FY 2012 FIREWORKS SAFETY STANDARDS DEVELOPMENT STATUS REPORT

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EXECUTIVE SUMMARY

The U.S Consumer Product Safety Commission (CPSC, the Commission) is evaluating the need to amend its regulations for fireworks devices. CPSC staff evaluated issues concerning the explosive power of aerial fireworks, as well as a relatively new type of device known as an "adult snapper."

Aerial fireworks devices intended to produce an audible effect are limited to 130 mg (2 grains) of pyrotechnic composition, according to 16 CFR §1500.17(a)(3). Staff conducted testing to evaluate two different ways of potentially eliminating the currently subjective method of determining intent to produce an audible effect. The American Fireworks Standards Laboratory (AFSL) developed a "Black Powder Equivalency Test." CPSC staff investigated and found that this test can distinguish between the energetics of black powder, hybrid powders, and flash powder, but the test does not consider the particular construction of a shell. Staff also investigated directly testing the energy released from an actual shell, as constructed, minus the propelling (lift) charge. Staff found it was possible to measure the total overpressure produced by the explosion of fireworks shells. These pressure waves typically were found to exhibit a rise time of about 10 nanoseconds and an overall duration of about 100 nanoseconds. Typical small shells (1-inch diameter) from devices meeting current regulations were found to produce approximately 15−30 psi total overpressure at a distance of 5.5 inches from the center of the device. Large shells (1.5 to 2 inch diameter) from "display rack" devices meeting current regulations were found to produce total overpressure similar to that of an illegal M-80 device, approximately 100−200 psi at a distance of 5.5 inches from the center of the device. These devices are designed to explode over 100 feet in the air.

A relatively new device on the market is commonly called an "adult snapper" and consists of a paper or plastic tube, similar in size and shape to a common firecracker, with a pressure-sensitive charge similar to 'traditional' snappers, but which produces a substantially louder snap or pop than the traditional loose-wrapped snappers. The CPSC does not have regulations specific to adult snappers, other than general regulations applying to fireworks devices. Staff evaluated the explosive force produced by these devices when they function individually, as well as the potential for mass explosion if a package of 20 devices or a carton of 30, 20-count packages were to fall from a height of up to 8 feet. Staff found that individual adult snapper devices exploded with about 1/8 of the explosive power of a common firecracker, and that no hazard was observed by dropping either a package of 20 devices or a carton of 30, 20-count packages from heights up to 8 feet.

Staff recommends that several options involving the Black Powder Equivalency Test and/or the measurement of the pressure wave from actual shells should be considered for possible changes to 16 CFR §1500.17 (a) (3), which bans fireworks devices intended to produce an audible effect, if the audible effect is produced by a charge of more than 130 mg of pyrotechnic composition. For FY 2013, staff will continue to develop a reasonable and repeatable method. Staff recommends that no further testing of adult snappers be conducted, based on the limited evaluation of their risk, which appears to be less than that for common firecrackers.

INTRODUCTION

The CPSC is evaluating the need to amend the regulations for fireworks devices at 16 CFR §§1500.17 and 1507. An advance notice of proposed rulemaking (ANPR) was initiated under the Federal Hazardous Substances Act (FHSA) on June 26, 2006. The ANPR identified the following possible alternatives to increase compliance with fireworks regulations and reduce the number of injuries associated with fireworks devices: (1) issue a rule requiring mandatory certification to the fireworks regulations under FHSA; (2) issue additional mandatory requirements that fireworks devices must meet; (3) rely on a voluntary standard; or (4) pursue corrective action on a case-by-case basis under section 15 of the CPSA. In 2011, staff prepared a report[1] summarizing the work done and the results of the staff effort since the issuance of the ANPR, including relevant changes to the fireworks regulatory landscape since the ANPR was issued and identifying a path for staff to develop additional information to brief the Commission.

Staff is considering whether CPSC regulations regarding fireworks devices (*e.g.*, 16 CFR §§1500.17 and 1507) may be improved or clarified, especially considering changes that have occurred over time in the design and manufacture of newer devices. This is noteworthy in the case of aerial devices, where "hybrid powders"[2] have replaced conventional black powder to enhance the expelling charge (break charge) and may also produce an audible effect. Rulemaking could be considered to clarify the language in these regulations or to address break charges containing hybrid powder.

Background

Aerial fireworks devices "intended to produce an audible effect" are restricted by CPSC regulations in the amount by weight of the pyrotechnic materials composition. Those not intended to produce an audible effect have no CPSC limitation on the amount of pyrotechnic materials composition. Under 16 CFR §1500.17(a)(3), aerial fireworks devices intended to produce an audible effect are limited to 130 mg (2 grains) of pyrotechnic composition. This regulation was promulgated by the U.S. Food and Drug Administration (FDA) prior to the formation of the CPSC. The FDA indicated in the *Federal Register*: "The intention is not to ban so-called "Class C" common fireworks, but only those designed to produce audible effects caused by a charge of more than 2 grains of pyrotechnic composition. (Propelling and expelling charges consisting of a mixture of sulfur, charcoal, and saltpeter are not considered designed to produce audible effects.) The Commission's primary concern in this matter is to close the loophole through which dangerously explosive fireworks, such as cherry bombs, M-80 salutes, and similar items, reach the general public.[3]"

At the time of the enactment of this regulation, consumer aerial fireworks shells were commonly constructed with black powder, used as the expelling or break charge, and "reports" or "salutes," intended to produce an audible effect, were small, paper-wrapped firecrackers contained within the shell, which would function after the shell burst. At that time, the 130mg

[1] Musto, Christopher, "Fireworks Safety Standards Status report," September 2011.
[2] Hybrid powders contain potassium perchlorate or similar oxidizers but no metal powder, representing a hybrid between black powder, which does not contain perchlorates, and flash powder, which consists of perchlorates and metal powder.
[3] FR Vol. 35, No 93 (May 13, 1970) Fireworks Devices: Classification as Banned Hazardous Substances and Revocation of Exemption.

limit was easily applied to the paper-wrapped reports. Later, the industry moved away from black powder as the break charge, instead using more energetic hybrid powders that spread the effects more rapidly and further, creating a more "impressive" function, but also with greater energetics. These newer hybrid powders, depending on the construction of the shell, packing density, and quantity of powder, in some cases, might produce an audible effect, considered to be the type of "report" in the regulation; while in other cases, the sound produced is considered to be incidental to the necessary function of expelling the effects.

Over the years, CPSC staff has provided extensive training to the fireworks industry to help improve the consistency of the audible determination of whether a particular device produces an audible effect as considered in this regulation. CPSC staff is investigating the possibility of developing a more objective, measurable method to determine what devices pose excessive risk, based on their energetics, rather than apply the regulation limiting pyrotechnic composition to 130 mg to devices based on their being "intended to produce an audible effect." A replacement for the current regulation has been suggested by many in industry, as well as the American Fireworks Standards Laboratory (AFSL). It is important to note that hearing damage is not the injury this regulation is designed to protect against, but rather, the sound of the report (because it is qualitatively similar to that of an illegal M-80 device) has been considered to determine that these are the type of fireworks that were intended to be limited to no more than 2 grains of pyrotechnic material.

CURRENT STATUS

One significant change in fireworks regulations since the issuance of the ANPR is the requirement under Public Law 110-314, Aug. 14, 2008, the Consumer Product Safety Improvement Act of 2008 (CPSIA), Section 102 (a)(1) that manufacturers of consumer fireworks must issue a General Conformity Certification based on a test of each product or upon a reasonable testing program, indicating that such product complies with all the rules, bans, standards, or regulations applicable to the product under any Act enforced by the Commission. This change deals explicitly with the first option considered in the ANPR, specifically, to issue a rule requiring mandatory certification to the fireworks regulations under the FHSA.

