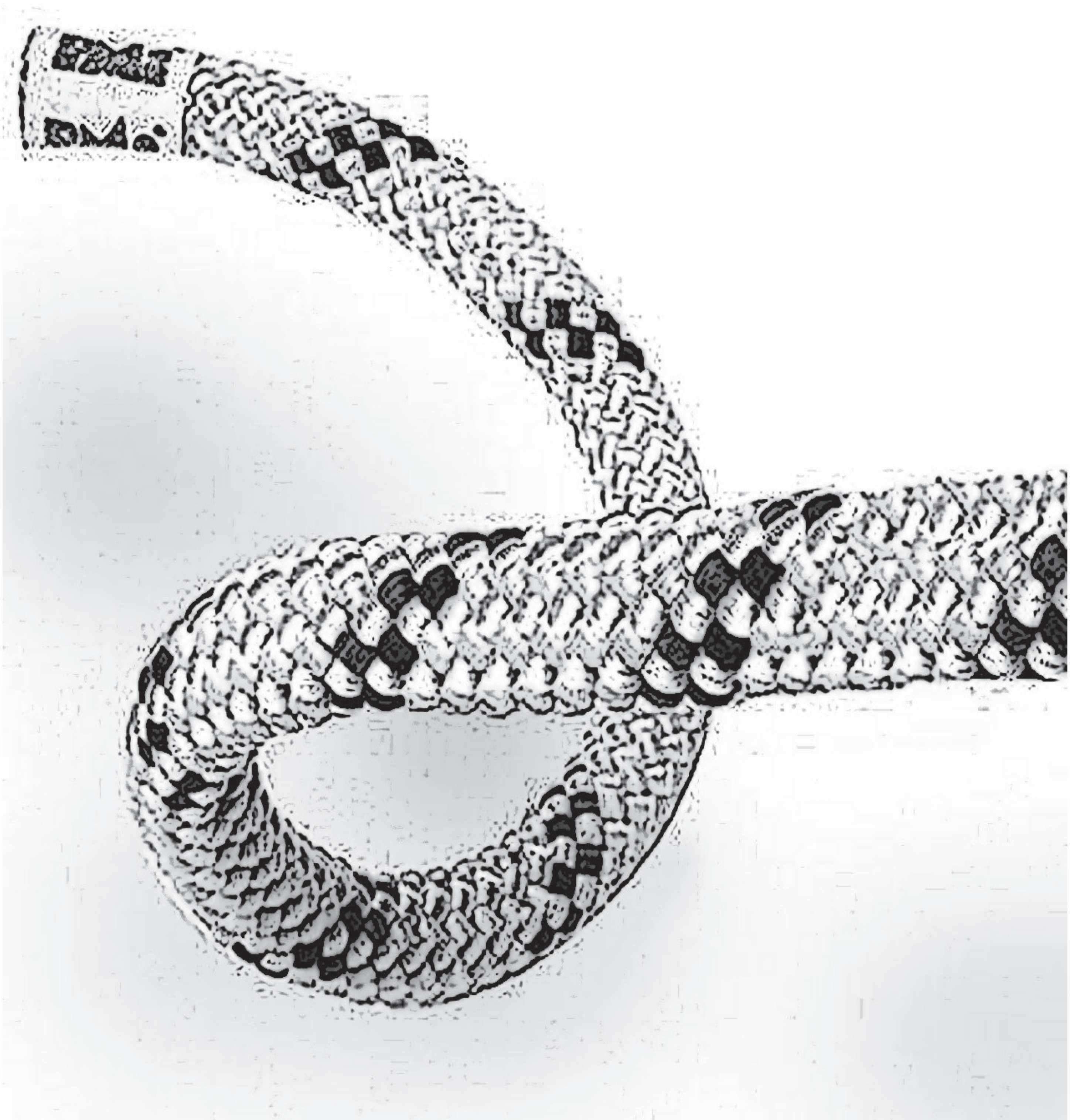
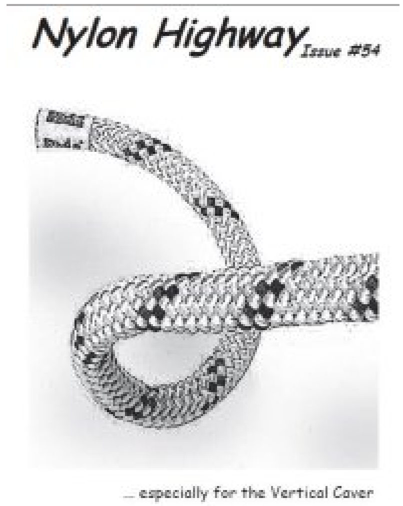
Nylon Highway Issue #54



... especially for the Vertical Caver



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Nylon Highway

Please send articles, art, exchange publications and other material for publication in the Nylon Highway to:
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In short, if you'd like to submit something for possible publication, send it to the Editor. Otherwise, send it to the Secretary/Treasurer.

ISSN

Year 2009
ISSUE #54

INFORMATION AND DISCLAIMER

The *Nylon Highway* is published by the Vertical Section of the National Speleological Society on a regular basis pending sufficient material. Material is posted on the Vertical Section's web site soon after being received by the Editor. A volume of all material is printed and distributed to those not having access to the electronic version on an annual basis.

It is the intent of this publication to provide a vehicle for papers on vertical work. All submitted articles containing unsafe practices will be returned to the author. Opinions expressed herein are credited to the author and do not necessarily agree with those of the Editor, the Vertical Section, its members or its Executive Committee. The reader should understand that some material presented in the *Nylon Highway* may be of an experimental nature and is presented herein for peer review. The reader should exercise good judgment and use common sense when attempting new vertical techniques or using new equipment.

WARNING: The reader must acknowledge that caving, climbing, mountaineering, rappelling, rescue work and other rope activities expressed in the *Nylon Highway* are inherently dangerous activities and serious injury or death could result from use and/or misuse of techniques and equipment described in this publication.

See our web page at: http://www.caves.org/section/vertical

Critical Angle Safety Factors

Presented by:

Bruce Smith

Safety Factors

By Bruce W. Smith
On Rope 1, Inc.

NFPA clearly states that prior to "Life-Loading" a System Safety Check should be conducted. This usually occurs in specific steps.

1. A physical and visual check must be made to ensure proper engineering and rigging.
2. A load test should be performed prior to life-loading the system.
3. Verbal confirmation of these actions must be announced and acknowledged before life-loading the rope rescue system.

Numbers 2 and 3 are pretty self explanatory, but number 1 has many intricacies that may take years to learn and master. One part of this inspection should be to ensure that you have engineered your desired safety factor throughout the engineered system. Inspections should take place to include each component and to be sure that a weak link hasn't been mistakenly engineered into the system.

The strength and safety factors of most system elements are intuitive. The strength of many components are stamped on the piece of gear. However, rope and webbing angles are not so intuitive. Determining the safety factor of a critical angle is not commonly discussed. To quantify critical angles in terms of useable safety factors requires looking at the problem from the "perceived load" on the system to then move through the math and determine the actual safety factor.

About the Presenter

Bruce Smith: Bruce has been passionate about rope work for well over 45 years and doing it professionally for the last 14. He was the curriculum developer for the NCRC for a number of years and a corporate educator in his professional life in the years from 1975-1995. He has been a Board Member of the vertical Section since 1971, Chairman, Treasurer, and was the newsletter editor for the Vertical Section for 14 years. He currently owns On Rope 1 and trains NFPA level students to a high degree of competency as rope technicians. On Rope 1 is an ISO 9001 manufacturing and retail facility with a reputation for the highest quality and reliability in the world of rope user products. Recently, in August 2008, he introduced the Vertical Section's Intermediate Training Course for the intermediate rope user at the National Convention. He has strong passions for caving, wild water, and travel, but especially rope work. He first presented at ITRS in 1988.

Safety Factors

By Bruce W. Smith
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Safety Factors and performing System Safety Checks Prior to Life Loading is a concern and important consideration and requirement everytime we rig to save a life.

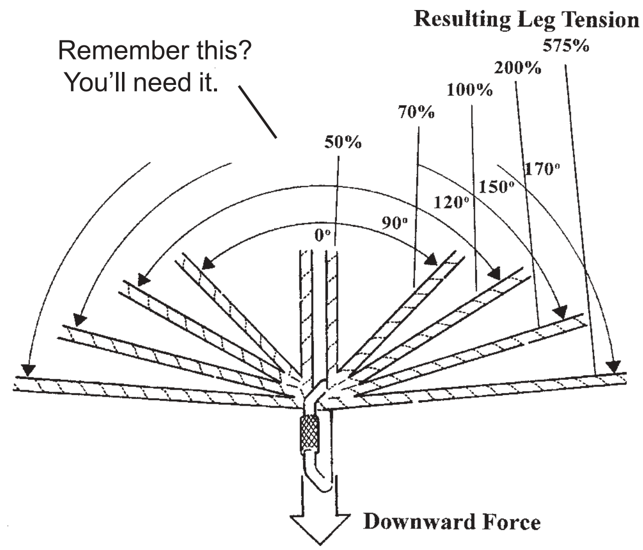
- NFPA asks that we complete a physical and visual check, and verbally confirm that all safety checks have occurred.
- We need to ensure that each element that is to be life loaded, be checked to ensure it is locked, or of the proper size and has a Safety Factor that complements the goals of the situation.

  e.g. An NFPA G rated pulley hs a 36 kN rating. If 1 kN is to be suspended from this pulley, the Safety Factor would be 36 : 1 -- Right?

- Critical angles are not so intuitive. Here is a new way to look at solving this part of **"What's happening when we rig?"**

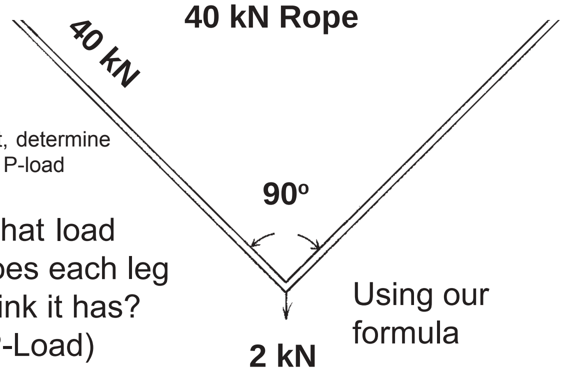
$$\textbf{Safety Factor} = \frac{\textbf{All you've got (support strength)}}{\textbf{Perceived Load (P-Load)}}$$

{P-Load is the load your rig thinks you have}



1.

40 kN Rope



First, determine the P-load

What load does each leg think it has? (P-Load)

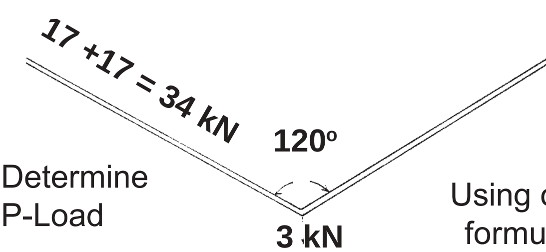
Using our formula

2 kN x 70% = 1.4kN

$$\frac{40}{1.4} = 28.5 : 1$$

2.

W3P2 w/1" tubular webbing



Determine P-Load

Using our formula

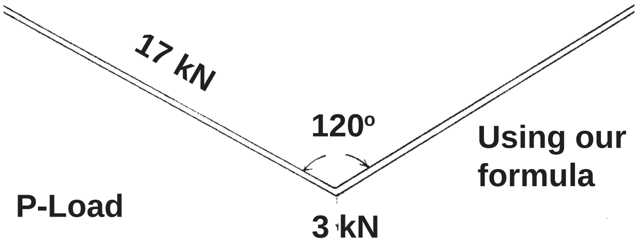
3 kN X 100% = 3kN

$$\frac{34}{3} = 11.33 : 1$$

More Safety Factors on the Critical Angle

3.

W2P1 w/1” tubular webbing



Using our formula

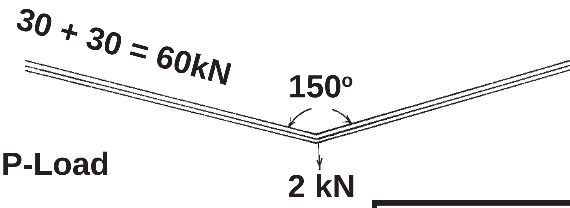
P-Load

3 kN x 100% = 3 kN

$\frac{17}{3}$ = 5.67 : 1

4.

Double Rope High Line w/ 30 kN rope



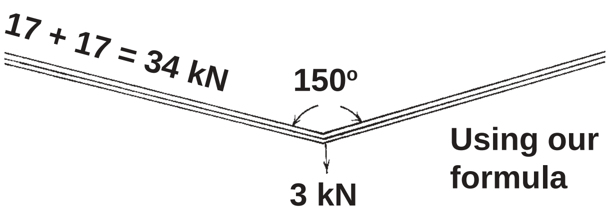
P-Load

2 kN x 200% = 4 kN

$\frac{60}{4}$ = 15 : 1

5.

W3P2 w/ 1” tubular webbing



Using our formula

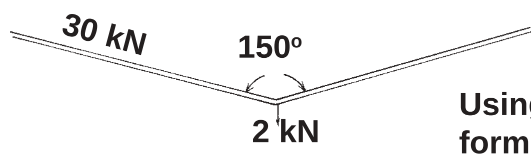
P-Load

3 kN x 200% = 6 kN

$\frac{34}{6}$ = 5.7 : 1

6.

Single rope High Line w/30 kN rope



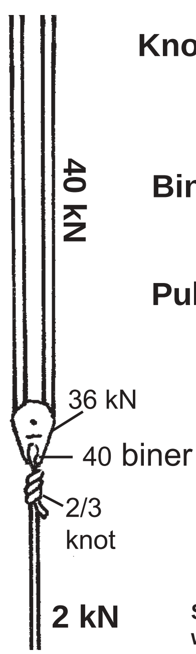
Using our formula

P-Load

2 kN X 200% = 4kN

$\frac{30}{4}$ = 7.5 : 1

7. 40 kN Rope



Knot 2/3 X 40 kN = 26.7 kN

$\frac{26.7}{2}$ = 13.3 : 1

Biner $\frac{40}{2}$ = 20 : 1

Pulley $\frac{36}{2}$ = 18 :1

Critical Angle

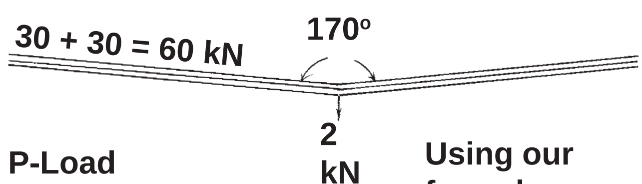
P-Load 0º = 50%

2 kN x 50% = 1 kN

$\frac{40}{1}$ = 40 : 1

Safety factor identifies with the weakest link--- In this case, The Knot!

