SIRIUS, SPARK AND SPARK TACTICAL

IN TYROLEAN TRAVERSES

WARNING!

- Techniques described in this guideline are not a substitute for a proper training.
- Before applying techniques described in this guideline read and understand user manuals of all used PPE equipment, in particular SIRIUS, SPARK and SPARK TACTICAL.
- We recommend learning work at height and rescue techniques on licensed courses with qualified instructors.

Tyrolean traverses, sometimes called just Tyroleans or high lines or telphers, are rope or cable systems suspended between two points that are used to move people or equipment between these two points and below lying ground. Tyroleans may be horizontal, where the two end points are at similar elevation, or sloping, where the two points are at different elevations. Most often they are used to span over terrain that is difficult or dangerous to pass or access such as canyons, bodies of water, rocky terrain, etc.

Descenders are effective for tensioning Tyrolean traverse main lines as they provide high tension and an easy release. Among the reasons why teams shy away from Tyroleans is the potential to overload the equipment and the anchors causing a system failure.

This is a legitimate concern and the below guidance is meant to indicate a safe way to use SKYLOTEC's descenders SIRIUS, SPARK & SPARK TACTICAL as means to tension and release the main line is such a system. They are very similar in their capacities and in further text their names will be used interchangeably. They are primarily intended for movements of one or two persons along the working line in vertical direction while being positioned either on the harness or at the anchor thus controlling the movements of the operator from a remote location.

The tension in the main line often exceeds one or two-person loads by a significant margin. The question this document aims to answer are:

- If or when the tension in the main line leads to dangerous or functionless situations and what are safe margins of initial tension before load is suspended from the main line.
- What are margins of initial tension to safely release the main line.
- How to tension the main line to establish a safe and functional tension.

RULES FOR DETERMINING TENSION

Throughout the evolution of roping techniques various rules of thumb have developed to help estimate a safe tension on the main line.

1. **One man rule**. This was an early rule by which the Tyrolean would be tensioned by one person pulling the line. The final tension is dependent on the strength of the person and efficiency of the progress capture system. This rule often resulted in too little tension for the Tyrolean to be of any use at all.

2. **Ten-percent rule** states that for every 100 kg of load the sag in the main line should roughly equal 10 % of span. With a span of 30 m the sag would equal 3 m after loading it with 100 kg and 6 m after loading it with 200 kg. For estimating the sag – especially in inclined Tyroleans –experience plays an important role.
3. With **fifteen-degree rule** a 15° angle of declination between the horizontal and the angle of the main line at the anchor should be allowed before loading it. Without an inclinometer this angle is hard to estimate. Non-horizontal Tyroleans are further complicating things.
4. **Number of persons rule**. If the force applied by each person pulling is known, along with the number of persons in the haul team, then the force exerted on the main line can be calculated. This is one of the easiest yet consistent-enough methods of limiting forces on the main line. Various sources state one-person pulling forces to be: between 100 N and 200 N; 50 lbf (23 kgf) for 50 ft (15 m) of pull; or with good foot support between 200 N and 400 N. The number of people in the haul team determines which mechanical advantage the team may pull to attain a safe *Static System Safety Factor*. With an 11 mm low stretch rope the rule of 12 and the rule of 6 have reached wider acceptance. The more conservative rule of 6 states that with 2 persons pulling a 3:1 mechanical advantage can be used (2 persons · 3:1 mechanical advantage = 6).
5. **Force measurement on the anchor**. In the past dynamometers were expensive and impractical to carry around. With the advent of small battery powered dynamometers more and more teams are affording one. Measuring forces at anchors is certainly the most accurate method to assess static or dynamic safety factors of the whole system or individual elements.

TENSIONING AND RELEASE TESTS

The tests were performed on a horizontal span of 14 m with a 250 kg of load with a new pre-soaked 11 mm Skylotec Superstatic rope. Single Tyrolean main line was employed for the tests. Readings of two force gauges were done in parallel: on the anchor and on the load. 250 kg weight was used as a proxy of a rescue load (two-person load including stretcher and equipment) and as the maximum load that should not be exceeded. The tests consisted in: tensioning the unloaded main line; applying load in the middle of the line; releasing the main line by means of a descender. Tensioning was done to roughly 1 kN, 2 kN, 3 kN, and 4 kN.

Table 1: results of tension and release tests (span = 14 m, load = 250 kg, pre-soaked Skylotec Superstatic 11 mm).