Among the other alternatives to the current regulations being considered are the voluntary standards developed by the American Fireworks Safety Laboratory (AFSL). The AFSL intends its standards to incorporate both the CPSC and U.S. Department of Transportation regulations (currently APA 87-1), as well as a number of standards developed by AFSL that are in addition to federal requirements.

Fireworks injuries continue to occur. According to the CPSC's 2011 Fireworks Annual Report (*www.cpsc.gov/LIBRARY/2011fwreport.pdf*), CPSC staff received reports of four fireworks-related deaths during 2011. CPSC staff has reports of three fireworks-related deaths in 2010, and two deaths in 2009. Reporting is not complete for those years, and the actual number of deaths may be higher. Fireworks were involved in an estimated 9,600 injuries treated in U.S. hospital emergency departments during calendar year 2011.

Staff Developments in FY 2012

The next two sections of this report present the results of CPSC staff's testing and evaluation work on the break charge audible reports issue and then an evaluation of a new product to the consumer fireworks industry: the "adult snapper" (also known as a "fuseless firecracker").

Break Charge/Audible Reports

The current test method for determining whether an aerial fireworks device produces an audible "report" that is subject to the limit of 130 mg of pyrotechnic composition is subjective and relies on listening to the functioning device in order to make an assessment. A method to directly test the energy released from ignition of the break charge used in a device was designed by AFSL. CPSC staff found that this "black powder equivalency" test can distinguish between the energetics of black powder and hybrid powders but does not consider the particular construction of a shell. Another alternative that staff investigated was testing the energy released from an actual shell, as constructed, minus the lift charge.[4]

Assessment of the AFSL Black Powder Equivalency Test:

The AFSL developed a new method for testing for a "report" in aerial shells, by comparing the energetics of the pyrotechnic effects to those of black powder. This "Black Powder Equivalency Test" is conducted by removing the break charge powder from an aerial shell. Exactly 1 gram of the dispersing powder is placed inside a plastic vial. The plastic vial is placed inside a steel mortar launch tube on which a 600 g steel ball is placed (Figures 1 and 2). The power is tested by exploding the charge and measuring the maximum launch height of the steel ball.

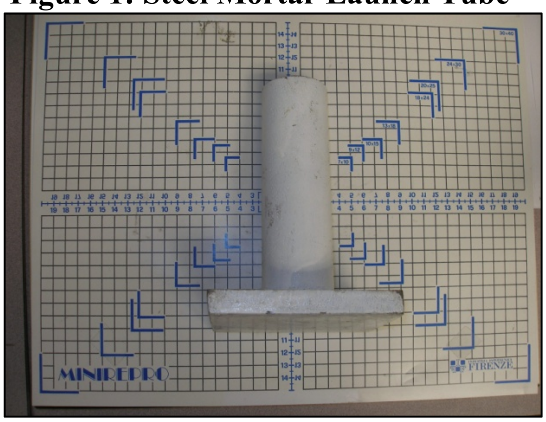

Figure 1: Steel Mortar Launch Tube

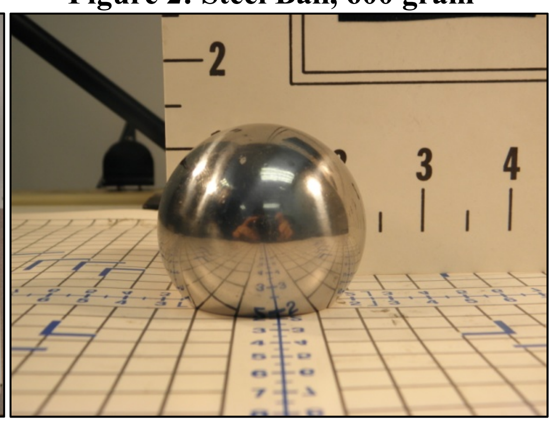

Figure 2: Steel Ball, 600 gram

The maximum height of the ball is measured to evaluate against a pass or fail threshold (currently 2.2 meters, as set by AFSL[5]). During FY 2012, staff tested the AFSL's proposed method to determine if it could be a viable substitute for the current test methods. Photographs of the plastic tubes affixed with an electronic match, as well as the electronic ignition device used in the testing are shown in Figures 3 and 4.

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[4] The lift charge is the pyrotechnic charge that propels the device into the air. By removing this charge, it is possible to test the energetics of the remaining shell while it is at rest.

[5] However, it should be noted that AFSL only performs this test after evaluating by sound that there is a possible audible report. Thus, this criterion does not apply if a qualitative determination that the device contains an audible report based on the sound is not first made.

Figure 3: Plastic Vial w/E-Match

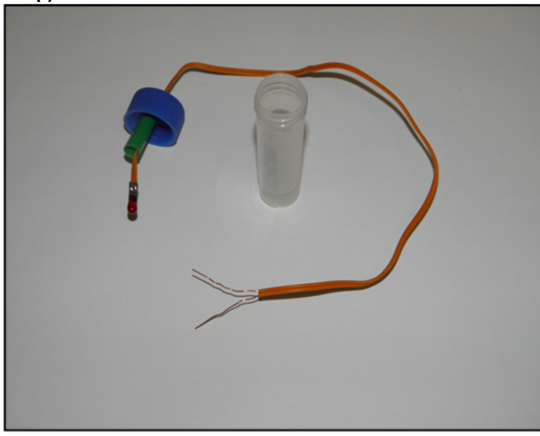


Figure 4: Electronic Ignition

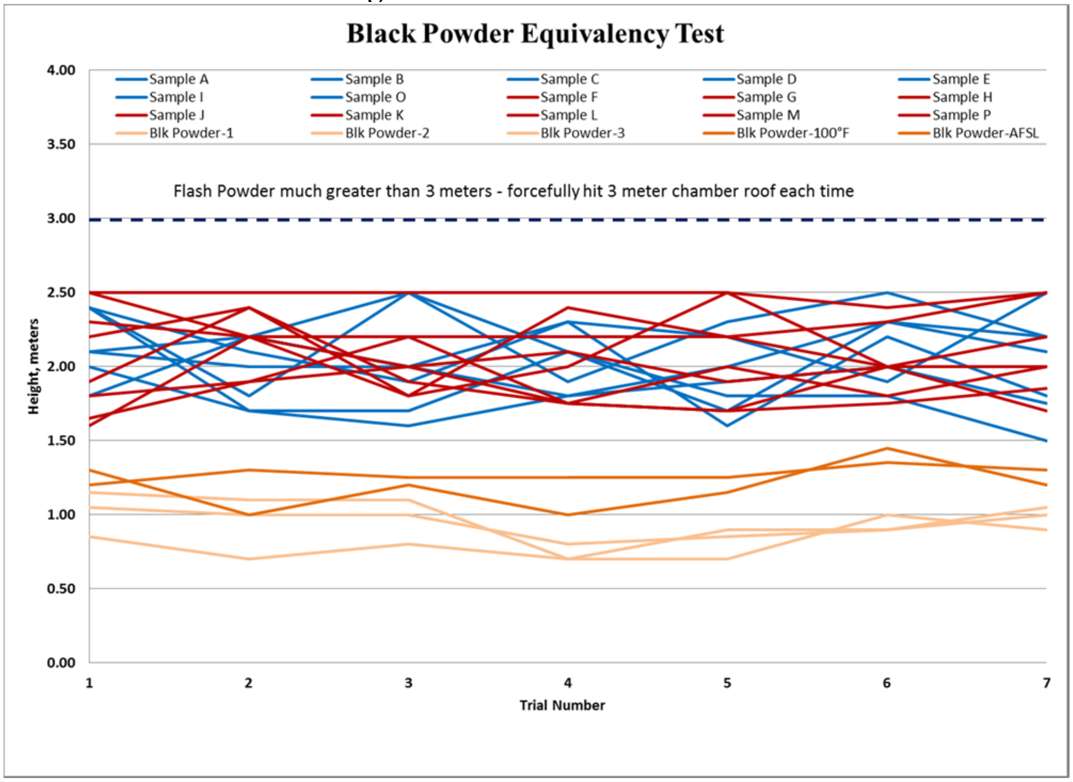
In order to execute the required testing safely, a suitable steel ball containment chamber is necessary. As shown in Figure 5, a steel box measuring 12 feet in height was constructed. The box was equipped with ventilation and a Plexiglas door for access. The figure also shows the launching tube and ball standing in front of a 3-meter measuring device, used to measure the height of the launched ball.

