The contents of this document will be discussed at a Commission Briefing scheduled for October 3, 2018.

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
4330 EAST WEST HIGHWAY
BETHESDA, MD 20814

This document has been electronically approved and signed.

DATE: September 26, 2018

THIS MATTER IS NOT SCHEDULED FOR A BALLOT VOTE.

A DECISIONAL MEETING FOR THIS MATTER IS SCHEDULED ON: October 17, 2018

TO: The Commission
Alberta E. Mills, Secretary

THROUGH: Patricia M. Hanz, General Counsel
Mary T. Boyle, Acting Executive Director

FROM: Patricia M. Pollitzer, Assistant General Counsel, Regulatory Affairs
Meridith L. Kelsch, Attorney, Regulatory Affairs

SUBJECT: Final Rule: Amendments to Fireworks Regulations

Staff is forwarding to the Commission a briefing package recommending that the Commission amend the regulations regarding fireworks in 16 C.F.R. parts 1500 and 1507 under the Federal Hazardous Substances Act (15 U.S.C. §§ 1261-1278) and direct staff to prepare a final rule *Federal Register* notice. The recommended final rule would:

- incorporate by reference sections of APA Standard 87-1, *Standard for Construction and Approval for Transportation of Fireworks, Novelties, and Theatrical Pyrotechnics*, to define terms used in the regulations;
- clarify requirements by eliminating inconsistencies and revising terminology;
- prohibit fireworks with a burst charge that contains metallic powder less than 100 mesh in particle size if the burst charge is produced by a charge of more than 2 grains of pyrotechnic composition;
- prohibit aerial devices that exceed device-specific chemical composition and pyrotechnic weight limits; and
- require bases on upright devices to remain attached during storage, handling, and normal operation.

If the Commission votes to issue a final rule, the Office of the General Counsel (OGC) will prepare and submit for Commission approval a *Federal Register* notice for the final rule.

Please indicate your vote on the following options:

I. Approve the final rule, as recommended in staff's briefing package, and direct OGC to prepare a *Federal Register* notice accordingly.

_____ _____
(Signature) (Date)

II. Approve issuance of a final fireworks rule with the following specified changes, and direct OGC to prepare a *Federal Register* notice accordingly.

_____

_____

_____

_____

_____ _____
(Signature) (Date)

III. Do not approve issuance of a final fireworks rule.

_____ _____
(Signature) (Date)

IV. Take other action specified below.

_____

_____

_____

_____

_____ _____
(Signature) (Date)

Attachment: Fireworks Final Rule Briefing Package: Final Rule to Revise Current Fireworks Regulations

Fireworks Final Rule
Briefing Package

Final Rule to Revise Current Fireworks Regulations

September 26, 2018

For Additional Information, Contact

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Table of Contents

Executive Summary

Since 1973, the U.S. Consumer Product Safety Commission (CPSC) has regulated fireworks devices under the Federal Hazardous Substances Act (FHSA).[1] The Commission issued a notice of proposed rulemaking (NPR) on February 2, 2017 (82 Fed. Reg. 9012). As directed by the CPSC Fiscal Year 2018 Operating Plan, staff prepared this final rule briefing package. CPSC staff reviewed and considered written comments submitted in response to the NPR, along with input from industry members, and also oral and written information submitted as part of an open hearing the Commission held on March 7, 2018. After considering this input, as well as conducting additional testing and analyses, staff developed recommendations for a final rule that is generally consistent with the NPR. However, the final rule recommendations do not include some of the proposed revisions, as delineated in Section F of this document.

Staff believes that updating the current regulations provides a more straightforward means of ensuring safety, reduces some testing burdens by clarifying requirements, aligns requirements with existing U.S. Department of Transportation (DOT) regulations and American Pyrotechnics Association (APA) industry standards, and imposes some additional requirements that address hazards indicated in fireworks incident data. This memorandum presents staff's recommendation for a final rule revising 16 CFR §§ 1500.17(a)(3), (8), and (14); 1500.83(a)(27); 1500.85(a)(2); and part 1507.

Staff recommends three substantive changes to the fireworks regulations:

- Identify the highly explosive devices that are limited to 2 grains of pyrotechnic composition, by replacing the phrase "devices intended to produce audible effects," in § 1500.17(a)(3), with a quantifiable method of identifying these devices. The proposed method states that devices with a burst charge containing metallic fuels less than 100-mesh in particle size are limited to 2 grains. Staff recommends that the Commission exercise enforcement discretion to allow up to 1 percent metal to account for inadvertent contamination and testing variability;
- Adopt limits on chemical composition, pyrotechnic weight, and the ratio of break charge-to-effects for specific types of fireworks devices in § 1500.17(a)(14); and
- Require the base of a fireworks device to remain attached during storage, handling, and normal operation in § 1507.4.

Staff also recommends revisions that would clarify and streamline the fireworks regulations, but would not establish new requirements.

Table 1 summarizes these changes, which are consistent with the rule changes presented in the NPR.

[1] 15 U.S.C. §§ 1261-1278.

TABLE 1. Summary of Changes to the Existing Fireworks Regulations	
Section	**Recommendations for Final Rule Requirements**
1507.1(b) Definitions	• Add APA definitions of relevant terms, including “burst charge,” “expelling charge,” “break charge,” “chemical composition,” “pyrotechnic composition,” “explosive composition,” “lift charge,” and “firecracker” (APA 87-1, Sections 2.5, 2.6, 2.6.1, 2.6.2, 2.10, and 3.1.3.1) • Define "aerial bomb”
1500.17(a)(3) Ban on devices intended to produce audible effects with more than 2 grains of pyrotechnic composition	• Adopt a quantifiable method of identifying devices that are limited to 2 grains of pyrotechnic content, namely those that contain a burst charge containing metallic powder less than 100 mesh in particle size • Replace references to “audible effects” with appropriate descriptions • Remove reference to firecrackers • Remove the term “aerial bombs”
1500.17(a)(8) Firecrackers	• Replace references to “audible effects” with appropriate descriptions
1500.17(a)(14) Chemical composition and pyrotechnic weight limits	• Add chemical composition and pyrotechnic weight limits for certain aerial fireworks devices.
1500.83(a)(27) Exemptions for small packages, minor hazards and special circumstances	• Clarify the language to replace “audible effects” with “burst charge” • Replace references to “audible effects” with appropriate descriptions
1500.85(a)(2) Exemption for firecrackers not more than 50 mg	• Replace references to “audible effects” with appropriate descriptions
1507.1(a) Scope	• Relocate exemption for firecrackers to specific substantive provisions
1507.2 Prohibited chemicals	• Move exemption for firecrackers from 1507.1 to this section
1507.3 Fuses	• Move exemption for firecrackers from 1507.1 to this section

1507.4 Bases	• Require that bases remain attached to devices during handling, storage, and normal operation • Define "base"
1507.6 Burnout and blowout	• Incorporate the APA definitions of "burnout" and "blowout"

Staff's recommended changes are consistent with provisions of the American Pyrotechnics Association Standard 87-1: Standard for Construction and Approval for Transportation of Fireworks, Novelties, and Theatrical Pyrotechnics (APA 87-1), and the American Fireworks Standards Laboratory's voluntary standards for consumer fireworks (AFSL standards). Firms usually certify that they comply with the APA standard to obtain approval from the DOT to transport fireworks.[2] Staff believes this harmonization will provide clarity and reduce burdens because it will replace one of CPSC's current requirements with a requirement that firms already meet to comply with APA 87-1. To meet the revised provisions to sections 1500.17(a)(3) and 1507.4, some firms likely will need to modify some of their fireworks devices. Staff estimates the costs of these modifications would be minimal, as discussed in the Final Regulatory Analysis in Tab B. Additionally, section 1500.17(a)(14), regarding pyrotechnic weight limits, could impose restrictions on some firms. However, staff does not believe these modifications will create a significant burden on those firms because bringing noncompliant devices into compliance will not be too costly. Manufacturers currently in compliance with APA 87-1 will incur no burden to comply with those requirements. The remainder of the changes in the recommended final rule pertain to clarification and alignment of existing requirements, which should not create costs.

[2] Under DOT regulations, firms have four options to obtain the required approval to transport fireworks in commerce (49 CFR §§ 173.56(b)(1), 173.56(f), 173.64, 173.65). Nearly all firms use only two of those options, and both options require certification that the devices comply with APA 87-1. The two remaining options do not require compliance with APA 87-1, but are not used regularly.

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
4330 EAST WEST HIGHWAY
BETHESDA, MD 20814

Briefing Memorandum

Date: September 26, 2018

TO: The Commission

Alberta E. Mills, Secretary

THROUGH: Patricia M. Hanz, General Counsel
Mary T. Boyle, Acting Executive Director
DeWane Ray, Deputy Executive Director for Safety Operations

FROM: George A. Borlase, Assistant Executive Director,
Office of Hazard Identification and Reduction

Andrew G. Stadnik, Associate Executive Director
Directorate for Laboratory Sciences

Aaron Orland, Director
Division of Chemistry, Directorate for Laboratory Sciences

Rodney Valliere, Chemist, Project Manager
Division of Chemistry, Directorate for Laboratory Sciences

SUBJECT: Recommended Final Rule to Revise Current Fireworks Regulations

I. Introduction

The U.S. Consumer Product Safety Commission (CPSC) regulates fireworks devices under the Federal Hazardous Substances Act (FHSA).[3] Under its current regulations, the Commission has declared certain fireworks devices to be "banned hazardous substances."[4] Additionally, there are various requirements that fireworks must meet to avoid being classified as "banned hazardous substances." These regulations prohibit the use of certain chemicals in fireworks devices, as well as specify requirements for the fuses, bases, pyrotechnic chambers, and handles and spikes.[5] Additional regulations prescribe specific warning labels because of the

[3] 15 U.S.C. §§ 1261-1278.
[4] 16 CFR §§ 1500.17(a)(3), (8), (9), (11) and (12).
[5] 16 CFR part 1507.

special hazards presented by a variety of fireworks devices.[6] Finally, the Commission's regulations also provide exemptions from full labeling for special circumstances and minor hazards associated with some fireworks.[7]

II. Background

I. History

After Congress established the CPSC in 1973, CPSC subsequently assumed administration of the fireworks regulations previously administered by the Food and Drug Administration (FDA). Since then, CPSC has issued additional requirements for fireworks devices. New types of devices have entered the market since some of these requirements were promulgated. Additionally, different types of explosive powders have replaced traditional black powder, which typically consists of charcoal, sulfur, and saltpeter. These replacement powders may include flash powder, usually made of fine mesh metallic fuel (such as aluminum, magnesium and Magnalium alloy metals) and perchlorate[8] or hybrid powders which may include mixtures using black powder and/or flash powder.

On July 12, 2006, the Commission issued an advance notice of proposed rulemaking (ANPR), discussing options and requesting comments regarding the fireworks regulations in 16 CFR parts 1500 and 1507.[9] Since then, staff researched methods to improve the fireworks regulations and published several memoranda on the work completed. This work included responding to public comments on the ANPR, evaluating new devices, and conducting specific research focused on the composition and energetics of the break charge of fireworks devices intended to produce audible effects.[10,11,12]

Staff reviewed the existing fireworks regulations, following the Commission's direction in the CPSC Fiscal Year 2015 Operating Plan. As a result of that review, on December 30, 2015, staff submitted to the Commission a rule review briefing package in which staff considered CPSC-researched methods, current technology, market information, compliance and injury data, as well as applicable domestic, international, and voluntary standards for the possible improvement of existing mandatory fireworks regulations.

After the rule review project, staff prepared a notice of proposed rulemaking (NPR) briefing package for the Commission, which contained staff's recommendations to provide more clarity to existing CPSC regulations, improve consumer safety, and harmonize with other

[6] 16 CFR § 1500.14(b)(7).
[7] 16 CFR § 1500.83(a)(27) and 16 CFR § 1500.85(a)(2).
[8] Christopher Musto & Andrew Lock, Consumer Product Safety Commission, "Fireworks Safety Standards Development Project FY 2013 Status Report" (2013).
[9] 71 Fed. Reg. 39249 (July 12, 2006).
[10] Christopher Musto & Andrew Lock, Consumer Product Safety Commission, "FY 2012 Fireworks Safety Standards Development Status Report" (2013).
[11]Christopher Musto, Consumer Product Safety Commission, "Fireworks Safety Standards Status Report" (2011).
[12] Christopher Musto & Andrew Lock, Consumer Product Safety Commission, "Fireworks Safety Standards Development Project FY 2013 Status Report" (2013).

mandatory fireworks regulations. The NPR was published in the *Federal Register* on February 2, 2017. 82 Fed. Reg. 9012.

II. Comments and Consultation

In response to the NPR, CPSC received more than 2,400 written comments. CPSC staff also met numerous times with industry representatives, including the National Fireworks Association (NFA), American Pyrotechnics Association (APA), and American Fireworks Standards Laboratory (AFSL), to hear their input. Extensive technical discussions took place with staff receiving valuable information and opinions from stakeholders about instrumentation and contamination limits. In addition, on March 7, 2018, the Commission provided an opportunity for interested parties to make oral comments on the rulemaking and submit additional written comments. CPSC staff also conducted testing and analyses to further assess issues raised by commenters. Staff considered all of the written and oral comments, input from the public meetings, and additional information collected in developing the recommended final rule.

Staff has summarized the oral and written comments CPSC received and responded to them in the memorandum in Tab A of this briefing package. This memorandum summarizes the comments and staff's responses.

III. Voluntary and International Standards

For this rulemaking, staff considered one international standard and two domestic voluntary standards on fireworks that are widely used by the fireworks industry.

Industry experts developed the European Standard, EN 15947-1–15947-5: Pyrotechnic Articles—Fireworks, Categories 1, 2, and 3 (European Standard). Thirty-one countries use this standard and most of these countries are EU member countries. Many fireworks devices that are available in Europe are not available in the United States. Some consumer devices allowed in the United States would be banned under the European Standard because of the standard's restrictions on noise levels.

The first of two U.S. standards staff considered is the APA Standard 87-1: Standard for Construction and Approval for Transportation of Fireworks, Novelties, and Theatrical Pyrotechnics (APA 87-1). The DOT regulates the transportation of fireworks and requires firms to obtain approval to transport in commerce display and consumer fireworks. Nearly all firms obtain that approval through the options requiring firms to certify that their fireworks comply with APA 87-1.[13] Staff focused on APA 87-1, in particular, because the DOT incorporates APA

[13] According to statements at the CPSC public hearing on March 7, 2018, by Julie Heckman, Executive Director for the APA, nearly all firms obtain approval to transport consumer fireworks through the options that require certification that the fireworks comply with the requirements in APA 87-1 (49 CFR §§ 173.64, 173.65). The remaining options do not require compliance with APA 87-1, but are rarely (if ever) used (49 CFR §§ 173.56(b)(1) (involving specific testing) and 173.56(f) (available when the competent authority of a foreign government has approved the explosive)).

87-1 by reference into its regulations, and most firms certify that their fireworks comply with APA 87-1 to obtain the required DOT approval.[14] Aligning the CPSC regulations with the requirements of another regulatory agency and recognized standards, where appropriate, would clarify applicable regulations and reduce compliance burdens by making applicable legal requirements more consistent across regulatory agencies. Such alignment is consistent with Executive Order 13563, which calls for agencies to "identify and use the best, most innovative and least burdensome tools for achieving regulatory ends."

The AFSL developed a series of voluntary standards and a certification for consumer fireworks that incorporate the CPSC and DOT regulations, including most of the provisions from APA-87 in the AFSL standards. The AFSL standard has a number of requirements in addition to CPSC and DOT requirements. AFSL is a nonprofit corporation established by members of the fireworks industry to: (1) develop and maintain voluntary safety and quality standards for fireworks; (2) assist manufacturers in improving safety and quality in fireworks; and (3) provide a testing and certification program to determine which fireworks comply with AFSL standards. The AFSL standards committee is appointed by the AFSL board and is comprised of technical experts; representatives that manufacture, import, distribute or retail fireworks; federal and state agencies that regulate the safety of fireworks; the insurance industry; and consumers.[15] Although CPSC staff attends AFSL standards committee meetings and offers input, CPSC staff does not have a vote. AFSL estimates that its members represent 85 to 90 percent of all U.S. fireworks importers,[16] and each AFSL member agrees to test fireworks to the AFSL standard.

For the final rule, staff recommends provisions that are consistent with APA 87-1, and in some cases incorporates by reference, provisions of APA 87-1. It should be noted, however, that APA is currently working to update its standard, and DOT is expected to incorporate by reference the updated standard, APA 87-1A, into its regulations in place of APA 87-1 when the draft is finalized by APA. According to APA's website, the current standard "remains in effect until DOT acts to adopt the 2018 version."[17] APA has formally submitted the revised APA standard to DOT for incorporation by reference and anticipates completing that update in Fiscal Year 2019. CPSC staff has reviewed the final draft of APA 87-1A, and the standard is consistent with the requirements staff recommends for the final rule that are intended to align with the APA standard. The organization and section numbers in APA 87-1A differ from APA 87-1 because the new standard places consumer fireworks requirements into a single, separate standard, and the arrangement of requirements is slightly different. However, the definitions, metal content, 1 percent allowance for metal content, device limits, and base attachment provisions remain consistent with the recommended final rule. The only difference between the recommended final rule and APA 87-1A is how they determine the break charge ratio; however, the recommended final rule does not aim to align with APA 87-1 on this provision.[18] If APA updates the standard

[14] 49 CFR §§ 171.7(f) (incorporating APA 87-1 by reference) and 173.56(b)(1), 173.56(f), 173.64, 173.65 (for approval requirements).
[15] http://www.afsl.org/content/about-us.
[16] http://www.afsl.org/content/about-us.
[17] http://www.americanpyro.com/assets/docs/2018WEC/2018-APA87-1A-Presentation(Complete)rvsd.pdf
[18] With the exception of the denominator in the permissible break charge ratio. APA 87-1A includes the lift charge in the denominator, whereas the recommended final rule does not. However, the recommended final rule does not attempt to align with APA 87-1 on this requirement, so APA 87-1A would not alter that deviation.

after the Commission adopts a final rule, there would be no additional conflicts between the final rule and the new APA standard or DOT requirements that incorporate it.

III. Incident Data

CPSC staff's Fireworks Annual Reports discuss the injuries treated in hospital emergency departments (ED-treated injuries) and fatalities associated with fireworks. For this briefing package, staff focused on the recent Fireworks Annual Reports, (*i.e.*, those for 2015,[19] 2016,[20] and 2017[21]). This section summarizes the most salient information in the reports; a more detailed discussion of relevant incident data, specific to each draft requirement, is in the Division of Chemistry (LSC) memorandum in Tab D of this briefing package.

According to the 2017 Fireworks Annual Report[22] (2017 Report), CPSC staff received reports of eight non-occupational fireworks-related deaths during calendar year 2017. U.S. hospital emergency departments treated an estimated 12,900 fireworks-related injuries during that year.

Staff obtained information on fireworks-related deaths from news clippings and other sources in the CPSC's Injury and Potential Injury Incident (IPII) databases and the CPSC's Death Certificate File. Staff estimated fireworks-related injuries from the CPSC's National Electronic Injury Surveillance System (NEISS).[23] To supplement the information available in these records, every year, during the month surrounding July 4th, staff conducts a special study of fireworks-related injuries. For 2017, staff completed this study between June 16, 2017 and July 16, 2017. This study provides a more detailed analysis of injuries, including the type of injury, the fireworks involved, how the injury occurred, and the medical treatment and prognosis. About 67 percent of the estimated annual fireworks-related injuries treated in emergency departments for 2017 occurred during this 1-month period.

Based on the completed telephone in-depth investigations of the fireworks injury incidents that occurred during the 1-month special study period in 2017, 45 percent of the incidents investigated involved fireworks devices malfunctioning, 48 percent involved the misuse of fireworks devices, and 7 percent were unknown. During the 1-month special study in 2016, 66 percent of the completed telephone in-depth investigation incidents involved malfunction, 30 percent involved misuse, and 4 percent involved debris.

Additionally, according to the results from the special study of the 2017 incidents, children younger than 15 years of age accounted for approximately 36 percent of the estimated fireworks-related injuries treated in U.S. hospital emergency departments.[25] The report also states that an estimated 1,200 fireworks-related injuries treated in emergency departments were associated with sparklers, which represents 14 percent of the total estimated fireworks-related

[19] Available at: https://cpsc.gov/s3fs-public/Fireworks_Report_2015FINALCLEARED.pdf.
[20] Available at: https://cpsc.gov/s3fs-public/Fireworks_Report_2016.pdf?t.YHKjE9bFiabmirA.4NJJST.5SUWIQJ.
[21] Available at: https://cpsc.gov/s3fs-public/Fireworks_Report_2017.pdf?Jr0lMG0Z5QYQMTyUtYr_3GR.991BKn4l.
[22] Yongling Tu and Jason Ng, Consumer Product Safety Commission, "2017 Fireworks Annual Report" (2018).
[23] NEISS is a nationally representative probability survey where injuries seen in about 100 hospitals are used to produce national estimates of emergency department visits associated with consumer products.

injuries treated in emergency departments during the special study. The device associated with the second largest number of injuries was reloadable shells, which accounted for 1,000 estimated emergency department-treated injuries (or 12 percent) during the special study. The report adds that:

- 10 percent (or 800) of the estimated fireworks injuries treated in emergency departments during the special study were associated with firecrackers;
- Rockets accounted for 7 percent (600); and
- Roman Candles accounted for 4 percent (400).

More than half of the estimated fireworks-related injuries, according to the special study, involved burns. Burns constituted the most frequent injury to hands, fingers, arms, head, face, ear, trunk, and other body part categories.

IV. Staff's Recommendations for Final Rule on Fireworks

This section discusses the requirements in the recommended final rule, arranged, with the exception of definitions, by the order in which the affected regulations appear in the Code of Federal Regulations (CFR). The recommended final rule regulatory text is provided after each section's discussion of the regulation and staff's recommendations. In summary, staff recommends:

- Identifying the highly explosive devices that are limited to 2 grains of pyrotechnic composition, by replacing the phrase "devices intended to produce audible effects," in § 1500.17(a)(3), with a quantifiable method of identifying these devices that states that devices that contain a burst charge containing metallic fuel less than 100-mesh in particle size are limited to 2 grains. Staff recommends that the Commission exercise enforcement discretion to allow up to 1 percent metal to account for inadvertent contamination and instrument variation;
- Adopting limits on chemical composition, pyrotechnic weight, and the ratio of break charge-to-effects for specific types of aerial fireworks devices, in § 1500.17(a)(14);
- Requiring that the base of a fireworks device remain attached during storage, handling, and normal operation in § 1507.4; and
- Revisions that would clarify and streamline the fireworks regulations, but would not establish new requirements.

The three substantive changes staff recommends concern aerial devices. These fireworks devices, as well as others, must have cautionary labeling to warn users of the hazards they present. For example, section 1500.14(b)(7) requires labeling on mine and shell devices to warn users to place the device on a "hard smooth surface [or] . . . upright on level ground," to not hold the device in their hands, and to "get away" after lighting the fuse. The section also requires that any fireworks not specifically listed in the regulation bear a label indicating necessary safety precautions. Despite these labeling requirements, incident data indicate that people are injured when these types of devices function near them when they malfunction, and in some cases, when misused. Although cautionary labels may address some misuse, they have limited utility in addressing a malfunctioning device. As noted in the previous section, the injuries associated with

these types of devices generally make up the most severe injury cases and account for most fireworks-related deaths. Staff believes that the recommended revisions could address some of the injuries and deaths involving these devices that occur despite the presence of cautionary labeling.

A. 16 CFR § 1507.1(b) Definitions

§ 1507.1(b)

The recommended final rule would add definitions to § 1507.1(b), which apply to both part 1507 and the sections in part 1500 that address fireworks. The NPR proposed to place these definitions in § 1500.3. However, the recommended final rule places them in part 1507. Staff believes this is a more appropriate location because the definitions will be easier for readers to find. Section 1500.3 includes definitions, but primarily consists of definitions of terms that appear in the statute. The terms defined in the recommended final rule do not appear in the statute. Because of this distinction, and because most of the fireworks requirements appear in part 1507, it would be clearer to place the definitions in that part. These definitions align with APA 87-1 and include several terms that are currently not defined in the FHSA regulations. Adding these definitions would aid in understanding the current regulations and improve compliance by providing uniform terms in the regulations.

The recommended final rule defines the following terms in § 1507.1(b): "aerial bomb," "pyrotechnic composition," "explosive composition," "chemical composition," "burst charge," "firecracker," and "lift charge." The terms "pyrotechnic composition," "firecracker," and "aerial bomb" already appear in the current regulation without definition, and the terms "burst charge," "chemical composition," "explosive composition," and "lift charge" are in substantive requirements being added to the regulations in the recommended final rule. For the most part, the recommended final rule incorporates by reference the definitions of these terms in APA 87-1 for consistency with the industry standard, with a few minor variations. For some terms, the recommended final rule adds to the APA 87-1 definition for clarity or detail. In some cases, the recommended final rule omits portions of the APA 87-1 section, because the omitted statement is not actually defining the term. Despite these minor differences, the definitions are substantively the same as APA 87-1. In addition, the definition of "aerial bomb" in the recommended final rule does not incorporate by reference a definition from APA 87-1 because the APA standard does not define that term.

CPSC received comments regarding the draft definitions, in response to the NPR. The comments, and staff's responses, are summarized in the comment and response memorandum in Tab A of this briefing package. In general, commenters supported the draft definitions.

Draft Final Regulatory Text

The recommended final rule adds the following definitions to § 1507.1(b):

Aerial bomb: A tube device that fires an explosive charge into the air without added visual effect.

Burst charge, Expelling charge or *Break charge*: Chemical composition used to break open a device after it has been propelled into the air, producing a secondary effect, such as a shower of stars. This definition is the same as Section 2.5 of APA 87-1. However, because Section 2.5 also includes requirements, in addition to the definition, the recommended final rule does not incorporate it by reference.

Chemical composition: All pyrotechnic and explosive material contained in a fireworks device. Inert materials, such as clay used for plugs, or organic matter, such as rice hulls used for density control, are not considered to be chemical composition. (This definition incorporates by reference Section 2.6 of APA 87-1, and the recommended regulation includes the following additional sentence that is not in Section 2.6: "This includes lift charge, burst charge, and visible/audible effect materials.")

Explosive Composition: Any chemical compound or mixture, the primary purpose of which is to function by explosion, producing an audible effect (report) in a fireworks device. (This definition will incorporate by reference Section 2.6.1 of APA 87-1.)

Firecracker: Small, paper-wrapped or cardboard tube containing not more than 50 mg of explosive composition; those used in aerial devices may not contain more than 130 mg of explosive composition per report. Upon ignition, noise and a flash of light are produced. (This definition will incorporate by reference Section 3.1.3.1 of APA 87-1.)

Lift charge: Pyrotechnic composition used to propel a component of a mine or shell device into the air. Lift charge is limited to black powder (potassium nitrate, sulfur, and charcoal) or similar pyrotechnic composition without metallic fuel. (This definition will incorporate by reference Section 2.10 of APA 87-1.)

