THREE DIFFERENT SHAPES OF AVALANCHE BALLOONS – A PILOT STUDY

Marek Biskupič[1,2]*,Jozef Richnavský[1], Milan Lizuch[1], Filip Kyzek[1], Igor Žiak[1], Pawel Chrustek[3], Emily Procter[4]

[1]Avalanche Prevention Center, Demänovská Dolina, Slovakia

[2]Faculty of Science, Charles Univesity, Prague, Czech Republic

[3]Anna Pasek Foundation, Cracow, Poland

[4]EURAC Institute of Mountain Emergency Medicine, Bolzano, Italy

ABSTRACT: Flotation devices are more and more frequently used. Their efficacy has already been demonstrated by field tests (Tschirky and Schweizer 1996; Kern et al. 2002; Meier and Harvey 2010) and retrospective studies (Tschirky et al. 2000; Brugger and Falk 2002; Brugger et al. 2007).
There are several systems on the market that differ in release mechanism and balloon shape. In general three different balloons shapes exist. In the winter season of 2011/2012 a pilot study of three differently shaped floatation devices was made for the first time. The aim of this study was to investigate the behavior of each inflated system during an avalanche event. Three human-weighted dummies were positioned on the slope and an avalanche was triggered with explosives. Several video cameras, installed on and beside the avalanche path, recorded the movement and final deposition of the dummies. The track of each dummy was measured with high accuracy GPS (<1m) and avalanche flow properties (flow height, velocity and pressure) were simulated with the Rapid Mass Movements (RAMMS) tool. The video material together with the GPS measurements and numerical simulation was used to analyze the behavior of different floatation systems. The burial grade differed for each dummy and none of them were completely or partially-critically buried. From this pilot study we cannot draw conclusions about the efficacy of the different shapes; further tests are needed for an in-depth comparison of the devices.

KEYWORDS: Avalanche balloon packs, avalanche airbags, field trial

1. BACKGROUND

The purpose of an avalanche airbag is to prevent complete burial. Currently, there are three different shapes of avalanche balloons produced by four manufacturers. One system uses a dual bag (ABS), the three other systems are mono bags (Mammut/Snowpulse, BCA, Warry). The packs differ in shape and place from which they inflate. The avalanche balloon packs have been previously tested using dummies in various conditions. Past field trials used:
(i) ABS mono airbags (Tschirky and Schweizer 1996),
(ii) ABS mono airbags, ABS dual airbags and Avagear collar mono type airbag vest (Kern et al. 2002)
(iii) ABS dual airbags and Snowpulse collar type mono airbags (Meier and Harvey 2010).

* *Corresponding author address:*
Marek Biskupič, Avalanche Prevention Center,
dom HS č.84, 032 51Demänovská Dolina Slovakia
tel: 00421 903 624 664
fax: 00421 44 5591 637; email: avalanches@hzs.sk

The volume of the chambers for dual bags is approx. 170 L and for mono bags approx. 150 L.

So far there has been no field trial using all three balloon shapes mentioned. The aim of the field test was to observe how the differently shaped avalanche airbags behave in an avalanche with specific attention on the grade of burial.

2. METHODS & TEST SITE INSTRUMENTATION

The three following packs were chosen because each of them differs in shape of the balloon(s).

Snowpuls/Mammut Lifebag is a collar type mono balloon backpack. When the pack is inflated, it creates a balloon around the backside of the neck and shoulders. The aim of this system is to prevent burial and simultaneously provide trauma protection forthe head and neck.

Backcountry Access (BCA) Float is also a mono balloon pack with the balloon positioned behind

the head. Besides preventing burial it provides some trauma protection for the head and neck.

The only dual airbag system tested was the ABS Vario. The system consists of two balloons located at the side of the backpack. Both airbags have an overall volume of 170 L (2x85 L) (www.abs-airbag.de).

The field test took part in Jasna, Slovakia, where numerous easily approachable gullies and couloirs can be found.

The test site was instrumented with 3 crash test dummies with a weight of 80 kg. The joints were adjusted to simulate the flexibility of real humans. The dummies were positioned by a ropeway system in a northeast orientated slope, 40 m below the snow cornice. Each dummy was instrumented with an avalanche balloon pack and they were placed side by side in one line. One dummy was equipped with the Snowpulse/Mammut Lifebag Guide 30 L backpack, one with BCA Float 18 L and one with ABS Vario 25 L. All three backpacks were deployed 60 seconds prior to the avalanche release.

The upper part of the avalanche path had an inclination of 37°. The release area was a snow cornice with a height ranging from 0.5 m to 3 m. The track was open and the run-out was smooth with no depression or terrain traps.

The position of the dummies was measured with high accuracy GPS (<1m) before and after the avalanche. Several cameras and point of view cameras were placed either in the track or across the track to shoot the movement of the dummies. Photographers were situated along the track to document the trial.

