DEVELOPMENT OF AN HELICOPTER-BORNE GAS DEVICE FOR AVALANCHE PREVENTIVE RELEASE

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ABSTRACT: This new device called DaisyBell® combines the helicopter mobility with the advantages of a gaz system. It is an interesting alternative to the helicopter bombing with explosive to control slide paths that are not equipped with permanent remote preventive release systems. Helicopter-borne over the zone to be cleaned, DaisyBell® consists of a cone-shaped device made of steel with high mechanical properties which contains the gaz mixture for the ignition and directs the explosion blast towards the snow cover. This mixture of less than half a cubic meter is injected at the top of the cone during stationary flight for a duration of 7s with stoechiometric proportions and then, is ignited by two plugs. The system is entirely autonomous in gaz and in energy with a capacity of about sixty shots before changing the bottles. DaisyBell® is remotely controlled by radio and all operations are controlled from the helicopter cockpit. The remote control indicates at all times, the level of gaz reserves and displays the distance between the device and the snow mantel. The shock wave produces an overpressure of 25 mbar in a 25-meter radius, above the snow cover similar in efficiency to a 0.8 m3 Gazex® exploder.

KEYWORDS: Preventive avalanche release, helicopter, gas device.

1. INTRODUCTION

Except at the end of the winter, periods just after snowfalls are the most dangerous regarding avalanches. So, important means to purge and preventively release avalanches are necessary, especially for roads and ski resorts , Margreth (2003). Different solutions exist; most of them are not mobile, Gubler (2002). Let see the example of the Gazex® system described in Schippers (2002): there are more than 1600 Gazex® in the world that operate safely, in particular for the main avalanche paths. But they are not mobile, so they can treat generally only one or some paths, Rice (2004). When an important area must be secured, these devices are not sufficient and mobiles ones must be used. Many times, these mobile devices use explosive as explained by Gubler (1977) that is transported to the starting area of the avalanche with different means and according to the regulation of the country: cable systems, ski patrol, helicopter, military artillery, Perla (1978), or equivalent.

However, many constraints exist, such as respecting very strict procedures about explosive transport and storage, and handlings that remain delicate to the ignition. For the matter, accidents evenly happen with explosive, even though there are more and more specialized trainings.

Another solution is the gas mixture that is simpler and safer to use. Indeed, as long as the gases are separated and in bottles, risks are nearly null and facilitate transport and storage. Then, it is relatively easy to master the mixture with usual industrial equipment: fittings, flexible foils, pipelines… Moreover, it is very difficult to create, into the open air, an explosive atmosphere just by releasing gas: another safety lies in the concentration range when the gas becomes dangerous, improved if the gas is very volatile: for example, hydrogen is explosive only for concentrations between 4% and 74.5% in the air. Actually, the true challenge that consists in developing a gas system in fields implies to confine a minimum of gas. For example, the Gazex® uses an oxygen-propane mixture, heavier than the air that remains at the base of the inclined pipe during injection.

2. 2. DAISYBELL®: PRINCIPLE OF OPERATION

DaisyBell® project is born from a desire for a gas system movable and operable, hung under a helicopter. The Avalhex® and Avalanche

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Blast® systems, which are already movable, use a latex balloon to confine the gas mixture. They are very useful to treat avalanches but they raise technical difficulties. Indeed, precise and complex mechanisms are necessary to connect gas reserves to the balloon to be pumped up and then to the next one. They are hardly compatible with use conditions (cold, frost…) and pose mechanical problems. Moreover, using balloons raises autonomy problems and these systems enable finally only a limited number of avalanche releases.

All these observations have led to the development of DaisyBell® with a basic idea: to replace the balloon temporary volume by a permanent metal one. At the beginning of the development, a flap system was foreseen to be closed during the gas injection and opened just before the ignition. Using an oxygen-hydrogen mixture was the second initial idea. This mixture is lighter than the air, so a system directed towards the bottom can be designed. Moreover, the explosion of an oxygen-hydrogen stoechiometric mixture is hardly explosive with maximum energy, so it is very interesting for an artificial avalanche release.

After that, different types of bells have been tested, first being hung to a crane. These first experiments had many goals:

•Choose the best shape and check its compatibility with the initial containment of the gas mixture injected from the top

•Check the ability to make a sufficient explosion

•Sort the explosion consequences according to the mixture parameters: proportion, volume.

These consequences of an explosion must ensure a compromise between the efficiency of the wave directed towards the ground and the reaction on the system and consequently on the helicopter. Indeed, the explosion causes a reaction on the volume to the top, which then falls under the effect of gravity. Concerning the helicopter, the constraint is to limit the fall of this mass that must remain compatible with sling and hook systems and the flying abilities of the helicopter.

