Avalanche Balloons - Preliminary Test Results

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ABSTRACT

Avalanche balloons are considered as rescue devices to prevent avalanche burial. Based on a limited number of test results and field experience the effectiveness of avalanche balloons is preliminarily assessed. The results suggest that the avalanche balloon is effective in reducing the frequency and extent of burial in avalanches. However, the limits of effectiveness could not be determined and many questions remain unresolved.

INTRODUCTION - DEVELOPMENT OF THE AVALANCHE BALLOON

Different means for detection and rescue of avalanche victims were intensively discussed in the late 1960's and the early 1970's during the meetings of the International Foundation Vanni Eigenmann and the International Committee for Alpine Rescue Systems (IKAR). A proposal by Ruth Eigenmann in 1970 was the wearing of a ski jacket that can be inflated by means of compressed air or generated gas. Around the same time Josef W. Hohenester presented his invention: the avalanche balloon. Both systems were considered as buoyancy elements supposed to keep the victim closer to the snow surface, and were partly seen as improvement of the avalanche cord (de Quervain, 1975). The avalanche balloon invented by Hohenester was further developed in the late eighties and offered for sale by Peter Aschauer, a German manufacturer. By the summer of 1996 more than 3000 so-called ABS backpacks were manufactured and sold on the premise that burial can be prevented by helping the victim to stay on top of the flowing avalanche. During travel in avalanche terrain the avalanche balloon is folded and carried in a specially designed backpack. In case of avalanche involvement, the skier triggers the balloon by pulling a rip-cord and releasing pressurized gas from the cartridge. The gas passes at high speed through jets drawing in outside air (Venturi effect) to inflate the balloon within 2 - 3 seconds.

This article represents a summary and update of the original work described in Tschirky et al. (1995). For additional details the reader is referred to this article.

THEORETICAL CONSIDERATIONS

Theoretically the avalanche balloon should help to prevent burial by two effects: by decreasing the apparent weight of the victim in the flowing snow and, in particular by increasing the victim's volume which supports the process of inverse size segregation in a flowing avalanche. By this dynamic process of inverse grading, large particles rise through the surrounding smaller particles to the surface layer, where, due to the higher velocity at the surface, they move on to the front of the granular avalanche. In laboratory granular-avalanche experiments, large particles were frequently moved to the front and top of the accumulation (Savage, 1993).
The unequal distribution of density between the balloon and the person however means that the balloon tends to locate above the person.

Static buoyancy alone cannot explain the proposed effect of the avalanche balloon, since flow densities are typically less than 400 kg/m^3 (approx. density of victim with inflated balloon).

KNOWN AND DOCUMENTED AVALANCHE INCIDENTS WITH AVALANCHE BALLOONS

As of 15 March 1996 we only know about seven incidents involving a total of 11 skiers equipped with the ABS backpack. All victims survived. Two balloons did not inflate due to human error or technical malfunction. These two skiers got completely and partly buried, respectively. Of the 9 people with inflated avalanche balloons, 6 were not buried or only partly covered with snow; 3 were buried critically[1], i.e. their heads were under the snow, but the balloon was visible on the surface of the avalanche deposit.

Definition of critically buried: A victim is considered as critically buried, if most of the body, in particular the head and the thorax are substantially buried with snow, so that the person can not free himself and is in mortal danger. Parts of the body or the equipment may be visible. This type of burial was previously described as totally buried.

PREVIOUS PRACTICAL TESTS OF THE AVALANCHE BALLOON

Hohenester intensively tested his invention at the Zugspitze (Germany) during 1975-79. One test by Allianz Technology Centre in 1978 is documented as well as two tests by the Canadian Parks Service from Banff National Park (Canada) in 1980-81. Some tests were also done with the further developed, ABS-Avalanche Airbag System, using video shots for documentation. As far as we know, in all previous tests, the balloon was not completely buried, but was visible on the avalanche deposit.

