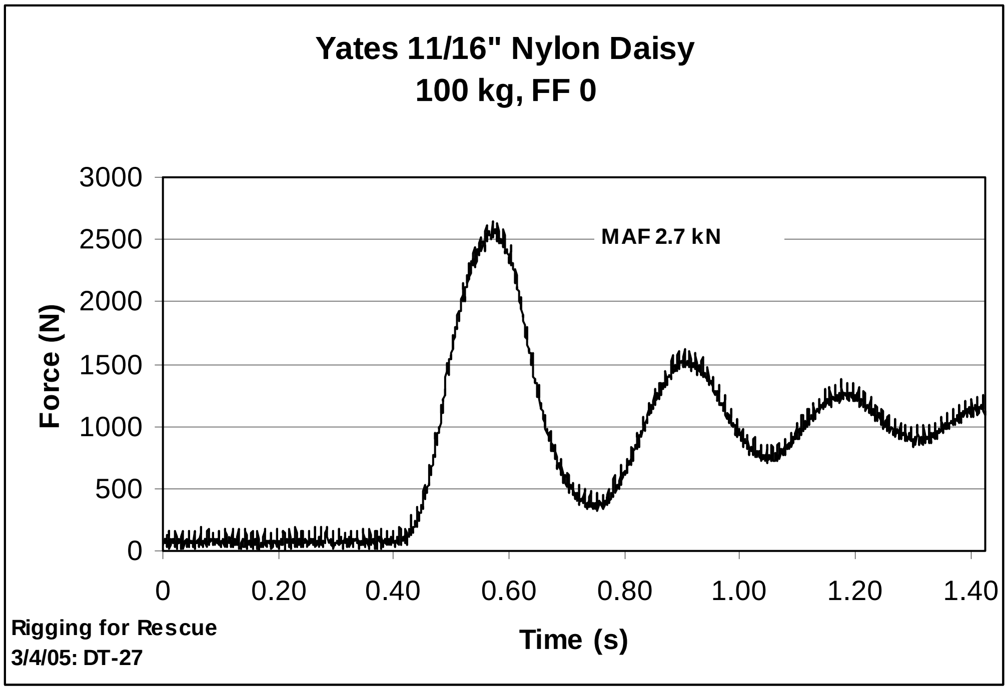

Yates 13 mm Spectra Daisy with Shorty Screamer
100 kg, FF1.5
MAF 12.5 kN
Force (N)
14000
12000
10000
8000
6000
4000
2000
0
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-22

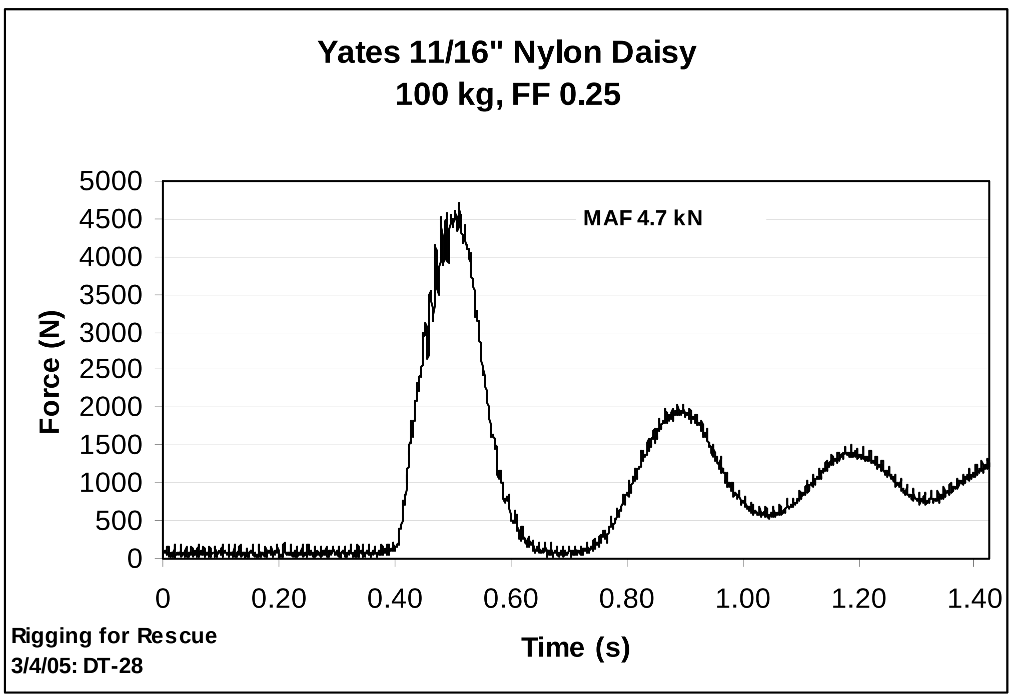

Yates 13 mm Spectra Daisy with Shorty Screamer
100 kg, FF1.25
Force (N)
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
MAF 16.1 kN
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-23

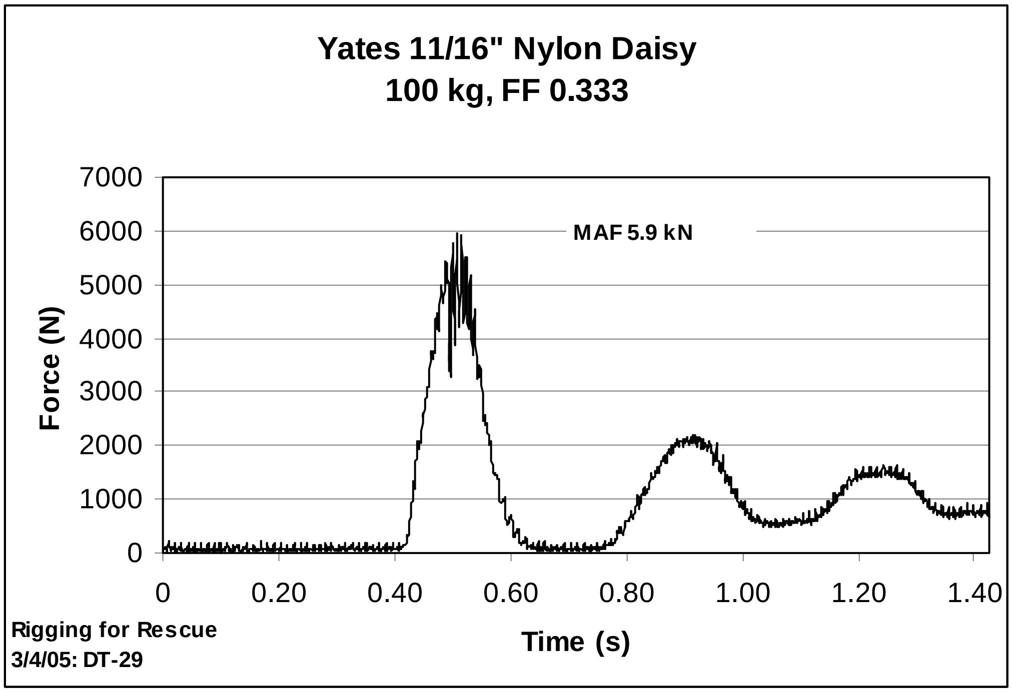

Yates 13 mm Spectra Daisy
100 kg, FF 0.75
Force (N)
12000
10000
8000
6000
4000
2000
0
Failed 10.8 kN
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-24

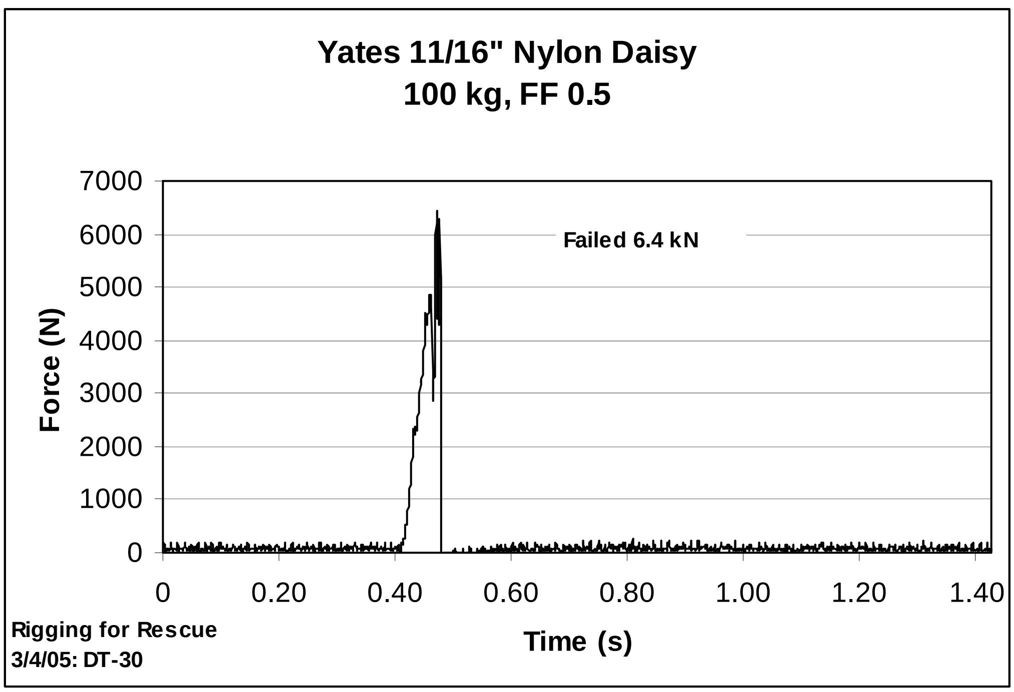

Yates 13 mm Spectra Daisy
100 kg, FF 0.5
Force (N)
12000
10000
8000
6000
4000
2000
0
Failed 11.3 kN
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-25

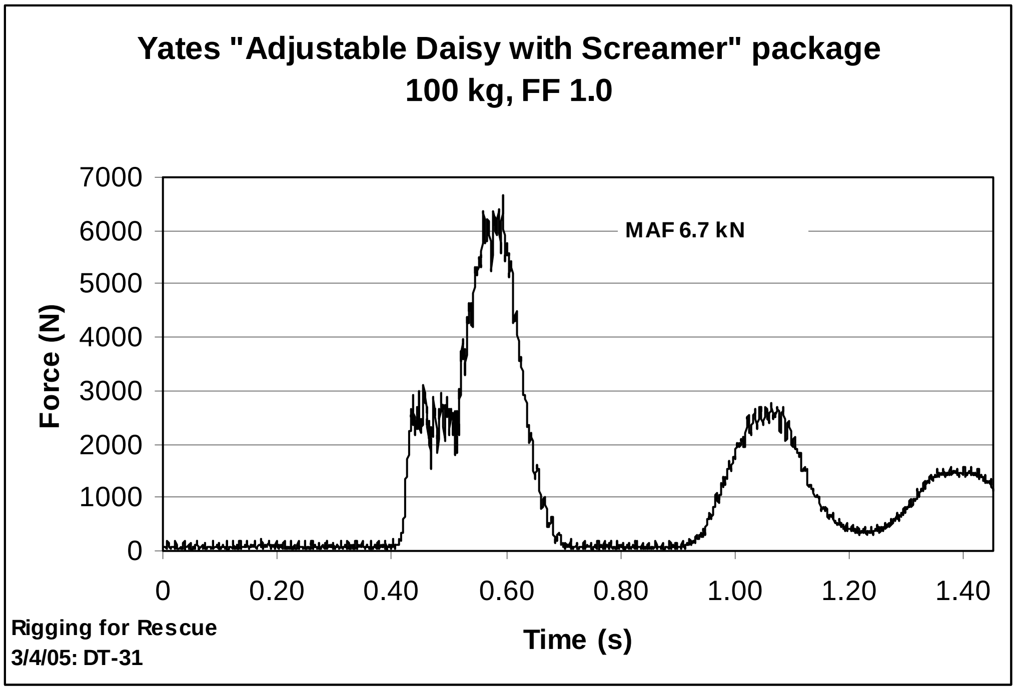

Yates 13 mm Spectra Daisy
100 kg, FF 0.25
Force (N)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
MAF 9.1 kN
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-26

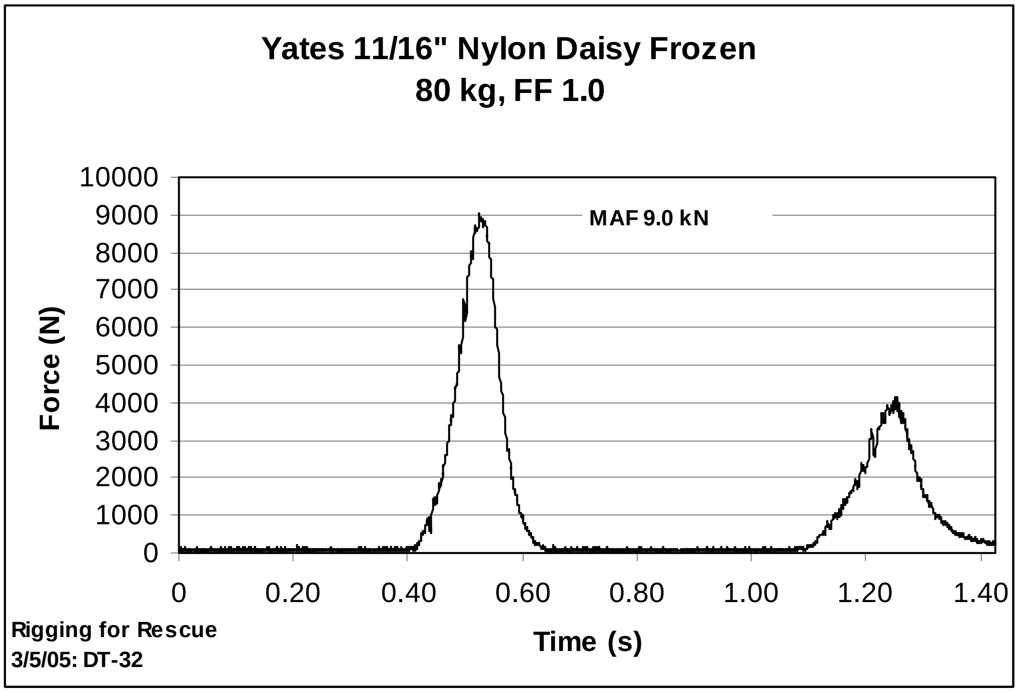

Yates 11/16" Nylon Daisy
100 kg, FF 0
3000
2500
2000
1500
1000
500
0
Force (N)
MAF 2.7 kN
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-27

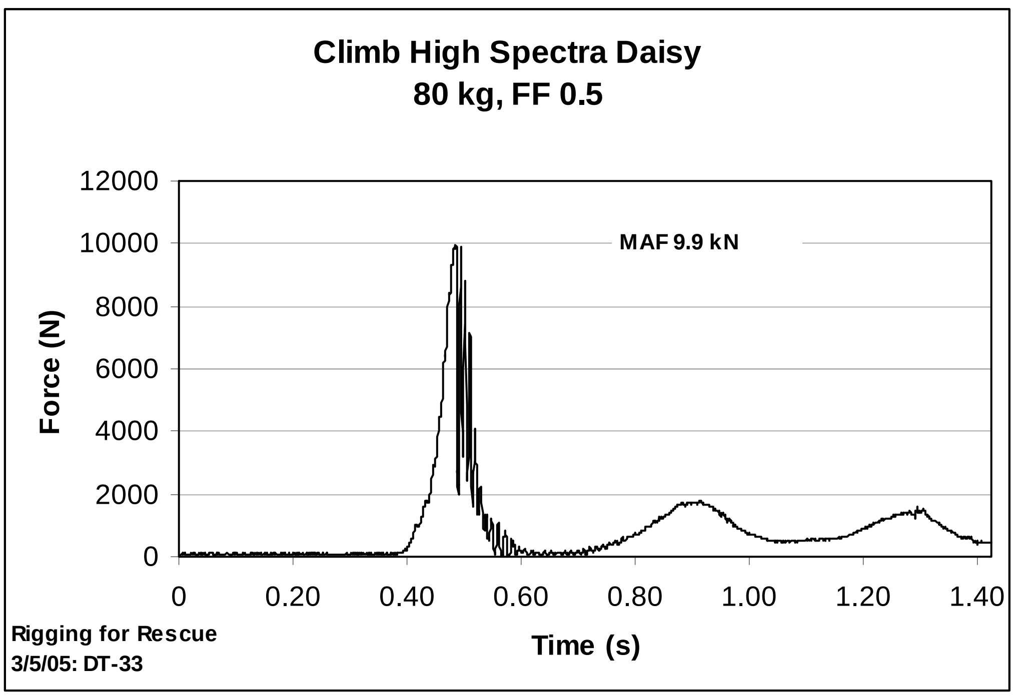

Yates 11/16" Nylon Daisy
100 kg, FF 0.25
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Force (N)
MAF 4.7 kN
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-28

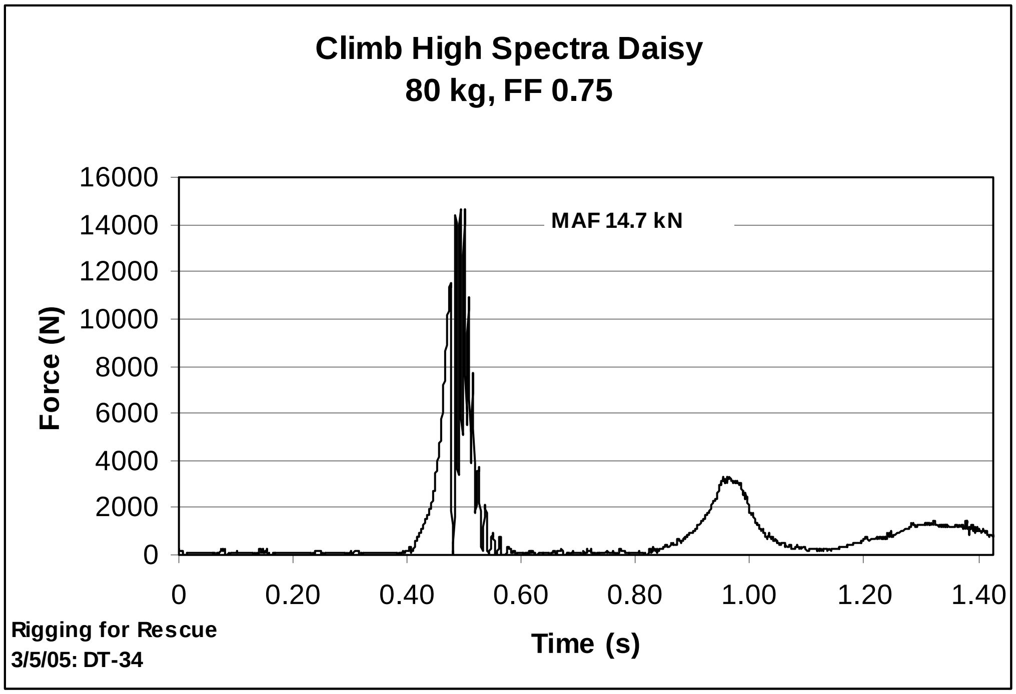

Yates 11/16" Nylon Daisy
100 kg, FF 0.333
MAF 5.9 kN
Force (N)
7000
6000
5000
4000
3000
2000
1000
0
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-29

