

Fatality Investigation Report 2003-20R

Young camp counselor killed when cannon bursts to pieces

Summary

On August 1, 2003, a 16-year-old youth working as a camp counselor was fatally injured when a cannon he was attempting to fire exploded and burst into pieces. This cannon had been used during evening flag ceremonies at the camp for about three years.

On the evening of the incident, the victim set up the cannon as instructed and attempted to fire it during the flag ceremony, but the wind twice extinguished the touch stick used to fire the cannon. After the second attempt failed, the ceremony proceeded without the cannon, and everyone retired for the evening meal.

The victim and another youth working as a counselor remained at the site to see why the cannon did not fire. They added a small amount of black powder to the touchhole and again attempted to fire the cannon. This time the cannon fired, and the explosion caused the cannon's breech to burst into pieces. One fragment struck the victim in the head, fatally injuring him.



Photo 1. Black-powder salute (no projectile). Note flame from touch hole and muzzle.

Cause of death: Traumatic injury to the brain

Recommendations

1. Develop written procedures to ensure the cannon is charged and fired by trained and knowledgeable persons, within the manufacturer's operational specifications, and with specific misfire procedures.
2. Adult counselors should conduct the firing of black-powder cannons used at youth camps.
3. Youth should not be employed in positions that include the use or handling of explosive materials.
4. Use only solid steel or seamless steel-lined cast-iron cannons to fire black-powder charges.
5. Do not obstruct the bore when firing for ceremonial salutes.
6. Use the appropriate grade and quantity of black powder as designated for the cannon.
7. Inspect the gun tube regularly to detect signs of stress.
8. Periodically review processes to ensure continuing adherence to safe work practices.

Investigation

On the evening of this fatal incident, the cannon was taken from its indoor storage location to its firing position, and the victim and another youth camp counselor prepared to fire the cannon at the flag ceremony as they had in the past. The adult black-powder instructor, responsible for supervising the appropriate use of the cannon, was on the field but not immediately supervising the procedure.



Photo 2. Remnants of cannon.

The two camp counselors poured a charge of black powder down the cannon's muzzle from two 35 mm film canisters. The black powder used was usually a cannon grade, but at times camp staff would use finer, faster-burning grades intended for black-powder muskets and rifles if cannon-grade powder was not available. On the evening of this incident, a finer-grade powder (FFFg) was used to charge the cannon.

The two counselors then filled two film canisters with sand and placed them into the bore of the cannon along with a wad of toilet paper and a discarded plastic bag off the ground. Without the wadding, the cannon was known to produce only a puff of smoke rather than a loud report. Sometimes a potato or carrot, or other convenient materials were used as wadding.

Next, the counselors placed a small amount of FFFg black powder as a priming charge over the cannon's touchhole. Some of this extra black powder probably fell down the vent and into the cannon's breech. Experience had shown that black powder over the touchhole was more effective than a fuse to ensure the cannon fired at the appropriate time during the flag ceremony. On the evening of the incident, the victim was using a 4-foot long stick to light the priming charge over the touchhole. When the two early attempts with burning twine on the end of the stick failed, the victim reportedly placed an additional charge of FFFg black powder over the cannon's touchhole and also wrapped toilet paper around the end of the stick for a better flame. This also failed to ignite the powder, but repeatedly pushing the end of the stick closer to the touchhole finally ignited the charge causing the cannon to burst. A large portion of the breech struck the victim in the forehead, and he fell unconscious to the ground. The other youth was spun around by the force of the blast, but was uninjured. The victim's injuries were obviously serious and a request was made to immediately transport him by air ambulance to a medical facility. He died in a hospital, 4 days later.

The youth camp has operated a black-powder program for years, providing instruction in the safe use of black-powder rifles and muskets. The program operates with a ratio of one adult instructor per youth to ensure safety while on the firing range. A camp volunteer with experience in firing black-powder weapons developed the original procedure used to fire the cannon. The original procedure was not written down, but reportedly included using only cannon-grade black powder.

The camp's national organization has written standards for black-powder programs that do not address using cannons. A training video for the cannon at the camp was prepared, but was not consistently used, and in many details did not demonstrate standard safety procedures. The camp did not develop written procedures for successive youth counselors and therefore procedures were subject to subtle changes over time.