8. Double High Line w/30 kN rope



Using our formula

P-Load

2 kN x 575% = 11.5%

$\frac{60}{11.5}$ = 5.2 : 1

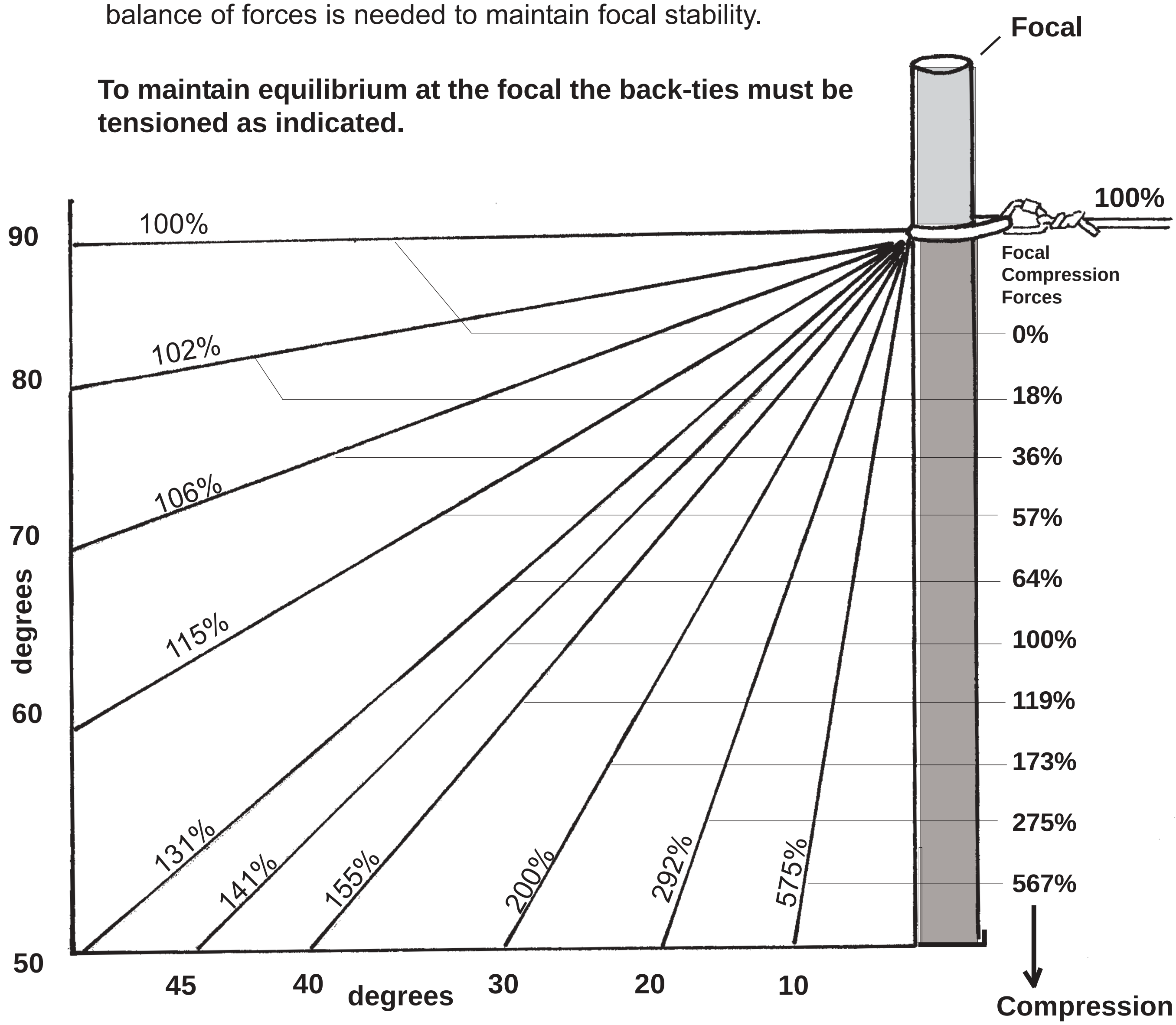
Note: The ultimate safety factor will be lowest of all the individual components--the weakest link so-to-speak. But here is a way to determine a not so intuitive elusive link that is not always obvious. If you’re not sure of the angle, get a **goniometer.**

Bonus Page

Pre-tensioned Back-tie Forces and Compression Forces

The steepness of the pre-tensioned back-tie determines its necessary force. Low angle = low forces, steep angle = high forces. This balance of forces is needed to maintain focal stability.

To maintain equilibrium at the focal the back-ties must be tensioned as indicated.



Compression forces add together if there is more than one

Compression Forces on the Focal

1. The focal must be able to handle the compression forces placed upon it by the Operational lines and Pre-tensioned back-ties.
2. **“Focals in space”** have no compression forces to worry about. Orbs provide the opportunity for clean Focals in space.

Fall Factors: Do They Apply to Rope Rescue and Rope Access?

Presented by:

Jim Kovach

FALL FACTORS: DO THEY APPLY TO ROPE RESCUE AND ROPE ACCESS?

The International Technical Rescue Symposium Jim Kovach

November 6-8, 2009 All About Rope, Inc.

The purpose of this presentation is twofold. One was to offer data showing that fall factors do not apply to static ropes and the other was to gather data for our teams and classes on the forces that might occur from a fall when using our ropes for fall protection. We would also like to encourage others to perform similar tests in the hope of persuading those of you who are members of standards making committees or have input with rope access organizations to consider the following statements: 1) *fall factors do not apply to static rope, 2) fall factors are not an indicator of the severity of a fall when applied to static ropes.*

Before we continue we need to define the term fall factor.

This first definition is from the book **Mountaineering the Freedom of the Hills,** the 1982 edition. *"Fall factor, the ratio of the length of the fall (excluding rope stretch) to the total length of rope between climber and belayer. Thus if the climber places a piece of protection 60 feet out and takes a fall 20 feet beyond it, he will fall 40 feet, with 80 feet of rope out, for a fall factor of 40/80, or ½. The fall factor, rather than the length of the fall, is the major determinant of the force on the climber's body and on the placement that holds the fall: the higher the fall factor, the greater the force."*

This definition of fall factor referrers to dynamic ropes now known as high stretch ropes but today we hope we can look at fall factors from a different perspective, not as climbers using dynamic ropes but as rescuers or rope access personnel using static ropes.

There are two points from that quotation we need to address. Number 1, "the fall factor, rather than the length of the fall, is the major determinant of the force on the climber's body". In our presentation we will show that this is not true with static rope. Number 2 "the higher the fall factor, the greater the force". We will also show how this does not hold true as we apply it to static ropes used for rescue or rope access. We want to make this point very clear that we are not disputing any part of these statements as they apply to dynamic rope or are used in the context of this book. Our presentation is on static ropes and their relationship to fall factors

The International Working At Height Handbook 2001 edition defines fall factor as "Method of working out the proportional seriousness of a fall. It is the relationship between the length of the fall and the amount of rope available to distribute the impact force of the fall." This definition does not differentiate between dynamic or static rope and it implies that the higher the fall factor the greater the severity of the fall.

The US Bureau of Land Reclamation has this definition of fall factor in their Guidelines for Rope Access Work. "The fall factor can be a useful way to describe the proportional seriousness of a fall. The fall factor is defined as the maximum distance a worker can fall divided by the length of rope (or lanyard connection) between the falling worker and the anchor." Notice that they added lanyard connection to the definition.

We first presented our findings on fall factors at the International Technical Rescue Symposium held in Tucson, Arizona in 2000. That presentation indicated that fall factors do not apply to static ropes. Our presentation was followed up in 2001 by Chuck Weber, PMI's quality control engineer and ISO coordinator with his presentation titled FALL FACTORS & LIFE SAFETY ROPES A CLOSER LOOK. In it he stated, "It was confirmed from this line of testing that the static and low stretch ropes exhibit a trend of increasing impact forces generated as the length of drop and rope are increased for any given fall factor." Mr. Weber also prepared a presentation for ITRS 2002 that was presented by Dr. Stephen Attaway titled ANALYSIS OF IMPACT FORCE EQUATIONS. That presentation was followed by Dr. Attaway's own presentation PREDICTING ROPE IMPACT FORCES USING A NON-LINEAR FORCE DEFLECTION. Since then there has not been much presented about fall factors and unfortunately it appears that not enough has been done to convince users of kernmantle rope that fall factors do not apply to static ropes.

As evidence of this please consider the following:

1) In the 2007 edition of SPRAT's Safe Practices for Rope Access Work, section 10.7.3 it states "Where a fall in excess of a factor .25 fall might occur, dynamic rope should normally be used in place of static or low stretch rope" end of quote. So SPRAT is implying that a .25 fall factor is okay and anything else is unsafe on static or low stretch rope.

2) Ropeworks, a highly regarded and well respected rope access training company makes this statement in their manual "Where a fall in excess of a factor .25 fall might occur, dynamic rope should normally be used in place of static or low stretch rope." Again, this implies static rope is not acceptable for any fall factor greater than 0.25.

3) In Annex A Explanatory Material of the NFPA 1983 standard they state "When fall factors of greater than 0.25 are anticipated, such as are possible in lead climbing, dynamic ropes specifically designed for climbing should be considered." Further on it states "A fall factor of 0.25 is the <u>maximum</u> considered for NFPA 1983." In the next paragraph they state "Recent testing indicates that the formula for calculating fall factors may not translate perfectly from dynamic ropes to the more static design ropes used for fire service operations." If we compare this statement to the definition in the 1983 standard, we find that it just adds to the confusion about fall factors. This is the NFPA definition of fall factor. "A measure of fall severity calculated by dividing the distance fallen by the length of rope used to arrest the fall." Our contention is that fall factors <u>are not</u> a measure of fall severity when using static ropes as we use them in rope access or rope rescue.

Fall factors used to be about a climber and their rope. Climbers used dynamic rope and tied themselves in with a knot and were belayed with a technique or device that allowed the rope to slip which helped to dissipate the impact force of a fall.

Rescuers and rope access personnel use static ropes and secure them to an anchor with a knot, then connect themselves to the rope with a rope grab or lanyard and rope grab.

So when a climber took a fall, their fall factor was determined by the amount of rope in service and their impact force was determined by the tightening of their knot, the elongation of their rope and the slippage within their belay technique or device. If fall factors are applied to a rescuer or rope access worker we need to consider the amount of rope in service and any extensions to their systems such as lanyards or prusik loops.

By using static instead of dynamic rope, and by placing our rope grabs and lanyards at the load end of the rope we have changed the dynamics, and the original intention of fall factors.

Here are a few questions we used to help us determine if fall factors apply to the static ropes we use for rescue or rope access.

1) Is fall factor severity determined by the mass? …..Let's compare a fall factor 1 with 300 lbs and a fall factor 1 with 200 lbs.

2) Are higher fall factors always more severe than lower fall factors?

3) Is the fall factor, rather than the length of the fall, the major determinant of the forces on the rescuer or rope access worker?

4) Will drops of the same fall factor create the same force when increasing the length of the drop with all other factors being equal?

5) Is a factor 1 fall always a severe fall?

6) Do fall factors only apply to ropes of the same diameter? …. If not, then how can a fall factor be a measure of fall severity?

7) Is there a difference in forces created with the same fall factor using different diameter ropes?

8) Do fall factors only apply to new rope? If not what is a used rope? Does one fall on a new rope now make it a used rope?

9) Do fall factors only apply to single strands of rope? If not what is the fall severity on a doubled rope? If we loop our rope over an object and put on a rope grab, does that change the definition of dividing the distance fallen by the amount of rope in service?

10) Are fall factors appropriate when using a rope grab?

11) Are fall factors appropriate when using a lanyard as part of a system?

Summary

It is our analysis that the answers we got from the questions we asked prove that fall factors are not appropriate for use with static ropes. We can't pick and choose which ropes we can apply fall factors to or which fall factors apply to a particular rope. If fall factors don't apply to all static ropes that we use, if fall factors are not a measure of fall severity, if fall factors don't apply to our use of lanyards or rope grabs, then fall factors should not be part of our standards.

We believe fall factors should be eliminated from NFPA and Sprat standards. It seems to us it would be more appropriate if the standards addressed the maximum force a rope access worker, rescuer or victim should ever be subjected to. All falls can be serious but by keeping the impact force manageable we can attempt to limit injuries to our rescuers and rope access personnel. As our presentation demonstrates, impact forces are not related to fall factors when using static ropes.

So what is a manageable impact force? The British Columbia Council of Technical Rescue has the following minimum standard: “200 kg mass tied to 3 metres of rope the belay system must be able to withstand a 1 metre drop of the load and stop it in less than 1 metre of additional travel and with less than 15 kilonewtons of force”. This is the original belay competency drop test standard quoted from a presentation given by Arnor Larson back on August 2, 1990.

The instructions for the 540 Rescue Belay state “designed to limit the “relative worst-case fall” of a rescue sized load (i.e. 200-280 kg) to no more than 15 kN peak force and with no more than 1 m stopping distance”. Further on the directions state “Note: due to the distribution of forces between the components that comprise a rescue-sized load, the patient and the attendant are subjected to much less (e.g., less than half for two people of equal mass) of the peak force applied to the rope and belay device.”

So as a rough estimate the BCCTR has said that a victim might be subjected to approximately 7 kN or 1,574 lbf. This figure is less than the maximum 8 kN or 1,800 lbf that OSHA allows an industrial worker in a full body harness to experience and one kilonewton greater than European standards permit. This could be a reasonable starting point for standards making committees to consider since in some instances we may be dealing with an already injured person.

And following that same train of thought, should any fall factor that creates less than 1,800 lbf be acceptable for a rescuer or rope access technician? OSHA doesn't care about the fall factor; they're concerned about the forces created. What should we and those that are writing our standards be concerned about, the fall factor or the impact forces?

