MAKING POWDER AND PRIMERS: SAFETY WHEN WORKING WITH PROPELLANTS AND PRIMING MIXTURES

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INTRODUCTION

The primers and propellants used in small arms ammunition are useful because they have the capacity to rapidly generate large amounts of intensely hot gas when ignited. Therefore, the very property that makes them useful also renders them dangerous. This means that a person working with these materials must take precautions to avoid serious injury or death, always remembering one overriding truth: anyone who spends enough time near these materials will eventually see them ignite unexpectedly. When this happens, the worker's life and health will depend entirely upon the safety measures he or she has put in place prior to starting operations.

This article attempts to identify some of the safety measures needed to prevent personal injury and damage to property. However, no fixed prescription can be stated which will cover all possible situations. Every person working with such materials must exercise prudent forethought before handling them. It is up to you to secure your own safety when making or using energetic materials.

THE CAUSES OF ACCIDENTS: AN INCOMPLETE LIST

As used in his context, the term "accident" means an unintended event which causes personal injury to people, damage to property, or both.
Unexpected and unintended ignition is the primary cause of accidents when working with propellants and primers. While this appears to account for most documented events, a host of other factors can cause accidents. It would be presumptuous of me to claim that **I** know the origin of all mishaps, but extensive reading over a period of many years has made me aware of some of the risk factors. The following causes are known and well documented:

Accidents Are Caused By Tendencies Inherent In The Materials Themselves

Some propellants and primers are inherently unstable, and will ignite or explode without provocation. Certain mixtures have a tendency to self ignite, degrade, or cause other problems with little or no outside influence applied to them.

Many of them become more sensitive with the passage of time. A good example is a priming mixture which combines a chlorate with sulfur. Mixtures of this type must be impact sensitive in order to work in primers, but they can also ignite spontaneously if improperly compounded. Spontaneous ignition becomes more likely as they age, unless an antacid is added to them to prevent the "souring" which occurs when the sulfur forms sulfuric acid. This souring reaction is probably caused by the sulfur combining with oxygen and water (humidity), though some authorities regard this as unproven. Whatever may be the precise mechanism of the danger posed by chlorate and sulfur mixtures, this combination has been the cause of many injuries, and more than a few deaths.

Accidents Are Caused By Unpredictable Reaction Speeds

Aside from the issue of spontaneous ignition, there is the problem of sensitive mixtures and compounds which produce varying and unpredictable responses when ignited. Certain pyrotechnic mixtures may burn in a flash in some instances, but detonate at other times, though the mass of material present be the same in both cases. This is a special danger inherent in "flash powders", which are usually a mixture of superfine powdered metal mixed with a powerful oxidizer.

This type of mishap is often referred to as "self-containment", meaning that these mixtures "burn so quickly that they cannot get out of their own way". Whether or not such a substance will self contain upon ignition appears to be dependent not only on the amount present, but the extent to which it is confined, the ambient temperature, local humidity, and the temperature of the surfaces it contacts.

Similarly, a large number of accidents are attributed to propellants whose burning rate is controlled by molding them into "grains" of specified size and geometry. If these grains are subjected to rough handling or prove insufficiently durable when carried about in cartridges, the additional surface area exposed by fracture of the grains can cause them to generate pressures far in excess of those which are safe when discharged in a gun, rupturing the weapon and injuring the shooter.

The foregoing examples represent cases in which the ignition of a material (flash powder, or grained propellant) may be intended, but the vigor of the ensuing reaction is unexpected and destructive.

Accidents Are Caused By Substances Which Can Release Uncommon Forms Of Energy

Still other mixtures have been found to release energy in what can only be described as an unexpected way. Conspicuous among these are pyrotechnic blends containing silicates, which in certain combinations will generate an intense blast of ultraviolet radiation when ignited. One eminent author in the field of pyrotechnics has written an article about his experience working with a silicate based mixture.

He took all the usual precautions to protect himself against blast, shrapnel, and burns generated by ordinary heat. When his experimental mixture ignited unexpectedly, he was not harmed by any of these usual risks, but suffered an exquisitely painful sunburn across his face, which was protected only by goggles. Had his goggles not been provided with ultraviolet resistant lenses, he avows that he would most certainly have been left blind.

Accidents Are Caused By Adulterants Or Unintended Application Of External Forces

Foreign substances can creep unnoticed into primer material or propellant, which changes their behavior by effectively modifying their composition. The primer or propellant can become sensitized and prone to spontaneous ignition through the presence of such adulterants. A well know example of this is the accidental introduction of small pieces of ferrous metal or hard rock into the raw ingredients which are to be milled into black powder. If these small items go unnoticed and the powder is milled in the usual commercial manner, by crushing under massive wheels, the chance of an unexpected ignition is very high. Similarly, the accidental introduction of even small quantities of chlorates into black powder will render it prone to spontaneous ignition.