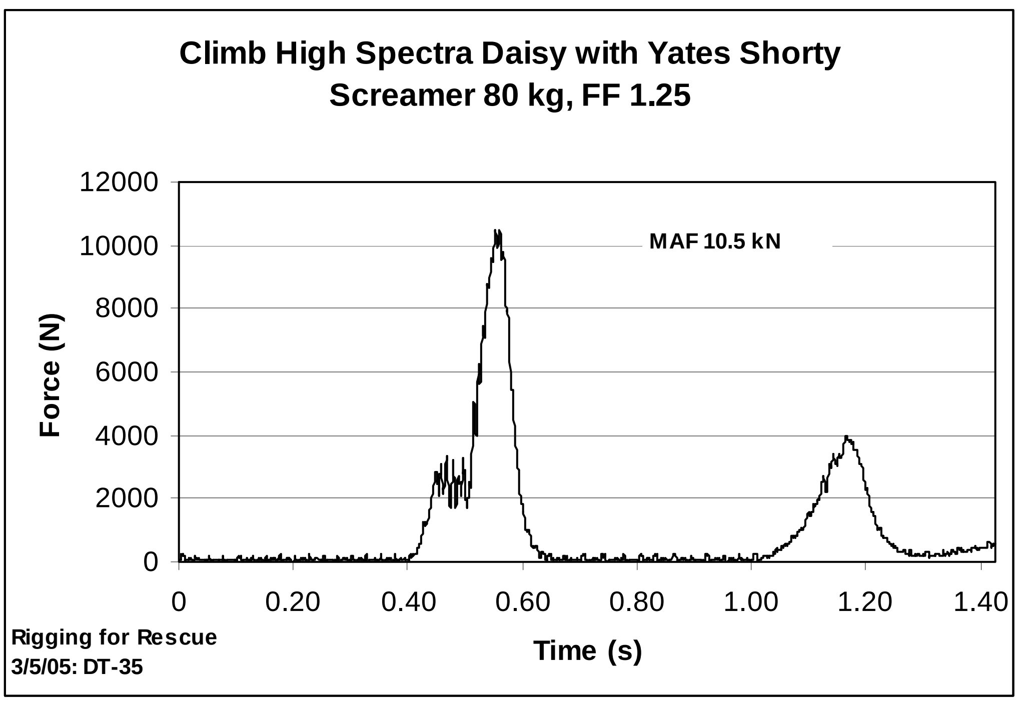

Yates 11/16" Nylon Daisy
100 kg, FF 0.5
Failed 6.4 kN
Force (N)
7000
6000
5000
4000
3000
2000
1000
0
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-30

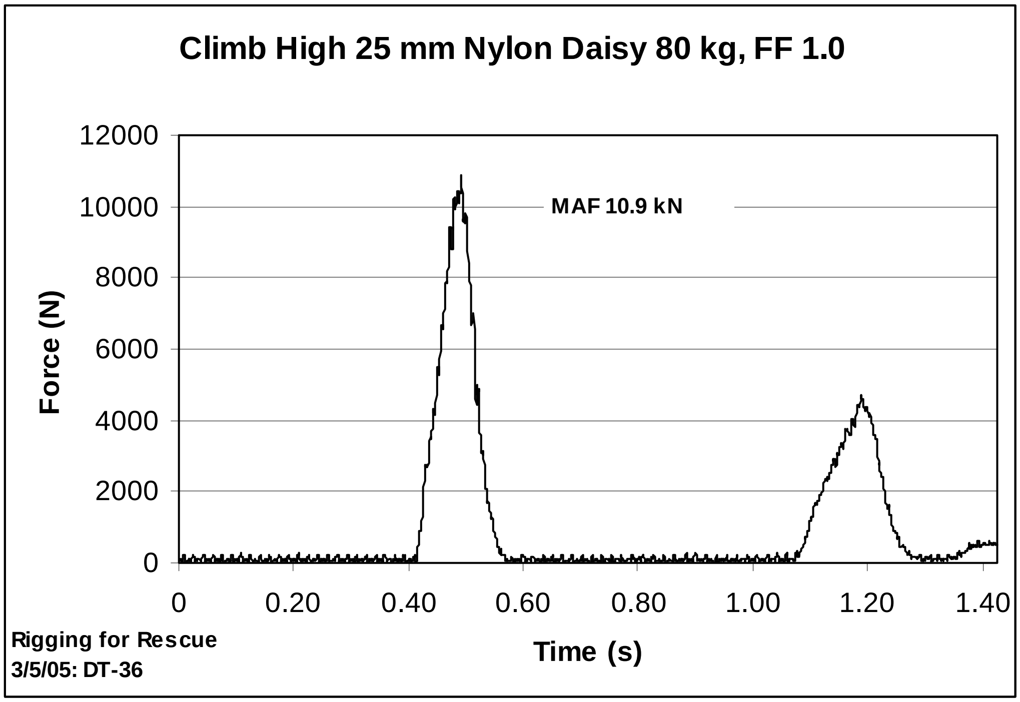

Yates "Adjustable Daisy with Screamer" package
100 kg, FF 1.0
MAF 6.7 kN
Force (N)
7000
6000
5000
4000
3000
2000
1000
0
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/4/05: DT-31


Yates 11/16" Nylon Daisy Frozen
80 kg, FF 1.0
MAF 9.0 kN
Force (N)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/5/05: DT-32

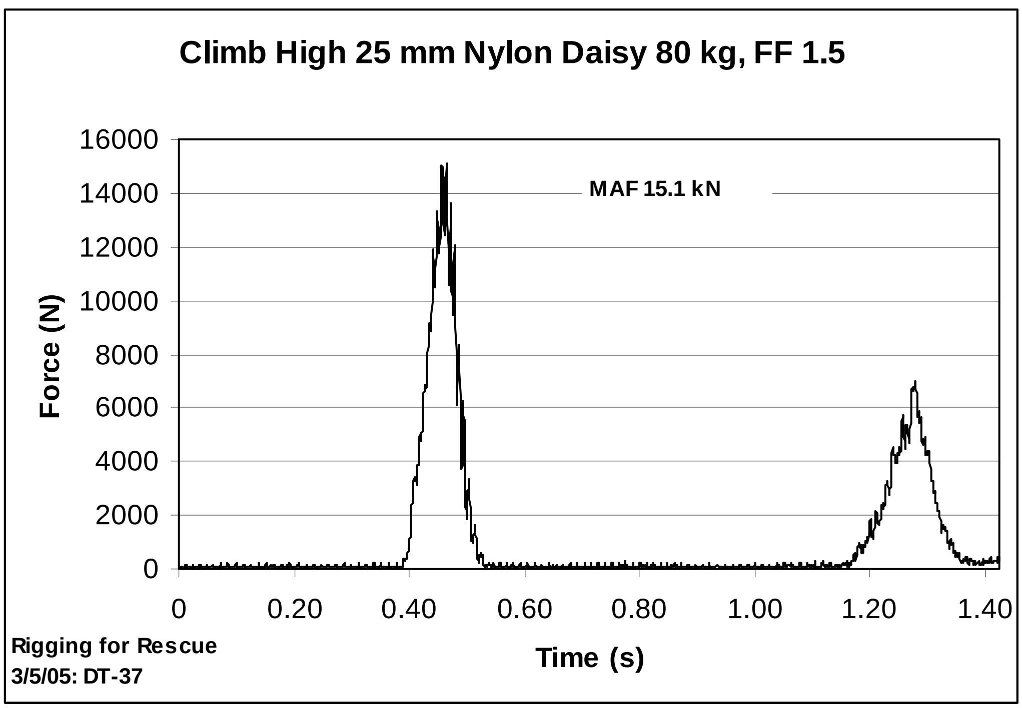

Climb High Spectra Daisy
80 kg, FF 0.5
MAF 9.9 kN
Force (N)
12000
10000
8000
6000
4000
2000
0
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/5/05: DT-33


Climb High Spectra Daisy
80 kg, FF 0.75
MAF 14.7 kN
Force (N)
16000
14000
12000
10000
8000
6000
4000
2000
0
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/5/05: DT-34

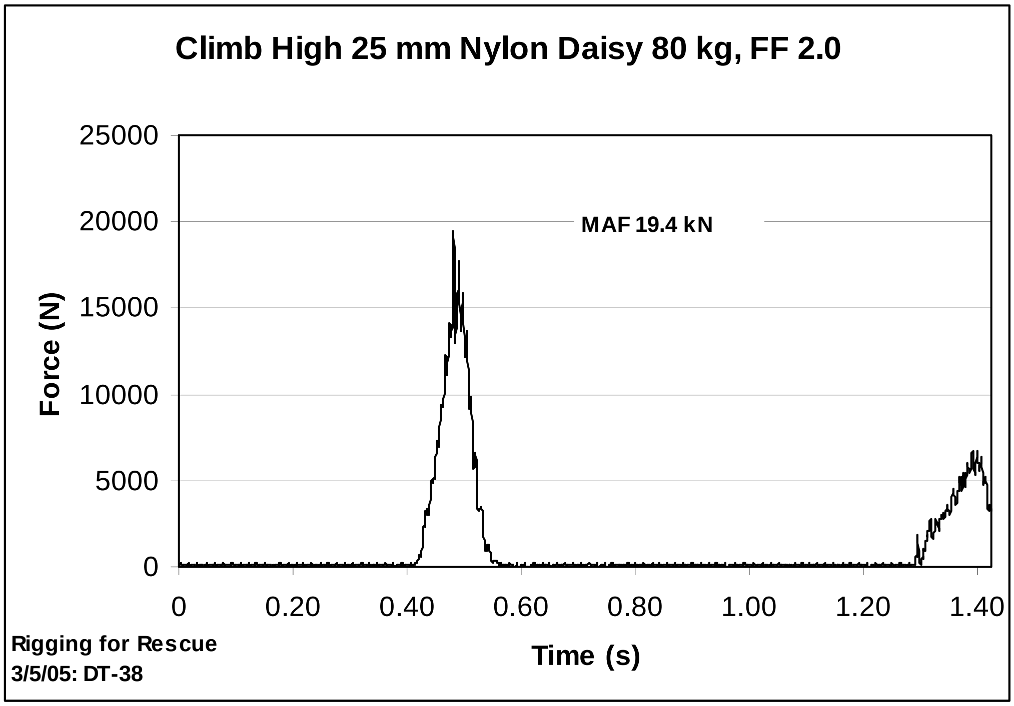

Climb High Spectra Daisy with Yates Shorty
Screamer 80 kg, FF 1.25
MAF 10.5 kN
Force (N)
12000
10000
8000
6000
4000
2000
0
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/5/05: DT-35

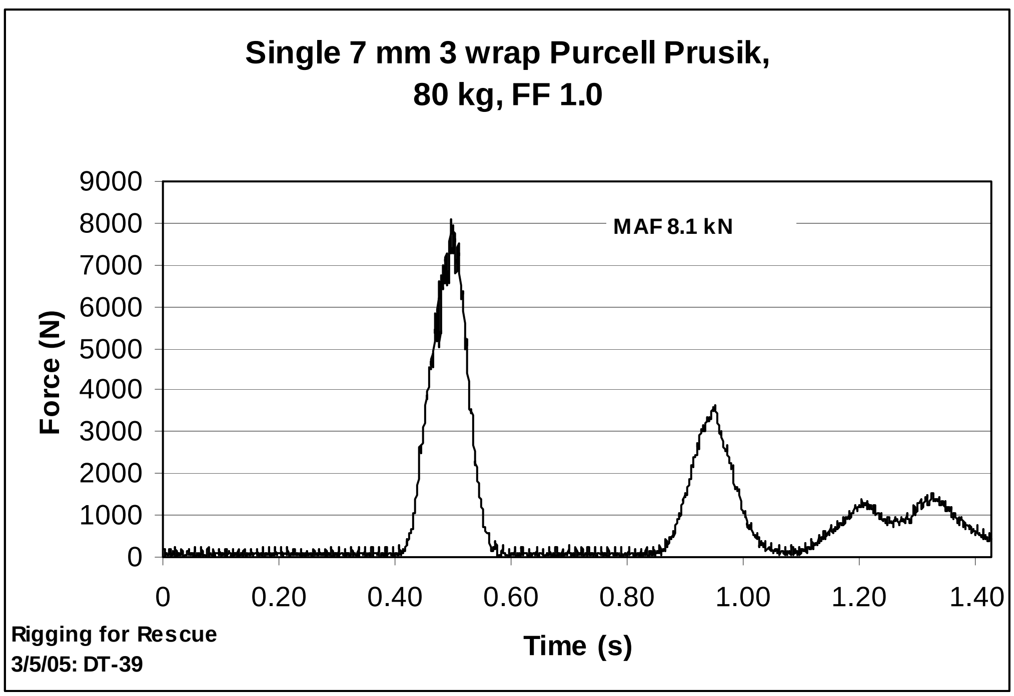


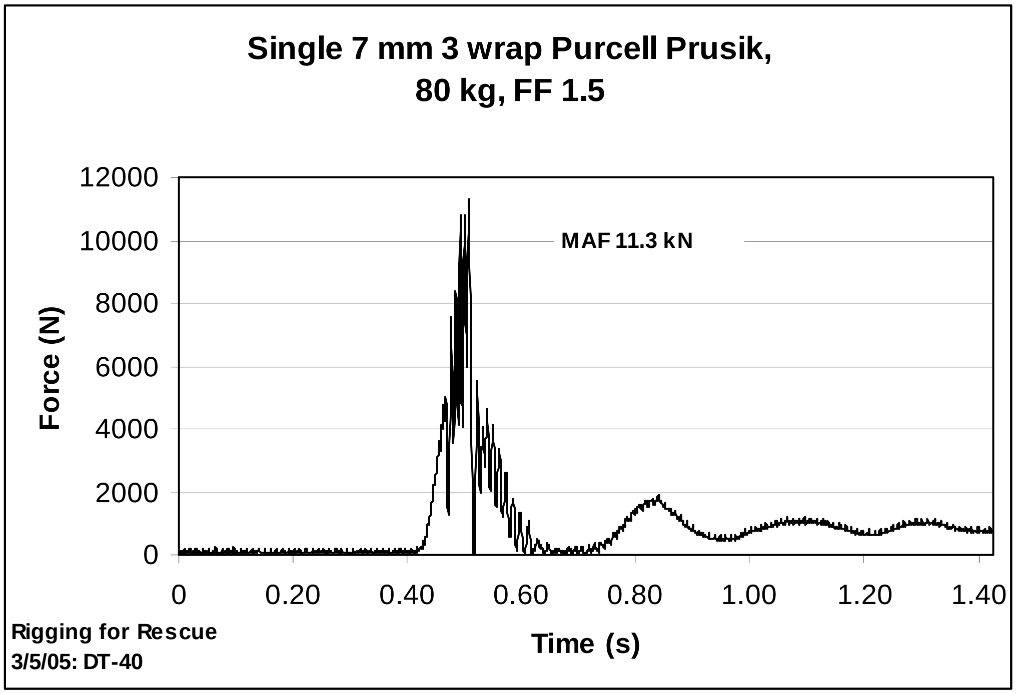
Climb High 25 mm Nylon Daisy 80 kg, FF 1.0
MAF 10.9 kN
12000
10000
8000
6000
4000
2000
0
Force (N)
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/5/05: DT-36

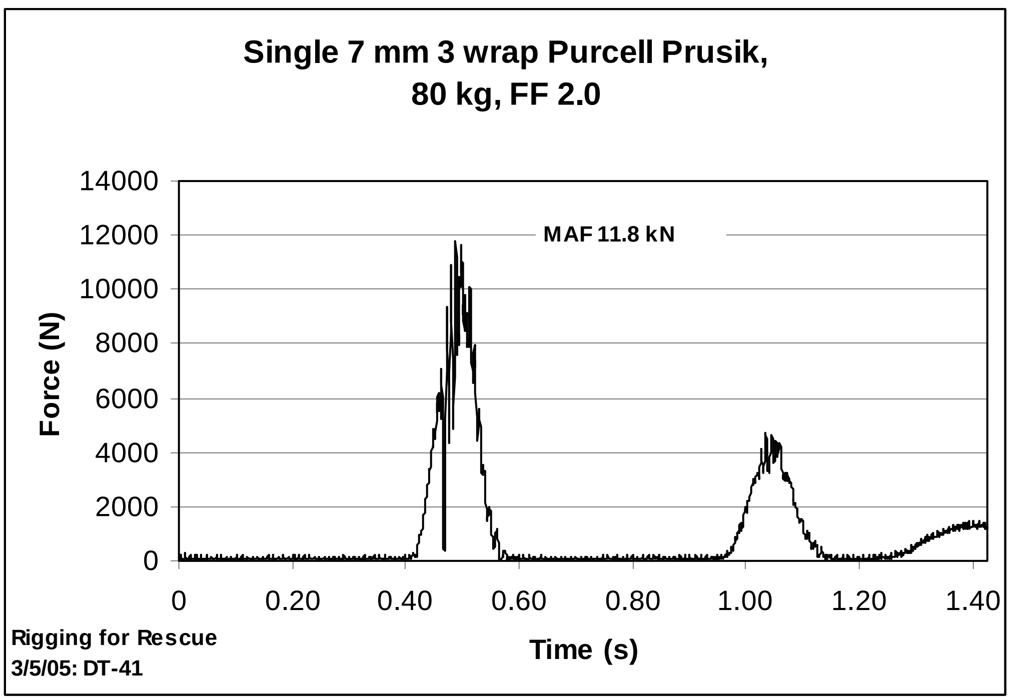


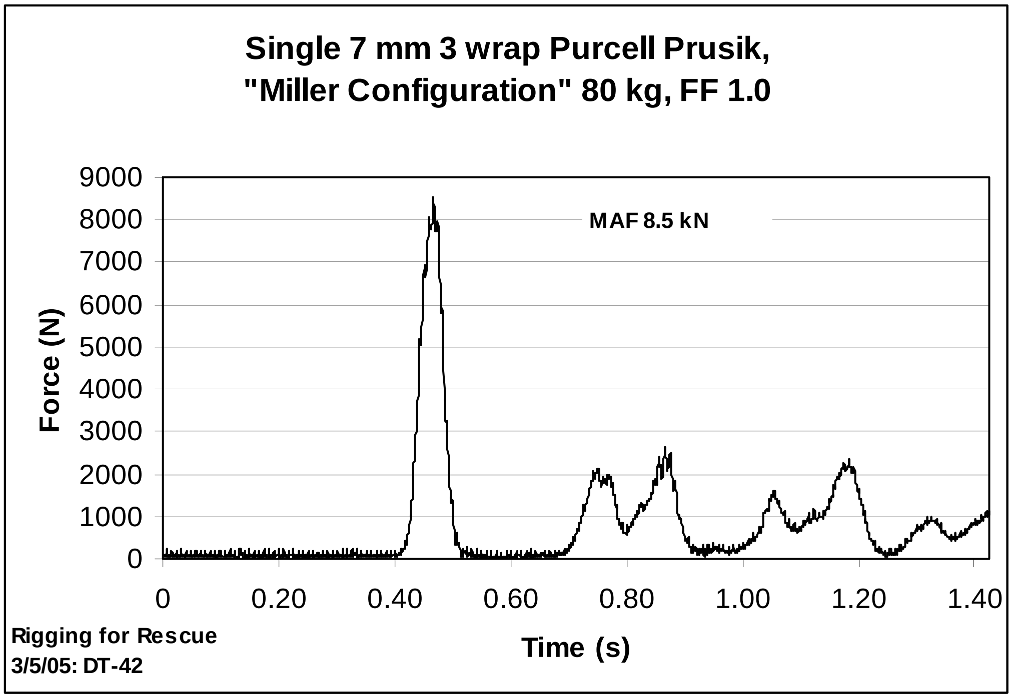
Climb High 25 mm Nylon Daisy 80 kg, FF 1.5
MAF 15.1 kN
16000
14000
12000
10000
8000
6000
4000
2000
0
Force (N)
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/5/05: DT-37

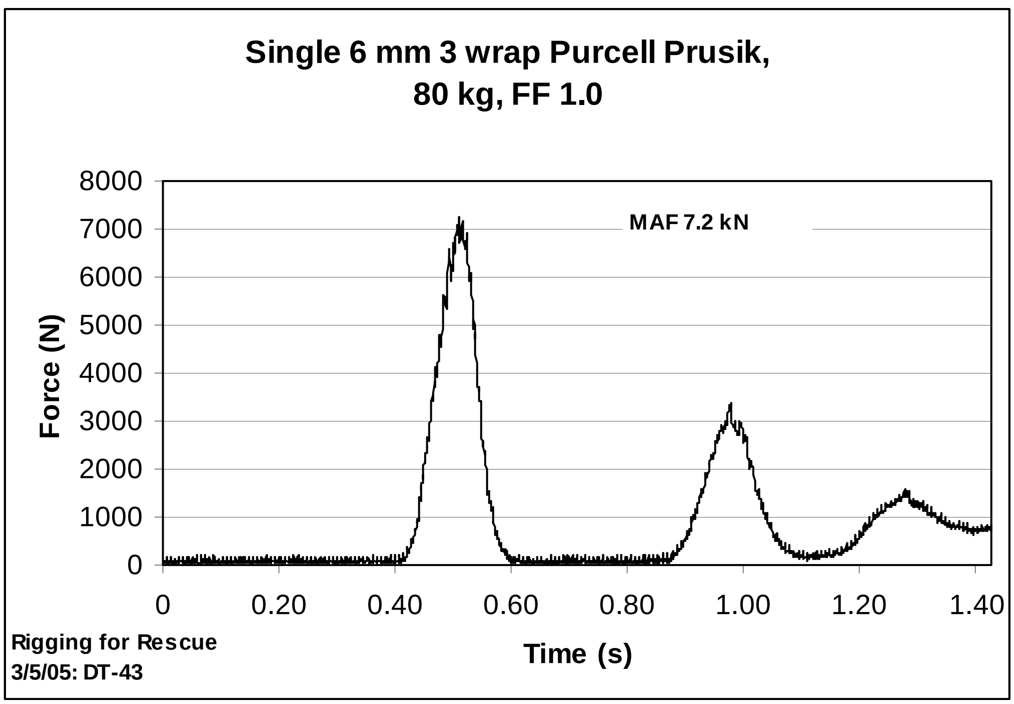

Climb High 25 mm Nylon Daisy 80 kg, FF 2.0
25000
20000
15000
10000
5000
0
Force (N)
MAF 19.4 kN
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/5/05: DT-38