3. RESULTS

The explosion released the cornice and initiated an avalanche of size 2 (US avalanche size classification). Additional snow masses were entrained in the main flow and formed a decent avalanche. The turbulent front hit the dummies after 4 seconds after release. The first dummy that was hit was wearing the BCA Float backpack and the other dummies were hit 0.25 s thereafter. Immediately all the dummies disappeared in the snow mass and were rotated and twisted, falling over the small cliff. A moment later all dummies were visible and floating on the avalanche surface. When the avalanche slowed down and snow deposition started, the dummies were segregated aside from the main flow.

The dummy equipped with the BCA Float stopped first and within a few seconds the dummy with the ABS and Snowpulse/Mammut Lifebag stopped also (Figure 1).

Figure 1. Position of the dummies after the avalanche stopped.

3.1. *Assessing the avalanche burial*

The grade of burial was classified according to Observational Guidelines for Avalanche Programs in the United States (Greene et al. 2010).

The dummy with the Snowpulse/Mammut Lifebag was dragged by the avalanche for 132 m in 20 s. The average speed was 6.6 ms^{-1} (23.76 kmh^{-1}) while it reached a maximum speed of 17.8ms^{-1} (64.08 kmh^{-1}). Acceleration occurred over 89m with an average velocity of 3.56 ms^{-2}. When the avalanche stopped moving, this dummy was buried from the hips down (Figure 2). The lower part of the body was anchored in the snow deposit and the whole body was partially buried in a tilted position. This was a partial-not criticalburial, the airways were not obstructed and the head was not impaired by the snow. The balloon was clearly visible on the avalanche surface.

Figure 2. Burial position of the dummy wearing the Snowpulse/Mammut Lifebag.

The dummy equipped with ABS Vario system was carried over 123 m in 18 s. The maximum velocity reached by this dummy was 18.6 ms^{-1} (66.96 kmh^{-1}) while the average speed was 6.9 ms^{-1}(24.84 kmh^{-1}).The avalanche reached the highest speed at 9 s. At 9 s the dummy had been carried 93 meters from its starting point, reaching an acceleration of 3.36 ms^{-2}. The dummy was deposited in a horizontal face-up position lying on its back with the head pointing down the slope. There was a block of snow (approximate diameter 70 cm) lying on its abdomen and additional snow laterally. The grade of burial was between partially buried and not buried. It is questionable if a human being would be capable of freeing himself in this position without additional help from companions. Important is that the airways were not obstructed and the head was not impaired with snow. One leg was visible and the balloons were clearly visible as well (Figure 3).

Figure 3. Burial position of the dummy with the ABS backpack.

The dummy wearing the BCA Float balloon was carried along the shortest distance of 114mwith an average velocity of 8.1 ms^{-1} (29.16 kmh^{-1}). The dummy reached a maximum speed of 16.8 ms^{-1} (60.48 kmh^{-1}) with an acceleration of 3.72 ms^{-2} after 84 m. From this moment the dummy started to decelerate until the point of stopping in a supine position (Figure 4). The head and the airways were free of snow except and only a few small snow chunks were deposited on the trunk. Probably a human could free himself with no additional help. Based on this the burial was classified as no burial. The surrounding chunks of snow left the airways unobstructed and the head was not impaired by the snow. Both legs and one arm were sticking out from the deposited snow. The balloon was clearly visible on the snow surface.

Figure 4. Burial position of the dummy with the BCA backpack.

The grade of burial was different for each dummy. The dummy which travelled furthest was the most seriously buried and the one with the shortest path had the least serious grade of burial. This was due to the fact that the dummy with the Snowpulse/Mammut Lifebag was transported closer to the main flow and therefore closer to the front of deposition zone than the others. The dummies stopped within 88 m to 116mofthe deposition front (BCA Float 116 m, ABS Vario 96 m and Snowpulse/Mammut Lifebag 88 m).

The extremities of the dummies were twisted and positioned in unnatural positions. In the case of real human beings, they would probably have sufferedinjuries. On the other hand, no dummy accurately represents a real human example in an avalanche and humans may, for example, try to actively escape from the main flow. The short trailer from the field test can be found on: http://www.youtube.com/lavinyHZS.