Pyrotechnic composition: A chemical mixture, which upon burning, and without explosion, produces visible or brilliant displays or bright lights, or whistles, or motions. (This definition will incorporate by reference Section 2.6.2 of APA 87-1.)

B. 16 CFR § 1500.17 Banned hazardous substances

1. § 1500.17(a)(3) (Audible effects)

Current Regulation

Section 1500.17(a)(3) bans fireworks devices that are "intended to produce audible effects" if the audible effect is produced by a charge of more than 2 grains (130 milligrams (mg)) of pyrotechnic composition. The FDA discussed this requirement in the 1970 *Federal Register* notice that adopted this section, which states:

> 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 as designed to produce audible effects.) The Commissioner'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.[24]

The current regulation essentially consists of two parts: first, determining whether the device is "intended to produce audible effects," and second, if so, the pyrotechnic composition must not exceed 2 grains. As noted in the FDA's preamble language and explained further below, the first step (is the device "intended to product audible effects") is a way to identify highly explosive devices.

Although most fireworks devices produce some form of an audible effect, not all audible effects are designed specifically with that intent. For example, certain fireworks devices, such as reloadable-tube mortars and mine shell devices, may focus on producing visible or other sound effects up in the air, with an audible effect that is a byproduct of the explosion of the burst charge required to disperse the visual effects and is not the primary intended effect of the device. Therefore, determining whether an aerial device is "intended to produce an audible effect" under the current regulation requires training and expertise.

To determine "intent to produce an audible effect," CPSC staff listens to the device during field testing, and based on the sound, determines whether the applicable "loud report" was detected. If staff hears a "loud report," staff considers the fireworks device "intended to produce an audible effect," in which case, the burst charge (which causes the audible effect) is limited to 2 grains (130 mg).[25] To be clear, staff does not listen for sound level produced by a device but for a certain type of sound. Specifically, staff listens for a crisp, sharp sound profile that is related to the pressure pulse associated with the ignition of a pyrotechnic material. In evaluating the pyrotechnical material in such devices, staff has typically found the devices contain metallic fuel.

As noted above, the type of sound is an indication of the energy of the explosion, which is CPSC's primary concern. Fireworks identified as "intended to produce an audible effect" in this screening test are not automatically in violation of § 1500.17(a)(3). Rather, these fireworks are subjected to additional testing. Specifically, for those devices identified as "intended to produce an audible effect" by the sound profile, staff examines the shell and weighs the break charge to determine compliance with the regulatory limits. A device found to be intended to produce an audible effect is banned if the pyrotechnic material exceeds 2 grains (130 mg).

Compliance data show that there currently is a high level of noncompliance with § 1500.17(a)(3). Between October 2005 and October 2014, Commission staff tested 2,547 fireworks samples and found 495 violations of § 1500.17(a)(3), in which devices "intended to produce audible effects" contained more than 2 grains of pyrotechnic composition.[26]

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[24] 35 Fed. Reg. 7415 (May 13, 1970).
[25] Consumer Product Safety Commission, "Consumer Fireworks Testing Manual" (Aug. 17, 2006).
[26] Data supplied by CPSC Compliance staff.

Relationship of Explosive Power to Injury Potential

Staff cannot calculate a statistical relationship between explosive power and injuries. However, there is a relationship between the increased explosive force of a device and severe injury. Incident data for device types that generally produce the greatest explosive power provide an indication of the hazard associated with highly-explosive devices. The two primary device types of this kind are multiple-tube mine and shell devices and reloadable-tube aerial shell devices. These two types of devices account for a large portion of the most severe injuries involving fireworks devices. During the 1-month special study period in 2017, multiple-tube and reloadable-tube aerial shell devices were involved in 1,200 estimated injuries (based on a nationwide probability sample), and 100 of these estimated injuries involved children under the age of 15 years. These devices accounted for 14 percent of all estimated fireworks injuries during that period.

During the 1-month special study period in 2016, multiple-tube and reloadable-tube aerial shell devices were involved in 1,400 estimated injuries, representing 18 percent of all estimated fireworks injuries during that period. During the 1-month special study period in 2015, multiple-tube and reloadable-tube aerial shell devices were involved in 1,200 estimated injuries, representing 15 percent of all estimated fireworks injuries during that period. In addition, in most of the cases for which staff completed in-depth investigations to collect detailed information, the most severe injuries were associated with these device types.

Moreover, these devices also account for 70 percent of all fireworks deaths in the last three years covered by the Annual Reports. Four of the 8 deaths[27] related to fireworks in 2017 involved reloadable-tube aerial shell devices; 3 of the 4 deaths related to fireworks in 2016 involved reloadable-tube aerial devices; and 9 of 11 deaths related to fireworks in 2015 involved reloadable-tube aerial shell devices. In most of these cases, victims died from direct impacts of fireworks. Devices with larger explosive forces not only have greater adverse health effects at a given distance, but also have effects at greater distances than those with lesser explosive force. Limiting the amount of explosive power of these types of fireworks devices will reduce the severity of health effects.

Changes in Fireworks Devices

Since promulgation of § 1500.17(a)(3), the fireworks industry has moved away from black powder as the break charge in some fireworks devices, to the use of hybrid powders (mixtures of other powders that may include metals). These powder formulations generally use fine mesh aluminum, magnesium, or an aluminum-magnesium alloy (Magnalium) powder as their fuel, based on cost and efficiency of the material in producing high-energy explosions. These hybrid powders, depending on the construction of the shell, packing density, and quantity of metallic fuel, in some cases, might produce an audible effect; while in other cases, the sound produced is incidental to the necessary function of dispersing the visual effects. In the case of the sound

[27] It is possible that one additional fatal incident in 2017 involved a reloadable aerial device. The incident involved a firework device that was in a "PVC pipe." Without more detail it is not certain whether the device was a reloadable tube device or another type of device that was placed into the pipe.

being incidental to the dispersion of visual effects, the limit in § 1500.17(a)(3) does not apply, and no CPSC regulation limits the quantity of explosive composition.

Some fireworks manufacturers shifted to the use of pyrotechnic materials that contain metallic fuels to produce the sharp, clear audible effects in aerial devices described above. As the LSC memorandum in Tab D explains, if the firework device functions in close proximity to a person the more energetic explosion that results from fine mesh metallic fuel creates greater potential for injury. Fireworks using metallic fuels with metal particles below 100 mesh in size have greater explosive force per volume of pyrotechnic material than fireworks using only black powder or coarser (larger than 100 mesh) metal powders. The finer size of the metallic powder results in a more efficient and thus more energetic combustion effect. In addition to the impact on explosive power, fine mesh metal powder presents a hazard because it is often highly sensitive to friction, heat or flame, and static electricity, particularly those that contain chlorates, sulfur, or potassium chlorate. These formulations are unpredictable.

Voluntary Standards Development

Since the promulgation of 1500.17(a)(3) in 1970, the development of voluntary standards has provided a more straightforward means of determining "intent to produce an audible effect," to identify devices that produce dangerously explosive force. For example, APA 87-1 states: "any burst charge containing metallic powder (such as Magnalium or Aluminum) less than 100 mesh in particle size, is considered to be intended to produce an audible effect, and is limited to 130 mg in 1.4G [consumer] fireworks devices." Additionally the APA standard states: "burst charge consisting of black powder or equivalent non-metallic composition is not considered to be intended to produce an audible effect when it is used to expel and ignite a secondary effect in a fireworks device."

As Table 1 shows, the European Standard, the AFSL standard, and the APA standard all address audible effects (also called "reports") through limits in the chemical composition of break charges as well as limits in total pyrotechnic composition (which are discussed below in the section on § 1500.17(a)(14)). The limits in the standards address both the metallic fuel content (*i.e.*, flash powder as well as newer hybrid powders) and total mass of the break charge. By limiting the chemical composition in the burst charge and the total pyrotechnic material of all devices, as is done in the industry standards listed, CPSC would address the explosive power produced by all fireworks devices that have a burst charge, not just those "intended to produce audible effects."

The APA standard considers the use of any metallic fuel in the burst charge as intended to produce an audible effect. The AFSL standard uses a black powder equivalency scheme, and the European standard addresses limits by the type of device and metallic composition. The standards limit the amount of burst charge containing metallic powder under 100 mesh to 130 mg of pyrotechnic composition, though again the European standard limits vary, based on the type of device and metallic composition).

Table 1
Audible Effect Regulations in Voluntary Standards Compared to CPSC Regulations

APA 87-1	AFSL Standard	CPSC Regulation	European Standard
States that "any burst charge containing metallic powder (such as Magnalium or aluminum) less than 100 mesh in particle size, is considered to be intended to produce an audible effect, and is limited to 130 mg in 1.4G fireworks devices." Additionally states that "burst charge consisting of black powder or equivalent non-metallic composition is not considered to be intended to produce an audible effect when it is used to expel and ignite a secondary effect in a fireworks device."	Break charge must consist of "black powder or equivalent" (non-metallic fuel or demonstrated by empirical testing data demonstrating that it is equivalent in performance to black powder.)	Limits fireworks devices intended to produce an audible effect to not more than 130 mg of pyrotechnic composition. Tests for "intent to produce audible effect" during field testing by listening to the device.	For report and/or bursting charges, the net explosive content is limited to the amount of black powder or the amount of nitrate/metal-based report composition or the amount of perchlorate/metal based report composition. These limitations vary based on type of device.
Limits on total chemical and pyrotechnic material for all fireworks devices	Limits on total chemical and pyrotechnic material for all fireworks devices	Current CPSC regulations only provide pyrotechnic limits for firecrackers (50 mg) and for "devices intended to produce audible effects"	Limits on total chemical and pyrotechnic material for all fireworks devices (some devices are different than what are used in the United States)
Limits the ratio of break charge to effects for mine and shell devices as well as aerial shells at "25% of the total weight of chemical composition in the component/shell"	Limits the ratio of break charge to effects for large (greater than 1 inch) mine and shell devices at "25% by weight of the chemical composition of the tube or 10 grams, whichever is less." Small devices (1 inch or less) are limited to "50% by weight of the chemical composition of the tube or 10 grams, whichever is	Current CPSC regulations do not limit the ratio of break charge to effects.	Limits total pyrotechnic weight for report charges containing nitrate at 40% of black powder limit or limits perchlorate based report charges at 20% of black powder limit

	less." Aerial shells are limited to "25% by weight of the chemical composition of the shell or 10 grams, whichever is less"		

Staff's Recommendation for the Final Rule

To update CPSC's fireworks regulations and to make them more consistent with industry standards, the recommended final rule includes the same requirements as APA 87-1 regarding fine mesh metal powder. In addition, the recommended final rule replaces the phrase "intended to produce audible effects" with a description of the devices to which the 2-grain limit would apply—namely devices with a burst charge containing metallic fuel less than 100 mesh in particle size. CPSC staff believes that, due to changes in devices and advances in technology, the CPSC's method of determining whether a device is "intended to produce an audible effect" should be updated to reflect those changes. Revising § 1500.17(a)(3) to establish a quantifiable limit on fine mesh metal powder in the burst charge will reduce the burden of certain field testing requirements because the change will enable field testers to analyze more easily and objectively the burst charge material for metallic fuel content, rather than listen for a distinct sound.

Contamination Allowance

The APA does not allow for trace contamination of metallic fuel less than 100 mesh in particle size in fireworks devices. Compliance with this strict limit of 0 percent may be difficult for several reasons. First, advances in technology mean that instruments can detect the presence of metals even when there is only an extremely small amount of metal. This may make it difficult to achieve consistent readings of zero. For example, the CPSC's current Inductively Coupled Plasma - Optical Emission Spectrometer (ICP-OES) has detection limits in the very low parts per million (ppm) range for Aluminum (1 ppm is equivalent to 0.0001%); whereas, the current X-Ray Fluorescence Spectrometers (XRFs) have detection limits of around 0.01-0.1 percent (100-1000 ppm) for Aluminum depending on the specific x-ray spectrum, x-ray energies and analysis algorithms used by the XRF manufacturer. CPSC staff believes that existing test equipment limits of detection for Aluminum and other lighter metals, such as magnesium, which are used in pyrotechnic materials, will change as technology evolves and over time will become more accurate at lower levels.

A second reason that compliance with a strict limit of zero may be difficult is that different instruments may yield different readings, which could result in varied detection results at low levels. For example, different XRF instruments from different XRF instrument vendors can provide different readings from the same materials due to the target materials and related use of specific x-ray frequencies, detector sensitivities, and analysis algorithms used in the specific XRF device. CPSC staff and Bureau Veritas (BV) assessed the potential variation among ICP and XRF. In the data set reported by BV in the NPR comments submitted by APA and AFSL,

BV found, on average, that instrument readings vary by approximately 0.15 percent (1500ppm), when comparing ICP and XRF.

A third difficulty in achieving strict compliance results from inadvertent contamination from the environment or from other components of the fireworks device into the burst charge. As explained in Tab D, and in Tab A's response to comments, staff tested various fireworks devices to assess whether such contamination or migration occurs, and if so, at what levels. Generally, staff found that very little, if any, contamination occurred in these ways. For example, even though all devices examined had large amounts of aluminum in the effects, only 43 percent had even small amounts of aluminum (less than 1 percent) in the break charge. BV's testing found similar results. Testing shows that inadvertent contamination and migration of fine mesh metal occurs at very low levels (roughly 0.5 percent), if at all. These test results indicate that some allowance for inadvertent contamination is needed, but an allowance of 1 percent would account for inadvertent contamination.

Staff also notes that allowing trace amounts of metal could reduce the burden on industry because very stringent measures and costly testing to ensure no contamination from metallic fuel would not be required.

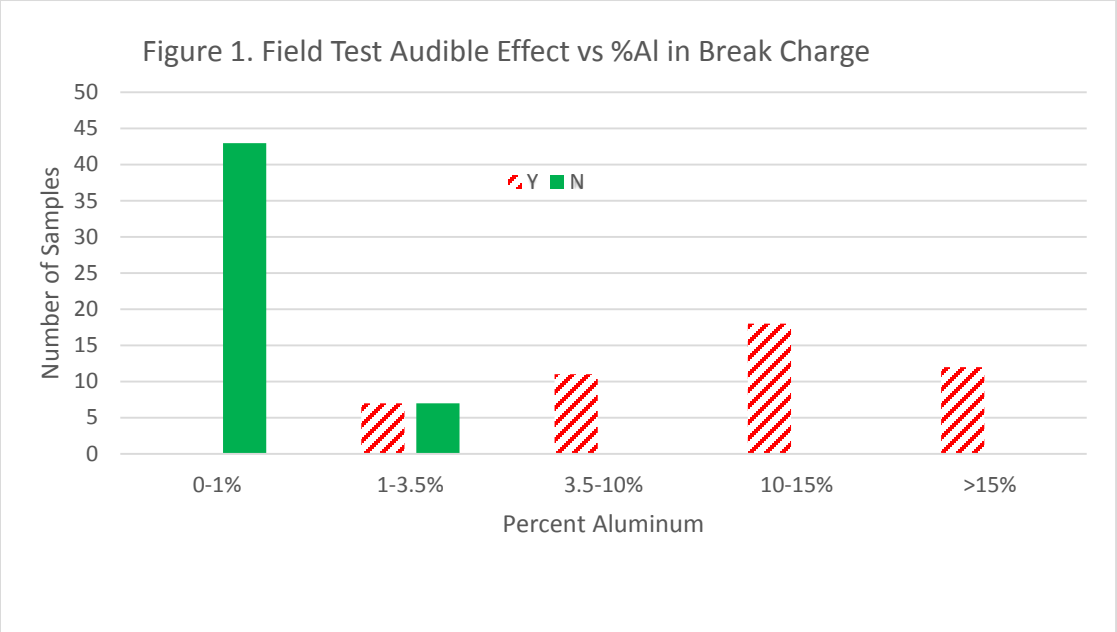
For these reasons staff recommends providing some allowance for fine mesh metal powder in a burst charge containing more than 2 grains of pyrotechnic composition. Staff recommends that Compliance staff exercise enforcement discretion to allow for contamination of up to, but not exceeding, a 1.00 percent level. Staff believes that a trace level of 1.00 percent would not cause a significant increase in the amount of energy, based on the information in Table 2 of Tab D. Based on the testing by CPSC and BV noted above, this level would also be sufficient to account for unintentional contamination and instrument variation.

In response to the NPR, CPSC received comments regarding the draft requirement and the contamination allowance. The comments, and staff's responses, are summarized in the memorandum located at Tab A of this briefing package. Staff considered these comments and the alternatives that commenters suggested. For the reasons explained below, staff recommends that the final rule remain as proposed: a zero limit for fine mesh metal in the burst charge (if it contains more than 2 grains) in the regulatory text, but the Commission would exercise enforcement discretion to allow for up to 1.00 percent.

As presented in more detail in Tab D, and as discussed above, staff concluded that a regulatory requirement that a burst charge containing more than 2 grains of pyrotechnic composition contain no (0 percent) fine mesh metallic fuel, with 1.00 percent as an enforcement discretion allowance, is the appropriate level to serve the public safety interest, while adequately accounting for inadvertent contamination. As noted above, a higher concentration of fine mesh metal increases the explosive power of a device. Therefore, selecting an appropriate contamination level requires balancing the safety need for limiting explosive power against the practical need to account for realistic levels of inadvertent contamination and instrument variation. CPSC's and BV's testing indicates that levels greater than 1 percent are intentional and not associated with contamination and measurement uncertainties; thus, a 1 percent allowance is sufficient. The staff's recommendation aligns with the APA standard, which also

prohibits fine mesh metallic fuel in a burst charge if it contains more than 2 grains of pyrotechnic composition, but unlike APA 87-1, the recommended final rule provides for an allowance for uncertainties associated with analytical instrument variation and low-level contamination.

CPSC test data presented in Tab D and as shown in Figure 1, indicate that devices begin to show "intent to produce an audible effect" under the current test method if the aluminum content is above 1 percent. Figure 1 shows that staff's recommendation to allow no more than 1 percent metallic fuel content would allow all devices that staff currently identifies as not being "intended to produce audible effects" to remain outside the scope of the 2-grain limit. That is, devices with less than 1 percent aluminum in the burst charge do not produce the sound that indicates that they are "intended to produce audible effects" and would continue to fall outside the updated regulation because they contain less than 1 percent fine mesh metal in the burst charge. Devices containing between 1 percent and 3.5 percent fine mesh Aluminum metal content may differ in the pass/fail results they yield under the new standard because staff identifies these devices as "intended to produce audible effects" about half the time.



In a joint comment submitted in response to the NPR, APA and AFSL provided test results from BV regarding the fine mesh Aluminum content in devices currently on the market. These results indicate that approximately 92 percent of mine shell devices (MSDV) and 77 percent of reloadable-tube aerial shell (RTAS) devices on the market would comply with a 1 percent enforcement discretion. Staff believes that this enforcement discretion will also provide some additional safety over the current method because the current method identifies only some devices that contain between 1 percent and 3.5 percent fine mesh metal as being subject to the 2-grain limit and the draft requirement would eliminate that variability.

A level of 1 percent fine mesh metallic fuel results in an increase in explosive energy of about 3 percent, as discussed in Tab D, and as shown in Charts 1 and 2 in Tab D. Although staff cannot relate an increase in explosive energy to a specific increase in injury potential, the farther an allowance moves from zero, the greater potential for severe injury.

Staff also considered alternatives to the recommendation of a zero limit for fine mesh metal in the burst charge with a 1 percent allowance. Staff considered different test methods, as well as alternatives to the 1.00 percent contamination allowance, including having no allowance, setting a different allowance level, and including the allowance in the regulation, rather than as enforcement discretion. These alternative are discussed in more detail in Section *IX. Alternatives*.

Non-Substantive Change to § 1500.17(a)(3)

In addition to adopting the metallic fuel test, the recommended final rule includes a non-substantive change to § 1500.17(a)(3) to clarify the regulation. Specifically, the recommended final rule removes the clause: "and other large firecrackers, aerial bombs, and other fireworks designed to produce audible effects" from the list of devices covered by this section because this refers to large firecrackers and aerial bombs, and the 2-grain limit does not apply to these devices. Firecrackers are subject to a 50-mg limit in § 1500.17(a)(8). The justification for removing "aerial bombs" from this list is addressed in the discussion of § 1500.17(a)(8), below.

Costs and Benefits of Recommended Amendments to § 1500.17(a)(3)

Staff expects the costs of complying with this requirement to be fairly low. Potential costs to comply with the recommended requirements include testing costs and material costs to switch from flash or hybrid powders to black powder, averaging approximately 1 cent per device. However, the impact would likely be far less because testing indicates that many devices already comply with the draft requirement. In addition, it is possible that there will be some cost to consumers in loss of enjoyment or utility if eliminating fine mesh metal content impacts the sound or visual effects of a device. Although staff cannot quantify the benefits of the rule in terms of reduced injuries, staff expects that the requirement may improve compliance with the 2-grain limit, more effectively limiting the explosive content of devices, which in turn, would reduce the severity of injuries and the potential for death from highly explosive devices. In addition, because many firms choose to obtain DOT approval for transporting fireworks devices, by certifying that their devices comply with the APA requirement, the draft rule may provide some benefit to firms from harmonizing with other regulatory requirements, and thereby, simplifying their compliance activities.

Draft Final Regulatory Text

(a) Under the authority of section 2(q)(1)(B) of the act, the Commission declares as banned hazardous substances the following articles because they possess such a degree or nature of hazard that adequate cautionary labeling cannot be written and the public health and safety can be served only by keeping such articles out of interstate commerce:

. . .

(3) Fireworks devices that contain a burst charge containing metallic powder less than 100 mesh in particle size (including but not limited to cherry bombs, M-80 salutes, silver salutes, and kits and components intended to produce such fireworks) if the burst charge is produced by a charge of more than 2 grains (130 mg) of pyrotechnic composition; except that this provision shall not apply to such fireworks devices if all of the following conditions are met:…

2. §§ 1500.17(a)(3) and 1500.17(a)(8) (Firecrackers and Aerial Bombs)

Section 1500.17(a)(8) applies a limit of 50 mg (.772 grains) of pyrotechnic composition for firecrackers that are "designed to produce audible effects." The language used in this regulation differs slightly, but significantly, from the language in § 1500.17(a)(3). Because firecrackers do not have any pyrotechnic effects and only produce an audible effect while functioning, all firecrackers are "designed to produce audible effects," and therefore, they are all limited to 50 mg of pyrotechnic composition.

Because the phrase "designed to produce audible effects" is redundant with the term "firecracker" and may be confusing because of its similarity to the phrase "intended to produce audible effects," the recommended final rule removes the phrase "designed to produce audible effects" from the regulations, and instead, simply refers to "firecrackers," where appropriate. Similarly, to provide consistency throughout the regulations, the recommended final rule replaces references to devices "designed to produce audible effects" with the term "explosive composition" to describe the function of the device and as used in other sections of the CFR

In addition, the language in § 1500.17(a)(3) is unclear because this section mentions "aerial bombs." The term "aerial bombs" appears in both §§ 1500.17(a)(3) and (a)(8), which is inconsistent because the former limits devices to 2 grains of pyrotechnic content, and the latter prohibits aerial bombs entirely. To clarify the requirements, the recommended final rule removes the term "aerial bomb" from § 1500.17(a)(3) and defines the term in § 1507.1(b) (as described above). Staff believes that § 1500.17(a)(8) is the appropriate section to address limits on aerial bombs because these devices' sole function is to produce audible effects without dispersing any visual effects, which is consistent with the types of devices covered by § 1500.17(a)(8).

CPSC received comments regarding "aerial bombs," in response to the NPR. The comments, and staff's responses, are summarized in the comment and response memorandum in this briefing package.

<u>Draft Final Regulatory Text</u>

(a) Under the authority of section 2(q)(1)(B) of the act, the Commission declares as banned hazardous substances the following articles because they possess such a degree or nature of hazard that adequate cautionary labeling cannot be written and the public health and safety can be served only by keeping such articles out of interstate commerce:
…

(8) Firecrackers, if the explosive composition is produced by a charge of more than 50 mg (.772 grains) of pyrotechnic composition, (not including firecrackers included as components of a rocket), aerial bombs, and devices that may be confused with candy or other foods, such as "dragon eggs," and "cracker balls" (also known as "ball-type caps"), and including kits and components intended to produce such fireworks, except such devices that meet all of the following conditions:

(i) . . ..

3. § 1500.17(a)(14) (Chemical composition and pyrotechnic weight limits)

The recommended final rule aims to address two factors that contribute to the explosive power of a fireworks device. The first of these, fine mesh metallic fuels, is addressed in the revision to § 1500.17(a)(3), discussed in the previous section. The second factor that increases the explosive power a device produces is increased amounts of pyrotechnic composition. The draft revision to § 1500.17(a)(14) addresses the second factor.

CPSC's regulations currently do not include device limits other than the 2-grain limit in § 1500.17(a)(3) for devices "intended to produce audible effects" and the 50-mg limit for firecrackers in § 1500.17(a)(8). In contrast, the European Standard, the AFSL Standard, and APA 87-1 each limits the total pyrotechnic weight of fireworks devices, regardless of whether the device is intended to produce an audible effect or contains fine mesh metal; and each limits the chemical composition of various devices (see Table 1, above). The standards impose this limit because the energetic power of the device is directly related to the amount of pyrotechnic material in the device. The standards apply different limits, depending on the type of device. Staff believes that a limit on the total pyrotechnic weight in certain devices (not only those intended to produce an audible effect) should be included in the CPSC regulations because devices containing large amounts of pyrotechnic composition have the potential to cause serious injuries or death, regardless of whether they are intended to produce audible effects or contain fine mesh metal in the burst charge. The pyrotechnic content in a device affects its energetic power, which affects the likelihood and severity of injuries it can cause, as well as the potential for death. As detailed in the section discussing § 1500.17(a)(3) above, devices that produce the highest amounts of explosive power are associated with the vast majority of fireworks fatalities and many fireworks injuries, including the most severe injuries.

Many companies choose to meet DOT requirements by certifying that their devices comply with APA limits on pyrotechnic composition and weights to transport fireworks in the Unites States. Staff believes that the limits in APA 87-1 are appropriate given current fireworks designs and consumer safety hazards. For these reasons, the recommended final rule adopts limits for aerial devices that are consistent with APA 87-1. Under APA 87-1, each type of device has its own pyrotechnic and chemical limit. In addition, APA 87-1 and the recommended final rule limit the ratio of burst charge relative to total composition permitted in a mine and shell device and an aerial shell with reloadable tubes. This limitation addresses the potential for flaming debris to disperse farther and reach ground level if a shell consists of too much break charge relative to effects.