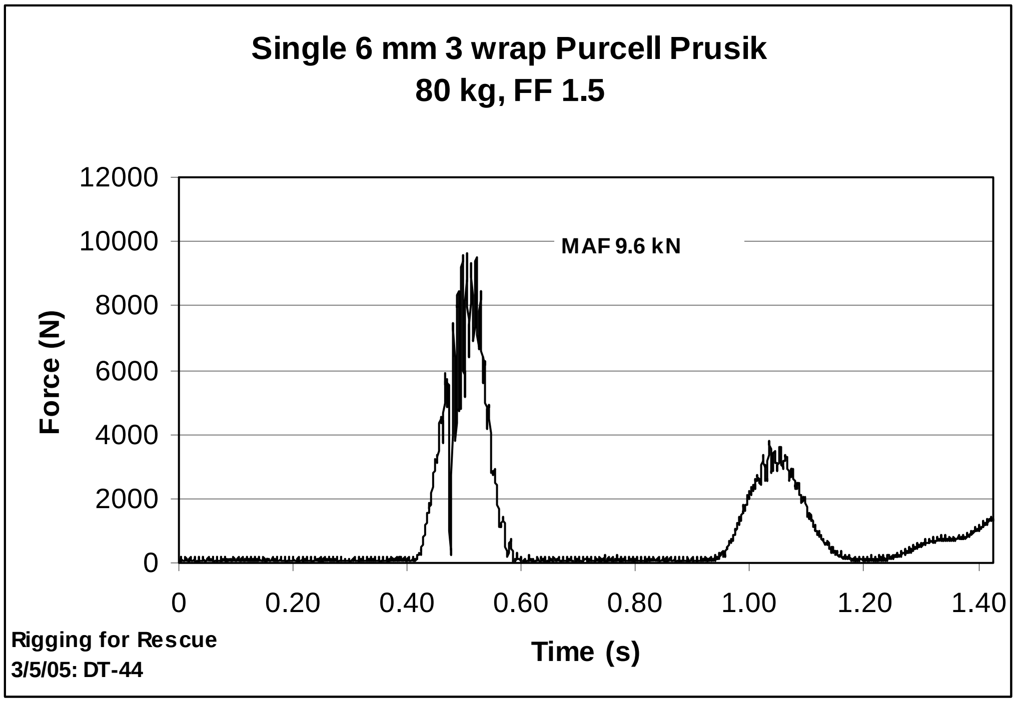

Single 7 mm 3 wrap Purcell Prusik,
80 kg, FF 1.0
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Force (N)
MAF 8.1 kN
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/5/05: DT-39

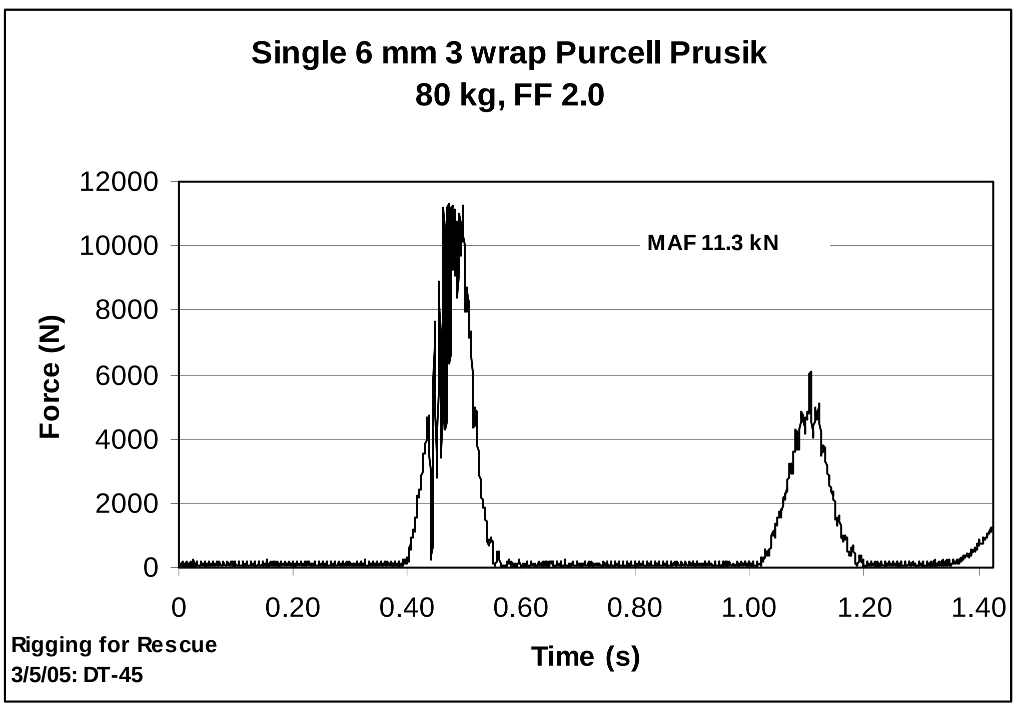

Single 7 mm 3 wrap Purcell Prusik,
80 kg, FF 1.5
Force (N)
Time (s)
MAF 11.3 kN
0
2000
4000
6000
8000
10000
12000
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Rigging for Rescue
3/5/05: DT-40

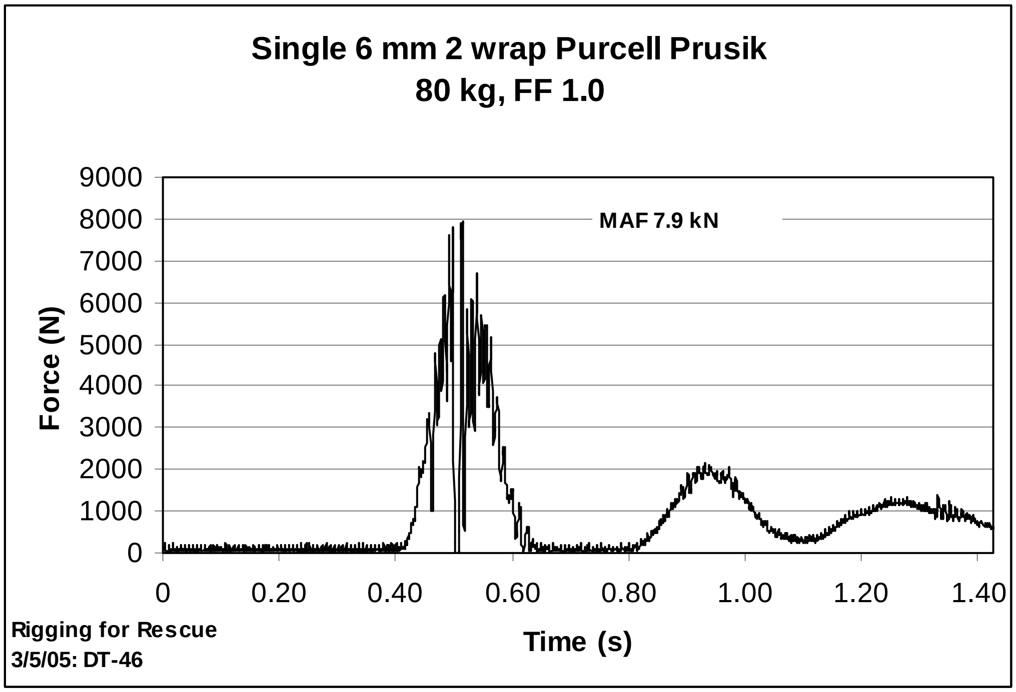

Single 7 mm 3 wrap Purcell Prusik,
80 kg, FF 2.0
Force (N)
Time (s)
MAF 11.8 kN
0
2000
4000
6000
8000
10000
12000
14000
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Rigging for Rescue
3/5/05: DT-41

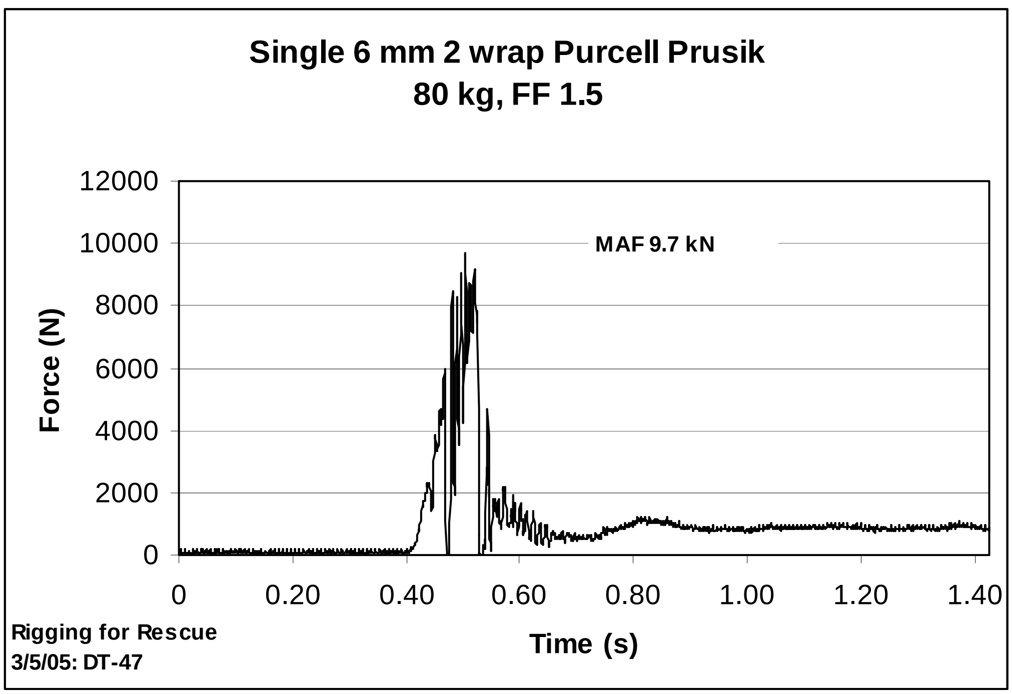

Single 7 mm 3 wrap Purcell Prusik,
"Miller Configuration" 80 kg, FF 1.0
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Force (N)
MAF 8.5 kN
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/5/05: DT-42

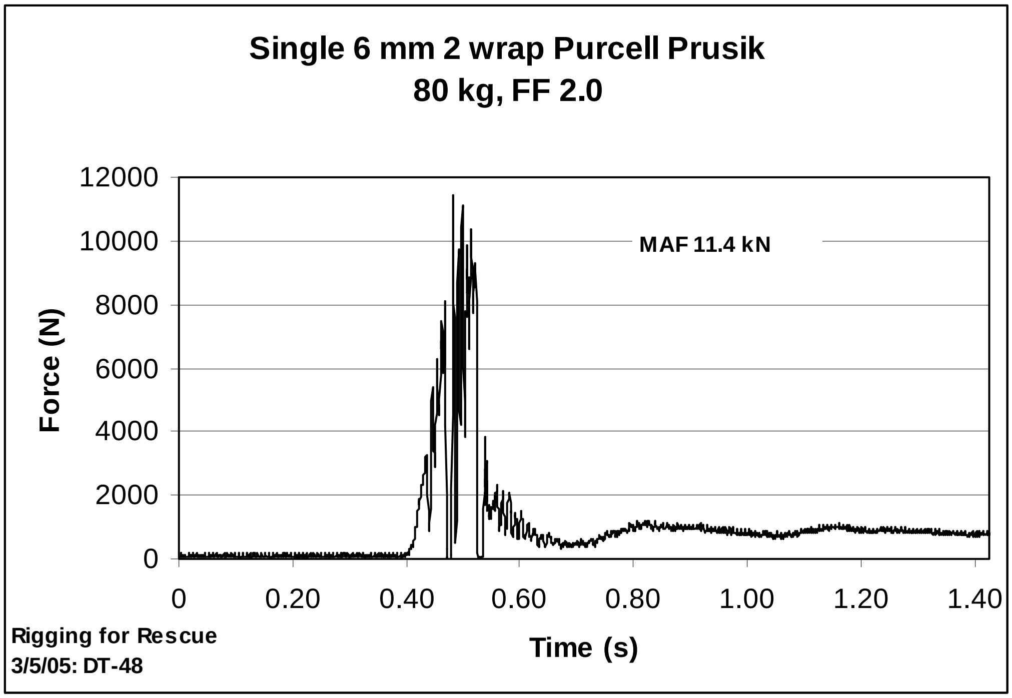

Single 6 mm 3 wrap Purcell Prusik,
80 kg, FF 1.0
8000
7000
6000
5000
4000
3000
2000
1000
0
Force (N)
MAF 7.2 kN
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/5/05: DT-43

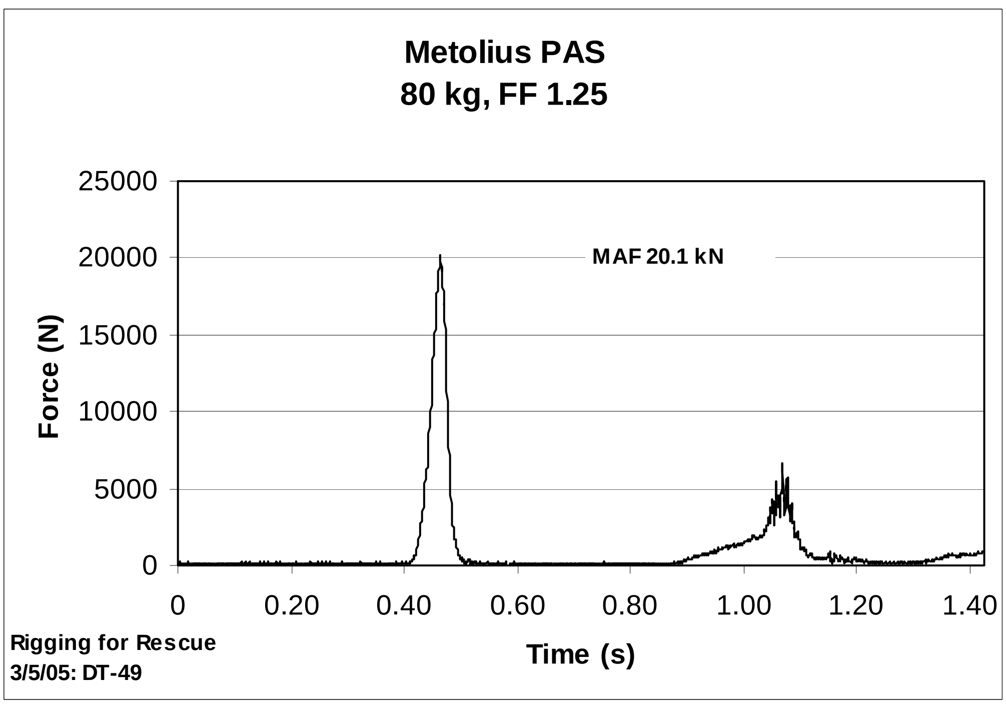

Single 6 mm 3 wrap Purcell Prusik
80 kg, FF 1.5
MAF 9.6 kN
Force (N)
12000
10000
8000
6000
4000
2000
0
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/5/05: DT-44

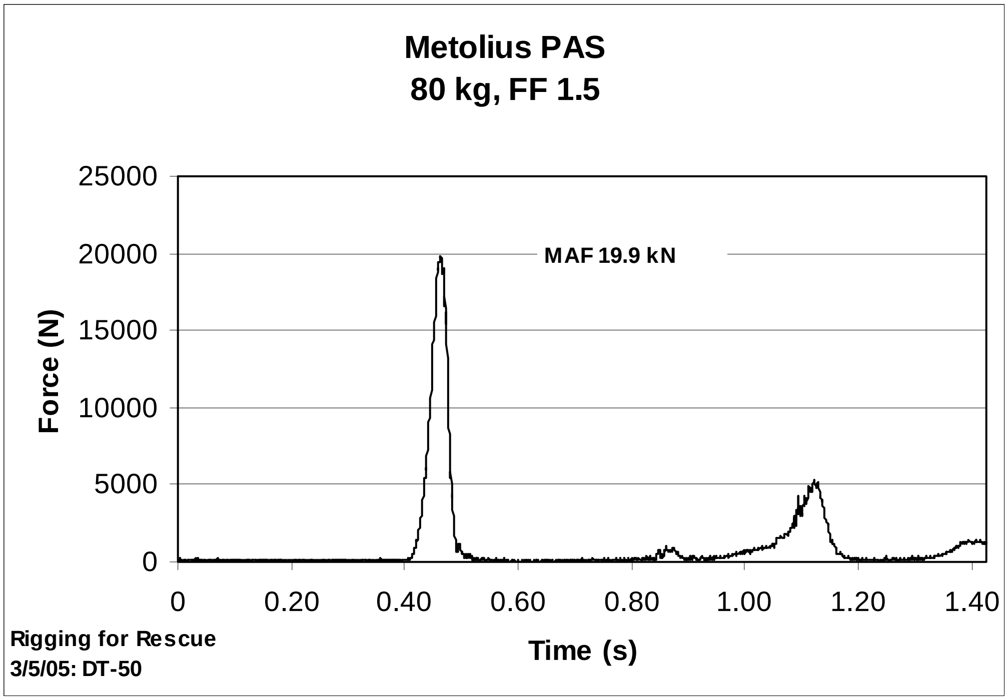

Single 6 mm 3 wrap Purcell Prusik
80 kg, FF 2.0
MAF 11.3 kN
Force (N)
12000
10000
8000
6000
4000
2000
0
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/5/05: DT-45

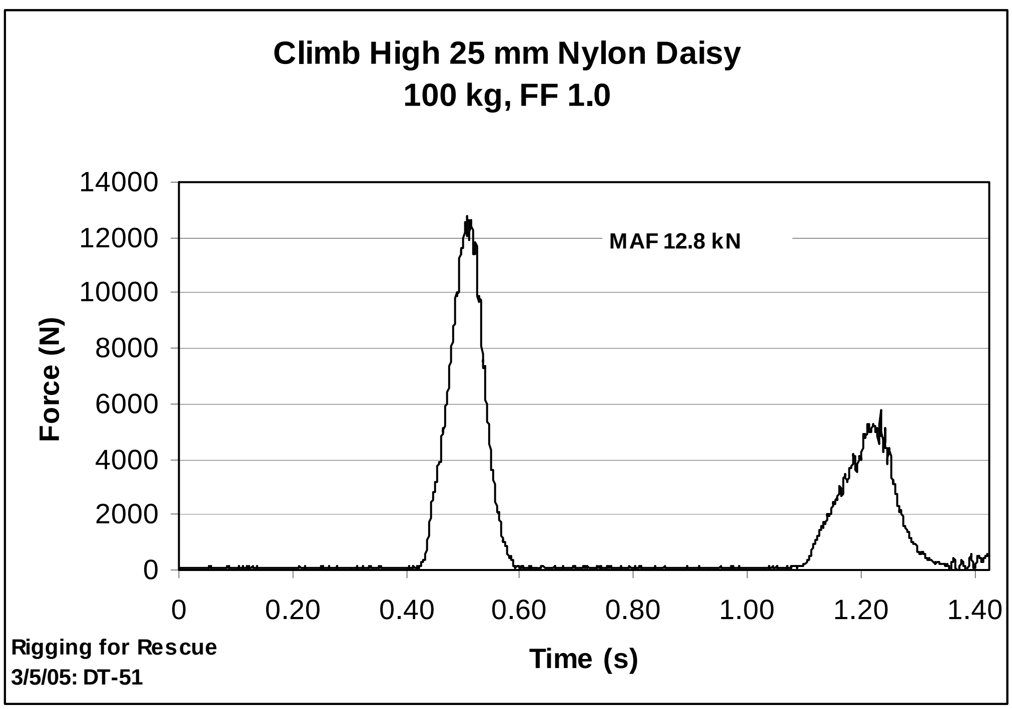

Single 6 mm 2 wrap Purcell Prusik
80 kg, FF 1.0
MAF 7.9 kN
Force (N)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/5/05: DT-46