Testing by staff resulted in two conclusions. One conclusion was that the method was incapable of differentiating between test samples deemed to contain only break charge (and thus not subject to the limit of 130 mg of pyrotechnic composition) from samples determined to contain a "report" (subject to the limit of 130 mg of pyrotechnic composition). The other conclusion was that the test was able to discern black powder, hybrid powder, and flash powder, as each was clearly in its own energetic regime.

Figure 5: Metal "Blast Box"

Figure 6 is a graphical representation of data collected via the AFSL's Black Powder Equivalency Test. Red and light blue lines represent hybrid powders, although the red lines represent devices found to produce an audible effect, while the blue lines represent devices found not to produce an audible effect. Amber lines represent black powder, while the dashed navy blue line at the top represents flash powder.

Figure 6: "Ball Test" Results



It is clear in the above figure that three distinct regimes can be identified: (1) black powder typically attains a maximum height below 1.5 meters; (2) flash powder is capable of displacing the steel ball much higher than 3 meters, the maximum height allowed in the current testing chamber; (3) commonly used "hybrid" powders cluster in the range of 1.5–2.5 meters, with the exception of Sample H (the nearly straight red line running along the 2.5 meter mark), which hit the upper plate set at 2.5 meters six of seven times. Out of 105 trials, the steel ball struck the plate a total of 13 times, 4 of which were due to Sample H, and 4 of which were due to samples found not to produce an audible report. Further studies with the plate raised to a minimum of 3 meters are under way.

Staff experience testing fireworks devices for compliance with current regulations indicates that the majority of fireworks devices are currently made with hybrid powders, similar to those seen in the red and blue lines in Figure 6.

Alternative Break Charge Test Method: Total Overpressure from Aerial Shells

CPSC staff designed a new test method based on the overall pressure released from a shell during functioning. Similar work has been done previously in academic studies of eye injury potential.[6] CPSC staff conducted tests as a proof-of-concept to determine if these types of measurements could be used to evaluate the potential risks associated with break charges from consumer fireworks aerial shells from typical devices.

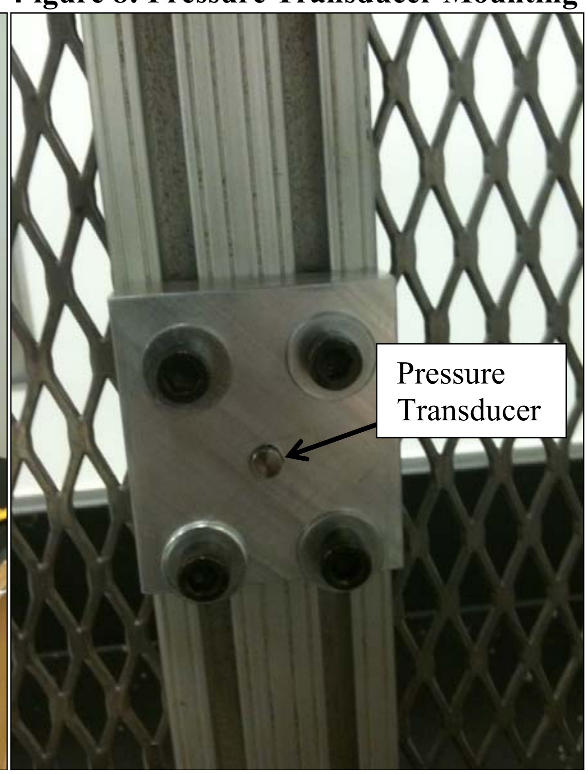
For safe laboratory practices, it was necessary to design and build a chamber to contain the shell debris and device effects and still be able to obtain pressure data with staff a safe distance away. A reinforced containment cage was assembled with two different containment screens built into the walls (Figure 7). Five high-speed dynamic pressure transducers were affixed on the inside of the cage frame using in-house-designed aluminum blocks (Figure 8). The transducers were threaded into the aluminum blocks at equal distances from the center of the box. Four sensors were placed along the horizontal plane of the box, with the fifth sensor directly above the center. The pressure sensors and data acquisition system parameters are summarized below:

Dynamic Pressure Sensor Range:	0–500 psi
Pressure Sensor Distance to Shell:	5.5 inches to center
Data Acquisition Rate:	50,000 acquisitions per second
Pressure Sensor Sensitivity:	10 millivolts per psi (1 volt = 100 psi)

In order to detonate the aerial shells at equal distances to the sensors, an aluminum block was placed at the center of the box to serve as a stabilizer. Electronic igniters were used to trigger the functioning of the shells.

Figure 7: Constructed Blast Cage

Figure 8: Pressure Transducer Mounting



[6] Alphonse, V. A. (2012). *Injury Biomechanics of the Human Eye During Blunt and Blast Loading.* (Master's thesis, Chapter 5). www.cib.vt.edu/people/bios/student_bios/bio_alphonse.html.

Staff has conducted dozens of tests using the blast chamber, and aside from some discoloration, the cage has proven to be durable. Testing has included a range of aerial devices from 1-inch diameter shells to 3-inch diameter display rack shells. The following sections will provide the results and discuss the information obtained.

Below are several examples of the results obtained by measuring the total pressure at a distance of 5.5 inches from the center of the device, in five directions: four along the horizontal plane that includes the device, and one placed directly above the device. The graphs show each of the five sensors; each is represented by a different color. In some cases, an additional peak to the right of the overpressure peaks represents a direct hit to the sensor by either shell or effect debris.

As a proof of concept, staff conducted experiments on a range of aerial shells. Starting with the smallest, a reloadable single-shot device, staff showed that the sensor cage could repeatedly measure the total pressure produced by the detonation of the shell. Figure 9, above, shows a representative result when detonating a single-shot reloadable device. The average pressure produced was 15 psi. Staff found that smaller nonspherical shells explode nonsymmetrically, with lower pressures seen along the axis of the cylinder, versus radially from the center. Staff constructed several cylindrical devices filled with varying amounts of either black powder or flash powder. The devices containing black powder showed a large effect of orientation, with two sensors recording lower pressures. The "spherical" shell with testing results, depicted in Figure 9, also displays some asymmetry, possibly due to its specific construction.