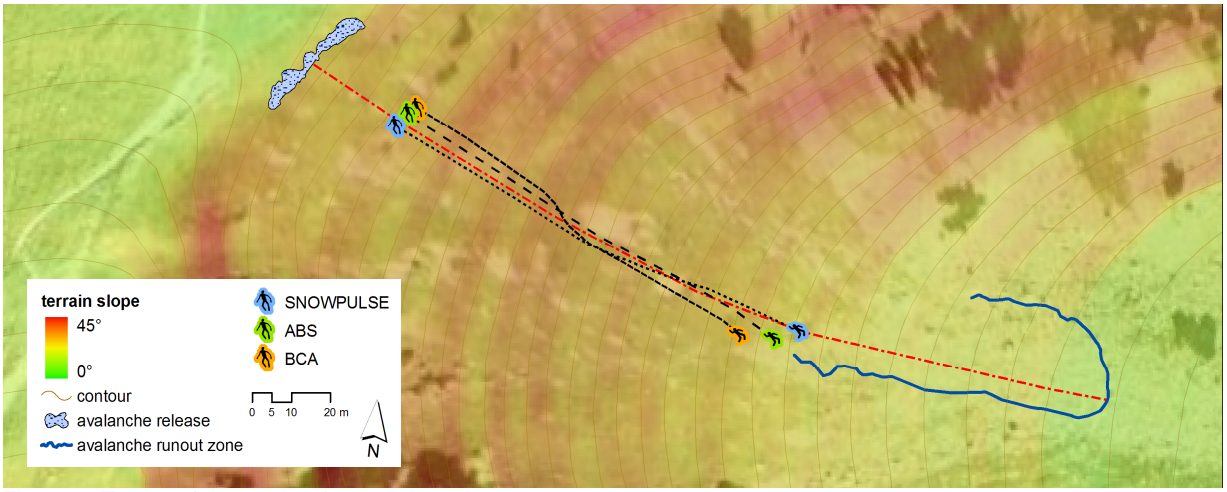

Figure 5. Tracks of the avalanche and dummies.

Dummy equipped with:	Movement duration	Track	Average speed	Max. speed	Acceleration	Grade of burial
BCA Float 18L	14 s	114 m	8.1 ms^{-1}	16.8 ms^{-1}	3.72ms^{-2}	not buried
ABS Vario 25L	18 s	124 m	6.9 ms^{-1}	18.6 ms^{-1}	3.36ms^{-2}	partially/not burried
Snowpulse/Mammut Lifebag 30L	20 s	132 m	6.6 ms^{-1}	17.8 ms^{-1}	3.56ms^{-2}	partially buried–not critical

Table 1. Overview of the of track lenghts, speeds, accelerations and burial grades.

3.2. *About the avalanche*

The triggered avalanche was a snow cornice fall type avalanche which loaded underlying snow. The cornice was 40 m long with a height from 0.5 m to 3 m. The maximum width of the avalanche track was 60 m and 25 m in the most confined section. The predominant snow which created the avalanche was moist. The initial volume of the snow mass used to trigger the avalanche was estimated as 280 m^3. The total distance of the avalanche was 250 m. Numerical simulation showed that the avalanche reached a maximum speed of 18.6 ms^{-1} (66.96 kmh^{-1}) and a maximum pressure of 125.13 kPa (Figure 6). The deposition area was 30 m wide and 130 m long with an average height of 1.5 m. Basic information is in Table 2.

Intial snow volume	Track	Avg. depostion depth	Max. pressure	Max. speed	Run-out size
280m^3	250m	1,5m	125,13 kPa	18.6ms^{-1}	130m x 30m

Table 2. Basic information on triggered avalanche.

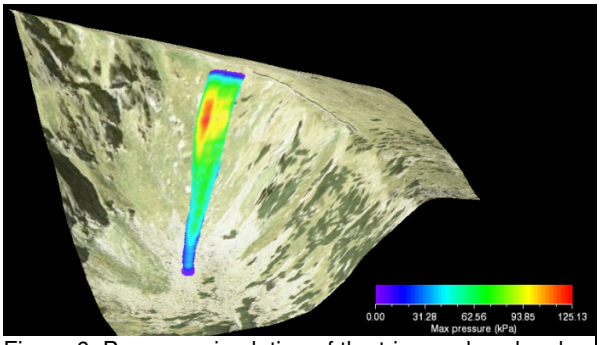

Figure 6. Pressure simulation of the triggered avalanche.

Impact pressure (kPa)	Potential damage
1	Break windows
5	Push in doors
30	Destroy wood – framed structures
100	Uproot mature spruce
1000	Move concrete structures

Table 3. Impact pressure and demage potential of avalanches. (after McClung and Shear 2012)

4. CONCLUSION

The field testing consisted of only one trial and there were no reference dummies (without an airbag). It is plausible that a reference dummy would have been buried, but this is speculative and cannot be tested. Thus, the results of the test are applicable for this particular avalanche. The most important result is that none of the dummies were completely buried. In all cases the heads were free from snow, the airways were not obstructed and the balloons were clearly visible on the surface of the avalanche. In this particular trial the grade of burial was more serious for the dummies which were carried further down the slope. This can vary in other cases and real life situations. However, this also is only true for this particular situation (terrain and avalanche conditions) and test results are not applicable to all other avalanches. Regardless of having an avalanche airbag backpack, one can be completely buried with all the associated consequences. Based on this trial we are not able to judge the efficiency and floating capabilities of the used avalanche backpacks. In future more field trials will be necessary to properly asses the various shapes of avalanche balloon packs

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