Closely related to these dangers is the unintended application of external forces to these substances. Such forces can take the form of heat, static electricity, impact or friction. This list is not intended to be exhaustive, but only covers the most commonly documented energy sources leading to accidents. Any and all priming materials and propellants must be assumed to be responsive, to some degree, to all of the listed forces.

In many cases, accident are caused by what may be termed the imprudent application of forces and energy to the less dangerous classes of propellants and primers. A prime example would be mixing black powder in a ball mill using sparking grinding media, such as steel balls, rather than non-sparking balls made of brass or lead. Similarly, some have neglected to use sufficient grounding to keep their mills free of static electricity, or have failed to ground themselves when making contact with an otherwise properly grounded mill, thereby generating sparks which set the powder off.

A FEW PRUDENT SAFETY MEASURES

If the foregoing list presents frequent causes of accidents, what may be done to reduce the risk of personal injury and property damage when using propellant and primer materials? Bear in mind that one can only reduce risk, but not eliminate it. Nothing can be done to eliminate all hazards. Whenever you manipulate these materials, you are to some degree endangered. The distinction to be made is not between dangerous and safe, but between dangerous and less dangerous. The following precautions must be in place at all times, and for all materials.

Know The Materials That Must Be Avoided Altogether

Please be aware that some materials simply should not be approached at all, if you tender your life. Among these, I place all fulminates, nitroglycerine, trinitrotoluene, flash powders, and any except the most miniscule quantities of chlorate and sulfur mixtures. These substances are used commercially, but they are manipulated remotely through various types of mechanized tooling and processors, and they go off frequently, with destructive results for the machinery in which they are processed.

Know The Materials You Use. Avoid Unknown And Insufficiently Documented Materials

Even in the case of well known mixtures and materials, testing their sensitivity is highly recommended as a way to determine what types of handling they can withstand. With experimental batches of newly designed propellants and primers, such testing is absolutely mandatory. Influences which have been found to set them off can thereafter be avoided, and they may be put to their appropriate uses while eliminating actions which provoke them.

Substances may be tested for sensitivity to impact by dropping a weight upon a test sample from increasingly greater heights. Sensitivity to friction can be determined by rubbing a sample between two hard, coarse surfaces, in a deliberate attempt to induce ignition. Placing a sample upon a metal plate and very slowly raising the temperature of the plate is one way to test how sensitive it is to changes in temperature, and to determine its ignition point. A sample should also be subjected to electrical discharges, to determine if current or electrical sparks will ignite it. Needless to say, all of these tests should be conducted with the operator at a safe distance from the material tested.

The suggested tests are useful for learning the characteristics of a material in its present state, but it is much more challenging to determine how stable a newly devised material will remain over extended periods of time. Certain propellants and primers can become exquisitely sensitive over period of years and even decades. Others slowly react with materials in their environment to produce dangerous conditions. These undesirable tendencies have often been revealed when disasters were caused by materials once thought to be perfectly safe.

Several famous examples of degradation over time come to mind, such as the "season cracking" of brass cartridge cases caused by the use of mercuric primers, and the tendency of grains of ammonpulver to fracture after exposure to the levels of heat encountered in desert climates. Cases cracked by mercuric primers can open up on firing and damage both the gun and the shooter. Fractured grains of ammonpulver can burn at a much faster rate than intact grains, increasing the chances of excessive pressure in a chamber.

Another good example of a material that becomes unstable over time is dynamite, at least as originally compounded by its inventor, Alfred Nobel. Nobel was fond of showing off the safety of his new explosive, subjecting it to impact and heat to demonstrate that it could only be set off by a cap filled with primary explosive. What nobody knew at the time was that in long term storage, the nitroglycerine contained in dynamite can leach out, leaving its owners with a pool of one of the most unstable explosives known. It took several spectacular accidents for Nobel and his customers to recognize this danger.

Because the passage of time is essential to producing the dangerous decay of these materials, only the passage of time could reveal their most menacing defects. The only test which could reveal their slow transformation would be to store them and transport them, preferably in various environments, for many years. Whether these "age test" methods can be accelerated is an open question.

Never trust any primer or propellant to behave as you think it ought. They are only useful because they are, to a greater or lesser extent, unstable. Were they not dangerous, they would be useless.

Do not believe that because you know the peaceable character of the individual ingredients in a mixture, that they will be controllable when combined. Consider the example of the nineteenth century novelty known as "fulminating powder", a mixture of potassium nitrate, potassium carbonate and sulfur. Examining these ingredients separately, one would not expect that a combination of them could produce more than a rather weak propellant similar to black powder. However, when subjected to prolonged slow heating and fusion, this mixture will first melt, then bubble and turn brown, and finally detonate so fiercely that it will deform or puncture the steel plate on which it is heated.