The recommended final rule specifies that the denominator in the burst charge ratio limit includes only the burst charge and effects, not the lift charge. This may not be consistent with APA 87-1, because the denominator in the ratio limit in APA 87-1 is open to interpretation. APA 87-1, section 3.1.2.5, for mine and shell devices, states that the burst charge in a "component" may not exceed 25 percent of the total chemical composition in the "component," but describes a "component" as the portion of the device that would only contain a burst charge and effects (not a lift charge). APA 87-1, section 3.1.2.6, for aerial shells with reloadable tubes, states that the burst charge in a shell may not exceed 25 percent of the total chemical composition in the shell, which in this type of device includes the burst charge, effects, and lift charge. To resolve this

inconsistency, the recommended final rule clarifies that the denominator in the ratio for both devices consists of the burst charge and effects, but not the lift charge. CPSC staff believes this better addresses the risk of injury resulting from an overly powerful burst charge that may disperse effects farther than the intended or safe distance, resulting in flaming debris reaching ground level and injuring consumers. Because the lift charge functions before the burst charge, to propel the burst charge into the air, the lift charge is not a relevant factor contributing to explosive force when the burst charge functions to disperse effects.

CPSC staff conducted research to determine whether the fireworks industry is complying with the pyrotechnic limits APA 87-1 imposes. The results of this research are included in more detail in the LSC memorandum at Tab D of this briefing package. We provide a summary below. Staff's results are generally consistent with results provided by BV, as well the comments submitted by AFSL.

Specifically, staff tested 42 fireworks samples that the Office of Compliance and Field Operations obtained during Fiscal Year (FY) 2014 and FY 2015. Of the 42 devices tested, 30 were mine and shell, and 12 were reloadable tube mortar devices. The 42 devices were selected at random from previously collected samples. Of the 30 multiple-tube and mine and shell devices, 6 contained a total pyrotechnic composition limit greater than the 200 g or 500 g allowed, depending on base construction, in APA 87-1 section 3.1.2.5. Three of these exceeded APA limits by only a small margin. Eight of the 30 mine and shell devices had a break charge-to-effect ratio greater than the 25 percent limit. No reloadable-tube aerial device contained more than the 20-g limit of lift charge or the 60-g limit of total pyrotechnic composition APA 87-1 allows. Two reloadable-tube aerial devices had a break charge-to-effect ratio greater than 25 percent. Overall, staff found that 56 percent of mine and shell devices and 45 percent of reloadable-tube aerial devices complied with all applicable APA 87-1 device limits.[28] BV found similarly low compliance levels, but tested only reloadable-tube devices.[29]

As presented in the Final Regulatory Analysis in Tab B, staff expects the costs to comply with this requirement to be low. Potential costs to bring devices into compliance with the recommended regulation include quality control measures or low cost steps to control the amount of material put in a device. In contrast, although staff cannot quantify the benefits of the rule in the form of reduced injuries, the requirement should reduce the frequency and severity of injuries and the potential for death, by limiting the explosive content of devices. As explained in the discussion of § 1500.17, the types of devices that would be subject to these limits (mine and shell devices and reloadable tube devices) account for a large number of the most severe injuries and most fatalities. Given the low level of compliance with the voluntary standard provision discussed above, it is likely that a mandatory standard that includes the device-specific limits would bring more devices into compliance with requirements that limit explosive force. This likely will lead to some reduction in injuries.

[28] The break charge ratio used to determine this compliance level was 25 percent, relative to the break charge and effects (excluding lift charge).

[29] BV's testing and results were provided in Attachment 1 to the joint APA and AFSL comment, which is available in regulations.gov under the docket for this rulemaking.

CPSC received comments regarding the draft requirement, in response to the NPR. The comments, and staff's responses, are summarized in the memorandum in Tab A of this briefing package.

Draft Final Regulatory Text

(a) Under the authority of section 2(q)(1)(B) of the Act, the Commission declares as banned hazardous substances the following articles because they possess such a degree or nature of hazard that adequate cautionary labeling cannot be written and the public health and safety can be served only by keeping such articles out of interstate commerce:

…

(14)(i) Fireworks devices that do not conform to the following chemical composition and pyrotechnic weight limits:

(A) *Sky Rockets, Bottle Rockets, Missile-Type Rockets, Helicopters (Aerial Spinners), and Roman Candles*. Each of these devices shall not contain more than 20 grams of chemical composition.

(B) *Mine and Shell Devices.*

(1) Each individual tube shall not contain more than 60 grams of total chemical composition. Total chemical composition includes lift charge, burst charge, and visual/audible effects composition.

(2) Each individual tube shall not contain more than 20 grams of lift charge.

(3) Each device (all tubes, combined) shall not contain more than 200 grams of total chemical composition; except that this limit increases to 500 grams if the tubes are securely attached to a wood or plastic base, and the tubes are separated from each other by at least 0.50 inches. Total chemical composition includes lift charge, burst charge, and visual/audible effects composition.

(4) The burst charge in any component (shell) shall not exceed 25 percent of the weight of the total chemical composition in the component. The total chemical composition in a component includes burst charge and visual/audible effects composition, but excludes lift charge.

(5) Lift charge composition shall conform to section 2.10 of APA Standard 87-1…December 1, 2001 version, which is incorporated by reference herein.

(C) *Aerial Shells with Reloadable Tubes.*

(1) Each individual shell shall not contain more than 60 grams of total chemical composition. Total chemical composition includes lift charge, burst charge, and visual/audible effects composition.

(2) Each individual shell shall not contain more than 20 grams of lift charge.

(3) All of the shells in a device or kit, combined, shall not contain more than 400 grams of total chemical composition. Total chemical composition includes lift charge, burst charge, and visual/audible effects composition.

(4) The burst charge in each shell shall not exceed 25 percent of the weight of the total chemical composition in the shell. The total chemical

composition in a shell includes burst charge and visual/audible effects composition, but excludes lift charge.
(5) Lift charge composition shall conform to section 2.10 of APA Standard 87-1…December 1, 2001 version, which is incorporated by reference herein.

(ii) [Will include incorporation by reference language.]

C. 16 CFR § 1500.83 Exemptions for small packages, minor hazards, and special circumstances

§ 1500.83(a)(27) (Exempting Fireworks Assortments from Full Labeling)

This section of the fireworks regulations was transferred to the CPSC from the FDA and the exemptions from full labeling are based on petitions granted by the Commissioner.[30] Ordinarily, hazardous substances must meet the full labeling requirements of section 2(p) of the FHSA. The provision listed in section 1500.83(a)(27) provides an exemption from full labeling for the outer packaging of fireworks assortments, which generally include different types of devices, such as sparklers, fountains, firecrackers, and aerial shells, as long as the individual products are fully labeled and the outer package bears required information. Staff is not recommending any substantive change to this section, but recommends editorial changes to make this provision clearer, by using more-precise terms and proper references to other existing substantive requirements.

The exemption in § 1500.83(a)(27)(i) applies, in part, to "small devices designed to produce audible effects . . ., if the audible effect is produced by" no more than 2 grains or pyrotechnic composition. This language is inconsistent with other regulatory requirements because a device that is "designed to produce audible effects" generally refers to firecrackers, which are subject to the 50-mg limit in § 1500.17(a)(8), rather than the 2-grain limit in § 1500.17(a)(3). The exemption stated in § 1500.83(a)(27)(i), including the reference to a 2-grain limit, predated the Commission's adoption of the 50-mg limit for firecrackers in § 1500.17(a)(8); and this reference should have been updated when the 50-mg limit was adopted. 42 Fed. Reg. 34873 (Jul. 7, 1977). The final rule corrects this inconsistency by referencing the 50-mg limit for firecrackers, as well as the 2-grain limit in § 1500.17(a)(3). The final rule also updates the wording in this section to replace references to "audible effects" with "explosive composition," and "burst charge" because these terms refer more precisely to the content that is limited.

Draft Final Regulatory Text

(a) The following exemptions are granted for the labeling of hazardous substances under the provisions of § 1500.82:

. . .

(27) Packaged fireworks assortments intended for retail distribution are exempt from section 2(p)(1) of the act (repeated in § 1500.3(b)(14)(i)), if:

[30] 38 Fed. Reg. 27012 (Sept. 27, 1973).

(i) The package contains only fireworks devices suitable for use by the public and designed primarily to produce visible effects by combustion, except that both small devices with an explosive composition of not more than 50 mg and devices with a burst charge containing metallic fuel at less than 100 mesh in particle size may also be included if the burst charge is produced by not more than 2 grains of pyrotechnic composition; (ii) …

D. 16 CFR § 1500.85 Exemptions from classification as banned hazardous substances

§ 1500.85(a)(2)(Exempting Certain Firecrackers)

This section of the regulation provides an exemption from the hazardous substance ban for firecrackers containing not more than 50 mg of pyrotechnic composition, as long as they bear labeling giving adequate directions and warnings for safe use. As discussed above, to provide consistency throughout the regulations, the recommended final rule removes the phrase "designed to produce audible effects," and replaces the reference to "audible effects," with the words "explosive composition" because the latter phrase describes more precisely the content that is limited. Staff is not recommending any substantive changes to this section.

Draft Final Regulatory Text

(a) The term *banned hazardous substances*, as used in section 2(q)(1)(A) of the act, shall not apply to the following articles, provided that these articles bear labeling giving adequate directions and warnings for safe use:
…
(2) Firecrackers, if the explosive composition is produced by a charge of no more than 50 milligrams (.772 grains) of pyrotechnic composition (See also § 1500.14(b)(7); § 1500.17(a)(8) and (9); and part 1507).

E. 16 CFR part 1507 (Requirements for Fireworks Devices Not Otherwise Banned)

Part 1507 sets forth requirements that fireworks devices must comply with to avoid being deemed banned hazardous substances. Staff recommends editorial changes to some of these provisions to clarify the regulations and to be consistent with the changes to other provisions that staff recommends. As explained below, staff also recommends a substantive change to the requirements for bases of fireworks devices.

1. § 1507.1 (Scope and Definitions)

Section 1507.1 details the scope of the fireworks regulations in part 1507. This section expressly exempts firecrackers from part 1507. The Commission concluded in 1976 that it was appropriate to allow flash powder firecrackers, which generally contain a composition of chlorates and perchlorates, sulfur, and aluminum powder, which would be prohibited under § 1507.2.[31] In that same rulemaking, the Commission explained that the fuses addressed in §

[31] 41 Fed. Reg. 9512, 9519 (note 36) (Mar. 4, 1976).

1507.3 were not being used in firecrackers, and there was conflicting information about whether they could be used in firecrackers; accordingly, the Commission concluded that the fuse requirements in § 1507.3 need not apply to firecrackers.[32] The remaining sections in part 1507 (which address bases, pyrotechnic leakage, burnout and blowout, handles and spikes, wheel devices, toy smoke and flitter devices, stick rockets, party poppers, and multiple tube devices) are not relevant to firecrackers; thus, there is no need to wholly exempt them from that part.

To clarify the statutory language and organize the regulations better, the recommended final rule moves the exemption for firecrackers from § 1507.1, where it applies to all of part 1507, to the parts of 1507 where it is relevant, namely, to § 1507.2 (Prohibited Chemicals) and § 1507.3 (Fuse Requirements). This clarification of the requirements for firecrackers would not add any additional requirements for firecrackers.

The recommended final rule also adds definitions to 1507.1, by creating a new paragraph (b). These definitions were discussed in section IV.A. of this memorandum, above.

Draft Final Regulatory Text

(a) *Scope*. This part 1507 prescribes requirements for those fireworks devices not otherwise banned under the act. Any fireworks device that fails to conform to applicable requirements is a banned hazardous substance and is prohibited from the channels of interstate commerce. Any fireworks device not otherwise banned under the act, shall not be a banned hazardous substance by virtue of the fact that there are no applicable requirements prescribed here.

(b) *Definitions*. These definitions apply to this part and provisions concerning fireworks in §§ 1500.17(a)(3), 1500.17(a)(8), 1500.17(a)(9), 1500.17(a)(14), 1500.83(a)(27)(i), and 1500.85(a)(2) of this chapter:

(1) *Aerial bomb* means a tube device that fires an explosive charge into the air without added visual effect.

(2) *Burst charge*, also known as *expelling charge* or *break charge*, means chemical composition used to break open a device after it has been propelled into the air, producing a secondary effect, such as a shower of stars.

(3) *Chemical composition* includes lift charge, burst charge, and visible/audible effect materials and is as defined in section 2.6 of APA Standard 87-1).

(4) *Explosive composition* is as defined in section 2.6.1 of APA Standard 87-1.

(5) *Firecracker* is as defined in section 3.1.3.1 of APA Standard 87-1.

(6) *Lift charge* is as defined in section 2.10 of APA Standard 87-1.

(7) *Pyrotechnic composition* is as defined in section 2.6.2 of APA Standard 87-1.

2. § 1507.2 (Firecracker Exemption to Prohibited Chemicals)

As discussed above, the recommended final rule moves the exemption for firecrackers from the scope section of part 1507 to § 1507.2 and § 1507.3, where the exemption specifically applies.

[32] 41 Fed. Reg. 9512, 9520 (note 43) (Mar. 4, 1976).

Draft Final Regulatory Text

Fireworks devices, other than firecrackers, shall not contain any of the following chemicals:

(a) Arsenic sulfide, arsenates, or arsenites

(b) Boron.

(c) Chlorates, except:

(1) In colored smoke mixtures in which an equal or greater amount of sodium bicarbonate is included.

(2) In caps and party poppers.

(3) In those small items (such as ground spinners) where the total powder content does not exceed 4 grams of which not greater than 15 percent (or 600 milligrams) is potassium, sodium, or barium chlorate.

(d) Gallates or gallic acid

(e) Magnesium (magnesium/aluminum alloys, called Magnalium, are permitted).

(f) Mercury salts

(g) Phosphorus (red or white). Except that red phosphorus is permissible in caps and party poppers.

(h) Picrates or picric acid

(i) Thiocyanates

(j) Titanium, except in particle size greater than 100-mesh

(k) Zirconium

3. § 1507.3 (Fuses)

As explained above, the recommended final rule moves the exemption for firecrackers from § 1507.1 to § 1507.3, where the exemption specifically applies. Staff also recommends correcting an editorial error in the existing regulation, which states: "whether," where it should state "whichever," under fuse attachment in § 1507.3(b).

Draft Final Regulatory Text

(a) Fireworks devices, other than firecrackers, that require a fuse shall:

. . .

(b) The fuse shall be securely attached so that it will support either the weight of the fireworks device plus 8 ounces of dead weight or double the weight of the device, whichever is less, without separation from the fireworks device.

4. § 1507.4 (Bases)

The recommended final rule includes two modifications to this section. The first defines "base," and the second adds a base attachment requirement. Currently, the regulation does not define the term "base." Although CPSC staff believes that the term "base" is well understood by the fireworks industry, because the regulation includes requirements applicable to bases, the recommended final rule defines the term to provide clarity. APA 87-1 does not define a "base"; however, the AFSL standard sets forth the following definition:

Base - The platform to which one or more tubes of a fireworks device are attached to provide a stable platform for the functioning of the item.

Staff believes that this definition of a "base," as set forth in the AFSL standard, accurately expresses CPSC's and industry's understanding of the term. As such, the draft FR includes a definition consistent with the AFSL definition, but with additional detail.

Currently, the only substantive requirement for bases in the regulation specifies that the minimum horizontal dimension or the diameter of the base of a fireworks device must be at least one-third of the height of the device. This is a non-dynamic stability test. That is, the purpose of the required ratio is to ensure that the device does not tip over. However, it is a static test and does not measure the stability of a device while it is being fired.[33] Tip overs present a serious safety hazard because a device may fire in the direction of users or bystanders, or users may return to a lit device to correct the tip over. If the base of a device that should fire in an upright position is not attached properly, injuries could occur because the device might be unstable.

The LSC memorandum in Tab D of this briefing package explains the safety reasons why bases should be attached to devices and should remain attached when they reach consumers and during use. Consumers may not properly attach a base to a device for various reasons, such as lack of attention or error. Without a properly attached base to stabilize a device, it can tip over. Both APA 87-1 and the AFSL standard require bases to remain attached to devices during transportation, handling, and normal operation. Incident data and CPSC staff testing indicate that there are devices on the market that do not comply with the requirements in these standards, and there are injuries associated with device instability.

Although the Annual Fireworks Reports do not specifically enumerate injuries or incidents that involve detached bases, they do list incidents that involve tip overs and errant flight paths, which are the types of incidents that can occur when a base detaches from a device, causing the device to tip over or fire in a direction other than upward. The 2015 Report indicates that one fatality may have been associated with a launch tube falling over. In addition, during the 1-month special study period in 2015, of the incidents selected for which in-depth investigations (IDIs) were completed, 6 percent involved devices tipping over, and 13 percent of incidents involved errant flight paths (including devices firing at bystanders instead of firing directly upward), which resulted in severe burns. The 2016 Report indicates that 22 percent of the completed IDI cases involved fireworks tipping over, and 15 percent involved errant flight paths, resulting in burns, lacerations, nerve damage, and puncture wounds. According to the 2017 Report, 17 percent of the completed IDI cases involved fireworks tipping over, and 7 percent involved errant flight paths, resulting in burns and lacerations. The incident data indicate that a requirement that bases remain attached could result in some reduction in injuries arising from these types of incidents.

In addition, as the LSC memorandum in Tab D details, staff's test reports provide a minimum number of base-attachment issues that staff observed. From October 2014 through May 2018, staff's test reports indicate that 9 percent of devices that should have bases to

[33] 59 Fed. Reg. 33928, 33931 (July 1, 1994).

function properly had no base, had a detached base, required base assembly, or tipped over during field testing.

The recommended final rule amends § 1507.4 to reduce the risk of injury associated with base detachment and to harmonize the regulation with DOT and industry standards. Unlike the APA and AFSL requirements, which include transportation, the recommended final rule focuses on storage, handling, and operation. Staff notes that transportation requirements are covered under DOT authorities. Based on staff's observations, as indicated in staff's fireworks testing reports, bases become detached during storage, handling, and operation. Therefore, it is appropriate for the rule to cover storage, handling, and operation.

Staff expects the costs to comply with this requirement to be low. For devices that do not already comply with the draft requirement, staff expects firms to comply by either securing the base to the device with an adhesive, or modifying the device design so that the base and device are a single piece. As such, the potential costs include quality control, minimal additional labor to affix the base, the cost for materials to affix the base (which is expected to be very low), and possibly increased shipping costs if devices take up more volume with attached bases. Based on staff's field observations, approximately 9 percent (at a minimum) of devices tested do not comply with the draft requirement, and therefore, those devices would require modifications to comply with the recommended final rule. In contrast, although staff cannot quantify the benefits of the rule in the form of reduced injuries, staff expects base attachment to improve the stability of fireworks devices, which would reduce the number of injuries resulting from tip-over incidents.

CPSC received comments in response to the NPR regarding this draft requirement. The comments and staff's responses are summarized in the comment and response memorandum in Tab A of this briefing package. In general, commenters supported the draft requirement, but some proposed an alternative, which staff determined would not be as effective, for the reasons explained in Tab A. Staff was unable to identify any less burdensome alternative, that would adequately reduce the risk of injury associated with unstable devices.

Draft Final Regulatory Text

(a) For purposes of this section, the base means the bottom-most part or foundation to which one or more tubes of a fireworks device attach and that serves as a flat, stabilizing surface from which the device may function.

(b) The base of fireworks devices that are operated in a standing upright position shall:

(1) Have the minimum horizontal dimensions or the diameter of the base equal to at least one-third of the height of the device, including any base or cap affixed thereto; and

(2) Remain securely attached to the device during handling, storage, and normal operation.

5. § 1507.6 (Burnout and Blowout)

According to existing § 1507.6, fireworks devices must be constructed to allow functioning in a normal manner without blowout or burnout, which has safety implications because blowouts often create a large explosion low to the ground, where debris can injure spectators. In addition,

burnouts can cause fires, leading to property damage and injury. A similar provision exists in APA 87-1 section 3.6.2.5, with definitions for the terms "blowout" and "burnout" in sections 2.3 and 2.4, respectively.

Although CPSC staff believes the terms "burnout" and "blowout" are well understood by the fireworks industry, staff recommends defining the terms in the regulations. Staff believes that the APA definitions accurately express the CPSC's and industry's understanding of these terms. Additionally, these definitions are incorporated by reference into DOT's regulations as part of APA 87-1. Adding definitions may clarify and streamline the regulation.

Draft Final Regulatory Text

(a) The pyrotechnic chamber in fireworks devices shall be constructed to allow functioning in a normal manner without burnout or blowout.

(b) As used in this section, the terms *blowout* and *burnout* are defined in sections 2.3 and 2.4, respectively, of APA Standard 87-1, Standard for Construction and Approval for Transportation of Fireworks, Novelties, and Theatrical Pyrotechnics, December 1, 2001 version, which is incorporated by reference here.

F. Requirements Proposed in the NPR that Are Not in the Recommended Final Rule

The NPR proposed several requirements that are not included in the recommended final rule. In the NPR, the Commission sought information pertaining to several proposed requirements, but did not receive substantive data and information for some of those proposed requirements. After further assessing these proposed requirements, staff believes that additional data or information are necessary to support including them in a final regulation. .

Limits on pyrotechnic weight of ground devices. The recommended final rule does not include pyrotechnic weight limits for ground devices because staff does not have detailed information regarding ground device incidents or the extent to which devices comply with the APA 87-1 limits. This information would be necessary to assess support for FHSA findings.

Adding to list of prohibited chemicals. The recommended final rule does not add hexachlorobenzene (HCB) and lead/lead compounds to the list of prohibited chemicals. Although staff believes these are dangerous chemicals, staff does not have information or exposure data regarding the extent to which these chemicals are present in fireworks in the United States, or data on the harm they pose to consumers when in fireworks. Although there are some studies regarding the presence of these chemicals in fireworks, the relevance of these studies is limited because most of the studies took place in Europe (which has different fireworks), date back to 10 to 20 years ago, or consisted of small sample sizes. Staff notes that HCB and lead/lead compounds are currently prohibited in voluntary standards, international standards, and in international treaties. Therefore, staff does not anticipate that excluding this requirement from the final rule would diminish safety.

Side-ignition test method. The recommended final rule does not include a method for testing side ignition. The proposed method, which CPSC staff uses when testing devices, is

consistent with APA 87-1, and 99.5 percent of devices comply with APA 87-1, making it difficult to support the required FHSA findings that a voluntary standard is inadequate or there is not substantial compliance. The method is described in the Consumer Fireworks Testing Manual, which staff will update to clarify the timeframe used in testing fuse side ignition.

Allowance for prohibited chemicals. The recommended final rule does not include a trace contamination allowance for prohibited chemicals. Staff does not have detailed information regarding the specific allowance needed that would still be safe for consumers. Compliance staff may use enforcement discretion, as appropriate, to account for minimal contamination.

Projected fragments. Finally, the recommended final rule does not include a provision to prohibit fireworks devices from projecting fragments. Staff believes that projected fragments do pose a safety hazard. However, staff does not currently have sufficient information about the frequency and type of fragments. Staff intends to collect additional information and may revisit this in a future rulemaking. The reasons for not including these proposed requirements are explained in greater detail in the LSC staff memorandum (Tab D).

V. Summary of Recommended Final Rule

Staff recommends two types of provisions. The first category includes provisions that do not create a new hazardous substance ban under the FHSA and are not expected to have any net effect on the fireworks industry; these recommendations streamline or clarify the regulations. The second category lists requirements that would create a new hazardous substance ban under the FHSA by establishing a new requirement. Staff believes that changes in this second category, which require the Commission to make the requisite findings under the FHSA, could provide greater safety to the public, and would align with voluntary standards and DOT regulations.

Draft changes intended to clarify and streamline the regulations that create no new requirements:

- Define “aerial bomb,” “lift charge,” “burst, expelling, or break charge,” “chemical composition,” “firecracker,” “pyrotechnic composition,” and “explosive composition” in § 1507.1(b);
- Remove the references to “aerial bombs” and “firecrackers” in § 1500.17(a)(3);
- Replace references to “firecrackers designed to produce audible effects” to simply reference “firecrackers” in §§ 1500.17(a)(8), and 1500.85(a)(2);
- Specify the sections (fusing requirements and prohibited chemicals) from which firecrackers are exempt, rather than exempt firecrackers from all of part 1507, in §§ 1507.2 and 1507.3;
- Define “burnout” and “blowout” in § 1507.6;
- Define “bases” in § 1507.4; and
- Revise § 1500.83(a)(27) to clarify language using “burst charge.”

Draft requirements that create new hazardous substance bans under the FHSA:

- Replace the phrase "devices intended to produce audible effects," in § 1500.17(a)(3), with a quantifiable method of identifying these devices that states that devices that contain a burst charge containing metallic fuels less than 100-mesh in particle size are limited to 2 grains;
- Adopt limits on chemical composition, pyrotechnic weight, and the ratio of break charge-to-effects for specific types of aerial fireworks devices, in § 1500.17(a)(14);
- Require that the base of a fireworks device remain attached during storage, handling, and normal operation in § 1507.4;

VI. Effective Date

Section 553(d) of the Administrative Procedure Act requires the effective date of a rule to be at least 30 days after publication of the final rule. Although fireworks are manufactured, imported, and sold year-round, there are two primary selling seasons: a period that includes July and the months prior to the 4th of July, and to a lesser extent, a period that includes December and the months before New Year's Eve. Fireworks are typically ordered, manufactured, tested, imported, and distributed many months in advance of these seasons. Any changes to the regulations before these seasons without advance notice may be particularly disruptive. The recommended final rule includes an effective date of 1 year after the final rule is published in the *Federal Register*. The NPR proposed a 30-day effective date and requested comments on that proposed date. Commenters, including APA, AFSL, and NFA, requested a longer effective date, including 6 months, 8 to 12 months, 1 year, and several years. The Office of Advocacy of the U.S. Small Business Administration also submitted a comment regarding the timeline of consumer fireworks imports and sales. CPSC staff recognizes that an effective date no earlier than January 1, 2019 will help to alleviate the burden caused by any product ordered before publication of the final rule that was not sold during the 4th of July season. Furthermore, an effective date no earlier than July 4, 2019 would provide time for the industry to move product ordered before publication of the final rule, to refine test methods, to reformulate products, and ultimately, to come into compliance with the new regulations. Therefore, the recommended final rule includes an effective date of 1 year after publication of the final rule.

VII. Economic Analysis

The Final Regulatory Analysis prepared by the Directorate for Economic Analysis, presented in Tab B, describes the expected benefits and costs of the recommended final rule. The recommended final rule is intended to improve consumer safety and harmonize CPSC regulations with those of the voluntary standard, APA 87-1, which is also incorporated by reference by DOT. The rule also may be marginally more stringent than the current CPSC regulations and could provide improvements in consumer safety by potentially reducing the frequency and severity of injuries.

The primary costs associated with the recommended final rule include the added cost of producing fireworks that comply with the rule and potential reductions in consumer utility if the rule impacts the quality of visual effects or sounds devices produce. Staff generally expects the

recommended final rule would have a limited economic impact on the U.S. market for fireworks because, where changes are needed, the costs of compliance are expected to be low. This would include the provisions relating to the prohibition of fine mesh metallic powders (with an allowance for contamination). As noted in Tab B, staff estimates that replacing the fine mesh metallic powder contained in a typical burst charge with black powder, would cost less than 1 cent per aerial device. Similarly, added costs for firms to comply with the requirements--including limiting the total pyrotechnic composition of fireworks, and costs for bases of fireworks devices to remain attached during storage and use, should also be small, given current levels of industry compliance and the low additional cost of making products compliant. However, these costs cannot be quantified. The rule could also potentially reduce the enjoyment or utility associated with the use of some fireworks for some consumers. However, these reductions will be small and cannot be quantified.

