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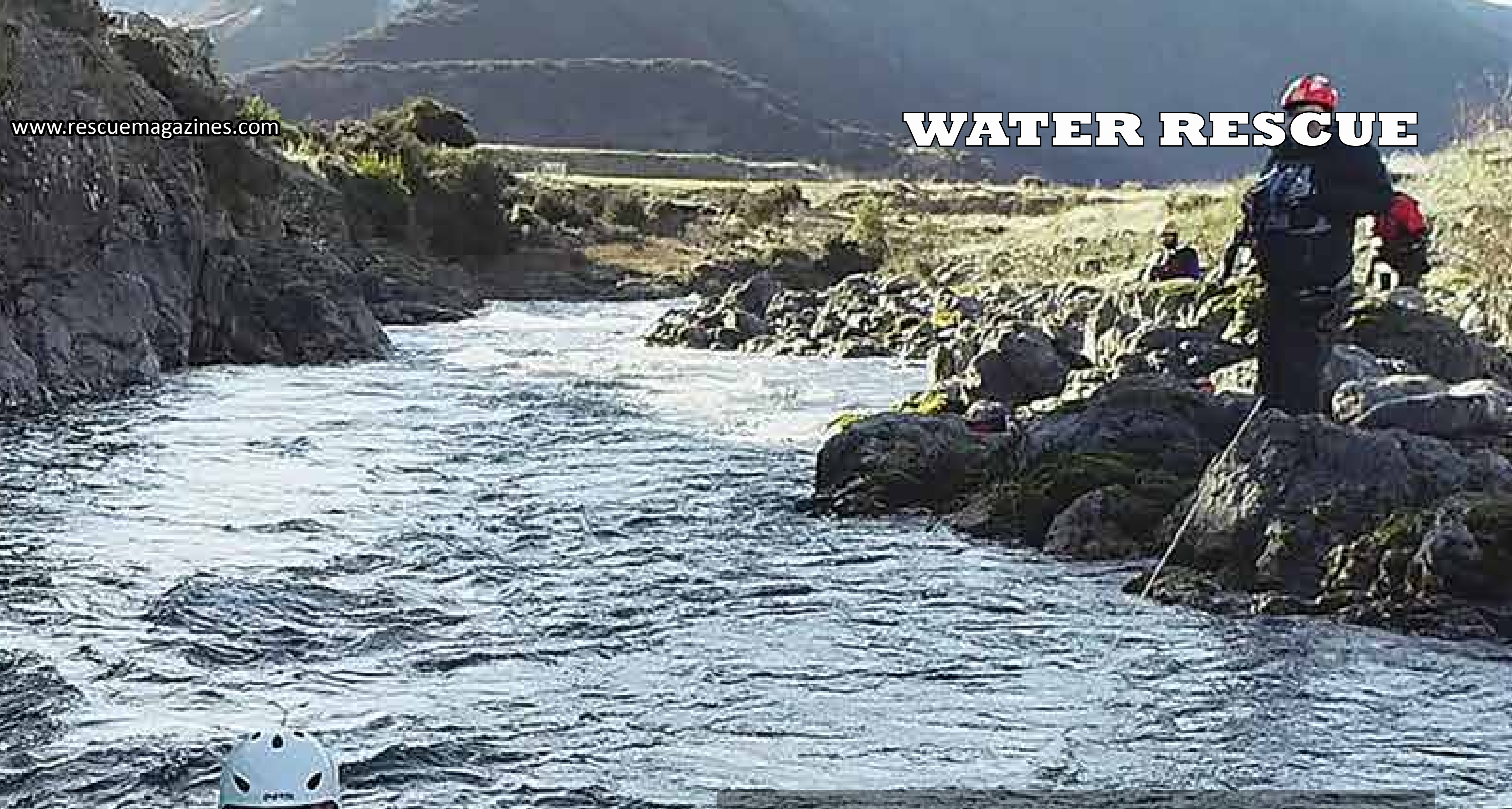
WATER RESCUE



New generation swiftwater rope systems using Teufelberger TEC Reep cord and other accessories

by Steve Glassey

MEmergMgt CEM® ITRA-S3A/B/V-INS
Steve has been a swiftwater instructor for 20 years and was a Higgins and Langley Memorial Award Co-recipient in 2014 Rescue 3 International's Instructor of the Year in the same year.
He is a founding member of the International Technical Rescue Association and owns and operates the Public Safety Institute, delivering consulting, research and training services world-wide.

