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Industrial Rope Access: The Quantum

The development of an industrial
rope access back-up device

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heightec.com

irata International Industrial Rope Access Trade Association

ISO 9001:2008 SGS UKAS MANAGEMENT SYSTEMS 005

Background

Back-up devices offer considerable design challenges for manufacturers and the use of these products has been the subject of strong debate within the rope access industry for many years[1]. heightec has followed the development of these issues whilst researching, testing and developing our own solution to the complex requirements of a versatile back-up device. This document describes the background and technical challenges involved in designing a new backup device that is intended to work on all types and condition of rope, with loads up to 200 kg.

The problem

The "problem" with back-up devices is quite specific. In certain situations there is a real risk that devices may not work as users expect, especially when working with used rope or heavy loads. The rope may break (caused by the device) or the device may not stop the fall.

heightec considers that industry has never fully addressed the issues of used rope and high loads and believes that the issue of back-up devices should be revisited. Equipment selection requires both legal and technical issues to be addressed. There should be a re-assessment of the risk and an acceptance that these issues exist and need to be dealt with.

Relying on product standards is not "enough". Some test requirements are imperfect and those selecting equipment can rely on them too much. Critically, product standards do not sufficiently consider aspects of use. Devices known to have passed a product standard have been shown to have problems, e.g. with excessive slippage or damage to used ropes. It is argued that these devices do not, in fact, meet the *basic health and safety requirements* of Directive 89/686/EEC on personal protective equipment, e.g. under foreseeable conditions of use, minimising collision with objects, etc.

The state of play

The technical challenge for manufacturers has resulted in a limited range of available devices, resulting in the status quo being maintained. With perhaps a couple of exceptions, real technical development has been limited. New devices tend to be variations of the same principle, with some manufacturers not analysing how their device behaves 'over-and-above' the product standard.

The whole concept of foreseeable misuse has been underplayed. Some manufacturers have identified risks, but allowed them to remain by creating excessive limitations in their user instructions. This can place limits on performance, thus requiring the user to restrict their activity to the capability of the device. Finally, some 'expert users' ignore user instructions considering them to be prepared for the 'novice user'.

What influences the performance of a back-up?

There are numerous variables that affect the performance of a back-up device:

- The age of the rope (and hence it's stiffness and degradation);
- The rope brand, diameter and the construction of the core and sheath;
- The condition and cleanliness of the rope, e.g. paint, grease, oils, dirt/grit);
- Whether the rope is wet, dry, cold/hot (air temperature), etc.;
- The number of users and their mass;
- The length of the fall (taking into account the length of the connecting element, e.g. cowstail, and the fall factor) and whether the lanyard length is shortened during a rescue;
- The type of lanyard, e.g. knotted dynamic rope, webbing, Dyneema®, etc.;
- The weight of the rope below the device and whether it is under tension, e.g. during a rescue; and
- The material from which the device is manufactured and its susceptibility to wear and tear.

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1 Industrial Rope Access: Back-up Devices - A Review, A summary of relevant technical and legal information relating to the historical development of industrial rope access back-up devices, heightec, v1.0713 (www.heightec.com/new.php#news96)

With such a wide range of variables affecting the performance of any device it may behave in an unpredictable way if the designer doesn't take them all into account.

A standards perspective

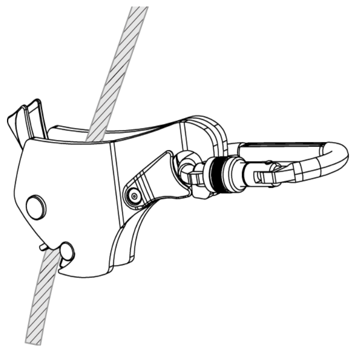
Harmonised product standards provide *presumption of conformity* with the *basic health and safety requirements* of Directive 89/686/EEC. Some standards may contain optional testing. Testing within standards is idealised, does not cover real-life scenario and, importantly, is conducted on new rope to ensure repeatability and reproducibility.

Back-up devices are tested to meet a standard (e.g. EN 353-2 and/or EN 12841). They are tested near the anchor point and required to achieve a braking ('impact') force of less than 6 kN. To achieve this, devices usually limit the impact force by allowing slippage. However, slippage is dependent on rope type, condition and the mass to be arrested and thus is variable. Tests have shown that some back-up devices fail to arrest a load by continuing to slip, i.e. once they start slipping they cannot arrest a fall.

BS EN 12841, of which some aspects heightec considers to be unsound, allows for multiple users but compensates by allowing a greater arrest distance. However, as we explain later, we believe slippage is the problem not the solution.