Staff anticipates three types of benefits from the rule: (1) harmonizing the requirements for existing fireworks safety rules; (2) providing a more objective test to replace the current "intent to produce audible effects" test CPSC uses; and (3) a potential reduction in fireworks-related injuries because of limits on explosive compositions for certain devices. Staff cannot quantify the anticipated benefits of the rule. However, staff states that a only a relatively small reduction in the number of injuries would be needed to make the benefits of injury reduction equal to the costs of modifying devices to comply with the requirements.

Some provisions of the recommended final rule merely clarify existing requirements and would not be expected to affect the costs to firms (or benefits). Moreover, most fireworks manufacturers opt to certify that they comply with the requirements of APA 87-1 (on which CPSC's recommended final rule is based) to obtain DOT approval to transport fireworks in this country.

VIII. Small Business Impacts

Staff prepared a final regulatory flexibility analysis of the recommended final rule discussing the impact on small businesses, and addressing issues raised by the Office of Advocacy of the Small Business Administration (Advocacy) and in comments by several small businesses on the initial regulatory flexibility analysis. One issue raised by Advocacy was the timeframe for consumer fireworks orders, imports, and sales. In the NPR, the Commission proposed a 30-day effective date for the rule. In response to this concern, the effective date in the recommended final rule is 1 year after its publication in the *Federal Register*.

Advocacy and others raised concerns about the cost and reliability of XRF testing for metallic powders and whether burst charges that consist only of black powder would result in devices that are "unmarketable." However, staff's assessment of XRF testing is that it is a reliable method for assessing the presence of fine mesh metallic powders and is also a reasonably low cost means of testing. Staff also believes that burst charges that consist solely of black powder will ignite the effects and would not result in devices that are unmarketable. Advocacy also provided a list of alternatives to the draft rule. Some of their suggestions are already permitted, such as allowing products to be tested during non-peak seasons. Other suggestions are beyond the authority of CPSC, such as requiring consumers to undergo safety training. Other

alternatives were considered by CPSC staff and are discussed elsewhere in this package, including establishing a higher contamination allowance and using sound level meters to assess explosive force rather than prohibit fine mesh metallic powders.

The full response to these and other comments is contained in the draft final regulatory flexibility analysis. In general, CPSC staff does not expect the draft rule to raise costs substantially for most small businesses, nor significantly affect their sales.

IX. Alternatives

In developing the recommended final rule, staff considered various alternatives. Staff primarily considered alternatives to address fireworks' explosive power, specifically the appropriate limits for fine mesh metal fuels. Staff also considered whether to finalize proposed provisions on ground device requirements, limits on specific chemicals, side fuse ignition test methods, and incorporating trace contamination limits for some prohibited chemicals and elements. As explained in section IV.F, staff is not recommending including these proposals in the final rule. As explained in section VI. staff considered whether the proposed 30-day effective date was appropriate, and staff is instead recommending a 1-year effective date. The remainder of this section focuses on alternatives related to the metallic fuel content.

1. Alternatives that Would Not Limit Metallic Fuel

Staff recommends limiting the allowable metallic fuel content of various fireworks devices, mainly reloadable shells and multi-tube devices. A variety of comments and test data submitted by several commenters addressed this issue. Instead of the fine mesh metal content requirement in the recommended final rule at § 1500.17(a)(3), staff considered alternative test methods, such as black powder equivalency, overpressure, and sound level meter testing. In the detailed analyses in Tab D, staff explained that none of those test methods provide as reliable, repeatable, and objective results for assessing explosive power and addressing the hazard to consumers as the draft requirement limiting metallic fuel content in certain devices.

2. Metallic Fuel Content Alternatives

Staff considered alternatives to the 1.00 percent discretionary contamination allowance, including no allowance (as in the current APA standard); setting a different allowance level; or including the allowance in the regulation, rather than as an exercise of enforcement discretion. This section reviews these alternatives.

a. **Metallic Fuel Limit with Discretionary Allowance of 1 Percent**: As presented in Section IV.B., staff concluded that a requirement of no (0 percent) metallic fuel with 1.00 percent as an enforcement discretion allowance would serve the public safety interest, while adequately accounting for inadvertent contamination.

b. **Metallic Fuel Limit with Higher Allowances**: The Commission could issue a rule that provides higher allowances of metallic fuel, greater than 1 percent. CPSC staff compiled a limited data set comparing the results of the current test method for determining an

audible report to the percent aluminum in the burst charge. The limited testing indicates shells containing less than 1 percent aluminum were never found to produce audible effects. Shells containing aluminum between 1 and 3.5 percent were found to produce audible effects in the field 50 percent of the time and shells containing greater than 3.5 percent of aluminum were found to contain audible effects 100 percent of the time (see Figure 1).[34] As such, the Commission could find that allowances up to 3 percent metallic fuel content provide an equivalent result to the existing test method with varying degrees of certainty. Several of these allowance options are presented in more detail below.

1. Two Percent Allowance: In their joint comments, AFSL and APA advocated for a 2 percent limit. They stated that at levels between zero and 2 percent of metal powder, there is no significant increase in the energetic/explosive force of the device. They provided data that an increase from a 1 percent to 2 percent metallic fuel allowance would result in a 1 percent to 2 percent increase in the "pass" rate, with approximately 94 percent of MSDV and 79 percent of RTAS devices meeting a 2 percent allowance. This allowance would be in the middle of the range, where CPSC test data show a transition in the audible effect results shown in Figure 1. Of the 50 devices CPSC evaluated with aluminum content below 2 percent, 10 percent were found to produce an audible effect. The CPSC data and data submitted by APA and AFSL are consistent. The data for Figure 1 (shown in detail in Tab D) show that devices with aluminum metal fuel content as low as 1.5 percent were found to produce an audible effect. A 2 percent allowance would result in about a 6 percent increase in explosive energy above the 0 percent level.

2. Three Percent or Three-and-One-Half Percent Allowance Options: Another alternative is to allow a higher limit of 3 percent up to 3.5 percent. The CPSC test data, shown in Figure 1, indicate that such an allowance could similarly replicate CPSC's current requirement. Of the 98 devices CPSC tested using the current "intent to produce an audible effect" test and the "metal content test," all of the devices that did not produce audible effects contained 3.14 percent aluminum or less, with 48 of the 50 "no audible effect" devices containing less than 3 percent aluminum. This indicates that a 3 percent allowance would replicate the results of the current test method about 88 percent of the time. Increasing the allowance to as much as 3 percent to 3.5 percent would result in an explosive energy increase of about 10 percent to 12 percent, based on Charts 1 and 2 in Tab D. Additionally, in the allowance range from 3 percent to 3.5 percent, about 12 percent to 15 percent of the devices tested produced an audible effect. Current product market compliance data provided by APA and AFSL indicate that approximately 96 percent of MSDV and 81 percent RTAS devices on the market would comply within the 3 percent to 3.5 percent allowance range.

3. Five Percent or Higher Allowance: Some commenters suggested considering a 5 percent or even higher allowance for metallic fuel content. The CPSC test data shown

[34] Staff notes that for devices tested in the field, corresponding devices tested in the lab may not have the same exact compositions due to variation in manufacturing that can occur from device to device.

in Figure 1 indicate that above 3.5 percent, all devices were found to produce an audible effect, and a higher limit would not be in line with the current level of safety provided by the current methods. That is, providing an allowance above 3.5 percent would mean that some devices that are currently prohibited would be permitted. At a 5 percent metallic fuel limit, explosive energy increases about 15 percent higher than at 0 percent. Using a metallic fuel limit above 3.5 percent would likely result in a less safe regime than the current standard.

c. **Enforcement Discretion Allowance vs. Express Regulatory Limit**: Staff recommends that the final rule text not specify any contamination allowance for metallic fuel content, but state in the preamble that the Commission, in exercising its enforcement discretion, allow up to 1 percent of metallic fuel. Alternatively, the Commission could state a specific metallic fuel limit in the regulation. Some commenters advocated that the limit be stated in the rule. They stated that this would provide greater transparency, certainty, and predictability to regulated entities. They observed that an enforcement discretion limit could be changed at any time without notice. In contrast, staff notes that to provide the greatest safety, the regulation should not allow any metallic fuel, consistent with the industry's own standard. Providing some allowance through enforcement discretion appropriately recognizes that, due to variability in instruments and possible contamination from metals in the environment or parts of the device other than the burst charge, attaining a zero level may not be possible. Enforcement discretion serves this purpose. Staff also notes that if instrument detection capabilities and inadvertent contamination levels change in the future, as technologies improve, modifying an enforcement discretion level to reflect these changes is easier than amending the regulation.

d. **Retain Existing Regulation**: Another alternative the Commission could consider is to retain the current audible effect provision without change. This alternative would not respond to the Commission's original direction to update the fireworks regulations in response to industry requests for a less costly, more quantifiable, and less uncertain method. For firms that certify compliance with APA 87-1 to obtain DOT approval, they would continue to need to conduct both audible effects and metal content tests. This option would also not align with changes that have occurred in the fireworks industry including new types of devices and changes in the use of different types of pyrotechnic materials. It would also leave in place a test method that is dependent upon trained experts, resulting in the potential for some variability between testers/locations, and does not address repeatability and reproducibility concerns raised by industry.

3. Alternative Approaches to Address Explosive Power of Aerial Devices

As an alternative to the overall device limits in draft § 1500.17(a)(14), staff considered whether to extend device limits to ground devices in addition to aerial devices, and whether to set the burst charge ratio relative to the effects and burst charge (as in the recommended final rule) or relative to the effects, burst charge, and lift charge. Staff concluded that available data at

this time support focusing on aerial devices, and that the draft requirement provides for consumer safety and consistent regulatory requirements.

Staff also considered adopting only one of the two draft requirements that aim to address the hazard associated with explosive power (§§ 1500.17(a)(3) and (a)(14)). Staff determined that both of these requirements are necessary to address the hazards associated with increased explosive power. Each of the draft requirements addresses a different contributor to explosive power (i.e., quantity vs. fine mesh metal content), and the permissible levels for black powder would be inappropriate for metallic powder, and vice versa.

4. Other Proposed Requirements

Staff also considered whether to include additional requirements in the recommended final rule, such as prohibiting hexachlorobenzene, lead, and lead compounds from fireworks; prohibiting fireworks from projecting fragments; or establishing a test method to evaluate side ignition of fuses. Staff excluded these requirements from the recommended final rule because existing mechanisms (*e.g.*, voluntary standards, international treaties) appear to address these hazards, or because additional information is needed. Staff also considered whether to ease the requirements of some existing regulations, such as by allowing for trace contamination of prohibited chemicals, but determined that case-by-case enforcement discretion would be the most appropriate way to provide this flexibility. For reasons discussed in section IV.F., staff does not recommend including those provisions in the final rule.

X. Conclusions

This briefing package describes the provisions in CPSC's regulations that staff recommends the Commission update in the recommended final rule. The recommended final rule changes are meant to achieve greater clarity, consistency, and reflect the current fireworks market and technology, and provide increased consumer safety. Many of the draft changes align with the voluntary standards, where they reduce consumer safety risks. Staff believes that this consistency with voluntary standards, as well as DOT regulations, provides the least-burdensome approach to protect the public.

Staff expects that the recommended final rule would have a limited economic impact because, where changes are needed to comply, the costs of compliance are expected to be low. Staff expects the rule to have some benefit in the form of reduced frequency and severity of injuries, but cannot quantify those benefits.

Based on comments received in response to the NPR, as well as staff's assessment of the typical timeline of fireworks production, import, and sales, staff believes that a 1-year effective date would provide sufficient time for firms to modify products to comply with the recommended final rule. Therefore, the recommended final rule would apply to products manufactured or imported on or after 1 year from the day the final rule is published in the *Federal Register*.

Tab A – NPR Comment Responses

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
4330 EAST WEST HIGHWAY
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SUBJECT : Fireworks Final Rule - NPR Comment Responses

Introduction

CPSC published a notice of proposed rulemaking (NPR) concerning the agency's fireworks regulations in the *Federal Register* on February 2, 2017. The Commission received 2,419 written comments in response to the NPR. The Commission also provided an opportunity for interested parties to present oral comments on the NPR on March 7, 2018. There were 11 presenters at this meeting. In addition, CPSC received written submissions from the oral presenters, as well as nearly 200 additional written comments in response to the notice of the meeting. CPSC staff's summary of written and oral comments and responses follow.

NPR Comments and Responses

1. General Comments Supporting the Proposed Rule

Comment Summary:
CPSC received comments indicating support for the proposed changes. These commenters stated that the proposed regulations would improve safety, address gaps in the current regulations and enforcement protocols, and that aligning with American Pyrotechnics Association (APA)

Standard 87-1 would provide clarity, reduce testing costs, and make it simple to comply with new requirements.

The American Fireworks Standard Laboratory (AFSL) and the APA commented jointly that AFSL ensures that devices its members import are tested and certified by an independent laboratory as meeting the AFSL standard. AFSL stated that 85 percent to 90 percent of consumer fireworks imported into the United States are tested and certified under the AFSL program, and therefore, comply with the AFSL standard, which largely aligns with the proposed rule.

2. General Comments Opposing the Proposed Rule

    a. General comments opposing the rule

Comment Summary:
CPSC received comments expressing general disapproval of the proposed rule out of concern that it would eliminate many or all fireworks. These commenters expressed that they enjoy fireworks and that fireworks are a valued part of family get-togethers, celebrations, and an American tradition. Commenters stated that many products can be unsafe if misused, but that misuse does not justify banning the product. CPSC also received a comment stating that fireworks regulations should focus on hazards that are not obvious to consumers, such as tip overs, rather than obvious hazards. Commenters also noted the value of fireworks for encouraging children's interest in science.

Response:
Staff agrees that fireworks are enjoyable, an American tradition, and can encourage children's interest in science. The recommended final rule does not eliminate any category of fireworks devices as a whole. For example, aerial devices, including mine and shell devices, and reloadable-tube devices, remain permissible under the recommended final rule. Instead, the recommended final rule aims to increase the safety of fireworks devices by limiting the total chemical composition and the explosive force in the break charge of the device, as well as addressing other identified safety hazards; aligning with current requirements in the APA Standard 87-1. Although some hazards associated with fireworks may seem obvious, consumers may not be able to avoid those hazards, such as device malfunctions. Each of the requirements in the recommended final rule aims to address a hazard to consumers.

Comment Summary:
CPSC received comments requesting that CPSC ban all fireworks, ban the use of fireworks in residential neighborhoods, or limit the use of fireworks to professionals. Commenters noted that fireworks are dangerous, pose fire hazards, cause injuries, and are harmful to the environment and atmosphere.

Response:
Staff agrees that misuse of fireworks devices poses a significant hazard. When used correctly and when fireworks meet all of the industry performance standards set in place to limit the potential hazards, staff believes fireworks can be enjoyed safely. By updating the existing mandatory standards, staff believes fewer injuries will occur.

b. Alternatives to the proposed rule

Comment Summary:
CPSC received comments suggesting alternatives to the proposed rule that CPSC could pursue to address the hazards associated with fireworks, including the following:

- *Require training*. Require consumers to receive training before buying and/or using fireworks;
  - This may include requiring completing a safety course, passing an exam, or obtaining a certificate of completion, permit, or license;
  - Training could address hazards associated with fireworks and proper use;
  - Such requirements could generate revenue through course or permit fees;
  - Training could be required for consumers reported to use fireworks unsafely;
  - Training could be offered through local fire departments, at retail locations, or online;
- *Raise awareness*. Educate consumers about the risks associated with fireworks, including: demonstrations of proper handling, storage, and use; or providing informational brochures, seminars, advertisements, or videos through retailers, news outlets, or social media;
- *Designated-use locations.* Establish designated "shoot sites," where consumers can set off fireworks;
- *Age restrictions*. Adopt a minimum age requirement to purchase fireworks;
- *Instructions.* Provide detailed instructions on fireworks so that consumers know how to use the product properly and safely;
- *Quality control.* Focus on quality control;
- *Labeling and packaging.* Regulations should focus on packaging and labeling to inform users of risks;
- *Guidelines for safe use.* Adopt guidelines similar to the National Fire Prevention Association's NFPA 1123, *Code for Fireworks Display*, but for consumer fireworks. NFPA 1123 contains information about setting up and operating professional fireworks displays in a manner that prevents fires and injuries to those handling the fireworks and viewers;
- *Waivers*. Require consumers to sign waivers, acknowledging the risk, when purchasing fireworks;
- *Insurance.* Require users to have insurance coverage;
- *Electronic ignition devices.* Require fireworks to include electronic ignition devices so that consumers do not have to be near devices to light them; and
- *Punishment*. Adopt and enforce punishments to hold consumers accountable for misusing fireworks;
- *Professional use only.* Limit the use of fireworks to certified professionals only;
- *Background checks*. Require background checks to purchase fireworks, similar to those required to purchase firearms.

Response:
Several of these suggested alternatives concern educating consumers about the hazards associated with fireworks, including training, instructions, labeling, and use guidelines. As CPSC's Division of Human Factors staff has noted elsewhere in these comment responses, literature on safety and warnings consistently identifies a hierarchy of approaches to controlling hazards. In this hierarchy, warnings are less effective at eliminating or reducing exposure to hazards than designing the hazard out of a product or guarding consumers from the hazard. This is because warnings do not prevent consumer exposure to the hazard. Rather, warnings rely on educating consumers, and persuading them to alter their behavior to avoid the hazard. The effectiveness of this approach varies, depending on consumer behavior, which varies with situational factors, such as fatigue, stress, or social influences. The same limitations apply to the related suggestions of training, instructions, and guidelines because these options also focus on informing consumers about hazards and how to avoid them. Consequently, warnings and similar awareness approaches should supplement, rather than replace, design standards or provisions that guard against hazards to consumers. In addition, research shows that a person's familiarity with a product has an inverse relationship to the ability to detect a warning, perceive the hazard and risk, and comply with the recommended hazard-avoidance behavior. Thus, warnings and instructions alone may not be effective for consumers who are familiar with fireworks.

Regarding the similar suggestion to raise awareness by focusing on educating consumers, CPSC continues to educate the public and create awareness about hazards related to fireworks through various channels, such as CPSC's OnSafety blog, posters, and fireworks demonstrations throughout the year. However, information and education campaigns alone are insufficient to mitigate the hazard. CPSC staff considers risk communication to be supplementary to, rather than a replacement for, performance requirements. Multiple factors, including who sends the message, what the message is, the channel, the receiver, and the environment, all affect the success of risk communication as a means of influencing and changing human behavior.

In addition, several of these suggestions are not within CPSC's authority to require. The Federal Hazardous Substances Act (FHSA) authorizes CPSC to classify a "hazardous substance" as a "banned hazardous substance" under certain circumstances, and as part of this authority, the Commission may also issue standards for products that qualify as "hazardous substances," such as performance standards and design standards, and requirements for labeling and instructions. Forester v. Consumer Product Safety Comm'n, 559 F.2d 774, 783 (D.C. Cir. 1977). Therefore, CPSC does not have authority to require consumers to receive training, establish designated-use locations, establish age restrictions for buying or using fireworks, require consumers to sign waivers, require insurance, or require background checks. Similarly, CPSC does not have authority to establish requirements on how consumers must use products. State or local jurisdictions may have authority to implement some of these suggested alternatives. CPSC also notes that some of these alternatives may not be effective at improving consumer safety because they do not affect the safety of the devices or how consumers use them.

The suggestion to limit the use of fireworks to certified professionals only is akin to banning all consumer fireworks. CPSC does not believe that such a broad approach is warranted to provide for consumer safety, and CPSC has selected targeted regulatory provisions to address consumer safety, without prohibiting the sale of all consumer fireworks.

Staff agrees that with greater quality control, the hazards of fireworks devices could be reduced.

Staff believes electronic ignition devices could be an option, but these devices would need to be explored for other potential hazards these devices could present. Staff believes making electronic ignition a requirement, however, would be too costly and burdensome to industry, when the current fuse-burn time requirements are effective.

c. Injuries associated with fireworks

Comment Summary:
CPSC received comments noting that injuries involving fireworks are commonly the result of misuse, and therefore, the proposed testing, performance, and design requirements would not be an effective way to reduce injuries.

Response:
CPSC's National Electronic Injury Surveillance System (NEISS) data do not provide sufficient specificity to determine whether an incident resulted from misuse. However, to collect more detail about incidents, staff annually conducts in-depth investigations (IDIs), by telephone, of cases that occur during the 1-month period around the 4th of July. In 2015,[35] staff completed 31 IDIs, of which 16 cases involved misuse, 11 resulted from malfunctions, and 4 involved debris. In 2016,[36] staff completed 27 IDIs, of which 8 involved misuse, 18 resulted from malfunctions, and 1 from debris. In 2017,[37] staff completed 29 IDIs, of which 14 involved misuse, 13 malfunction, and 2 unknown. Although IDIs do not provide a statistical representation of incident types, this information suggests that many incidents do not involve misuse.

Testing, performance, design, and labeling requirements are already required under current regulations (16 CFR parts 1500 and 1507). The draft additions to the current regulations are intended to limit the potential energetic force of a fireworks device, which may reduce the severity of an injury, including cases of misuse, as well as address other hazards associated with normally functioning or malfunctioning fireworks devices. For example, in 2015 two misuse incidents involved an individual putting a reloadable shell upside down in the tube. In 2016, two misuse incidents involved an individual placing a device on a surface that was not sufficiently flat. Changes in the regulations might reduce the injury severity in such incidents, when a highly explosive device functions near a user, rather than in the air.

Comment Summary:
CPSC received comments stating that fireworks safety has improved and injuries have declined, suggesting that further regulations are unnecessary. Commenters stated that injury rates have not increased although fireworks consumption and use have increased. Commenters also stated that

[35] Yongling Tu, U.S. Consumer Product Safety Commission, "2015 Fireworks Annual Report" (June 2016), available at: https://cpsc.gov/s3fs-public/Fireworks_Report_2015FINALCLEARED.pdf.
[36] Yongling Tu, U.S. Consumer Product Safety Commission, "2016 Fireworks Annual Report" (June 2017), available at: https://cpsc.gov/s3fs-public/Fireworks_Report_2016.pdf?t.YHKjE9bFiabmirA.4NJJST.5SUWIQJ.
[37] Yongling Tu and Jason Ng, U.S. Consumer Product Safety Commission, "2017 Fireworks Annual Report" (June 2018), available at: https://cpsc.gov/s3fs-public/Fireworks_Report_2017.pdf?Jr0lMG0Z5QYQMTyUtYr_3GR.991BKn4l.

injury rates have not increased in states that have lifted restrictions on fireworks, suggesting that injury rates are not related to the restrictiveness of fireworks regulations.

Response:
CPSC staff does not have any information about injury rates at the state level. However, at a national level there is no statistically significant trend, either increasing or decreasing, in the estimated fireworks-related injuries treated in U.S. hospital emergency departments from 2002 to 2017.[38] Although several states have reduced restrictions on fireworks, the requirements for fireworks under the FHSA still apply in those states, so conclusions regarding the effectiveness of federal regulations cannot be supported by such a comparison. Staff also notes the limited nature of this recommended rulemaking, which includes staff recommendations for only three substantive revisions to existing requirements and additional non-substantive conforming changes.

Comment Summary:
CPSC received comments suggesting that the CPSC Fireworks Injury Report does not support the NPR. Commenters noted that the devices most commonly associated with injuries in the report are sparklers, which are not addressed in the NPR. Commenters also noted that the information CPSC receives could be inaccurate (*e.g.*, inaccurate patient statements, erroneous reporting) and the causation of injuries in the report is not conclusive enough to support rulemaking.

Response:
The NEISS data come from a statistical sample of approximately 100 hospital emergency departments (ED). Trained coders at the hospitals review every ED record, and they abstract reportable records into a PC-NEISS application, which is then transmitted to CPSC. National estimates (with corresponding confidence intervals) are calculated based on the statistical design of the NEISS. CPSC staff conducts on-site evaluations at least annually at every NEISS hospital to verify the accuracy and integrity of the reporting. In addition, CPSC assigns some individual cases for a follow-up investigation with the injured person using a structured questionnaire or CPSC field staff to obtain additional information.

As the 2016 Fireworks Annual Report indicates, in 2016, approximately 12 percent of the estimated fireworks-related injuries treated in U.S. EDs involved sparklers. This percentage is greater than several other categories of devices, but is also smaller than some, such as reloadable shells, which were involved in 14 percent of injuries and are addressed in this recommended final rule. According to the 2017 Fireworks Annual Report, in 2017, approximately 14 percent of the estimated fireworks-related injuries treated in U.S. EDs involved sparklers. These percentages do not reflect the extent or severity of injuries associated with respective products. The suggestion to adopt regulations to address sparkler-related injuries is discussed below (section 14.b. of this comment section), in response to comments regarding sparklers.

[38] Yongling Tu and Jason Ng, U.S. Consumer Product Safety Commission, "2017 Fireworks Annual Report" (June 2018), available at: https://cpsc.gov/s3fs-public/Fireworks_Report_2017.pdf?Jr0lMG0Z5QYQMTyUtYr_3GR.991BKn4l.

d. Black market sales, homemade devices, and unreliable products

Comment Summary:
CPSC received comments expressing concern that the proposed rule would lead to a black market for non-compliant fireworks or lead to homemade devices, which would be dangerous for consumers. CPSC also received comments stating that new requirements may decrease safety because existing formulas and products have a history of safe use and consistent performance, but new requirements that require formula and product changes would not provide the same certainty and may not function properly or safely.

Response:
CPSC has considered this issue in previous rulemakings regarding fireworks. In 1976, when considering regulations on firecrackers, the Commission heard evidence on this issue and stated: "The evidence of record indicates that a strong probability exists that any ban on firecrackers will increase the availability and use of illegal and homemade devices."41 Fed. Reg. 9512 (March 4, 1976). In its findings of fact, the Commission concluded:

- *"A ban on all firecrackers will result in an increase in bootlegging or clandestine sales of firecrackers including larger more dangerous Class B firecrackers."*
- *"A ban on all firecrackers will increase the incidence of homemade bombs which are in many cases more dangerous than production firecrackers."*
- *"The allowance of some form of firecracker will to some degree reduce the extent of bootlegging and homemade devices."*

Id. at 9523. The Commission determined that it could best balance competing factors, including improving consumer safety and reducing the likelihood of illegal and homemade devices, by allowing some form of the devices, specifically, a form with less explosive force. Id. at 9519.

These findings are likely to hold true for aerial devices as well. However, as stated above, the recommended final rule does not eliminate any category of fireworks devices, as a whole. For example, aerial devices, including mine and shell devices, and reloadable tube devices, remain permissible under the recommended final rule. Like with firecrackers, the existing rule and recommended final rule limit the explosive force of aerial devices, without banning them, with the goal of improving consumer safety, while limiting the motivation for "bootlegging and homemade devices."

e. Defer to state and local jurisdictions

Comment Summary:
CPSC received comments stating that fireworks regulations should be left to states and local governments. Commenters noted that state and local governments already restrict fireworks, are better able to require permits, can reflect differing needs and desires of a community, and can use local law enforcement to address hazardous misuse.