FORCES CREATED WITH DIFFERENT FALL FACTORS
ON PMI 12.5, 11 and 10 mm EZ-BEND ROPES

JIM KOVACH
ALL ABOUT ROPE, INC

	12.5 bow-bow	12.5 & 8m	12.5 bow-bow	12.5 & 8m	11 bow-bow	11 & 8m	11 bow-bow	11 & 8m	11 & Shunt	10 bow-bow	10 & 8m	10 & 8m	10 & 8m	10 & 8 m	2-10 & 8m
fall factor	300 lbs	300 lbs	200 lbs	200 lbs	300 lbs	300 lbs	200 lbs	200 lbs	300 lbs	300 lbs	300 lbs	300 lbs	225 lbs	200 lbs	300 lbs
0.25	new	new	pretested	pretested	new	new	pretested	pretested		new	new	used	new	used lanyd	new
1 on 4	1750	1286 3/4"			1363	1299 1 1/2"			696 13 3/4"	1767	1081 n/a		1000 4 3/4"	846 1/2"	1367 1 1/4"
2 on 8	2073	1598 1 1/2"			1880	1565 1 5/8"			699 26 1/4"	1995	1485 4"		1105 12 1/8"		1699 1 1/4"
3 on 12	2122	1750 2"			2132	1585 4"				2196	1458 17 1/4"		1218 6 1/8"		1830 1 5/8"
4 on 16	2306	**C1805 1 3/4"			2095						1581 6 3/8"		1259 4 1/2"		2046 1 1/8"
0.33															
1 on 3	1914	1380 1"			1975	1132 1"			762 12 1/4"		1178 3 1/2"			907 1/4"	1414 3/4"
2 on 6	C 2450				2129	1512 n/a			701 25 1/8"	2257	1463 3 1/4"				1823 1 1/4"
3 on 9	2472				2472	1581 3 3/4"			813 32 1/4"		1434 7 7/8"				2046 1 1/2"
4 on 12	2723				2586	1911 4 3/8"					1451 11 1/2"				2083 2 3/4"
5 on 15	2737				2637						1357 20 1/8"				
0.5															
1 on 2	3154				2066						1521 2 1/8"		1215 2"		
2 on 4	3272	1747 1 1/2"	1767	1360 3/4"	2627	1635 4"	1706	1282 1"		2355	1430 6 3/8"		1507 7"		1992 1 1/8
30" on 60"														1169 1/2"	
3 on 6	2818	2024 3"	1914	1470 1"	2929	1725 7 3/4"	1874	1870 4 1/2"		2730	**C2185 8 1/2"		1742 6 1/4"		2306 1 5/8"
4 on 8	3267	2243 1 3/4"			3019	grounded					1669 10 1/2"				2519 1 7/8"
5 on 10	3539	2291 4 1/4"			3220	1767 3 1/2"					1568 17 3/4"				
1															
1 on 1	2502				2068										
18" on 18"						1531 2 1/8"					1531 2 1/4"			981 1 1/8"	
2 on 2	3267	1725 1 7/8"	1794	1269 1 7/8"	3053	1585 6 1/4"	1512	1373 1"		3009	1605 4 1/4"	1225 n/a	1320 7 1/4"	985 4 1/4"	2110 1 1/4"
30" on 30"															
3 on 3	3483	2243 2 1/2"	2163	1504 1 1/8"	2509	C1945 6 3/8"	1944	1649 1/2"		2855	1750 6 1/8"	1335 n/a	C1360 4 1/8"	1350 1 1/8"	2472 1 3/4"
4 on 4	3912	2431 2 1/4"	2355	1786 1 7/8"	3933	2088 6 1/4"	2250	1894 3"		C 3215	1948 7 1/8"	1910 n/a	1468 7 1/4"	1296 6 1/4"	2744 3 1/4"
5 on 5														1404 5 1/2"	
0.33															
1 on 3															*Shunt failed 1526

bow-bow means bowline at anchor and bowline at mass   12.5 & 8m, 11 & 8m, 10 & 8m means bowline on one end and 8mm Prusik on other end

2-10 & 8m means doubled 10mm rope and 8mm Prusik

pretested means the rope was used in a previous drop test   all ropes were new PMI EZ-Bend except where it states "pretested"   Prusiks were used, three wrap PMI 8mm accessory cord

the numbers to the right of the recorded forces were Prusik or Shunt slippage   the letter "C" in front of a recorded force means Chatillon load cell

none of the Prusiks failed

the bowlines were not backed up and none of the bowlines failed   all but a couple bowlines were easy to untie

*the Shunt had caught 7 drops on 11mm rope with 300 lbs before it failed on this drop on the doubled 10mm rope

*for 2 of the 7 drops the Shunt was attached to a Sterling Marathon 24 inch lanyard and caught a ff 1 (825 lbf) and ff 2 drop (810 lbf) of 300 lbs, before this series of testing

**no reading on Load Cell Central Force Meter

	bowline-bowline	bowline-8mm Prusik	bowline-bowline	bowline-8mm Prusik	
	300 lbs	300 lbs	200 lbs	200 lbs	
fall factor	new	new	pretested	pretested	
0.25					
1 on 4	L-1750 C-1700	L-1286 C-0000 ps 3/4"			L=Load Cell Central Force Meter
2 on 8	L-2073 C-2010	L-1598 C-1245 ps 1 1/2"			C=Chatillon indicator
3 on 12	L-2122 C-2075	L-1750 C-1415 ps 2"			ps=Prusik slippage
4 on 16	L-2306 C-2275	L-0000 C-1805 ps 1 3/4"			
0.33					
1 on 3	L-1914 C-1870	L-1380 C-1035 ps 1"			petested means the rope was new but had been used in a
2 on 6	C-2450 L-2382				previous test
3 on 9	L-2472 C-2420				
4 on 12	L-2723 C-2675				bowline-bowline means the rope was tied to the mass
5 on 15	L-2737 C-2705				and the other end was tied at the anchor
0.5					
1 on 2	L-3154 C-3105				bowline-8mm Prusik means the rope was tied at one end
2 on 4	L-3272 C-3230	L-1747 C-1400 ps 1 1/2"	L-1767 C-1520	L-1360 C-1095 ps 3/4"	and the other end was secured with a Prusik
30" on 60"					
3 on 6	L-2818 C-2765	L-2024 C-2000 ps 3"	L-1914 C-1670	L-1470 C-1230 ps 1"	none of the bowlines were backed up and none of the
4 on 8	L-3267 C-3215	L-2243 C-2185 ps 1 3/4"			bowlines failed
5 on 10	L-3539 C-3485	L-2291 C-2235 ps 4 1/4"			
1					the used Prusiks were triple wrapped PMI 8mm accessory
1 on 1	L-2502 C-2440				cord tied with a double overhand bend
18" on 18"					none of the Prusiks failed
2 on 2	L-3267 C-3220	L-1725 C-1680 ps 1 7/8"	L-1794 C-1745	L-1269 C-1215 ps 1 7/8"	
30" on 30"					
3 on 3	L-3483 C-3440	L-2243 C-2200 ps 2 1/2"	L-2163 C-1910	L-1504 C-1250 ps 1 1/8"	
4 on 4	L-3912 C-3885	L-2431 C-2215 ps 2 1/4"	L-2355 C-2095	L-1786 C-1545 ps 1 7/8"	

FORCES CREATED WITH DIFFERENT FALL FACTORS
ON PMI EZ-BEND 11mm STATIC ROPE

	bowline-bowline	bowline-8mm Prusik	bowline-bowline	bowline-8mm Prusik	bowline-Shunt	
fall factor	300 lbs new	300 lbs new	200 lbs pretested	200 lbs pretested	300 lbs new	
0.25						
1 on 4	L-1363 C-1300	L-1299 C-1250 ps 1 1/2"			L-696 s=13 3/4"	L=Load Cell Central
2 on 8	L-1880 C-1535	L-1565 C-1520 ps 1 5/8"			L-699 s=26 1/4"	Force Meter
3 on 12	L-2132 C-2075	L-1585 C-1535 ps 4"				
4 on 16	L-2095 C-2040					C=Chatillon indicator
0.33						
1 on 3	L-1975 C-1925	L-1132 C- 865 ps 1"			L-762 s=12 1/4"	ps=Prusik Slippage
2 on 6	L-2129 C-2075	L-1512 C-1175			L-701 s=25 1/8"	
3 on 9	L-2472 C-2420	L-1581 C-1240 ps 3 3/4"			L-813 s=32 1/4"	pretested means used
4 on 12	L-2586 C2535	L-1911 C-1865 ps 4 3/8"				in a previous test
5 on 15	L-2637 C-2590					
0.5						bowline-bowline means
1 on 2	L-2066 C-2025					knot used each end
2 on 4	L-2627 C-2570	L-1635 C-1625 ps 4"	L-1706 C-1450	L-1282 C-1030 ps 1"		
30" on 60"						bowline-8m Prusik
3 on 6	L-2929 C-2885	L-1725 C-1720 ps 7 3/4"	L-1874 C-1620	L-1870 C-1645 ps 4 1/2"		means knot one end &
4 on 8	L-3019 C-2970	hit ground				Prusik other end
5 on 10	L-3220 C-3170	L-1767 C-1425 ps 3 1/2"				
1						bowlines not backed up
1 on 1	L-2068 C-2010					no bowlines failed
18" on 18"		L-1531 C-1525 ps 2 1/8"				
2 on 2	L-3053 C-3000	L-1585 C-1280 ps 6 1/4"	L-1512 C-1475	L-1373 C-1110 ps 1"		Prusiks were used, three
30" on 30"						wrap PMI 8mm accessory
3 on 3	L-2509 C-2775	C-1945 L-1592 ps 6 3/8"	L-1944 C-1700	L-1649 C-1395 ps 1/2"		cord tied with a double
4 on 4	L-3933 C-3880	L-2088 C-2080 ps 6 1/4"	L-2250 C-2180	L-1894 C-1650 ps 3"		overhand bend
5 on 5						
						none of the Prusiks
						failed

FORCES CREATED WITH DIFFERENT FALL FACTORS
ON PMI 10mm EZ-BEND STATIC ROPE

JIM KOVACH
ALL ABOUT ROPE, INC

	bowline-bowline	bowline-8mm Prusik	bowline-8mm Prusik	bowline-8mm Prusik	bowline-8mm Prusik	doubled 10mm-8mm Prusik
fall factor	300 lbs new	300 lbs new	300 lbs used lanyard	225 lbs new	200 lbs used lanyard	300 lbs
0.25						
1 on 4	L-1767 C-1420	L-1081 C-1030		L-1000 C- 940 ps 4 3/4"	L-846 ps 1/2"	L-1367 ps 1 1/4"
2 on 8	L-1995 C-1940	L-1485 C-1430 ps 4"		L-1105 C-1045 ps 12 1/8"		L-1699 ps 1 1/4"
3 on 12	L-2196 C-2150	L-1458 C-1410 ps 17 1/4"		L-1218 C-1160 ps 6 1/8"		L-1830 ps 1 5/8"
4 on 16		L-1581 C-1530 ps 6 3/8"		L-1259 C-1195 ps 4 1/2"		L-2046 ps 1 1/8"
0.33						
1 on 3		L-1178 C-1135 ps 3 1/2"			L-907 ps 1/4"	L-1414 ps 3/4"
2 on 6	L-2257 C-2205	L-1463 C-1405 ps 3 1/4"				L-1823 ps 1 1/4"
3 on 9		L-1434 C-1370 ps 7 7/8"				L-2046 ps 1 1/2"
4 on 12		L-1451 C-1405 ps 11 1/2"				L-2083 ps 2 3/4"
5 on 15		L-1357 C-1315 ps 20 1/8"				
0.5						
1 on 2		L-1521 C-1450 ps 2 1/8"		L-1215 C-1210 ps 2"		
2 on 4	L-2355 C-2295	L-1430 C-1385 ps 6 3/8"		L-1507 C-1495 ps 7"		L-1992 ps 1 1/8"
30" on 60"					L-1169 ps 1/2"	
3 on 6	L-2730 C-2380	L-0000 C-2185 ps 8 1/2"		L-1742 C-1535 ps 6 1/4"		L-2306 ps 1 5/8"
4 on 8		L-1669 C-1630 ps 10 1/2"				L-2519 ps 1 7/8"
5 on 10		L-1568 C-1510 ps 17 3/4"				
1						
1 on 1						
18" on 18"		L-1531 C-1485 ps 2 1/4"			L-981 ps 1 1/8"	
2 on 2	L-3009 C-2950	L-1605 C-1565 ps 4 1/4"	L-1225	L-1320 C-1265 ps 7 1/4"	L-985 ps 4 1/4"	L-2110 ps 1 1/4"
30" on 30"						
3 on 3	L-2855 C-2515	L-1750 C-1710 ps 6 1/8"	L-1335	C-1360 L-1252 ps 4 1/8"	L-1350 ps 1 1/8"	L-2472 ps 1 3/4"
4 on 4	C-3215 L-3110	L-1948 C-1915 ps 7 1/8"	L-1910	L-1468 C-1210 ps 7 1/4"	L-1296 ps 6 1/4"	L-2744 ps 3 1/4"
5 on 5					L-1404 ps 5 1/2"	
0.33						
1 on 3						Shunt failed 1526 after
						multiple drops
L=Load Cell Central Force Meter, C=Chatillon indicator, ps=prusik slippage						
bowline-bowline means knot used each end, bowline-8m Prusik means knot one end and Prusik other end						
Prusiks were used, 3 wrap PMI 8mm accessory cord tied with double overhand bend, bowlines not backed up						

On the Utility of Rescue Randy Mannequins in Rescue Systems Drop Testing

Presented by:

Tim Holden, Bill May

&

Rich Farnham

On the Utility of Rescue Randy Mannequins in Rescue System Drop Testing

Tim Holden[1]
Bill May[2]
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1. Introduction

In 2007 the Rocky Mountain Rescue Group (RMRG) received a grant from the Mountain Rescue Association to subsidize the purchase of three Rescue Randy[4] mannequins to support a series of vertical evacuation system tests. The test plan was intended to evaluate the ramifications of main line failures in two widely used vertical evacuation systems: a two line “scaffolding” system, and a main line plus belay line system. It was clearly undesirable to use actual rescuers in these tests, and it was predicted that the use of steel weights in place of the rescuer(s) and patient would produce unrealistic and potentially misleading results.

Prior to initiating the full system testing, it was important to determine how well the Rescue Randy mannequins simulated actual humans in drop tests. It was also relevant to establish whether the Rescue Randy mannequin was sufficiently better as a human-body analog, when compared to steel plates, to merit the additional cost and complexity associated with the mannequins.

This paper provides an overview of the testing performed to evaluate the utility of Rescue Randy mannequins in rescue system testing. Low impact force comparisons were made among actual humans, Rescue Randys, and steel plates. Higher impact force comparisons were made between Rescue Randys and steel plates (for these tests the risk to human subjects was deemed too high). For drop tests designed to determine realistic peak forces or force histories, it was found that the results produced using Rescue Randy as a test load differ significantly from results produced using steel plates; the Rescue Randy results better simulate the results expected with a human load. Specifically, tests with the steel plates provide realistic peak forces and force histories only for scenarios with significant energy absorption, and lacking inherent nonlinearities (for example, breaking bartacks or slipping prussiks). For determining forces generated by drops on highly static systems, or on systems with inherent nonlinearities, the use of Rescue Randy produces more realistic results.

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[1] Qualified Member, Rocky Mountain Rescue Group
[2] Retired Qualified Member, Rocky Mountain Rescue Group
[3] Qualified Member, Rocky Mountain Rescue Group
[4] 165 lb. model, manufactured by Simulaids, Inc.

This paper is organized as follows: Section 2 provides a detailed description of the test tower and equipment used in this testing (additional detail is provided in an appendix). Section 3 describes the Rescue Randy mannequins, including the harness arrangement used in this testing. Sections 4 and 5 contain results from representative testing for low force tests and high force tests, respectively. For each scenario, the tests were conducted multiple times to verify accuracy and repeatability. In this paper, "typical" results are presented. The results of testing are discussed in Section 6.

2. Test Tower and Equipment

The testing presented in this paper was conducted on RMRG's 35 foot (10.7m) tall steel test tower (Figure 1). The tower is outfitted with a hoist and a stack of thirty 33 lb. (15 kg) steel plates (for a total of 1000 lb. (455 kg)), which can be used to create a wide range of test loads. Drops are initiated using a pneumatic release mechanism (McMillan Design's "Sea Catch"), which can be triggered either manually or via computer. Additional details of the tower are provided in Appendix A.