> **You Must Not Only Learn The Properties Of The Finished Materials You Use, But Also Understand The Risks Incident To Making Them. The Risks Of Compounding A Primer Or Propellant Are Not The Same As The Risks Of Using Them; The Risks Of Manufacturing Are Often Greater Than The Risks Of Use.**

Maximum prudence dictates that you work only with substances of known, stable composition, with well researched and thoroughly documented characteristics. Before handling them, you must be completely familiar with said research and the relevant documents. Many of these may properly be referred to as "traditional" primers and propellants, a category which includes black powder and some commercially available primer compounds.

The category of "traditional" materials may also include materials you have fabricated yourself, if following well known formulas and processes, but it must be expressly understood that the fabrication processes involved in making these things have a set of risks distinct and separate from the risks attached to them once manufacturing is complete. For example: accidents with finished black powder are few, but history shows that powder mills have exploded with alarming frequency, leading companies such as DuPont to design mills with detachable roofing and collapsible walls to dissipate the force of unexpected explosions. The risks of manufacturing a primer or propellant are distinct from, and usually greater than, the risks of using such items in the ordinary quantities in which they are sold to consumers.

Work Only With Small Amounts Of Material

What is small is relative to the power and the proclivities of the substances you choose to handle. For example, most pyrotechnic texts recommend that one have no more than one pound of black power in close proximity at any given time, and that all work be done completely away from powder storage facilities and magazines.

On the other hand, a fraction of a gram is too much if you even suspect that a material may be susceptible to detonation. How much of any given primer or propellant you choose to handle is a matter of good judgment, and your life and health depend upon nothing so much as the exercise of good judgment and situational awareness.

Protect Yourself From The Risk Of Burns

Propellants, such as black powder, black powder substitutes, and smokeless powders, are formulated to produce self-sustained burning, and instantly generate large volumes of intensely hot gas. If they cannot produce such a reaction, they cannot do the work of driving a projectile. Indeed, guns are characterized as a type of "heat engine", machines which do their work by harnessing high pressure combustion, and are thereby related to rockets, automobile engines and jet propulsion systems.

Finely divided black powder burns with a sudden flash. Its ignition is often referred to by the term deflagration, a reaction far faster than ordinary burning but slower than detonation. Some propellants straddle the line between deflagration and detonation, e.g., flash powders compounded out of finely divided metal fuel and a powerful oxidizing agent. These compositions are rightly feared for their propensity for "self containment"; when ignited in sufficiently large quantities they generate hot gas at such an astonishing rate that their deflagration can become a detonation. Their exceedingly fast reaction rates makes them unsuitable for use as propellants in guns.

When ignited in confinement, propellants can burst through the container constraining them, and envelope surrounding objects in a fireball. Black powder produces a cloud of incandescent gas at a temperature in excess of 1400° C, more than sufficient to inflict massive third degree burns on the heedless handler, and ignite anything combustible in proximity to it. Distressingly, the clothes of a person burned by a large quantity of black powder are frequently set aflame. However, if made of synthetic material, the victim's garments are often melted to his body, retaining heat on the surface of the skin and rendering the burn injuries more severe than they otherwise might have been. At the very least, any and all primers and propellants can inflict severe burns. Burns are probably the most commonly encountered form of injury among those who manipulate these materials.

A minimal regard for your own well being demands that you at least wear an OSHA approved, full-face mask, a pair of UV blocking OSHA approved safety glasses, a high quality leather welder's apron, heavy duty welder's gloves, fireproof leggings, and commercial grade welder's sleeves whenever you approach these materials. Beneath all of this personal protective equipment you should wear several layers of all-cotton clothing. Your head, including your ears, should be covered with a heavy cotton bandanna. Scrupulously avoid all synthetic clothing, which can melt onto your skin.

Have copious amounts of water available, to douse yourself if things go awry. An even better measure would be to construct an overhead tank in your workplace, with a pull chain that will allow you to douse yourself with its contents all at once. Work in close proximity to this appliance. Do not neglect to test its function from time to time. Assure yourself that it works.

In addition to your personal protective equipment, that is, the protective clothing and shields that you wear, you should also insure that you have physical barriers in place to separate you from the substances with which you work. These might best be described as portable walls and enclosures.

Although materials such as plywood can protect you from a fireball, it is preferable that the barriers you use be made from materials impervious to flame. Sheet metal and cement board are useful fireproof barriers, reasonably light in weight, and generally affordable. They can be attached to lightweight tubular metal stands to give them rigidity and portability.