The cannon involved in this incident had been purchased from a local dealer, who was well known for his support of the youth organization running the camp. The cannon, a scaled down replica of a historical British naval artillery piece, was shipped, along with many others like it, into the United States from England in the 1960's. The cannon had been imported as a solid casting and then had been bored, and a touchhole added, by a subsequent owner in the United States. The dealer acquired and sold the piece as a cannon prepared to fire black-powder charges. According to the employer, there was no literature accompanying the cannon at the time of sale, and a minimal amount of verbal instructions on how to load, fire, or care for the weapon.

The cause of the cannon failure could not be conclusively established. However investigators have considered several possibilities:

1. Metal fatigue exacerbated by corrosion in the cannon's bore may have reduced its material strength to the point that it was no longer able to contain the pressure of firing.
2. The method of loading resulted in an overload charge that developed too much pressure for the cannon to withstand.
3. The sand-filled film canisters used to occlude the bore may not have been placed directly against the powder charge, leaving an air gap between the powder charge and the projectile. This condition has been known to generate pressures well in excess of those developed by correct loading procedures.

Recommendations/Discussion

- 1. Develop written procedures to ensure the cannon is charged and fired by trained and knowledgeable persons, within the manufacturer's specifications and intended use, and with specific operating procedures, including misfire.**

The employer purchased the cannon and then used internal resources from its black-powder program to develop safe operating procedures. These procedures were not written down, and changed over time when communicated to successive counselors. The employer was apparently not aware of these changes. Written procedures should address proper use, firing/charging, storage, and how to manage misfires. Cannons purchased without accompanying literature from the manufacturer, documenting firing and maintenance procedures, should not be fired.

Additional sources of representative safety procedures for black-powder cannons, developed from historical records and practical experience of shooting organizations for antique cannons, are listed in the reference section of this report.

- 2. Adult counselors should conduct the firing of black-powder cannons used at youth camps.**

Instead of using an unobstructed charge of cannon-grade (Fg) black powder, the counselors used a charge of FFFg powder, and obstructed the cannon bore with two sand-filled 35mm film canisters. Either of these alterations to the established procedure creates conditions that can cause increased pressures in the cannon upon firing. Instead of a "salute" charge the procedure resulted in a "service" charge that fired a projectile. An experienced adult instructor with knowledge in safe

black-powder firing procedures would have been able to recognize the hazard of the altered firing method and would have initiated a more formalized misfire protocol.

On this occasion, it is not known if the film canisters were tamped down securely against the black-powder charge. Witnesses reported the victim had some trouble in ramming down the first canister. According to safety rules published by the American Artillery Association, all projectiles should pass easily through the bore and be firmly seated against the powder charge. The difficulty in seating the first film canister may indicate an air pocket existed between the powder charge and the film canisters. According to cannon experts consulted as part of this investigation, occlusion of the barrel with the projectile not firmly seated against the powder charge can result in an explosive blast outward instead of moving the projectile down the bore toward the muzzle. Some reviewers speculate that this appears to be what happened in this case, based on evidence from photographs and the damage to the cannon, sustained entirely in the area behind its trunnions. (See photo 4, below) To avoid an air pocket, a ramrod with two markings should be used: one showing the position completely against the back of the bore with no load, and a second showing the position with a properly seated projectile against the powder charge. The ramrod used at the camp had no markings to verify the depth of the load.

Similarly, the adult program manager, not youth counselors, should handle misfires. A cannon misfire must be approached cautiously with a specific misfire procedure. The American Artillery Association recommends a six-step procedure to safely discharge the cannon or remove the charge following a misfire. Details of misfire procedures along with safe loading and firing procedures can be found at:

<http://www.civilwarnews.com/artillerysafety.htm>
<http://www2.control.com/~emoore/AAA/mrt.htm>

3. Youth should not be employed in positions that include the use or handling of explosive materials.

Federal child labor regulations for agriculture have identified the handling or using of a blasting agent, including black powder, as a particularly hazardous activity for youth under age 16 (29 CFR 570.71). Youth under age 18 may not be employed in plants or establishments manufacturing or storing explosives or articles containing explosive components (29 CFR 570.51). We recommend that the nonagricultural and agricultural regulations be harmonized, recognizing that exposure to explosive materials is particularly hazardous and the differences between these work environments do not warrant different protective orders. It is our recommendation that youth under age 18 should not be employed in positions that include the use or handling of explosive materials, including ammunition, black powder, blasting caps, dynamite, high explosives, fireworks, primers and primer cord, smokeless powder, and other goods and materials designated as explosives by the United States Interstate Commerce Commission.

