RESCUE BELAYS:

Important Considerations for Long Lowers

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Introduction:

Incorporating a belay system within a rope rescue system is common practice in rope rescue because, although the probability of a mainline failure is low, the consequence may be dire. Mainline system failures have occurred and will continue to occur, but what happens as a *result* of those failures will largely be driven by (1) the inclusion or exclusion of a belay system, (2) the specific nature of that system and (3) how that system is managed throughout the operation. The outcome depends on, among other parameters, the length of rope in service. Many studies have looked at belaying with a few metres of rope in service, but little data exists for larger amounts of rope. This paper will describe initial examinations of the problem of belaying on long lowers.

Background:

It stands to reason that if you are going to go to the trouble of including a belay system, then the system should be capable of actually arresting the fall. The Tandem Prusik Belay and the 540° Rescue Belay are examples of systems that have been put through rigorous testing by a number of different groups in a variety of settings. These investigations have largely followed the British Columbia Council of Technical Rescue (BCCTR) Belay Competence Drop Test Method (BCDTM).

The BCDTM 'designed event' of a 200 kg mass falling 1 metre on 3 metres of belay rope is meant to simulate a mainline failure during the initial edge transition. Because of the high fall factor (1/3) and the small amount of rope-in-service available for energy absorption, this test method is considered the 'relative worst case event' to which a given belay system would be subjected as a result of a mainline failure. To pass the test, a belay system must meet several criteria, including reliably stopping the fall with maximum arrest force (MAF) <15kN and stopping distance <1m. The Tandem Prusik Belay and the 540° Rescue Belay both pass this test method.

The probability of failing a mainline is likely highest during the initial edge transition, because the initial application of force on the system may reveal a rigging error, poor command and communication may result in a weakly executed edge transition, or the litter attendant may lose footing or balance at a critical juncture, to name just a few scenarios. The ensuing fall may expose the anchors and other rigging to high forces or the mainline to sharp, unprotected edges and pinch points.

The edge transition will likely continue to be a major focus in rescue belay testing (and appropriately so). Additionally, it will likely continue to be a catalyst of actual mainline failures. That aside, there does exist the real possibility of failing the mainline when you are well past the edge transition with a great deal more rope-in-service (e.g. 30 metres or more). An obvious trigger for such a failure is rock fall, but there are many others. For example, the mainline may slide across a sharp edge if the litter attendant misjudges a change in fall line; a strong wind may blow the mainline behind or over a flake; or a rigging error may be made as the team changes over to a raise.

With so much rope in service, the fall factor and MAF decrease dramatically, and a strong argument can be made that a belay system meeting BCDTM criteria with 3 metres of rope in service will safely arrest a fall under these less severe circumstances. Some important new considerations arise, however:

1. Managing the belay rope by hand becomes difficult, even impossible, as rope-in-service increases beyond 30m, so adding friction to the rope in the form of a descent control device (DCD) is usually required. Although this is not a new practice in rope rescue, our experience as rope rescue educators lead us to believe that it is highly underutilized.

2. Managing the belay device itself may require changes in procedure as the weight of the rope increases. Very little emphasis is placed on this problem by rope rescue literature, rope rescue educational organizations or general practitioners.

3. In the event of a fall arrest, the stopping distance will be greater simply because of the stretch in the longer belay rope, even with a fall factor of zero, i.e., no initial slack or tension in the rope. In fact, at typical lowering distances the fall could be several metres, and it increases roughly in proportion to rope in service. The risk of serious or fatal injury from striking ledges, girders, or the ground itself is obviously very high.

Proactively managing this risk requires:

1. Employing a belay rope of the lowest possible elongation (stiffness) that will still meet the BCDTM force criteria for the 1m drop on 3m rope in service and

2. gradually transferring part of the load from main line to belay line as rope length increases, so that the belay is at least partially pre-stretched if and when the mainline system fails. In other words, the system evolves toward a Two Tensioned Rope Lower once the load has transited the initial edge and the litter attendant has managed to identify their ‘plumb line’ for the balance of the descent.

3. Operating the belay device in the most reliable manner for the new conditions.

Objectives:

Keeping in mind the problems stated above, our objectives in this drop test series were to examine:

1. optimum ways to add friction via a DCD to a long belay line,

2. the requirements for rigging and managing certain rescue belays both with and without a DCD in the system,

3. the reliability of these belays in arresting rescue-load falls after mainline failure, and,

4. the stopping distance of the test mass as its fall is arrested by a long belay rope, both with and without a DCD in the system.