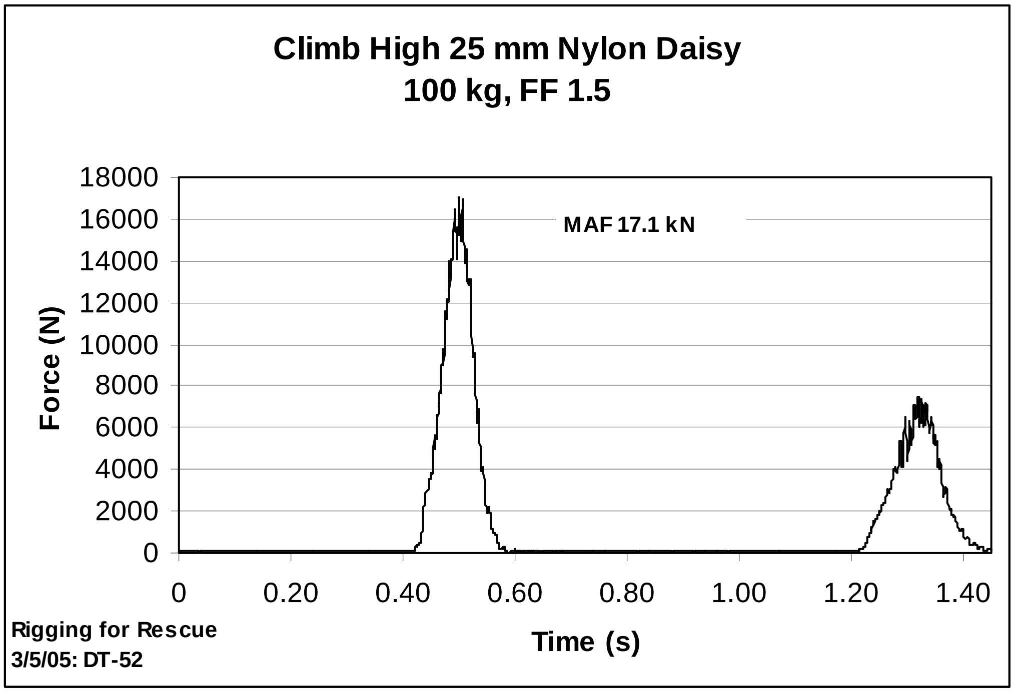

Single 6 mm 2 wrap Purcell Prusik
80 kg, FF 1.5
MAF 9.7 kN
Force (N)
12000
10000
8000
6000
4000
2000
0
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/5/05: DT-47

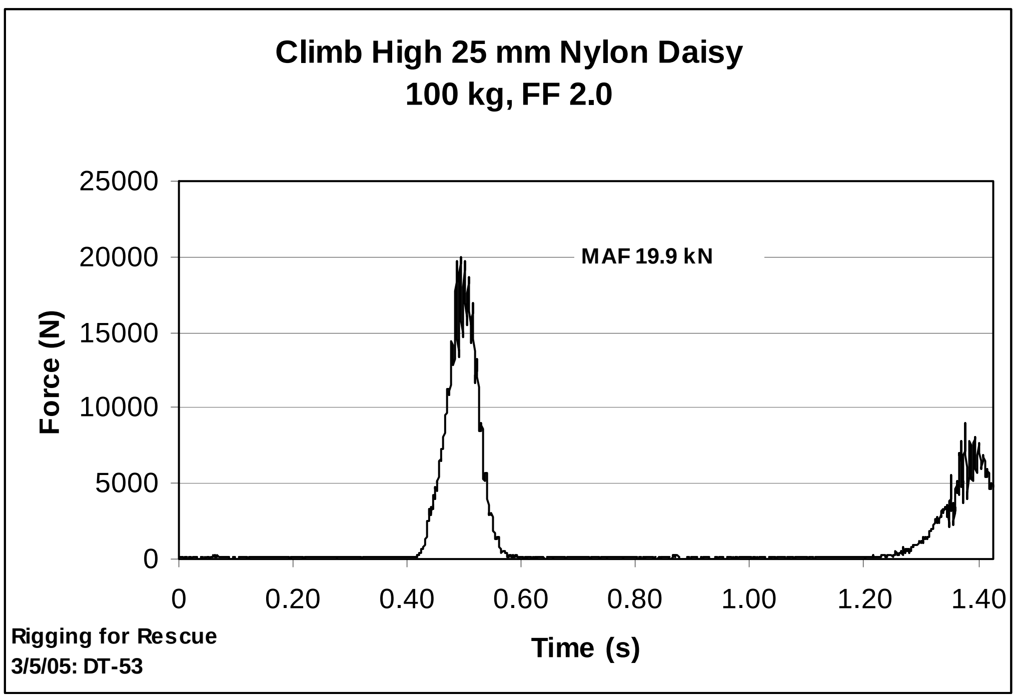

Single 6 mm 2 wrap Purcell Prusik
80 kg, FF 2.0
12000
10000
8000
6000
4000
2000
0
Force (N)
MAF 11.4 kN
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/5/05: DT-48


Metolius PAS
80 kg, FF 1.25
25000
20000
15000
10000
5000
0
Force (N)
MAF 20.1 kN
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/5/05: DT-49


Metolius PAS
80 kg, FF 1.5
25000
20000
15000
10000
5000
0
Force (N)
MAF 19.9 kN
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/5/05: DT-50


Climb High 25 mm Nylon Daisy
100 kg, FF 1.0
14000
12000
10000
8000
6000
4000
2000
0
Force (N)
MAF 12.8 kN
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/5/05: DT-51


Climb High 25 mm Nylon Daisy
100 kg, FF 1.5
MAF 17.1 kN
Force (N)
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/5/05: DT-52


Climb High 25 mm Nylon Daisy
100 kg, FF 2.0
MAF 19.9 kN
Force (N)
25000
20000
15000
10000
5000
0
0
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Time (s)
Rigging for Rescue
3/5/05: DT-53

Lanyards Part II:
An Examination of Purcell Prusiks
as Personal Restraint Lanyards

Presented to:
The International Technical Rescue Symposium
November 2006
Golden, CO
USA

Presented by:
Mike Gibbs
Rigging for Rescue
Ouray, Colorado
USA

Introduction:

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 personal restraint lanyards. Our primary focus in those two drop test series was to test daisy chains and other similar lanyards. We presented our findings at the 2005 ITRS held in Ft. Collins, Colorado.

Several of the lanyards examined in 2002 and 2005 demonstrated serious shortcomings in a shock loading scenario due to either (1) excessive maximum arrest force (MAF) and/or (2) the lanyard failed or its condition was severely compromised.

One of the lanyard configurations tested in 2002 and 2005 that showed some promise was the Purcell Prusik. Our intent in the 2006 drop test series was to conduct a number of drop tests on Purcell Prusiks in order to gain a better understanding of their capabilities and limitations as a personal restraint lanyard in a shock loading scenario. Our hope was to identify a suitable alternative choice to traditional lightweight personal restraint lanyards such as the daisy chain, for example.

Background Information:

Purcell Prusiks are a user-configured tie – commonly made out of either 6mm or 7mm cord. Purcells are used for a variety of ropework applications including ascending a fixed rope, use as a release hitch as well as a primary attachment lanyard for securing oneself to an anchor.

The tie itself is configured such that it includes a prusik hitch around two strands of cord creating an adjustable loop. The loop can be expanded or contracted through movement of the prusik hitch. The tie also includes a separate end loop for attachment purposes.

Suggested Performance Guidelines:

There are a number of criteria to choose from in selecting a personal lanyard such as weight, cost, adjustability and other qualities. At the conclusion of our 2005 study, we recommended that a lanyard should ideally be able to meet the following performance guidelines:

(1) Acceptable MAF at a fall factor of 1 – less than or equal to 8 kN.

(2) Lanyard integrity OK at a fall factor of 1

Our testing was geared towards examining the Purcell Prusik against those performance guidelines.

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 Purcell Prusiks in a dynamic event at various fall factors.

(2) to examine the integrity of the connection on Purcell Prusiks in a dynamic event at various fall factors.

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 standing up to adjust some rigging while at a belay station, 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
(4) 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.

All of the Purcell Prusiks were tied using 350cm (per Purcell) of 6mm cord from two different manufacturers – Sterling and PMI. The Purcells were all tied with a 3-wrap prusik hitch. The knots were all set by the same person using body weight to cinch them tight.

The drops were conducted with a 100 kg mass (≈ 224 lbs.). 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’.

The log sheets (included in this proceedings paper-12 pages in total) from the drop test series outline the individual parameters and data points for each of the respective drop tests.

Null Hypothesis:

A Purcell Prusik is incapable of being an appropriate positioning lanyard for rescue and climbing due to:

(1) unacceptable peak force values in a shock loading scenario (dynamic event) at a fall factor of 1

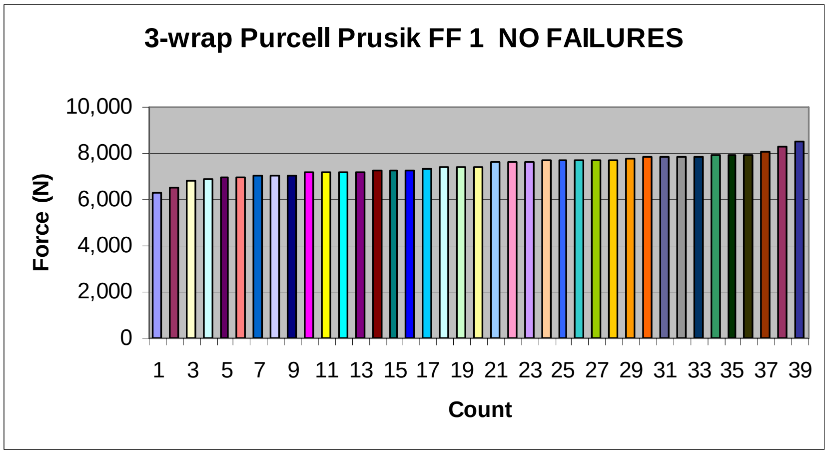
and/or

(2) inability to maintain its integrity (e.g. it breaks) in a shock loading scenario (dynamic event) at a fall factor of 1

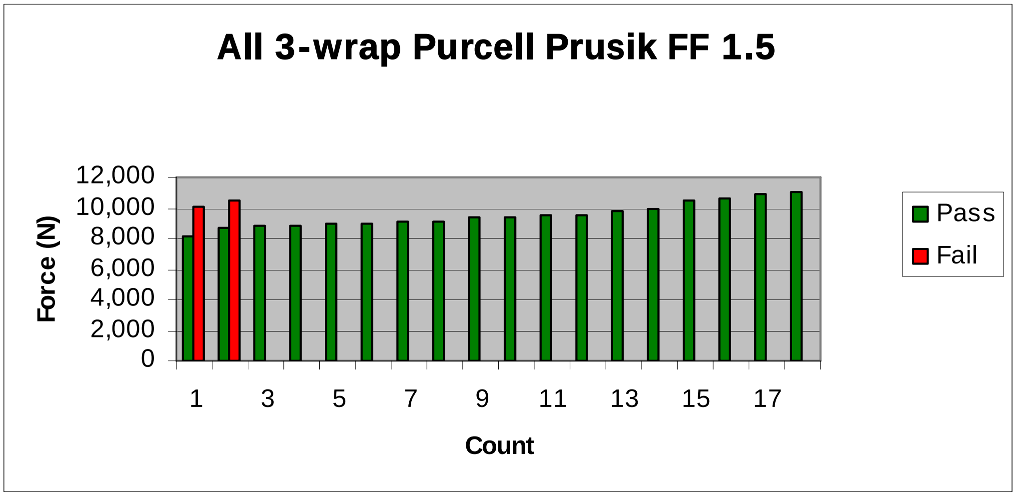
Data Summary:

The following are a number of charts and summary spreadsheets that are a compilation of the data from the 12 log sheets for the drop test series.

All of the force values in the right hand columns of the spreadsheets are expressed in Newtons. For example, the mean value of 7459.1 Newtons for the 39 drop tests at fall factor 1 is approximately equivalent to 7.46 kN or around 1676 lbs. force.



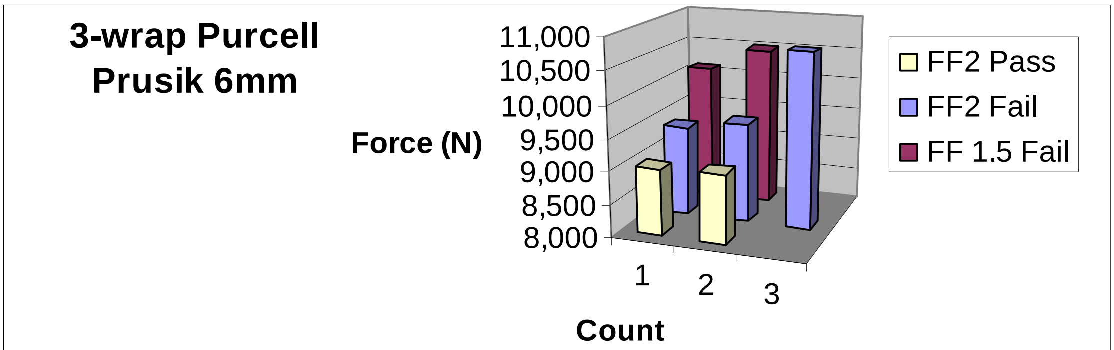
3-wrap Purcell Prusik FF1 {force in Newtons}	
Mean	7459.1
Standard Error	74.7
Median	7428.0
Standard Deviation	466.6
Minimum	6321.0
Maximum	8488.0
Count	39.0
Largest(1)	8488.0
Smallest(1)	6321.0
Confidence Level(95.0%)	151.2



3-wrap Purcell Prusik FF 1.5 PASS *{force in Newtons}*	
Mean	9505.5
Standard Error	188.4
Median	9376.0
Standard Deviation	799.2
Minimum	8196.0
Maximum	11100.0
Count	18.0
Largest(1)	11100.0
Smallest(1)	8196.0
Confidence Level(95.0%)	397.5

3-wrap Purcell Prusik FF 1.5 FAIL *{force in Newtons}*	
Mean	10307.5
Standard Error	181.5
Median	10307.5
Standard Deviation	256.7
Minimum	10126.0
Maximum	10489.0
Count	2.0
Largest(1)	10489.0
Smallest(1)	10126.0
Confidence Level(95.0%)	2306.2

All totaled there were 64 drop tests conducted on Purcell Prusiks – 39 at fall factor 1; 20 at fall factor 1.5; and 5 at fall factor 2. All of the lanyard failures occurred at either fall factor 2 or fall factor 1.5. The smallest recorded MAF that produced a lanyard failure was 9399 N at fall factor 2.



	1	2	3
FF2 Pass	9,024	9,058	
FF2 Fail	9,399	9,546	10,709
FF 1.5 Fail	10,126	10,489	

Recommendations:

No different than our conclusion generated from our previous drop test study completed in 2005: 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 testing conducted on Purcell Prusiks was by no means a comprehensive examination. However, the testing conducted certainly suggests that a Purcell Prusik constructed out of 6mm cord with a 3-wrap prusik hitch meets the recommended lanyard performance guidelines of being able to withstand a fall factor 1 event with acceptable levels of MAF and no observable degradation of the lanyard. The testing also demonstrates that the margin over and above that minimum performance criteria is *approaching* the 50% level at fall factor 1.5.

The Purcell Prusik used as a lanyard can certainly be considered a worthwhile alternative to the traditional daisy chains and other personal restraint lanyards available in the marketplace.

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 or similar lanyards is simply a poor application of the materials.

The very low elongation at break and the low melting point 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.

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 - at least at fall factor 1.
(not to exceed 8 kN)

(3) 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.

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Test #	Lanyard Type: model, make, 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	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied	70	100	140	2	28.5	101	9024
Comments: Light chafing on the two standing parts of cord between figure 8 knot and prusik. Light fusing on the girth hitch where it is attached to the shackle of the test mass.									
2	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied	70	100	140	2	31	102.5	9058
Comments: Light chafing on the two standing parts of cord between figure 8 knot and prusik.									
3	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied	68.5	100	137	2	17	102	10709
Comments: Failure on one standing part @ entrance point of figure 8 knot on the shackle side.									
4	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied	70	100	140	2	38.5	111.5	9399
Comments: Failure on one standing part @ entrance point of figure 8 knot on the prusik side.									
5	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied	69	100	138	2	17	110.5	9546
Comments: Failure on one standing part @ entrance point of figure 8 knot on the shackle side.									
6	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied	68.5	100	68.5	1	10	89	7913
Comments: Very light chafing on the two standing parts of cord between figure 8 knot and prusik.									
7	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied	67.5	100	67.5	1	10.5	90.5	7939
Comments: Very light chafing on the two standing parts of cord between figure 8 knot and prusik.									

Rigging for Rescue ®

Date: 7-20-06

Test #	Lanyard Type: model, make, 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)
8	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied	70	100	70	1	12	92	7422
Comments: Very light chafing on the two standing parts of cord between figure 8 knot and prusik.									
9	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied	69.5	100	69.5	1	12.5	91.5	6524
Comments: Light chafing on the two standing parts of cord between figure 8 knot and prusik.									
10	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied	68.5	100	68.5	1	6.5	88	7869
Comments: Very light chafing on the two standing parts of cord between figure 8 knot and prusik. Light chafing at the girth hitch location where the lanyard attaches to the test shackle.									
11	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied							
Comments: Bad test. Test mass fall was arrested such that the girth hitch on the shackle slipped to the side of the shackle causing uneven loading.									
12	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied	69	100	69	1	13.5	91.5	7161
Comments: Light chafing on the two standing parts of cord between figure 8 knot and prusik.									
13	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied							
Comments: Bad test. Test mass fall was arrested such that the girth hitch on the shackle slipped to the side of the shackle causing uneven loading. Same as Drop #11.									
14	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied	68	100	68	1	11	90.5	7815
Comments: Light chafing on the two standing parts of cord between figure 8 knot and prusik. Light chafing at the girth hitch location where the lanyard attaches to the test shackle.									

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Test #	Lanyard Type: model, make, 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)
15	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied	68	100	68	1	13	90.5	7277
Comments: Very light chafing on the two standing parts of cord between figure 8 knot and prusik.									
16	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied	70	100	70	1	11.5	92	7671
Comments: Very light chafing on the two standing parts of cord between figure 8 knot and prusik. Light chafing at the girth hitch location where the lanyard attaches to the test shackle.									
17	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied	66.5	100	66.5	1	12	88	7428
Comments: Very light chafing on the two standing parts of cord between figure 8 knot and prusik.									
18	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	68	100	68	1	12	89.5	7737
Comments: Light chafing on the two standing parts of cord between figure 8 knot and prusik.									
19	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	72	100	72	1	23	98	8488
Comments: Moderate to heavy chafing on the two standing parts of cord between figure 8 knot and prusik.									
20	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	70	100	70	1	20	93.5	7064
Comments: Moderate chafing on the two standing parts of cord between figure 8 knot and prusik.									
21	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	71.5	100	71.5	1	25	97.5	6321
Comments: Moderate chafing on the two standing parts of cord between figure 8 knot and prusik.									

Lanyard Testing
Drop Test Log Sheet
Date: 7-20-06

Rigging for Rescue ®

Test #	Lanyard Type: model, make, 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)
22	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	71	100	71	1	20.5	94.5	6825
Comments: Moderate chafing on the two standing parts of cord between figure 8 knot and prusik.									
23	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	70.5	100	70.5	1	23.5	95	7231
Comments: Light **/** Moderate chafing on the two standing parts of cord between figure 8 knot and prusik.									
24	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	70.5	100	70.5	1	19.5	93	7211
Comments: Light **/** Moderate chafing on the two standing parts of cord between figure 8 knot and prusik.									
25	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	70	100	70	1	12.5	88.5	8080
Comments: Light chafing on the two standing parts of cord between figure 8 knot and prusik. Light chafing at the girth hitch location where the lanyard attaches to the test shackle.									
26	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	70.5	100	70.5	1	23	95.5	7642
Comments: Light **/** Moderate chafing on the two standing parts of cord between figure 8 knot and prusik.									
27	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	71.5	100	71.5	1	20.5	94.5	7613
Comments: Light **/** Moderate chafing on the two standing parts of cord between figure 8 knot and prusik.									
28	PAS; Metolius; Black	"Monster Webbing"; Dyneema/Nylon Blend	94	100	94	1	NA	107	20219
Comments: Fusing on the first and second chain links (proximal to the test mass side).									