4. Use only solid steel or seamless steel-lined cast-iron cannons to fire black-powder charges.

The dealer referred to the cannon as being made of "grey steel," an older term used to describe what is today commonly known as "cast iron." A metallurgical engineer consulted as part of this

investigation reported that current manufacturing standards for ceremonial salute cannons require a solid-steel body or cast iron with a seamless steel insert. Cannons made from poured or casted processes, the engineer reported, are prone to failure with time and use.

Solid cast cannons should always be checked for containing solid seamless steel bores. If they do not have the seamless steel bore, they should not be used to fire any kind of high explosive.

5. Do not obstruct the bore when firing for ceremonial salutes.

There are two kinds of firings: ceremonial salutes and service loads. A ceremonial salute does not include firing a projectile. The black-powder charge may be doubled as long as the cannon's bore is not occluded. A service load refers to a black-powder charge used in a cannon for the purpose of firing a projectile. Always follow manufacturer's recommendations when designing procedures for setting the amount of black powder used to fire a cannon.

6. Use the appropriate grade and quantity of black powder as designated for the cannon.

Black powder comes in different grades and ranges. The finer-grained grades of black powder have an increased surface area compared to coarser grain. Finer grains burn more rapidly and are more explosive. Usually the main charge should be of the coarsest granular powder designed for the type of firing (ceremonial/salutes or service loads). One should consult the manufacturer of the cannon for specific firing instructions.

The standard safety procedure that designates preparing the powder charge by wrapping it in heavy aluminum foil had been abandoned at the camp a year before, because it made cleaning difficult. National safety standards establish a maximum charge of 656 grains of grade F powder, or about 1½ film canisters. The camp's firing procedure had been designed for a salute charge, with powder alone, and a training video shows three film canisters of grade FFFg powder used for a charge. Some 900 grains was used regularly. Particularly with the introduction of a means to occlude the cannon's bore, the cannon was overcharged. Additionally, a more explosive grade of black powder was being used. Long use with extra explosive stress is likely to have weakened the structural integrity of the cannon.

7. Inspect the gun tube regularly to detect signs of stress.

Cannons should be magnafluxed periodically to determine suitability for continued use. Regular assessments assure the cannon's structural integrity is being maintained. A cannon should also be magnafluxed between changes in program directors to ensure integrity as the new director assumes responsibility for the program.

A cannon should be stored where it will not be damaged between uses. After every firing, a cannon should be cleaned according to the manufacturer's recommendations. Black powder is hygroscopic (moisture attracting), and moisture can degrade and weaken the metal with rust. Recommended maintenance involves washing the bore from muzzle to breech using hot soapy water followed by a thorough rinse and then allowed to thoroughly dry. The camp reportedly stored the cannon inside between firings, but it was not cleansed after each use, but weekly.

8. Periodically review processes to ensure adherence to safe work practices.

Although the employer follows nationally developed standards for conducting periodic reviews of its at-risk activities, locally implemented programs, like cannon usage, were not included in a periodic review and performance evaluation. The employer had developed an unwritten procedure for safely charging/firing and managing misfires with the cannon at its local youth camp, but youth counselors, without review or oversight, gradually modified the verbal procedures they received. At another youth camp managed by this employer, an adult volunteer counselor has been using his personal cannon without incident for several years. The staff at this camp, however, did not communicate with the other camp's cannoneer, who had extensive experience with cannon use and safety procedures.