ABSTRACT

The emergence of advanced fibre micro ropes in technical rescue is receiving considerable interest mainly by those in the rope rescue, mountaineering and tactical rope industries. Many of the examples found are in studies focusing on high angle applications and not in swiftwater environments. With minimal studies available on the use of advanced fibre micro ropes for swiftwater rescue, this study aimed to see whether or not there were advantages of using such ropes, specifically Teufelberger TEC REEP cord, along with the use of the VT prusik and the DMM Revolver in the water rescue context. A non-scientific trial using these new technologies was integrated into a scheduled swiftwater rescue technician course, including throw bag rescues, live bait rescues, boat on highline, strainer drill and zip lines. The results were that the combined use of these technologies significantly increased the efficiency and safety of swiftwater rope operations, with no significant limitations observed. Swiftwater rescue practitioners may also observe similar benefits in trialling new generation swiftwater rope systems including reduction in equipment required to be purchased and carried, increased strength in water rope rescue systems and ease of deployment through equipment space and weight savings.

INTRODUCTION

Not much has changed in swiftwater based rope rescue systems since the discipline was pioneered by legends such as Jim Segerstrom, Slim Ray, Charlie Wallbridge and others back in the 1970s.

The operating environment has always called for lightweight improvised solutions that could be quickly rigged using the bare necessities contained in a practitioner's personal floatation device – usually consisting of only a couple or Prusiks, a couple of karabiners and a webbing sling. In the past, for swiftwater, it was typical to have low-strength ropes for use in throwlines, these were/are often cheaper rope like polypropylene and an MBS of 7-13kN is common. Larger and heavier static lifelines (typically MBS >20kN) were used for any significant rigging, such as boat-on-a-highline and zip lines because they provide a higher safety margin. But ask any swiftwater practitioner and you are likely to find that this mix and match approach was never ideal and the Holy Grail was a single rope that could function for both throwlines and rescue rigging.

Swiftwater practitioners don't generally have the luxury of being able to carry a kaleidoscope of hardware and other accessories. This restriction makes it difficult to carry and rig lightweight rope rescue systems that are truly capable of rescue loads, until now. Sixty years on from the introduction of kernmantle ropes, Teufelberger has developed TEC REEP cord, a game-changing rope that may well revolutionise how we approach swiftwater rescue.

WATER RESCUE ROPES

The author was originally introduced to Teufelberger RESC TECH by Craig Raskin who also provided advice on how to seal the cut ends with super glue. Teufelberger's RESC TECH was also a 8mm lightweight rescue rope, but it only came in tan/black/olive which made it somewhat counter-productive in a swiftwater environment where you need to easily spot throwlines – it would have been like having tactical matt black traffic cones. This lack of visibility appeared to be common across most of the 8mm Polyethylene/Aramid lightweight, rescue-capable ropes on the market, with the exception of Teufelberger TEC REEP cord which came in three colour options, including yellow. In comparison to the RESC TECH cord, the TEC REEP cord also had the addition of XLF (polypropylene) in its sheath which is likely to improve its buoyancy in water.

TEC REEP cord is a 32 strand braided kernmantle rope that uses a Ultra High Molecular Weight Polyethylene (UHMWPE) core, covered with a Technora®/Dyneema®/XLF sheath. It floats in water and features low elongation, self-lubricating, good abrasion resistance, good grip and has an MBS of 30kN (Teufelberger,2020). See table 1 for characteristics of the fibres used to construct TEC REEP rope.