Lanyard Testing
Drop Test Log Sheet
Date: 7-20-06

Rigging for Rescue ®

Test #	Lanyard Type: model, make, 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)
29	PAS; Metolius; Black	"Monster Webbing"; Dyneema/Nylon Blend	94	100	117.5	1.25	NA	Failure	17068
Comments: Failure of lanyard.									
30	PAS; Metolius; Black	"Monster Webbing"; Dyneema/Nylon Blend	94	100	94	1	NA	106.5	19578
Comments: No visible damage.									
31	PAS; Metolius; Black	"Monster Webbing"; Dyneema/Nylon Blend	94	100	105.75	1.125	NA		
Comments: Bad test. Not a clean release of the test mass. Test mass got twisted during release; likely due to ring on quick release mechanism getting hung up on something during the drop.									
32	Monster Daisy; Metolius; Blue	Dyneema	127	100	63.5	0.5	NA	149.5	11885
Comments: Fall arrested. One blown pocket mid-lanyard. Two other blown pockets near anchor side.									
33	Monster Daisy; Metolius; Gray	Dyneema	127	100	95	0.75	NA	146.5	10625
Comments: Three blown pockets proximal to anchor side.									
34	Monster Daisy; Metolius; Blue	Dyneema	127	100	127	1	NA	164	12100
Comments: Multiple blown pockets. Only one pocket failure away from catastrophic failure of the lanyard.									
35	Monster Daisy; Metolius; Blue	Dyneema	127	100	127	1	NA	166	11698
Comments: Multiple blown pockets. Only one pocket failure away from catastrophic failure of the lanyard. Almost an identical result to Drop Test #34.									

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Test #	Lanyard Type: model, make, 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	Monster Daisy; Metolius; Blue	Dyneema	127	100	127	1	NA	Failure	12148
Comments: Failure of lanyard.									
37	Monster Daisy; Metolius; Gray	Dyneema	127	100	95	0.75	NA		
Comments: Bad test. Test mass fall was arrested such that the girth hitch on the shackle slipped to the side of the shackle causing uneven loading. Similar to Drop Tests # 11,13.									
NOTE: This was the last drop test on 7-20-06. Drop tests #38 and on were conducted on 8-01-06.									
38	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	71.5	100	71.5	1	20	94	7776
Comments: Light chafing on the two standing parts of cord between figure 8 knot and prusik.									
39	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	69.5	100	69.5	1			
Comments: Bad test. Test mass fall was arrested such that the girth hitch on the shackle slipped to the side of the shackle causing uneven loading. Similar to Drop Tests # 11,13,37.									
40	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	69.5	100	69.5	1	21.5	94.5	7851
Comments: Light chafing on the two standing parts of cord between figure 8 knot and prusik.									
41	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	69.5	100	69.5	1	26.5	96	7887
Comments: Light chafing on the two standing parts of cord between figure 8 knot and prusik.									
42	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	72.5	100	72.5	1	25	96	6998
Comments: Light chafing on the two standing parts of cord between figure 8 knot and prusik.									

Rigging for Rescue ®

Test #	Lanyard Type: model, make, 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)
43	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	70.5	100	70.5	1	18.5	92.5	7679
Comments: Light chafing on the two standing parts of cord between figure 8 knot and prusik.									
44	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	71.5	100	71.5	1	16.5	93	6853
Comments: Light chafing on the two standing parts of cord between figure 8 knot and prusik.									
45	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	70.5	100	70.5	1	19.5	93.5	7601
Comments: Light chafing on the two standing parts of cord between figure 8 knot and prusik.									
46	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	70	100	70	1	17.5	90.5	7065
Comments: Light chafing on the two standing parts of cord between figure 8 knot and prusik.									
47	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	70.5	100	70.5	1	20.5	93.5	7208
Comments: Light chafing on the two standing parts of cord between figure 8 knot and prusik.									
48	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	70.5	100	70.5	1	19.5	92	7357
Comments: Light chafing on the two standing parts of cord between figure 8 knot and prusik.									
49	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	71.5	100	71.5	1	30	99	6939
Comments: Light chafing on the two standing parts of cord between figure 8 knot and prusik.									

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Test #	Lanyard Type: model, make, 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)
50	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	70.5	100	70.5	1	18.5	93.5	7917
Comments: Light chafing on the two standing parts of cord between figure 8 knot and prusik.									
51	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	69.5	100	69.5	1	20	93.5	7190
Comments: Light chafing on the two standing parts of cord between figure 8 knot and prusik.									
52	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	69	100	69	1	18	91	7680
Comments: Light **/** Moderate chafing on the two standing parts of cord between figure 8 knot and prusik.									
53	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	69.5	100	69.5	1	18.5	93	7011
Comments: Light chafing on the two standing parts of cord between figure 8 knot and prusik.									
54	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	71	100	71	1	21.5	96	7397
Comments: Light chafing on the two standing parts of cord between figure 8 knot and prusik.									
55	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	70	100	70	1	11	89	8325
Comments: Very light chafing on the two standing parts of cord between figure 8 knot and prusik.									
56	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	70.5	100	70.5	1	19.5	93	7268
Comments: Light chafing on the two standing parts of cord between figure 8 knot and prusik.									

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Test #	Lanyard Type: model, make, 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)
57	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	70.5	100	70.5	1	25.5	96	7672
Comments: Light chafing on the two standing parts of cord between figure 8 knot and prusik.									
58	Daisy Chain (used); Black Diamond; Green	Spectra; 13mm	127	100	127	1	NA	NA	9135
Comments: Failure. Snapped lanyard @ the anchor side.									
59	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	70.5	100	105.75	1.5	26	99.5	8794
Comments: Light / Moderate chafing on the two standing parts of cord between figure 8 knot and prusik.									
60	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	72	100	108	1.5			
Comments: Bad test. Shackle misalignment during fall arrest. Similar to drops # 11,13,37,39									
61	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	69	100	103.5	1.5	34.5	101	9165
Comments: Moderate chafing on the two standing parts of cord between figure 8 knot and prusik.									
62	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	70.5	100	105.75	1.5			
Comments: Bad test. Shackle misalignment during fall arrest. Similar to drops # 11,13,37,39,60									
63	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	71	100	106.5	1.5	22	97.5	9516
Comments: Light / Moderate chafing on the two standing parts of cord between figure 8 knot and prusik. Some glazing of the Nylon in the prusik coils.									

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Test #	Lanyard Type: model, make, 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)
64	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	71	100	106.5	1.5	23	97.5	9413
Comments: Light / Moderate chafing on the two standing parts of cord between figure 8 knot and prusik. Some glazing of the Nylon in the prusik coils. Some fusing of the sheath on to itself within the prusik coils									
65	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	70	100	105	1.5	32	101.5	10831
Comments: Light / Moderate chafing on the two standing parts of cord between figure 8 knot and prusik. Some glazing of the Nylon in the prusik coils. Some fusing of the sheath on to itself within the prusik coils									
66	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	72	100	108	1.5	35	104	10580
Comments: Light / Moderate chafing on the two standing parts of cord between figure 8 knot and prusik. Some glazing of the Nylon in the prusik coils. Some fusing of the sheath on to itself within the prusik coils									
67	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	70	100	105	1.5	26.5	98	9339
Comments: Light / Moderate chafing on the two standing parts of cord between figure 8 knot and prusik. Some glazing of the Nylon in the prusik coils. Some fusing of the sheath on to itself within the prusik coils									
68	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	71	100	106.5	1.5	24.5	97.5	8669
Comments: Light / Moderate chafing on the two standing parts of cord between figure 8 knot and prusik. Some glazing of the Nylon in the prusik coils. Some fusing of the sheath on to itself within the prusik coils									
69	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	69.5	100	104.25	1.5	29.5	99	8962
Comments: Light / Moderate chafing on the two standing parts of cord between figure 8 knot and prusik. Some glazing of the Nylon in the prusik coils. Some fusing of the sheath on to itself within the prusik coils									
70	3-wrap Purcell Prusik; Sterling; yellow/black	6mm Cord; Nylon; tied	70	100	105	1.5	30	100	8196
Comments: Light / Moderate chafing on the two standing parts of cord between figure 8 knot and prusik. Some glazing of the Nylon in the prusik coils. Some fusing of the sheath on to itself within the prusik coils									

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Test #	Lanyard Type: model, make, 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)
71	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied	70	100	105	1.5	13	96.5	10445
Comments: Light / Moderate chafing on the two standing parts of cord between figure 8 knot and prusik. Some glazing of the Nylon in the prusik coils. Some fusing of the sheath on to itself within the prusik coils									
72	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied	69	100	103.5	1.5	25	98	8845
Comments: Light / Moderate chafing on the two standing parts of cord between figure 8 knot and prusik. Some glazing of the Nylon in the prusik coils. Some fusing of the sheath on to itself within the prusik coils									
73	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied	69	100	103.5	1.5	24.5	98	8918
Comments: Light / Moderate chafing on the two standing parts of cord between figure 8 knot and prusik. Some glazing of the Nylon in the prusik coils. Some fusing of the sheath on to itself within the prusik coils									
74	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied	70	100	105	1.5	15.5	95	9779
Comments: Light / Moderate chafing on the two standing parts of cord between figure 8 knot and prusik. Some glazing of the Nylon in the prusik coils. Some fusing of the sheath on to itself within the prusik coils									
75	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied	67	100	100.5	1.5	15.5	92	9160
Comments: Light / Moderate chafing on the two standing parts of cord between figure 8 knot and prusik. Some glazing of the Nylon in the prusik coils. Some fusing of the sheath on to itself within the prusik coils									
76	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied	70	100	105	1.5	12.5	93.5	11100
Comments: Light / Moderate chafing on the two standing parts of cord between figure 8 knot and prusik. Some glazing of the Nylon in the prusik coils. Some fusing of the sheath on to itself within the prusik coils									
77	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied	68	100	102	1.5	16	92.5	9904
Comments: Light / Moderate chafing on the two standing parts of cord between figure 8 knot and prusik. Some glazing of the Nylon in the prusik coils. Some fusing of the sheath on to itself within the prusik coils									

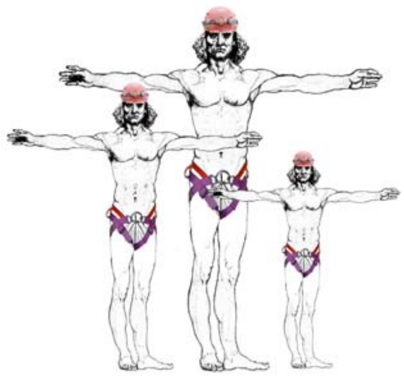
Date: 8-1-06

Rigging for Rescue ®

Test #	Lanyard Type: model, make, 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)
78	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied	71	100	106.5	1.5	NA	Failure	10489
Comments: Failure of one standing part in bight @ test mass side as it entered the figure 8 knot.									
79	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied	69	100	103.5	1.5	NA	Failure	10126
Comments: Failure of one standing part on anchor side as it entered the figure 8 knot.									
80	3-wrap Purcell Prusik; PMI; purple/yellow	6mm Cord; Nylon; tied	69.5	100	104.25	1.5			
Comments: Bad test. Load cell attachment bolt failed due to too few threads into the load cell itself. Threads failed at 9400N.									

Typecasting The Vertical Caver

By John Woods   NSS # 10503



My curiosity about how different body types affected the efficiency of a climbing system was sparked by watching students. Some struggled with the Frog Ascending system while others had little or no trouble using it. The more I watched, the more it became clear: The efficiency of the Frog System was significantly affected by a person's body type. I wondered if there was a point at which the system itself became detrimental to some cavers. It is important to remember that I am not writing about people who are out of shape or physically disadvantaged. These are merely people whose body type may not correspond with what is efficient for the Frog system.

I felt that body characteristics should be seriously considered in accessing personal vertical efficiency. Universal techniques are generally effective, but when a specific climbing system hinders individual efforts, it should be reconsidered in favor of a broader view of the effectiveness of the individual and subsequently of the caving group at large.

The most common justification for the Frog System is: *Use a standard system and everyone will be happy forever after.* A noble goal, but it denies the aphorism: "Foolish consistency is the hobgoblin of small minds." The key word here is "foolish." A "consistency above all" doctrine fosters the impression that an ascending method other than the Frog somehow subverts Alpine SRT technique and causes fires, floods, and disasters of biblical proportions. Personally, I doubt the competence of any caver who cannot master a second ascending system without forgetting the first.

Staunch proponents of any specific system cleverly address their favorite only within the context where it excels. Froggers cite crossing obstacles like rebelays or equipment simplicity as the highest priorities. They claim that other systems are "heavy," "slow to cross mid-rope obstacles," or "very slow on/off rope." Climbing efficiency is never mentioned since it does not suit their arguments. Of the 20 cavers that I polled (from the U.S. and abroad) who advocated that the Frog System was definitively superior, only 2 had ever actually *used* any other system. Eighteen of them formed their opinions without either testing or personal experience.

Ropewalker and Mitchell advocates (all U.S. cavers) stress climbing efficiency as the highest priority. They suggest that the Frog is not the most efficient system in this respect. They also claim that time lost in crossing rope obstacles is compensated for by faster climbing times and energy saved. They ignore versatility, weight and simplicity when it compromises their position. Out of the 20 U.S. cavers with strong "anti-Frog" opinions, 18 had previous experience with two or more systems including the Frog.

Unfortunately, none of the advocates paid more than cursory attention to the relationship of body characteristics to the effectiveness of a system and NONE had ever compared the effectiveness of systems when ALL aspects of ascending were considered. This prompted me to conduct two sets of tests:

1. **The Frog System body type tests.** This is an investigation of the Frog System's relative effectiveness in real-world situations with different body types.

2. **Comparisons of the Frog and the Mitchell ascending systems for crossing common mid-rope obstacles.** I tested the overall vertical efficiency when using both the Frog and the Mitchell systems under common Alpine SRT rigging conditions.

The Frog System body type tests

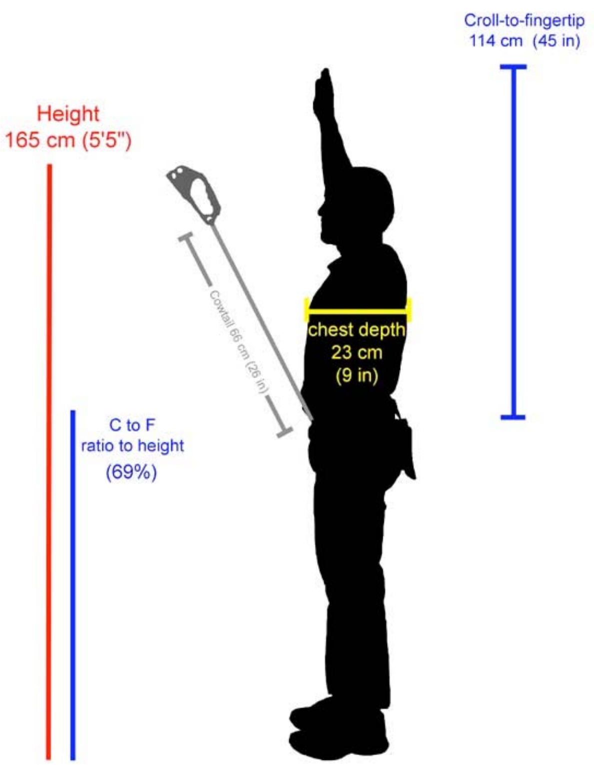


Fig 1: My actual body measurements. Overall height: 165 cm, Croll to Fingertip distance 114 cm (percentage to height - 69%), chest depth 23 cm, actual cowtail length 66 cm (without ascender). With a 35 cm (14 inch) stoke, my body type limits me to the low end of average for Frog System effectiveness.

The basic body characteristics affecting the Frog system are:

1. Overall height
2. Torso length
3. Arm and leg length
4. Chest depth: *To clarify: This is NOT a circumference measurement. It is the distance as measured straight through the body from the sternum to the backbone (see Fig. 1). A wide chest (left to right) does not necessarily indicate a deep chest*
5. Weight distribution top-to-bottom (top heavy or bottom heavy people).

I could find no published evaluations of how each body characteristic affected the Frog system. Not being an engineer, my best option was to test each effect on a practical level. Ten (10) different cavers were selected for body type testing. They represented a variety of body types ranging from short and stout to tall and lean. They comprised a reasonable cross section of cavers in the U.S., both in body type and degree of vertical experience.

Overall height: I'm a short guy at 1.65 meters (5'5") and my Frog vertical progress per stroke is only about 35 cm (14 inches). I measured the stroke of a very tall, long-limbed, narrow-chested caver (aka: "the perfect Frog body") and his bite was almost 63 cm (25 inches). This means that I must do 86 sit-stand cycles to ascend 30 meters (100 feet) while the taller caver does only 48 sit-stand cycles. When I mentioned this as a personal disadvantage to one Frog fanatic, he rashly declared that the total amount of energy required to climb a rope was ALWAYS the same for everyone. This is technically, but not effectively true because the efficiency of the climbing system has not been considered. Publications suggest that a properly adjusted Frog System should provide a stroke of approximately 25% of the caver's height. Because of the nature of the Frog System, this could only be literally true if everyone's body proportions were identical. By those calculations, my stroke should be approximately 40 cm (16 inches). Due to my body type however, my practical stroke limit is 35 cm.

Even if all body proportions were identical, this single assertion acknowledges that shorter cavers are inherently disadvantaged when using the Frog. I challenged the "perfect Frogger" to limit his stroke to equal mine and then tell me he used the same amount of energy to climb the rope as before. He wisely refused. He then countered with "But you have less mass to move each time!" The conversation ended when I replied "You have more muscle mass to move it!" It appears that even for advocates, the Frog is much less appealing with a 35 cm bite than a 63 cm bite. It would be equally inaccurate to state that long-limbed, broad-shouldered cavers can pass through small holes and tight "S" turns with the same amount of energy that I use. After all, it's the same horizontal distance isn't it? The lesson here is the imprudence of saying: "It works perfectly for me, so it must therefore be perfect for you!"

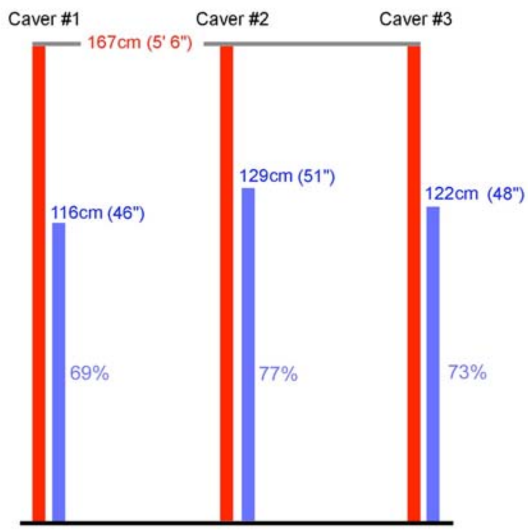


Fig 2: Combined torso and arm length varies between cavers of the same height. Red line = overall height, blue line = Croll to fingertip distance. Percentages are C to F distance to overall height. This affects the Frog "stoke" because it affects the length of the safety tether.

Torso length: A major consequence of torso length is that, when combined with arm length, it determines the maximum practical length of the Frog security tether attached to the upper ascender. This affects the maximum *Croll-to-upper ascender* distance and therefore the maximum potential bite. A tether longer than someone's reach is both pointless and problematic. Conversely, a tether that is too short limits the Frog stroke.

Torso length varied considerably between the people of similar heights who were tested. The worst case (shortest torso) lost bout 4 cm (2 in) on every stroke compared to a longer torso. This is an accumulating effect and is impossible to correct by altering the system in any safe way. Observations suggest that leg length is less important than torso/arm length to the amount of stroke because it does not affect the length of the safety tether that limits the stroke. Most Frog systems are initially adjusted to accommodate proper cowtail (safety tether) lengths and then the foot loops are adjusted in relation to the tether. The maximum stroke however, is still limited by tether length. More tests are needed to determine the precise effect of leg length on the Frog system, but I'm not sure how to conduct them.