Response:
CPSC staff believes that several requirements in the recommended final rule are necessary for public health and safety and other revisions make useful clarifications. Therefore, it is appropriate for the Commission to adopt the recommended final rule. A federal standard can address consumer safety issues uniformly nationwide, providing greater consistency in the safety of products consumers can obtain and use across jurisdictions. States and local jurisdictions may issue requirements for fireworks as well, as long as those requirements provide a higher degree of protection.

3. Definitions

Comment Summary:
CPSC received comments that expressed support for the proposed definitions, noting that the definitions are consistent with industry practice and voluntary standards. CPSC also received comments that opposed adding definitions or opposed specific proposed definitions. With respect to specific definitions, commenters noted that:

- the definition of "lift charge" should explicitly apply to all aerial devices, including shells, shots, mines, and comets; and
- "pyrotechnic composition" should be defined as a mixture of elements or compounds that is capable of self-contained exothermic reaction, for the production of heat, light, gas, smoke, propulsion, and/or sound.

Response:
Staff believes that the APA Standard 87-1 definitions most accurately represent the industry understanding of pyrotechnic composition and lift charge. The definitions the commenters proposed are not significantly different from the ones in the NPR and recommended final rule, and staff believes they do not add any further understanding or clarification of the terms.

- *APA Standard 87-1 defines "pyrotechnic composition" in section 2.6.2 as "A chemical mixture which on burning, and without explosion, produces visible or brilliant displays or white lights, or whistles or motion." Staff believes that this definition accurately describes "pyrotechnic composition." For this reason, and to align with the industry standard, staff believes it is appropriate to incorporate by reference the definition of "pyrotechnic composition," as set forth in APA Standard 87-1, section 2.6.2.*
- *APA Standard 87-1 also defines "lift charge" in section 2.10 as "Pyrotechnic composition used to propel a component of a mine or shell device into the air. Lift charge is limited to black powder (potassium nitrate, sulfur, and charcoal) or similar pyrotechnic composition without metallic fuel." Staff believes that this definition accurately describes this term. For this reason, and for consistency with the comparable requirements in APA Standard 87-1, staff believes it is appropriate to incorporate by reference the definition of "lift charge," as set forth in APA Standard 87-1, section 2.10. Staff observes that the devices the commenter noted—shells, shots, mines, and comets—are all subsets of the term "mine and shell device" used in the proposed definition.*

4. Clarifying Requirements Regarding "Aerial Bombs"

Comment Summary:
CPSC received a comment supporting the proposed definition of "aerial bomb" and the proposed removal of the reference to "aerial bombs" from 16 CFR § 1500.17(a)(3). CPSC also received a comment opposing the proposed definition, stating that the definition does not align with the historical definition of powerful devices that were not intended to produce an audible effect. The same commenter opposed removing "aerial bomb" from 16 CFR § 1500.17(a)(3), stating that it is a useful example of the types of devices addressed in that section.

Response:
This regulatory change is intended to eliminate an inconsistency in the regulations, as aerial bombs cannot both be limited and banned at the same time. Section 1500.17(a)(3) effectively limits the devices to 2 grains, and § 1500.17(a)(8) bans them. Staff believes § 1500.17(a)(8) is the appropriate location for this term because an aerial bomb's sole function is to produce audible effects without any visual effects.

5. Audible Effects

    a. Support for applying the 2-grain pyrotechnic composition limit to devices containing fine mesh metal powder in burst charges.

Comment Summary:
CPSC received comments supporting the Commission's proposal to replace the current first step in 16 CFR § 1500.17(a)(3), determining whether a device is "intended to produce audible effects," with a limit on fine mesh metals. Commenters stated that the current method, which involves listening to the sound a device produces, is problematic because it is subjective, results are not repeatable or quantifiable, and several factors can cause results to vary (*e.g.*, human perception; environmental conditions that impact sound or the perception of sound; and variability of products due to material, manufacturing, storage, and shipping conditions).

Commenters expressed support for the proposed identification method in the NPR because it is an objective standard, which makes enforcement fair and predictable. Commenters also supported aligning with the AFSL standard and APA Standard 87-1 because it would improve clarity, consistency, and those standards represent the industry's determination of the level of fine mesh metals that is necessary for functioning without generating excess explosive force. CPSC also received comments stating that the proposal aligns with the purpose of 16 CFR § 1500.17(a)(3) better than the current method. Commenters noted that the purpose of the regulation is to limit the explosive force of devices to reduce the hazard to consumers and that testing has shown that fine mesh metals increase the explosive force of devices.

Response:
CPSC staff agrees that the proposed change to § 1500.17(a)(3) will provide an objective and repeatable test method for assessing fireworks to limit explosive force that will align with voluntary standards and be easier to apply in the field than the current approach.

Comment Summary:
APA's and AFSL's joint comment included testing data that AFSL collected through Bureau Veritas Consumer Product Services, Inc.'s (BV) testing.

In 2017, AFSL commissioned BV to conduct testing to determine: (1) the percentage of AFSL-certified aerial fireworks currently on the market that have various percentages of aluminum (Al), and magnesium; and (2) the correlation between X-ray fluorescence Spectroscopy (XRF) measurement and inductively coupled plasma-optical emission spectroscopy (ICP-OES), or so-called "wet chemistry." The data show:

1) BV data show 92.4 percent of mine and shell devices (MSDV) tested would be compliant with the proposed regulation and contamination allowance (≤1% Al) and 78.4 percent of reloadable tube aerial shell devices (RTAS) tested would be compliant with the proposed regulation and contamination allowance (≤1% Al).

2) The XRF results for screening metal fuel in break charges are reliable when compared with ICP-OES testing of the same samples. There was an average of about 0.15 percent (~1500 ppm) variability between the two analytical techniques. Additionally, BV screened 56 samples by XRF and then compared the results to ICP-OES results of the same samples.

In 2016, AFSL commissioned BV to conduct testing to measure the recoil force from reloadable tube aerial shells (RTAS) with specially manufactured canister-shaped shells prepared with known, varying total weight percentage quantities of fine mesh (130 mesh) aluminum metal particles. BV data show that there is an approximately three percent increase in the energy contained in a break charge for every one percent increase in fine mesh metal (Al) content.

Response:
Staff agrees with BV's interpretation of the test results. Results show that the majority of devices currently on the market would not violate the recommended final rule. Staff also notes that the 7.6 percent of MSDV and the 21.6 percent of RTAS devices that would not be compliant with the recommended regulation, are also not compliant with the current AFSL Standard, as well as APA Standard 87-1. Staff has found similar results with the comparison between XRF and ICP-OES. Staff found a 0.254 percent difference between the XRF and the ICP-OES readings for samples containing less than 2 percent aluminum, with the XRF reading being higher than the ICP-OES reading 75 percent of the time. A low percent difference, combined with the finding that XRF readings are generally higher than ICP-OES readings, indicates that XRF is useful as a screening tool. This means that it is unlikely that a less than 1 percent reading on the XRF would have a reading of more than 1 percent via quantification by ICP-OES.

The testing of the recoil force demonstrates the consistency between limiting metallic content in break charges and the intended safety purpose of § 1500.17(a)(3)—namely, to limit the explosive power of devices, to reduce injuries associated with more explosive devices. Additionally, adding aluminum or other metallic content to an energetic material may increase sensitivity to impact, spark, and friction, which may present additional safety hazards.

b. Relationship between metal powder and hazards to consumers

Comment Summary:
CPSC received comments stating that the proposed method of identifying devices that are subject to 16 CFR § 1500.17(a)(3) would be ineffective at reducing injuries. Commenters stated that injuries result from misuse, not metal powder, so the proposed regulation would not reduce injuries. Commenters noted that small, non-aerial devices can pose more of a hazard than aerial devices. Commenters also stated that the lift charge poses more of a risk to consumers than the break charge, which is not addressed by the proposed rule. These commenters stated that the lift charge is associated with injuries because it propels a device, which can result in blunt-force trauma; whereas, they argue, a burst charge functions high in the air, posing little risk to consumers.

Response:
Staff disagrees that the proposed method would be ineffective at reducing injuries. The method limits break charges containing metal powder less than 100 mesh to 130 mg. This limits the explosive force of fireworks devices containing greater than 130 mg, and therefore, staff believes that when injuries do occur, including in cases of misuse, they will be less severe. Small, non-aerial devices, such as sparklers, are the cause of the majority of fireworks-related injuries; however, they are not the cause of the most severe fireworks-related injuries. Additionally, as described elsewhere in this memorandum, many incidents do not involve misuse.

Regarding the comment that the rule should address lift charge, staff agrees that the lift charge can pose a risk to consumers. Although the limit on metal content of powder does not address the lift charge, other provisions of the recommended final rule do. Staff recommends two requirements to address highly explosive aerial devices: one limits the fine mesh metal in the burst charge, and the other sets device-specific limits on the chemical composition and pyrotechnic weight of aerial devices and their components. As part of the device-specific limits, the recommended final rule would limit the lift charge to a maximum of 20 grams, which is the current industry standard. The recommended final rule would also limit the lift charge in mine and shell devices and aerial shells with reloadable tubes to black powder (potassium nitrate, sulfur, and charcoal) or similar pyrotechnic composition without metallic fuel. This is also already the industry standard to which the industry largely certifies under the DOT regulations. The lift charge in the fireworks device is necessary to propel the device upwards to a safe distance before it functions. Reducing the power of the lift charge further, could place consumers at a higher risk. If the device is not high enough in the air when it detonates, the break charge in the device will burst open closer to the ground, causing consumers to be more at-risk of injury. Regulating lift charge alone would not adequately protect against injuries. Such a rule would not address several types of incidents that occur when a lift charge functions properly but the device functions near a person for other reasons, such as tip overs, errant flight paths, and blowouts. For example, of the 29 IDIs completed in 2017, 17 percent involved tip overs; 14 percent involved debris; 7 percent involved errant flight paths; 6 percent involved blowout or backfire; and many more involved circumstances that a functioning lift charge would not have mitigated.

Comment Summary:
CPSC received comments stating that there is no link between injuries and the presence of metal powder in fireworks. Commenters asserted that black powder can be as powerful as metal powder; hybrid powders are safer than flash powder; the low rate of injuries associated with professional-grade devices that contain metal powder demonstrates that it does not contribute to injuries; and there is no data showing that the current level (or any level) of metal powder in fireworks increases the hazard to consumers or causes injuries.

Response:
Staff does not have specific data available from IDIs and other reports to establish a direct link between varying amounts of metal powder and severity of injuries. However, staff has assessed that the increased energy metal powders generate can result in more severe injuries. The recommended final rule limits burst charges containing metal powder less than 100 mesh in particle size to 130 mg. This will limit the explosive power of devices containing greater than 130 mg of break charge. Similar amounts of a typical metallic fuel, such as flash powder (a mixture of perchlorate and aluminum) and black powder (a mixture of charcoal, sulfur, and saltpeter), do not produce the same heat and energy when detonated. Commercial black powder, when ignited, has an average heat reaction of 0.66 kcal/g, as compared with flash powder (which contains metallic fuel), which has a heat reaction of 1.7 kcal/g. Consequently, flash powder has almost 3 times as much energy per mass as black powder. A report by Tang, et al., states that adding metals or metal alloys to black powder formulations may generate unnecessary pressure, causing danger to the operators or audience.[39] Furthermore, BV data show that there is an approximately 3 percent increase in the energy contained in a break charge for every 1 percent increase in fine mesh metal (Al) content. This is consistent with the heat reactions of black powder, as compared to flash powder. Staff believes the comparison to the rate of injuries in professional-grade devices is inappropriate, given that professionals (not the general public) are trained in the use of those devices and safety measures associated with them.

Comment Summary:
CPSC received comments that took issue with CPSC's proposed method of assessing explosive force, asserting that CPSC should consider the total explosive power of a device. Commenters stated that the proposed method only focuses on whether there is metal powder in a device and does not consider other factors that affect explosive power. Other relevant factors include shell construction (*e.g.*, thickness, tightness of wrappings), the amount of pyrotechnic composition in a burst charge, and the explosive efficiency of the powder. Commenters provided examples to illustrate that considering metal powder alone could result in devices with greater explosive power passing the proposed requirement and devices with less explosive power failing. In one example, a commenter claimed that a device with a 1-gram burst charge made up of 99 percent black powder and 1 percent metal powder would fail the proposed standard, but a device with a 10-gram burst charge containing only black powder would pass, although the latter device has far more explosive power. In another example, one device is a 500-gram cake shot with a 4-gram burst per shot, made of 100 percent black powder. The commenter compared this device to a 200-gram cake shot with a 2-gram burst charge per shot, made of 99 percent black powder and 1 percent metal powder. The commenter stated that the first device has far more explosive power

[39] Andrew Tang, Hilary Chen, and Andy Tang, "A New and Fast Method of Evaluating Powder Energy," *Journal of Pyrotechnics*, Issue 28, 2009.

in the burst charge than the second device, but the proposed requirement would only prohibit the first device.

Response:
Staff agrees that shell construction, and other factors, can affect explosive power. The recommended final rule includes several provisions that are aimed at reducing the explosive power of fireworks devices, to reduce the likelihood and severity of injuries from devices. One draft requirement limits burst charges that contain metal powder less than 100 mesh to 130 mg. Another draft requirement limits the total chemical composition and pyrotechnic weight in all aerial devices. Under these draft requirements, burst charges that do not contain metallic fuel less than 100 mesh in particle size are limited to 25 percent of the total chemical composition in the component. The various limits in the different types of burst charge powder in these provisions take into account that fine mesh metallic fuel makes the burst charge more energetic. Staff agrees that limiting metallic fuel in break charges alone would overlook other factors that contribute to the energetic force of a device. This is the reason that the recommended final rule takes into account total chemical composition. The examples the commenters provided do not provide sufficient information to determine whether the fireworks device would comply with the recommended final rule.

Comment Summary:
CPSC received comments about the appropriateness of limiting the explosive force of devices. Commenters noted that the explosive force of a device may not indicate the hazard it poses because most injuries are associated with smaller, weaker devices, and there are no data linking explosive power to injuries (stating that, during testing, CPSC staff could not find a correlation between the pressure released from a device and injury potential).

Response:
Although staff agrees that most fireworks-related injuries are due to smaller devices, the most severe injuries are due to larger aerial devices. By limiting the total chemical composition, as well as the break charge in devices, staff aims to reduce injury potential and severity. Fine mesh metallic Al or Mg increases the explosive power of devices. This is why industry standards limit the use of metallic fuel in burst charges to 2 grains. The recommended final rule aligns with those standards. Staff could not correlate the pressure released to a specific injury; however, staff concluded that a device that released a larger pressure when functioning near a user would result in a greater injury than a device that released a smaller pressure. This conclusion is consistent with common approaches to explosive safety (e.g., Department of Defense DoD Manual 6055.09-M -- DoD Ammunition and Explosives Safety Standards).

Comment Summary:
CPSC received comments stating that the proposed requirement could increase hazards to consumers. Commenters stated that reducing the amount of powder in a lift charge or using black powder instead of hybrid powders in devices could increase the risk to consumers because: (1) devices could detonate at lower heights because there is less lift power and devices would be heavier; (2) more black powder than is currently present in devices would be necessary to break shells, which would increase the explosive content of devices; and (3) burst charges would be weaker than in current devices, which could result in improper lighting of effects, devices not

breaking apart properly, and effects or debris falling while ignited. Commenters noted that the metal powders that are currently in fireworks devices have tested ingredients that are well-known and have predictable properties. Commenters asserted that changing the powder in burst charges could result in unpredictable, unstable, unreliable, and unsafe products. They stated that substitutes for metal powder, such as "whistle compositions" and black powder, could increase risks to consumers. Commenters stated that "whistle compositions" burn rapidly and can function as flash composition, and they asserted that more information is needed to understand the safety implications of using only black powder in devices.

Response:
Staff disagrees that the recommended final rule would increase hazards to consumers. Staff agrees that if the lift charge is not sufficient to propel the device high enough, consumers would be at a higher risk of injury from the exploding device. However, staff believes that the requirements in the recommended final rule will not result in less-effective lift charges. The recommended final rule limits lift charges in mine and shell devices and aerial shells with reloadable tubes to "black powder (potassium nitrate, sulfur, and charcoal) or similar pyrotechnic composition without metallic fuel." Typically, a lift charge is made of coarse granulated black powder. As explained in Tab D, CPSC staff analyzed lift charge content and did not find any significant metallic fuels in the lift charge of these devices. Thus, devices currently on the market establish that compliant designs can be safely produced. In addition, the recommended final rule would limit the amount of lift charge powder to 20 grams per device, which is the current industry standard, suggesting that that amount of lift charge is sufficient.

Data do not support the commenters' assertion that more black powder than is currently in devices would be needed to burst open the devices. BV data show 92.4% of MSDV and 78.4% of RTAS currently on the market would comply with the draft final regulation and enforcement discretion for contamination (≤1% Al) and meet testing, performance and design requirements. This high percentage of compliance with the draft requirement suggests that compliant products function properly. Additionally, the recommended final rule limits the total chemical composition in all aerial devices, including devices with a burst charge consisting of black powder. In a device containing only black powder in the break charge, the recommended regulation would limit the amount of black powder to 25% of the total weight of the chemical composition of the component. The commenter states that the metal powders that are currently in fireworks devices have tested ingredients that are well-known and have predictable properties. However, commenters did not provide any references to studies. The fact that the recommended final rule aligns with the industry standard and data show that the majority of samples on the market meet the draft requirement, demonstrate that a burst charge that does not contain metallic fuel is sufficient for fireworks to function properly.

In years of testing, staff has not encountered any "whistle compositions" used as break charges to date, despite the DOT use of the APA 87-1 requirements that CPSC is mirroring, and believe this to be unlikely due to the sensitivity during manufacturing and that these compositions become less efficient over time.

Comment Summary:
CPSC received a comment stating that commercial black powder, when ignited, has an average heat of reaction of 0.66 kcal/g, as compared with flash powder (which contains metal), which has a heat reaction of 1.7 kcal/g. Consequently, flash powder has almost 3 times as much energy per mass as black powder.

Response:
As this commenter states, flash powder (a mixture of perchlorate (oxidizer) and aluminum or magnesium (fuel)) is more energetic than black powder. Therefore, staff assesses that limiting the break charge in devices that contain metallic fuel to 2 grains (130 mg) will reduce the injury potential of those devices.

Comment Summary:
CPSC received a comment disputing the applicability of the quadratic analysis that the NPR briefing package cites from Akhavan, J. (2011), *The Chemistry of Explosives*, Cambridge, UK: The Royal Society of Chemistry, regarding the relationship between the addition of fine mesh aluminum and the corresponding increase in energy. The information cited in the NPR package indicates that a 1 percent addition of aluminum increases the energy of a device by 3 percent, up to about 25 percent aluminum, at which point the explosive power begins to diminish. The briefing package explains that this information is based on "TNT equivalence," which is a normalization technique for equating properties of an explosive to TNT, which serves as a standard. The commenter states that TNT is not appropriate to determine the effect on energy for pyrotechnic burst charges because TNT functions differently than pyrotechnic compositions suitable for fireworks burst charges.

Response:
The oxidation of aluminum is highly exothermic, producing a heat of combustion of -1590kJ, as shown by the following reaction.

$$Al_{(s)} + 1½O_{2(g)} \rightarrow Al_2O_{3(s)} \quad \Delta Hc = -1590kJ$$ [40]

In an oxygen-deficient explosive composition, the aluminum reacts with the gaseous products, particularly in compositions where no free oxygen exists, as shown in the following reactions.[41,42]

1) $3CO_{2(g)} + 2Al_{(s)} \rightarrow 3CO_{(g)} + Al_2O_{3(s)} \quad \Delta Hc = -741kJ$
2) $3H_2O_{(g)} + 2Al_{(s)} \rightarrow 3H_{2(g)} + Al_2O_{3(s)} \quad \Delta Hc = -866kJ$
3) $3CO_{(g)} + 2Al_{(s)} \rightarrow 3C_{(s)} + Al_2O_{3(s)} \quad \Delta Hc = -1251kJ$

[40] Chetah, ASTM computer program for chemical thermodynamic and energy release evaluation, ver. 7.3
[41] Knock, C., Lecture Notes "Explosive Ordinance and Engineering Thermodynamics", Department of Environmental and Ordinance Systems, RMCS, Cranfield University, 2004.
[42] Tang, A. (2009). "A New and Fast Method of Evaluating Powder Energy" Journal of Pyrotechnics. Issue 28, Pages 51-64

The volume of gas does not change in Reactions 1 and 2. Consequently, the increase in the output of heat from the oxidation of aluminum prolongs the presence of high pressures.[43] *However, there is a limit to the amount of aluminum that can be added to an explosive composition before competing reactions begin to dominate.*

In Reaction 3, the addition of aluminum increases the heat of explosion (Q), but the volume (V) of gas decreases (Table 1 in Tab D). To obtain the explosive power, the heat of explosion and the volume of gas are multiplied (Column 4 in Table 1).[9] *Table 1 demonstrates that as aluminum is increased, so is the amount of explosive power, where it reaches a maximum at 18 percent aluminum content. Trinitrotoluene (TNT) is the standard for comparing explosive power of different explosives, so research into the effects of explosives is often compared with TNT. The term "Relative Effectiveness Factor," or RE factor, is a normalization technique for equating the energy of an explosive to TNT. The greater the RE Factor, the more powerful the explosive.*

When aluminum is added to black powder, the aluminum and carbon will compete for the oxidizer and will result in an oxygen deficiency.[44] *The reactions that transpire during the after burn, as described above in Reactions 1-3, are identical to that of the mixtures of TNT/Aluminum. Therefore, trends found in TNT/Al mixtures will be identical to trends found in black powder/aluminum mixtures. This is also described in the LSC memorandum in Tab D.*

c. Injuries and metal powder content

Comment Summary:
CPSC received comments stating that fireworks injury data do not support the proposed regulatory change. Commenters noted that, according to CPSC's recent Fireworks Annual Reports, most injuries are caused by misuse or by devices that do not contain metal powder and would not be subject to 16 CFR § 1500.17(a)(3), such as sparklers. Most injuries are not associated with break charges or aerial devices that fall under the 2-grain limit. As a result, commenters stated that the proposed change would not prevent or reduce injuries.

Response:
Although the commenter is correct that many of the injuries associated with fireworks involve smaller devices, such as sparklers, and sparklers do not contain metallic fuel, many incidents also involve the types of devices that would be subject to § 1500.17(a)(3). These devices are associated with the more severe injuries and fatalities, and they commonly contain metallic fuels in the burst charge. CPSC staff compiles data on non-occupational, fireworks-related deaths and injuries; the most recent compilations are the 2015 Fireworks Annual Report (issued June 2016), the 2016 Fireworks Annual Report (issued June 2017), and the 2017 Fireworks Annual Report (issued June 2018). In 2015, 9 of the 11 deaths were caused by reloadable aerial devices, which are devices that would fall under the 2 grain limit, if they contained metallic fuel less than 100 mesh in particle size. In 2016, 3 of the 4 reported fatalities involved such devices (2 involved

[43] Akhavan, J. (2011). The Chemistry of Explosives. Cambridge, UK: The Royal Society of Chemistry.
[44] Myatt, S, G, Davies M. L. (2005). Explosive output from black powder/metal compositions.

mortar devices and 1 involved a tube device). In 2017, 4 (or 5)[45] of the 8 reported deaths involved such devices.

Looking at the NEISS estimated injuries during a 1-month special study in 2016, the device categories associated with the largest numbers of injuries were firecrackers (17 percent), sparklers (12 percent), and reloadable shells (14 percent). CPSC staff conducted In-Depth Investigations (IDIs) of a portion of the 2016 injuries (which is not a statistically representative sample due to selection criteria and participation). For the 4 IDI incidents in which victims reported suffering or possibly suffering long-term effects from their injuries, 2 involved reloadable shells and 1 involved a mortar tube. Looking at the NEISS estimated injuries during a 1-month special study in 2017, the device categories associated with the largest numbers of injuries were sparklers (14 percent), reloadable shells (12 percent), and firecrackers (10 percent).

Taken together, the incident data suggest that one of the largest categories of fireworks associated with injuries are devices such as reloadable shells, mortar devices, and tube devices, which are the types of aerial devices that would be subject to § 1500.17(a)(3). These devices are associated with most of the fatal fireworks incidents and are involved in more severe or long-term injury incidents. For this reason, the rule aims to limit the more powerful devices that cause the most severe injuries.

Comment Summary:
CPSC received comments stating that the NPR did not provide information about the energy, pyrotechnic composition, or metal content of the devices involved in the incidents CPSC cites as being related to reloadable aerial shells. A commenter stated that CPSC would need a 30-year time series of injuries and burst charge composition to show a relationship between fine mesh metal in burst charges and injuries. The commenter further stated that the injury information would need to be normalized by sales per capita, exclude illegal fireworks, and account for increased reporting due to technology.

Response:
Aerial fireworks devices that are involved in incidents that result in injuries or deaths generally function and explode when the incident occurs, making it impossible to retrieve or examine the device to analyze its energy, pyrotechnic composition, or metal content. Because of this, CPSC considered the types of devices involved in these incidents, as well as the typical pyrotechnic composition and metal content in these devices, based on laboratory analyses. Although staff cannot examine the particular devices involved in incidents, staff can determine the types and quantities of material in similar devices.

Staff does not believe that a 30-year time series is necessary to see the relationship between fine mesh metal in burst charges and injuries; the incident data described in this briefing package demonstrate that relationship. Furthermore, the data that the commenter describes are not available to CPSC. Not only is the information needed for such a series absent from the NEISS injury cases, but often, even the type of fireworks device is unknown, making it difficult, if not

[45] One fatal incident in 2017 involved a firework device that was in a "PVC pipe." Without more detail it is not certain whether the device was a reloadable tube device or another type of device that was placed into the pipe.

impossible, to obtain the information needed for the type of study the commenter suggests. The commenter's suggestion that information be normalized to account for increased reporting due to technology would be unnecessary because technology has no effect on reporting of incidents in NEISS. The commenter's suggestion is based on the assumption that the number of incidents CPSC is aware of depends on victims' reporting, but that is not how CPSC obtains most of its data. Rather, a hospital ED record is entered into NEISS, if the injury incident involved a consumer product (e.g., fireworks).

d. Need for metallic powder in fireworks devices

Comment Summary:
CPSC received comments stating that metal powder is necessary for fireworks devices to function properly, for break charges to operate effectively, and for devices to produce effects. Commenters stated that metal powder is necessary to produce and disperse certain effects in fireworks devices, such as strobing, crackling, colors, designs, stars, illumination, and reports (audible effects). Without metal powder, commenters stated that the variety and entertainment value of products would decrease. One commenter stated that manufacturers would reduce the size of break charges in aerial devices to comply with the proposed standard. Commenters noted that chemicals containing metals, such as Al (aluminum), Ti (titanium), Mg (magnesium), and Cu (copper), are integral to fireworks. CPSC also received comments stating that the fireworks industry only began using metal powder in fireworks within approximately the last 20 years.