The TEC REEP UHMWPE core is 7-9 times stronger than steel (by weight) and is 15 times more abrasion resistant than carbon steel [*Tong et. al.,2006*]. UHMWPE is used for a variety of applications from ballistic armour for people and vehicles, to connections in skydiving equipment and even in astronaut tethers in space, and now swiftwater rescue. A review of other high performance water rescue ropes was also undertaken for comparison (table 2), with TEC REEP cord being 3-6 times more expensive than other water rescue ropes.

	SHEATH BLEND			CORE
	Dyneema®	Technora®	XLF	UHMWPE
Denier Strength (daN/mm2)	345	250	56	240
Specific Gravity (kg/cm3)	0.97	1.45	0.91	0.97
Water Absorption (%)	0	3.0	0	0
Elongation (%)	3.5	3.5	20-25	3-4
Abrasion Resistance	Very Good	Very good	Sufficient	Very good
Melting Point (°C)	140	450	160	130-136
UV resistance	Good	Poor	Good	Good

Table 1: TEC REEP fibre characteristics (adapted from Robline,2020).

The nearest product found in this rudimentary study was PMI Dura-Shield (Pics below and table 2: water rope comparison), however the colour options did not provide sufficient visibility for swiftwater applications and had a slightly lower MBS (accepting that test methods may vary between the options reviewed).

TEC REEP 8mm Yellow

TEC REEP 8mm Blue

TEC REEP 8mm Red

RESC TECH 8mm Tan/Olive/Black

PMI Dura-Shield 8mm (Green/Blue/Tan)

	Diam mm	MBS kN	FLOATS	SHEATH	CORE	COST US$/m
Teufelberger TEC-REEP cord	8	30	Yes	Technora /Dyneema/ Polyprop.(XLF)	UHMWPE	6.40
Teufelberger Water Rescue	11	16.5	Yes	Nylon	Polyolefin	1.08
PMI Water Rescue Rope	7	8	Yes	Nylon	Polypropylene	2.09
PMI Dura-Shield	8	27.8	Yes	Technora /Polyester	Dyneema	6.20
CMC NFPA Throwline	8	15	Yes	Polypropylene	Dyneema	1.16
CMC SRT Throwline	9.5	15	Yes	Nylon	Polyester	1.03

Table 2: Water rope comparison

DMM REVOLVER KARABINER

The author has been using the DMM Revolver Kwik Lock karabiner (Fig 1) which has an MBS of 22kN for several years. It is a compact lightweight alloy karabiner with integrated pulley and a two-stage gate *[DMM, 2020]*. The DMM Revolver is also available in a wire gate, screw gate and triple (three-stage) gate option. The Kwik Lock (two-stage) allows for a locking karabiner that can be opened easily using one hand, a common necessity in swiftwater. Wire-gate karabiners are generally not suitable for swiftwater rescue as they are prone to unintentionally snagging or clipping onto ropes. Screw-gate karabiners, though suitable and common, have the limitation they may not be easily undone with one hand which is important during zipline rescues or containment.

Fig 1

When TEC REEP is used with the DMM Revolver, it sits neatly without lateral overhang on the integrated pulley. These characteristics make it a good choice when rigging swiftwater systems such as mechanical advantage and travelling across a zip line.

VT (Valdotain Tresse) PRUSIK IN SWIFTWATER

Finally, adding to the mix, is the VT Prusik (Fig2). This was developed primarily for arborists as an ascending hitch with a sewn eye at each end but has gained popularity among those using micro-rope systems such as in tactical and certain mountain rope operations. The VT Prusiks, like the TEC REEP cord have a heat resistant Aramid fibre sheath allowing them to be used in high friction situations traditionally not suited to nylon prusiks. It is the combination of these new ropes that allow for us to completely rethink what ropes we use for swiftwater rescue. We now can have a single rope that can be used for throwlines and rope rescue systems in the swiftwater environment. Testing carried out by Rigging for Rescue in 2019, concluded that the "VT Prusik appeared to be a superior alternative to the traditional nylon Tandem Prusik" *[Gibbs, 2019]*. As space in one's PFD is limited, having a rescue load belay method (i.e. the VT Prusik) that only requires one prusik rather than two (as required for the tandem prusik) saves precious space. Simply put, two VT Prusiks replaces four traditional prusik slings. For this study, we used a Tendon Timber Prusik (80cm, 8mm, 22kN MBS) which we will refer to as the VT Prusik. It is important to note that in this study, the Valdotain Tresse was used to allow for release of load, over the Schwabisch 'Max-over-One' hitch as used in the Rigging for Rescue testing.