Figure 9: Total Pressure Data—Reloadable Shell

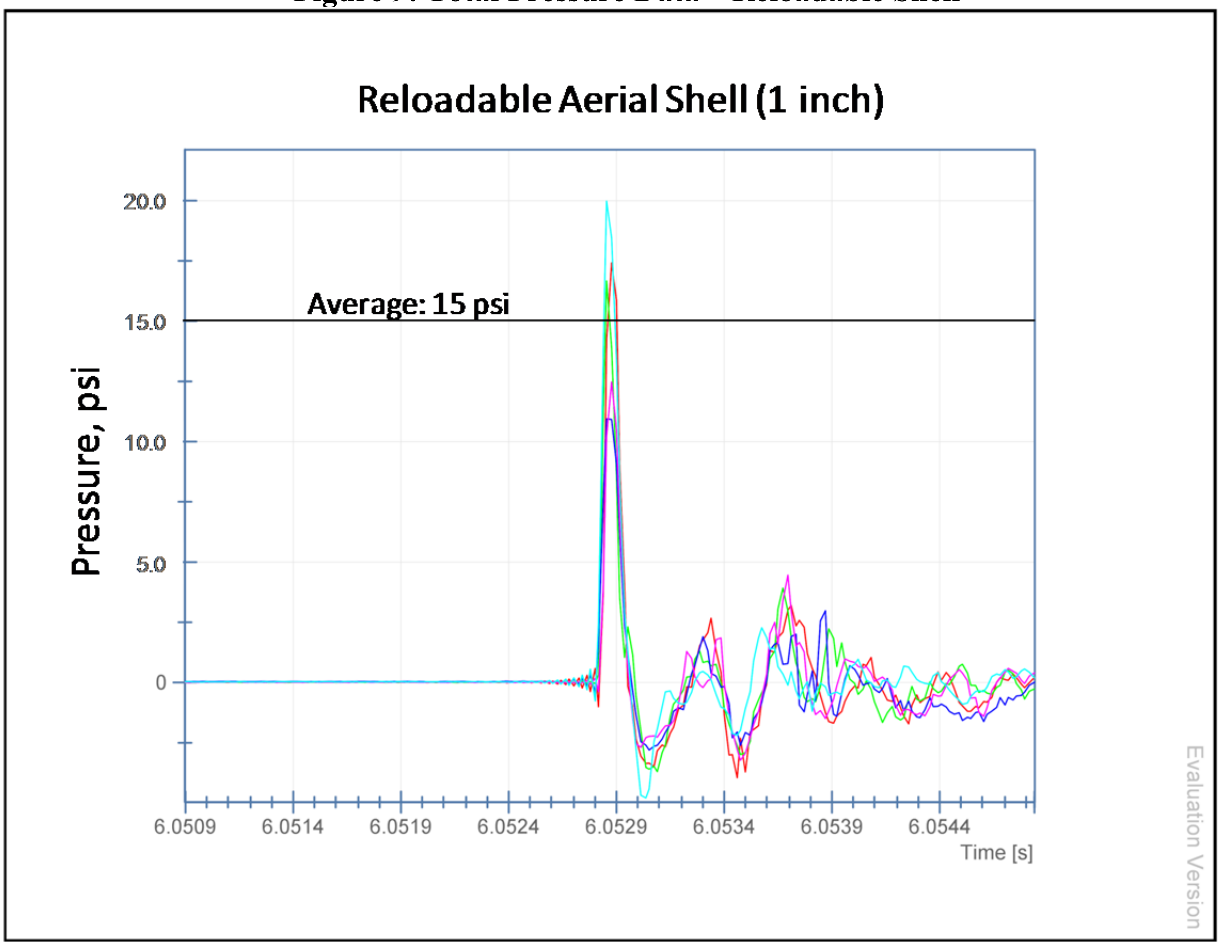
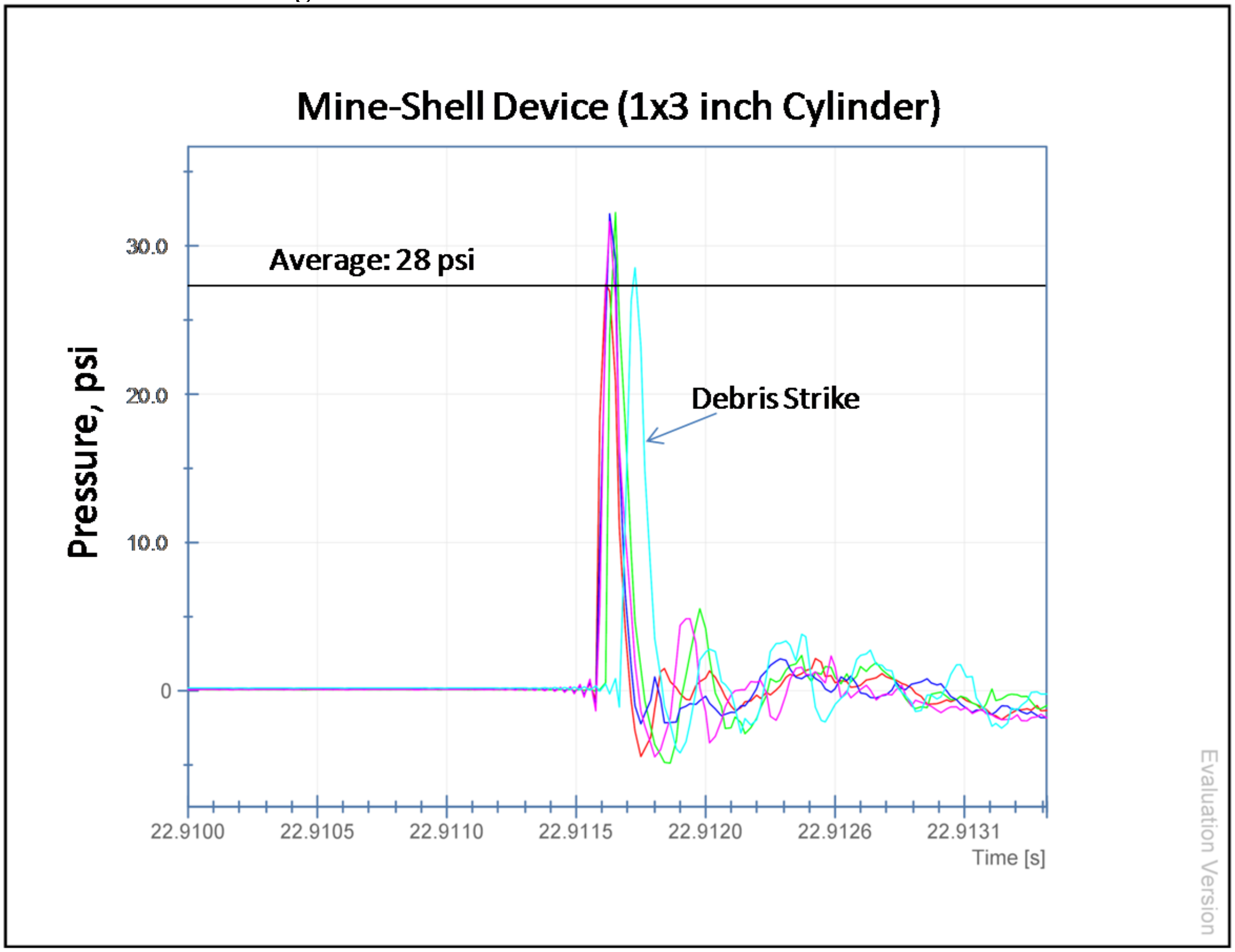