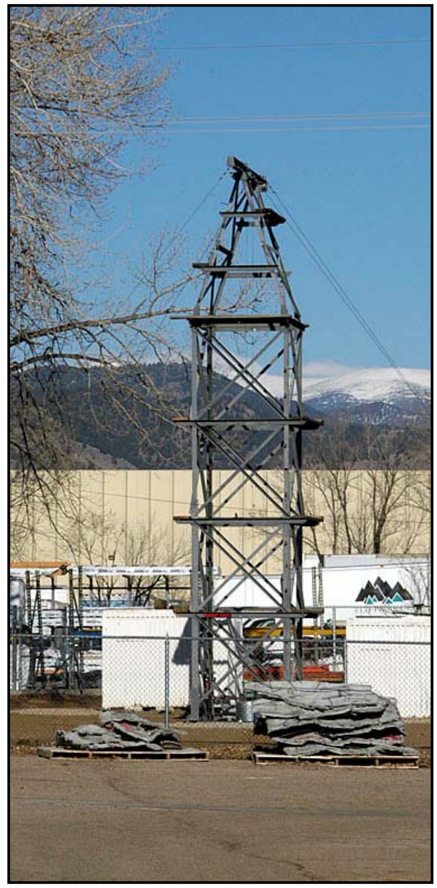


Figure 1: The RMRG test facility includes a 35' (10.7m) tall test tower, with 1000 lb (4.45N) of steel weights and a built-in hoist.

Data is collected by a Lenovo Thinkpad, with a National Instruments data acquisition card Model 6251, and running LabView 8.2. A variety of sensors are available, including temperature sensors, load cells, and a custom-made distance measurement system using rotary encoders (string pots). The load cells have an operational range up to 10,000 lb (44.5kN).

Significant test errors can result from using measurement devices that collect data at a rate slower than the phenomena being measured. For this reason, the load cells and data acquisition system were characterized to establish that their data sampling rates were sufficiently fast for this type of testing. Testing showed that the load cells have a self-resonant frequency near or above 7 kHz, and that the data acquisition amplifier has an effective bandwidth of roughly 5 kHz. This allows sampling rates greater than 2500 samples/second, which is more than adequate to capture the critical information in these drop tests.

3. Rescue Randy

The Rescue Randy is a commercially produced mannequin (from Simulaids Inc.), weighing 165 lbs (75 kg)[5]. For their intended use in training by emergency response personnel, the Randys simulate the weight, weight distribution, and articulation of a human. However, they are not intended to have (or at least they aren't marketed as

[5] Simulaids also sells lighter and heavier mannequins, and they sell separate weight vests to allow for heavier simulated patients.

having) human-like response to dynamic loading, including energy absorption and damping effects.

A great deal of experimentation was used to determine the ideal method of attaching the Rescue Randys to the system in order to get the most human-like behavior (and force histories) from them. The Rescue Randys were each fitted with a standard climbing harness; however, because the mannequins are significantly top-heavy, and lack muscles to keep themselves upright, they hang head-down with an arched back unless they are provided with additional support. For this reason they were fitted with chest harnesses to maintain the more upright body position typical of a live rescuer[6]. This position (Figure 2) made Randy a better analog, but also limited his movement during an impact. Slow motion video of a falling human shows that all body parts don't start falling simultaneously. For a human suspended by his waist, when the tension disappears, some parts of the body initially move upward relative to the body, even though the center of mass is moving down. Likewise, at the end of a drop, as the system pulls on the harness to stop the falling human, not all parts decelerate at the same rate. The distribution of this deceleration over time is one of the reasons that peak force is lower with a human in the system than with steel plates. Randy's limbs do not respond as well as a human's, but his articulation does allow for some distribution of acceleration and deceleration over time during drops. A properly designed chest harness does not limit this movement.

Figure 2: The Rescue Randy mannequins were typically fitted with a chest harness to better emulate a rescuer's body position.

The Rescue Randy's chest harness was tied with 1 inch nylon tubular webbing. It was found that keeping the chest harness as high as possible produced the most human-like

[6] Attempts to make the Rescue Randy "grip" the litter rail prior to drops were unsuccessful.

body position. The chest harness was joined to the seat harness with a single loop of 1 inch nylon tubular webbing (water knot to close the loop). The effect of knot tightening in these harness connections was found to be insignificant after the first drop onto a freshly-tied chest harness. Variations of the chest harness were tested, including clipping the chest harness and the seat harness directly into the knot in the main line, each with its own carabiner (this is the configuration shown in Figure 2), which did not produce a significant change in the force history. In general, small changes in the tilt of Rescue Randy's body had little effect on the force history generated during isolated drop tests.[7]

For the Rescue Randy to be a useful test subject, drop test results employing it had to be repeatable, i.e. similar drops needed to produce similar measurements. Producing this repeatability turned out to be somewhat challenging. The manufacturer sells a special plastic reinforcement piece (a "truss"), to be used if the Rescue Randy will be hanging in a harness. The truss spans between his thighs to keep the harness leg loops from sliding into the hip joints. If the harness slid into the hip joint, the Rescue Randy behaved more like a rigid mass, significantly changing the forces measured during drops. After several repeated drops, the plastic trusses broke. New steel trusses were fabricated, thereby increasing the overall mass by a few pounds. This reinforcement helped, but did not completely prevent the harness leg loops from going into the hip joints. Although the harness-in-hip problem was mitigated, it was found that variations in the force v. time histories resulted from varying the initial position of Randy's limbs for a given drop. In general, we were most successful at getting repeatable results when we kept the mannequin's harness positioned as it would be on a human, and his limbs oriented consistently (arms hanging straight down).

4. Low Impact Force Testing

A number of distinct tests were run to compare the behavior of humans, Rescue Randy, and steel plates in drop tests. For obvious reasons, these three-way comparisons were limited to tests that resulted in low forces safe for humans to endure. The goal of these tests was twofold: to look at qualitative (behavioral) differences among the loads, and when a test involved a human subject weighing the same as the Rescue Randy, to compare quantitative results as well.

A typical low-force test was to drop each of the three loads (steel plates, a Rescue Randy, and human), using 8 inch (20.3 cm) drops onto 66 inches (1.67 m) of steel cable[8]. With a fall factor of <0.12, these would seem to be low force tests; however, because of the extremely low energy absorption of the steel cable, these drops can generate surprisingly high forces, and the load itself may provide the majority of the energy absorption and damping. Figure 3 shows typical force histories for these drops. Peak forces for the Rescue Randy and the human are 712 lbs (3.17 kN) and 647 lbs (2.88 kN)

[7] The pendulum tests, described later, and vertical system failure tests that we have conducted, have demonstrated that the Rescue Randy's initial orientation – either facing the direction of swing or facing across the direction of swing – does influence the generated forces. In tests that involved movement in more than one direction, repeatable results were achieved when the Rescue Randy started in the same body position relative to the system and the direction of movement.

[8] The cable is 3/16" 7x19, Mil Spec Mil-W-83420 aircraft cable (non-jacketed), also called "wire rope".

respectively, and they scale approximately with the dropped weights (712 lbs/647 lbs = 1.10 and 170 lbs/158 lbs = 1.08). Both of these loads absorb a significant amount of energy, and show similar damping. The peak force generated by the steel load was more than 3 times the peak forces generated by the other two loads. The ratio of the peak force to the load weight for steel is 13.5, much larger than the same ratio for Randy (4.2) or for the human (4.1). Qualitatively, the force histories for the Rescue Randy and the human are quite similar; on the other hand, the steel plates show a very different behavior, including much higher peak forces, distinctly less damping (including a conspicuous bounce during which tension in the cable drops to zero), and a chaotic ringing. It is clear here, as in most of the other testing, that despite having somewhat less intrinsic damping than a human, the Rescue Randy emulates the human much better than the steel plates do.

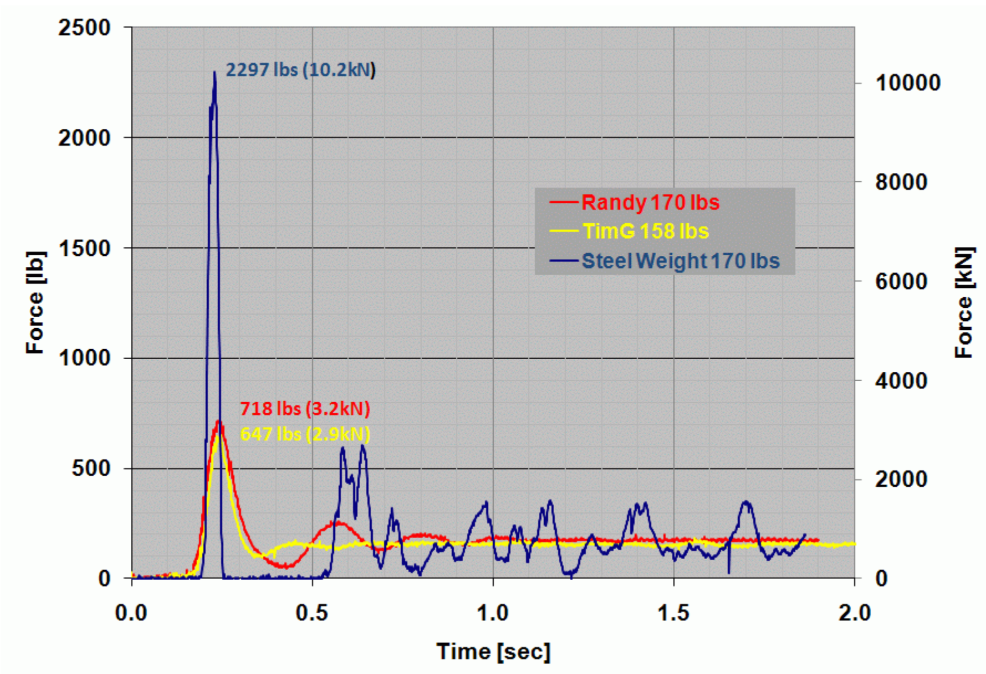


Figure 3: Force v. time histories of short drops (8") onto 66" of 3/16" aircraft cable show very different results for the three different loads.

A second type of low-force test again used steel cable, (the 3/16" aircraft wire rope) but this time in pendulum drops rather than vertical drops. These drops were done on 66.5 inches (1.7m) of steel cable, with the load initially displaced 37.5 inches (0.95m) horizontally from the anchor (see Figure 4), resulting in a vertical displacement of 11.6 inches (0.29m). The cable was under tension prior to load release. Figure 5 shows the force histories for each of the three loads. The human load and the Rescue Randy again show qualitatively similar behavior, with some large initial rapid oscillations (associated with rocking of the load at the bottom of the cable), followed by slower pendulum oscillations. The damping of the rocking motion and the peak forces are similar for the human and the Rescue Randy. The behavior of the steel plates is distinctly different in character, and shows significantly higher peak loads. The oscillations of the steel weights about their attachment point to the cable are conspicuous, and do not damp out as quickly as the oscillations of the mannequin or human.

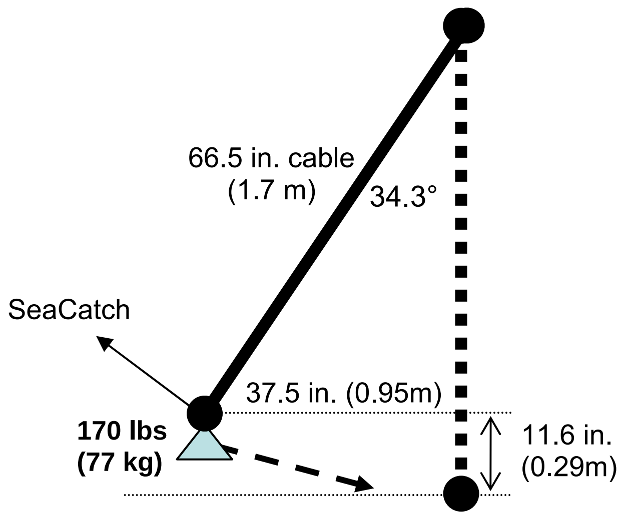


Figure 4: Pendulum drops were performed using 3/16" steel cable.

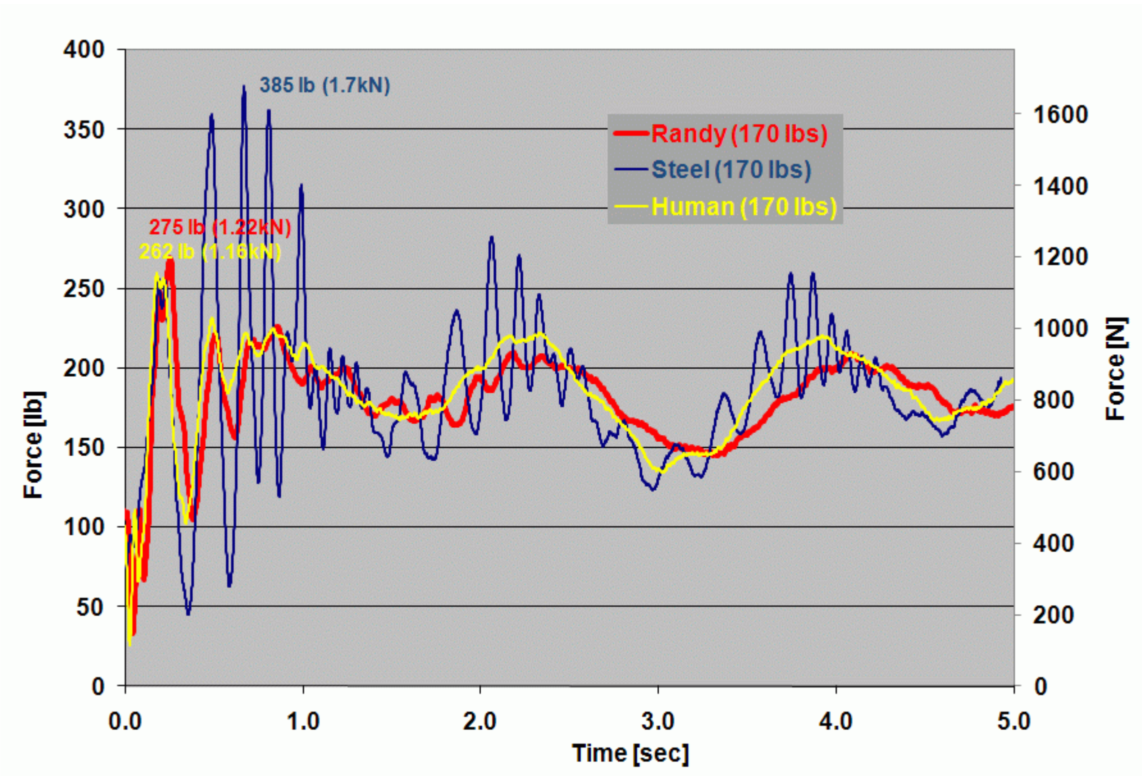


Figure 5: Force v. time generated by steel plates, Rescue Randy, and a human during pendulum drops on steel cable (3/16" aircraft wire rope).

A third test implemented fall factor $^1/_3$ drops on Goldline, a very dynamic rope (Figure 6); the resulting peak forces (and distances) are similar to relatively gentle climbing lead falls. In each test, the drop used 10 feet (3m) of Goldline with a bowline tied in each end (the length is measured from loop-end to loop-end). The knots were pre-tensioned to ~200 lb. (890N) to provide more consistent energy absorption at the knot. In this series of drops, the human subject weighed about 14% more than the mannequin or steel load. Even so, the peak forces were highest for the steel load, and lowest for the human. Note that while the peak force of 808 (3.6kN) for the human drop is close to the 828 lb (3.7kN) peak force generated by the Rescue Randy, the results are not actually that close due to the higher weight of the human. If the system response is assumed to be linear, the peak force for a 176 lb (80 kg) human would be approximately 708 lb (3.2kN), about 85% of the peak for the Rescue Randy and only about 78% of the peak for steel plates. For these tests, the damping behavior of the Rescue Randy more closely resembles that of steel than that of the human body. In all of these drop tests, the results are dominated by the high energy absorption of the Goldline rope.