Test Method:

Lacking a 30 metre tall drop tower, we used a 10m tower with two changes-of-direction through efficient ball bearing pulleys to bend the belay rope out to a vehicle anchor, thus allowing 30 metres of rope in service. One change-of-direction (COD) was approximately 180° and the other was around 90°. Based upon the static force readings at the anchor, we estimated the 180° COD to be around 0.9 efficient and the 90° COD to be around 0.95 efficient.

All drops were conducted with 30 metres of belay rope in service and a fall factor of zero; i.e., a snug top-rope belay with no initial stretch and no free fall.

The test mass, 200 kg of steel plates, was initially raised 3 metres above the designated failure location, leaving 27m rope in service, and the mainline was then lowered through a brake rack at a controlled and consistent pace. A belayer (an experienced rope rescue technician) operating either a Tandem Prusik Belay or a 540° Rescue Belay kept pace during the lower and received no verbal or visual warning as to the simulated mainline failure (executed at the 30m rope-in-service mark).

> We elected to conduct the tests with the mainline failing while the test mass was in motion, thus simulating a failure during a controlled lowering of the rescue package. This test method made the examination more relevant to actual field conditions, but less repeatable from a scientific standpoint (e.g., slightly different lowering speeds from one test to the next; the resulting different momentum values of the test mass itself; etc.).

Stop distances were recorded by video camera (1/30 second), forces were measured at the anchor by a Dillon Dynamometer (mechanical) and belayer observations were captured as well.

These tests were conducted in a ‘quick look’ exploratory style, i.e., only a handful drops were made for each combination of variables, in order to confirm/refute certain suspicions as well as to identify further areas of study.

Variables:

Two different rescue ropes were examined: 11mm PMI EZ Bend, a nylon core/nylon sheath "static" (low elongation) rope, and 11mm Petzl Vector, a nylon core/polyester sheath "low stretch" (medium elongation) rope. "Static" and "low stretch" are elongation categories established by Cordage Institute (CI) standard 1801-98.

Two different rescue belay devices were examined: the Tandem Prusik Belay (TPB) made with 8mm nylon accessory cord, and the 540° Rescue Belay.

Two different DCDs were examined: a BMS brand Microrack (steel) and a slot-style Belay Tube (a typical single-person DCD commonly carried by mountain rescue personnel and climbers).

> The DCDs were rigged either 'in front' (on the load side) of the belay device or 'behind' (on the anchor side of) the belay device, as proper functioning allowed.

Results and Discussion:

Twenty eight drop tests were conducted over three consecutive days in August, 2007 in Ouray, Colorado. The log sheets (Appendix A) describe the drops and the results for the key parameters.

Despite all drops having the same amount of rope in service, the fall arrest system (FAS) extension values varied considerably.

Peak forces varied within the expected range of values. However, peak force was of minimal interest, since it is a well understood physics principle that the peak force recorded in a fall factor zero scenario will be around two times the static force of the suspended mass, regardless of rope elasticity.

In the end, the test results speak for themselves. However, during the testing process we did key in on some obvious indicators as well as some subtleties that are not readily apparent from simply reviewing the log sheets. Our observations and impressions are described in the following sub-sections:

No DCD in system

- The 540° Rescue Belay without a DCD had a shorter stopping distance than the TPB without a DCD, regardless of rope type.
  - For example, see FAS extension values from tests #13 (TPB) and #17 (540° Rescue Belay), when no DCD was used on the "Low Stretch" Petzl Vector rope.
  - Presumably this is due to the belay technique differences between the two devices (e.g. some slack in between hands for TPB; back-tension used with 540°)

DCD in system

- "Low Stretch" ropes absolutely need some friction added to the belay once you have greater amounts of rope-in-service (e.g. 30m or more).
    - The FAS extension values for the Petzl Vector rope with no DCD were considerable. See data from tests #13 and #17.
    - Compare the data from #13 to #14 (TPB) and #17 to #20 (540°)
- Once a DCD is added, more friction appears to be better than less friction (assuming the DCD in question has variable friction; e.g. a brake rack). This seems to be the case for both decreased FAS extension and belay device actuation.
    - See data from drop tests #16 and #19 (2 bars of friction on brake rack) versus #'s 20, 24-26 (4 bars engaged).