Response:
Certain metal powders are added to fireworks for visual effects, such as adding colors to the effects. But metal powder used for visual effects is typically larger than the 100 mesh size that would be subject to draft rule § 1500.17(a)(3). Consequently, metals needed for visual effects are not affected by the draft rule. Metals under 100 mesh in size are not intended for use in visual effects, and their use creates greater injury potential in those devices. Metal fuel is added to burst charges to increase the heat and energy produced. In addition, it should be noted that titanium under 100 mesh and magnesium metal are already prohibited by current CPSC regulations in § 1507.2.

BV data show 92.4 percent of MSDV and 78.4 percent of RTAS currently on the market would comply with the recommended regulation and enforcement discretion for contamination (≤1% Al) and meet testing, performance, and design requirements. This high percentage of compliance with the draft requirements suggests that compliant products operate effectively without fine mesh metal powder in the burst charge. Accordingly, there is no evidence to suggest the recommended final rule would eliminate the entertainment value of devices currently on the market.

Comment Summary:
CPSC received comments stating that the presence of metal powder is not an appropriate standard for identifying devices that are "intended to produce audible effects" because metal powder is commonly used to distribute visual effects, not audible effects. CPSC also received comments stating that the presence of metal powder is not an appropriate way of limiting

explosive force because black powder and compression causes the explosion of devices; metal powder merely produces effects.

Response:
Comments stating that metallic fuel merely produces visual effects are incorrect. Fine mesh metallic fuel is added to burst charges of devices to increase the heat and energy of that device, also increasing the explosive force of devices. BV data submitted in the joint AFSL and APA comments, confirm that there is an approximately 3 percent increase in the energy contained in a break charge for every 1 percent increase in fine mesh metal (Al) content. On the other hand, the recommended final rule does not limit metals greater than 100 mesh, which are used for visual effects. Moreover, APA Standard 87-1 aligns with staff's conclusion that metal powder is not used in fireworks solely for visual effects. The APA Standard 87-1 states: ". . . Any burst charge containing metallic powder (such as Magnalium or aluminum) less than 100 mesh in particle size, is considered to be intended to produce an audible effect, and is limited to 130 mg in 1.4G fireworks devices." Also, as noted elsewhere, limiting fine mesh metal powder in the burst charge is only one of the recommended final rule requirements that would address the explosive force of fireworks devices. The draft rule also sets limits on chemical and pyrotechnic composition for aerial devices. This would address the explosive force of black powder.

Comment Summary:
CPSC received comments stating that metal powder is the least expensive and most effective way to fuel burst charges and that there is no safe replacement for metal powder that would produce the same effects.

Response:
Staff believes that non-metal powder is an effective way to fuel burst charges. Staff has found shells that do not contain fine mesh metallic fuel that function effectively. In addition, BV data show 92.4 percent of MSDV and 78.4 percent of RTAS currently on the market would comply with the proposed regulation and enforcement discretion for contamination (≤1% Al) and meet testing, performance, and design requirements, indicating that devices that conform to the recommended final rule would function properly. Moreover, current industry standards in place for decades already prohibit the use of fine mesh metallic fuels when a burst charge contains more than 130 mg of pyrotechnic composition, just as the recommended final rule does, suggesting that devices can function effectively and safely under these limits.

Staff assesses that the costs of switching from metallic and hybrid powders to black powder will not create a significant economic impact for firms that have to change formulations. Staff compared wholesale prices of ingredients used to make flash powder to ingredients used to create black powder and found black powder formulations to be less expensive than flash powder.[46] Wholesale prices for flash powders range from approximately 2.75 to 3.94 times greater than black powder. Staff notes that some flash powder formulations can be slightly less expensive than black powder formulations to produce the same level of explosive force.

[46] CPSC Memorandum from Mark Bailey to Rodney Valliere, "Final Regulatory Analysis of the Amendments to the Fireworks Regulations," U.S. Consumer Product Safety Commission, Bethesda, MD (March 23, 2018).

e. Considerations regarding the test method and screening equipment that could be used to meet the proposed requirements

Comment Summary:
CPSC received comments supporting the use of XRF to test the metal powder content in products. Commenters stated that XRF testing is cost-effective, provides consistent results, and is portable, which allows for field testing. Commenters noted that a portable test method is important because most fireworks testing occurs near manufacturing facilities. AFSL noted that it tested products using XRF and ICP-OES and found that XRF and ICP-OES results for the same samples were generally consistent. AFSL reported that the average difference in readings between XRF and ICP-OES was 0.150 percent, with ICP-OES readings generally lower than XRF readings. APA and AFSL commented that XRF is the best available testing device that can be used in the field. CPSC also received comments stating that XRF screening is appropriate as long as there is an allowance to accommodate variations in readings (see discussion of contamination allowance comments).

Response:
Staff agrees with the commenters that XRF is an accurate screening tool. As described above, BV testing data show that XRF results for screening metal fuel in break charges are reliable when compared with ICP-OES testing of the same samples, with an average of about 0.15 percent (~1500 ppm) difference between the readings for the two analytical techniques. CPSC data showed similar results. CPSC staff found the percent difference between XRF and ICP-OES for samples containing less than 2 percent aluminum was 0.254 percent. Given the consistency in readings across screening methods and known quantities of fine mesh metal content, XRF is a reliable and effective screening tool for metallic fuels in the break charge powder.

Regarding comments requesting an allowance to accommodate variations in XRF readings, staff recognizes the potential for variations in readings. Staff notes that the recommended final rule provides that a burst charge that contains any amount of metallic powder less than 100 mesh in particle size is limited to 130 mg. However, staff recommends that the preamble state that the Commission will exercise enforcement discretion to allow up to 1 percent of metallic powder in burst charges to account for variables such as inadvertent contamination during manufacturing and possible instrument detection variability.

We also note that the draft rule does not require use of XRF. The change to a limit on fine mesh metal rather than the current "intended to produce audible effects" test would be more conducive to (the less expensive) analytical methods, such as XRF technology, if companies choose to use that method to test compliance.

Comment Summary:
CPSC received comments opposing the use of XRF testing to assess metal powder content in fireworks devices. Commenters stated that XRF screening was intended for testing solids, and is unreliable for non-homogeneous compositions and powders (non-solids). Commenters stated that XRF results can be distorted by climate and humidity, air pockets, and static created by plastic (Mylar) sheeting used to contain test samples. Commenters expressed concern that products tested in high-humidity areas, such as China, may yield different test results in a drier climate,

such as the United States, or after drying during shipment. Commenters requested that CPSC research the impact of testing conditions and the environment on test results (*e.g.*, compare test results of the same samples when tested in China and the United States), and assess the accuracy of possible test methods, before determining an appropriate method of testing fireworks devices. Commenters were concerned that without a reliable test method, importers will be unable to rely on manufacturers' test results.

Response:
Staff agrees that there is some limitation to using an XRF for analysis, as there are limitations with any analytical instrument. However, due to the lower cost and portability of the XRF, staff concludes that it is the most efficient and practical instrument for rapid field screening of break charge powder. Staff notes, however, that the recommended final rule does not require the use of XRF for testing. In 2017, AFSL commissioned BV to conduct testing to determine: (1) the percentage of AFSL-certified aerial fireworks currently on the market that have various percentages of aluminum and magnesium; and (2) the correlation between XRF measurements and inductively coupled, plasma-optical emission spectroscopy (ICP-OES), or so-called "wet chemistry." The data show:

1) BV data show 92.4 percent of MSDV tested would be compliant under the proposed regulation ≤1% Al) and 78.4 percent of RTAS tested would be compliant under the recommended regulation (≤1% Al).

2) The XRF results for screening metal fuel in break charge are reliable when compared with ICP testing of the same samples. Fifty-six samples where the XRF readings for Al ranging between 0.34 percent and 2.88 percent were also analyzed by ICP-OES for aluminum content. There was an average of about 0.15 percent (~1500 ppm) variability between the two analytical techniques. CPSC data showed similar results. The percent difference between XRF and ICP-OES for samples containing less than 2 percent aluminum was 0.254 percent, confirming that when screening for powders, it is unlikely that there will be metallic fuel present in the sample if the XRF does not detect it.[47] *These data confirm that the XRF is a reliable and effective screening tool for metallic fuels in the break charge powder.*

BV testing in China was consistent with CPSC testing performed in the United States. All proper safety protocols should be followed when handling energetic materials and XRF instruments.

Comment Summary:
CPSC received a comment stating that XRF is not appropriate for testing light elements. The commenter noted that an Environmental Protection Agency document, *SW-846 Test Method 6200: Field Portable X-Ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment*, indicates that XRF is appropriate for granular samples; XRF can generally detect and quantify elements with atomic number 16 or greater; XRF is not appropriate for light elements, such as magnesium and aluminum; variations in the character of samples (*e.g.*, particle size, uniformity, homogeneity) can result in physical matrix effects; and XRF should be used as a screening method with confirmatory analysis using other techniques, such as ICP-OES.

[47] Tab D – LSC Memorandum.

Response:
Staff agrees that there is some limitation to using an XRF for analysis, just as there are limitations with any analytical instrument. The commenter states that XRF is not appropriate for testing light elements and cites a document from 2007. XRF technology has greatly improved since 2007, and the paper does not reflect the current capabilities of the instrumentation. Due to the lower cost and portability of the XRF, it is the most efficient and practical instrument for rapid field screening of break charge powder. In 2017 AFSL commissioned BV to conduct testing to determine: (1) the percentage of AFSL-certified aerial fireworks currently on the market that have various percentages of aluminum and magnesium; and (2) the correlation between XRF measurements and inductively coupled, plasma-optical emission spectroscopy (ICP-OES), or so-called "wet chemistry." The data show:

1) BV data show 92.4 percent of MSDV tested would be compliant under the proposed regulation ≤1% Al) and 78.4 percent of RTAS tested would be compliant under the proposed regulation (≤1% Al).
2) The XRF results for screening metal fuel in break charge are reliable when compared with ICP testing of the same samples. Fifty-six samples where the XRF readings for Al ranging between 0.34 percent and 2.88 percent were also analyzed by ICP-OES for aluminum content. There was an average of about 0.15 percent (~1500 ppm) difference between the two analytical techniques. CPSC data showed similar results. The percent difference between XRF and ICP-OES for samples containing less than 2 percent aluminum was 0.254 percent, confirming that when screening for powders, it is unlikely that there will be metallic fuel present in the sample if the XRF does not detect it.[48] These data confirm that the XRF is a reliable and effective screening tool for metallic fuels in the break charge powder. We also note that the draft rule does not require use of XRF. The change to a limit on fine mesh metal rather than the current "intended to produce audible effects" test would be more conducive to (the less expensive) analytical methods, such as XRF technology, if companies choose to use that method to test compliance.

Comment Summary:
CPSC received comments opposing the use of ICP-OES testing to assess metal powder content in fireworks devices. Commenters stated that ICP-OES equipment is accurate, but is expensive and not affordable for many industry members, and small businesses, in particular. Commenters also stated that ICP testing is time-consuming and is difficult to use for fireworks because testing must occur in a laboratory, rather than in the field.

Response:
Staff agrees that ICP-OES analysis is expensive, and testing must be performed in a laboratory. However, the recommended final rule does not require the use of any specific instrument to determine compliance with the limits in § 1500.17(a)(3). Similarly, although products that are subject to a consumer product safety rule must be tested to confirm they comply with applicable regulations (15 U.S.C. § 2063(a)), those requirements do not mandate that firms use a particular method of testing products. Due to the lower cost and portability of the XRF, CPSC staff concludes that it is the most efficient, cost effective, and practical instrument for rapid field

[48] Tab D – LSC Memorandum.

screening of break charges. ICP-OES can be used for quantification and confirmation of screening results.

Comment Summary:
CPSC received comments stating that neither XRF nor ICP-OES can distinguish metals from metal compounds. Commenters stated that metal compounds (*e.g.*, aluminum silicate) are in fireworks construction materials (*e.g.*, clay, adhesives) and serve non-energetic functions (*e.g.*, anti-caking, flow agents). In contrast, metals, such as aluminum, increase the energy a device produces.

Response:
Staff tested multiple aerial shell devices to investigate if the aluminum found in the break charge powder is the result of aluminum migration into break charge from other various components of the device such as the visible effects or the clay plugs. The analysis showed that there were several devices where the effects contained large amounts of aluminum (5-6%), the clay plugs contained a small amount (0.5-1%) aluminum, and the break charge contained no aluminum. It is important to note that even though the effects are comingled with the break charge, no aluminum migration occurred. Additional testing on the lift charge inside each device revealed similar findings. Although the clay plugs are in direct contact with the lift charge, no migration occurred. Similarly, any effects that are in contact with the lift charge showed no migration of aluminum.

In order to verify that the elemental metals identified via the ICP-OES are, in fact, base elements and not metal oxides, staff studied representative aluminum and titanium samples with a Hitachi S3400N-II VP-SEM and Oxford INCA Energy 350 Energy Dispersive X-Ray Microanalysis system and compared the samples to aluminum oxide and titanium dioxide standards. Images were obtained following a modified ASTM procedure.

Comment Summary:
CPSC received comments requesting that the Commission specify a process for testing for metal powder content, to reduce variability in test results. Commenters suggested that a test procedure should require agitating samples and cleaning the sieve with solvent and distilled water between samples. Commenters also stated that test results should allow for errors, require three scans of each sample, and rely on mean results.

Response:
If the Commission issues the recommended final rule, staff would revise the Consumer Fireworks Testing Manual that describes how CPSC staff tests to determine compliance. Staff would provide specific testing procedures for the analysis of pyrotechnic powders in a fireworks device. Details regarding equipment, materials and reagents needed, and sample preparation/collection will be provided. Field screening for fine mesh metals via XRF will also include recommended settings (parameters) for the instrument. CPSC staff will update the Consumer Fireworks Testing Manual accordingly and publish it on the CPSC website. Current testing is described in Tab D – LSC memo of this briefing package.

f. Contamination allowance

Comment Summary:
CPSC received comments stating that a contamination allowance for fine mesh metal powder in break charges is necessary because several factors can contribute to its unintentional presence. These factors include contamination from other materials or effects (*e.g.*, clay plugs, lift charge, stars); large metal particles that can carry or generate fine-mesh particles; trace metals remaining in technical grade chemicals after the chemical refining process; variability of measurements; environmental and manufacturing conditions (e.g., airborne or container cross-contamination); and black powder composition. Commenters stated that achieving complete purity, particularly in light of current instrumentation, would be very expensive and likely unattainable.

Response:
Staff agrees that complete purity would be difficult because of instrument detection variability and inadvertent contamination. For this reason, staff recommends that the preamble to the recommended final rule indicate that the Commission will exercise enforcement discretion, in part to account for inadvertent contamination of fine mesh metal powder. To assess the potential for the unintentional presence of fine mesh metal powder in burst charges, staff analyzed the potential sources of migration/contamination of metallic fuel into the break charge and found the following: [49]

Clay Plugs: Staff found the majority of samples contain less than 1% of aluminum in the clay. If migration was occurring from the clay into the break charge, it would also be occurring from the break charge or effects into the clay. Various samples staff tested contained large amounts of aluminum in the break charge or effects, yet the clay still contained minimal amounts of aluminum. This confirms that little to no migration occurs from the clay into the burst charge.

Lift charge: Staff analyzed a number of lift charges and no lift charge contained Al greater than 0.05%. Sometimes the lift charge is comingled with effects. Staff found that those effects can contain large amounts of aluminum, yet the lift charge still does not contain aluminum. This confirms little to no migration occurs from the lift charge into the break charge.

Effects: Staff found that although all shells contained large amounts of aluminum in the effects (large and small), multiple shells contained no aluminum in the corresponding break charge. Even though the effects are comingled with the break charge, no migration occurred. This confirms that migration of fine mesh aluminum powder does not occur from the effects into the break charge.

Additionally, BV data show 92.4% of MSDV and 78.4% of RTAS tested would comply with the recommended regulation and enforcement discretion allowance (≤1% Al). This suggests that the vast majority of MSDV and RTAS currently on the market already meet the recommended final rule without the need for additional modifications to the manufacturing process for quality control to reduce contamination levels. Further analysis of the data show that 3.49% of MSDV and 6.6% of RTAS tested contain >6% Al. This, in conjunction with the high level of devices containing less than 1 percent fine mesh aluminum, suggests that the excessive amount of Al

[49] Tab D – LSC Memorandum.

(>6%) in both the MSDV and RTAS is not due to contamination from other materials, variability of measurements or environmental and manufacturing conditions and is likely the result of intentionally introducing the powder. Given the minimal levels of contamination evident in products currently on the market, the enforcement discretion should adequately account for this issue.

Comment Summary:
CPSC received comments stating that a contamination allowance is necessary because of variability in XRF screening. Commenters stated that XRF readings vary for lighter metals, such as aluminum and magnesium, which are the most common metals in fireworks break charges. This variation can result in compliant devices appearing to be noncompliant, and can be compounded by the heterogeneous nature of break charge compositions. Commenters noted that the variability of XRF devices can be impacted by the calibration of the instrument (*e.g.*, the level of measurements, the elements measured, and substrate materials), the sample type and related instrument settings (*e.g.*, solids, solid-type), and the amount of time allowed for the instrument to analyze a sample. Commenters noted that XRF instruments display the product's variability in accurately measuring metals, commonly as a range of parts per million.

Response:
Staff agrees that there are some limitations to all analytical instruments (which include, but are not limited to, sample preparation time, calibration, adjusting instrument settings, etc.), including XRF. In recognition of this, staff recommends that the preamble to the recommended final rule indicate that the Commission will exercise enforcement discretion not provided in APA 87-1 or the DoT regulations, in part to account for potential variability in instrument readings. Due to the lower cost and portability of the XRF, CPSC staff believes it is the most efficient, cost effective, and practical instrument for rapid field screening of break charge powder, particularly when using ICP-OES to confirm and quantify screening results. Nevertheless, the recommended final rule does not require the use of XRF, or any other particular instrument, to assess compliance with § 1500.17(a)(3).

In addition, as explained above, BV conducted testing to determine the correlation between XRF and ICP-OES measurements and found that XRF results for screening metal fuel in break charge are reliable when compared with ICP-OES testing of the same samples. BV found an average of about 0.15 percent (~1500 ppm) variability between the two analytical techniques. This data confirms that the XRF is a reliable and effective screening tool for metallic fuels in the break charge powder.

Staff also notes that commenters stated that aluminum and magnesium are the most common metals found in fireworks devices. However, magnesium is currently prohibited by CPSC regulation in § 1507.2 and BV's testing demonstrated that the break charges of most devices on the market contain ≤1% aluminum.

Comment Summary:
CPSC received comments stating that trace amounts of fine mesh metal content would not present an increased safety hazard. In particular, BV reported that it tested the recoil force of reloadable tube aerial devices prepared with known percentages of 130 mesh aluminum and

found that for every 1 percent increase in fine mesh metal (Al) content, there is approximately a 3 percent increase in energy in the break charge. Using a force measurement test method, BV also found no statistical difference in the force generated by shells containing 0 percent, 1 percent, and 2 percent fine mesh aluminum in the break charge; the increase in explosive force was only notable when the fine mesh metal powder concentration exceeded 2 percent. BV found that there was only a statistically significant increase in the recoil force generated by a device (which is a reliable analog for the total explosive force of the break charge) when there were 5 percent or 10 percent fine mesh metal concentrations in the break charge. Samples containing 10 percent aluminum generated forces above the capacity of the load cell and were not contained in the launch tube. Based on these findings, commenters stated that a 2 percent contamination allowance would be appropriate because the energy output would not create a notably greater hazard to consumers than devices containing no metal powder.

Response:
As CPSC's and BV's testing have demonstrated, there is approximately a 3 percent increase in energy in the break charge for every 1 percent increase in fine mesh metal content. The recommended final rule would ban devices that contain any amount of metallic powder less than 100 mesh in particle size in the burst charge, when the burst charge is produced by more than 2 grains of pyrotechnic content. As described elsewhere in this memorandum, this requirement aims to reduce the explosive power of devices, thereby reducing the severity and occurrence of injuries. For this reason, staff believes that it is appropriate to restrict the amount of fine mesh metal content in break charges to the greatest extent possible, and recommends aligning with the APA 87-1 limits adopted by DOT in their regulations.

However, CPSC recognizes that it may be difficult to ensure that there is no such metallic powder present due to potential contamination from visual effects or environmental contamination, and it may be difficult to consistently identify the presence of metallic powder because of detection limitations and variations in specific instruments. Consequently, staff recommends that the preamble state that the Commission will exercise enforcement discretion to allow for minimal contamination of up to, but not exceeding, 1.00 percent of metallic powder in burst charges that are subject to 1500.17(a)(3). Staff concludes that allowing up to 1.00 percent is adequate to account for contamination and instrument variation, while still reflecting the goal of increasing consumer safety but limiting fine mesh metal powder in break charges to the greatest extent possible.

As explained in detail in the LSC memorandum at Tab D and in other responses to related comments this memorandum, staff has analyzed the potential sources of migration/contamination of metallic fuel into the break charge and found that inadvertent fine mesh metal contamination from sources within a fireworks device, including clay plugs, lift charge, and effects, generally is minimal.[50] In addition, as BV's test results indicate, the average difference in readings using different instruments (XRF and ICP-OES) is 0.15 percent. Consequently, enforcement discretion allowing up to 1.00 percent contamination should be adequate to account for potential contamination and instrument variation. Increasing the allowance to 2 percent, as commenters request, appears to be unnecessary to account for these levels of inadvertent contamination and variations in instrument readings, and would further increase the explosive force of devices by

[50] Tab D – LSC Memorandum.

as much as 6 percent in energy, as shown in Tab D Charts 1 and 2. It is not straightforward to quantify the additional injury severity that a 3 percent increase in explosive energy causes but any added amount of additional explosive energy will increase the severity and extent of injuries sustained. To balance the goal of consumer safety with the practical limitations of instruments and potential contamination, staff concludes a 1 contamination allowance is appropriate. With regard to a lack of a statistically significant increase in the recoil force generated by a device containing 5 percent and 10 percent fine mesh metal fuel, this could be attributed to a lack of sensitivity in the instrumentation, which in result, would not be able to discern between measured amounts of fine mesh metallic fuel.

Comment Summary:
CPSC received a comment stating that the Commission should adopt a contamination allowance for fine mesh metal powder in break charges similar to the defect action levels the U.S. Food and Drug Administration (FDA) allows for food in 21 CFR § 110.110. The commenter stated that the FDA allows for defects or contamination up to a certain level that presents no hazard and that, similarly, trace amounts of fine mesh metals pose no risk to consumers.

Response:
The FDA regulation that the commenter cited states that even when food is produced under good manufacturing practices, "natural or unavoidable defects" can occur at low levels that are not hazardous to health. In recognition of that, FDA sets maximum levels for such defects in foods, which are subject to change. However, the regulation specifically states that compliance with the maximum defect levels does not excuse unsanitary conditions or other violations of FDA's regulations, and that "natural and unavoidable defects" must be reduced to "the lowest level currently feasible."

The commenter does not provide a basis for believing that FDA allowances for defects in food would be appropriate for determining appropriate fine mesh metal levels in fireworks. The allowance for fine mesh metal contamination that staff recommends be stated in the preamble is based on data regarding the increase in energy that incremental amounts of fine mesh metal produce, and the competing need to reflect the limitations of testing instruments and the potential for minimal inadvertent contamination. The levels of aluminum that are seen in break charges (up to 30%) are not from natural or unavoidable defects. As explained above, staff has analyzed the potential sources of migration/contamination of metallic fuel into the break charge.[51] Staff has analyzed numerous break charge powders from both mine and shell devices (MSDV) and reloadable tube aerial shell devices (RTAS) currently on the market and found that there is no contamination from the visual effects and/or the clay "plugs."

The enforcement discretion staff recommends be described in the preamble, allowing up to 1.00 percent of metallic powder in burst charges, is more than sufficient to account for variables such as inadvertent contamination during manufacturing and possible instrument detection variability. Therefore, staff believes a 1 percent contamination limit is reasonable.

[51] Tab D – LSC Memorandum.

Comment Summary:
CPSC received comments about the appropriate level for a contamination allowance.

One percent. CPSC received comments stating that a 1 percent contamination allowance would be arbitrary because BV's testing showed that there is only a statistically significant increase in force when there is 5 percent fine mesh metal content, and that there is no statistical difference in energy between devices containing 1 percent and 2 percent fine mesh metal.

Two percent. CPSC received comments, including APA's and AFSL's joint comment, stating that the Commission should allow 2 percent contamination of fine mesh metal powder in break charges. Commenters stated that 2 percent contamination aligns with the safety goal of the regulation, reflects the way aerial fireworks are manufactured, prevents the intentional introduction of metal powders, is consistent with U.S. Department of Transportation (DOT) requirements and voluntary standards, and is reasonable and achievable. Commenters reiterated BV's findings that there is little or no effect on explosive force of a device until fine mesh metal concentrations exceed 2 percent. Commenters noted that BV assessed the level of fine mesh metal powder in devices currently on the market and found that approximately 85 to 90 percent of mine and shell devices and 80 to 85 percent of reloadable devices currently on the market would meet the proposed requirement with a 2 percent contamination level. Commenters stated that concentrations of fine mesh metal powder greater than 2 percent are likely the result of intentionally introducing the powder, rather than inadvertent contamination. In contrast, less than 2 percent concentrations are likely unintentional because adding fine mesh metal at that concentration would not significantly increase the sound or energetic effect of the device. APA also noted that it expects to finalize a revised standard that includes a contamination allowance of 2 percent.

Between two and five percent. CPSC received comments requesting a contamination allowance of 2 to 5 percent because technical grade chemicals used in fireworks typically have 95 to 98 percent purity, meaning that 2 to 5 percent of the content of these chemicals could contain unintentionally-added metals. CPSC also received a comment requesting a contamination allowance of 3 to 4 percent, to reflect a feasible level and avoid reducing the marketability of products. CPSC received a comment requesting an allowance of no less than 5 percent because there is no statistical increase in energy below 5 percent fine mesh metal.

Fifteen percent. CPSC received comments requesting a contamination allowance of 15 percent. These commenters claimed that this level would reflect the current market, and account for contamination and mischaracterization resulting from test methods.

Twenty percent. CPSC received a comment requesting a 20 percent contamination allowance. The commenter stated that one XRF manufacturer reports a ± 20 percent variance in the device's powdered metal measurements.

Response:
Regarding the different levels of contamination allowance:

One percent: To clarify, the recommended final rule does not allow devices to contain any amount of metallic powder less than 100 mesh in particle size in the burst charge, if the burst charge exceeds 2 grains. This aligns with the APA 87-1 standard as incorporated by DOT regulations. Staff recommends that the preamble state that the Commission will exercise enforcement discretion to allow up to 1.00 percent of metallic powder in burst charges to account for variables such as inadvertent contamination during manufacturing and possible instrument detection variability. CPSC staff believes that the 1 percent discretionary contamination allowance is an appropriate level in light of the increase in energy that additional fine mesh metal powder products, balanced against the levels of inadvertent contamination found in devices, and the variability in instrument readings shown in data.