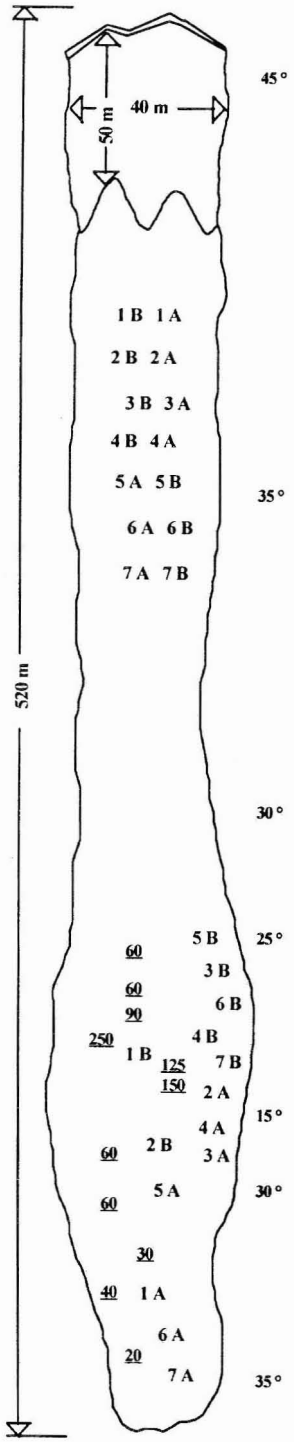
TESTS BY SFISAR WINTER 1994-95

The Swiss Federal Institute for Snow and Avalanche Research (SFISAR) at Weissfluhjoch/Davos carried out preliminary tests with the ABS avalanche balloon during the winter of 1994-95. The objective was to examine whether the avalanche balloon folded into a skier's backpack, triggered and inflated in time could effectively prevent a person from being buried in a slab avalanche. Product-specific characteristics such as technical reliability and ease of handling of the ABS avalanche backpack were not the main objective of the tests. The test equipment included 18 different life-size dummies (mass: 65-85 kg) and 10 ABS avalanche backpacks, 6 of which were equipped with a radio for remote triggering of the balloon.

The dummies fully equipped as skiers, with and without the avalanche balloon, were placed in pairs by helicopter in avalanche slopes. An avalanche was then triggered by explosives. Only the third and major test is described in detail.

RESULTS OF MAJOR TEST AT ROSSTÄLLISPITZ (DAVOS, SWITZERLAND) ON 10 MARCH 1995

In this test 14 dummies were used: 7 dummies with balloons, each beside dummies without balloons (Figure 1). The size of the avalanche triggered was: 520 m long, 40 m wide, 0.5 m fracture height (mean). One of the balloons did not work, so that 6 dummies with properly inflated balloon can be compared to 8 dummies without balloon. Four out of 6 dummies with properly working avalanche balloon were critically buried (Figure 2) (head buried, most



Avalanche:

type:	dry snow slab
length:	520 m
width:	40 m
aspect:	north
elevation:	2800 m a.s.l.
fracture height:	0.1 - 0.9 m
	average: approx. 0.5 m
slope angle:	45°
volume:	approx. 1500 m^3

Legend:

1 A - 7 A	Positions of dummies with balloon
1 B - 7 B	Positions of dummies without balloon
20 - 250	Deposition depth in the runout zone

Burial / Location method:

1 A	pb	
2 A	cb / vi	balloon partly filled; cartridge triggered
3 A	cb / vi	
4 A	cb / vi	
5 A	pb	balloon uninflated; cartridge not triggered
6 A	cb / vi	backpack strap partly snapped
7 A	nb	

1 B	cb / tv, 80 cm
2 B	cb / tv, 20 cm
3 B	cb / vi (ski pole)
4 B	cb / tv, 30 cm
5 B	cb / vi (ski pole)
6 B	pb
7 B	cb / tv, 50 cm

Abbreviations:

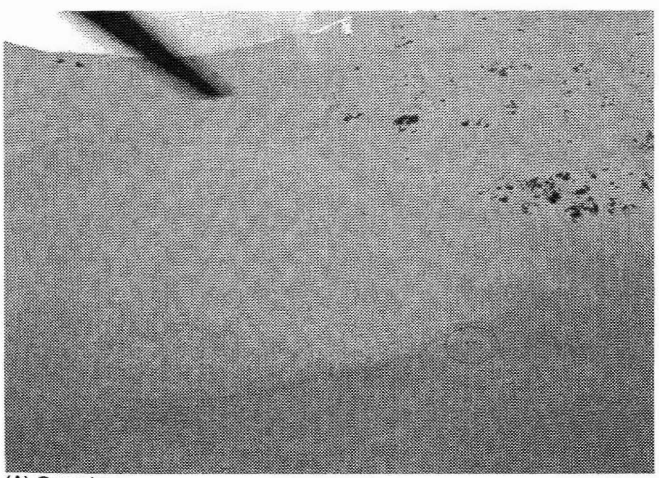
nb:	not buried
pb:	partly buried
cb:	critically buried
vi:	visible parts
tv:	transceiver
20 cm	burial depth

Figure 1: Test avalanche on Rosställispitz (Davos, Switzerland) at 10 March 1996: test configuration, avalanche extent and details on burial of the 14 dummies.