Fig 2. Valdotain Tresse VT Prusik on TEC REEP low angle system, being changed over with optional karabiner below pulley across both ropes to assist with Prusik minding during haul. In this photo the 80cm Tendon Timber Prusik was used, however the author recommends using the 100 or 120cm variant instead to remove the additional off-set prusik sling as illustrated.

With a combination of the TEC REEP rope, VT Prusiks and the DMM Revolver, the platform was set for modernising swiftwater rigging. The last hurdle to was confirm this hypothesis with some initial testing using these products in real-life swiftwater situations. With Teufelberger supplying 100m of TEC REEP cord for testing, a scheduled swiftwater rescue technician course for Coastguard New Zealand, held in Canterbury (NZ), was used to carry out initial testing.

HOW THE TESTING WENT

Dry rigging of swiftwater rope rescue systems was undertaken to pre-test suitability prior to in-water testing. This included boat-on-a-highline, zip line and low angle stretcher set ups. Feedback from students at that point was that TEC REEP cord was easy to work and tie knots with. We then moved onto the water in two locations including the Jollie Brook on the Hurunui River, a Class II flow ideal for the swiftwater technician course.

LOW ANGLE

As part of the International Technical Rescue Association's (ITRA) Introduction to Swiftwater Technician (IST) course, students were asked to construct a basic low angle lowering and raising system for situations where resources were limited during swiftwater incidents. The system comprised of TEC REEP as the main rope connected to webbing at the head of the litter, protected with a Valdotain Tresse using a VT Prusik, with either an Italian (Munter) hitch for lowering, or running through a pulley in raising mode (3:1), (fig.2). A doubled Prusik sling was used to offset the VT Prusik away from the Italian hitch and allowed the hitch to be changed over to a pulley for hauling and vice-versa while protected. This simple method allowed students to rig a low angle system capable of rescue loads with ease that were easy to change over between raising and lowering using minimal equipment. The heat resistance of the Technora® covered VT Prusik and TEC REEP mainline in this system allows for this unique combination. It is imperative that users understand that this proposed system can only be used with prusik slings and micro ropes made of specific heat-retardent fibres to make this combination possible and safe.

THROW BAGGING

Three 20m polyester throw bags were retrofitted with TEC REEP (fig 3). These were used throughout the course for numerous techniques including throw bagging. Prior testing using an NRS Co-Pilot knife confirmed the TEC REEP was able to be cut without much issue despite its abrasion resistance. This is a critical requirement in the event of an emergency such as throw bag entanglement. TEC REEP was easily gripped whether dry or wet. No major limitations were observed in using the TEC REEP cord for throw bagging swimmers or rescuers. The only 'limitation' is that the partial yellow colour of the TEC REEP cord may not be as high-vis as traditional solid yellow and red water rescue throwlines, but this limitation was not significant.

Fig 3: Throw bags retro-fitted with TEC REEP. Note red inner core (unsealed)

TETHERED SWIM

The floating TEC REEP cord performed well, comparable with traditional economical throwlines with no observed limitations.