It is also important to position your safety barriers in such a way that any unintended ignition is directed away from you. Since I advocate that your operations be conducted outdoors, the safest direction to channel a propellant fireball is up. Hot gases will have a natural tendency to rise in any event, and you can use this physical fact as a safety feature. In most situations, the worst direction to channel an ignition is horizontally, where it can contact other persons or flammable materials in your environment.

It goes without saying that any operations carried out on energetic materials are probably best conducted outdoors, unless you have the luxury of a specially constructed facility for your operations. This consideration leads to the next point, that you must be totally alert to your surroundings when working with primers and propellants.

Be Completely Aware Of Your Surroundings When Working With Primers And Propellants, And Avoid Any Situation In Which Physical Objects Can Channel A Blast Back At You.

The worst possible scenario would be the case of ignition of a large mass of propellant, with no safety barrier between the powder and the worker, the worker lacking any protective clothing, the accident occurring in a closely confined space filled with large amounts of other combustible substances.

To focus on the latter part of this statement, for purposes of safe practices with primers and propellants a "closely confined space" may not always be apparent to the inexperienced observer. If you work with a propellant like black powder on an open table which is pushed up against a wall, the wall may very well well push an accidental fireball back in your direction. Do not work in a location where your physical surroundings are so composed that they can channel a cloud of incandescent gas or the force of an explosion in your direction.

The case of Bushnell Smith, a famous gunsmith of the early twentieth century, presents the most egregious example of lethal channeling of the byproducts of an explosion. Smith worked in a room which had a window looking out into a rural field, where he had targets set up. He would try out weapons he had repaired and modified by firing them at the targets through his shop window, checking his scores with a spotting scope. At the back of his workshop was a room, more in the nature of a closet, in which he stored large quantities of reloading powders. This storeroom communicated with the shop by means of a narrow doorway.

One day, when preparing to a fire a rifle out the window at his targets, Smith accidentally discharged the weapon into the powder storage room. A subsequent investigation by law enforcement determined that all the powder ignited at once, producing a blowtorch flame which emerged instantly through the doorway and incinerated Smith.

Take heed of the path a fireball will take in the event you have an accident.

An Uncommon But Necessary Safety Measure: Test To Destruction

The prudent handler of primers and propellants must frequently stop in the midst of his operations and ask the following question: What would the consequences be for me if this material were to ignite now, without any warning? If he concludes that he would suffer injury, he has failed to implement proper safety measures. He should cease all operations immediately, and not resume them until reliable protective measures can be implemented.
What will happen to you if you have an unexpected ignition? There is only one way to know the answer to this question with reasonable certainty, and that is to test samples of your materials and equipment to destruction.

Assume that it is your practice to produce black powder one pound at a time, in a ball mill filled with non-sparking brass grinding media , using a heavy plastic container turned by rubber rollers. Whenever you load your mill, or approach it to check on the progress of the powder, you are properly clad in all the personal protective equipment previously described, and the mill is located outdoors and surrounded by what you believe to be adequate barriers.

The best information you can acquire concerning your safety in the event of an accidental ignition while you are in close proximity to the apparatus, can be gathered by dressing a mannequin in the protective clothing you customarily use, placing the dummy close to the mill at the distance you usually occupy, and setting off a pound of black powder in the mill jar by means of a remote ignition switch. This experiment must be conducted in a remote area, far from any buildings and far from flammable material. The center of a large field, freshly plowed, would be ideal for such a study, as would an area of remote desert.

If you place stadia rods in the background directly behind the mill, you can take a video of the explosion and use the rods to visualize how large a fireball is generated. The condition of the mannequin should provide you with some concrete idea of what injuries you will suffer in the event of an accident. Track the location of the mill jar and any displaced parts of the mill assembly. How far has the debris traveled? Do the results lead you to believe that you have taken adequate measures to protect yourself from an accidental ignition?

Experiments of this type are indispensable, because one thing is certain: If you work with primers and propellants long enough, you will eventually experience an accidental ignition. How you fare will depend entirely upon the protections you have put in place before the event occurs.

Conclusion

The foregoing is the briefest summary of the measures you must take to protect yourself from injury. It is not a complete list of all risks faced by those who work with primers and propellants, because the number of possible mechanisms of accident is likely infinite. Therefore, I urge all those who perform the type of work described on this website to study the subject of safety ceaselessly, and learn as much as possible about the properties of primers and propellants with a view to avoiding mishaps. In particular, thoroughly research each and every material with which you work, to learn of any risks peculiar to it. Test the processes which you intend to apply to that material; test them to destruction. These measures will reduce the peril in which you place yourself when you experiment with these materials.