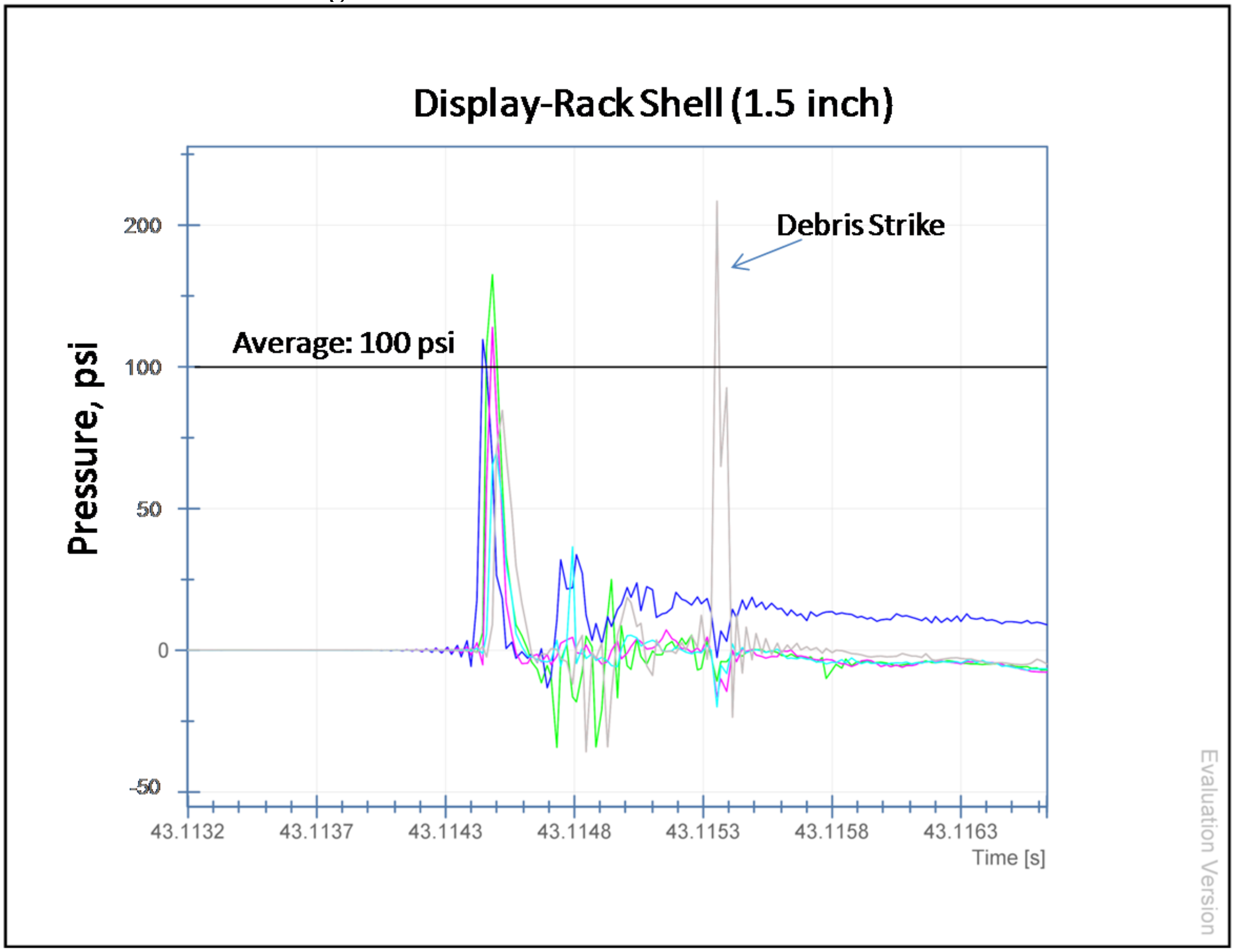
Figure 10 shows a representation of a 1″ x 3″ mine-shell device. Unlike the reloadable device, the pressure produced in the explosion was more spherical in nature, as shown by the five sensors measuring nearly equal pressures. Multiple trials of this sample were conducted and each produced a pressure near 30 psi. This symmetry was also seen with cylindrical devices approximating an M-80 in composition and quantity of powder. It should be noted that Figure 10 also depicts a debris strike (typically from a piece of the shell directly hitting the pressure transducer), which was picked up by the sensors only a fraction of a millisecond after the initial pressure wave was recorded.

Figure 10: Total Pressure Data—Mine-Shell Device



Finally, Figure 11 shows the pressure produced by a 1.5 inch display-rack shell. Display racks are large multiple-tube mine and shell fireworks with any tube measuring 1.5 inches or more in inside diameter. These devices are subject to enhanced tip-over regulations under 16 CFR § 1507.12. It can be seen in Figure 11 that these shells produce higher overall pressure than those in Figures 9 and 10 and, as in the case of the mine-shell devices previously mentioned, show a symmetrical pressure distribution, averaging about(?) 100 psi. The debris strike one millisecond after the initial pressure wave measured even higher than the overpressure.

Figure 11: Total Pressure Data—1.5-Inch Shell

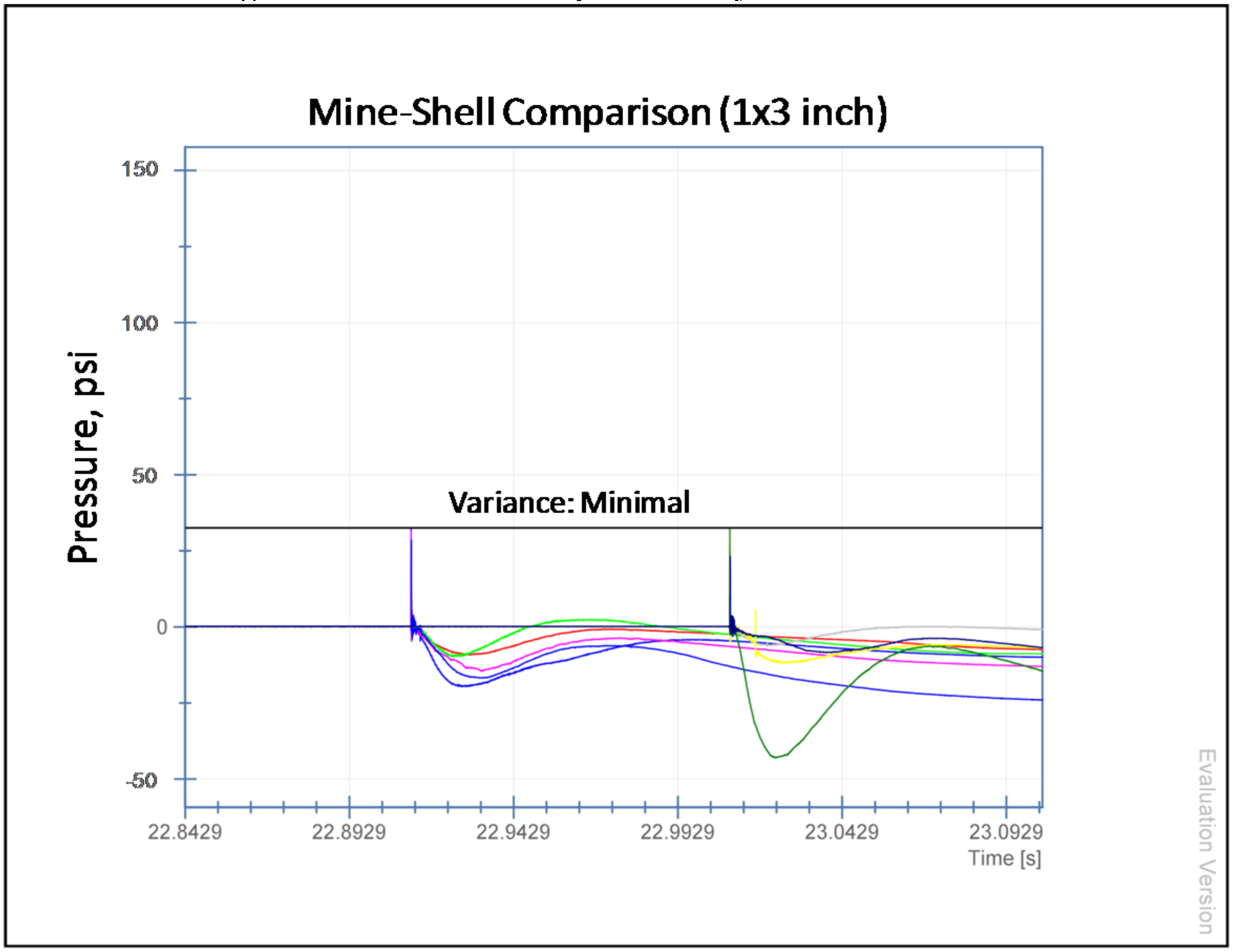


This device was not found to produce an audible report and, as such, was not found to be subject to the limit of 130 mg of pyrotechnic composition. Other display rack shells with up to 2-inch shells (from devices which were not found to produce an audible report) produced pressures from about 100 psi to 200 psi, similar to the pressure produced by an M-80 device at this same distance of 5.5 inches from the center of the device. Unlike M-80 devices (which explode on the ground), aerial devices typically explode between 100 and 300 feet in the air, reducing the risk of the explosion occurring in proximity to consumers. Tip over and other malfunctions can result in aerial devices exploding in proximity to consumers, however the CPSC established a regulation in 1996 for large, "display rack" devices, 16 CFR §1507.12, which requires that these devices shall not tip over when subjected to a 60-degree tip-angle test. This requirement results in devices that are stable and resistant to tip over, which helps to ensure that the devices explode in the air, rather than firing at bystanders after a tip over.

