Blasting Caps at Kennecott

Draft for discussion @ October 11, 2011

The problem

Blasting caps have been found in two debris scatters at Kennecott and represent a serious hazard to employees and the public. One cap was found in a relatively small scatter (approximately 50' by 50') of burned fuse and other refuse on the north side of the mill downslope from the door to the crushing level. A dozen caps have been found several years ago in a larger dump on the moraine immediately to west of the north end of the leaching plant. The caps found so far are from the mining operations and are at least 70 years old.

Both areas know to contain blasting caps are currently behind barrier tape and posted with signs warning of the hazard. These responses to the problem are temporary. Mitigation must be undertaken to protect the public and make it possible to do stabilization work in the area.

The debris scatters on the north side of the mill at Kennecott. When the mill was operating, burnt fuse and the occasional misfired blasting cap, as well as other material removed from the ore stream, was discarded here. The view above shows approximately one-half of the mill scatter.

Origin of the caps

Mining as practiced at Kennecott was one long series of blasting operations. Blasting occurred daily at numerous points in the mine. The purpose was to break rock and copper ore into manageable pieces that could be removed from the mine. Thousands upon thousands of blasts occurred between 1901 when the first exploration work was conducted and 1938 when the mines closed. Additional blasting was done in the 1960s in conjunction with the efforts of the Consolidated Wrangell Mining Company.

Basic blasting operations involved assembling a length of fuse, a blasting cap, and dynamite. The burning fuse detonated the blasting cap which set off the dynamite. Each hole in a blast had a blasting cap. Blasting caps were purchased in lots ranging from 20,000 to 62,500 caps per order. As early as 1915, bi-monthly orders were as large as 60,000 caps at one time. As the size of the mines increased the number and size of the blasts increased and the number of blasting caps used increased accordingly.[1]

Not every cap used in a blast detonated. A few caps misfired due to moisture in the fuse or cap, a poor fit between the fuse and the cap, or dirt or other foreign materials between the fuse and the cap. The problem was not with the cap, rather with the assembly of the fuse and cap.[2] Misfires were not common, but the sheer number of blasts meant even if one in a thousand or one in ten thousand did not function properly, the number of misfired caps built up over time.

The cap from a misfire was and is still dangerous. Since most blasts involved at least a dozen caps, typically many more, the rock still breaks and the misfired cap is mixed in with the broken ore. The cap and the unexploded dynamite may be collected by the muckers as they shovel the ore into cars, or it may stay in the ore. Evidence suggests the muckers were not particularly concerned with sorting out unexploded materials. Still, there is no evidence to date suggesting intact dynamite made it to the mill.

Ore containing broken steel, scraps of wood, discarded clothing, worn out gloves, burned out fuse, and the occasional misfired blasting cap was moved

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[1] E. I. du Pont De Nemours, 6/5/303, Kennecott Copper Corporation Collection, National Park Service, Alaska Region, Anchorage, Alaska

[2] California Cap Company, *Detonators for High Explosives; A Handbook on Blasting Caps, Electric Blasting Caps, and Delay Electric Blasting Caps* (Oakland, California: California Cap Company, 1932), pp. 11 – 14.

from the mine, down the tramway, through the jaw crushers, and into the main ore bin of the concentrator. As ore was fed from the bin into the mill, the debris was removed by hand and magnets. It was sacked and discarded. Two areas where the material was dumped have been identified—on the north side of the mill below the crushing level and on the edge of the moraine west of the leach plant.

Most of the residue from blasting operations in the debris consists of burned fuse and represents no particular hazard. However, a few fuses still have unexploded blasting caps attached which means no piece of burned fuse can be considered safe until it has been collected and examined.