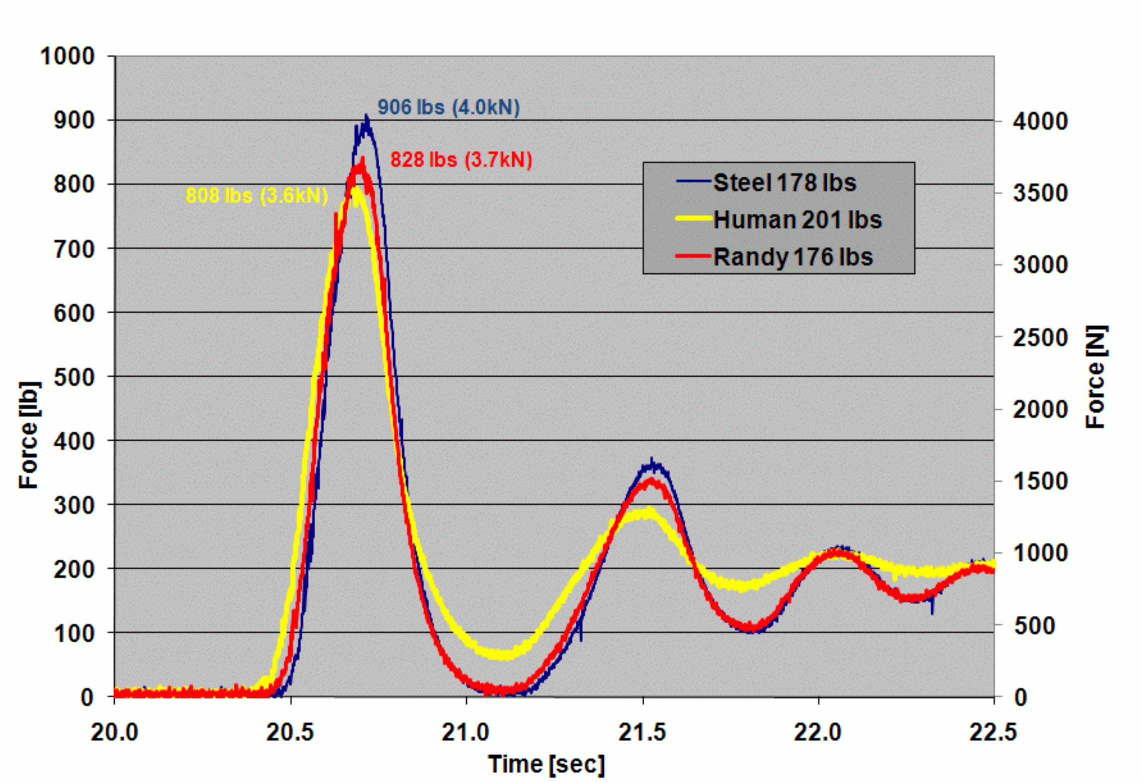


Figure 6: Force v. time for fall factor 1/3 drops on 10 ft 7/16" Goldline rope (dynamic) using three different loads.

5. Higher Impact Force Testing

Higher force testing was performed comparing only Rescue Randy and steel plates; these tests were considered too risky for direct comparison with human subjects. The goal of these tests was to look again at qualitative (behavioral) differences between the observed forces, and when appropriate to compare the peak forces generated by loads of similar weight.

One set of high-force tests consisted of fall factor ½ drops onto static rope with knots. These drops generated qualitatively different damping histories for steel plates and for Rescue Randy. Figure 7 shows the force histories as a function of time for drops onto 10 feet (3m) of PMI MaxWear tied with bowlines in each end (again, pre-tensioned to ~200 lb (890N)). As expected, the peak loads are roughly 25% higher using steel weights versus using the Rescue Randy. Both loads show a distinct bounce after first impact; the damping is much more rapid with the Rescue Randy.

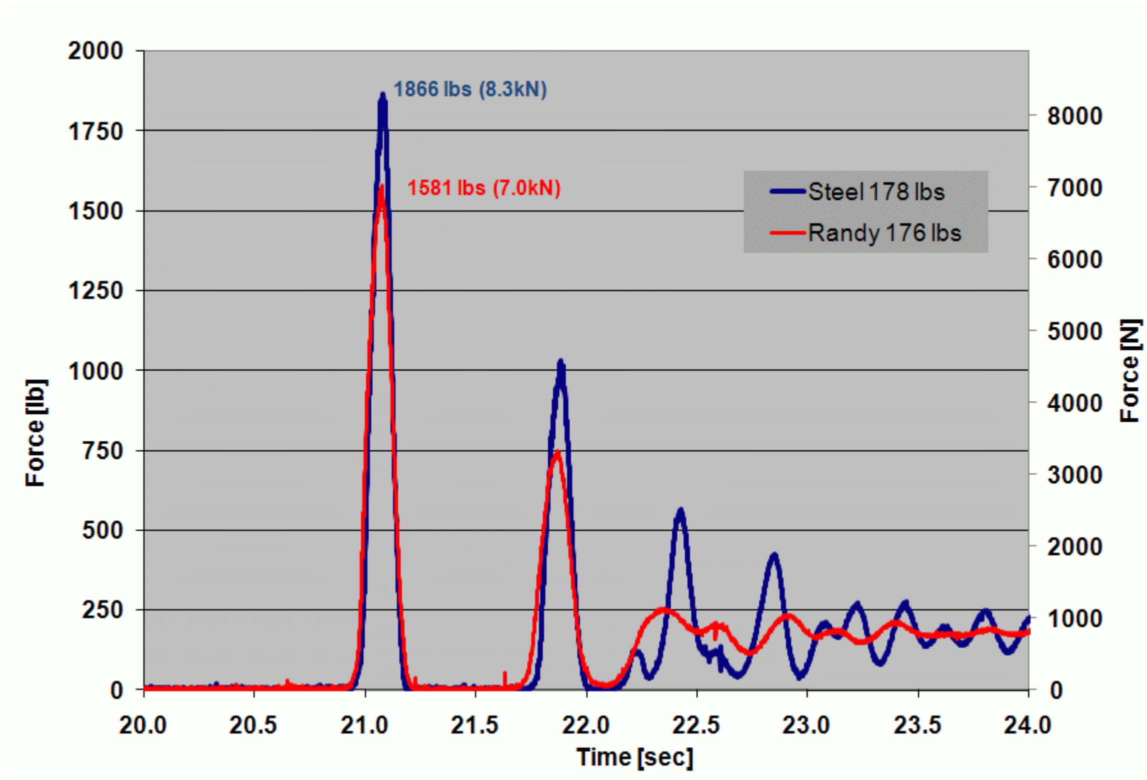


Figure 7: Force v. time histories for fall factor 1/2 drops on 10 ft (3 m) PMI MaxWear, 11mm, comparing steel load with Rescue Randy.

Another high force test consisted of fall factor 1 drops onto Spectra daisy chains. All of these tests were conducted using Black Diamond ½" Dynex (Spectra with a small amount of nylon) daisy chains. Some of the daisy chains were 55 in (140 cm) with 14 bartack sets, and some were 45 in (115 cm) with 12 bartack sets; but in none of these drops did all of the bartacks break (in which case we would expect a spike in the peak force). All the daisies were manufactured with 2 tacks per bartack set (providing similar energy absorption per bartack set). Figure 8 (vertical bar chart) shows that the peak forces vary significantly even for a given type of load. The peak forces generated by the steel plates are anywhere between 5% and 37% greater than the peak forces generated by the Rescue Randy. The diamond markers in Figure 8 show the number of bartacks broken for the five drops. Measured this way, the differences between the steel load and the Rescue Randy are obvious: much more energy was absorbed by the many bartack failures during the drops of steel weights (the energy being associated with not only the greater number of bartacks broken, but also the larger total distance through which the load fell). In other words, much more energy was absorbed by the Rescue Randy than by the steel plates, indicating unrealistic results for tests with steel weights simulating drops with humans.

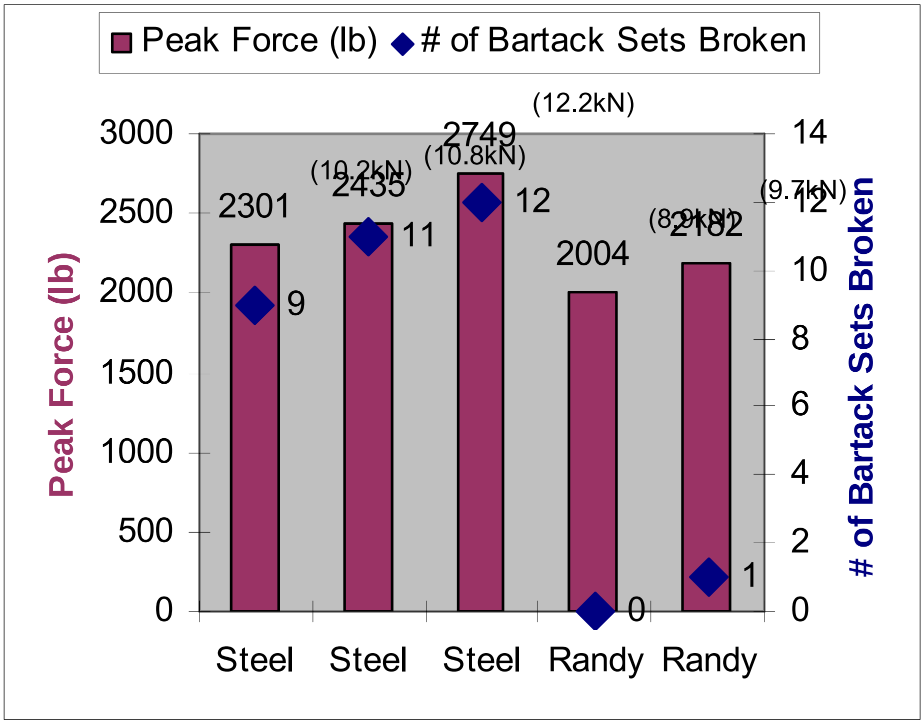


Figure 8: Peak force and # of bartack sets broken for fall factor 1 drops on Spectra daisy chains

The final high-force tests included here were fall factor 1 drop tests onto Purcell prussiks (Figure 9-10). This test was conceived after it was noticed that Rescue Randy and steel plates generated significantly different forces in systems that had nonlinear behavior, such as when daisy chain bartacks break, or presumably when a prussik slips.[9] The Purcells were made from Beal 7mm static cord, and were tied with three wrap prussiks; the load was attached to the small loop, and the large prussik loop was attached to the fixed load cell. These tests were run for Purcells of two lengths (80 cm and 130 cm), all with similar results. Figure 10 shows the (typical) force v. time histories for two drops, one with a load of steel plates, and the other with a Rescue Randy. In both data plots, the initial slip of the prussik is conspicuous, followed by the prussik catching the load and creating peak forces. In various tests, the force at which the prussik initially slips varies considerably (this variability is normal for prussiks in general); however, in all cases the peak force for the steel load is approximately 35% higher than for the Randy, again indicating unrealistic results for tests with steel weights simulating drops with humans.

[9] Recent testing by Gibbs (*Daisy Chains and Other Lanyards: Some Shocking Results when Shock Loaded*, ITRS 2005) did a thorough examination of daisy chains and Purcells (among other lanyards) using steel loads. Our goal was to determine whether the use of Rescue Randy as a test load might result in significantly different results.

Figure 9: Drops were conducted on Purcell prussiks using two different loads

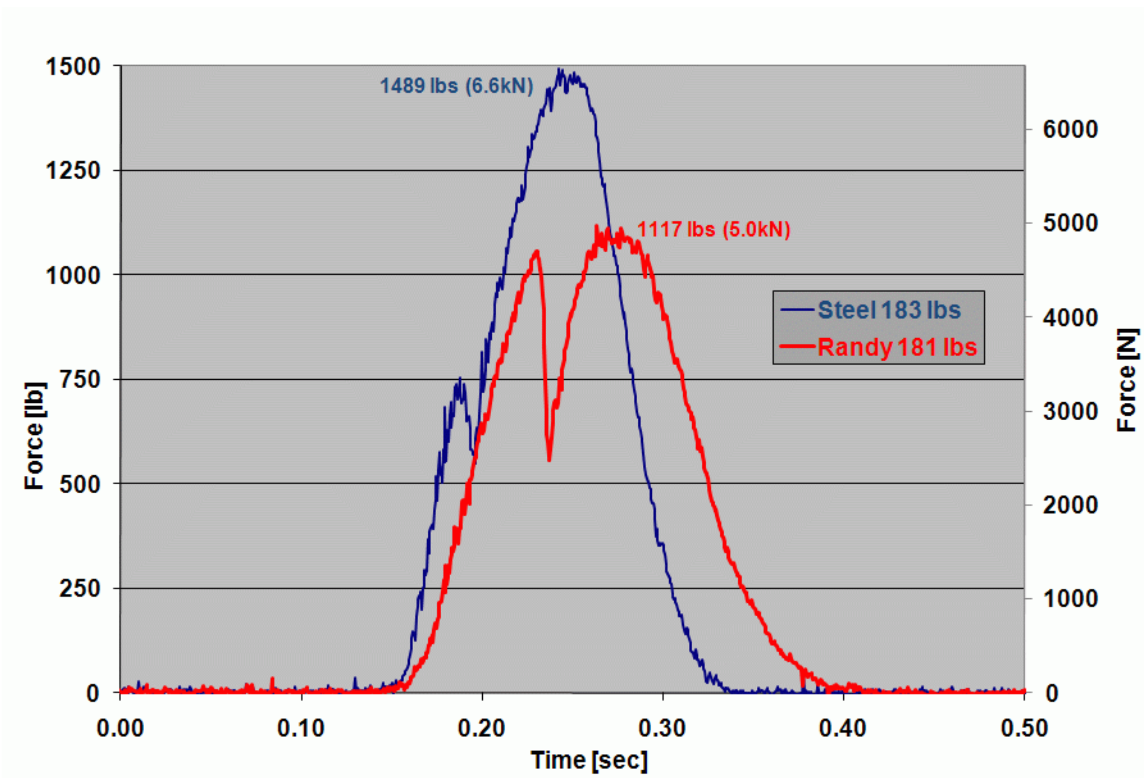


Figure 10: Typical peak force v. time for drops of steel and Randy onto Purcell prussiks, using Beal 7mm static cord and 3-wrap prussik, FF=1

6. Discussion of Results

All of the low-force testing indicated that in drop testing scenarios the Rescue Randy mannequin provides a better analog for the human body than steel weights do, and for some systems, a *much* better analog. Similarly, the high-force testing showed potentially important differences between the behavior of the mannequins and the behavior of steel plates in drop testing; however, the question of whether the use of Randy is worth the added expense and complexity of testing is more difficult to answer.