Figure 1 shows drawings of the three first tested volumes: the first one was too large and could not confine correctly the gas mixture during injection without a supplementary closing system of the opening. The second one was the first to be equipped with a cylindrical room: its smaller shape limits the turbulences and the external rejections of gas before the explosion to ensure, in every case, the explosion. Therefore, the advantage is not to have to close the opening during injection, and consequently not to have a flap system. Finally, the cone was retained: it is easier and simpler to make and it has the same advantages as the second volume limiting, on the top of that, the rise effects. The preliminary series of DaisyBell® used during winter 2007-08 in the Alps being almost too heavy, the height of the definitive cone is being reduced further by 25 cm.

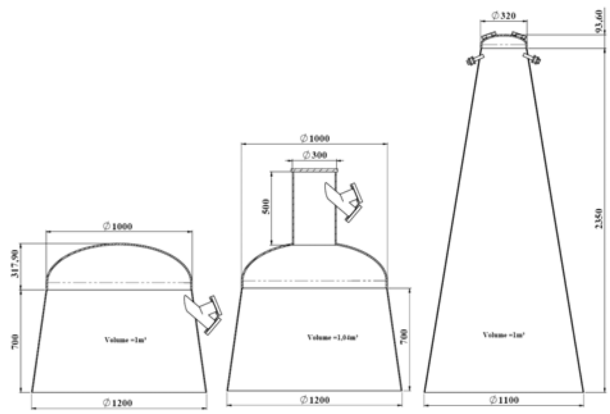

Figure 1: three preliminary tested shapes

3. DESIGN FEATURES

Figure 2 and 3 shows the equipment installed on the conical volume. Two bottles of hydrogen and one of oxygen are maximum fixed on a damped support linked to the metal cone. Both gases are injected separately from the top of the volume in a mix chamber: this chamber forces the two gas to mix each others in order to obtain a sufficiently homogeneous mixture before ignition. This part of the system was one of the keypoint to solve during development period.

The initial 200-bar pressure in bottles is reduced to some bars by a double-expansion system linked to a calibrated hole: this combination enables to know with precision the injected flow and so the characteristics of the mixture before the explosion. Its volume has been set at 350 liters; it is lower than the total volume of the cone to ensure the containment before ignition but also just after not to eject and lose too rapidly non-exploded gases in the air. Even if the system is only at about twenty meters below the helicopter, the important air flow and turbulences due to the main rotor seem to have limited influence on filling and explosion conditions. It is the same for the wind (in conditions compatible with helicopter flight) and a preliminary idea to add a secondary deflective cone to deflect external air flows is being now abandoned.

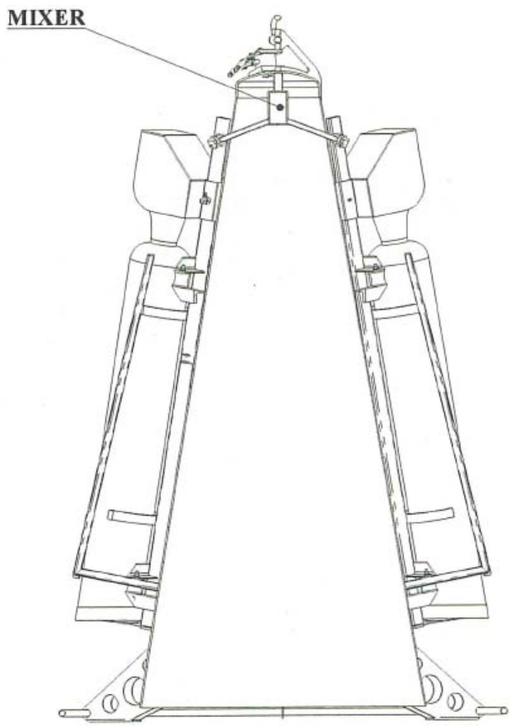

Figure 2: inside view of the cone with the mix chamber

Figure 3: external view of DaisyBell® and its equipment

Two plugs, placed on the top of the system where the mixture accumulates, launch the explosion. Concerning the injection, systems of check valves prevent the explosion from going to the gas reserves.

The control system is placed in a protected box, remotely controlled by an operator from the helicopter. The firing procedure is semi-automatic because the operator just needs to remain pressing on two buttons to automatically carry out the operations: simultaneous injection of both gases during 7 seconds and ignition of the sparks. In case of trouble and to exploit human reflexes, the simple release of at least one button stops the procedure. It can be started again within 30 seconds or the system will ask for the draining of the volume. It consists in saturating the mixture with oxygen to make it non-explosive: it can be activated to secure the system in case of problem.

