THE DEVELOPMENT OF THE UIAA 157 STANDARD FOR AVALANCHE RESCUE PROBES

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ABSTRACT: In 2013, the Safety Commission (SafeCom) of the International Climbing and Mountaineering Federation (UIAA) has decided to develop standards for avalanche rescue equipment such as avalanche rescue shovels and avalanche rescue probes. Previously, except for the International Ski Mountaineering Federation (ISMF) racing regulations, no standards to ensure minimum performance, reliability and durability existed. 18 different models of commercially available probes have been tested in the laboratory to establish a comprehensive, quantitative understanding of their characteristics and to be able to identify a wide range of possible failure modes. The following laboratory tests have been carried out for evaluation purposes: 4 points bending of the interface between two adjacent segments, 3 points bending over the total length of the probe and axial elongation. In order to identify the relevant failure modes, multiple unique user groups in multiple countries were recruited to perform the testing to build up a large-scale field test database. Besides the identification of failure modes, the pull force applied by companion and organized rescuers in the mounting process of the probe has been quantitatively determined. This value is critical as it sets the pretension of the probes for the laboratory tests, for example when determining axial stiffness and elongation. The analysis of the data has shown that it is possible to identify critical weaknesses of a probe based on the 3 points bending and axial elongation tests, thus reducing the overall qualification process costs for the manufacturers. The laboratory testing as well as the field testing has demonstrated that a slight increase of probe diameter dramatically improves the bending stiffness in the overall handling, averting premature failures. This reflects the fact that flexural inertia increases in power four to the increase of diameter. Therefore, the minimum diameter for a probe to fulfil the UIAA SafeCom 157 standard has been set to 11mm. The minimum required length of 240cm has been determined based on accident data and the required length the probe shall protrude out of the debris to allow ergonomic probing. In order to optimize the balance between the required penetration effort and the safety of the buried subject, the shape of the tip of the probe in terms of minimum tip radius and aspect ratio between tip length and probe diameter has been defined. The requirement for the last segment of the probe to be in a distinctively different color is motivated by the fact that it allows to excavate the buried subject with maximum speed and impact of the shovel without triggering hesitation to injure the buried subject as long as the color coding of the probe does not indicate immediate proximity to it. Other design and ergonomic requirements include a metric scale printed on the probe.

KEYWORDS: UIAA Safety Label, Avalanche Rescue Probe, Product Standards, Material Testing.

1. INTRODUCTION

The Avalanche Rescue Probe is an integral and important part of the personal avalanche rescue equipment. As Stumpert et al. have previously demonstrated, rescue times increase very considerably when the probe is missing as the imprecise determination of the final position of the buried subject and the lack of visual guidance during excavation lead to a considerable increase of unnecessary excavation volume.

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When we started the work in the UIAA Safety Commission on avalanche rescue equipment standards in 2013, the situation was equal for probes and for shovels concerning the fact that there were absolutely no formal product standards.

However, there were still differences in the way that the level of awareness for ergonomic and durability criteria for shovels have increased over years due to the introduction of systematic and widely taught excavation strategies. A more informed clientele and publications highlighting differences in the characteristics and performance of different shovel models have triggered the manufacturers to start improving the design of their shovels. In contrast, avalanche rescue probes have not seen the same increase in use

in training, even though the time spent on pinpointing is a considerable factor of the overall search time. In despite of the fact that we were aware that the situation concerning the average quality of probes is worse, we decided to prioritize the UIAA SafeCom 156 standard concerning shovels, as we clearly felt that the greater interest in the performance of a shovel would make it easier for UIAA SafeCom standards to become accepted and widely recognized in the snow and avalanche world.