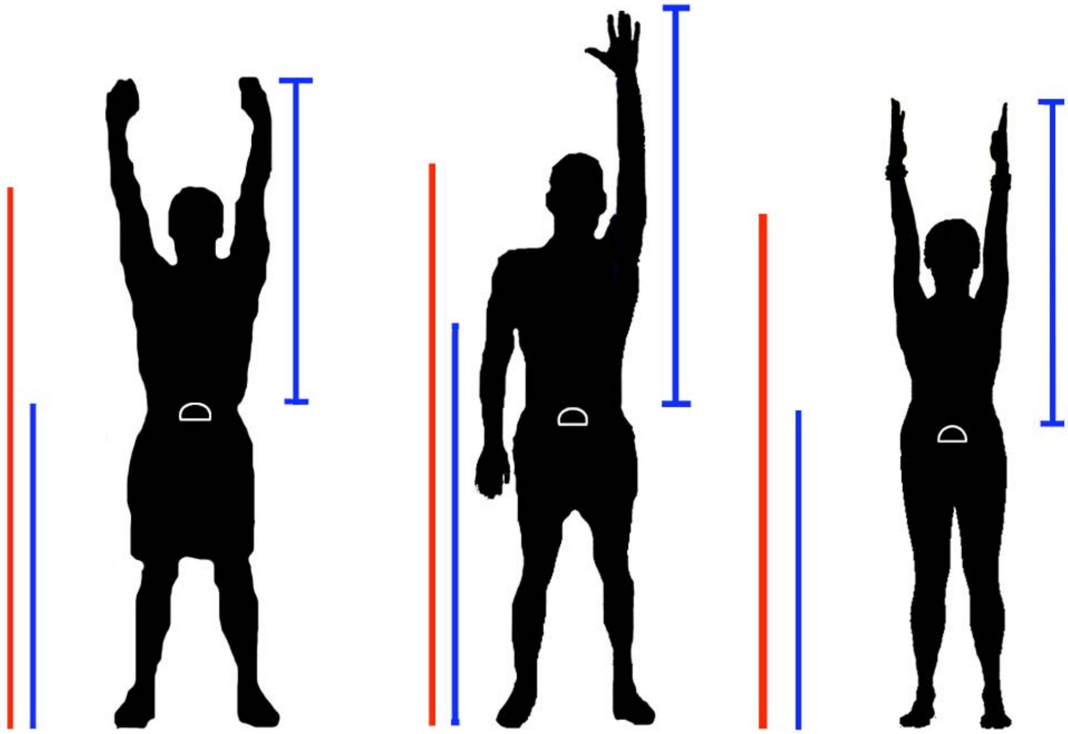


Fig 3: These silhouettes are made from photos and are proportionally accurate. The Maillon was added for clarity, but is located correctly for each person when standing. Measuring the Croll-to-fingertip distance on different cavers reveals the ratio of a caver's torso and arms to their height. The man in the center is not only 8 cm (3 in) taller than the man on the left; his Croll-to-fingertip distance is also a larger proportion of his height. Given equal body conditioning and skill levels, the Frog System is inherently most effective for the man in the center. The woman (right) is not only the shortest individual; she also has the lowest Croll-to-fingertip ratio. Her body type is the least effective of the three for the Frog System.

Arm length: Combined with torso length, the shortest torso and shortest arm combination that was tested showed a loss of about 10 cm (4 in) per cycle compared to people of similar overall height: 5 cm for the arms plus about 5 cm for the torso. The shortest torso and shortest arm proportion also happened to be on the shortest person overall: 160 cm (5' 3"). Their total stroke with the security tether length keeping the upper ascender within reach, was about 33 cm (13 in) per cycle.

Chest depth (front to back): I modified a Jumar ascender (see illustration) to measure how much relative load (pull) was being placed on it. Admittedly, the tests were not very precise, but I was after general load *differences*, not literal measurements. Climbing speed was not an issue and climbing times were not measured in this test. I instructed the climbers to use the best Frog technique possible and the climbing distance was kept short at 20 meters (65 feet), so fatigue would be a small factor. In reality, Frog climbing technique gets worse with longer ascents. Because literal arm loads varied with the climber, the distance and the individual climbing style, the results are expressed in percentages compared to the normal arm load of each subject.

The front-to-back chest depth was increased 4 cm (2 in) using a padded chest harness (See Fig. 5). The harness simulated the consistency and flexibility of the human body as closely as possible within my budgetary limitations. I then measured the arm load *difference* from each subject's norm without the vest. A two-inch increase in chest depth resulted in a *minimum* of 25% more load on the arms even with the best possible Frog technique. This 25% increase in load is not to be confused with 25% of the total body weight – it means that the individual climber placed 25 % more weight on the upper ascender than without the padded harness. Although the literal amount of pull varied with each person's technique, the percentage changes were fairly consistent in each individual as the chest depth increased.

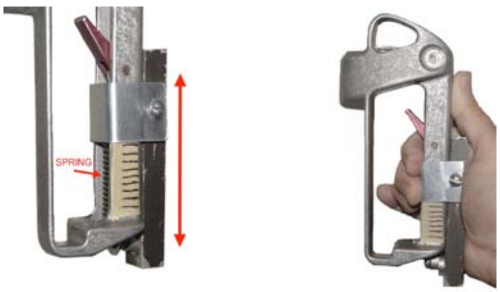


Fig 4: To measure arm load, I converted an old Jumar to a scale with a spring and a sliding hand grip. Load *differences* were recorded while climbing with the Frog and calibrated using a fishing scale. The ascender on the right shows a 500 g load.

Moving the upper body weight further away from the rope forced a significantly larger reliance on the arms to carry the load regardless of all attempts to remain vertical. It also forced the climber to thrust their head uncomfortably forward to maintain equilibrium. This makes it impossible for people with deeper chests to stay as vertical as people with narrower (front to back) chests. Due to fatigue, the arm load inevitably increased as the length of the climb increased.

Weight distribution (top to bottom): Since increased chest depth virtually always indicated greater upper body weight, the subjects were loaded up with chest weights equaling approximately 5% of their total body weight. The extra upper body weight forced the climber away from the vertical with every sit/stand cycle, subsequently forcing greater reliance on the arms to ascend. Increasing the chest depth 4 cm (2 in) AND chest weight 5% resulted in an arm load increase of about 33% (average) per sit/stand cycle compared to their norm.

Compounding the chest/weight problem

It is important to note that the above chest depth and chest weight tests measure only the arm load difference between each individual's normal technique and the modified chest test. Comparing the relative effort between climbers of different body types is even more revealing. My sampling included two subjects of approximately the same chest *circumference*, 104 cm and 106 cm (41 and 42 inches), and of approximately the same weight, 81 kg and 86kg (180 -190 lbs) respectively. The first subject however, was barrel-chested and the other had a relatively broad (wide), but not a deep chest. Despite the similar chest circumference and relatively equal weight, the barrel-chested subject routinely loaded the upper ascender with 10-12% more weight than the wide-chested subject. If equal strength and stamina are assumed for all subjects, the barrel–chested caver is at considerable disadvantage compared to the "average" caver.

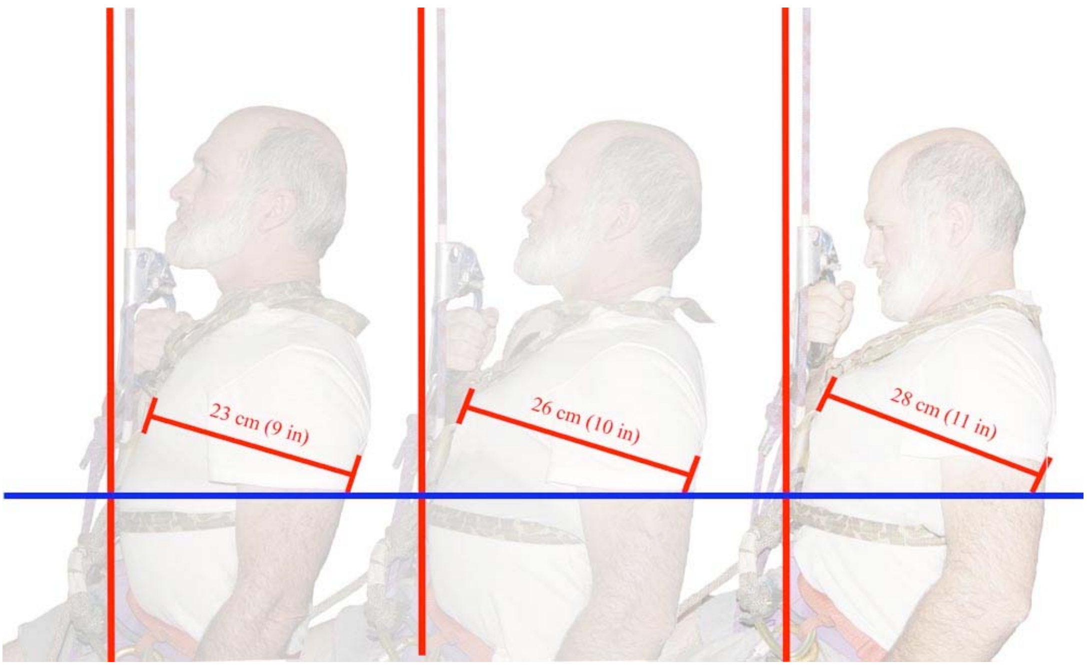


Fig 5: Relative body positions while on rope with increased chest depth. The vertical red lines are a true vertical reference, the blue line a true horizontal reference. Numbers indicate effective chest depth. The climber is grayed out to show measurements more clearly. The padded chest harness is worn underneath the shirt and is slightly visible. The left photo is without chest harness (normal). The center photo shows a 2 cm (1 in) increase. The right photo shows a 4 cm (2 in) increase. In each case, an effort was made to remain as vertical as possible. Note the changing head positions in each photo as the climber involuntarily adjusts to being thrown off the vertical. The 2 inch increase forced climbers into uncomfortable head positions to maintain proper equilibrium and verticality.

Body type test conclusions

Although I do not consider these tests definitive, they do provide insight into how body type affects the Frog system. The results suggest that with the Frog System, the amount of wasted energy significantly increases for some body types compared to others. The negative effects of greater chest depth, greater upper body weight, short stature, short arms and short torsos are cumulative and negative. They result in progressive inefficiency as the number of sit/stand cycles increases and fatigue sets in. Every time the climber is forced to compensate for being thrown off vertical or is required to use more sit stand cycles, energy is expended that the ideal Frog body type does not expend. The degree of efficiency varies with each climber, but the cumulative, negative effects cannot be denied. These factors indicate that for some climbers, there may be a point where the Frog system cannot be justified due to the body type. This suggests a need for an alternate ascending system that combines the versatility of the Frog under Alpine SRT rigging conditions, with greater climbing efficiency for those body types.

Europeans have recognized this systemic problem and some are addressing it through the addition of a low-placed foot ascender such as a Petzl Pantin for longer climbs. Current publications have suggested that the Pantin may be used to create a semi-ropewalker system. I have even found a couple of British websites illustrating a method of converting a Frog System to a bungee-assisted ropewalking system for very long ascents.

For many body types, the Frog System offers adequate climbing efficiency combined with minimal equipment and high versatility. Due primarily to its universality, most cavers should consider another ascending system ONLY if the caving situation warrants it, such as for extremely deep pits. However, with body types where the Frog System is significantly less effective, switching to an alternate system could improve overall personal vertical efficiency in nearly every situation. This would also improve group efficiency whenever that caver is present. The amount of individual improvement would depend upon the alternative system, the number of mid-rope obstacles (rebelays. knots etc.) and the length and spacing of the pitches.

The primary argument against using any system other than the Frog for Alpine SRT is that no other system can efficiently negotiate the rope obstacles found in expedition (universal) style rigging. Part 2 of this article compares the actual performance of both the Mitchell and Frog systems under standard Alpine SRT rigging.

Comparisons of the Frog and the Mitchell
ascending systems for crossing common mid-rope obstacles

By John Woods   NSS# 10503

I am a staunch advocate of protecting the climbing rope. I favor the intelligent use of rebelays, deviations and Alpine SRT rigging where appropriate. Conversely, I think a *properly used* rope pad can fulfill all Alpine SRT safety concerns. When a pad is inappropriate, Alpine SRT methods offer an effective method of protecting the caver.

Cavers kept telling me that their particular system was better for this or that, but they always emphasized specific situations where their system was clearly superior and minimized situations where improvement was possible. I never heard an intelligent evaluation of OVERALL vertical effectiveness for an individual using a specific system. I quickly discovered that this was because no one (that I could find) had done the tests.

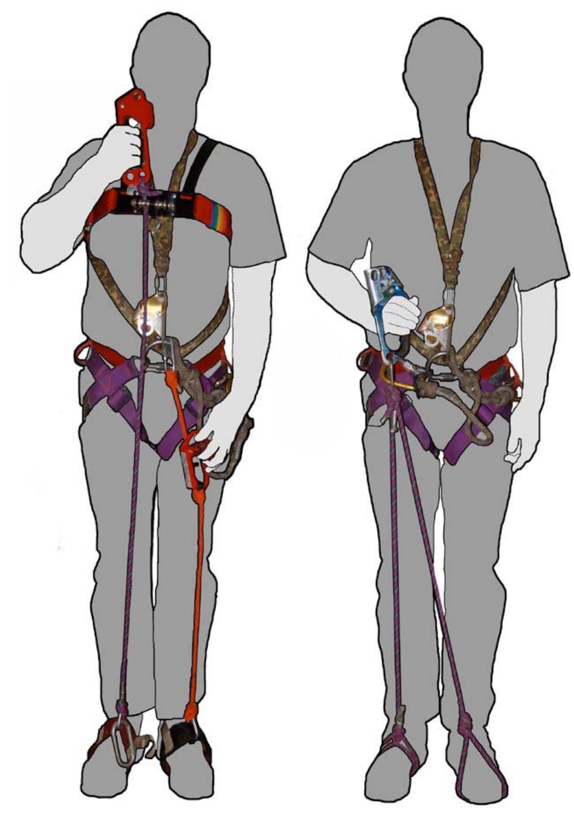


Fig 1: The Mitchell (left) and Frog Systems (right). Although the sit harness and cowtails are an integral part of the Frog system, they were not included in weight and bulk measurements. This Mitchell System includes a Croll and chest strap from the Frog System and a carabiner at the Mitchell System's right foot stirrup. These are used to convert the Mitchell to a Frog system when necessary.

I compared the Frog and the Mitchell systems: The former because it represents the world-wide standard and the latter because it was the "ropewalking" system that seemed most compatible with Alpine SRT rigging. Although the traditional American double-bungee ropewalker system is undoubtedly the most energy efficient method of climbing an unobstructed rope, it lacks the versatility of the Mitchell System for crossing obstacles and can be problematic in muddy situations. Aside from greater weight and bulk, the Ropewalker's low foot cam and bungee cords are considerable disadvantages at mid-rope obstacles. For these reasons, I felt that the Ropewalker could not be employed effectively with expedition-style Alpine SRT rigging.

Fifteen (15) different cavers took part in my tests and I took every test myself. The tests were conducted in several locations: my home, an outdoor climbing location near my home and at NSS Conventions. Rebelays, knot crossings and changeovers employed cavers who were very familiar with the system they used. This was to prevent needless fumbling that would skew data. These tests were not about ***learning*** a system, they were about ***using*** a system. In other tests, such as the free-fall climbing tests, and "gearing up and down" tests, all 15 cavers were tested. This provided relative speed and efficiency information as well as evaluations of the inherent difficulties in setting up and using each system at different experience levels. "Racing" was prohibited and realistic caving speeds were maintained.

General characteristics of the Mitchell and Frog Systems

The ***general advantages*** of each system:

1. The Frog System is lighter and more compact than the Mitchell. It is *slightly* faster than the Mitchell System (my opinion AFTER testing) for crossing certain mid-rope obstacles such as rebelays. It is also well-suited for multiple pitch caves where the pitches are relatively close together or relatively short (less than 40 meters). "Gearing up" and "gearing down" (travel readiness) times are minimal with the Frog. Its primary attributes are simplicity and high versatility, both in equipment and in method.

2. The Mitchell requires significantly less energy to ascend than the Frog. My tests indicate that it is a *minimum* of 25% faster for any body type when ascending unobstructed ropes. It is well-suited to situations when pitches are either relatively long (more than 40 meters) or spaced far apart. Its primary characteristics are high climbing efficiency for almost any body type and high versatility. With the addition of a Croll ascender and the elimination of the roller box, the Mitchell can be converted into a Frog system without other modifications.

The ***general disadvantages*** of each system:

1. The Frog requires more energy and/or more time to climb an unobstructed rope compared to the Mitchell. The longer the pitch, the less effective the Frog becomes. Tests indicate that certain body types are significantly less effective with the Frog system than others.

2. The Mitchell is heavier and bulkier than the Frog (see below for specifications). In addition to two ascenders with foot loops, it requires a double-roller chest box and harness. It takes *slightly* longer to cross certain mid-rope obstacles such as rebelays (see tests). It requires more "gearing up" and "gearing down" in order to travel. It is less suited than the Frog for closely-spaced multiple pitch situations or when pitches are generally short.

The goal of my testing was to determine how much these advantages or disadvantages actually affect the OVERALL vertical experience for both the individual AND the group. The main question is: Is one system definitively superior in terms of vertical effectiveness in real-world Alpine SRT situations?

Fig 2: My personal system components. Frog at left and the Mitchell system used for testing at right. Weight and bulk measurements did NOT include the sit harness and cowtails for either system. A dedicated safety tether (gray webbing) was included for the Frog. These systems are built to my specifications and both systems can be further minimized in both weight and bulk.

"Results at a Glance" from all tests may be found at the end of the test section

Comparative system weights

Weight of my *personal* **Mitchell** System shown above: **1470 grams (3.2 lbs)**.

This includes a Petzl Ascension handled ascender, a Petzl Basic (non-handled) ascender, a "Fritzke" double roller chest box, harness and foot loops. **A sit harness and cow tails were NOT included in the weight.** This is a *very* comfortable system. Its 2 inch sewn foot loops, well-padded padded chest harness, and other creature comforts increase both weight and bulk over a minimized Mitchell system.

With the lightest commercial chest box assembly ("Flash Box" plus harness), two Petzl "basic" ascenders and rope foot loops similar to the standard Frog foot loops, the weight of the Mitchell system can be decreased to about **1200 g**. This set-up can be considered the approximate minimum weight of a Mitchell System that does not compromise climbing efficiency (See Fig. 3b).

Approximate weight of light Mitchell System: **1200 grams (2.6 lbs)**.
Approximate weight of light **Frog** system: **870 grams (1.9 lbs).**

The light Frog System includes two ascenders, a Petzl Ascension and Petzl Croll, 1 long foot loop, a 1" "serpentine" chest harness. **Although required by the Frog system, the sit harness and cow tails were NOT included in the weight.**

With both systems optimized for minimum weight, there is approximately a **330 gram (.7 lbs)** difference between the Frog and the Mitchell systems. With more comfortable (and more common) Mitchell chest harnesses, sewn foot loops and larger chest boxes, the weight difference averages between **500** and **544 grams (approx. 1 lb)**. Personal comfort levels are highly individualistic and no attempt was made to access them. They are however, real-world concerns, particularly during long cave trips or on long pitches.

Note: European publications have indicated the increasing use of Petzl Pantin foot ascenders as standard equipment for longer pitches. Using the Pantin, Frog climbing technique can be modified (semi-ropewalker) to improve efficiency, but this system was not tested. A Pantin ascender adds approximately 80 grams (2 oz.) to the Frog System weight and approximately 30% to its bulk. The difference between the modified Frog and the lightest Mitchell system is approximately **250 grams (.5 lbs)**.

Comparative Systems bulk

This was somewhat difficult to measure, so I stuffed the system components tightly into a bag and measured the bag. Two ascenders are used for each system and the foot loop weight and bulk is approximately the same for both systems if rope foot loops are used for the Mitchell. Additional weight and bulk is mainly from the Mitchell roller box and chest harness. On average, the addition of the Mitchell system chest box and harness increases the total ascending system bulk about **50%** over the Standard Frog (see illustration). Actual bulk depends largely upon the chest harness and box that is used, so no definitive comparison is possible except in specific cases. The smallest Mitchell System has about **20%** more bulk than a Pantin-modified Frog System.

Fig 3a: The left bag (above) contains the complete expedition-style Mitchell System shown at right. The right bag contains my normal Frog System as shown above (no sit-harness, no Pantin). The Mitchell bag measures approx. 25 x 18 x 10 cm. (10 x 7 x 4 in). The Frog bag measures approximately 20 x 16 x 10 cm (8 x 6 x 4 in).

Fig 3b: This Mitchell has been reduced to minimum weight (1200 g) and bulk without reducing climbing efficiency. It uses 8 mm rope instead of sewn foot loops, a Flash Bar roller box and two Petzl Basics. The tan webbing (left) is the "chicken loop" loop for the upper ascender. The other ascender uses a sit-harness tether instead of a chicken loop.