Specifically, data show that there is approximately a 3 percent increase in energy in the break charge for every 1 percent increase in fine mesh metal content. To reduce the likelihood and severity of consumer injuries, staff believes it is appropriate to restrict the amount of fine mesh metal powder to the extent possible. Nevertheless, staff recognizes that inadvertent contamination is possible, at very low levels, less than 1 percent. Staff also recognizes that, as BV data indicate, there can be variability in the amount of fine mesh metal powder different instruments identify, with an average difference of 0.15 percent. At those levels, enforcement discretion allowing up to 1 percent fine mesh metal powder, is more than adequate to account for variables in devices and instruments, without undermining the safety purpose of the regulation. Moreover, BV data show 92.4 percent of MSDV and 78.4 percent of RTAS tested would comply with the proposed regulation at a discretionary contamination allowance of 1.00 percent (≤1% Al), thereby demonstrating that this is a reasonable allowance level to set.

Two percent: Staff disagrees that 2 percent is consistent with DOT requirements and voluntary standards. The DOT incorporates by reference the APA Standard 87-1. APA Standard 87-1 states that "burst charge containing metallic powder (such as Magnalium or aluminum) less than 100 mesh in particle size, is considered intended to produce an audible effect and limited to 130 mg." Therefore, APA Standard 87-1 and, by extension, DOT regulations, do not allow for ***any*** *contamination, i.e., 0 percent metallic fuel with no allowance provided. Furthermore, as noted previously, for every 1 percent addition of metallic fuel, the energy increases by approximately 3 percent. Additionally, based on the BV data, an increase from 1 percent to 2 percent contamination allowance would increase the "pass" rate under the recommended final rule for MSDV from only 92.4 percent to 93.97 percent and for RTAS from 78.4 percent to 79.4 percent. Further analysis of the data show that 3.49 percent of MSDV and 6.6 percent of RTAS tested contain >6 percent Al. This, in combination with the majority of devices containing less than 1 percent Al, suggests that the excessive amount of Al (>6%) in both the MSDV and RTAS is not due to contamination from other materials, variability of measurements or environmental and manufacturing conditions and is likely the result of intentionally introducing the powder.*

Two percent to five percent: Staff disagrees with the commenter's conclusion that the 2-5% impurities in technical grade chemicals used in fireworks would be metallic powder. There are other materials added to commercially purchased metallic powders such as small amounts of surfactants and sand for example to prevent clumping of the powder. It cannot be assumed that the 2-5% of impurities would be all metal powder and not a range of other materials and

contaminants. As explained elsewhere, a level of 1% should adequately accommodate variation sources, while minimizing the explosive power that results from increased fine mesh metal.

Fifteen percent: Staff disagrees that 15 percent reflects the current market. The current industry standard does not allow for any contamination and BV data show that 92.4 percent of MSDV and 78.4 percent of RTAS tested would comply with the recommended regulation and enforcement discretion allowing for 1 percent (≤1% Al). In addition, this level of fine mesh metal powder in a break charge would significantly increase the explosive energy of the device, contrary to consumer safety. As described above, in 2016, BV measured the recoil force of RTAS fireworks prepared with known, varying total weight percentage quantities of fine mesh (130 mesh) aluminum metal particles. This testing confirmed CPSC's finding that there is an approximately 3 percent increase in the energy contained in a break charge for every 1 percent increase in fine mesh metal (Al) content. With 15 percent fine mesh metal content, the increase in energy would be substantial. BV reported that during this testing it found that the shells it prepared that contained 10 percent aluminum and 90 percent black powder "generated forces above the 50,000 pound capacity of the load shell and were not properly contained in the launch tube."

Twenty percent: Staff disagrees that 20 percent contamination allowance would be appropriate for the same reasons that 15 percent would be inappropriate. Additionally the commenter states that an XRF manufacturer reports a ± 20 percent variance in the device's powdered metal measurements. This is not the same as ± 20% total composition. For example, this does <u>not</u> mean that if the Al content is 20 percent by weight that the XRF is accurate between 0 to 20 percent Al content by weight. If the XRF reading reports a 1% ± 20% Al content, this means that the actual Al content is anywhere from 0.8 percent to 1.2 percent. The 1 percent contamination allowance that staff has proposed accounts for this variability.

Comment Summary:
CPSC received comments requesting that the Commission adopt an additional allowance that accounts for the variation or margin of error in XRF test equipment readings. APA's and AFSL's joint comment requested that CPSC allow contamination up to 2 percent plus the variability range of the individual XRF instrument. For example, if an XRF device's variability is ± 0.1 percent, then a fireworks device would not be subject to the 2-grain limit in 16 C.F.R. § 1500.17(a)(3) unless the XRF screening yielded a reading of greater than 2.1 percent fine mesh metal powder (*i.e.*, 2 percent contamination allowance + 0.1 percent device variability = 2.1 percent permitted). Commenters requested that the specific variability of each instrument be included in the allowance, but as an alternative, requested that the Commission at least allow an additional 0.15 percent variability (in addition to the 2 percent contamination) to reflect the margin of error of testing instruments. This 0.15 percent variability is based on BV's finding that there was an average difference of 0.15 percent between the readings XRF and ICP provided for the same samples.

Response:
Staff agrees that the contamination allowance should account for variations or margins of error in testing equipment. BV provided data demonstrating the difference between XRF and ICP-OES readings for fine mesh metallic powder in burst charges. BV found an average of 0.15%

difference exists between the readings on the XRF and the ICP-OES. This data confirms staff data. The 1% contamination allowance that staff has proposed accounts for that 0.15% margin of error. It would be impractical for CPSC to provide a contamination allowance that reflected the specific margin of error of the particular XRF device a firm used for field screening. This information would not be available to CPSC, and the 1.00 percent contamination allowance should adequately account for variation, as described. Staff also notes that the recommended final rule does not require that XRF be used to evaluate compliance with the regulations.

Comment Summary:
CPSC received comments stating that the contamination allowance for fine mesh metal in break charges should be in the regulatory text, rather than part of enforcement discretion outside of the regulation. Commenters stated that an allowance that is discretionary or can change over time does not provide certainty, transparency, or predictability for regulated entities. Commenters also noted that because CPSC knows that contamination exists, it should account for it in the regulation itself.

Response:
The recommended final rule prohibits fine mesh metal powder in break charges, if the burst charge is produced by more than 130 mg of pyrotechnic composition. This aligns with the APA 87-1 standard and DOT regulations to which the fireworks industry has certified for decades. However, the recommended preamble would state that the Commission will exercise enforcement discretion to allow up to 1.00% fine mesh metallic powder in burst charges to account for variables such as inadvertent contamination during manufacturing, and possible instrument detection variability. CPSC staff believes that it is appropriate to set the regulatory limit at 0 because that is the appropriate limit for safety purposes, and is consistent with existing voluntary standards and DOT regulations. However, in recognition of the potential for inadvertent contamination or instrument variation, staff recommends that the preamble state that the Commission will provide enforcement discretion at a reasonable level to accommodate these issues. Because the safety purpose of the regulation is consistent with the regulatory limit, and the contamination allowance reflects current levels of contamination and instrument variation, staff believes it is appropriate to include the allowance in enforcement discretion instead of the regulation. If the potential for inadvertent contamination or the detection levels of instruments change in the future, CPSC would be better able to adapt its enforcement discretion to reflect these changes.

Comment Summary:
CPSC received a comment stating that CPSC's enforcement of the proposed requirement should focus on grossly-overloaded items and penalties should reflect the level of contamination. For example, a device containing 3.5 percent fine mesh metal powder in the break charge should receive a lower penalty than a device containing 20 percent fine mesh metal powder in the break charge, since the latter device would produce more energy and pose a greater hazard.

Response:
This rulemaking revises the fireworks regulations. This comment concerns penalties for violating the Commission's regulations. Such issues are not in the scope of this rulemaking.

g. Impact of proposed requirement

Comment Summary:
CPSC received comments stating that the proposed rule would ban most consumer aerial devices currently on the market. Commenters stated that industry members have tested samples of fireworks that are currently on the market, using XRF to detect the presence of metal at less than 2 percent, and found that 90 percent of devices failed the proposed requirement. CPSC received comments stating that 17 percent of devices fail using the current test method and 84 percent fail using the proposed method, which means that the proposed standard would result in a 394 percent increase in failures.

APA's and AFSL's joint comment included BV's test results regarding the impact that the proposed standard would have on fireworks devices currently on the market. In 2017, APA and AFSL commissioned BV to conduct testing to determine the percentage of AFSL-certified aerial fireworks currently on the market that have various percentages of aluminum and magnesium. BV tested 315 MSDV and 301 RTAS. Based on BV's data, 92.4% of MSDV tested and 78.4% of RTAS tested would comply with the recommended final rule and enforcement discretion allowance (≤1% Al).

Response:
The recommended final rule would not ban most consumer aerial devices currently on the market. As BV's data show, 7.6 percent of MSDV and 21.6 percent of RTAS currently on the market would not comply with the recommended final rule and enforcement discretion for up to 1 percent contamination. BV data also show that an increase from 1 to 2 percent contamination allowance would only increase compliance with the recommended final rule for MSDV from 92.4 percent to 93.97 percent and for RTAS from 78.4 percent to 79.4 percent.

In addition, staff notes that the draft requirement in § 1500.17(a)(3), without any contamination allowance, is already part of APA Standard 87-1, which the DOT incorporates by reference into its regulations. Specifically, the Pipeline and Hazardous Materials Safety Administration (PHMSA), which is part of DOT, requires fireworks to be approved by PHMSA before they may be shipped in commerce. PHMSA's regulations provide four options for firms to obtain a PHMSA approval for consumer fireworks (49 CFR §§ 173.56(b)(1), 173.56(f), 173.64, 173.65). Nearly all firms opt to obtain PHMSA approval through the two alternatives that require firms to certify compliance with APA Standard 87-1.[52] *Therefore, those fireworks should already comply with APA Standard 87-1.*

Comment Summary:
CPSC received comments stating that the proposed regulation would impact numerous products, including snakes, sparklers, comet tails, large stars, bright stars, large fountains, medium to large missiles, and mortar shells. One commenter stated that powdered metal is present in black powder, so the proposed regulation would effectively ban all fireworks.

[52] According to supplemental information provided by APA following the March 7, 2018 oral hearing the Commission held on this rulemaking, approximately 99 percent of consumer fireworks approvals are obtained by certifying compliance with APA Standard 87-1.

Response:
Powdered metal is not present in black powder. The recommended final rule does not ban powdered metal, rather it limits a burst charge to 130 mg if it contains metallic powder (such as Magnalium or aluminum) less than 100 mesh in particle size. This limit is already in the industry standard and should not impact most products.

h. Alternatives to the proposed rule

i. Sound level meter testing

Comment Summary:
CPSC received comments advocating that the Commission adopt sound level meter (SLM) testing instead of the proposed requirement and as a replacement for the current test that assesses the quality of sound a device produces. Commenters stated that SLM testing, similar to a sound level test in the European Standard, assesses the decibels a device produces at a set distance from the device. Commenters stated that SLM testing is a quantifiable and reliable way to measure the energy output of a device through acoustic (sound) waves and accounts for sound quality (not just volume) and factors that contribute to the explosive force of a device. Commenters suggested that CPSC set a decibel limit equivalent to devices that are currently on the market and have a good safety record. Commenters noted that SLM testing is less expensive than the test equipment that would be required to meet the proposed regulation.

CPSC also received comments opposing the use of SLM testing. Commenters stated that there is no evidence that SLM testing assesses the hazard a fireworks device poses and there are many variables in SLM testing that make it unreliable. Variables include environmental factors (*e.g.*, humidity, altitude, temperature, physical or geographic surroundings), instrumentation (*e.g.*, type and quality of SLM instruments vary widely and affect test procedures and results), and testing (*e.g.*, distance from fireworks device, height of functioning, orientation to instrument). APA's and AFSL's joint comment stated that SLM testing would not improve the reliability or accuracy of testing over the current test method.

Response:
Staff has reviewed the European Standard. The European Standard EN 15947-4 currently prohibits a consumer fireworks device from producing a noise level above 120 dB (EN 15947-5, section 7.2.7) when tested using the procedures and at the distances stated in the standard (EN 15947-4). The European Standard categorizes fireworks devices, in part, by how much sound they produce with the lowest-level category presenting a "negligible noise level" and the highest-level category presenting "a noise level [that] is not harmful to human health" (EN 15947-2, section 4). This suggests that the standard's requirements regarding noise levels are used to assess and limit the amount of noise generated from an exploding firework, because of the health implications or nuisance associated with loud volume, rather than any relationship the sound has to explosive force and the hazard patterns identified by CPSC.

The European Standard is not measuring the aluminum content in the fireworks device; rather, it is measuring the loudness of the device. CPSC is not aware of a test method for SLM that would measure the force generated from the shell without removing various variables including

environmental factors (e.g., humidity, altitude, temperature, physical or geographic surroundings), instrumentation (e.g., type and quality of SLM instruments vary widely and affect test procedures and results), and testing (e.g., distance from fireworks device, height of functioning, orientation to instrument). One commenter provided a technique[53] involving the use of two Class 1 sound meters and a fixed test sample, but staff does not believe this to be a viable option due to its dependence on the aforementioned variables. The technique submitted did not describe how to account for environmental factors, and the test method describes a fixed test sample, which would mean that the lift charge would need to be removed. For these reasons, along with organizing testing with a specific facility, staff believes this to be a burdensome option.

ii. Retain current regulation

Comment Summary:
CPSC received comments stating that the Commission should continue to use the current test method because it has been used for many years, is effective, relies on actual product demonstration, would result in fewer product failures than the proposed method, and is inexpensive. As an alternative, commenters suggested that CPSC could retain the current test, but also allow testers to use the APA Standard 87-1 test method, as an alternative.

Response:
CPSC has received numerous comments, through this rulemaking and elsewhere, requesting that CPSC replace the current method of evaluating fireworks for compliance with § 1500.17(a)(3) with a quantitative method that is easier to assess and replicate. In addition, because the draft revision to the regulation aligns with APA Standard 87-1, it is consistent with existing standards. As explained above, DOT regulations require fireworks to be approved by PHMSA before they may be shipped in commerce and nearly all firms obtain that approval by certifying compliance with APA Standard 87-1. For this reason, staff believes that the harmonization with APA Standard 87-1 will provide for more streamlined compliance with this requirement, because it eliminates the need for firms to assess products multiple ways to meet CPSC and DOT requirements regarding limits on explosive force of devices subject to § 1500.17(a)(3).

Comment Summary:
CPSC received a comment stating that 16 CFR § 1500.17(a)(3) should continue to apply to devices that are "intended to produce audible effects," rather than replacing that language, because devices that are intended to produce audible effects have significantly different combustive energy than devices that are not intended to produce audible effects, even when they contain the same amount of metal powder. For example, a pure salute shell (which is intended to produce an audible effect) expends all of its explosive energy at one time, while the same amount of metal powder in a color burst shell (which is not intended to produce an audible effect) would produce a slower-paced effect that takes time to develop in the air. Consequently, whether a device is intended to produce an audible effect is relevant to the energy it produces and the hazard it presents, while the amount of metal powder is not.

[53] Myatt, S, G, Davies M. L. (2005). Explosive output from black powder/metal compositions.

Response*:*
Staff agrees that the energy expelled from burst charges and effects are different. When devices contain metal powder such as aluminum or Magnalium in their burst charge, the energy increases significantly. BV data confirm that there is an approximately three percent increase in the energy contained in a break charge for every one percent increase in fine mesh metal (Al) content. This demonstrates the consistency between limiting metallic content in break charges and the intended safety purpose of § 1500.17(a)(3)—namely, to limit the explosive power of devices in order to reduce injuries associated with more explosive devices. Additionally, adding aluminum or other metallic content to an energetic material may increase sensitivity to impact, spark, and friction, which may present additional safety hazards. The recommended final rule does not ban the use of metals in fireworks devices; rather, the recommended final rule is limiting burst charges containing metallic powders to 2 grains. This is consistent with the industry standard. Current devices such as firecrackers (which contain a separate regulatory limit of 50 mg vs 130 mg) would not be affected.

Comment Summary:
CPSC received a comment advocating that the Commission keep the current test method, but create a high-power category of consumer fireworks, separate from general consumer fireworks, and adopt additional requirements for the high-power devices (such as training and registration). For example, the commenter stated that 500 gram multiple shot devices and aerial shells larger than a specified diameter could be classified as high-powered. The commenter stated that this categorization would allow serious hobbyists to continue to use more powerful devices, reduce the costs of the proposed rule, and focus on the potency of devices rather than their metal content.

Response:
Staff does not believe that this is a viable option for addressing hazards associated with consumer fireworks. What the commenter suggests is not within CPSC's authority and would not provide for consumer safety. Under the suggested approach, there would be two categories of consumer fireworks, with limits on who may purchase devices in the "high-power" category (i.e., only trained and registered consumers may purchase them). CPSC does not have authority to restrict who may purchase fireworks devices; rather, the FHSA (and court decisions interpreting the statute) authorize CPSC to adopt labeling requirements, classify a substance as a "banned hazardous substance," or adopt design or performance requirements. In addition, this approach may not protect consumer safety, since it would allow certain consumers to access devices that CPSC believes present a hazard to consumers.

Comment Summary:
CPSC received a comment stating that the Commission should leave 16 C.F.R. § 1500.17(a)(3) in its current form, but make it less stringent by allowing more metal powder in break charges in larger devices.

Response:
As explained above, greater amounts of fine mesh metal powder in a break charge correspond with greater explosive power and thereby greater hazard potential. Therefore, allowing more

fine mesh metal powder in break charges in larger devices would be contrary to the purpose of the regulation, which is to protect consumer safety by reducing the explosive force of devices. In addition, the recommended final rule would align with current DOT regulations most firms meet to transport hazardous materials and APA Standard 87-1. Staff believes that limiting burst charges containing metallic powder such as Magnalium or aluminum to 2 grains (130 mg) will reduce potential injuries and increase compliance with the 2-grain limit.

iii. Other alternatives

Comment Summary:
One commenter requested that CPSC incorporate section 2.5 of APA Standard 87-1 by reference, rather than omitting the additional details that are in the APA standard.

Response:
The NPR and recommended final rule include the same substantive requirements as APA Standard 87-1, Section 2.5, with respect to limits on fine mesh metallic powder in burst charges, without specifically incorporating that provision by reference into the regulations. CPSC is using this approach because incorporating Section 2.5 by reference, in its entirety, would be confusing and inconsistent with the structure of § 1500.17(a)(3).

Section 2.5 is in the "Definitions" section of APA Standard 87-1 and states: "Burst Charge: Chemical composition used to break open a fireworks device after it has been propelled into the air, producing a secondary effect such as a shower of stars. Burst charge is also sometimes referred to as expelling charge or break charge. Any burst charge containing metallic powder (such as Magnalium or aluminum) less than 100 mesh in particle size, is considered to be intended to produce an audible effect, and is limited to 130 mg in 1.4G fireworks devices. Burst charge consisting of black powder or equivalent non-metallic composition is not considered to be intended to produce an audible effect when it is used to expel and ignite a secondary effect in a fireworks device. Burst charge for use in 1.3G fireworks is limited to black powder (potassium nitrate, sulfur, and charcoal) or similar pyrotechnic composition without metallic fuel for approval under the provisions of this standard." (Note underlining does not appear in original comment, added for emphasis in response).

The only relevant portion of Section 2.5 for purposes of amending § 1500.17(a)(3) is the underlined portion above. Incorporating Section 2.5 by reference, in its entirety, would add provisions to § 1500.17(a)(3) other than the limit on fine mesh metallic powder in burst charges, such as a definition of "burst charge." Section 1500.17(a) lists articles that the Commission has declared to be "banned hazardous substances"; it is not the appropriate section to list definitions of terms. In addition, § 1500.17(a) states, in pertinent part, ". . . the Commission declares as banned hazardous substances the following articles . . ." and goes on to list various products, including certain fireworks in subparagraph (3). Inserting the language from APA Standard 87-1, Section 2.5 into subparagraph (3) of the regulation would not make sense because it is not worded to align with the introductory language in § 1500.17(a).

Comment Summary:
CPSC received a comment stating that the proposed rule should only apply to small, handheld devices, not large display devices.

Response:
The recommended final rule would align with the current industry standard and apply to all devices. Since the limit is two grains (130 mg), smaller devices would be unaffected since they contain less than 130 mg of pyrotechnic powder.

Comment Summary:
CPSC received a comment stating that CPSC should assess the explosive power of devices by measuring the blast wave pressure, peak amplitude, and rise time they produce to obtain a full picture of the force devices produce.

Response:
CPSC staff has researched possible test methods to assess blast wave pressure, peak amplitude and rise time.[54,55,56] *Staff could not correlate a specific pressure to injury potential. However, staff has concluded that a burst charge with metallic powder under 100 mesh in particle size is more powerful than a burst charge without metallic powder under 100 mesh in particle size. Staff has also concluded that a more powerful device has a greater injury potential than a less powerful device.*

Comment Summary:
CPSC received a comment stating that the proposed test is a design standard, rather than a performance requirement, because it focuses only on whether metal powder is present in a break charge. The commenter stated that CPSC should adopt a performance test, rather than a design standard, because a performance test accounts for various factors that contribute to the energy of a device.

Response:
Staff has assessed various alternatives for assessing the explosive force of fireworks devices discussed in Tab D including overpressure, sound levels, and blast force measurement, and is not aware of a performance standard that would protect consumers as well as the standard in the recommended final rule that limits burst charges containing fine mesh metal content to no more than 2 grains of pyrotechnic composition.

[54] Christopher Musto, Consumer Product Safety Commission, "Fireworks Safety Standards Status Report" (2011).
[55] Christopher Musto & Andrew Lock, Consumer Product Safety Commission, "Fireworks Safety Standards Development Project FY 2013 Status Report" (2013).
[56] Christopher Musto & Andrew Lock, Consumer Product Safety Commission, "FY 2012 Fireworks Safety Standards Development Status Report" (2013).

i. Miscellaneous Comments

Comment Summary:
APA's and AFSL's joint comment requested that CPSC adopt an enforcement policy and test procedure formally recognizing XRF as an acceptable test method for assessing compliance with 16 CFR § 1500.17(a)(3) and accounting for the variation of XRF test equipment (described above).

Response:
Staff is not recommending that the rule mandate a particular method of testing for consumer fireworks devices. Screening by XRF and confirmation by ICP-OES is similar to other product categories CPSC regulates, such as lead in children's products. Over time, staff has been able to develop and confirm that XRF could be used assess compliance with CPSC regulations for certain toy products containing lead. As for fireworks devices, XRF seems to be a useful screening tool for assessing whether or not metallic powder under 100 mesh in particle size is present in break charge powders. At present, staff recommends using XRF to screen, because it is significantly less expensive than ICP-OES analysis and can be used in the field. Staff recommends the use of ICP-OES, if results need to be quantified or confirmed with sufficient accuracy to meet the requirements and/or are within a discretionary limit. As CPSC worked with industry to develop enhanced XRF methods and techniques after the Consumer Product Safety Improvement Act (CPSIA)'s lead limits went into effect, staff believes additional method development may allow for more routine use of XRF technologies for quantification purposes.

Comment Summary:
CPSC received a comment asking that CPSC explain why it is aligning with the requirement in APA Standard 87-1 rather than similar provisions in other standards.

Response:
In 2015, staff reviewed provisions in other fireworks standards for possible incorporation into the regulations and made recommendations to the Commission. Although other standards may include the same or similar provisions to APA Standard 87-1, the DOT has incorporated APA Standard 87-1 by reference. Staff believes that aligning with the DOT will be less burdensome to manufacturers since industry will only need to comply with one standard instead of multiple ones.

Comment Summary:
CPSC received a comment indicating that the original, historical meaning behind, "intended to produce audible effects," was in reference to "salutes." The commenter also advocated for the allowance of chlorates in fireworks formulations.

Response:

Staff agrees with this historical assessment. M-80s, cherry bombs, and silver salutes are currently banned, all containing flash powder, which typically contains metallic fuel less than 100 mesh. Chlorates are currently a prohibited chemical due to their sensitivity. This rule does not propose to change that requirement.

Comment Summary:
CPSC received comments stating that the proposed rule is inconsistent with the original purpose of 16 CFR § 1500.17(a)(3). Commenters stated that the original purpose of the regulation was to ban consumer use of certain powerfully explosive ground devices (such as M80s and cherry bombs) because ground devices pose a greater safety risk to consumers because they explode near users and bystanders, unlike aerial devices, which explode in the air.

Response:
When the U.S. Food and Drug Administration (which administered the FHSA before CPSC assumed the responsibility) adopted the requirement that now appears in § 1500.17(a)(3), it stated that its primary concern was to "close the loophole through which dangerously explosive fireworks, such as cherry bombs, M-80 salutes, and similar items, reach the general public." 35 Fed. Reg. 7415 (May 13, 1970). To accomplish this, the regulation adopted a limit of 130 mg (i.e., two grain) of pyrotechnic composition for aerial devices that "were intended to produce audible effects." The intention was not to ban devices that use black powder (a mixture of charcoal, sulfur, and saltpeter) as the break charge, but rather, to ban devices using large quantities of flash powder (a mixture of perchlorate and aluminum or magnesium) also referred to as salute powder.[57] Limiting the total content of devices "intended to produce audible effects" was not intended to protect consumers from loud sounds; rather, it was intended to limit the total powder content of the more powerful devices.

However, the manufacture and makeup of fireworks devices has evolved since this regulation was first adopted. Because most fireworks devices produce a sound, the tester must determine if the sound is an audible effect or necessary for the functioning of the device. Further complicating matters, fireworks devices tend to be handmade, so devices that are intended to be identical often are not, and thus, do not produce the same audible effect. The amount of powder, effects, as well as shell width and height, often vary greatly within devices from the same manufacturer and lot, as described in Tab D. The draft amendment to § 1500.17(a)(3) remains consistent with the original purpose of the regulation to limit the total powder content of more powerful devices, while also reflecting the current manufacturing and makeup of fireworks devices, because the more powerful devices are now the ones that contain metallic fuel. Moreover, staff believes that aligning with the industry standard will improve compliance and a quantifiable method will improve consistency in identifying which devices should be limited to 2 grains.

Comment Summary:
CPSC received a comment stating that CPSC has not shown by how much the proposed rule would reduce the hazard to consumers and that the benefits are speculative.

Response:
Staff believes that the rule will reduce the potential severity of injuries from highly-explosive devices by limiting the explosive force a device contains. Incident data show that large aerial devices sometimes malfunction so that the device explodes near consumers rather than in the air

[57] Conkling, J. (2017) Boom, America's Ever- Evolving Fireworks Industry. Alabama: Whitman Publishing, LLC.

where it was intended to. When this occurs, reducing the explosive force the device produces would reduce the severity of the injuries.