Drop tests generally come in one of three flavors: dropping to determine the breaking strength of certain components or sets of components, dropping to determine if a particular scenario does break a system, or dropping to determine realistic estimates of the forces generated by specific scenarios. Clearly, steel loads are adequate for breaking components; however, for the latter types of testing, trying to determine the survivability of a system or to determine realistic forces in specific scenarios, it is clear that Rescue Randy is valuable as a test load. The primary conclusion from the wide variety of testing performed is that steel weights provide an adequate and cost-effective test load for simple peak-force measurements of drop testing on systems *only* if the *system* being tested is inherently capable of absorbing significant amounts of energy. As shown in Figures 6 and 7 (for a dynamic rope and for a rope with knots not previously loaded), in systems with energy absorption potential *based on elongation of components*, the steel loads produce conservative peak forces but similar initial dynamic behavior. Note that we include the drops onto the low stretch MaxWear rope as having sufficiently high energy absorption potential, because the knots in the system absorb significant energy beyond what can be absorbed by the rope itself.[10] Drop tests using steel loads with such systems will produce conservative (high) peak forces, but this often satisfies the requirements of the testing. If the goal of the testing is *realistic* forces, or realistic damping and dynamic behavior beyond the initial impact, then the mannequins show a significant advantage: more realistic force measurements.

More significantly, for dropping onto highly static systems such as steel cable (Figures 3 and 5), or for dropping onto nonlinear systems such as Dynex (Spectra) daisy chains (Figure 8) or Purcell prussiks (Figure 10), the use of a steel load can lead to significantly unrealistic results (much higher peak loads, significantly more bartacks broken, very different dynamics, etc.). In these tests, the use of steel loads may produce grossly misleading results rather than just conservative (higher force) results. Although it adds significant cost, *realistic* force data combined with adequate analysis (material strengths, etc.) will lead to better system designs and operating procedures.

We have developed a mathematical model allowing for predicting whether a particular simple drop test using steel weights would have produced significantly different peak loads with a mannequin. The model has undergone only limited validation, but our results so far support its validity. For the interested reader, further details are provided in Appendix B.

The impetus for this mannequin evaluation was to support a program of testing main line failure scenarios in vertical evacuation systems. The primary question was whether the added expense and complexity of using Rescue Randys in place of steel weights was justified; additional questions pertained to such topics as whether drops on Randy produced repeatable results. While our vertical system testing has demonstrated that there is generally a large reservoir for energy absorption in a complex litter system (main

[10] Note that these were fairly short drops, relative to which the tensioning of the knots represented a significant amount of energy absorption. For longer drops *with the same FF*, the knots become less important, and the system begins to behave more statically. Additionally, if drops are conducted a second time on the same knots, the system behaves more statically. In either of these alternative scenarios, the steel load produces less realistic forces.

line, main line tie-in knot, spider tie-in knot, spider leg knots, spider materials, litter bearer tie-in material and knot, slip in the brakes, etc.), the comparative testing described here indicates that the use of steel loads would likely produce unrealistic peak forces and unrealistic dynamics in these tests.

Appendix A: Further Detail on the Test Tower and Equipment

Tower Structure

The testing facility is outdoors, thus without temperature or humidity control. We do note weather conditions for the day realizing that nylon properties vary with ambient conditions.

The **tower itself** is a 35 ft (10.7m) steel structure originally used in a high voltage transmission line, 6 ft (2m) square at the base. The structure is mounted on a very substantial underground concrete foundation and is further secured from tipping by four guy wires to Manta Ray earth anchors. Maximum peak drop loads are limited operationally to 10,000 lbs (44kN).

A 14 ft **horizontal beam** was added across the top, cantilevered 4 ft (1.2m) outward from each side. This beam is built from two 6” (15 cm) C-channels and is used to support load anchors, pulleys, etc. The center of the beam deflects <0.1” (<0.25cm) under 8000 lb (35.6kN) load, and the outboard end of the cantilevered beam deflects <0.6” (<1.5cm) at 5000 lb (22.3kN) load. These deflections were calculated using an Ansys Mechanical FEA , for AISI 1005 steel, E=29,000 ksi, Poisson’s Ratio 0.29, and confirmed via measurement.

The steel **drop weight** is a stack of up to thirty plates 33 lb (147N) each, for a maximum of 1000 lb (4.45kN). Several additional smaller weights are available for ‘fine tuning’ the dropped weight.

The weight can be guided by an **arm** running on low friction wheels in a **track**, positioning the weight at the center of the tower. The vertical motion of the arm is measured by a string and rotary optical encoder.

A Cordem Golo power **winch** Model 1200 is used to lift the weight stack.

Extension bars (7/8” dia.) hung from the high horizontal beam are used to position anchor points as needed, internal or external to the tower. The anchor point usually supports a load cell and the release device.

The load **release device** is a pneumatic McMillan Design’s “Sea Catch”, controlled manually or by computer.

Instrumentation

Most data is recorded by computer; simple load cell monitoring readouts may be used on occasion.

The **computer** is a Lenovo Thinkpad R60 with sufficient performance to cause no limitation in our measurements.

Data acquisition is by a National Instruments M series USB-6251 DAQ, 16 bit with 1.25Msamples/sec input.

Software is LabView 8.2 programmed to accept 8 bipolar channels of analog input and 2 counters, with a digital output for load release control.

Video (not high speed) and still **photography** are used to document experiment set ups and actual tests, synchronizing the image time with computer file time.

Various sensors are available.

The **load cells** are Honeywell (Sensotec) with 2000-lb or 10,000-lb rating.

Rotary **optical encoders** (DataTorque, HP) are used with pulley and Kevlar string to record distance at 500 counts/revolution, providing high resolution.

T**hermocouples** imbedded in a device are used occasionally for temperature rise measurements.

Amplifiers

InLine amplifiers are used with the load cells to provide necessary signal level for the analog input to the DAQ card. Cables between load cell and computer are 75 ft (23m) with amplifier near the load cell. The actual load cell excitation level is sensed to eliminate errors from cable length. A shunt calibration resistor is available to unbalance the load cell bridge and give a calibration check. All inline amplifiers are Sensotec Universal series powered from the computer interface.

Rotary optical encoders use quadrature converters at the encoder, providing suitable signal conditioning for the DAQ counter inputs. The pulse output of the quadrature converters is chosen long enough so that capacitance of the cable is not a limitation, and short enough that there is no pulse overlap at the highest speeds.

Thermocouples use a Fluke TC-to-millivolt temperature converter giving an adequate analog signal to the DAQ, resolving better than 1deg C or F.

Monitoring of load cell output is normally done with the computer and LabView, but on occasion, a Honeywell (Sensotec) portable instrument Model NK is used for convenience. The NK allows monitoring of the real-time load while storing the peak load since last reset; the peak detecting circuit has shorter than 1ms response time.

Resolution, Calibration, Speed, Bandwidth Issues

Resolution - load cell. With the inline amplifiers, the signal at the maximum 10,000 lb load to the DAQ is 10 volts, i.e. 1 lb is 1 mv = 0.001 volt. The resolution of the DAQ is better than that. Noise is a bigger limitation - we see typically +/- a few lbs of noise. The precision of a few lbs is entirely adequate for our studies.

Resolution - distance. The rotary encoders have 500 counts/revolution, each count is resolved. With the pulleys in use, that becomes a linear distance of only 0.16mm, much better resolution than we need. We have not seen dropped counts in high-speed encoder performance testing.

Calibration, accuracy. Load cells are specified to ~0.2% full scale for various characteristics (shunt calibration, linearity, repeatability, temperature, etc.). We expect and are satisfied with 1%. Likewise, we expect and are satisfied with 1% for the distance measurement calibration; bigger errors may occur because of obvious geometry (2D) issues on drops. Special consideration may be appropriate when looking at very precise measurement requirements.

Recording speed. We usually record data at 1000 samples/sec, which is adequate to record almost all data of interest. Occasionally we raise the rate to 2500samples/sec to see if all useful features in the data at 1000samples/sec are resolved. The sampling rate can go much higher. The DAQ can handle 1.25Msamples/sec for the analog inputs.

Bandwidth issues - load cells. A fundamental limitation of load cell speed of response is the load cell self-resonant frequency. The manufacturer (Honeywell-Sensotec) specifies, and our direct measurements show, that the self-resonant frequency is > 6.4kHz for all load cells. The inline amplifiers (Sensotec) have bandwidth of 5kHz. Our upper rate of 2500samples/sec should give reliable performance, and is not limited by the DAQ. Capacitance of the cable is not a factor given these bandwidth considerations.

Speed issues - rotary encoder. The DataTorque encoders used for these tests are specified to 200kHz/3000rpm. We tested these to higher speeds and found no data loss. Our experiments reported in these papers do not exceed the specified numbers. We also found no data loss in performance stress tests of the encoder in the distance measuring system including a pulley and associated Kevlar string, i.e., no string slippage on the pulley.

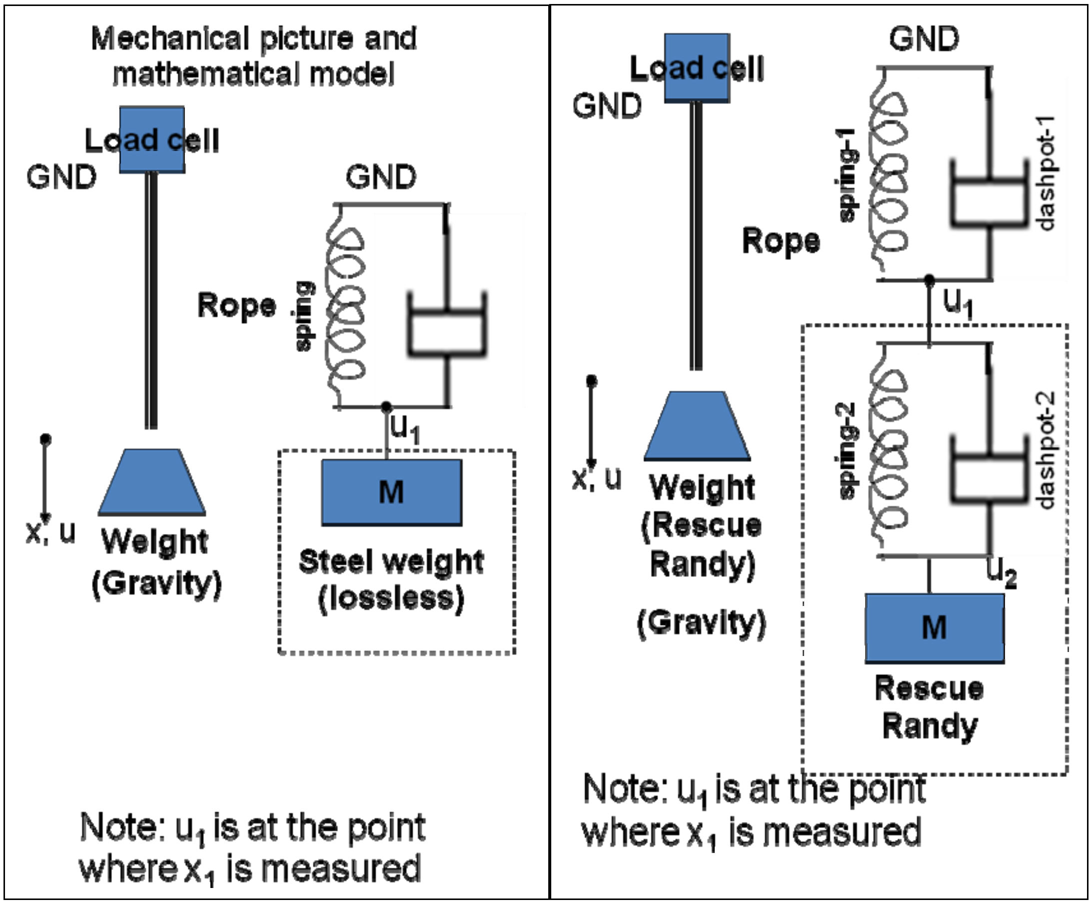
Appendix B: A Proposed Mathematical Model for Predicting the Realism of Drop Test Results Using Steel Weights

As discussed above, drop tests using steel weights as a load may result in much higher peak forces in the rope than would occur with a human load. We present here a simple physical model that may be used to compare quantitatively the behavior of drop tests on rope etc., using a steel weight or mannequin in place of a human, and may indicate validity of results from the steel weight for predicting peak forces for a human weight.

If, during the rise in force to the first peak, the energy gained by the rope under test is much greater than the energy absorbed by the human or mannequin weight, then the steel weight simulation will be valid. If the opposite occurs, then expect the peak forces measured with the steel weight to be significantly greater than for the human or mannequin. This happens because the steel weight cannot absorb and dissipate significant energy, but the human can.

Summary of the method:

A drop test of a steel weight on a rope can be reasonably modeled as a spring-mass-dashpot system (Figure B1), assuming linear relation F(x). The parameters (spring constant and damping constant) can be determined from force and distance measurements taken from a drop test using steel. (Note, however, that the system parameters may change after a drop, for example, if knots in the system cinch tight.) The same drop with a human as the load can similarly be modeled as a spring-mass-dashpot system attached as the load on the original spring-dashpot system (Figure B2). The behavior will generally be dominated by the “softer” of the two spring-dashpot systems.



Figures B1 (left) and B2 (right): a reasonable model of dropping a steel weight in a simple drop test is a spring-mass-dashpot (left); a human or mannequin can be reasonably modeled as a second spring-mass-dashpot system in series with the first.

The physical parameters that go into the simplified mathematical model of the rope under test are readily derived from the drop test of the steel weight by using force vs. time and distance vs. time data. The spring constants k are readily found from experimental data by plotting force vs. distance and finding the slope *k* during the initial rise of force to the peak. Because *k* varies with conditions (velocity, recent history), in this Appendix, we apply the model only for the initial rise to the first peak of force, during which time, F(x) is often close to a straight line (constant *k*). This approach assumes that the damping or dissipation or loss may be neglected during the initial rise to the peak in rope force.

The parameters for the mannequin have been measured and the spring constant of the Rescue Randy is estimated to be 876 lbs/in. This value is assumed to apply for any drop test with the mannequin.

A simple comparison of the rope spring constant and the mannequin spring constant will indicate validity of the test with steel weight. If the mannequin dominates the behavior in the model, i.e. has the lower spring constant, then the results with the steel weight will be in error.

The table below provides some experimental numbers comparing drops of 175 lbs of steel plates and RescueRandy on three systems.

Test	Drop load	Drop free fall	Peak force (lbs)	k lb/in	Ratio of peak forces
MaxWear - 10 ft	Steel	FF = 0.5	1866	k =150	1.17
	RR	FF = 0.5	1593		
Goldline -10 ft	Steel	FF = 0.5	1080	k =40	1.13
	RR	FF = 0.5	955		
Cable - 5.6 ft	Steel	FF = 0.12	2573	k =2000	2.51
	RR	FF = 0.12	1024		

Notes:

k is calculated from F(x) for 1st peak

Rise time (to 1st peak) is less than decay time for oscillatory behavior after the first peak

For drops of steel plates onto MaxWear and Goldline the calculated spring constants were 150 lb/in and 40 lb/in, respectively – both significantly lower than the 876 lb/in of Rescue Randy. For both of these cases, the peak forces generated by the steel plates are a reasonable approximation of the loads generated by Rescue Randy (13% and 17% higher).

