Blasting for Avalanche Control using Shock-Tube and Non-Electric Detonators

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1. Background Explosive manufacturers are increasingly concerned regarding liability from the use and users of their products. Avalanche control blasting has traditionally utilized fuse cap and time fuse for explosive initiation. The rest of the explosive industry has been decreasing their use of cap and fuse in favor of "non-electric" detonators and shock-tube, leaving avalanche control programs in danger of becoming the sole user of cap and fuse. Reliable sources from which to purchase the fuse/cap components are becoming more difficult to find. Non-Electric (Non-el) Detonators are a #8 equivalent blasting cap purchased pre-assembled with a fixed length of shock tube. Shock Tube is a small diameter laminated plastic tube internally coated with a thin layer of aluminum powder and the high explosive HMX. This tube transmits a low energy explosion from the point of initiation to the delay cap at approximately 6500 feet per second. A number of different firing devices are available; ours utilizes a very low cost shotgun primer and is easily cleanable after each session of use.

2. Intent The WSDOT Avalanche Control Program for Snoqualmie and Chinook Passes added the shock-tube and non-electric initiation system to established routines during the winter of 2001-2002. Our observations share some of the pros and cons learned both first-hand and from other sources in the industry. A cost comparison is also done.

3. Manner of Use Our typical avalanche control charge is 12-25 pounds of ANFO primed with a cast booster. 50 grain detonating cord is used to initiate the primer and 18 grain detonating cord is commonly used to remotely fire either tram-deployed or buried charges. Non-electric detonators were used as a direct replacement for timed fuse/cap assemblies to initiate the cord. Shock tube was also used to replace some of our longer detonating cord runs.

4. Safety The most important information came from *Snap, Slap and Shoot – A Possible Cause for Premature Ignition of Shock Tube; Holmberg & Salomonsson – ISEE Proceedings of the 28th Annual Conference on Explosives and Blasting Technique*. The paper is a review of documented blasting accidents that have occurred while using non-electric initiators, and a study that attempts to reproduce the conditions causing these accidents. It demonstrates that blasts have been initiated through the stretching and snapping of the shock tube. While these accidents are quite rare, it is important to be aware of their potential. Our own use indicates the importance of maintaining stress-free continuity in the shock tube. Stretching the tube may result in a failure of the initiated shock to reach the detonator and fire the shot. The tube splice connectors can also be pulled apart causing a misfire. If the tube is not protected from moisture, the same result becomes likely, but even in our rainy northwest environment, reasonable care prevented a repeat of this problem. Another point worth noting is that the non-electric detonators we have used contain a considerably heavier "slug" of metal debris that can be thrown a fair distance. Each Non-el Detonator contains a built-in static shunt to protect it from accidental firing due to static electricity.

5. Advantages The immediate and obvious advantage is the blast zone control. As soon as the shot is prepared and the area has been secured, the shot can be fired. There is no "wait time" while a 90 second (or longer) fuse is burning and unapproachable. Blast zone security does not have to be maintained for the entire wait time. In a highway setting, the traffic also does not have to be waiting for that same burn time. That may not seem like a big issue at first, but with average hourly traffic volumes of around 1500 vehicles, and peaks loads of more than ten times that, the downstream effect can be quite significant. Independent studies have estimated Interstate 90's value to state commerce at $750,000 per hour. Even if these figures are inflated, it is apparent that any timesaving on a traffic delay will have high value. Direct cost savings have also been noted. We routinely double cap any shot that would create a hazard or delay in the event of a misfire, so cap and fuse costs are typically $6.56 per shot. Non-el initiation is generally about $2.85 each. The cost of additional shock tube to remove you from the immediate area is about $0.064 per foot. 18 grain detonating cord is almost three times the cost per foot.

6. Disadvantages Non-electric initiation is most suitable for only certain types of avalanche control blasting. For hand-placed or tram delivered charges it works quite well. For cornice removal it seems ideal. We did not attempt to use this system to initiate any hand charges that must be thrown or dropped. Any situation where the tube cannot be smoothly deployed or managed should be avoided. The tube itself is a cleanup problem; it is not consumed by the blast like detonating cord. The waste can be a tangled mess and is not currently recyclable. Tests are being conducted to determine how quickly it will degrade when left in the environment. The tube is not strong enough to be used for belaying charges into position; it will stretch with surprisingly little force. At this time, setup takes us slightly longer due to additional care regarding connections and moisture issues. The extra time will most likely become negligible with additional experience.

7. Cost Breakdown

Time Fuse per/ft	$0.28	Shock Tube per/ft	$0.064	#8 Fuse Cap	$1.25
Time Fuse 90 sec	$0.53	Shotgun primers	$0.022	Non-el Detonator (Unidet)	$2.85
18 grain det cord per/ft	$0.165	Pull wire igniters	$1.50	Non-el firing shooter	$171.00

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