ZIP LINE

The Zip Line (Tensioned Diagonal) is where the TEC REEP showed significant advantages. Having a low elongation (core 3.5% cf. Polyester 10-16%, Polypropylene 20-25%) meant that tensioning the system was easier because there is less creep, and after initial loading, less requirement to re-tension. Two 20m TEC REEP throwlines were used as anchors, connecting to a 20m TEC REEP zip line through a Valdotain Tresse VT Technora® Prusik as part of a 3:1 mechanical advantage (same set up as low-angle to keep methods simple- fig 4). There was some initial slippage of the VT Prusik, but this was easily resolved with two extra wraps added to the Valdotain Tresse. This initial slippage was likely due to the mainline and VT Prusik being the same diameter and both being new. Using the DMM Revolver as the travelling device across the TEC REEP zip line (fig 5) worked well for both single and two-person zip line operations. The benefit of using TEC REEP over traditional ropes was that retrofitted throw bags could be used for anchoring *and* the zip line, and that lack of elongation decreased the amount of time wasted re-setting the tension during instruction. The author also left a part of the loaded TEC REEP cord unprotected to a sharp edge and monitored it for abrasion. It was observed that the rope suffered minor abrasions at that contact point, but in the author's experience, traditional polypropylene or polyester ropes suffer more adversely under the same conditions. This is not to suggest that TEC REEP cord does not require edge protection, in fact, given the cost of this rope, such protection is strongly encouraged. One related benefit of the TEC REEP cord is that the UHMWPE core is distinctively red in colour, so any damage to the light yellow covered sheath should easily indicate damage (fig 3). No limitations were observed in using the TEC REEP for the zip line.


Fig 4: Technora® VT on TEC REEP cord


Fig 5: DMM Revolver in use as the travelling device on a TEC REEP zip line.

STRAINER DRILL (see title picture p.58)
Using the same river-right anchor, the zip line was reconfigured for the strainer drill. Both upstream tag lines used TEC REEP cord. Traditionally, ropes used for this activity ranged from lifelines (i.e. 11mm nylon static kernmantle) to throwlines (8mm polyester/polypropylene). Both of these traditional ropes generally have markedly more elongation leading to the strainer post constantly recoiling back upstream, causing a serious risk to student safety. The recoiling of the strainer post in high-flow can often result in facial, head, and/or dental injuries. To minimise this risk, it is best practice to place an attendant (often an instructor) at one or both ends of the strainer to soften the recoiling motion of the post. In this test, the water depth and speed did not allow for this, so a downstream tag line was set up to provide downstream tension to soften the recoil. The minimal amount of elongation using TEC REEP cord in this trial resulted in the strainer post having minimal recoil and the downstream tag line became unnecessary. The use of TEC REEP cord in the strainer drill proved effective in reducing post recoil and improving student safety. No limitations were observed in using the TEC REEP cord for the strainer drill.
Figure 6- SEE TITLE PAGE: Strainer drill with TEC REEP tag lines.

BOAT-ON-A-HIGHLINE

Though there are numerous ways to rig boats on highlines, the author opted for simple rigging with hand controlled tag lines with a 2:1 reeve on a TEC REEP main (track) line. The use of TEC REEP cord in this instance shows how versatile having a high strength 8mm rope is. It was easier to carry in with the TEC REEP cord already being carried as throw bags, so no extra big/heavy 11mm ropes were needed. As with the strainer drill and zip line, the low elongation meant less time re-tensioning the system and more time for students to focus on the skill of boat-on-a-highline. We used an inflatable rescue sled which proved effective for the task. The smaller diameter rope (TEC REEP cord) also meant larger diameter pulleys were not required. The dry rig of the boat on highline (fig 7) has larger pulleys that could easily be replaced with the DMM Revolver.
There were no observed limitations in using TEC REEP cord for the boat on highline technique.


Fig7: Boat-on-a-highline dry rigging using TEC REEP.

SHORE BASED VEHICLE STABILISATION

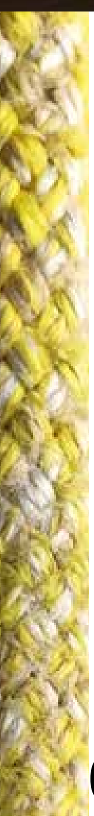
The author's original interest in high strength micro rope systems for swiftwater was for shore-based vehicle stabilisation. Traditionally, low strength throwlines were used to create the initial stabilisation, and then a lifeline rope e.g. 11-12.5mm static kernmantle rope, with >30kN MBS, could be pulled through to replace them and provide a stronger connection. Anecdotal evidence at swiftwater vehicle rescue courses, found that stabilisation lines and their respective anchors were not loaded as much as previously expected. However, it makes sense to maximise the strength of such systems if

Fig 8: TEC REEP being used for shore based vehicle stabilisation (dry rigging)

rigged with lower strength (typically around 6kN) conventional low-cost throw rope, with high strength micro ropes such as TEC REEP (30kN). The abrasion resistance of TEC REEP cord is more effective in protecting the rope from glass and sharp edges, often found in vehicle accidents. In dry testing there was no limitations observed in using TEC REEP for shore-based vehicle stabilisation. However, though conceptually the use of TEC REEP cord for shore based vehicle stabilisation appears promising, realistic testing in high flows is needed to provide any conclusion to its suitability or not in such applications.