For the drop of steel plates onto cable, the calculated spring constant was 2000 lb/in – significantly greater than the 876 lb/in of the Rescue Randy. In this case the, the peak force generated by the steel plates was significantly high compared to the loads generated by the Rescue Randy (2.5x).

In the two drops where the Rescue Randy is the much stiffer spring, the steel plates and Rescue Randy give similar peak forces. For the drop where Rescue Randy is the much softer spring, the peak force measured based on dropping steel is misleading.

We are currently developing a model that should allow, not only a determination of the validity of the drops of steel plates, but also a rough prediction of the peak forces for the mannequin drop based on the measurement of the peak forces from the steel plate drop.

Acknowledgements

The authors would like to thank the Mountain Rescue Association for providing the original grant used to purchase the Rescue Randy mannequins, as well as Honeywell/Sensotec, National Instruments, and Black Diamond for contributing significant equipment used in this testing. Thanks also go to the many members of RMRG who volunteered their time to make this testing possible.

Minutes of the
2009 NSS Vertical Section Board E-Meetings
August, 2008 to June, 2009

The NSS Vertical Section Executive Committee held a series of E-meetings on a variety of issues during the period from August 5, 2008 to June 11, 2009. All Executive Board members participated in the meetings via email.

December 4-10, 2008 - NSSVS EIN Issue and Related Bylaws Change

On December 4, 2008, Secretary/Treasurer Bill Boehle notified the EC about some recent activity affecting the VS. About a month previous we received a notice from one of our banks (GMAC Demand Notes) that the IRS had a discrepancy with our account and that the bank would start backup withholding unless we could straighten things out. Seems our federal EIN wasn't in their system. Much time was spent on the phone with the IRS trying to figure out the problem and how to fix it.

Since we were so small, we never had to do any filing, and, as a result, we dropped off the IRS system. After a period of time, the EIN gets archived with no way to resurrect it from that status. Further communication with the IRS Exempt Organizations Unit finally figured out what to do to fix our problems. We had to get a new EIN number from the IRS which we were able to do on the phone. We then completed the info needed to be registered as an exempt organization. It will take until February 2009 for the information to appear in their system. That means we can file our 990-N form (called an e-Postcard) sometime after 2/4/2009. This is something new that exempt organizations have just started filing this year. It's not a tax return, but more of an informational filing. We remain eligible as a small exempt organization as long as our gross receipts remains below $5000 per year.

On to the bylaws change. Part of the info we needed to give the IRS was our filing year. The books are generally cut on June 30 just before convention. This is what we told the IRS. Later, looking at the bylaws revealed that in Section 8 of the bylaws, it says: "The SECTION's Fiscal Year shall run from June 1 to May 31." We don't want to go back to the IRS and change it with them, and the Treasurer prefers the standard fiscal year anyway.

Bill Boehle makes a motion to amend Section 8 of the bylaws so that the first sentence is changed to read as follows: "The SECTION's Fiscal Year shall run from July 1 to June 30." Terry Mitchell seconded the motion on December 4, 2008. By December 10, 2008 there were 8 votes in favor and 1 no-response (Brice Williams). The motion carried.

December 5-15, 2008 - NSSVS Election of New Section Chair

Beginning of December 5, 2008 the EC began a discussion of the availability of Section Chair Brice Williams to conduct section business. Various EC members have had no success contacting Brice via email and telephone. There are several pending issues/actions requiring the attention of the Section Chair and the rest of the EC. Our ability to deal with arrangements for the upcoming NSS convention/ICS are being impaired. On December 5, 2008, Bill Cuddington made a motion (as amended December 6, 2008) that "the executive committee select a new chair to serve until the next regular election". Terry Clark seconded the motion. Bill Cuddington nominated Dick

Mitchell for Section Chair. Much discussion followed. On December 7, 2008, the EC was finally contacted by Brice Williams who apologized for not keeping in better contact with the EC. He stated that he agrees that we should replace him as Section Chair since he does not have the time to fulfill the duties of the office due to personal demands. Due to the resignation, the need for the motion became moot. On December 10, 2008 Bill Cuddington made a motion to close the nominations for Section Chair. Miriam Cuddington seconded the motion. By December 11, 2008, there were 7 votes in favor and 2 no-responses (Terry Clark and Brice Williams). The motion to close the nominations carried. On December 11, 2008, Bill Boehle (acting as chair) moved that the EC select Dick Mitchell as Section Chair by acclimation. By December 15, 2008, there were 8 votes in favor, none opposed, and 1 abstained (Dick Mitchell). The motion carried and Dick Mitchell was elected Section Chair to serve until the next regular election.

August 5, 2008 to January 2, 2009 - NSSVS Awards and Related Bylaws Change

Discussion began on the need to formally recognize those who have made significant contributions to and otherwise served the Vertical Section over the years. The need for a consistent way to address this issue was emphasized. On August 26, 2008, Chair Brice Williams called an e-meeting to order for the purpose of recognition of service to the vertical section. Tim White made two motions: 1. That we present Ed Sira and John Woods with engraved plaques to honor their service to the NSS VS; and 2. The VS Board appoint a committee to establish a set of guidelines for Service Awards. The motions were seconded by Bruce Smith and by September 4, 2008 both motions were approved. Bruce Smith volunteered to take the lead to prepare the plaques for Ed and John (motion 1). Discussion continued for some time on the mandate for the committee covered by motion 2. On September 27, 2008, Chair Brice Williams established the Award Guidelines Committee with Dick Mitchell as chair and Bill Tozer, Terry Mitchell, and Bruce Smith as members. On November 7, 2008, Dick Mitchell made a motion to amend our Bylaws to establish a Vertical Section Awards Committee and define their responsibilities. The Motion was seconded by Tim White. As of November 13, 2008 there were 5 votes in favor of the bylaw change establishing the Awards Committee Chair and revising the Awards and Recognition process. The Bylaws change passed. Dick Mitchell was already appointed as chair by Brice Williams on 9/27/08. The bylaw change just formalizes the position.

The adopted Bylaws change is as follows:

5) SPECIAL COMMITTEES (Add Paragraph F)

(F) Vertical Section Awards Committee: - The Vertical Section Chairman shall appoint an Awards Committee Chairman who may, in turn, select additional Committee members to assist in carrying out the responsibilities of that Committee. The Awards Committee's responsibilities are to:

* Review nominations and recommend approval or disapproval;
* Determine the applicable award/recognition;
* Obtain such an award and/or develop the recognition means; and
* Ensure that such award/recognition is distributed.

7) AWARDS AND RECOGNITION:

The VERTICAL SECTION may present an award to, or otherwise recognize, a person, persons, or group for an outstanding contribution in promoting, supporting or advancing the sport or technical aspects of vertical caving.

(A) Any member of the VERTICAL SECTION Executive Committee may nominate a person, persons, or group for an award/recognition. Nominations must be in writing together with a brief summary of justification. Such nominations are to be provided to the VERTICAL SECTION Awards Chairman.

(B) The VERTICAL SECTION Awards Committee Chairman, within 60 days of receipt of the nomination, shall forward the results of his Committee's recommendations to the VERTICAL SECTION Executive Committee. The VERTICAL SECTION Executive Committee, by majority vote, shall approve or disapprove the Awards Committee's recommendations.

(C) Awards to the recipients will be presented in a timely and appropriate manner and, wherever possible, will be presented at a meeting attended by fellow cavers.

Following adoption of the bylaw establishing the Award Committee, discussion of and drafting of an Awards Guidelines document began and continued into December 2008. On December 27, 2008, Dick Mitchell made two motions:

1. I hereby move that the Awards Committee Guidelines (Revision 5) be approved, adopted and implemented; and
2. I hereby move that a budget be established for the Awards Committee in the amount of $2750 for the calendar year 2009.

The motions were seconded by Bruce Smith. By January 2, 2009 there were 7 votes in favor (not counting Dick), and 1 no-response (Tim White). The motions carry.

June 5-11, 2009 - Purchase of 9mm Rope for Rebelay Course

Gary Bush notified the EC that the two 100' ropes (9mm static) the VS use for the Rebelay Course are now 9 years old. One is definitely ready to retire. The other may be serviceable for another year or two. He inquired if there is money in the budget for two ropes. He'd prefer a supple rope, like PMI EZ Bend, to make tying/untying the knots easier in the smaller rope. We received an estimated cost for 200 feet of EZ Bend to be $114 + shipping ($0.57/foot). On June 8, 2009 Bill Boehle made a motion to approve this purchase. Tim White and Miriam Cuddington both seconded the motion on June 8, 2009. By June 11, 2009 there were 8 votes in favor and 1 no-response (Terry Clark). The motion carried. The rope will be delivered to Gary Bush at Karst-O-Rama. There will be no shipping charge.

Respectfully Submitted,
Bill Boehle

Minutes of the
2009 NSS Vertical Section Board Meeting
July 19, 2009

The NSS Vertical Section Executive Committee held a meeting on Sunday, July 19, 2009 at a motel near the 2009 NSS Convention in Kerrville, Texas. Executive Board members present were Chair Dick Mitchell, Secretary-Treasurer Bill Boehle, At-Large Executive Members Miriam Cuddington, Terry Mitchell, and Bill Boehle (proxy for Brice Williams), 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. Vertical Section members Gary Bush and Ed Sira were also in attendance.

Meeting opened at 7:00 PM by Chair Dick Mitchell.

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

1. **Awards Committee** - Dick Mitchell reported that nearly all the service awards for past officers and other EC members have been sent out. Dick and Bruce Smith were given a round of applause in recognition of their extensive efforts to accomplish this feat. Terry Clark requested that the Awards Committee look into appropriate recognition for long time Vertical Workshop Instructors. Dick requested that Terry Clark submit the nominations to the Awards Committee for consideration.

2. **Vertical Techniques Workshop** - Terry Clark reported that 35-36 students were enrolled for the workshop on Thursday. He also said that he may need to order more instructor t-shirts during the coming year.

3. **EC E-mail List** - Terry Clark suggested that there should be other section members on the Executive Committee (EC) email distribution list. These members have provided continuing services to the Section and would benefit from being aware of ongoing issues being discussed by the EC and the EC would benefit from their input. It was agreed that an email distribution list for an EC Advisors Group be established to enable these members to participate in routine EC discussions. It was initially suggested that Lynn Fielding, Bart Rowlett, John Woods, Ed Sira and Gary Bush be included on this list. Confidential issues would continue to be circulated to EC members only, and only EC members may vote. A new list should be sent each year to all EC members to reflect any changes due to elections at convention.

4. **Climbing Contest** - Bill Cuddington reported that this year PMI donated two 600-foot lengths of rope for the climbing contest.

5. **Website** - Gary Bush (webmaster) discussed the section website. It was agreed that we need more content and should otherwise embellish the site. It was suggested we could add a photo gallery with more photos from past conventions, and a listing of past officers and EC members (based upon the list prepared for the Awards Committee). Ideas should also be solicited from the membership at the annual meeting.

6. **Nylon Highway** - Bruce Smith (acting as Tim White's proxy) raised the questions posed by Tim in his July 16, 2009 email:

   ... "I would like for the Board to continue the discussion regarding where the NH should be headed. We started this topic at the Sunday night Board meeting in 2008.

We all know that the golden days of SRT development are behind us. There are very few new techniques being developed that are of great relevance to cavers. (John Wood's article is one of the exceptions) While there are many techniques and new equipment being developed and modified for work access and rope rescue, very little of this is adaptable to the cave environment. Once, the NH was the venue where other disciplines came to research SRT, but rope access has moved on and developed its own set of skills and techniques.

I feel the NH should be for cavers. What does our audience need from us? What should we be offering them? I am open to your input.

I have been working with a couple of "gear nerds" on the idea of a regular equipment review column. Watch for this soon! I will continue to seek out appropriate article from the internet. I only wish to include those that have not been widely read and published elsewhere for easy access.

I believe one of the avenues of communication for the vertical caver is the On Rope! Forum of CaveChat.org. As NH Editor, I will continue to be the Moderator of that Forum and communicate with those who post there."

Gary Bush stated that we need to be more timely in getting articles out in the Nylon Highway. He is aware that Tim has some articles that he has not yet given to Gary for posting. It is important that we don't hold articles until we have a full issue. The purpose behind making the Nylon Highway an electronic publication was to avoid delays in timely distribution. The EC suggested that Gary push Tim for any articles he presently has ready for publication.

The subject of the future direction of the Nylon Highway and a request for articles will be raised to the membership at the Thursday meeting.

7. **By-Law Change** - Bill Boehle and Terry Mitchell have been working on a bylaw addition addressing parliamentary procedure and the conduct of e-meetings by the EC. The draft of this proposal had previously been circulated to the EC via email on July 6, 2009. Copies were also provided to the EC at the meeting. There had been some discussion via email and some further discussion ensued. Terry Clark made a motion that we adopt the proposed new bylaw #9 as proposed. Bruce Smith seconded the motion. The motion PASSED unanimously.

   The adopted Bylaws change is as follows:

   9) PARLIAMENTARY AUTHORITY AND RULES OF ORDER:

   A. Meetings: Conduct of regular (face-to-face) meetings of the VERTICAL SECTION and of the Executive Committee (EC) shall be governed by the current edition of Robert's Rules of Order Newly Revised, when it is applicable, and when it is not inconsistent with the VERTICAL SECTION CONSTITUTION, By-Laws, or Articles of Incorporation. To facilitate business in rare cases, the EC may decide to relax these rules of order, i.e. Suspend the Rules as provided for in Robert's Rules of Order itself. Special meetings may be conducted as necessary to conduct SECTION business.

      i. The annual regular meeting of the VERTICAL SECTION at the NSS convention will be scheduled by the Chairman or the Executive Committee in coordination with the convention staff. Additional special meetings of the VERTICAL SECTION may be called by majority vote of the EC, or by the written request of 51% of the current SECTION members. Notice of the special SECTION meeting must be emailed and/or postal-mailed to all members no less than

30 days prior to the date of the meeting.

ii. Regular meetings of the Executive Committee normally occur during the week of the annual NSS Convention. Regular or special EC meetings will be scheduled by the Chairman or may be called by three or more EC members.

iii. Quorums: The quorum for a regular or special meeting of the VERTICAL SECTION shall be ten or more members. The quorum for regular or special meetings of the Executive Committee shall be a majority of the EC members.

iv. Proxies: Proxies will be accepted at all meetings and may be counted for quorum purposes.
   a. All proxy authorizations shall be in writing. Email proxies are acceptable. The authorization may designate alternate proxy holders by name, or by method of appointment, to serve if the named holder is absent.

   b. A "specific proxy" as to a particular question must specifically identify that question and instruct the proxy holder to vote for or against the particular question or candidate, or specifically authorize the proxy holder to exercise his/her discretion regarding that particular question, or otherwise set forth a method to determine how to vote on that particular question (including, but not limited to, obtaining telephonic instructions).

v. Minutes: A written record of the minutes of all SECTION and EC meetings shall be published annually in the VERTICAL SECTION's on-line publication, the NYLON HIGHWAY.