References

The Civil War News, Artillery Safety <http://www.civilwarnews.com/artillerysafety.htm>

Reenactment Safety Regulations for Tannenbaum Historic Park and Greensboro Country Park
<http://www.ci.greensboro.nc.us/leisure/Regional%20Parks/DOC%205%20-%20Reen%20Safety%20Regs.doc>

California Historical Artillery Society: Safety Rules and Procedures for Muzzle Loading Artillery
<http://www.geocities.com/mountedarty/saferule.doc>

Sample Rules for Black Powder use in Battle Reenactments
<http://www.luckhardt.com/ecwsa106.html>

Cannon Shooting Instructions & Warranty Information
http://www.traditionsfirearms.com/files/Cannon_manual.pdf

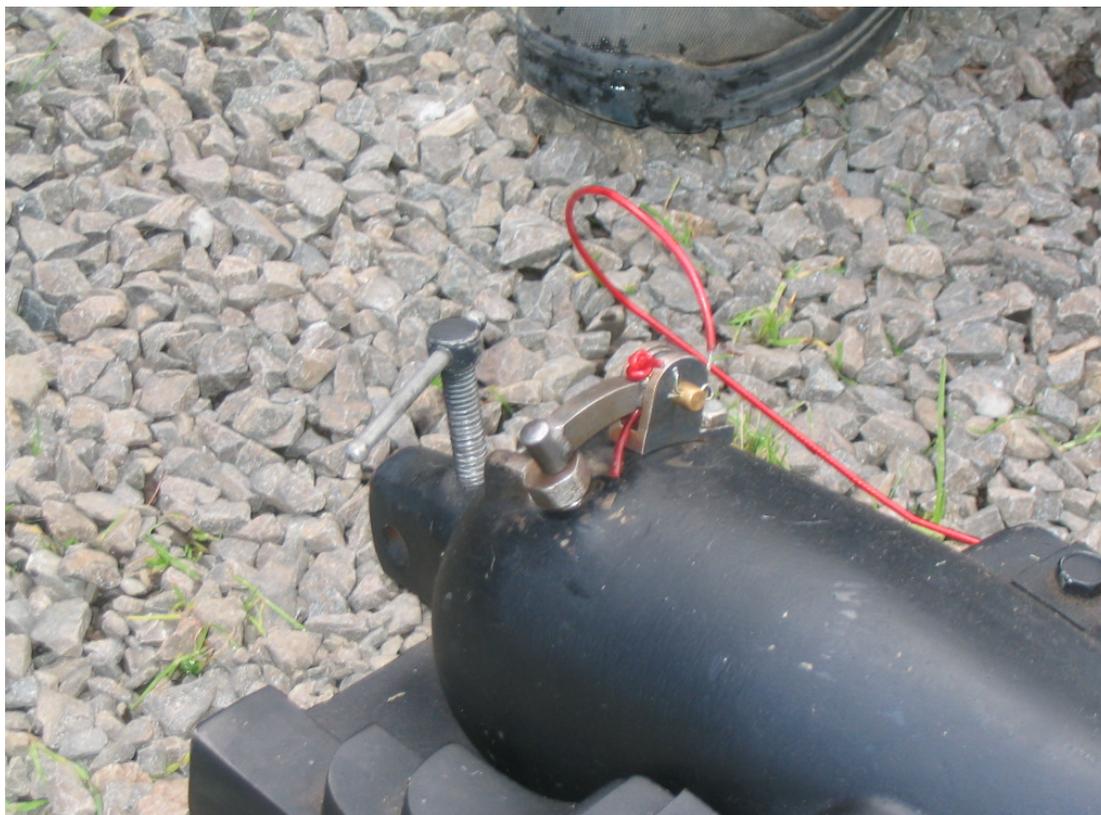


Photo 3. This photo shows a solid steel cannon in use at another of this employer's youth camps. This cannon is equipped with a 'slap hammer' for firing. Problems encountered with other firing methods, i.e., touchstick, fuse, loose powder, etc. are eliminated. The person firing the cannon typically stands 4-5 feet from the cannon and pulls a lanyard to set off a small cap-like primer charge in the cannon's touchhole.

Photo 4. Section of failed cannon breech behind trunnions.



For More Information

The Center for Research on Occupational and Environmental Toxicology at Oregon Health & Science University performs Fatality Assessment and Control Evaluation (FACE) investigations through a cooperative agreement with the National Institute for Occupational Safety and Health (NIOSH), Division of Safety Research (DSR). The goal of these evaluations is to prevent fatal work injuries in the future by studying the working environment, the worker, the task the worker was performing, the tools the worker was using, the energy exchange resulting in fatal injury, and the role of management in controlling how

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