A system of distance measurement with the snow cover surface has been added to well place the system above snow from the helicopter: an about 2 to 3-meter distance is in principle desirable. All in all, the system weighs about 550 kilos with maximum bottles capacity. This weight can be modulated using only one bottle of each gas. The limiting parameter concerning the number of fires is the hydrogen reserve: a single bottle allows about 30 shots so that the total capacity (2 bottles of hydrogen and one of Oxygen) reaches about 60 shots before refilling with new bottles.

4. PERFORMANCES

The shape of the volume will direct the explosion vertically to the snow cover, creating an explosion that will hit this cover. As shown in the figure 4, it is a typical profile with first an overpressure front followed by a depression period: it has a double effect on the snow cover; first to break its resistance and then to lift it and ease its move.

Measurements made with an air overpressure sensor on ground without snow give very positive results: the maximum overpressure obtained at a 12-meter horizontal distance reaches 80 to 90 mbars for the wave reflected on the ground, which is equal to the 0.8m3 Gazex® system. The main difference is the duration of the explosion, which is twice shorter than the propane-oxygen one (Gazex® system). The influence of this parameter will be tested during next winter depending on snow caracteristics. A priori, DaisyBell® would stand between the classical explosive and the explosion of the propane-oxygen mixture, in terms of effects and wave speed.

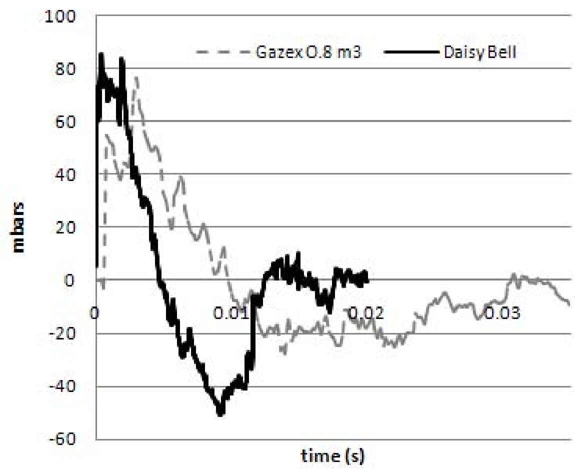

Figure 4: Air overpressure obtained at a 12m horizontal distance for a fire at 3m above a ground without snow and compared with the Gazex® system in similar conditions

The consequence on the helicopter are shown on the next curve : the equivalent dynamical mass on the hook varies in the range of ± 200kg due to explosion consequences: the overweight is limited to less than 20% in mass but mainly in time with no significant effect on the helicopter flight.

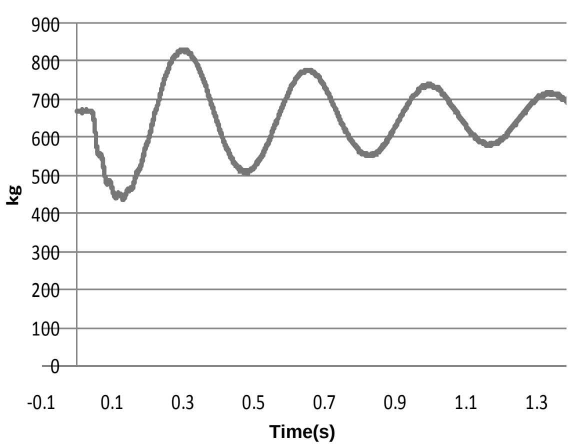

Figure 5: effort measurement on the helicopter hook after explosion

To improve the performance of the system, the introduction of a tightening (or sonic pass) at mid-height inside the cone is possible. Preliminary tests show a gain of 20 to 30% on the total amplitude of the wave. A complete study including numerical simulation of the volume filling and experimental measurements of the explosion effect cone deformation) is being carried out to completely understand DaisyBell® behavior and ensure reliability and safety.

5. CONCLUSIONS

DaisyBell®, new system of avalanche prevention release has many advantages to secure an important area after snowfalls. Its simplicity is the guarantee of the best reliability and its transport by helicopter ensures a great mobility and a rapidity of treatment.

About ten first devices were produced for winter 2007-08 and used in the Alps with roads authorities or ski resorts for real-conditions use and different demos: this first season has confirmed the potential of the system according also to users and pilots opinions. Small adjustments are now being made to obtain the definitive release of the system. In parallel, the development is being validated and approved by INERIS, French national institute for industrial risks, civil aviation services and helicopter manufacturers to reach all necessary standards.

DaisyBell® will be ready for operating in Europe during winter 2008-2009 and rapidly in others countries.

Figure 6: View of DaisyBell® in operation in the Chamonix Valley

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