Despite the large number of variables, all considered *reasonably foreseeable*, standards "expect" that a device will perform within very tight parameters, stopping within 1 m (EN 353-2) or 2 m (EN 12841, Type A) with an impact force at the anchor of less than 6 kN. But in any experiment, if you change the variables you would expect to get a changed result. An analogy would be to expect cars to stop within similarly tight parameters regardless of model, tyre pressure, tyre type, tyre tread depth, speed, road surface (e.g. tarmac, gravel, etc.), conditions (e.g. wet, dry, etc.) and number of passengers. Most would agree that this is impossible.

The design challenge

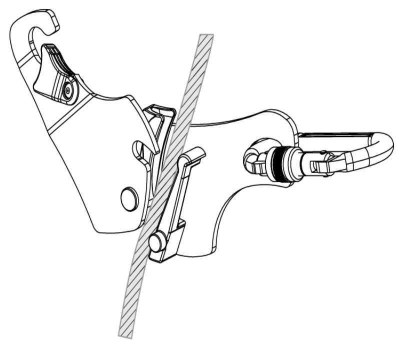


The challenge in creating a device that works in situations that are beyond current norms is to accept the difficulties, rather than avoid them by unnecessarily limiting the methods of use in user instructions, e.g. different length lanyards for different rope diameters. The most pertinent variables are those of used ropes and high loads; especially in combination.

We decided to completely re-assess the problem adopting a structured and rigorous methodology rather than rely on 'post-test tweaking'. We tried to eliminate assumptions by analysing results, forming a hypothesis, devising a solution, testing; and then repeating the whole process.

At the heart of the process has been the need to carefully isolate individual variables in order to determine performance change.

What we learned



We established that the outcomes in a test are predictably *either* slippage or rope damage. Devices struggle when the load is increased, but especially on *used* rope, which causes them to behave very differently – typically to damage the rope more easily.

The only way to avoid rope damage is to reduce the impact force either by allowing slippage or introducing additional elements, e.g. an energy absorber, but we feel that that this adds to the potential for misuse.

If you allow slippage this can be difficult to control with a higher mass – resulting in longer falls, higher risk and an unpredictable final conclusion, e.g. the device may not stop. The number of variables that a device is trying to cater for is too great.

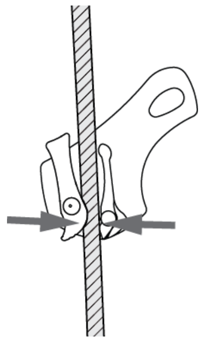
The heightec solution

For a device to be regarded as reliable, a structured and rigorous methodology requires that its performance be both predictable and demonstrable. However, behaviour cannot be predicted when a device is at the limit of its performance; and this is especially the case with slippage. We believe the key to success in designing a back-up device is therefore to *control slippage*.

If slippage is reduced the load on the rope is increased. We observed that in falls with a high user mass, for most devices the sheath of a rope can't withstand the high forces that are applied by the cam's single point of contact – there is just not enough sheath in a small area to take the load.

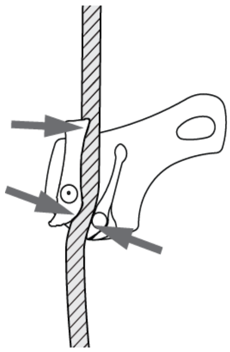
We hypothesised that the final solution would be found in a cam design that *spread the load over a larger area of the sheath* … the key lay in the cam. This indeed did turn out to be case...

The elusive cam



Different cams were tested in order to determine the behaviour of different geometries and their effects on rope integrity under load. We isolated an ideal geometry and adjusted dimensions to optimise the applied braking force. The device needed to limit the slippage and not damage the rope. This was often achievable on new rope but not always easy, especially on early versions, for used rope. Likewise, a device whose geometry was idealised for use on used rope tended to damage new rope.

The result

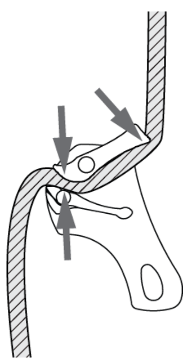


The result is a versatile device (patent pending) that is very strong, has a simple mode of operation and which is highly tolerant of an exceptional range of performance parameters. The Quantum locks quickly, thus limiting slippage (eliminating the need to control all the variables) and does not cause catastrophic damage to the rope.

The Quantum is suitable for loads up to 200 kg, e.g. two-person rescue at fall factor two, and will work on a wide variety of rope types; new, used, wet, etc. (all of which are considered *reasonably foreseeable*). It is capable of trailing (again considered *reasonably foreseeable*) and can be parked (thus meeting a regulatory requirement to 'minimise the distance and consequences of a fall').

The Quantum exhibits improved performance away from the anchor, where most rope access work takes place. It benefits from the inclusion of a catch so that the device can be opened and placed on the rope without the risk of it being dropped.