DCD with 540° Rescue Belay

- The 540° Rescue Belay must be operated according to the manufacturer's instructions, by applying back-tension on the rope load-side of the 540° with a gloved hand. Therefore, the DCD must also be on the load side of the 540°, so that the belayer can work with the low-tensioned rope *behind* the DCD and *in front* of the 540°.
    - This technique prevents inadvertent lock-ups and *more importantly* decreases the stopping distance when a DCD is used. See data from drop tests #7 and #8 versus data from #6 and #9.
- The 540° Rescue Belay with a DCD on the load-side of the rope but *no back-tension* appears to be worse than no DCD at all, with respect to FAS extension.
    - See drop tests #5 versus #6 and #9.

DCD with TPB

- The TPB needs to be operated using a technique that prevents a 'panic reaction' by the belayer from interfering with the belay actuation. For example, avoid a 'closed hand' technique on the Prusiks, since instinctively gripping the Prusiks could prevent them from engaging. This would result in increased FAS extension or possibly even a complete failure of the belay. Which technique is appropriate depends on whether the TPB is on a tensioned line (load side of the DCD) or on an un-tensioned line (anchor side of the DCD).
- The DCD can be on either side of the TPB. Both methods *seemed* to arrest the fall similarly with respect to FAS extension and belay reliability. However,

    - Review of the video footage from tests #16 and #27 revealed some concerns as to the *delay* in the Prusiks being 'ripped' from the belayer's hands (thereby engaging and actuating the belay) when using the DCD 'in front' of a TPB.

    - Additional testing of DCD 'in front' of TPB would certainly be warranted prior to adopting this technique without reservation.

- The choice to place the DCD 'in front of' or 'behind' a TPB may depend on other criteria. Here are several 'pros and cons' for choosing one technique over the other. Rather than rewriting all of the corollaries of one pro against a con for the opposite system, that relationship is assumed.

<u>**TPB with DCD 'behind'** (proximal to anchor)**:**</u>

Pros:

- One person can operate both TPB and DCD

- Compact profile

- Easy knot pass
    - You are already set up with TPB and RRH on standing part of the rope

- Easy to add/remove DCD
    - Think about converting to a raise mid-face in a pickoff scenario

- Easy to manage a transfer of tension in the event of a mainline failure

Cons:

- Requires a change in belay technique
    - e.g. 2-fingers 'scissor' technique for minding the Prusiks

<u>**TPB with DCD 'in front'** (proximal to load)**:**</u>

Pros:

- Belayer maintains same belay technique before and after DCD is added to system

- Easy to free up an inadvertent Prusik lock-up (running end tension only)

- Same set up as the 540° for teams that use both devices

Cons:

- Typically requires a second person to manage the operation
  - i.e. while still maintaining the same belay technique (2 hands) and managing the DCD

- Increased profile
  - Need to pay close attention to *separation* of TPB and DCD
    - Think about the Prusiks ‘plowing’ into the DCD and getting minded

- A COD on the DCD running end to control the rope tension by using the brake rack in *compression*, creates another issue:

  - Increased slack in the belay system should the mainline fail

- If you convert the mainline into a mirror image of the belay, the rigger must have anticipated that change and made room for the TPB between the anchor and the DCD.

Recommendations:

As a rope rescue training organization, Rigging for Rescue has advocated and taught for many years the practice of adding friction to the belay line at the appropriate time. This technique seems to be underutilized among rope rescue practitioners that operate a single mainline and separate belay line system. Hopefully this presentation material will aid in raising awareness of the real risks of stopping distance due to stretch in the belay.

For those looking to add this technique to their tool box, we offer the following:

- Consider morphing your mainline and belay systems into mirror images of each other once you reach around 30 metres of rope-in-service, by adding friction to your belay in the form of a DCD and a ‘hands free backup’ in the form of a rescue belay device to your mainline. This would be particularly true if you had many more metres to go on the lower.
- For the 540° Rescue Belay, follow the manufacturer’s recommended technique, with or without a DCD on the standing part of the rope.
- Avoid TPB techniques whereby the belayer could defeat the device by virtue of a ‘panic reaction’ (e.g. closed hand over the prusiks).
  - For the TPB with the DCD *behind* the Prusiks, employ the use of the two-finger ‘scissor’ technique for minding the prusiks. Pay careful attention to Prusik ‘snugness’ and be able to hear the nylon-on-nylon friction between the rope and Prusiks.
- Do not belay rescue-sized loads with climbing rope.