Nature of the hazard

Blasting caps do not mellow with age; they are more likely to deteriorate, become unstable, and even self-destruct. There is no simple, convenient way to determine the condition of a blasting cap in the field or predict if and when one might self-detonate. Chemicals used in blasting caps are sensitive to heat, flame, friction and/or impact. Caps contained lead azide and mercury fulminate may explode spontaneously. Primer charges and base charges constitute the explosive mass in a fuse detonator (blasting cap). Quantities per cap are small. Kennecott used caps from the California Cap Company ranging in strength from #5 to #8 and containing from 0.80 to 2.00 grams of an explosive charge.[3]

Individual blasting caps can cause serious injury. Feet and hands can be maimed or worse, eyes damaged beyond repair, and slivers of metal embedded in any part of the body with considerable force. Children have been known to

[3] Du Pont, *Blasting Supplies* (Wilmington: E. I. Du Pont de Nemours Powder Company, 1911), p. 62.

put caps in their mouths. Death is a possibility. There is a risk to the disposers as well. Lawyers will be involved if anything happens.

While all blasting caps represent a hazard, the caps at Kennecott should be considered especially dangerous. There is no way to tell what chemicals were used in the manufacture of the caps by visual observation. Some of the chemicals used while the mines were in operation are less stable than others. Exposure to the elements for so many years will have made some types of caps especially sensitive to any disturbance. There is no way to conveniently identify these caps from others in the field. All must be considered extremely dangerous.

Some Chemicals Used in Fuse Blasting Caps, 1900-1938[4]

Date Range	Explosive	Notation	Explosive and ...
To 1935	Mercury Fulminate	$C_2HgN_2O_2$	Toxic
To 1935	Potassium Chlorate	ClO_3K	Toxic
1926-1945	Tetryl	$C_7H_5N_5O_8$	Moderately toxic
1935-date	Lead Azide	N_6Pb	Deadly poison
1935-date	Lead Styphnate	$C_6(HN)_3O_9Pb$	Poison
After 1945	PETN	$C_5H_8N_4O_{12}$	Moderately toxic

Notes: Date Range indicates period of general manufacture. Not all manufactures stopped using specific mixtures at the same time. Generally, use will extend past the end dates as stocks are depleted.

Since the caps are associated with burnt fuse, all the fuse in the piles should be collected to ensure all caps are found. At the same time, the fuse—a marker for the possible presence of blasting caps—will be removed from the site as the caps are removed.

[4] Du Pont, *Blasting Supplies* (Wilmington: E. I. Du Pont de Nemours Powder Company, 1911), p. 62; date ranges and chemical data from Mike Shields "Explosives Related Chemicals, 2008 Update" and his "Abandoned Explosives Disposal Workshop, Instructor" Manual, circa 1998.

Mitigation methods—mill scatter

While the caps are dangerous, it is possible to mitigate the risk. Once the caps have been identified and collected it is relatively simply to destroy them. The identification and collection is the problem. The number of caps is an unknown. Some of the caps will be attached to some small pieces of burnt fuse and the area is literally littered with burnt fuse. Some may not be attached to anything. The area of potential discovery covers a rectangular area measuring at least 50 feet by 50 feet. The surface is steeply sloping (30° +/-) and partially covered with scrap lumber and other building materials. The scatter has depth as it was built up over time and caps are as likely to be found at some depth as exposed on the surface. Finally, the scatter is not homogeneous. It consists of decaying jute bags, scrap steel, wooden wedges, wire, and discarded work clothing. Siding from the upper mill has fallen over the area. Identifying the caps in the scatter is not a straight forward exercise.

The debris scatter can be examined and processed by raking the material down slope to screens in a pre-established pattern. Larger items including burnt fuse with caps still attached can be segregated and collected in a relatively large mesh. Single caps without fuse attached can be caught when the screened material is processed a second time through a finer mesh.

The area of the mill scatter also contains elevated levels of hydrocarbons. Evidence suggests machine oil was discarded over the side of the hill over time.[5] The fabric wrapping of fuse is tar which may have an influence on the sample results

Present thinking suggests the best way (so far) to examine the debris scatter and collect burned fuse and any caps is to rake the debris downslope in small quantities and screen it. Caps may be identified immediately; they may not. The sensitive nature of the caps, the difficulty in identifying them as they are raked, the risk of detonation during raking, and the need to sort a wide variety of materials from the mix means the collection of the caps must be a cautious, measured activity.

