A152 Coming Apart at the Seams: The Anatomy of a Pipe Bomb Explosion

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After attending this presentation, attendees will understand the process by which pipe bombs explode, the effects of container type and explosive filler on fragmentation, as well as the mass distribution and velocity of the resultant fragments.

This presentation will impact the forensic community by providing forensic examiners with guidelines for interpreting pipe bomb blast effects as well as an appreciation of the potential lethality of pipe bomb fragments.

Pipe bombs are one of the most common types of improvised explosive devices encountered in the United States. The interpretation of pipe bomb blast effects can often lead to crucial information regarding the type of container as well as explosive filler used. For example, steel pipe bombs containing black powder or black powder substitutes such as Hodgdon Pyrodex® will produce few large fragments and the pipe may split at its seam. The end cap face plates are often blown out and fragments will exhibit square, 90° edges. Heavy grey or black residue will be present on the interior surfaces of the pipe, sometimes with a "rotten egg" smell. Finally, the pipe may be rusted due to the formation of corrosive by-products. In contrast, pipe bombs containing double-base smokeless powder (DBSP) such as Alliant Red Dot® will have no apparent residue and the interior surfaces of the pipe may even be "shiny". There will be extensive fragmentation, including 90° breaks as well as 45° reversing slants on edges. Finally, the pipe fragments may be thinned due to the force of the explosion. These observations, although based on the extensive experience of forensic chemists, have not been fully studied in a quantitative fashion. The lethality of pipe bomb fragments is also not fully appreciated and the velocity and momentum with which container fragments leave the site of an explosion is not well known.

The goals of this project were to compare the effects of container material and explosive fill on pipe fragmentation. A total of seven devices were constructed from 1-inch nominal diameter galvanized steel, black steel and PVC pipe with either Pyrodex® or DBSP filler. All devices were suspended in open air and initiated with electric matches. Container fragments were gathered and examined for morphology, mass distribution and explosive residue. The mass distribution of the container fragments was evaluated using the slope of the Fragment Weight Distribution Map (FWDM).[1] In this approach, steep slopes correspond to the production of many small fragments, whereas shallow slopes correspond to the production of fewer larger fragments. Video footage of the pipe bomb explosions was also captured using a high-speed digital video camera with telephoto lens at astandoff distance of ~60 feet. Videos were shot at 10,000 frames per second (100 μs/frame) with a 1/51,000 second (19.6 μs) shutter speed. Analysis of this footage revealed the locations where the pipe containers first failed as well as provided estimates for the velocity of expelled fragments.

The distribution of fragment masses for all devices was approximately exponential. However, PVC pipes generated larger numbers of smaller fragments. For example, over 75% of the fragments from PVC pipe filled with DBSP had individual masses less than 300 mg, with each representing only a tiny faction (< 0.3%) of the total mass of all recovered material. In addition, the initial slope of the FWDM for devices filled with DBSP showed a clear difference between PVC (m= - 61.5) and either black steel (m= -2.9) or galvanized steel (m= -2.5). The high-speed video footage of the pipe bomb explosions also shows a clear difference between devices consisting of PVC pipe versus steel pipe. Devices made from PVC pipe first ruptured along the pipe nipple itself, regardless of explosive filler. Devices made from steel pipe first ruptured at the end caps. The estimated velocity of the container fragments also varied depending on their origin. For example, the estimated velocity of a fragment originating from a PVC pipe nipple filled with Pyrodex was 465 mph. Similarly, the estimated velocities of fragments originating from a PVC pipe nipple filled with DBSP ranged from 252 mph to 469 mph. In contrast, the estimated velocity of a fragment originating from the end cap of a PVC/Pyrodex device was only 86 mph. Overall, the highest estimated fragment velocities originated from the galvanized steel/DBSP (351 mph – 476 mph) and black steel/DBSP (291 mph – 556 mph) devices.

Reference:

[1] Oxley, J.C., et al., *Improvised Explosive Devices: Pipe Bombs.* Journal of Forensic Sciences, 2001. **46**(3): p. 510-534.

Explosives, Pipe Bomb, Improvised Explosive Device