Key to Acronyms on Log Sheets

Item	Description
mm	millimetre
m	metre
kg	kilogram
kN	kiloNewton
MNT	Measurement Not Taken
FAS	Fall Arrest System
TPB	Tandem Prusik Belay
RRH	Radium Release Hitch
DCD	Descent Control Device
NLSK	Nylon Low Stretch Kernmantle
NA	Not Applicable
COD	Change of Direction
PMI	Pigeon Mountain Industries
CI	Cordage Institute

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Appendix A
Rescue Belay Testing-Log Sheet
Date: 8-05-07 ; 8-06-07

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Test #	Rope Type: make, model, color	Rope Type: size, material & construction	Initial Rope in Service (m)	Mass (kg)	Fall Factor	Belay Device	DCD	FAS Extension (m)	Maximum Arrest Force (kN)
1	PMI, EZ Bend, White	11mm, NLSK, CI = 'Static'	30	200	0	TPB w/ RRH	Belay Tube (behind)	2.25	MNT
Rope was *very wet* prior to drop test; *soaked* in a rain storm.									
Only drop test on 8-05-07.									
Belay Tube positioned on the rope proximal to the anchor (behind TPB).									
Belayer using a two fingers "scissor" technique to carefully mind the prusiks while also controlling the DCD.									
Fall was arrested by TPB.									
2	PMI, EZ Bend, White	11mm, NLSK, CI = 'Static'	30	200	0	TPB w/ RRH	none	2.75	3.6
Prusik Cord for Tandem Prusik Belay and RRH was PMI 8mm nylon kernmantle cord.									
Rope passed through two friction points (pulleys); one change of direction @ ~90° and another @ ~180°.									
180° COD was ~ 0.9 efficient and the 90° COD was ~ 0.95 efficient.									
Load was lowered ~ 3m prior to release. Belayer was an active rescuer using 'standard' TPB technique.									
First drop on 8-06-07. Fall was arrested by TPB.									
3	PMI, EZ Bend, White	11mm, NLSK, CI = 'Static'	30	200	0	TPB w/ RRH	Belay Tube (in front)	2	3.2
Slot style descent control device (aka Belay Tube) positioned on the rope proximal to the load (in front of TPB).									
Belayer using 'standard' TPB technique - incorporating a 'twist of the hand' on the prusiks themselves.									
Fall was arrested by TPB.									
4	PMI, EZ Bend, White	11mm, NLSK, CI = 'Static'	30	200	0	TPB w/ RRH	Belay Tube (behind)	1.5	2.9
Belay Tube positioned on the rope proximal to the anchor (behind TPB).									
Belayer using a two fingers "scissor" technique to carefully mind the prusiks while also controlling the DCD.									
Fall was arrested by TPB.									
5	PMI, EZ Bend, White	11mm, NLSK, CI = 'Static'	30	200	0	540° Rescue Belay	none	1.5	2.15
Belayer using manufacturer's recommended technique for belaying 540° - gloved hand providing back-tension on rope.									
Fall was arrested by 540°.									
6	PMI, EZ Bend, White	11mm, NLSK, CI = 'Static'	30	200	0	540° Rescue Belay	Belay Tube (in front)	2 +	3.2
Belay Tube positioned on the rope proximal to the load (in front of 540°).									
Belayer allowing test mass to *pull* belay rope through the DCD, while shuffling rope in generously to the 540°.									
Fall was arrested by 540°.									
7	PMI, EZ Bend, White	11mm, NLSK, CI = 'Static'	30	200	0	540° Rescue Belay	Belay Tube (in front)	1 +	2.5
Belay Tube positioned on the rope proximal to the load (in front of 540°).									
Belayer placing gloved hand on rope *between* DCD and 540° providing back-tension on rope.									
Fall was arrested by 540°.									