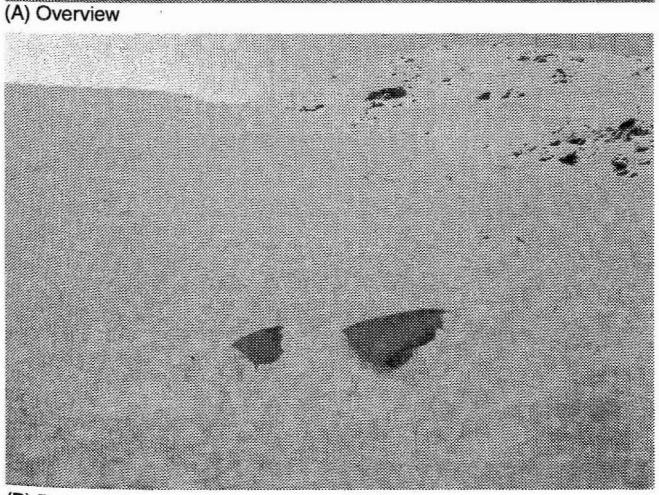
Test result (10 March 95); avalanche burial	dummies with inflated avalanche balloon	dummies without (or with uninflated) balloon
completely buried (no parts visible)	0	4
Head/thorax buried,but some parts (e.g. balloon) visable ("critically buried")	4	**2**
Head/thorax not buried: ("partly buried")	1	2
not buried	1	0

Table I: Consequences for the 14 dummies involved in the test avalanche on Rosställispitz, Switzerland at 10 March 1995. Bold figures indicate critically buried dummies. All inflated balloons were visible. 4 dummies without balloon were found by transceiver search.

in prone position, balloon visible) compared to 6 out of 8 dummies without or not inflated balloons. All inflated balloons were visible on the avalanche deposit; all dummies with avalanche balloons were carried further than the control dummies. The consequences are summarized in Table I.



(A) Overview



(B) Before

CONCLUSIONS

Based on the limited number of preliminary test results and documented incidents:

- The avalanche balloon seems to fulfil its objective to reduce the frequency and extent of burial in avalanches.
- Even when the victim is critically buried, there is a good chance that at least part of the balloon will be visible, facilitating the quick rescue by party members.

However, human error and technical malfunction can reduce or prevent the effectiveness of the avalanche balloon.

DISCUSSION

Generally, the precise limits of effectiveness of avalanche balloons have not yet been determined. To mention some factors: terrain characteristics (terrain traps), large avalanches, wet snow conditions, risk of injuries have not yet been considered.

(C) During recovery

Figure 2: Two test dummies with avalanche balloon buried in prone position in a depression (burial depth about 1 m, deposition depth: 1.5 to 2 m): (a) overview, (b) before and (c) during recovery (second preliminary test on 8 January 1995). Avalanche size: 300 m long, 100 m wide, 0.5 m fracture height. (Photos: J. Gebhardt).

- The balloon only appears to be effective as long as the unit consisting of the victim and the balloon can flow along with the avalanche snow. When the unit and its surrounding snow come to rest, in particular in a terrain trap, the victim and the balloon still may get completely buried by further avalanche snow.
- In many cases victims with inflated balloons will be carried further by the avalanche than victims without avalanche balloon. The consequences depend on the terrain.
- During avalanche action and after standstill of the avalanche the balloon is frequently located well above the victim. It is likely that the victim will be buried in prone position.
- Some of the results may be product specific.
- It is not fully clear how and/or under which circumstances the proposed theoretical mechanisms contribute to the observed effect of the avalanche balloon.

These questions will be subjects for an extended study in 1996-99 at SFISAR.

However, in every single case of which we know, the balloon was not completely buried and hence represented a good marker for the immediate rescue by other members of the party.

Finally, while the avalanche balloon has to be considered as a technical device that can reduce the risk of avalanche burial, it is at least as important to take precautions to reduce the risk of being caught in an avalanche.

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