Trial Reproducibility:

In order to test the reproducibility of the new method, staff conducted multiple trials of shells from the same device and compared each set of results. Although typical verification tests consisted of five or more trials, for easy comparison, the following graphs show only a representative two sets of data and are considered illustrative of the method in this proof-of-concept preliminary testing. The test conditions for these tests were the same as those above.

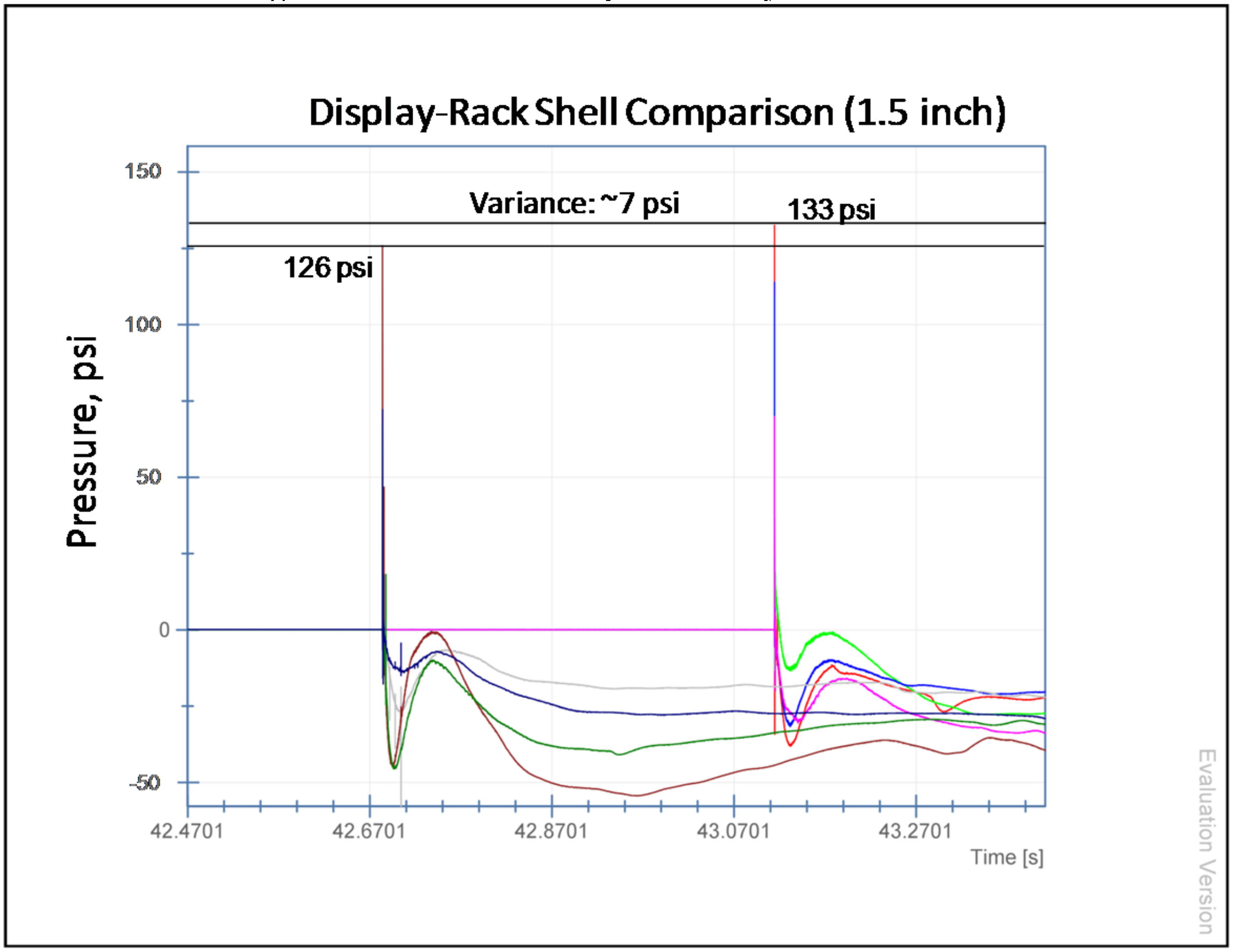
Figure 12: Test Method Reproducibility- Mine-Shell Device



The above graph (Figure 12) shows that the method has good reproducibility. As mentioned above, only two sets of data are compared in this figure; however, multiple trials of each device type have been tested and show comparable results. Here, the two pressure results show a minimal variance for the peak height, both near 30 psi.

As expected, the higher pressure-producing devices exhibited slightly more variance, but as Figure 13 shows, only a 5 percent variance was observed by staff for the peak heights for two tests for aerial shells measuring above 100 psi. Again, only two representative examples are shown.

Figure 13: Test Method Reproducibility- 1.5-Inch Shell



Examination of a new type of fireworks device, "Adult Snappers"

Adult Snappers

Snappers are small, novelty fireworks devices, typically consisting of a loose paper wrap around a charge made of sand or gravel, coated with trace quantities of silver fulminate, such that when thrown to the ground, the device emits a small snap or pop, similar to a cap gun. A relatively new device on the market is commonly called an "adult snapper" and consists of a paper tube, similar in size and shape to a common firecracker, with a pressure-sensitive charge similar to 'traditional' snappers, but which produces a substantially louder snap or pop than the traditional loose-wrapped snappers. The CPSC does not have regulations specific to "adult snappers," other than general regulations applying to fireworks devices.

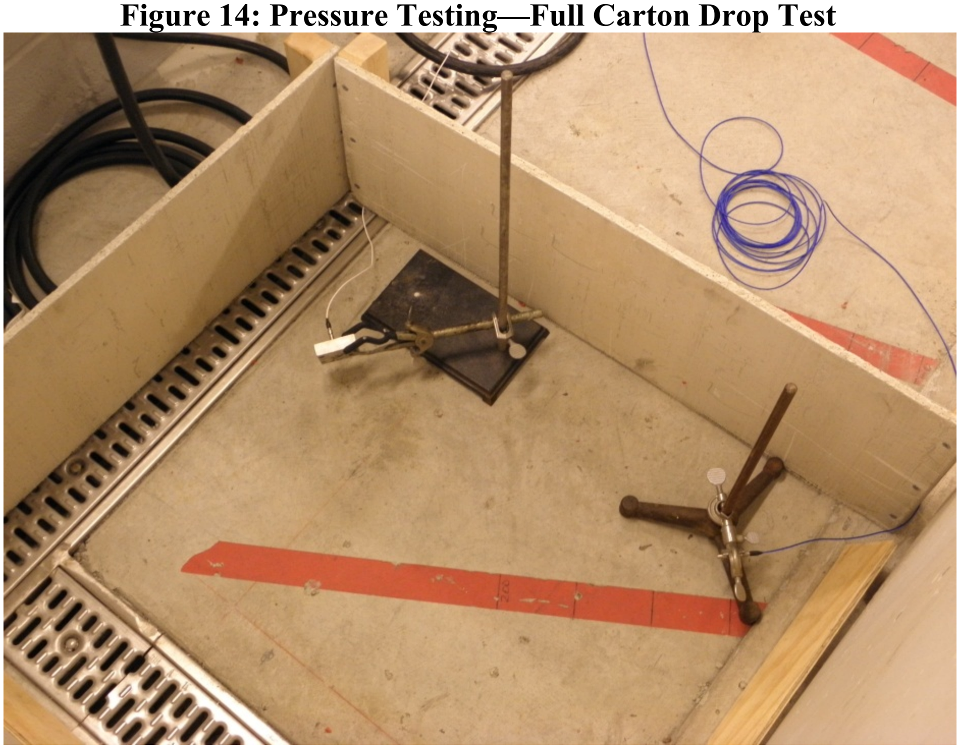
The AFSL has expressed concern that these products could pose additional hazards if one or more boxes of these devices are dropped, particularly when several 20-count boxes are transferred together. Much of that potential hazard would be associated with transport, as opposed to consumer use; but AFSL expressed concern that adult snappers potentially could also pose some consumer hazards.