Free climbing test (no mid-rope obstacles)

It should be remembered that the professed goal of Alpine SRT rigging is to eliminate ALL rope abrasion. The ultimate expression of this would be that ALL drops would be rigged as free drops, leaving only man-made rope obstacles (rebelays, deviations etc.) to be negotiated. This of course, is possible only in theory.

For straight free-fall rope climbing with no obstacles, the Mitchell was demonstrably superior to the Frog when the same climber used both systems. Even with minimal experience, Mitchell climbing speed was often more than 30% faster than the Frog. This was measured by total climbing time over the same distance at a moderate (cave worthy) pace with each system.

Participants climbed 20 meters (65 feet) with the Frog System first. There was a 45 minute rest period before the Mitchell system was used by the same test subject. The results were fairly consistent with the "worst" Frog body types (see body type tests) improving to the greatest degree. Heart rates were measured before and after the climbs to determine if the climbers were favoring one system over another. Heart rate increases were surprisingly similar at the end of each climb (for each individual climber), but overall times were a minimum of 25% faster (35% maximum) for the Mitchell.

Crossing rebelays

The ability to cross rebelays was one of the major factors cited as a significant advantage of the Frog system. After watching my friend Peter Jones negotiate a free-hanging rebelay in 30 seconds with his Mitchell system, I wondered how much of a practical issue it really was. I conducted two different tests.

Rebelay Test #1

The test rebelays were free hanging. They were crossed several times by several different cavers, all familiar with their chosen systems and with rebelays. Each caver was allowed to use whatever procedure they desired as long as it was safe (minimum two points of contact). The **first** test was timed from the point where the climber **clipped in** their safety cowtail to the rebelay loop or anchor (beginning the crossing) and the time that the safety cowtail was **removed**, ending the crossing.

The Frog System *averaged* about **15 seconds** to cross a simple rebelay with an experienced Frogger. The shortest crossing time was about 10 seconds. The Mitchell System averaged about **30 seconds** for an experienced Mitchell user. The shortest crossing time was 20 seconds.

In this test the Frog was measurably faster, but afterwards I realized that it was not necessarily indicative of overall efficiency for several reasons:

1. I wanted to measure the efficiency of the systems based on the TOTAL ascent time, including mid-rope obstacles. The first test measured only the rebelay crossing time.
2. When Frogging, the safety cowtail is usually removed once both ascenders have been relocated above the anchor, but BEFORE the climber begins climbing again. Efficient Mitchell technique makes it easier to actually ascend a couple of steps above the anchor BEFORE removing the safety cowtail. This places the climber higher on the rope when the cowtail is removed and some vertical progress has been made.
3. The two systems have a difference in their "re-start" efficiency AFTER the cowtail is unclipped and when climbing is resumed. Crossing a rebelay effectively means that the climber is starting over with no rope weight to assist them. Froggers cannot clamp the rope with their feet until they have progressed high enough in the rebelay loop to do so. They usually have to pull the rope through their lower ascender for two or three sit-stand cycles before they gain sufficient height to climb normally. This slowed their upward progress immediately after the rebelay. The Mitchell system however, functioned almost normally as soon as both ascenders had passed the rebelay anchor. This is because the cams can be manually thumbed open. The first test did not take this into account because the timing ended when the cowtail was removed.

Rebelay Test #2

I retimed the rebelay crossing starting from the same point as before, clipping in the cowtail, but ending it when the climber had ascended 3 meters (10 feet) ABOVE the rebelay anchor. This test was designed to include restart efficiency and any procedural differences for crossing rebelays.

The Frog system *averaged* about **30 seconds** to cross the rebelay and ascend 3 meters above the anchor. The Mitchell *averaged* about **40 seconds** to cross the rebelay and ascend the same distance above the anchor. There was no significant time expended to regain full ascending efficiency with the Mitchell, so there was only a 10 second difference when measured in this manner.

Rebelay conclusions: The Frog is certainly faster than the Mitchell on the rebelay itself. When measured as part of the practical, overall vertical progress however, the difference is slight. Unless there are numerous rebelays or the pitch is short (less than 10 meters), the faster climbing times of the Mitchell outweigh the time lost at any single rebelay.

Fig 4: A Frogger on our outdoor treadmill (left). Negotiating one of the practice rebelays (center) and a first-time Mitchell user on the treadmill (right). The treadmill was also used for knot crossings and deviation crossings.

Photos courtesy Ryan Baker and Rich Collier

Changeovers (ascent to descent)

All published tests involving rappels were conducted using a Petzl Stop descender.

The Frog averaged about **40 seconds** for an experienced user with descending equipment ready to attach to the sit harness. This means the rappel device was attached to a sit harness accessory loop and NOT buried in a cave pack. If the descender is already attached to the sit harness, changeover times decreased equally for both systems. Two points of rope contact were maintained at all times until the rappel began. This is the total time required to attach the descender, thread the main rope into the descender, lock off the descender, remove all ascending gear and unlock the descender for rappel.

The Mitchell averaged about **45 seconds** for an experienced user with descending equipment ready to attach. Two points of contact were maintained at all times until the rappel began. This is the total time to attach the descender, thread the main rope, lock off the descender, remove all ascending gear and unlock the descender for rappel.

Note: With both systems it can be significantly more difficult to changeover with racks than with capstan-type descenders such as the Petzl Classic. This not only due to the length of the rack, but also because racks load from the top down while the capstan type descenders load from the bottom up. The “bottom up” loading allows the capstan descenders to be drawn much closer to the lower ascender, reducing the amount of slack in the rope. With long (6-bar) racks, changeovers are slightly easier with the Mitchell system than with the Frog. This is because the lower Mitchell ascender can be raised to a point just below the chest box allowing the rack to be placed much higher on the rope than with the Frog system. Mini-racks are the less affected by system differences due to their shorter lengths. Either system can be effective with either rappel device, but the step-by-step changeover procedures are different.

Changeover (ascent to descent) conclusions: Although measurably different, there is little practical time difference between the Frog and the Mitchell system for doing ascent to descent changeovers. The type of descender used can dramatically affect both the time and effort required to do changeovers with either system.

Changeovers (descent to ascent)

For this test, all *ascending* gear was worn by the caver during the rappel.

The Frog System *averaged* about **40 seconds** to convert from descent to ascent. Most of this time was spent disconnecting the rappel device *and adjusting the tension of the Frog chest harness.*

The Mitchell *averaged* about **45 seconds** to convert from descent to ascent with the chest harness already on the caver. Most of this time was spent disconnecting the rappel device and connecting the chest box to the main rope. In practical caving, some Mitchell users do not wear their chest harness while rappelling. If the Mitchell chest harness is not worn, it would add considerable time **(about 1 _ minutes)** to put it on while on rope. Since a Mitchell system can be converted to an effective Frog system by wearing a Croll ascender when on rappel, the use of the Mitchell chest harness is not necessary for a safe descent. See my Mitchell-to-Frog Conversion article for details.

Changeover (descent to ascent) conclusions:

In this case the Frog system is generally easier to manipulate than the Mitchell because it has only two components. It is not significantly faster however. In real-world scenarios many Mitchell system users do not wear their chest harnesses while rappelling. Froggers can wear their Croll and harness strap continuously without impairment. Several tests conducted on rope indicate that donning a Mitchell chest harness required between 1 and two minutes extra depending upon the type of harness used. With all ascending gear on the caver however, the Frog showed only a tiny time advantage. The Frog’s slight advantage may be offset by the Mitchell's faster ascent times if the overall vertical time is considered (see other test results).

Knot crossing on ascent

For all knot crossing tests, a loop in the main rope allowed safety cowtails to be attached.

The Frog System required about **15-20 seconds** to clip in a cowtail safety, pass both ascenders above the knot and unclip the cowtail safety. The Mitchell System required about **20-30 seconds** to clip in a cowtail safety, pass both ascenders and chest box above the knot and unclip the safety.

The Frog is slightly superior when crossing this obstacle. In both changeovers and knot crossings, the time differences were mainly due to the removal and re-attachment of the Mitchell chest box (averaging about 10 seconds). There was no significant difference in energy expenditure.

Knot crossing on descent

It is possible to cross a knot on descent without full ascending gear. *Since these tests were designed to compare ascending systems, a method utilizing full ascending gear was teste*d. In this test, the caver descends to a point a few feet above the knot, switches to their ascending system, down climbs past the knot and does a changeover to continue the rappel. Two points of contact were maintained at all times.

The Frog system averaged about **1 _ minutes**.
The Mitchell system averaged about **1 _ minutes**.

There was no significant difference in the time required with either system. While the Frog System could be attached to the rope more rapidly than the Mitchell, the Mitchell's superior down-climbing speed made up the time difference. The Mitchell user however, was forced to wear the chest box and foot loops while rappelling. This could be a disadvantage in some circumstances. See the Mitchell-to-Frog conversion article for an alternative knot crossing possibility.

Passing Deviations

There was no difference between the two systems for passing several different deviations. Times are not listed because they seemed to be more dependent upon the nature of the specific deviation and not the ascending system. No ascender was unclipped from the rope to pass any deviation.

"Gearing up and Gearing down"

"Gearing up and down" means taking vertical gear on and off and/or stowing it for travel. Most complaints directed at the Mitchell System were not about the actual "on/off" rope time, but rather that Mitchell users must remove their ascending gear to travel effectively between drops. This may or may not be a serious concern in practical caving for several reasons. Actual “gearing up” time (putting on vertical gear) only matters for the **first** caver to ascend. In addition, once the Mitchell system is on the caver, the “clip in” time for the Mitchell is actually faster than the Frog (see tests results below). Unless the caver is pushing on alone, “gearing down” time usually coincides with waiting for the next caver to descend. Overall rope occupation time (including all mid-rope obstacles) is far more important than any single aspect of a system when vertical effectiveness is the criteria. Time lost at “clip in” may be regained by climbing with a more effective system. Total energy expenditure of the climber should also be considered.

Fig 5: For “gearing up” tests, systems were placed in a random pile similar to ones left at the bottom of a last pitch. The Mitchell System is at left and the Frog at right. Although the Mitchell System is not sit harness dependent, the same type harness was used for all tests. Cowtails were included for both systems.

The “gearing up” tests

These tests measured how long it took to put on equipment and clip onto the rope ready to ascend. The first test involved putting on ALL vertical gear and clipping into the main rope. The second test measured clipping onto the rope only. The results varied greatly depending upon the test. While it is possible for Mitchell users to ascend without a sit harness and effectively rest on their haunches, we felt that safety concerns prohibit climbing this way except in emergencies. A sit harness was included in gearing up times for the Mitchell system.

Test #1 –Caver starts with no vertical gear (no sit harness, no chest harness etc.). Timing ends when caver has donned full vertical gear, is clipped onto rope in adjusted climbing position and takes first “step.” With all of the climbing gear accessible in pile (no searching around in a cave pack or groping for equipment in the dark) it takes an average of about **1 _ minutes** to put on the complete Frog gear and clip onto the main rope. This includes donning the sit harness with Croll ascender and cowtails, attaching the ascenders to the rope and adjusting the chest harness tension for climbing. This is done at a cave worthy pace, not a racing pace.

The Mitchell “gear up” time includes the proper attachment of the sit harness with cowtails (a Croll is not necessary with the Mitchell), both ascenders, and the donning, adjustment and attachment of the double roller chest box to the main rope. This averaged about **2 1/2 minutes**. The increased time was strictly due to donning the chest box. This makes the Frog system a total of about 1 minute faster on average than the Mitchell when gearing up from a “dead start.”

Once again, a single test did not account for all real-world conditions. It is reasonable to assume that the Mitchell user would not always be the first person to ascend, so a second test was conducted using different start/stop points.

Test #2 – "Clip in" time only: With all vertical gear on the caver (ready to climb), timing starts when caver attaches first piece of vertical gear to main rope and ends when caver takes first "step": Froggers averaged about **20 seconds** to clip both ascenders onto the main rope, weight the Croll **AND** adjust their chest harness tension properly. Mitchell clip-in time averaged about **10 seconds** when measured to the first "step." The difference was mainly due to the need for Froggers to adjust their chest harnesses AFTER their Croll ascender was loaded. Mitchell users were able to clip in and ascend virtually immediately because the chest harness can be properly tensioned while off rope.

"Gearing down" and Travel efficiency

For "gearing down" the Frog was clearly superior in regard to cavers being ready to travel almost immediately after getting off rope. Froggers need only "stow" their upper ascender by clipping it to their sit harness. This required only **10 seconds** on average. Mitchell users had to remove and stow at least one foot loop and usually the chest box in order to travel, although the chest box need only be loosened, not removed, in some cases. Most Mitchell users were able to remove and stow their foot loops and chest box for travel in about **1 minute**. Gearing down time may be a significant factor depending upon the nature of the cave and the number and spacing of vertical drops.

Results at a glance

Relative system weights (approx)

Frog: **907 g (2.0 lbs)**
Frog with Pantin foot ascender: **987 g (2.2 lbs)**
Mitchell (comfortable system) **1470 g (3.2 lbs)**

Frog (light system): **870 g (1.91 lbs)**
Mitchell (light system): **1200g (2.6 lbs)**

Relative system bulk (approximate)

Mitchell vs. Frog: Mitchell = **+ 50% (average)**
Mitchell vs. Frog with Pantin: Mitchell = **+20% (average)**

Free climbing ascent 20 meters (65 feet) at cave appropriate speed

Mitchell: **30% faster** (average per individual)

Rebelay test #1: rebelay time (cowtail on to cowtail off - average time)

Frog: **15 seconds**
Mitchell: **30 seconds**

Rebelay test #2: rebelay time (cowtail on to 3 meter (10 foot) ascent above rebelay)

Frog: **30 seconds**
Mitchell: **40 seconds**

Changeovers: ascent to descent (average)

Frog: **40 seconds**
Mitchell: **45 seconds**

Changeovers: descent to ascent (average with all vertical gear on)

Frog: **40 seconds**
Mitchell: **45 seconds**

Knot crossing on ascent

Frog: **20 seconds**
Mitchell: **30 seconds**

Knot crossing on descent (wearing full gear)

Frog: **1.5 minutes**
Mitchell: **1.5 minutes**

Note: the Mitchell chest box need not be worn to cross a knot safely on rappel.

"Gearing up" (putting on ALL necessary vertical gear to first "step" on rope)

Frog: **1.5 minutes**
Mitchell: **2.5 minutes (average)**

"Gearing down" (travel readiness between ropes on descent)

Frog: **10 seconds**
Mitchell: **1 minute**

Clip in time (ready to climb, all gear on, clip onto rope, take first "step")

Frog: **20 seconds**
Mitchell: **10 seconds**

"Statistics don't lie, but liars use statistics"

It is essential that the relative importance of each test be evaluated in terms of *overall vertical effectiveness*. It is galactically stupid to limit criticism to specific situations (either favorable or unfavorable) simply to justify an opinion. Adherence to situational arguments is the sanctuary of the feeble-minded and Speleo politicians. Here's why:

Situational argument #1: Statistically, the Frog System can be said to be *overwhelmingly* superior because it is measurably faster than the Mitchell when crossing most obstacles and performing most rope maneuvers. **HOWEVER**, the differences are small in most cases and amount to an insignificant percentage of the TOTAL time spent on rope.

Situational argument #2: Statistically, the Mitchell System can be said to be *overwhelmingly* superior because during the majority of the time spent on rope (actual climbing) it is demonstrably faster than the Frog System with the same climber. This makes it superior for 95% of the *rope time* for almost any caver using it properly. **HOWEVER**, some of its disadvantages cannot be discussed in rope terms alone. Extra weight and bulk have an indirect effect on overall vertical effectiveness because they affect the caver both on and off rope and therefore for a larger percentage of the caving trip. These effects are difficult to quantify, but they cannot be ignored.

Considerations

I tried to avoid the fanaticism from both sides of the issue by basing my judgments on the essential question: *If two cavers were placed into the same circumstances using these two different ascending systems, what would be the overall efficiency of those cavers individually and indirectly for the group as a whole?* It is important to remember several things about these tests and my conclusions:

1. These are empirical tests. I did not confuse them with scientific tests and you should not either. I do not consider these tests definitive, just indicative.
2. We must assume equal physical condition for all climbers for comparison purposes. The actual effects of personal conditioning are extremely difficult to test. Done properly with both systems, there is little practical energy expenditure at rebelays, knot crossings, or other mid-rope obstacles.
3. Specific circumstances alter the effectiveness of either system. Tight crevices can jam Mitchell chest boxes. Climbing times for Froggers are always longer on all but the shortest drops.
4. It is imperative that certain tests be conducted with *experienced* system users with PROPERLY adjusted equipment. I have seen poorly constructed systems of both types in publication and in use. Inefficient systems and/or inexperience yield false results.
5. Don't try to justify an opinion. Try to form an intelligent one. Ignorance is the greatest obstacle.

Conclusions

My tests indicate that the most common arguments favoring either the Mitchell or Frog Systems are based more upon prejudice than fact. Whatever practical problems may exist with either system, the ones that cavers constantly argue about make little or no difference in overall vertical efficiency. Both systems are completely compatible with Alpine SRT methods and neither shows a definitive overall advantage in practical caving when total rope occupation time and/or energy expenditure is considered.

1. The greater the number of rope obstacles, the more efficient the Frog becomes.
2. The longer or more obstacle-free the drop(s), the more efficient the Mitchell becomes.
3. It takes a lot of rope obstacles to make any significant difference in overall rope occupation times. With the exception of relatively short drops (10 meters or less), the slower times for the Mitchell at rope obstacles are almost always compensated for by faster climbing rates.
4. Specific circumstances can significantly affect the effectiveness of either system.
5. The Frog System favors specific body types. See my article "Typecasting the Vertical Caver" for specifics. The Mitchell is less affected overall.
6. Overall vertical effectiveness of some individuals is significantly improved by ascending systems better suited to their body type. This improves group effectiveness.
7. Overall rope occupation times are virtually identical between the two systems when all factors and potential caving conditions are considered. Energy expenditure is significantly less with the Mitchell System during actual climbing, but greater equipment weight and bulk may offset this advantage during off rope travel.
8. Experienced Mitchell System users would not negatively affect the total rope time under real-world Alpine SRT rigging conditions. Switching systems however, may significantly increase the vertical effectiveness of specific individuals.
9. A dogmatic approach to ascending systems is counterproductive to some individuals and therefore counterproductive to any group with whom those individuals go caving.
10. Tests can be deliberately designed to favor either system, yielding false results.

Converting the Mitchell System to a Frog System

By John Woods NSS#10503

Two basic rope ascending styles have existed since I started caving over 40 years ago: The sit-stand type (including most knot systems) and the "ropewalking" systems. Not including the many hybrids, the most common types today are the universal sit-stand Frog System and the two ropewalking type systems used primarily in the U.S.: The Mitchell System and the bungee-assisted "Ropewalker."

There is perhaps only one characteristic of all these systems that is virtually undebatable: ropewalking systems are almost universally more efficient for ascending than sit-stand systems. Speed however, is only one of the aspects of ascending that must be considered. Weight, bulk and versatility are very significant factors in overall vertical performance.

Fig 1: Wearing the Mitchell roller box over the Croll allows rapid conversion to the Frog System. The Croll serves as the Mitchell QAS.

The International adoption of the Frog System clearly shows a practical compromise between efficient climbing and system versatility. This does not mean however, that everyone using the Frog system is content with these compromises or that they are the only methods that work.

Europeans have recognized the systemic problems with sit-stand systems and some are addressing it in creative ways. Although it increases system weight and bulk, the addition of a low-placed foot ascender such as a Petzl Pantin increases Frog climbing efficiency, particularly for longer ascents. I have even found a couple of British websites illustrating a method of using a third ascender to convert a Frog System to a bungee-assisted ropewalking system for very long ascents. Rather than debate the merits of the sit-stand verses the ropewalking systems, I offer another option.

Recent testing shows that the Mitchell System is in fact, very well-suited for Alpine SRT rigging methods and offers significantly greater climbing efficiency than the standard Frog for certain body types. It can also be converted to a Frog system when desired.

Traditionally, the Mitchell System has been presented as a "three phase" system. Using a third ascender on a tether called a Quick Attachment Safety (QAS), the Mitchell can be converted to the sit-stand Texas system (phase 2) or a modified system for climbing slopes (phase 3). Although these alterations increase Mitchell System flexibility, my testing suggests a simpler modification that addresses the problem more effectively. The modification is also compatible with International Alpine SRT rigging styles.