The UIAA SafeCom 156 standard on avalanche rescue shovels was consequently published in 2017 and as of August 31st, 2023, there are already 28 certified products. The standard has triggered very considerable innovation: Whereas very lightweight products previously where notoriously weak, there are today products weighing 400 g on the marked which fulfil the standard. ISMF issues its own product standard concerning equipment approved for ISMF races. ISMF standards are specific for the very particular and highly controlled race environment where the likelihood of an avalanche burial is low. Moreover, a high level of readiness of organized rescue is on site and, in case of a companion rescue event without organized rescue, there would be multiple athletes to respond with rescue equipment within moments. If each shovel is only withstanding a fraction of the full excavation effort, there is a high probability that the total number of available equipment is able to compensate the failure rate accepted by a standard which asks for much lower strengths and durability thresholds. However, there are constant concerns that ISMF certified products is as well used during training in a non-controlled environment, for which the safety margins of their standard have never been designed. The fact that leadership of Patrouille des Glaciers, a famous ski mountaineering race taking place in an alpine environment took the decision to abandon ISMF certified shovels and ask for UIAA SafeCom 156 certified shovels is a compelling plea for a more robust standard.

The development of the UIAA SafeCom 157 standard on avalanche rescue probes started immediately when the shovel standard was published. The standard on probes has been published in 2021 and as of August 31st, 2023, there are 15 certified products.

2. METHODS

The initial laboratory study population included 18 different models of commercially available probes. A four-point bending test for the interface of two adjacent segments, a 3-point bending test over the total length of the probe and an axial elongation test have been performed to understand the basic characteristic of the products and a wide range of potential failure modes.

In parallel, a field test database has been built up in multiple nations with multiple user groups in order to detect the practically relevant failure modes.

Considerations on the minimal length of the probe include the median burial depth of skier triggered avalanches worldwide of 100cm, and the requirement to be able to use the probe for spot probing and at least the first passage of a probe line, where the probing depth is 150cm. Ergonomic probing requires that the rescuer does not need to bend forward to push the entire length of the probe into the debris.

To reduce friction when retracting the probe and avoid freezing of the inserted probe on a larger surface of the probe, the diameter of the tip must be larger than the diameter of the probe segments.

The tip shape needs to reduce the required penetration force, but at the same time, its shape must not create a hazard for the buried subject.

As the axial stiffness is an important characteristic of a probe as it directly influences how much undesired bending the probe will suffer when inserted in the debris, leading to an unevenly distributed probe hole pattern, and therefore lowering the anticipated probability of detection. The axial stiffness of a probe is influenced by its axial pretension. The pull force applied by the user when assembling the probe in the field wearing gloves was measured using a tension scale.

Axial elongation when retracting the probe will lead to possible interface opening, in extreme cases even to interface separation. This will lead to failure and potentially fatal damage of the probe when in the subsequent insertion of the probe, the interface remains partially open and the force is applied at an angle.

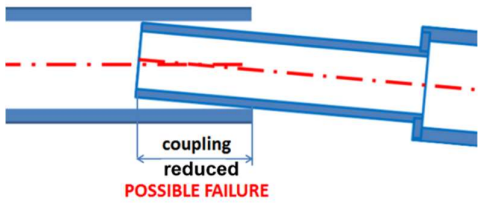

Figure 1: Critical interface opening

3. RESULTS

Taking median burial dept of 100cm, the requirement of 150cm probing depth in probe line and the criterion for ergonomic probing into account, the minimum length of the probe needs to be ≥ 240cm.

The tip diameter must be between 2mm and 4mm larger in diameter than the diameter of the segments. The tip lengths Lt must be within 1,6 to 3.2 x Ds and the tip radius R must be between 1,5mm and 2mm.