While transportation issues are regulated by the U.S. Department of Transportation, often these products are sold to consumers by the carton; a carton consists of 30, 20-count boxes.
In FY 2012, in order to evaluate better the risk and injury potential for these devices, staff developed new techniques to measure the energy release of these devices. Staff undertook this investigation to assess the potential consumer risk in handling such cartons. Staff has conducted a series of drop tests of individual snappers, 20-count boxes of snappers, as well as cartons containing 30 of these 20-count boxes.

The first set of tests involved dropping individual, 20-count boxes. The boxes were dropped from a height of 6 feet onto cement board. As a control, 20-count boxes of small, paper-wrapped snaps were dropped. In 12 trials, not one of the paper-wrapped snaps functioned. Next, single 20-count boxes of "adult snappers" were dropped. These boxes were not shrink-wrapped and could open freely. In the first set of trials, a box burst open, and several unexploded snappers were ejected. These eventually either functioned or came to rest a short distance from the drop point. The tests were repeated several times with similar results. In each case, one or more devices would function, causing the box to open and spill sawdust and unspent devices onto the floor. Several boxes did not have a single device function when dropped multiple times. Staff concluded that the pressures emitted from the exploding boxes were barely large enough to expel the contents of the box.

Next, staff repeated the experiments with cartons of 30, 20-count boxes. These cartons were wrapped in a thin film of clear plastic. The cartons were arranged such that three rows of five boxes were contained in the bottom of the carton, and three rows of five boxes were contained in the upper portion of the carton. A cardboard divider separated the upper and lower portions. A pressure-sensing array was set up, as shown in Figure 14. The contents of the carton were inspected prior to drop testing. The pressure of the carton ignition would be measured from two directions and mere inches from the target.

Figure 14: Pressure Testing—Full Carton Drop Test



Three cartons of 600 snappers (30, 20-count boxes) were dropped from heights of 4′, 6′, and 8′. The cartons were dropped in several different orientations to include contact on each of the carton's sides, top, bottom, and corners. In almost every case, the only damage exhibited by the carton was from the impact with the floor. In only a few cases, the smell of a spent snapper could be detected, but no pressure increase was measurable from the sensing array. Upon completing the drop testing, each carton was opened carefully and the contents inspected for damage. The sample boxes that were nearer the corners of the carton showed the most distortion, but when their contents were examined more closely, none of the snappers had functioned. As expected, the plastic wrapping took the brunt of the damage and was torn in several places from impacting the floor; otherwise, no appreciable damage was detected. Staff concludes that without a more serious impact to the carton, simply dropping the carton or a box of adult snappers will not cause a "mass explosion"; but rather, at most, it causes a collection of independent, parallel functioning of individual adult snapper devices.

Adult Snappers: Comparison with Firecrackers

In order to study the potential risks associated with adult snappers, several samples of each were tested for overall pressure release. A single dynamic pressure transducer was placed at a distance of 2 inches from the impact/ignition point of each device. Multiple trials were conducted for firecrackers and adult snappers, and the results can be seen below in two representative pressure profiles (cf. Figures 15 & 16). In the first graph, the snapper exhibited a pressure of approximately 0.88 psi. Five successive trials produced the same approximate value, averaging 0.85 psi. Below, in the second graph, a representative response to a typical firecracker can be seen. With a pressure of approximately 6.5 psi, the typical firecracker produces nearly eight times the pressure wave of the tested adult snappers at the same distance. Comparing the value obtained with the adult snappers to the pressures measured from a typical firecracker, adult snappers appear to present a less severe hazard than common firecrackers, due to the lower power of their explosions.

Debris from fireworks is known to play a factor in fireworks injuries, as shown in the CPSC Fireworks Annual Reports (*www.cpsc.gov/LIBRARY/2011fwreport.pdf*), and by Alphonse, et al.[7]; but staff made no attempt to assess the comparative risk of firecrackers and adult snappers from a debris perspective. Adult snappers are intended to function on the ground, and debris fields were not observed to extend over large distances from these devices.

[7] Vanessa D. Alphonse, BS; Andrew R. Kemper, PhD; Brock T. Strom, BS; Stephanie M. Beeman, MS; Stefan M. Duma, PhD. Journal of the American Medical Association. 2012; 308(1):33–34. doi:10.1001/jama.2012.6964.