Initial force on anchor [kN]	Force on anchor after load applied [kN]	Sag [m]	Angle at anchor [°]	Rope slippage after load applied	Release under load
1	3.75	3.1	27	NO	Yes, easy & controlled
2	4.2	2.8	25	NO	Yes, controlled
3.3	5.5	1.9	16	NO	Yes, possible
4.3	6.3	1.5	12	YES, few cm	**Not possible**

FINDINGS

1. A 4-fold change in initial force results in a 2-fold change in sag. It means that a lot more initial tension will not result in a desired decrease in sag.
   - *If height of the system is sought after, try finding higher anchors or adding a second main line or both.*
   - *If nothing works, look for a different solution.*

2. Main line release was done rather comfortably and smoothly with an initial force of 2 kN, which resulted in 4.2 kN on the main line after the load was suspended from it.
    - *Using a re-directional carabiner on the free end is essential for better control and smoother lowering.*

Table 2 summarizes forces on the top of the handle necessary to release a load with SIRIUS or both SPARKS.

Table 2: forces on handle pulled by the handle's hole during release.

Main line tension [kN]	Force on the handle [kN]
2	0.17
4	0.28
5.2	0.34

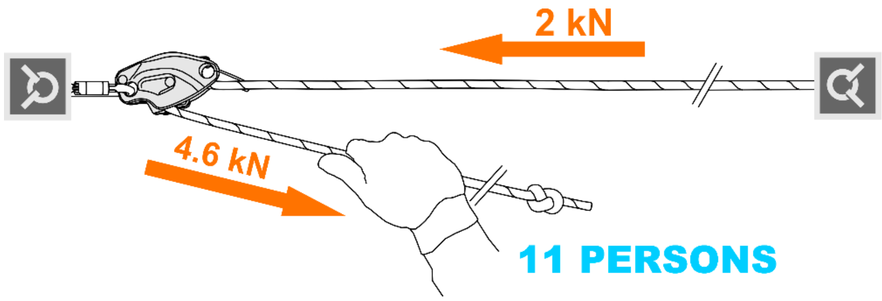
1. Releasing of the system became less reliable above 5 kN of tension after load was applied. While it would still be possible to safely use a Tyrolean with tensions around 5 kN, the release under load would prove difficult and jerky. *Such practice is, therefore, discouraged.*
2. After applying load to a pre-tensioned system to 4 kN the force rose above 6 kN causing rope slippage in SIRIUS indicating its *force limiting capabilities*. While this is good news, it does not relate to it being useful, or as a substitute, to an energy absorber. *Unless used with a dynamic rope for belaying, SIRIUS and both SPARKs are not intended for dynamic loads*. Rope slippage in SIRIUS and SPARK is consistent with the values measured in laboratory.

METHODS OF TENSIONING TO ACHIEVE SAFE TENSIONS

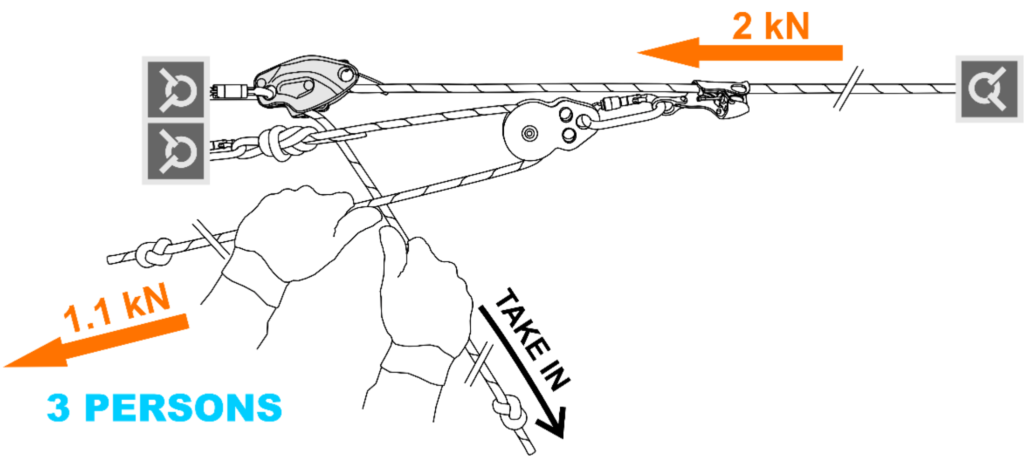
Pre-load tensions up to 2 kN on a single main line with either SIRIUS or both SPARKs may be considered safe (within constraints of the load and suitable ropes used).

Descenders' efficiency values are calculated between testers in a bit different ways. If efficiency is a ratio between the force of gravity of the load and the force of pull of the rope out of the descender, the efficiency of SIRIUS or its siblings was measured at 0.43 (11 mm low stretch rope). Suppose that good quality pulleys have efficiency values of around 0.9 on 11 mm low stretch rope. The below figures are indicating the force of the pull on the free end and estimating the number or persons pulling to attain a 2 kN force on the main line based on the mechanical advantage employed in the tensioning system. They line up quite well with the mentioned rule of 6. With a 3:1 mechanical advantage 2 persons would be needed to tension the main line. With a 6:1 only 1 person is needed.