POST USE INSPECTION

After the TEC REEP cord was washed and dried, an inspection was carried out. The area that was subjected to intentional abrasion had minor wear but the core was not exposed. Upon



palpation of the rope, it was able to be compressed (fig 9) and evened out. When used for swiftwater rescue in the methods described in this study, this sheath slippage is unlikely to be of significant concern. Further research is needed to determine if this slippage is an issue for use with mechanical devices.

Fig 9 ABOVE: Flattened TEC REEP cord

Fig10 LEFT: Minor abrasion on TEC REEP cord

LIMITATIONS & FURTHER RESEARCH

Scientific test conditions were not used in this study. This rudimentary review would benefit from an empirical study being conducted. Further research on the application of TEC REEP for swiftwater vehicle rescue operations in swiftwater environments is also needed as this was not wet-tested during the study. Additionally, further research is required to more comprehensively evaluate the effectiveness of the Valdotain Tresse and similar Prusik knots using a VT Prusik sling in the swiftwater environment. Though the author made reasonable efforts to identify other similar rope to TEC REEP, no other rope/cord with similar specifications and colours could be found. It is quite possible that other brands and variations exist that or have been subsequently introduced that would be suitable but these were unknown at the time of study. As mentioned previously, the observed sheath slippage warrants further research in regard to the ropes suitability for use with mechanical devices.

DISCUSSION

The initial hypothesis was that TEC REEP cord could be a game changer for swiftwater rescue, as much an evolution as the change from manilla to nylon ropes in the 1950s. Back then the argument would have been similar “but we have been using this for years, it is fine – and this new stuff costs too much anyway”. The cost of TEC REEP is high, but only about 20% more than conventional NFPA 'T'-category rope, and has the additional benefits of saving space and weight which is often restricted when wearing a PFD. TEC REEP is also more abrasion resistant than traditional nylon, polyester or polypropylene, so it can be reasonably assumed that it will outlast traditional rope, thus saving on replacement costs. The accessories recommended such as a Technora® VT Prusik and the DMM Revolver are also typically less expensive than larger mechanical devices such as descenders, ascenders, pulleys and the like. The entire system cost may be less with TEC REEP, VT Prusin=c and DMM Revolution, than traditional rigging systems. This, however is an assumption that may be challenged.

The application of TEC REEP as a main line, beyond being an accessory cord (of which it is certified to EN 564) challenges the traditional standards for rescue ropes with the NFPA 1983 standard requiring Technical “T” ropes to be 9.5-12.5mm in diameter and 20kN in its simplest terms (NFPA, 2017). The same NFPA standard also requires throwlines to have a breaking strength of less than 13kN, but between 7 and 9.5mm (and float). To recap, TEC REEP is 9mm and has a 30kN breaking strength. This means the NFPA standard fails to consider a rope that can be both a throwline and a technical (“T”) category rope and may no longer be relevant so a new category is needed for water rescue ropes or micro rope systems used in swiftwater, mountaineering and tactical applications.

There are some caveats with the new generation swiftwater rigging systems discussed in this paper. As with any rope or webbing, it needs to be protected from UV/Sunlight given part of the sheath fibre is Technora® which has poor UV resistance (table 1). The use of the VT Prusik requires a new knot/hitch to be learned, the Valdotain Tresses, which is not common in swiftwater. The users of the system must also critically know that both the TEC REEP and Technora® VT Prusik are specialised products and substituting them for traditional nylon or polyester ropes may lead to serious injury or death. Swiftwater practitioners should always carry a knife, and it is essential that the knife has a sharp serrated edge for the emergency cutting of TEC REEP (but this is should be true of working with any rope around water anyway).