Other considerations



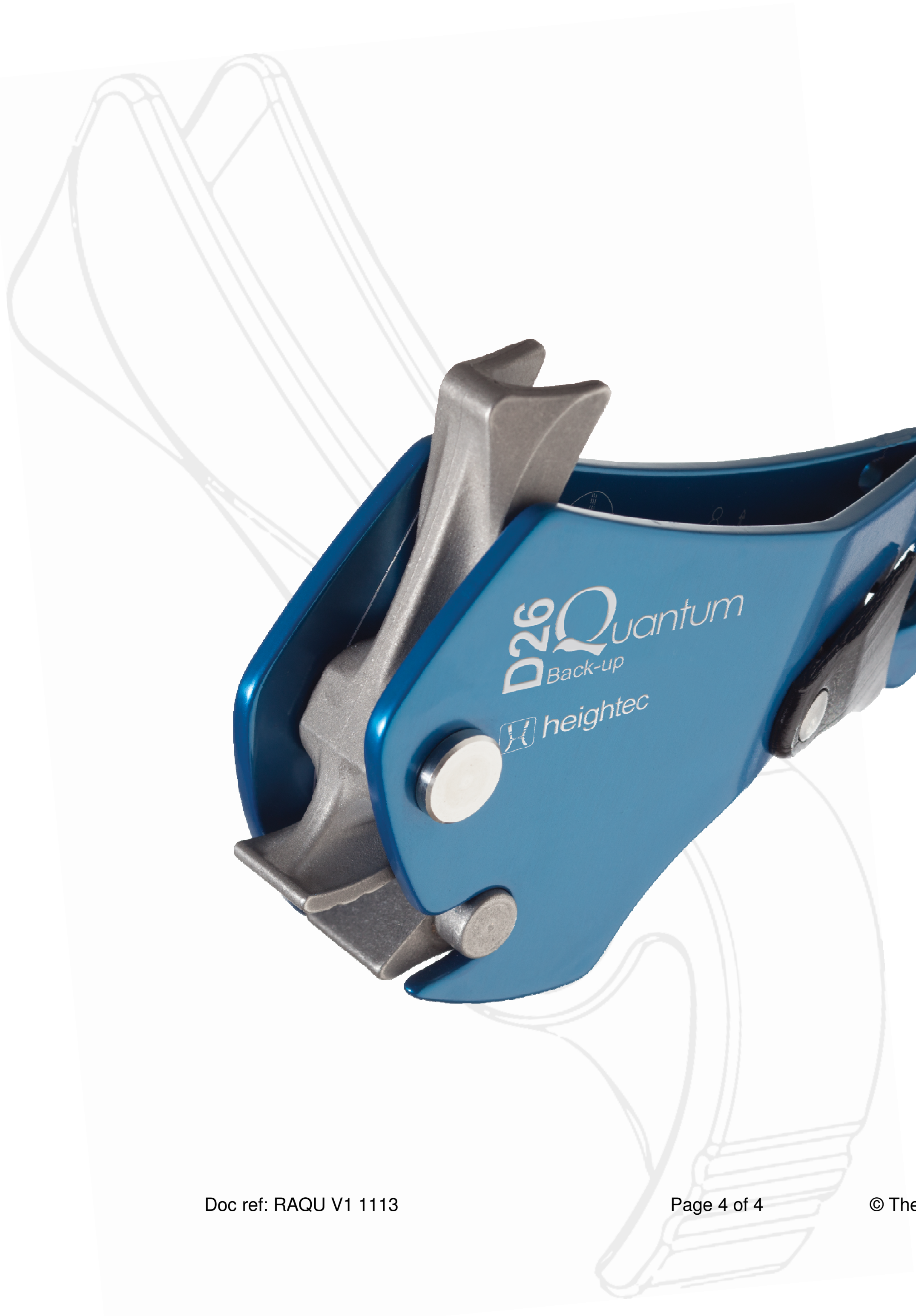
Directive 89/686/EEC does not mandate the use of 6 kN. Indeed, ANSI allows 8 kN so a device exceeding 6 kN is not necessarily considered to be dangerous. In developing the Quantum back-up device the rationale has been to ensure, across a range of ropes, that:

- when greater than 3 m from an anchor the impact force is less than 6 kN; and
- 8 kN is, in any case, not exceeded.

NOTE:
These are maximum values ('Fall Factor 2'). If the device is managed well the impact load will be much less.

In conclusion

The Quantum back-up device is an exceptional engineered solution achieved through extensive research, continuous development and rigorous testing. It controls slippage with no rope damage, works on new or used rope, is suitable for two-person rescue and cannot be dropped. Not only is it a step forwards in simplicity, strength, durability and performance, but it is a significant advancement in safety for users.



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