Instead of attaching a third ascender to a short tether as a QAS, I wear my normal Frog rig (Croll ascender and chest strap) underneath the Mitchell chest box. When ropewalking the Croll is NOT attached to the main rope and does not hinder normal Mitchell climbing. It does however, provide a QAS that allows me to rest when using my Mitchell System. Since I always carry a third ascender for safety, this modification does not change the total weight/bulk of my normal Mitchell or Frog Systems.

My Mitchell System with the added Croll, can be converted to a two-footed Frog in about 45 seconds, even when on rope.

Fig 2: The standard Mitchell System with Croll addition is shown at left. The Croll does not interfere with normal Mitchell System ascents. To convert to a Frog, first attach the Croll to the main rope. The long foot line is then shortened by twisting it into a carabiner, then the lower ascender is clipped into the foot loop line and adjusted to proper height (center photo). The roller box is disconnected from the main rope entirely. The long cowtail is used as the Frog safety tether. For short drops or sequential pitches, the chest box is not used and the Frog System is used exclusively (right photo). There are several possible variations to the conversion shown here depending upon the initial Mitchell configuration. (See figures 3 and 4)

Using the Croll instead of the traditional QAS has several advantages over the standard Mitchell three-phase:

1. The chest box and lower Mitchell ascender can remain stowed until needed. This eliminates the need to wear the Mitchell chest box on rappel, while still providing an effective, safe Frog System. (See Fig 2)

2. The Frog is more energy efficient than the Mitchell phase 2 (Texas system) for general rope climbing and particularly for short pitches.
3. The systems can be interchangeably converted on rope.
4. I find the Frog more effective on slopes than the Mitchell Phase 3.

Procedure

A standard Croll ascender and Frog chest strap are worn under the Mitchell roller box.
1. Attach the Croll to the main rope and sit down on it for comfort.
2. Attach your long cowtail to the upper ascender as the Frog safety tether.
3. Loosen the Mitchell chest box and tension the Croll chest strap.
4. Disconnect the chest box from the main rope.
5. Remove the upper foot loop from the roller box. Although the normal long foot loop is too long for full Frog efficiency, it is easily shortened by twisting the rope and clipping it into a carabiner at the foot stirrup.
6. Attach the lower Mitchell ascender to the upper foot loop and adjust to proper height.
7. Frog normally.

Some Mitchell users have built their systems for minimum weight and bulk. If your Mitchell foot loops are made with rope instead of sewn stirrups, the lower Mitchell ascender is not used and the conversion produces a two-foot Frog system (See fig. 3).


Figs 3 (left) and 4 (right): Double rope loops may be used in place of sewn stirrups for the Mitchell System. This decreases system weight and bulk and greatly facilitates the Frog conversion. Both loops go over the same foot when using the Mitchell and one loop on each foot for Frogging (Fig 3). The double foot loop requires a chicken loop when using the Mitchell. The short Mitchell ascender is not used in this configuration and can be stored until needed. Fig 4: A complete minimum weight (1200g) and bulk Mitchell System is shown at right.

Rope foot loops may be substituted for sewn loops to decrease Mitchell System weight and bulk (See Fig 4). A double loop knot such as the double figure eight, in the end of the Mitchell's upper foot line, provides the standard Frog foot loop setup. This Mitchell configuration has approximately the same weight and bulk as the bungee-assisted "Frog to Ropewalker" conversion that uses a third handled ascender.

Minutes of the
2008 NSS Vertical Section Board Meetings

The Executive Committee of the Section held two separate Board Meetings prior to the General Meeting. The Minutes of those meetings are included below.

Board Meeting of 8/10/2008

The NSS Vertical Section Executive Committee held a meeting on Sunday, August 10, 2008 at the 2008 NSS Convention Campground in Lake City, Florida. Executive Board members present were Chair Brice Williams, Secretary-Treasurer Bill Boehle, At-Large Executive Members John Woods, and Bill Boehle (proxy for Miriam Cuddington), Nylon Highway Editor Tim White, Vertical Techniques Workshop Coordinator Terry Clark, Education/Training Coordinator Bruce Smith, and Terry Clark (proxy for Contest Coordinator Bill Cuddington). At-Large Executive Member Ed Sira was unable to attend the Convention. Approximately 9 additional Vertical Section members were also in attendance.

Meeting opened at 7:10 PM by Chair Brice Williams.

The purpose of the meeting was to discuss and deal with various issues that needed to be addressed before the annual business meeting on Wednesday.

1. The status of the rigging for the vertical contest and workshop was gone over. It was agreed that it would be best if we could have someone "pre-check" the facilities and rigging points before convention in order to avoid last minute problems.

2. The status of the Vertical Workshop was discussed. Six (6) persons are pre-registered, so far. To avoid problems getting paid by the convention for workshop registrations, we need to get a list of the participants to the convention Treasurer on Thursday so they can get a check to us on Friday.

3. Membership. It was brought up for discussion as to whether we need to charge dues anymore. Most of our income comes from the Vertical Workshop registration fees and from sales of various Section items. Since the Nylon Highway is now an electronic publication, most of the costs for printing and mailing no longer exist. The discussion also centered on how the Vertical Section should serve the caving public. To get our message out to the largest audience by increasing our membership, it was agreed that we would no longer charge dues to be a member of the Section. The Bylaws need to be amended to make this change. Gary Bush stated that any bylaws action regarding a dues change must be approved by the membership. It was agreed that the bylaws change would be drafted and acted upon by the Executive Committee before the business meeting, so that it could be brought before the section at the business meeting.

4. Bruce Smith has spent a lot of time thinking about where vertical caving is today. Vertical caving is much more mature than long ago when the techniques commonly used today were first being testing and developed. The techniques are not changing as rapidly as in the past. However, a review of vertical caving accidents seems to

indicate that the average person is not very skilled in applying the various vertical techniques under difficult circumstances. In this context...what is our mission? The Vertical Contest is for fun. The Vertical Workshop and the equipment tuning sessions are for education. Training is the key to ensuring that there are more competent vertical cavers. We need to position the Vertical Section as a mentor, or maybe a "mentor of mentors". It was agreed that there should be more discussion of this topic. Perhaps a roundtable at the Vertical Session?

5. Bruce Smith reported on the status of the Intermediate Vertical Training Course. We have a curriculum. Samples of the course material were distributed and examined by the Executive Committee. What we now need to do is some beta testing to figure out "how" the course material should be taught. A motion was made and seconded to accept the form of the curriculum developed. The motion PASSED.

6. Bruce Smith reported on some revisions being developed for the Basic Vertical Training Course. The main thing needed is a "cheat sheet" for instructers to get students to work through dealing with problems (i.e., blowouts). It was agreed to revise the course as suggested. More last minute suggestions can be made and incorporated this week.

7. Gary Bush (webmaster) discussed the section website. It was agreed that we need more content, more training and education, and some articles on vertical caving for the NSS News.

Adjournment - Motion to adjourn was made and carried. Time of adjournment was approximately 8:49 PM.

Respectfully Submitted,
Bill Boehle

Board Meeting of 8/13/2008

The NSS Vertical Section Executice Committee held a short meeting on Wednesday, August 13, 2008 prior to the section business meeting at the 2008 NSS Convention to act on the bylaws revision (drafted by Bill Boehle) concerning membership dues that was discussed at the Executive Committee meeting on August 10, 2008. Executive Board members present were Chair Brice Williams, Secretary-Treasurer Bill Boehle, At-Large Executive Members John Woods, and Miriam Cuddington, Bruce Smith (proxy for Nylon Highway Editor Tim White), Vertical Techniques Workshop Coordinator Terry Clark, Education/Training Coordinator Bruce Smith, and Contest Coordinator Bill Cuddington. At-Large Executive Member Ed Sira was unable to attend the Convention.

Meeting opened at 12:55 PM by Chair Brice Williams.

1. A motion was made by Bruce Smith and seconded by Bill Boehle to replace Section 2)(B) of the Bylaws with the following:

   "(B) Membership Qualifications:

   i. The Membership consists of those who attend an annual General Meeting and/or other official Vertical Section function at the Annual NSS Convention and who sign the roster with their name and email (or regular) address. The duration of membership shall be 5 years from the last meeting (function) attended, if the member's dues are not in arrears.

   ii. Applications for membership shall be in writing, as specified above, and shall be accompanied by dues as specified herein. Online registration shall also be available to those who cannot attend an annual meeting (function) in a form provided by the Executive Committee.

   iii. Membership Classifications:

      FULL REGULAR MEMBER: Full membership is limited to members of the NSS, who have paid current dues to both the SECTION and the NSS. Full regular members will receive all rights and benefits of SECTION membership. Regular members can vote and hold office.

      SUBSCRIBER: Non-NSS members, or groups, who have paid Subscriber's dues are entitled only to receive a electronic subscription to SECTION publications."

   Motion was voted on and PASSED.

2. A following motion was made by Bill Boehle and seconded by Bruce Smith:

   The Executive Committee sets the Vertical Section dues for all membership classes to $0.00 (zero).

   Motion was voted on and PASSED.

Adjournment - Motion to adjourn was made and carried. Time of adjournment was approximately 12:59 PM.

Respectfully Submitted,
Bill Boehle

Minutes of the
2008 NSS Vertical Section General Meeting
August 13, 2008

The 2008 NSS Vertical Section meeting was held Wednesday, August 13, 2008 at the Lake City Community College in Lake City, Florida. Executive Board members present were Chair Brice Williams, Secretary-Treasurer Bill Boehle, At-Large Executive Members John Woods, and Miriam Cuddington, Bruce Smith (proxy for Nylon Highway Editor Tim White), Vertical Techniques Workshop Coordinator Terry Clark, Education/Training Coordinator Bruce Smith, and Contest Coordinator Bill Cuddington. At-Large Executive Member Ed Sira was unable to attend the Convention. Approximately 28 additional Vertical Section members were in attendance.

I. **Meeting opened at 1:02 PM by Chair Brice Williams.**
Announcements - Welcome to everyone who came. We will try to keep things rolling along and quickly get through the meeting.

II. **Minutes of the Last Meeting** - were published on the website and read at the meeting. Minutes were accepted as published.

III. **Officer Reports:**
   - **Secretary's Report** - Bill Boehle. See attached. Accepted as presented.
   - **Treasurer's Report** - Bill Boehle. See attached. Accepted as presented. Regarding getting paid for the Workshop registrations collected by the conventions for us, it was suggested that it would speed things up if a bill were given to the convention treasurer right after the workshop. Lynn Fielding handles the registrations for the Vertical Workshop for Terry Clark. Terry was present and agreed that this was a good idea and would pass this suggestion along to Lynn.
   - **Nylon Highway Editor's Report:** -
   Information from Tim White (not present) relayed by Bruce. The supplies (stock) of the Basic Vertical Training Course have been depleted. At our Executive Committee meeting on Sunday 8/10/2008 it was decided that there needs to be some minor adjustments to the Basic course which will be discussed later in the meeting during Bruce's Training/Education report. Printing of more copies of the Basic course will be done after the course material is revised.
   - **VS Symbolic Items** - Bill Boehle. See Treasurer's Report for sales numbers.

IV. **Committee Reports:**
   - **Contest:** Bill Cuddington -
   Thanks to all who help during the vertical contest. We had a lot of new people help out this year. We can always use more help. Without help it would be impossible to run the contest. We appreciate any help from section members and others with timing, pulling rope, running the rack (the racketteers), etc. Thanks also to the college for the great facilities. It was nice and cool in the gym. Thanks to PMI for donating 1200 feet of rope for the climbing contest and two Mitchell Climbing Systems, including two double roller

plates, to the Vertical Workshop. On Rope 1 donated two pairs of climbing stirrups to the Workshop. Terry Clark mentioned that some people complained to him about contest workers cutting in the line for climbs. Bill noted that we try to have workers climb early in the day, but that some times we accommodate workers when someone is not ready to climb. We ask the other person if they wouldn't mind a worker going first. Usually this is not a problem. Some flexibility is needed to adjust to conditions. Awards will be given out on Friday at 1:00 PM. Climbers need to be there to pick up their awards.

- **Vertical Workshop:** Terry Clark -
  Six students signed up for the Vertical Workshop prior to convention. We are now up to 11 students, so we will be able to set up two rotations. We had good help setting up the ropes this year, as opposed to last year. We are not sure what the status of the workshop will be next year at the ICS in Texas. This will be brought up for discussion later under New Business. Otherwise, things have been going well, with a bunch of new equipment (mentioned above under the Contest Committee report) being donated to the workshop.

- **Education:** Bruce Smith -
  The Basic and Intermediate Courses have specific goals and objectives that were laid out back in 1996. We have been working with the Basic course now for 12 years with varying degrees of success. There are three primary goals of the Basic course. There are about 250-275 different vertical skills that are available to learn. These were divided down into three separate categories: Basic, Intermediate, and Advanced. Things have changed over the last 12 years and we have been revisiting some of the goals and objectives of the course.

  Basic Training Course - The course only has one manual. We may want to provide some additions notes to assist the instructors. There has been increased use of the Frog System and rebelays. We probably need to adjust the course to address this. There are plusses and minuses to the use of each of the different systems. Much discussion followed. It was agreed that rebelays need to be in the training and that people need to really know whichever system they use. A cheat card for overcoming obstacles and dealing with blowouts is something that Bruce would like to provide to instructors. Working through these problems with students is a highly effective learning tool. The treadmill climb versus a real experience during training was discussed. A real experience is probably better. Other topics discussed were harnesses, gear, and use of gear. Once the changes are incorporated the Basic course material can be reprinted. Questions were raised about whether we should look into electronic distribution. There are pros and cons and the Board will look into it.

  Intermediate Training Course - We had a great meeting last year and Bruce was challenged. He received a lot of good feedback and suggestions. Bruce was inspired and has come up with a draft for the Intermediate course. Copies of the draft were distributed for discusssion. The package consists of a task book, a task completion mentor/trainer sign off card, and the course completion certificate. The structure, goals, and objectives of the course were presented and discusssed. The manual contains the talking points that should be addressed by the student and the mentor/trainer. The course is structured on a "go learn" mentor model versus the traditional "teach me" model. The student can take the lead to search out competent mentors as compared to attending a training class as is used for the Basic course. John Woods pointed out that the course book is not a mandate but an advisory guide. It provides a mechanism for people who want to learn or otherwise improve their vertical skills. This is the version of the course that the Board has approved once the typos have been corrected.

- **Rebelay Course:** Gary Bush and John Woods -
  This year there were about 6 people who showed up for the rope course. It was well received by all who participated.

- **"Dial In Your Gear" Session** John Woods -
  We had 12 people show up, including some new people who had never done any vertical work. They were interested in getting into vertical caving and came to find out what kind of gear to get. They wanted to talk to cavers rather than to the vendors. This provided a place, for the first time, that they could come to where someone would directly answer their questions. It was well received and some of them stayed for hours.

- **Web Page:** Gary Bush, webmaster -
  Gary noted that he has received no comments on improving the website, but has received several comments about objects on the website. Last year it was raised that some of the old PDF copies of the Nylon Highway were fuzzy and unreadable. It was also noted that the later issues (43 to 52) were not available as PDF files. Gary has now made high quality PDFs of these newer issues from the source files. He notes, however, that in looking back at the old issues in his files, that the original print issues are also fuzzy. He feels that the available PDFs are as good as we can get since the original source files are not available. A lot of time was invested doing individual page scans trying to make them as good as possible. Unless someone wants to retype all the old issues so that PDFs can be made directly from a source file, what we have is as good as it will get. All future issues will be available on the website as PDFs. If people would like other things on the website, send Gary an email and we will see what can be done. As of now, the PDFs of the old issues are available to anyone. The newer issues are only available to the members via the passcode. That could change in the future. There are advantages to open availablity of this information.

V. **Old Business:**

- No old business from the floor.

VI. **New Business:**

- Brice explained the recent Board actions eliminating the dues requirement for section membership. Dues was mainly to pay for the postage and other costs associated with the Nylon Highway. Since we now publish electronically, that is no longer the case and the collection of dues involves a lot of work. Dues is also not our main source of income. So the Board acted to eliminate dues and to make several other changes to the bylaws concerning membership. To be a member now only requires a person to attend the annual meeting (or other official meeting) and sign the roster or to submit an application requesting membership. We are also creating a Yahoo Group to use as a mailing list for communications from the Executive Committee. It is required by the bylaws that the membership vote to ratify any dues change enacted by the Board. A motion was made(Gary Bush),seconded (Gary Storrick), and carried to set the section dues to zero.

- Gary Storrick brought his vertical equipment collection to this years convention and has been asked to bring it again next year to the ICS in Texas. He asked for a few volunteers to help him set it up on either Sunday evening or Monday morning. He expects that it will take a few hours. Brice asked Gary to send us an email about it a little bit before the ICS and will will send a reminder out to the membership via the new Yahoo mailing list.

- Terry Clark raised the question of whether or not we should do the Workshop at the ICS. Bill Frantz thinks we should because this is a combined International Conference and NSS Convention. It will be attended by a lot of people from all over the country and the world. Terry stated that Texas has not yet asked us to put this event on. The section is interested, but Terry needs to talk to George Veni and find out what they would like us to do and to work out any details regarding scheduling and facilities. We obviously will need members to help out in conducting the vertical activities at the event.

VII. **Elections:**

- **Secretary/Treasurer** (1-year term) - Bill Boehle was nominated and reelected by acclamation.

- **Editor** (1-year term) - Tim White was nominated and reelected by acclamation.

- **At-Large Board Members** (2-year term, 2 to be elected) - Dick Mitchell, Terry Mitchell and Rory Tinston were nominated. A ballot of the section members present was taken. Dick Mitchell and Terry Mitchell were elected in a close vote. [Note: Current At-Large members Miriam Cuddington and Brice Williams have 1 year remaining in their terms.]

VIII. **Motion to Adjourn:**

Motion to adjourn was made and carried. Time of adjournment was approximately 2:35 PM.

[Additional note: Subsequent to the Meeting, the Board Members elected Brice Williams as Chair. The three appointed members were re-appointed to serve for another year. They are:

- Contest Committee - Bill Cuddington
- Vertical Techniques Workshop Committee - Terry Clark (Assistant: Lynn Fielding)
- Education Committee - Bruce Smith]

Respectfully Submitted,
Bill Boehle

NSS VERTICAL SECTION

SECRETARY'S REPORT

AUGUST, 2008

By Bill Boehle

Number of Members (current/just expired)	 120
Number of Members Current as of 2008	 81
Number of Subscribers Current as of 2008	 3
Number of Annual Volumes Paid for 2008	 13
Number of Complementary Subscriptions	 3

YEARS PAID:	MEMBER	SUBSCRIBER	ANNUAL VOLUME
Comps	--	--	4
2008	32	3	7
2009	33	1	2
2010	13	1	0
2011	1	0	0
2012	2	0	0
2008 TOTALS:	81	5	13
Expired 2007:	39	1	
TOTALS:	120		

NSS VERTICAL SECTION
TREASURER'S REPORT
AUGUST, 2008
By Bill Boehle

INCOME:

New Memberships, Subscriptions, & Renewals	.... $ 372.00
Nylon Highway Annual Volume Sales	.... $ 240.00
2006 Convention Workshop Registrations	.... $ 825.00
2007 Convention Workshop Registrations	.... $ 650.00
Vertical Training Course Sales	.... $ 260.00
Symbolic Item Sales	.... $ 428.00
Nylon Highway Back Issue Sales	.... $ 10.00
Shipping/Postage Charges	.... $ 46.75
Donations	.... $ 1.00
Bank Interest (GMAC) July 2007 - June 2008	.... $ 522.98
TOTAL INCOME	**$3,355.73**

EXPENSES:

Shipping/Postage Costs	.... $ 12.28
2007 VTW Transportation Subsidy (Terry Clark)	.... $ 123.00
2007 Climbing Contest prizes	.... $ 320.00
2006 Vertical Workshop expenses (Lynn Fielding)	.... $ 20.81
NH Annual Volume Production & Mailing Costs (1)	.... $ 0.00
Symbolic Items Restocking (T-shirts, Sweats)	.... $ 0.00
Vertical Instructor T-shirts	.... $ 0.00
Vertical Training Course Mailing Costs (billed by Tim White)	.... $ 41.20
Vertical Workshop Supplies	.... $ 0.00
Printing - Climbing Contest Certificates	.... $ 171.25
Photocopying for NSS Convention paperwork	.... $ 14.87
Petty Cash for postage	.... $ 20.00
TOTAL EXPENSES	**$723.41**

ACCOUNT BALANCES: (as of 7/31/2008)

Commerce Bank (NJ)	.... $5,488.17
GMAC	.... $9,385.16

BALANCE ON HAND: **$14,873.33**

(1) Not Yet Billed by Nylon Highway Editor