The heaviest concentration of use and other debris is at the bottom of the slope where a walk way has been cut across the slope. The nature of the matt of fuse and other fabric is fully exposed in profile.

In addition to raking, the soil should be screened. An initial screening through a mesh with opening one inch or larger will segregate most of the larger

[5] American North/EMCON, Inc., "Kennicott Mine Site Investigation Final Report," Vol. 1, Anchorage, Alaska, August 1992, p. 38 and Table 21: Soil Analytical Results—Petroleum Hydrocarbon Content."

material from the dirt. Scrap steel, wood, clothing, and fuse can be segregated at this point. The remaining material passing through the larger screen can then be passed over a finer mesh, possibly one-quarter inch square, which should identify any additional caps. At this point, mesh sizes are provided for illustration; effective mesh sizes can only be established by experimentation bearing in mind blasting caps are approximately one-quarter inch in diameter.

The fuse and debris matt overlies some copper ore and moraine material which should provide a readily visible bottom to the deposit. Everything above the moraine material—the original 1900 surface—should be removed to ensure all blasting caps are identified and collected.

The slope can be used to advantage. Wood can be collected and debris raked over screens working down slope and across the slope in a predetermined pattern. Wooden fencing should be established at the bottom of the scatter and possibly at one or more intermediate positions to prevent disturbed material from flowing further downslope and out of the work area. More detailed plans for the collection of debris and caps will be developed well before the disposal action. This brief sketch provides an overview for planning purposes.

Raking and screening the material on the slope down to the surface of original moraine will produce a significant amount of screened earth-like material below the work area. The eventual disposition of this material is beyond the

scope of the disposal operation. The search will also isolate cultural items originating in the mine and may be of interest to archaeologists and curators.

Detailed operations planning and a risk assessment process will be undertaken separately from this summary document. The disposal operation will be defined in the NPS/Alaska Explosives Disposal Operations Plan, and the risk assessment will be conducted within the framework of the SPE and/or GAR Risk Assessment methodologies.

Mitigation methods—leach plant scatter

The debris scatter on the old moraine west of the leach plant and the machine shop presents a different problem given its larger size. Fortunately, it is much more accessible allowing the consideration of mechanized solutions to the problem. Otherwise, collecting and screening this quantity of material by hand would be prohibitively time consuming. The initial investigation of the site employing grid lines and a close inspection of the surface took a full week and only confirmed the presence of caps and the extent of the scatter.

Several methods of capping the scatter can be considered. The area could be encased in shotcrete or the debris can be buried. In either event, before the debris should be covered with a long-lasting geo-fabric to establish a distinct barrier over the covered material. The fabric must carry a repetitive warning that will serve to alert anyone opening the area in the event institutional memory and/or records of hazardous materials operations are lost. The labeling should read "WARNING / UNSTABLE EXPLOSIVES / EXTREME DANGER / KEEP AWAY."

Personnel and basic rules[6]

A. The work area MUST be considered an exclusion zone.

B. No one may enter the exclusion zone during the disposal operation except with the express permission of the blaster-in-charge (BIC).

[6] While NPS-65 and Director's Order #65 are not currently in force, they still represent best practice and licensing requirements for NPS blasters and disposers. These documents will provide the regulatory basis above and beyond that required by federal and state law guiding any abandoned, deteriorated commercial explosives on NPS land in the Alaska Region.

C. The BIC shall have a current “Blasting & Explosives Certificate” or “Explosives License” issued by the National Park Service which is endorsed for “Deteriorated or Abandoned Explosives Disposal.”

D. The qualifications of others entering the work area must be determined, examined, and approved by the BIC before those persons enters the area.