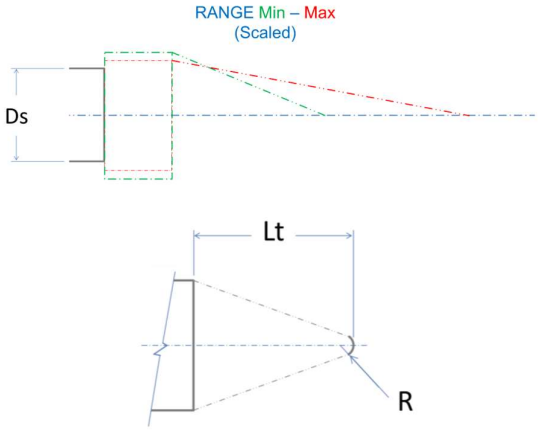

Figure 2: Tip design requirements

The pull force applied by a rescuer in the field during the assembly of the probe is 100N, which sets the pretention of the probe for the 3-point bending test.

The bending stiffness requirement of > 2.5N/mm is exactly at the interface of the field test ranking categories of “just acceptable” and “good”.

The axial pull test with 250N is passed when at least 60% of each probe section's socket-joint remains engaged, when loaded. This avoids that the mechanically particularly delicate interfaces get damages or destroyed, or the probe segments disconnect entirely.

At the time of the development of the standard, there was no non-metallic (polymeric) string material which was able to deliver the required stiffness. A particular concern with such materials is the potential for degradation with ageing, thus that in pristine conditions, non-metallic materials would fulfil, but over time, the stiffness would considerably decrease.

Furthermore, all probes must have a printed metric scale with one mark at least every 5cm.

In order to allow a full speed excavation effort without hesitation to unnecessarily injure the buried subject, the colour of the first segment of the probe must be in a distinctively different colour than all other segments. This ensures that the rescuers are not losing valuable minutes by verifying the residual distance on the scale, but continue to dig full speed until the contrast colour of the last segment becomes visible.

4. DISCUSSION

The choice of the threshold for the bending stiffness of > 2.5N/mm being exactly at the interface between the field test ranking categories “just acceptable” and “good”, shows that the UIAA SafeCom 157 standard is clearly not asking for exaggeratedly high minimum requirement. It thus leaves room for products at a lower price point or very lightweight products.

Based on UIAA SafeCom rules, the alpine club federation representatives have more voting power compared to the manufacturers. As UIAA SafeCom standards are neither legally enforced nor a legal requirement to sell products, such as it is the case for CEN standards, success of SafeCom is dependent on a productive collaboration between federations representatives and manufacturers.

While one side of the workgroup was leaning towards setting the threshold for bending stiffness to >2.3N/mm, thus within the field test ranking “just acceptable”, it is thanks to the voting power of those who directly represent the interests of the users that the argument “just acceptable is not good enough” won and the >2.5N/mm threshold was instated.

5. CONCLUSIONS

The development of the UIAA SafeCom 157 standard is based on quantitative, evidence based criteria. Since the standard has been published, 15 products have been certified.

It is important for professional, recreational, and institutional users of mountain related safety equipment to understand and appreciate that the distribution of voting power within UIAA SafeCom ensures that the voice of the users has a particularly strong influence compared to other product standards such as CEN.

The initial development and constant updating of well-designed product standards is time consuming and costly. When equipment related safety problems occur in the field, it often requires extensive laboratory and field testing to identify the underlying problems and to modify existing or develop new standards with the aim to avoid the concerned failure pattern in future products. UIAA and UIAA SafeCom invest very considerable amounts to support such costly investigations

and the development of modern product safety standards in general.

As instructors of avalanche safety courses, it is recommended to make participants aware of the advantage of using UIAA SafeCom certified products. By purchasing certified products, you not only support UIAA, and therefore the future development of high-quality product standards, but you foremost support those manufacturers which commit to the considerable extra effort to develop, pay for certification and manufacture particularly safe, reliable, and long-lasting products.