From a manufacturing perspective, there could be benefit in future productions to include a contrasting red strand or fleck to make TEC REEP more visible in aerated water, commonly encountered in the swiftwater environment. The inclusion of a reflective marker thread would be advantageous also.

The VT Prusik (80cm) used in this study appeared to be too short and in future application (fig 2), the 100cm or 120cm may be a better option to eliminate the need to extend the connection.

As some swiftwater rescue teams are mobilised by helicopter, the need for lightweight, multi-purpose, high strength equipment is needed. TEC REEP cord enables this by replacing multiple variations of rope diameter to a simple 8mm micro rope that can be used for rescue loads when used in conjunction with other accessories such as the VT Prusik.

CONCLUSIONS

This preliminary study highlights the potentially significant improvements to efficiency and safety of new swiftwater rope systems rendered by Teufelberger TEC REEP or similar cords. The integration of the VT Prusik and DMM Revolver karabiner enhances the versatility of the systems and all key components exceed an MBS of 22kN (as stand-alone components and not including knot efficiency). The combination of these products resulted in light weight, flexible and high strength rope systems suitable for the swiftwater environment. The unique yellow colour option for TEC REEP made it more suitable for swiftwater rescue than competing tactical products reviewed.

The cost of TEC REEP cord is two to six times higher than other throwlines but could be justified with the 8mm cord replacing traditional nylon/polyester 11-12.5mm rescue ropes, meaning savings through reduction in the number of ropes (and rope bags) required for a swiftwater rescue team. As TEC REEP cord offers higher abrasion resistance than traditional water throwlines, it may well be that this also contributes to savings in the long term. It may be easy to fall into viewing the change to TEC REEP cord as an expensive way to replace throwlines, but maybe it is more appropriate to view it as the cost, weight and storage space benefits of replacing both throwlines and rescue ropes with a single rope type solution.

If further testing validates the findings of this study, then manufacturers and equipment suppliers should give consideration for the supply of both standard (bucket type) and waist-mounted throw bags being fitted with TEC REEP (or equivalent product if available). Rescue kits could be also supplied containing such throwlines along with DMM Revolvers or similar pulley-carabiners like the Petzl and VT prusiks or a similar product as produced by Sterling Rope and Edelrid.

In summary, preliminary testing using TEC REEP cord for swiftwater rope operations observed the following benefits:

- **Lightweight**
- **High strength** – able to cater for rescue loads
- **Acceptable visibility** in water
- **High abrasion resistance**
- **Easily gripped** when wet or dry
- **Easy to tie knots** and work with
- **Micro-Hardware Integration**. Works well with the DMM Revolver given the diameter of the integrated pulley
- **Less elongation** reducing time spent on tensioning mechanical advantage systems
- **Less elongation** for strainer drills leading to reducing the risk of timber post recoil injuries
- **Highly versatile** – able to be used from throw bagging to highline and stretcher work
- **Compact** – saving space in storage and in user pockets (often limited with PFDs)
- **Potential long term cost savings** due to using a single type of rope and abrasion resistance
-

There were minimal limitations in using TEC REEP, but the following were observed:

- **Initial higher cost** may be prohibitive to some users/ organisations
- When used in conjunction with a VT prusik, users must be aware of **fibre limitations**
- A **sharp serrated knife** should always be available when in use
- **Observed sheath slippage** requires further research before use with mechanical devices.

Just as the rescue industry evolved from manila rope to nylon hawser laid then to kernmantle rope, perhaps we are now in a new era of smaller, lighter ropes for rescue rigging. It is important that the swiftwater industry further explores and challenges the systems tested in this study to ensure we can provide the best possible and safest response to water emergencies in the future.

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Conflicts of Interest

The author discloses the conflict that the rope supplied for testing was provided at no charge by Teufelberger. No other incentive or benefit was received as part of this testing. No other conflicts are disclosed. DMM and Tendon devices were used in this study, but without affiliation sought or received.

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