GAZ-EX AVALANCHE CONTROL SYSTEM

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I am greatly honored to have the opportunity to present the GAZ-EX Avalanche control System to you.

Since 1973, my company has been manufacturing and installing avalanche control equipments. Our 150 CA.T.EX (the "Bomb-Tram") with traditional explosives has been used with good success on three continents.

The advantages of the "Bomb-Tram":

- The explosion takes place just a few meters above the snow surface, providing better efficiency than a hand delivered charge
- Through the use of installed towers and a cable delivery system, avalanche control personnel do not have to go up on dangerous slopes to set off explosives.

Drawbacks of the "Bomb-Tram":

- During snow storms, explosives sometimes hang up on the towers, or ice is formed on the cable, causing derailments
- Access to the power station can often be dangerous and time consuming
- Our customers complained that time required to refire is too long
- Sometimes it is necessary to cut trees or dig trenches in environmentally sensitive areas to install the cable and towers
- Towers are often very conspicuous because they have to be located on ridges or open space above avalanche prone areas
- The essential maintenance required can be a problem, especially for the long CA.T.EX.

Research and development of the GAZ-EX system:

To avoid some of the drawbacks associated with more traditional methods, I wanted to develop a system that would allow explosives to be stored all through the winter at the avalanche control device site. Additionally, I wanted a system that would work effectively with remote controls, that could be operated safety and easily accessed from a road or railway, from power stations, from the center of a resort area, etc.
I worked on a lot of different options and possibilities, both in design and system components. In most countries, it is against the law to store explosives without following strict security measures. In place of explosives, we could use propane gas --it is not classified on the explosives list-- and it has many of the qualities we needed, including having higher power than explosives on powder snow and the noise of the explosion is usually quieter than more traditional methods.
After a lot of trial and error (like blowing a plastic bag with an explosive mixture), I had the idea of using a metal tube with the power generated by ignition at the base of the tube and exploding the gas out of the open end. The inertia of the gas explosion out through the end of the tube against the snow surface --at least 30° slope-- causes it to slide with a path up to 60 feet in width. The hemispherical expansion creates a shock wave, effectively releasing any avalanche prone snow. The force of the explosion can be regulated at the remote base by controlling the amount of gas/oxygen mixture sent to the exploder.
We tested many possibilities on the mountains in the snow. We measured air pressures resulting from the gas explosions --with Cemagref assistance-- and experimented with many different gases and combinations. A mixture of propane and oxygen finally appeared to be the most efficient.
The test results and our operational experience clearly confirm that the shock wave resulting from a GAZ-EX explosion is longer than an explosive detonation shock wave, giving much better avalanche control:

- just 1 Kg of gas is needed to produce the same shock wave as 8 Kg of TNT (about 25 mb)
- a single 1.5 cubic meter GAZ-EX installation, at 7500 ft elevation, is equivalent to 15 Kg of TNT !

Operational GAZ-EX system:

an operational GAZ-EX system is made up of the following components:

- A shelter installed to protect the following equipment:
. An oxygen reserve and a propane gas reserve brought during good weather
. Release tanks for the oxygen and propane
. Pressure gauge for the oxygen
. Valves
. Electrically operated controls for the valves using either a radio remote control system or a direct wired key system
- In addition, the system includes one or more exploders --depending on the site-- with their firing systems, and a gas line consisting of two tubes, one for oxygen, the other for propane, between the release tanks in the shelter and the exploder(s).

Principle of the GAZ-EX system:

- The firing is controlled by opening the valves for the oxygen and propane of predetermined and accurate levels. Gas from the release tanks goes through the tubes to the exploder. The valves are closed and the gas mixture is ignited, using an electric arc between two electrodes, setting off the gas explosion.
- Using pressure measuring equipment after each firing, oxygen and propane gas reserves rebalance the pressure in the release tanks until they are back up to required pressures. At this point, the system is ready to refire.
- The radius of action of the GAZ-EX is between 150 and 450 feet, depending on the degree of the slope, the power of the equipment and the snow conditions.
- It is possible to release heavy snows on moderate slopes of up to 50 %, thanks to the movement in the center of the pack which slides and draws the lateral parts with it, while simultaneously being broken up by the shock wave. This is nearly impossible to achieve with explosives. Using the old CA.T.EX method, more than half of the energy from the explosion is lost on the bottom and laterally.
- In case of powder snow and steeper slopes, we record a larger area of action with the GAZ-EX than with standard explosive methods. The pressure on the snow is spread four times higher than with the CA.T.EX. The measurements of air pressures over the snow surface, using 6 Kg of TNT hanging at the open end of an exploder, resulted in a pressure of only 18 mb at 183 feet. Under the same conditions, the 3 cubic meter GAZ-EX resulted in 40 mb of pressure.
- Using measurements with a soundmeter, GAZ-EX test explosions conducted in summer without snow, are very loud. However, in winter, the noise is dampened considerably and more particularly in fresh and powder snow conditions. From a distance of 3000 to 4500 feet, we can see the flash of lightning but can hardly hear the sound. The reason is that the detonation occurs in the tube and shock waves are spread into the snow surface at the open end with the snow absorbing most of the energy and noise.
- The force of the detonation, and thus the size of the controlled avalanche, can be regulated from the control center by programming the gas injection for longer or shorter blasts. It is also possible to program a single or double action explosion.

Double action:

- In some areas, it may be beneficial to send a portion of the energy from the explosion directly into the ground rock. This is accomplished by igniting the mixture in the middle of the exploder rather than in the closed end. One wave spreads across the ground and the other wave goes out the open end into the snow. In order to send waves across the rock itself, a good coupling between the GAZ-EX and the rock is essential and the rock must be stable, with very few faults.

CAUTION: a shock wave across rock diminishes less quickly than shock waves in the air. A ground wave is able to cross a mountain and may release an avalanche on the other side. This can be dangerous ! Particularly if there are people, houses, roads, open ski slopes, etc. on that side.

- If people or buildings are located within a 3000 ft radius of the GAZ-EX exploder, it is absolutely necessary that ignition takes place near the closed/rear end --rock side-- of the exploder, thus guaranteeing a single action explosion on the snow, with no rock or ground waves.
- A shock wave can also be sent across ice by setting the release into the snow, just a few inches above the ground surface. This is particularly efficient in case of goblets and spring snow.

Example of double action:

- In Aminona, Switzeland, thick layers of snow were released in an area over 1200 feet away from the exploder. Although the rock formation there has many faults, there were no coupling problem thanks to a solid coating of ice
- The double acting GAZ-EX of Corrençon-en-Vercors, France, simultaneously releases on both sides of Villard de Lans and Corrençon en Vercors. The rock is limestone and the wave crosses over 450 feet through the montain
- In Val Thorens, France, a double-acting GAZ-EX is located on the north side of the mountain and is effective on the south side as well. The rock formation there is granite.

Conclusions:

Thanks to its efficient design, the GAZ-EX equipment performs easily and well, through the planned release of successive small avalanches, whatever the weather. GAZ-EX provides a highly efficient method of protecting roads and rails, ski lifts, electric towers, homes and buildings that may not resist the force of a natural avalanche. By setting off small, controlled avalanches over a period of time during a storm, we are able to protect these areas from disaster.

A sampling of GAZ-EX installations throughout the world:

. In Val Thorens, France, a GAZ-EX system protects a tram, gondolas and ski runs

. In Disputada, Chile, it protects a concentration copper ore complex where, in 1982, a natural avalanche caused over sixty million dollars in damages

. At Echo Summit, California, GAZ-EX systems have been installed in an avalanche prone area above US Highway 50, additional installations at Frog Pond, Carson Spur and Red Lake have been installed, with additonal installations planned by Caltrans

. In Aminona, Switzerland, it protects ski lifts and runs

Since 1988, 180 GAZ-EX exploders have been manufacturing and installing with good success on three continents (France, Switzeland, Italy, Spain, Austria, Germany, USA, Canada, Chile, Argentina, Japan)

We can truly say that the GAZ-EX is the better existing avalanche control method, thanks to its efficiency, its reliability, its low operational cost --both in material and personnel, especially when compared to the other methods-- its quick action, and its excellent safety record.

Thank you for your interest in our product. We will be happy to answer any questions that you may have about the GAZ-EX avalanche control system and its application to your specific area.