Rigging for Rescue ®

Test #	Rope Type: make, model, color	Rope Type: size, material & construction	Initial Rope in Service (m)	Mass (kg)	Fall Factor	Belay Device	DCD	FAS Extension (m)	Maximum Arrest Force (kN)
8	PMI, EZ Bend, White	11mm, NLSK, CI = 'Static'	30	200	0	540° Rescue Belay	Belay Tube (in front)	0.5 +	1.95
Belay Tube positioned on the rope proximal to the load (in front of 540°).									
Belayer placing gloved hand on rope *between* DCD and 540° providing back-tension on rope.									
Repeating same parameters as Drop #7.									
Fall was arrested by 540°.									
9	PMI, EZ Bend, White	11mm, NLSK, CI = 'Static'	30	200	0	540° Rescue Belay	Belay Tube (in front)	4.25	3.8
Belay Tube positioned on the rope proximal to the load (in front of 540°).									
Belayer allowing test mass to *pull* belay rope through the DCD, while shuffling rope in generously to the 540°.									
Repeating same parameters as Drop #6.									
Fall was arrested by 540°.									
10	PMI, EZ Bend, White	11mm, NLSK, CI = 'Static'	30	200	0	TPB w/ RRH	Belay Tube (behind)	2.5	3.5
Belay Tube positioned on the rope proximal to the anchor (behind TPB).									
Belayer using a "closed fist" technique with the hand positioned *forward* of the prusiks.									
Belayer carefully minded the prusiks while also managing the DCD with the opposite hand.									
Fall was arrested by TPB.									
11	PMI, EZ Bend, White	11mm, NLSK, CI = 'Static'	30	200	0	TPB w/ RRH	Belay Tube (behind)	Ground	MNT
Belay Tube positioned on the rope proximal to the anchor (behind TPB).									
Belayer using a "closed fist" technique with the hand *intentionally* minding the prusiks while also controlling the DCD.									
Belayer focused on keeping their hand in front of the TPB while also *avoiding* rope friction on their belay hand.									
Belayer stated based upon the feel of Drop #10, "that if I could mind them a little, I could mind them a lot."									
Load went to the ground.									
12	PMI, EZ Bend, White	11mm, NLSK, CI = 'Static'	30	200	0	TPB w/ RRH	Belay Tube (behind)	3	4
Belay Tube positioned on the rope proximal to the anchor (behind TPB).									
Belayer using a "closed fist" technique with the hand *intentionally* minding the prusiks while also controlling the DCD.									
Belayer focused on keeping their hand in front of the TPB while also *maintaining solid* rope friction on their belay hand.									
Belayer attempted to defeat the TPB and was able to partially defeat the long prusik, but the short prusik engaged.									
Fall was arrested by TPB.									
13	Petzl, Vector, Black	11mm, NLSK, CI = 'Low Stretch'	30	200	0	TPB w/ RRH	none	4.5 +	3.8
Prusik Cord for Tandem Prusik Belay and RRH was PMI 8mm nylon kernmantle cord.									
Fall was arrested by TPB.									
14	Petzl, Vector, Black	11mm, NLSK, CI = 'Low Stretch'	30	200	0	TPB w/ RRH	Belay Tube (behind)	0.75	1.75
Belay Tube positioned on the rope proximal to the anchor (behind TPB).									
Belayer using a two fingers "scissor" technique to carefully mind the prusiks while also controlling the DCD.									
Fall was arrested by TPB.									

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Date: 8-06-07 ; 8-07-07

Test #	Rope Type: make, model, color	Rope Type: size, material & construction	Initial Rope in Service (m)	Mass (kg)	Fall Factor	Belay Device	DCD	FAS Extension (m)	Maximum Arrest Force (kN)
15	Petzl, Vector, Black	11mm, NLSK, CI = 'Low Stretch'	30	200	0	TPB w/ RRH	Belay Tube (in front)	0.75 +	1.6
Belay Tube positioned on the rope proximal to the load (in front of TPB).									
Belayer using 'standard' TPB technique - incorporating a 'twist of the hand' on the prusiks themselves.									
The descent of the load was largely managed by the belay line (unintentionally), resulting in a quick catch.									
Somewhat of a *skewed* result from other drops due to the 'two-tensioned rope lower' nature of the test.									
Because of the *tight fit* of the rope type into the DCD, it became more of a single rope lower with a 'hands free' backup.									
16	Petzl, Vector, Black	11mm, NLSK, CI = 'Low Stretch'	30	200	0	TPB w/ RRH	BMS Microrack (in front)	4.5+	3.75
BMS Microrack positioned on the rope proximal to the load (in front of TPB) - 2 bars engaged.									
Belayer using 'standard' TPB technique - incorporating a 'twist of the hand' on the prusiks themselves.									
A light rain began just prior to this drop test.									
Fall was arrested by TPB.									
17	Petzl, Vector, Black	11mm, NLSK, CI = 'Low Stretch'	30	200	0	540° Rescue Belay	none	3.25	2.9
First drop test on the morning of 8-07-07.									
Belayer using manufacturer's recommended technique for belaying 540° - gloved hand providing back-tension on rope.									
Fall was arrested by 540°.									
18	Petzl, Vector, Black	11mm, NLSK, CI = 'Low Stretch'	30	200	0	540° Rescue Belay	Belay Tube (in front)	0.75*	1.8
Belay Tube positioned on the rope proximal to the load (in front of 540°).									
Belayer placing gloved hand on rope *between* DCD and 540° providing back-tension on rope.									
540° *did not engage* due to high friction on the interface between the rope type and the DCD.									
* *Initial* stop was made by belayer at 0.75m of elongation simply using their grip on the rope.									
The test mass then continued to *slowly descend* when the belayer *intentionally* reduced his grip.									
19	Petzl, Vector, Black	11mm, NLSK, CI = 'Low Stretch'	30	200	0	540° Rescue Belay	BMS Microrack (in front)	2.75 +	3
BMS Microrack positioned on the rope proximal to the load (in front of 540°) - 2 bars engaged.									
Belayer placing gloved hand on rope *between* DCD and 540° providing back-tension on rope.									
Fall was arrested by 540°.									
20	Petzl, Vector, Black	11mm, NLSK, CI = 'Low Stretch'	30	200	0	540° Rescue Belay	BMS Microrack (in front)	1 +	1.8
BMS Microrack positioned on the rope proximal to the load (in front of 540°) - 4 bars engaged.									
Belayer placing gloved hand on rope *between* DCD and 540° providing back-tension on rope.									
Very gentle catch; negligible rebound effect on the belay rope.									
Fall was arrested by 540°.									
21	PMI, EZ Bend, White	11mm, NLSK, CI = 'Static'	30	200	0	TPB w/ RRH	Belay Tube (behind)	2.5 +	3
Belay Tube positioned on the rope proximal to the anchor (behind TPB).									
Belayer using a "closed hand" technique- firmly gripping the prusiks themselves.									
The idea on this technique being that the belayer's hand will get *moved* as the prusiks engage during fall arrest.									
Fall was arrested by TPB.									