1:1 SYSTEM



2:1 SYSTEM



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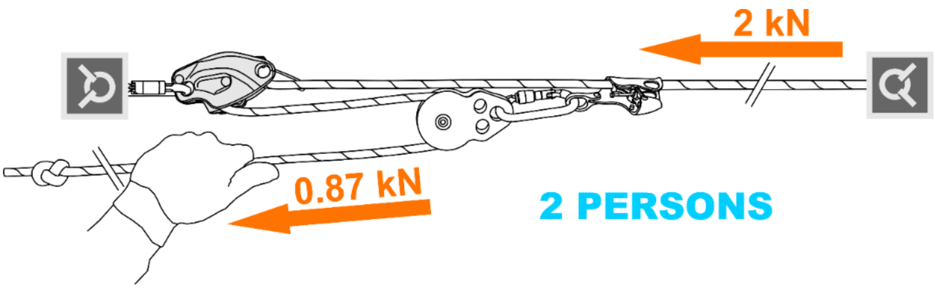

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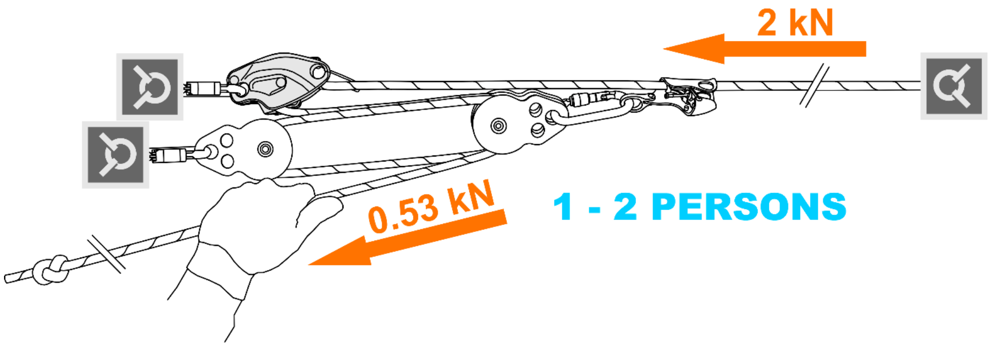
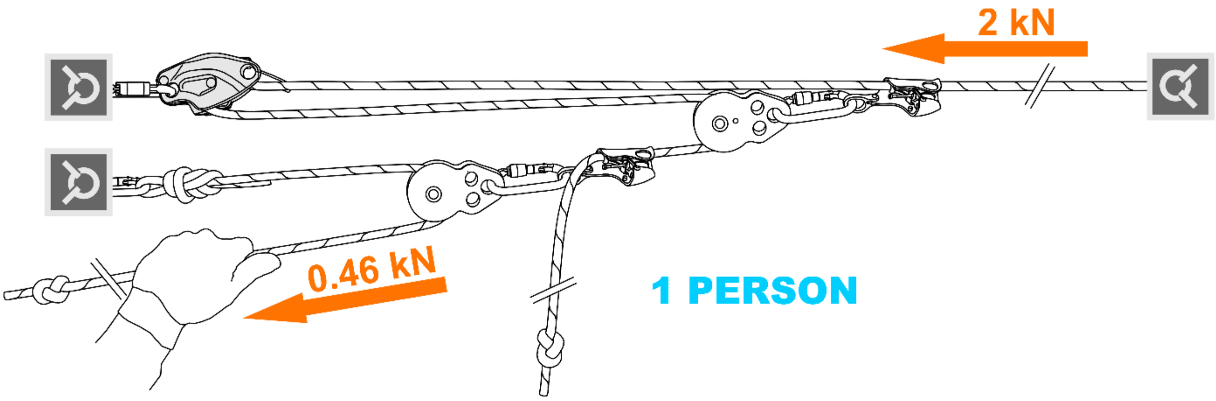


6:1 SYSTEM



WARNINGS!

- In Tyroleans, anchors and the interface between the rope and the descender in the main line are stressed most. Assess their strength against your safety factors.
- Do not over-tension. Safe initial tension interval is given above. If height is sought after, try finding higher anchoring possibilities, add additional main lines or seek an entirely different solution.
- If lowering the main line during load suspension is needed re-direct the free end of the rope over a carabiner.
- Do not bring into resonance the main line by jerk pulling the reeve or the tag lines. Very high loads on the anchors may result from such poor line management.
- In a controlled environment a tie-off of the main line not compulsory. There are two reasons a team may decide to use it: to prevent accidental release; to limit slippage in overload cases. While SIRIUS or SPARK have experienced slippage in overload cases, uncontrolled catastrophic slippages have never occurred. The decision whether to tie-off a device or not is, therefore, left to individual team's internal procedures and safety protocols.