E. All persons working on the mitigation and disposal will be under the direct control of the BIC at all times. Conversely, the BIC is responsible for the safety of all persons working on the disposal.

F. Additional persons working within the exclusion zone individually or as part of a team effort will have a current NPS Explosives License as a minimum requirement. Further, they must be given specific training in abandoned explosives disposal before they enter the work area and will work under the direction and responsibility of the BIC.

G. Others not directly at risk may be involved as guards or in support positions. They will also be under the direct control of the BIC who will be personally responsible for the safety of the guards and support personal working to assist the disposal.

H. Sufficient guards shall be posted to prevent anyone from coming within 200 feet of the work area while disposal operations are underway.

I. Guards will receive clear instructions in their duties and will be equiped with appropriate PPE.

J. The use of machinery to cover or bury the caps and debris puts the operator at risk. The machine operator must be fully informed of the risks associated with the work, have a major role in determining appropriate PPE for him/herself and the machine, and have the right to decline the work or stop work at any time it seems unsafe.

K. While manipulation of the material with a back hoe may cause one cap to detonate, there is little risk of a mass detonation. Still, the operator should wear appropriate personal protective equipment, especially safety glasses, and the glass on the machine should be reinforced with Plexiglas sheets as necessary. There must always be a barrier between the work

and the operator to protect the operator from detonation, no matter how small.

L. Machinery should not operate in or on the dump but approach the debris from the side. If the material is buried, the hole should be close by but no within the area of the dump.

M. Machine operations shall be monitored by the BIC as any other disposal.

Addendum

For the purposes of this project, appropriate additional personnel will be currently licensed NPS blasters with an Abandoned/Deteriorated/ Unstable Explosives endorsement. These people are few and far between. Failing that, those who meet the qualifications for training in Abandoned/Deteriorated Explosives Disposal can be put through the course immediately prior to starting work on the project. The training option is attractive as it will produce workers with immediate knowledge of the risks and techniques but without pre-established work patterns in disposals. The Mill disposal will serve as the practical/field exercise part of the training and move the students along to conducting the three supervised disposals required to earn the endorsement. An additional benefit to the training will be the presence of the instructor who will be present as a consultant but will not actively participate in the project.[7]

Law enforcement, maintenance, and personnel working at Kennecott should not feel slighted when they are excluded from the disposal area. Working with abandoned explosives is an unusual undertaking—a hybrid between blasting and hazardous materials work. A brief discussion of abandoned explosives disposal within the National Park Service written by Mike Shields is attached as an appendix.

A detailed work plan and a RAM risk assessment is forthcoming.

Any concerns related to these two blasting cap mitigatoins at Kennecott should be directed to Logan Hovis, Alaska Regional Blasting Officer, Anchorage, Alaska; phone number 907-644-3468 and email at logan_hovis@nps.gov.

[7] Deteriorated/Unstable Explosives Disposal is a hazardous materials operation where the disposer needs to be a blaster to conduct the work. Requirements are spelled out in NPS-65: Explosives Use and Blasting Program, Appendix D, p. 2. Additional considerations in training as an NPS abandoned explosives disposer are laid out by Mike Shields in a statement attached as an appendix to this summary.

Appendix

ABANDONED EXPLOSIVES DISPOSAL in the NPS

Some History:

NPS-65 (now DO-65), the Explosives Use Policy and Program for the NPS, was implemented in 1986 after 3 years of work by a 6-member Blasting Policy Task Force, of which I was the Chairman. (As an aside, we purposely had the final draft reviewed by OSHA, ATF, Bureau of Mines, and Corps of Engineers). Originally it did not address abandoned explosives (its focus was driven by a 1983 blasting fatality at Yosemite), but in 1987 the Stampede Mine fiasco at Denali raised serious concerns about our reliance on military EOD Teams to deal with old commercial explosives. In 1988 I was detailed to Alaska to review the Stampede blast circumstances and to perform 10 disposal operations in 3 parks, and became aware of the magnitude of the problem in Alaska, including an almost universal ignorance of the potential risks involved. Back at Kings Canyon, a bit of phone networking revealed that the same problem existed in many other parks (mostly Western), though the scale and frequency were much lower. In 1989 the Task Force was briefly reconvened to prepare an amendment to NPS-65 specific to the handling of abandoned or otherwise unstable explosives, and in 1990 I conducted the first Abandoned Explosives Disposal Workshop at Grand Canyon. Since then I've conducted 4 more Workshops, and there are now roughly 8 NPS employees licensed to perform disposals ("roughly", since I'm unsure how many of the original 20 are now retired or have dropped their license).

What Are "Abandoned Explosives":

Any commercial explosive, detonator or initiator which, due to age or conditions of storage, has become unpredictable in its stability and performance. It does not include excess materials that have exceeded their shelf-life by one or two years but are still stable and can be handled and disposed of safely by normal means (burning, flushing, or detonation in small quantities). It also does not include military ordnance (bombs, shells, mines, grenades, etc.), which should be handled only by a military EOD Team.

What's the Risk:

There are two: (1) unanticipated detonation, and (2) ignorance of the chemistry and mechanics of explosives deterioration (ie., the type and level of hazard that may be present). The detonation risk comes from the decrease of stability and increase in sensitivity of some explosive ingredients, due to age, environmental influences, or both. Of particular concern are nitroglycerin, nitrocellulose, mercury fulminate, lead azide, lead styphnate, picric acid, ethylene glycol dinitrate, and potassium chlorate.

The "ignorance risk" is best demonstrated by the common belief (even within the Blaster community) that anyone holding a Blaster's License is qualified to handle and dispose of unstable products. We also continue to send cultural resource and structure rehab folks to old

mine sites who have no clue about the possible hazards they may face and usually cannot even recognize explosives when they see some.

The Role of the Licensed Disposer:

The obvious primary duty is to safely remove and dispose of found explosive materials, while minimizing the risk of damage to cultural and natural resources, but some additional duties come with that: (1) conduct a thorough investigation of the site to make sure all explosives have been found, which is often the most time-consuming and riskiest task to perform; (2) nearly all these sites require Section 106 clearance which, despite what many Resource Managers think, cannot be adequately or accurately done without input from the selected Disposer prior to the disposal action; (3) be prepared to provide 4 to 8 hours of "Abandoned Explosives Orientation" instruction to the staff, including managers and seasonals, of your own park and any other park you are called to; (4) provide technical guidance and support to park and Region management staff, usually through your Regional Blasting Officer. That can include reviewing the Disposal Plans of disposal contractors (there are a few), providing on-site guidance for EOD Team disposals, and providing your best technical and operational analysis of any incident or accident involving abandoned explosives.

Disposer Qualification Requirements:

Must be a currently licensed Blaster.

Must attend a minimum 3-day Abandoned Explosives Disposal Workshop, which includes field exercises.

Must participate in at least 3 disposal actions under the supervision of a licensed Disposer (usually the toughest hurdle to clear in a timely fashion).

Must continue to improve his/her knowledge of explosives history, chemistry, and deterioration processes.

Must voluntarily accept the Disposer license. This is a high-risk activity (in fact the only "blasting activity" for which I readily support hazard pay, though no one [other than Logan Hovis] ever gotten it), not to be forced onto any employee or lumped under "other duties as assigned". Before accepting it, there should be a discussion with any "significant other" (wife, girlfriend, parent, etc.) – they should be aware that, though we try very hard to prevent it, you just might come home as pieces in a body-bag. At the end of the Disposal Workshop I always interview each participant to give my assessment of their qualifications and further training/experience needs, and since they now have far more knowledge than they did 3 days prior, I start with "Do you still want to be licensed for disposals?" – I've had 3 say "No thanks".

Mike Shields 9/25/11