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Date: 8-07-07

Test #	Rope Type: make, model, color	Rope Type: size, material & construction	Initial Rope in Service (m)	Mass (kg)	Fall Factor	Belay Device	DCD	FAS Extension (m)	Maximum Arrest Force (kN)
22	PMI, EZ Bend, White	11mm, NLSK, CI = 'Static'	30	200	0	TPB w/ RRH	Belay Tube (behind)	2	3.1
Belay Tube positioned on the rope proximal to the anchor (behind TPB).									
Belayer using a "two finger pinch" technique- firmly *pinching* the long prusik with thumb and forefinger.									
Fall was arrested by TPB.									
23	PMI, EZ Bend, White	11mm, NLSK, CI = 'Static'	30	200	0	TPB w/ RRH	Belay Tube (behind)	2 +	2.7
Belay Tube positioned on the rope proximal to the anchor (behind TPB).									
Belayer using a two fingers "scissor" technique to carefully mind the prusiks while also controlling the DCD.									
Fall was arrested by TPB.									
24	PMI, EZ Bend, White	11mm, NLSK, CI = 'Static'	30	200	0	TPB w/ RRH	BMS Microrack (in front)	2	3
BMS Microrack positioned on the rope proximal to the load (in front of TPB) - 4 bars engaged.									
Belayer using 'standard' TPB technique - incorporating a 'twist of the hand' on the prusiks themselves.									
Fall was arrested by TPB.									
25	PMI, EZ Bend, White	11mm, NLSK, CI = 'Static'	30	200	0	540° Rescue Belay	BMS Microrack (in front)	1.75 +	2.65
BMS Microrack positioned on the rope proximal to the load (in front of 540°) - 4 bars engaged.									
Belayer placing gloved hand on rope *between* DCD and 540° providing back-tension on rope.									
Fall was arrested by 540°.									
26	Petzl, Vector, Black	11mm, NLSK, CI = 'Low Stretch'	30	200	0	TPB w/ RRH	BMS Microrack (in front)	1.75	2.2
BMS Microrack positioned on the rope proximal to the load (in front of TPB) - 4 bars engaged.									
Belayer using 'standard' TPB technique - incorporating a 'twist of the hand' on the prusiks themselves.									
Fall was arrested by TPB.									
27	Climbing Rope, unknown brand	10.5mm, High Stretch	30	200	0	TPB w/ RRH	BMS Microrack (in front)	3.75	2.15
BMS Microrack positioned on the rope proximal to the load (in front of TPB) - 4 bars engaged.									
Belayer using 'standard' TPB technique - incorporating a 'twist of the hand' on the prusiks themselves.									
Fall was arrested by TPB.									
28	Climbing Rope, unknown brand	10.5mm, High Stretch	30	200	0	TPB w/ RRH	none	> 5	1.35
Test mass grounded out due to excessive elongation.									