B. Special Rules of Order for the conduct of business by email:

i. The Executive Committee may decide to hold special meetings by email, hereinafter referred to as "e-meetings", as necessary to conduct SECTION business at other times throughout the year.

ii. E-meetings may be called either by the SECTION Chair or 3 or more members of the Executive Committee.

iii. E-meetings will take place using the process outlined below.

iv. Each e-meeting shall address one issue only. If additional issues need to be addressed, a separate meeting for each issue shall be called.

v. The e-meeting shall be chaired by the SECTION Chair. If the SECTION Chair is unavailable, the meeting chair shall be the Secretary/Treasurer, unless another Executive Committee member is designated by the SECTION Chair to act in that capacity for a specific meeting. The meeting secretary (MS) shall be the Secretary/Treasurer unless otherwise designated by the meeting chair.

vi. The rules applying to the conduct of regular meetings shall also apply to e-meetings with the following exceptions:
   a. The Motion to Table rule shall be suspended for 72 hours (3 days) immediately following the announcement of the start of the discussion period by the meeting chair. Following the suspension period, any Motion to Table brought forth shall be disposed of within 48 hours (2 days).

   b. The motion to Call the Question rule shall be suspended and replaced with the rules in Items (vii) e, f and g below.

vii. The order of business shall be as follows:

a. The SECTION Chair shall send a notification to all the EC members stating the reason for calling the e-meeting and providing an outline of the issue to be discussed. The SECTION Chair should also state in the notification if another EC member will be designated to act as meeting chair and/or MS for the meeting. The meeting shall not begin until the meeting chair has received acknowledgement of the meeting from a quorum of EC members. The meeting chair will make an additional attempt by telephone to contact all EC members who have not acknowledged the meeting within a reasonable period of time.

b. The notification from the SECTION Chair shall contain a unique subject line identifying the topic of the e-meeting. This unique subject line shall be used in all communications related to this e-meeting to aid in tracking. Any EC member sending a public communication relating to an e-meeting must send it simultaneously to all EC members.

c. Motions shall be presented, seconded and opened for discussion by following the same rules and procedures followed in regular meetings with the exceptions noted above.

d. Once a motion has been seconded, the meeting chair shall then start a discussion period which shall be open for a minimum of 5 days.

e. At the end of the discussion period, unless the Executive Committee votes to extend the discussion or call the question sooner, the meeting chair shall then start the voting period by submitting the motion to a vote by the members. The voting period shall be open for a minimum of 4 days or until the number of returned votes is sufficient to determine the outcome of the vote. Any votes submitted during the discussion period cannot be counted - the member must submit the vote again during the voting period.

f. Each voting member shall send his/her vote to all members of the Executive Committee. The MS shall tally the votes and announce the results at the end of the voting period along with a list showing the vote of each member. If a motion to hold a secret ballot had previously been passed, each voting member shall send his/her vote only to the meeting chair and the MS. The MS shall then announce only the results of the vote.

g. Once the voting results are announced, the meeting chair shall declare the e-meeting closed.

h. A written record of the vote shall be recorded in the minutes of the e-meeting.

8. **Approval of E-Meeting Minutes** - It was discussed that the EC needs to formally approve the minutes from the EC meetings that were held in the preceding year. These minutes were previously circulated via email to all EC members on June 24, 2009, with copies distributed at this meeting. Terry Mitchell made a motion to approve the EC minutes as distributed. Bruce Smith seconded the motion. The motion PASSED unanimously. The approved minutes will be published in the Nylon Highway.

9. **Education** - Bruce Smith (Education Coordinator) reported that the updated Basic Vertical Training Student Manual and other course materials are now posted on the VS website in PDF format, and that the Intermediate SRT Training Course is also posted in PDF format.

10. **Membership** - Bruce Smith suggested that the Section needs to get its name out there as a means of bolstering our membership. He stated that there are many vertical cavers out there who don't

participate in our activities and who could support our mission. He suggested that we investigate the cost of running ads in the NSS News.

11. **Need For A Vice-Chair** - Bruce Smith previously raised (in an email) the issue of whether the Section needs a Vice Chairman to take over for the Chairman in the event that person is unavailable to conduct business. The consensus was that such a position should be created. The point was brainstormed to identify the options available for us to consider. They included:

    a. Add a new board member since the Chair does not normally vote except when there is a need to break a tie. Adding one would still keep the number of regular votes odd.

    b. Make the three appointed board members able to be elected internally and assume the office of the Vice Chair.

    c. The Secretary/Treasurer could temporarily assume the Chair's role in the Chairman's absence. and

    d. Similar to the Chairman, the position could be filled by one of the existing four At-large EC members. It was noted that a constitution and bylaws change would be needed to make any change to the number of the officers. It was decided that Terry Mitchell and Bill Boehle would consider the suggestions made and draft proposed language for consideration of the EC.

Adjournment - Motion to adjourn was made and carried.
Time of adjournment was approximately 9:14 PM.

Respectfully Submitted,
Bill Boehle

Minutes of the
2009 NSS Vertical Section General Meeting
July 23, 2009

The 2009 NSS Vertical Section meeting was held Thursday, July 23, 2009 at the Schreiner University in Kerrville, Texas. Executive Board members present were Chair Dick Mitchell, Secretary-Treasurer Bill Boehle, At-Large Executive Members Miriam Cuddington, Terry Mitchell, and Bill Boehle (proxy for Brice Williams), 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. Approximately 14 additional Vertical Section members were in attendance.

I. **Meeting opened at 9:03 AM by Chair Dick Mitchell.**
Announcements - Welcome to everyone who came. Introduced EC members present and announced proxies. We are on a tight schedule and will try to quickly get through the meeting.

II. **Minutes of the Last Meeting** - were published on the website and there were no amendments or changes. 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. No further discussion. Accepted as presented.
- **VS Symbolic Items** - Bill Boehle. See Treasurer's Report for sales numbers.
- **Nylon Highway Editor's Report:** -
Information from Tim White (not present). Tim has a question to the membership: Where should the Nylon Highway be headed? What would you like to see in future issues? Gary Storrick asked where were the printed issues he had paid for. Some of the issues that he had received only came after he inquired as to their whereabouts and Bill Boehle had followed up with Tim. It was explained that each January a list was sent to Tim for the issues that needed to be printed and mailed. Some members also think they had paid for a particular year only to find out that their paid subscription for the annual volume had run out in an earlier year. The EC agrees that paid annual volumes need to be mailed in a timely manner and will look into this as an action item. Other items a member raised as something they would like to see in the Nylon Highway were for more collaborative articles such as Section research projects on topics like the ergonomics of the Frog or Ropewalker systems. Such collaborative articles would present more diverse opinions and points of view than a single author article. Terry Clark stated that there are some ideas being developed for studies of this kind. Dick Mitchell requested that if any person or group has an idea for a project or for some type of original research that the Section should pursue that they should contact someone on the EC to volunteer to do the study or at least enable the EC to find someone who would be interested in doing the project.

IV. **Committee Reports:**
- **By-Laws Committee:** Terry Mitchell & Bill Boehle -
Several amendments and additions were adopted in the previous year.
    1. Bill Boehle reported that the Section's fiscal year specified in Section 8 of the bylaws was changed to end on June 30 rather than May 31. This was done to aid our required annual filings of form 990-N with the IRS. This amendment was adopted on December 10, 2008.

2. In September 2008 an Awards Guidelines Committee was formed to establish a set of guidelines for Service Awards. The committee developed and presented a proposal for the EC to consider. After discussion and some modification, a new Section 5 Paragraph F and Section 7 of the bylaws was adopted on January 2, 2009.
3. Bill Boehle and Terry Mitchell have also been working on a bylaw addition addressing parliamentary procedure and the conduct of e-meetings by the EC. Since the EC has been conducting more business via email, the bylaws needed to be updated to address how these meetings should take place. This amendment was adopted on July 19, 2009.

All these are documented in various Section and EC minutes that have been, or will be, published in the Nylon Highway.

- **Contest Committee:** Bill Cuddington -
  Thanks to PMI for donating 1200 feet of rope for the climbing contest. We were able to cut it up into three 300 foot and two 150 foot lengths for prizes. Thanks to Bill Stephens and Gonzo Guano Gear for contributing a lot of prizes to the contest. In addition, there was an anonymous donor who also contributed a lot of prizes to the contest. 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 racketeers), etc. We also had the first Father/Son side-by-side climb with Ed and Ray Sira. This year we had 60 climbers with the participation of many of the international cavers. Several world records were set. Awards will be given out later today after the training class (workshop). Next year we will be going back to a day and a half for the contest.

- **Vertical Workshop Committee:** Terry Clark -
  Last year we had 9 students. This year we have a full course of 35. Terry wants to recognize and thank the instructors who help him and Lynn run the vertical workshop. Thanks to PMI, Gonzo Guano Gear, and On Rope 1 for their support of the vertical workshop.

- **Education Committee:** Bruce Smith -
  We had a lot of goals that we wanted to achieve this year. We completed the Intermediate Course and wanted to make it available via download for no charge on the website. We achieved that goal just two weeks ago. The changes to the Basic Training Course that were discussed last year have been incorporated and a new and improved version is now also available on the website. This includes the instructor's card for overcoming obstacles and dealing with blowouts. Without the printing and mailing being necessary, we elected to also make this material available for no charge. In keeping with our education mission, we feel it is more important to get the information out than to make a few dollars for the Section. Thanks to Tim White, Gary Bush, and Dick Mitchell for making this happen and getting both training courses completed and on the website.

- **Rebelay Course / "Dial In Your Gear" Session:** Gary Bush and John Woods -
  This year there were less people who showed up for the rope course, but they were busy throughout the day. As in the past, John spent a lot of time with people setting up and adjusting their gear. It was well received by all who participated. This year we replaced our 10 year old ropes with new 9mm rope.

- **Web Page:** Gary Bush, webmaster -
  Gary noted that we will be putting up a photo gallery on the website where we can display photos from past events. If anyone has photos of past meetings, contests, or other events, they should send them to Gary Bush to be included. Please identify dates, locations and people, if possible. If people would like other things on the website, send Gary an email and we will see what can be done. It was suggested that we could send out a request for ideas and suggestions for website content and Nylon Highway articles via the Section listserv.

- **Awards Committee:** Dick Mitchell -
  This is a new committee. This arose out of a desire to recognize and thank those individuals who have served the Vertical Section since 1972 as officers, at-large board members, committee chairs, and Nylon Highway editors. This was long overdue. The awards consist of a letter accompanied by a plaque. This task is complete with a few exceptions to be presented today. Today's honorees are: Miriam Cuddington, Gary Bush, Bruce Smith, Bill Cuddington, and Kirk MacGregor (expected, but not present). Much tears and applause followed each presentation. Bruce Smith commented on how the awards were presented to the honorees (in most cases) in front of their peers. Feedback from this initiative has been very positive.

V. **Old Business:**

- Ernie Coffman asked if we had ever received any information on the whereabouts of the old Nylon Highway editor who stole funds from the Section. Bruce Smith related that his NSS life membership was revoked, but that none of our funds was recovered.

VI. **New Business:**

- The EC asked the question "How do we increase our membership and improve the communication and involvement of younger cavers? Our membership is aging. Elaine Hackerman suggested articles spotlighting younger vertical cavers in the Nylon Highway or the NSS News. John Woods suggested that creating a spotlight on a younger vertical caver would be quicker and easier if placed on the Section website. Dick Mitchell pointed out that we just had a short article on the Vertical Section in the current issue of the NSS News. It was also suggested that a discussion thread could be started on CaveChat somehow featuring younger vertical cavers. Tim White is the moderator of the OnRope forum on CaveChat. He needs to be informed of this need and may be able to steer some discussion on getting more younger vertical cavers involved with the Section. Workshop participants receive memberships in the Section as part of their registration. We need to keep these people involved. All Section members need to promote the benefits of being a member of the Vertical Section back in their grottoes. There are a lot more vertical cavers out there than are members of the Vertical Section. We need to seek them out through multiple approaches. Send us any ideas you may have.

- A question was asked if an attorney has ever reviewed our waiver for the contest or workshop. It has been in use for a long time. It was pointed out that any waiver doesn't means squat, but that it is better that one be used to at least indicate that the person was warned and had some idea about any potential dangers.

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) - Miriam Cuddington and Rory Tinston were nominated. A ballot of the section members present was not necessary. Miriam Cuddington and Rory Tinston were elected by acclamation. [Note: Current At-Large members Dick Mitchell and Terry Mitchell have 1 year remaining in their terms.]

VIII. **Motion to Adjourn:**
Motion to adjourn was made and carried. Time of adjournment was approximately 10:14 AM.

[Additional note: Subsequent to the Meeting, the Board Members elected Dick Mitchell 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
JULY, 2009
By Bill Boehle

Number of Members (current/just expired)	 177
Number of Members Current as of 2009	 168
Number of Subscribers Current as of 2009	 7
Number of Annual Volumes Paid for 2009	 13
Number of Complementary Subscriptions	 3

YEARS PAID:	MEMBER	SUBSCRIBER	ANNUAL VOLUME
Comps	--	--	3
2009	13	1	7
2010	7	1	3
2011	1	0	0
2012	0	0	0
2013	127	4	0
2014	20	1	0
2009 TOTALS:	168	7	13
Expired 2008:	9	3	
TOTALS:	177		

NSS VERTICAL SECTION
TREASURER'S REPORT
JULY, 2009
By Bill Boehle

INCOME:

New Memberships, Subscriptions, & Renewals	.... $ 9.00
Nylon Highway Annual Volume Sales	.... $ 40.00
2008 Convention Workshop Registrations	.... $ 325.00
Vertical Training Course Sales	.... $ 0.00
Symbolic Item Sales	.... $ 221.00
Nylon Highway Back Issue Sales	.... $ 11.50
Shipping/Postage Charges	.... $ 2.00
Donations	.... $ 18.00
Bank Interest (GMAC) Aug. 2008 - June 2009	.... $ 383.20
TOTAL INCOME	**$1,009.70**

EXPENSES:

Shipping/Postage Costs	.... $ 0,00
North Carolina Corporate Filing Fees (Bill Bussey)	.... $ 10.00
2008 VTW Transportation Subsidy (Terry Clark)	.... $ 237.00
2008 Climbing Contest prizes	.... $ 180.45
Vertical Workshop & Rebelay Course Supplies/Expenses	.... $ 150.02
NH Annual Volume Production & Mailing Costs	.... $ 36.34
Symbolic Items Restocking (T-shirts, Sweats)	.... $ 0.00
VS Recognition Awards Production & Shipping	.... $ 2377.13
Vertical Training Course Mailing Costs (billed by Tim White)	.... $ 0.00
Climbing Contest Record Boards (deposit)	.... $ 280.00
Printing - Climbing Contest Certificates	.... $ 0.00
Photocopying for 2008 NSS Convention paperwork	.... $ 25.41
Petty Cash for postage	.... $ 0.76
Training/Education Committee Printing Costs	.... $ 371.45
TOTAL EXPENSES	**$3,668.56**

ACCOUNT BALANCES: (as of 6/30/2009)

TD Bank (NJ)	.... $2,515.87
GMAC	.... $9,768.36

BALANCE ON HAND: **$12,284.23**