

Explosions and Detonations

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The proper use of technical and scientific terms is fundamentally important for clear and effective communication. It is also a mark of a professional to use the vocabulary correctly. Toward that end, the following brief article is offered. There are a series of notes [a–e] included for additional and qualifying information at the end of the text. However, it is suggested that the article be read first in its entirety before diverting to read the notes.

Too often the word detonation is incorrectly used in place of the more general term explosion. While it is true that all detonations are explosions, most definitely not all explosions qualify as detonations. Thus care should be exercised before declaring an explosion to be a detonation. The definition of a detonation adopted by the US Bureau of Alcohol, Tobacco and Firearms (BATF) is taken from the Institute of Makers of Explosives (IME).^[1] Specifically, a detonation is defined as:

“An explosive reaction, also called a detonation wave, that moves through the material at a velocity greater than the speed of sound in the material.”^[2] [a]

Note that it is the capacity for detonation which the BATF and others use to characterize high explosives. Specifically, high explosives are defined as:

“Explosive materials which can be caused to detonate by means of a blasting cap when unconfined, (for example, dynamite, flash powders, and bulk salutes).”^[3] [b]

By contrast, note that the IME defines deflagration as:

“An explosive reaction such as a rapid combustion that moves through an explosive material at a velocity less than the speed of sound in the material.”^[2]

Further that the BATF defines low explosives as:

“Explosive materials which can be caused to deflagrate when confined, (for example, black powder, safety fuses, ..., and ‘special fireworks’”^[3] [c]

Thus, in discussing explosives and pyrotechnic materials, unless one has specific knowledge of the speed of sound in the unreacted material, and the speed of the reaction under specific conditions, the term detonation should not be used. Rather, the more general term, explosion is the correct choice [d,e].

Notes:

- [a] There may be a number of reasons why this definition for detonation is a better rule-of-thumb than it is the best technical definition. However, it works well for the vast majority of explosives and is the one invoked by regulation. A more complete discussion of this subject might be interesting to a few but is well beyond the scope of this short article.
- [b] There are at least 108 published formulas for flash powder, many of which differ radically from the rest. It must be noted that there are almost no published results of measurements of the speed of sound in various flash powders and very little data on the speed of their explosive reactions. Thus, it is not clear that there is sufficient data to suggest that ALL flash powders and ALL bulk salutes meet the definition of high explosives. Nonetheless, it is important to recognize that since 1990 the BATF has made this declaration regarding flash powders and bulk salutes.
- [c] It must be noted that there is at least a potential difficulty with the definitions for high and low explosives. Specifically, explosives can exist which are not covered in either definition. For example, consider an explosive which only deflagrates when left

unconfined. Such an explosive falls below the definition for a high explosive. Suppose, however, that it is capable of detonation when confined. Thus the explosive exceeds the definition for a low explosive. This undefined class of explosives might be of no consequence if it were not possible (likely) that at least some explosive materials fall into that category. This is of concern because confinement acts to greatly accelerate the reaction rate of pyrotechnic explosives; thus making it possible (probable) that some will only transition to detonation when confined. If this is the case, then it is reasonable to ask, why has it been overlooked? One likely reason is because the explosives considered by the IME (e.g., those used in large quantity for commercial blasting) tend to fall clearly into the high explosive category and essentially all the rest clearly fall into the low explosive category. It is primarily in the fireworks and match trades where likely candidates for the undefined category would come. Unfortunately, there is no representation of these very small industries in the IME. It is also reasonable to ask whether there are explosives which are known to fall into the “only detonates when confined category?” None come immediately to mind, but recognize that essentially none of the pyrotechnic compositions used by the fireworks trade have ever been tested to find out. In fact, interest in this area has only begun to develop since the BATF moved flash powder and bulk salutes from the low to high explosive category.

- [d] There is one exception that should be made to this rule; that is for the very strong explosion of an aerial shell inside a mortar. It is quite possible (probable) that many of these are not actual detonations. However, use of the descriptive term “shell detonation” is so firmly entrenched, and there would be much confusion if a new term were introduced, that it should not be changed. However, most definitely, the word “detonate” should not be used to mean ignite or fire, as in “going out to detonate some aerial shells for a fireworks display”. It is surprising how often this is

heard, and it is not even close to being correct usage.

- [e] It is believed by some, that, if upon initiation an unconfined explosive material reacts to produce an explosive “bang”, then a detonation must certainly have occurred. It is true that unconfined detonating (high) explosives always produce such a bang. However, the converse, that unconfined deflagrating explosives do not produce such an explosive bang, is not universally true. For example, it is well known that Black Powder, which is a low explosive, when present in sufficient quantity, can produce an explosive bang. This is because all that is necessary is that the rate of the explosive reaction exceed the speed of sound in air (≈ 330 m/s). When ever this occurs, a shock wave will be produced in the air surrounding the explosive, and this is heard (felt) as an explosive bang. If the explosive is a solid mass, the speed of sound in the unreacted explosive will exceed the speed of sound in air. Thus for such an explosive, if its reaction rate was between the speed of sound in air and the speed of sound in the explosive, it would produce a bang when unconfined but the reaction would be a deflagration and not a detonation. This is what can happen with Black Powder when present in sufficient quantity.

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References

- 1) *Explosives Newsletter*, Bureau of Alcohol, Tobacco and Firearms, vol. V (1991).
- 2) “Glossary of Commercial Explosives Industry Terms”, *Safety Library Publication*, No. 12, Institute of Makers of Explosives (1991).
- 3) *ATF—Explosives Law and Regulations*, Bureau of Alcohol, Tobacco and Firearms, ATF P 5400.7 (6/90).