Figure 15: Single Sensor Pressure- Adult Snapper

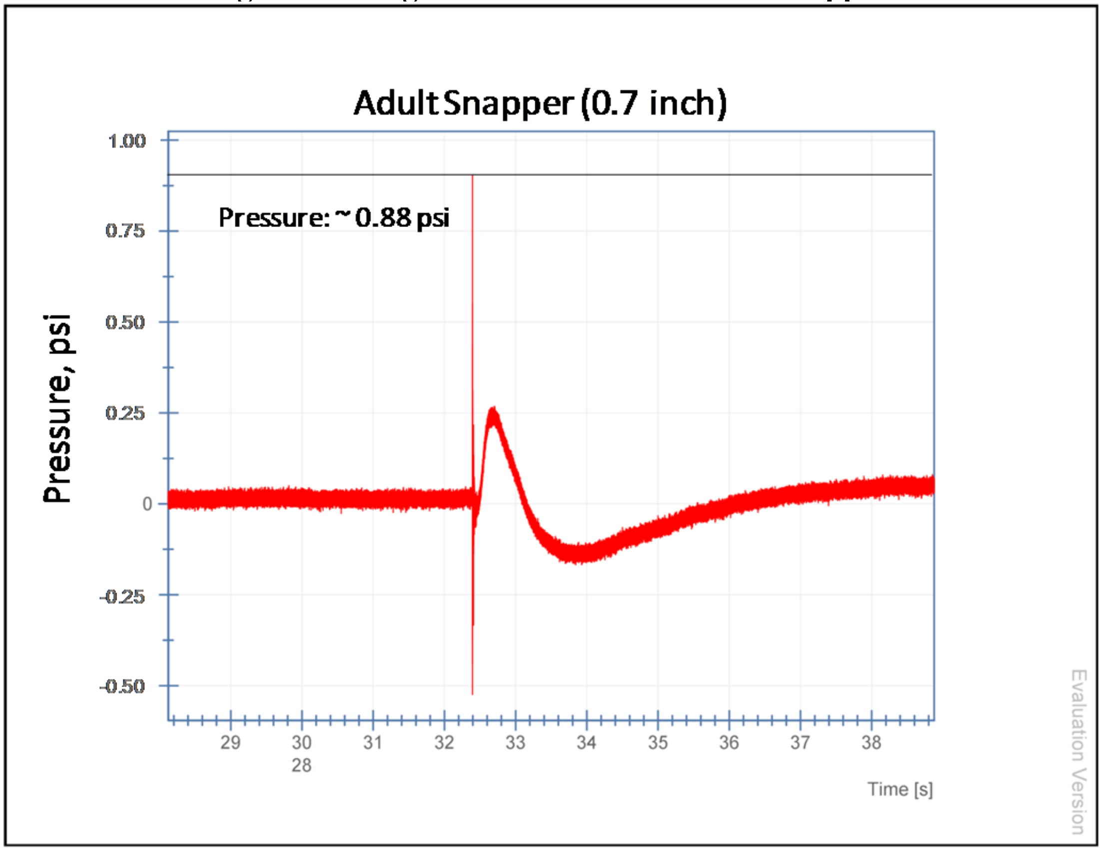
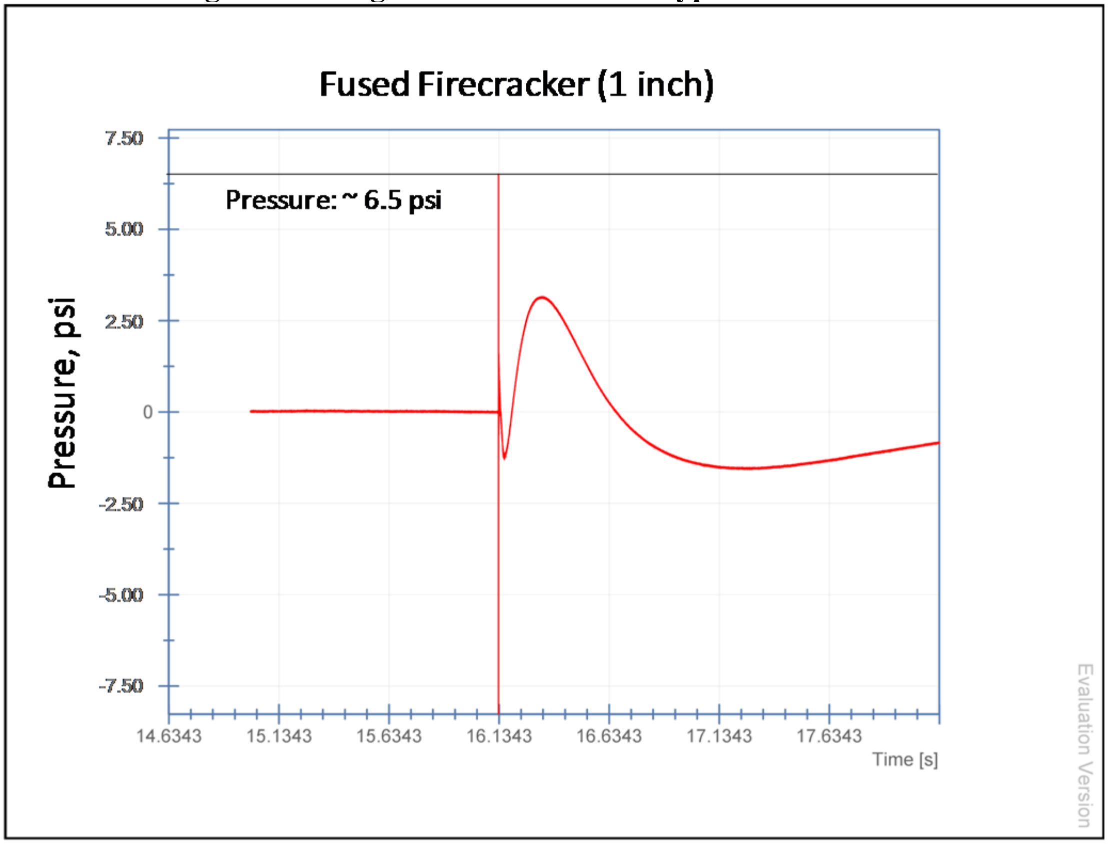


Figure 16: Single Sensor Pressure- Typical Firecracker



Conclusion

In FY 2012, staff explored alternatives to the current test methods for evaluating whether aerial devices were considered to be intended to produce an audible effect, and thus, limited to 130 mg of pyrotechnic composition. Thus far, staff has devised a new test method, wherein the total overpressure of the aerial shell can be determined using high-speed, dynamic pressure sensors. A test chamber has been fabricated and tested and has been found to be a useful, robust device for the examination of spherical shells, cylindrical aerial devices, firecrackers, and other similar fireworks. Large aerial shells currently considered to meet regulations limiting pyrotechnic quantities (due to no audible "report" found) were found to produce pressures exceeding 100 psi at a distance of 5.5 inches from the center of the shell, similar in magnitude to illegal M-80 devices. Staff also evaluated the results of testing of pyrotechnic compositions, using AFSL's "Black Powder Equivalence" test. Three regimes were easily discernible by this test: (1) black powder was the least energetic, with ball heights of up to about 1.5 meters; (2) hybrid powders were slightly more energetic, with ball heights of up to about 2.5 meters; and (3) flash powder was most powerful, with heights well in excess of 3 meters.

Data suggest that significant injury could occur from close-proximity functioning of aerial shells, even those not intended to produce an audible effect (even if they meet current regulations); however, these shells are designed to explode between 100 and 300 feet into the air, well away from consumers, which reduces the likelihood of explosions in proximity to consumers, except for incidents of tip over, other malfunction or misuse. While the CPSC 2011 Fireworks Annual Report includes about 1,000 emergency room-treated injuries attributed to Multiple Tube Devices and Reloadable Devices out of 6,200 injuries in the "special study," conducted during the month surrounding July 4, it is unknown which of these devices was large or small; which ones were designed to produce an audible effect; or which injuries were caused by the power of the explosion, as opposed to being caused by burns, debris in eyes, or other injury patterns. It is believed, based on discussions with AFSL over the years, that the market for such large devices has expanded significantly from 1996 to the present day, but the annual fireworks injury report does not find a statistically significant trend in injuries in that period. Staff believes that the requirement in 16 CFR §1507.12 that these larger devices shall not tip over when subjected to a 60 degree tip-angle test helps prevent accidental tip overs that could cause the shells to explode near bystanders.

In addition, staff performed a series of tests for adult snappers. Testing included evaluating explosive pressures from individual snapper devices, the explosion potential from 20-count boxes of snappers, and the explosion potential from 30-count cartons of 20-count boxes. Preliminary data suggests that mass detonation is highly unlikely based on multiple trials.

Recommendation

In FY 2013, staff will continue to examine alternatives to the current break charge testing, including further testing of total overpressure from aerial shells using the method developed in FY 2012.

Several options should be considered for possible changes to 16 CFR §1500.17 (a) (3), which bans fireworks devices intended to produce an audible effect if the audible effect is produced by a charge of more than 130 mg of pyrotechnic composition.

One option is to eliminate the consideration of intent to produce an audible effect, and instead, limit the energetics of the pyrotechnic composition, possibly by evaluating the composition in a manner similar to the AFSL's black powder equivalency test. Advantages of this option are that it may be less burdensome to adopt by the affected industry and that it could objectively limit the energetics of burst charges to that of the current marketplace (or even more stringently, if justified). A disadvantage of this option is that it may be possible for firms to develop shells where greater total explosive power is produced by the allowed pyrotechnic charge by improving how the charge is packed and confined. Staff will assess the extent to which this is possible.

Another option would be to replace §1500.17 (a) (3) with a restriction on the explosive power of the shells, as constructed by the manufacturers, possibly by evaluating the shells with a simplified version of the total overpressure testing described in this memo. An advantage of this option would be that it assesses directly the power of the shells, as constructed. A disadvantage is that it may be more burdensome a testing regimen for both the affected industry and for CPSC enforcement. Staff will consider possible simplifications of the method used in this memo, based on the findings of the work conducted to date.

Additionally, staff could consider having different requirements for shells from devices subject to the 60-degree tip-angle test in 16 CFR §1507.12 (possibly allowing for shells in these devices similar to the powerful shells seen in the current marketplace), with a more stringent requirement for those smaller shells which are not subject to 16 CFR § 1507.12, recognizing the greater chance of tip over for such devices.

Staff recommends that no further testing of adult snappers be conducted, based on the limited evaluation of their risk, which appears to be less than that for common firecrackers.

CONSUMER PRODUCT SAFETY COMMISSION
UNITED STATES OF AMERICA