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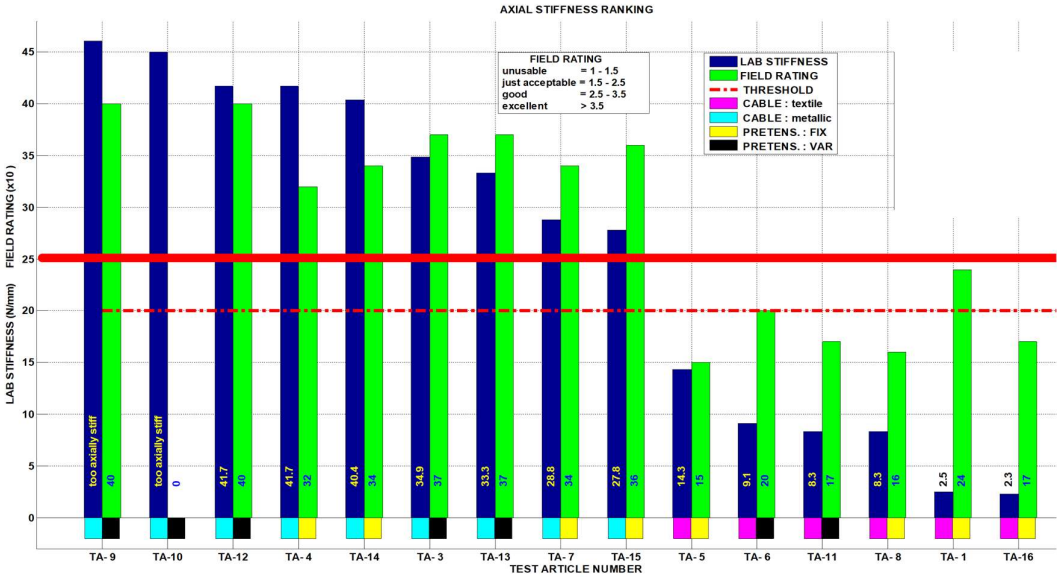

Figure 3: Axial stiffness ranking of studied sample with thresholds: *proposed* (phantom line) and *elected* (solid line) for UIAA 157 spec purpose.

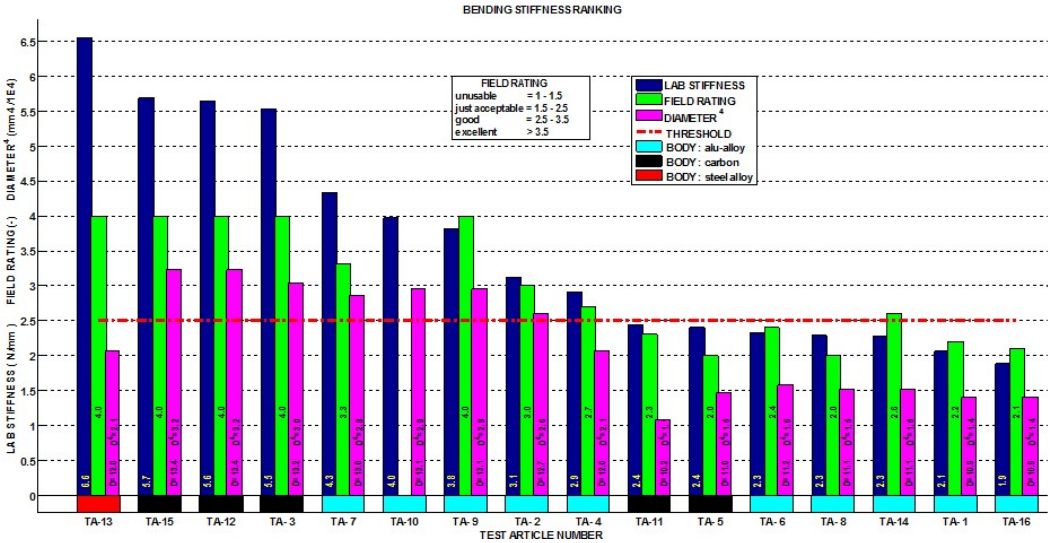

Figure 4: Bending stiffness ranking of studied sample with thresholds: *proposed* and *elected* (red line) for UIAA 157 spec purpose.