Devices containing fine mesh metal powder or large amounts of pyrotechnic composition create greater explosive force, which increases the risk and severity of injury to consumers. Injury data do not provide information about whether a device was overloaded, let alone the level of metallic fuel for a given injury level. However, incident data for device types that generally produce the greatest explosive power and commonly contain metallic fuel as shown in Tab D provide an indication of the hazard associated with highly-explosive devices or devices containing fine mesh metal content. The two primary device types of this kind are multiple-tube and reloadable shell devices. Incident data for 2015, 2016, and 2017 indicate that these devices account for 70 percent of fireworks-related deaths and were associated with many of the most severe injuries, including those requiring hospital admission. Furthermore, BV data confirm that a 1% increase in metallic fuel accounts for a 3% increase in power. In addition, commercial black powder, when ignited, has an average heat of reaction of 0.66 kcal/g, as compared with flash powder (which contains metallic fuel), which has a heat reaction of 1.7 kcal/g. Thus, although staff cannot determine the precise reduction in injuries or deaths that the recommended final rule would produce, limiting the explosive power of devices should reduce the frequency and severity of injuries.

Comment Summary:
CPSC received comments stating that, before adopting a rule, the Commission should: (1) establish the percentage of metal content that is acceptable in burst or lift charges; (2) establish an empirical method of testing that provides a repeatable and accurate assessment of the percentage of metal present; (3) identify metal powder particle size; and (4) identify the oxidation state of the metal to determine whether it is fuel (as opposed to inert compounds with no explosive potential).

Response:

1) *Staff has discussed elsewhere in this memorandum the rationale for recommending that no metallic powder under 100 mesh in particle size be present in burst charges, unless that burst charge is limited to 2 grains.*
2) *Staff has discussed elsewhere in this memorandum an explanation of the relative merits of several methods of assessing metal content and recommends the use of XRF to screen for metallic powder under 100 mesh in particle size and to quantify it by using ICP-OES, however the recommended final rule does not require any particular test method.*
3) *Staff has determined as described in Tab D that anything less than 100 mesh in particle size can significantly increase the explosive force of devices.*
4) *Staff believes that identifying the oxidation state is unnecessary because oxidation state alone does not determine whether or not a metal can be used as a fuel.*

Comment Summary:
CPSC received comments stating that the proposed requirement is unnecessary because DOT's regulations address the amount of metal permitted in devices and PHMSA approves all fireworks product designs, which ensures that all approved products do not present an unreasonable risk of harm.

Response:
Although PHMSA's regulations incorporate APA Standard 87-1 by reference, this does not ensure that all fireworks comply with that standard. First, as explained earlier, fireworks must be approved by PHMSA before they may be shipped in commerce. PHMSA's regulations provide four options for firms to obtain a PHMSA approval for consumer fireworks (49 C.F.R. §§ 173.56(b)(1), 173.56(f), 173.64, 173.65). Two of these options require a firm to certify that the fireworks comply with APA Standard 87-1, but the other two options do not. Although most firms use the APA options to obtain approval, based on APA's comments, firms have the option to use the other two options and not comply with APA Standard 87-1. Second, CPSC staff testing, as well as BV testing, has demonstrated that there are devices on the market that do not comply with the fine mesh metal powder and 2 grain limits in APA Standard 87-1. In addition, PHMSA's primary form of assessing the composition of fireworks devices is through its approval process, not through product testing.

Comment Summary:
CPSC received comments stating that it is inconsistent and unfair to limit the metal content of aerial consumer fireworks, but not limit the metal content in professional display devices. Commenters stated that display devices contain more metallic content than consumer devices, so either display devices should be subject to the same limits or metal content in consumer fireworks should not be limited.

Response:
The Commission does not have authority to regulate professional display devices. CPSC's authority to regulate fireworks comes from the FHSA. Under the FHSA, CPSC may classify a hazardous substance (such as fireworks) as a "banned hazardous substance" The FHSA defines a "banned hazardous substance," in pertinent part, as a hazardous substance that is either a "toy, or other article intended for use by children" or is "intended, or packaged in a form suitable, for use in the household." 15 U.S.C. § 1261(q)(1). This definition, in essence, means that the Commission may issue regulations for products that consumers use, such as children's products and household products. For this reason, the Commission may issue limits for consumer aerial devices, but not professional display devices.

Comment Summary:
CPSC received a comment expressing concern that the strict limit in the proposed revision to 16 CFR § 1500.17(a)(3) would result in manufacturers altering their formulas to narrowly avoid violating the requirement.

Response:
The recommended final rule does not allow for any fine mesh metallic powder in a burst charge if the burst charge is produced by more than 130 mg of pyrotechnic composition. Outside of the strict limit in the regulation, staff recommends that the preamble provide for enforcement discretion to provide for up to a 1 percent tolerance to account for manufacturing contamination and instrument variability. Because of the potential for contamination and instrument variability, it would be difficult for manufacturers to deliberately alter their products to include fine mesh

metal powder, but narrowly avoid exceeding 1percent Moreover, staff does not believe that there would be any benefit in adding less than 1 percent Al.

Comment Summary:
CPSC received a comment stating that CPSC should not regulate the metal content of fireworks because metal does not pollute the air since it vaporizes with reports.

Response:
The recommended final rule regarding fine mesh metal powder in break charges is intended to address consumer safety hazards when highly-explosive devices function near a consumer. The regulation does not aim to address air pollution, or any hazard that may pose to consumers. In general, air pollution falls under the Clean Air Act, which the Environmental Protection Agency administers.

Comment Summary:
CPSC received a comment stating that the proposed test does not consider the sound volume of devices and expressed concern that manufacturers may replace metal powder with content that makes devices louder.

Response:
Under the FHSA, CPSC may adopt regulations to address public health and safety hazards posed by household products that are or contain a hazardous substance. Therefore, CPSC cannot adopt regulations regarding the sound fireworks produce unless it relates to a health or safety hazard. As such, CPSC would not be able to regulate fireworks sound volume as a noise nuisance unless it reached a level dangerous to human health. To consider whether the volume of fireworks sounds present a health or safety hazard, staff examined fireworks incidents data for reports of hearing-related injuries. CPSC staff identified 31 fireworks incidents in NEISS that occurred between 2014 and 2016 that reported injuries potentially involving hearing damage and found that most reported minor short-term injuries, such as "ringing" in the ear. There is no way to determine from incident data what the volume of the firework involved in the incident was. Moreover, staff does not have information about a possible correlation of sound volume to injuries. Because CPSC does not have information indicating that injuries are related to particular volumes of fireworks sound, it did not consider adopting a requirement to limit the volume of fireworks sounds. As noted elsewhere, the phrase "intended to product audible effects" was intended as a proxy for high explosive power, not to limit some harmful level of sound.

6. Chemical Composition and Pyrotechnic Weight Limits

Comment Summary:
CPSC received comments agreeing with the proposed chemical composition and pyrotechnic weight limits, indicating support for aligning with the limits in APA Standard 87-1 and the AFSL standard. CPSC also received comments that opposed these proposed limits. Opposing commenters indicated that the proposed limits would be overly burdensome; stated that, in addition to specifying chemical composition limits, the rule should also consider total explosive

force; and requested that CPSC increase the limits from 500 grams to 1,000 grams, consistent with the United Kingdom, European, and Asian standards.

Response:
Staff believes composition limits are an important safety factor to reduce the potential severity of injuries from highly-explosive devices by limiting the explosive force a device contains. As some comments about the proposed fine mesh metal screening noted, non-metal content can also generate highly-explosive devices. Injury data suggest that the most severe injuries associated with fireworks involved the types of devices, such as mine and shell and reloadable tube devices that contain high explosive forces. Staff assesses that increasing the pyrotechnic limits of devices currently on the market could result in more severe injuries, so raising composition limits from 500 grams to 1000 grams would undermine the safety purpose of this provision. In addition, staff believes that aligning with current industry standard will increase compliance and reduce the potential of overloaded devices to cause injuries.

7. Prohibited Chemicals and Tolerance Levels

Comment Summary:
CPSC received comments that supported the proposed addition of HCB and lead tetroxide and other lead compounds to the list of prohibited chemicals, as well as the tolerance limits proposed for prohibited chemicals. AFSL and APA requested that instead of adopting these provisions on chemicals and tolerance limits, that CPSC specify that it is sufficient for devices to be subjected to a "reasonable testing program" under 16 CFR part 1107, subpart A, or AFSL's testing program.

Response:

The recommended final rule does not include the proposed addition of HCB, lead, or other lead compounds to the list of prohibited chemicals. Staff believes that they are dangerous chemicals, but lacks recent, comprehensive information about the extent to which these chemicals are present in devices in the United States and pose a hazard to consumers. Although there are some studies that have evaluated this, most occurred in Europe (which has different devices), were 10 to 20 years ago, or included small sample sizes. Staff also does not have exposure data to determine the hazard posed to consumers. These chemicals are already prohibited in voluntary standards, international standards, and/or in international treaties.

The recommended final rule also does not include a formal tolerance level for currently prohibited chemicals. Staff does not have sufficient information to determine a specific level that would protect consumers, while accommodating minimal, unintentional contamination or high device detection capabilities. Instead, compliance staff may use enforcement discretion, as appropriate, to account for minimal contamination.

Section 14(a)(1) of the Consumer Product Safety Act (CPSA; 15 U.S.C. §§ 2051-2089) requires "every manufacturer [and private labeler] of a product which is subject to a consumer product safety rule" that the Commission enforces, to certify, "based on a test of each product or upon a reasonable testing program" that the product complies with all applicable requirements

the Commission enforces. 15 U.S.C. § 2063(a). Therefore, not all devices in a particular lot of fireworks need to be tested; as an alternative, a "reasonable testing program" is sufficient. At this time, the Commission has not issued a regulation mandating the general requirements for a "reasonable testing program" for all general use (non-children's) consumer products. A reasonable testing program should provide a manufacturer or importer with a high degree of assurance that its consumer product complies with the applicable consumer product safety rule or standard.

A reasonable testing program should be in writing and should be approved by the senior management of the manufacturer (or importer).

A reasonable testing program should be based on the considered judgment and reasoning of the manufacturer (or importer) concerning the number, frequency, and methods of tests to be conducted on the products. The reasons should be reasonable assumptions for the industry in which the manufacturer (or importer) operates, including such factors as the nature and length of the manufacturer's relationship with their vendors and suppliers, and for the types of materials and processes used in production, including the potential for variability in those materials or processes. In other words, a product with fewer components and with a lower risk of variability in those components (e.g., a dyed t-shirt) would likely have a very different testing program than a product with many more components and for which those components have a higher risk of variability (e.g., chemical products involving a mixture of hazardous or potentially hazardous or volatile substances.)

Comment Summary:
CPSC received comments opposing the proposed addition of HCB and lead tetroxide and other lead compounds to the list of prohibited chemicals. Opposing comments stated that there was no evidence that HCB and lead tetroxide and other lead compounds are dangerous or have caused injuries, and suggested that seasoned pyrotechnic technicians have not developed health problems from exposure. Others noted that lead oxide creates the crackle effect in fireworks devices and poses no hazard because it is vaporized upon release, eliminating the risk of contamination on the ground.

Response:
There is ample evidence that HCB and lead compounds are dangerous and can cause adverse health effects. Several regulatory and research agencies have determined that HCB and lead are possibly or probably carcinogenic to humans. Non-cancer effects of HCB include reproductive, developmental, and liver toxicity. Lead can adversely affect almost any tissue in the body, and the primary health effects of lead are in the nervous system in children and adults. HCB and lead are already prohibited in industry standards. Traditionally, lead tetroxide was used to create a crackle effect in fireworks devices. However, due to the toxicity of lead compounds, bismuth trioxide and bismuth subcarbonate are now used. Because these chemicals are already prohibited in voluntary standards, international standards, and/or in international treaties, the recommended final rule does not include the proposed addition of HCB, lead, or other lead compounds to the list of prohibited chemicals.

8. Side Ignition

Comment Summary:
CPSC received comments supporting the proposed test method for evaluating side ignition, stating that it would improve safety and is consistent with industry practice and voluntary standards. CPSC also received comments opposing the proposed test method and a comment stating that the proposed test is inconsistent and instead requested that CPSC require a flame retardant cap on fuses that can be removed when a user is ready to light a device.

Response:
The recommended final rule does not include a test method for side ignition because there is an extremely high level of compliance with the APA 87-1 provision that is the same as the proposed test, making a regulatory requirement unnecessary. The description of CPSC's test method and timeframe used in the NPR, as well as the preamble discussion staff recommends for the final rule, provides the same transparency, without adopting a mandatory method. Staff also plans to update the testing manual to provide the clarity about timeframes discussed in the NPR, without amending the requirement.

9. Base Attachment

Comment Summary:
CPSC received comments that supported the proposed requirement for base attachment, indicating that it would improve safety, is consistent with industry practice and voluntary standards, and would have a minimal impact on industry members. CPSC also received comments that this issue could be adequately addressed through warnings and instructional requirements, such as including a warning on aerial devices instructing users to stabilize devices to prevent tip overs. Commenters also indicated that a required weight or balance could prevent tip overs.

Response:
Section 1507.4 describes the performance requirement for the base of a firework device. Both APA Standard 87-1 and the AFSL Standard require that the base remain attached during transportation, handling, and normal operation of the device. If the base is not attached properly, injuries can result from unstable devices. For this reason, staff believes that it is important to address this safety issue effectively, as recommended in this draft rule.

Safety literature identifies a hierarchy of approaches to follow to control hazards. In this hierarchy, designing the hazard out of a product is the most effective way to eliminate or reduce exposure to a hazard, followed by guarding users from the hazard; and finally, the third option is warnings. Using hazard communications, such as warning labels, is less effective than designing the hazard out of the product or guarding the consumer from the hazard. This is because warnings do not prevent consumer exposure to the hazard. Instead, warnings rely on educating consumers about a hazard and then persuading them to alter their behavior to avoid the hazard, which depends on various factors that can impact behavior, such as fatigue, stress, social influences, and other situational factors.

Research shows that a person's familiarity with a product has an inverse relationship with warning detection, perceived hazard, perceived risk, and compliance likelihood. Therefore, for those consumers for whom fireworks are familiar products, warnings and instructions may not be effective. In addition, people tend to use fewer precautions when using a product if they have had safe experiences with the product in the past. Requiring fireworks devices to come attached to the base would ensure that the device is as stable as it can be without requiring consumers to take further action to make the product stable, thus reducing the likelihood that consumers improperly attach the base or do not attach it at all.

10. Projected Fragments

Comment Summary:
CPSC received comments in support of the proposed requirement that would prohibit devices from projecting fragments when functioning, stating that the provision is important for safety and consistent with industry practice and voluntary standards. CPSC also received comments that the proposed prohibition is not specific enough, stating that CPSC should limit specific sizes, amounts, characteristics (*e.g.*, hardness), and materials that are related to potential health risks.

Response:
Staff agrees the projected fragments or hard or sharp materials can present a safety hazard. However, at this time staff does not have adequate information to support making this part of the final rule. Additional information regarding the characteristics of hazardous fragments and incidents would be helpful to provide adequate detail to effectively address the hazard. Staff will continue to collect this information for possible future action.

11. Economic Burden

CPSC received comments regarding the economic impacts of the rule, including impacts on small businesses. Summaries of those comments, and staff's responses, are provided in the Fireworks FR Regulatory Flexibility Analysis memorandum (Tab C) and the Final Regulatory Analysis of the Amendments to the Fireworks Regulations memorandum (Tab B), included in this briefing package.

12. Comments About Legal Authority and Issues

a. Proposed requirements regarding metal powder

Comment Summary:
CPSC received comments stating that the proposed requirements regarding metallic powder in fireworks devices do not conform to statutory requirements for rulemaking. The commenters stated that CPSC is required to identify a specific product that poses an unreasonable risk of harm and identify injuries that resulted from that product's design, but that the NPR failed to do either. The commenters stated that data supporting the proposed requirement is unclear, the NPR does not provide product or injury data to show that metal powder makes devices more dangerous, the NPR does not cite any injuries resulting from the presence of metal powder, the NPR does not identify a risk or link explosive power to injuries, the NPR does not identify a

specific product at issue, and the NPR does not explain why the amount of metal powder in devices that are currently on the market is unsafe. Commenters stated that the proposed provisions regarding metallic powder are contrary to CPSC's test results finding that there is no clear relationship between kinetic energy and injury potential. Commenters stated that the proposed rule is arbitrary and capricious because a numeric limit on metal powder content is arbitrary, and the NPR did not clearly state the specific hazard being addressed or explain how the rule addresses that hazard. Another commenter stated that a numeric limit on metal powder content in burst charges is arbitrary and unreasonable. One commenter referenced Zen Magnets, LLC v. Consumer Prod. Safety Comm'n, 841 F.3d 1141 (10th Cir. 2016), stating that the court concluded that it is insufficient to assert that injuries *can* result from a product.

Response:
Staff recommends revising the fireworks regulations. Most revisions clarify or streamline current regulations. Three of these changes might have the effect of banning fireworks devices not currently prohibited. Under the FHSA, for the Commission to classify a "hazardous substance" as a "banned hazardous substance" (or, by extension, issue standards for a hazardous substance), the Commission must make the following four findings:

1. *"notwithstanding such cautionary labeling as is or may be required under [the FHSA] for that substance, the degree or nature of the hazard involved in the presence or use of such substance in households is such that the objective of the protection of the public health and safety can be adequately served only by keeping such substance . . . out of the channels of interstate commerce";*
2. *when the regulation relates to a risk of injury for which there is a voluntary standard that has been adopted and implemented, compliance with the voluntary standard is not likely to result in the elimination or adequate reduction of the risk of injury, or it is unlikely that there will be substantial compliance with the voluntary standard;*
3. *"the benefits expected from the regulation bear a reasonable relationship to its costs"; and*
4. *"the regulation imposes the least burdensome requirement which prevents or adequately reduces the risk of injury for which the regulation is being promulgated."*

15 U.S.C. §§ 1261(q)(1), 1262(i)(2). The briefing package explains the support for these findings for the three changes that could create a new hazardous substance ban. As those discussions explain, CPSC staff identified the hazard involving fireworks products or features that are addressed in the recommended regulations, as well as injuries associated with those products or features.

In addition, the NPR, and this briefing package supporting the recommended final rule, include detailed information about the relationship between fine mesh metal powder and explosive power and injuries. As those discussions indicate, there is a measurable increase in explosive power corresponding with increases in fine mesh metallic powder in break charges, and the most severe injuries associated with fireworks involved devices that will be subject to the limit on fine mesh metallic powder, in order to reduce the severity of injuries. These discussions also explain why the fine mesh metallic powder limit of 0, with a 1 percent contamination allowance is

appropriate in light in of increase in explosive power with the presence of fine mesh metal powder.

Finally, regarding Zen Magnets, that case concerned findings required for a rule (determining that a rule is necessary to eliminate or adequately reduce an unreasonable risk of injury) under the CPSA that are not required for the fireworks rulemaking under the FHSA.

b. Applicable statute

Comment Summary:
CPSC received a comment stating that CPSC must meet the "stricter procedural and review provisions" in the CPSA, according to Forester v. Consumer Product Safety Comm'n, 559 F.2d 774, 783 (D.C. Cir. 1977), rather than relying on the FHSA alone.

Response:
The discussion in the Forester case that the commenter refers to addressed the rulemaking requirements of both the CPSA and the FHSA. However, the court did not decide that the CPSA requirements applied. The court expressly stated that it was not reaching a decision on the question, because it was not raised by the parties (Id.).

Because CPSC regulates fireworks under the FHSA, those are the requirements that apply when the agency amends the fireworks regulation. CPSC followed the procedural requirements for rulemaking under the FHSA in this rulemaking. The Commission issued a notice of proposed rulemaking, describing the proposed requirements and the rationales for them, and provided interested parties with the opportunity to submit written comments during the comment period. Moreover, the briefing package discusses support for findings that the FHSA requires regarding the nature of the hazard, the need for rulemaking, the potential effect of the rulemaking (costs and benefits), alternatives, and voluntary standards. 15 U.S.C. §§ 1261(q)(1), 1262(i)(2).

c. Jurisdiction Over Fireworks

Comment Summary:
CPSC received a comment stating that CPSC does not have jurisdiction to regulate fireworks because they fall under the Bureau of Alcohol, Tobacco, Firearms, and Explosives' (ATF) jurisdiction.

Response:
Several federal agencies have jurisdiction over fireworks, including ATF, DOT, and CPSC. The FHSA grants CPSC jurisdiction over "hazardous substances," which are defined in 15 U.S.C. § 1261(f)(1)(A), and provides for CPSC to issue regulations concerning hazardous substances that are "packaged in a form suitable for use in the household." Id. § 1261(q)(1)(B). Fireworks meet the definition of a "hazardous substance" and meet the criteria provided in the FHSA for rulemaking, as discussed in the briefing package.

d. Sherman Act

Comment Summary:
CPSC received a comment stating that the Sherman Antitrust Act of 1890 was adopted to protect against such rulemakings and that the NPR is inconsistent with Executive Orders 13771 and 13777 regarding regulatory reform.

Response:
The Sherman Act (15 U.S.C. §§ 1-7) addresses monopolies, contracts, and conspiracies that restrain trade or commerce, and imposes criminal penalties for violations of the act; it does not address rulemakings. In the FHSA, Congress granted CPSC authority to issue regulations regarding hazardous substances, such as fireworks, to protect public health and safety.

Executive Order 13771, "Reducing Regulation and Controlling Regulatory Costs" (January 30, 2017), and Executive Order 13777, "Enforcing the Regulatory Reform Agenda" (February 24, 2017), do not apply to independent agencies, such as CPSC. The Office of Management and Budget (OMB) issued Memorandum M-17-21, entitled "Guidance Implementing Executive Order 13771, Titled 'Reducing Regulation and Controlling Regulatory Costs'" (April 5, 2017),[58] and Memorandum M-17-23, entitled "Guidance on Regulatory Reform Accountability Under Executive Order 13777, titled 'Enforcing the Regulatory Reform Agenda'" (April 28, 2017).[59] In these memoranda, OMB expressly states that Executive Orders 13771 and 13777 do not apply to independent agencies. Independent agencies are listed in 44 U.S.C. § 3502(5), and CPSC is included in that list.

e. FHSA Findings

Comment Summary:
APA and AFSL, in a jointly-filed comment, provided input on the findings required for rulemaking under the FHSA. The comment noted that warning labels on products are important, but have limited effectiveness, making regulations regarding proper use and foreseeable misuse necessary. AFSL and APA also stated that there is not substantial compliance with the voluntary standards that is likely to result in an adequate reduction of the risk associated with fireworks devices. AFSL and APA believe that because fireworks are intended to explode, produce flames, and reach extremely high temperatures, only near-universal compliance with voluntary standards that address the hazards would adequately reduce the risk, since the risk is so significant. For that reason, they conclude that because there are products on the market that do not comply with the voluntary standards, there is not sufficient compliance. APA and AFSL also noted that there is a reasonable relationship between costs and benefits because each of the provisions in the NPR is a reasonable way to address the hazards at issue and those hazards warrant addressing. The joint comment also stated that the NPR is the least burdensome alternative. They asserted that their standards committees have spent substantial time considering alternatives to address various hazards, consulting injury data, scenarios and patterns, experts, fire marshals, chemists, epidemiologists, factories, news accounts, and other sources to identify and understand hazards and address them in a reasonable and least-burdensome manner. Because the provisions in the

[58] Available at: https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/memoranda/2017/M-17-21-OMB.pdf
[59] Available at: https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/memoranda/2017/M-17-23.pdf

NPR largely align with their standards, they conclude that the NPR also represents the least-burdensome alternative.

Response:
CPSC agrees with this assessment, as discussed in the support for the recommended rule in the briefing package.

13. Effective Date of Final Rule

Comment Summary:
CPSC received comments requesting a longer effective date for the rule than CPSC proposed in the NPR. Commenters requested various timeframes, including 6 months, 8 to 12 months, 1 year, and several years. Commenters noted that a longer effective date would be necessary to account for the time it will take to adjust fireworks production to meet new requirements, allow distributors to sell inventory ordered before the final rule, and allow time to acquire compliant inventory before the next season. AFSL and APA's joint comment noted that aerial devices make up an important segment of the consumer fireworks market, so factories and importers need time to reformulate products, and industry members need time to refine the test methods. Therefore, they stated that an effective date after July 4th season would allow suppliers and importers to modify orders and prepare for the next fireworks season.

Response:
In the NPR, the Commission proposed to establish an effective date for the rule 30 days after the publication of the final rule. Staff believed at the time, that this effective date was reasonable because many of the proposed requirements aligned with existing standards and CPSC expected the costs associated with the proposed requirements to be low. CPSC received several comments in response to the NPR requesting a longer effective date than proposed. CPSC staff believes this request is reasonable, given the fireworks market. Although fireworks are manufactured, imported, and sold year-round, there are two primary selling seasons: a period that includes July and the months before the 4th of July, and to a lesser extent, a period that includes December and the months prior to New Year's Eve. Fireworks are typically ordered, manufactured, tested, imported, and distributed many months in advance of these seasons. Any changes to the regulation prior to these seasons without sufficiently advanced notice may be particularly disruptive. CPSC staff recognizes that an effective date of approximately one year would provide ample time for the industry to import products ordered prior to the publication of the final rule, to refine test methods, to reformulate products, and ultimately to come into compliance with the new regulation in time for the next fireworks season. Furthermore, an effective date after the next fireworks season will help to alleviate the burden caused by any product ordered prior to the publication of the final rule that is not sold in the most-recent season. Therefore, the recommended final rule includes an effective date for the rule that is 12 months after publication of the final rule.

14. Other Comments

a. Hearing Damage

Comment Summary:
CPSC received comments requesting a rule to reduce the noise fireworks generate to address hearing damage that occurs and reduce the noise nuisance.

Response:
CPSC does not have authority to adopt a regulation to address a noise nuisance because the FHSA requires regulations to address a safety hazard. With respect to hearing damage, CPSC staff identified 31 fireworks incidents in NEISS that occurred between 2014 and 2016 that reported injuries potentially involving hearing damage. Although a small number (approximately 6) of these incidents involved a perforated or ruptured ear drum, most reported "ear pain" or "ringing" in the ear. The incident reports did not indicate whether these conditions resulted in permanent damage, or were temporary. Because CPSC does not have further information indicating that these injuries resulted in serious or permanent hearing damage, it did not consider proposing a sound requirement at this time.

b. Sparklers

Comment Summary:
CPSC received comments stating that most injuries are associated with sparklers, which is not addressed in the NPR. One commenter stated that all sparklers should be required to use wood rods instead of metal rods.

Response:
Because staff does not have information indicating that sparklers with metal rods are causing a greater hazard to consumers than sparklers with wooden rods, there is not a safety justification for adopting design standards like the commenter proposed.

c. Stick Rockets

Comment Summary:
CPSC received a comment stating that CPSC should require stick rockets to be sold with directional firing tubes to address the risk of tip overs.

Response:
Under CPSC's regulations, stick rockets are required to use a "straight and rigid stick" that must remain attached to the driver, to have a "direct and stable flight" (§ 1507.7). This provision aims to address the hazard the commenter references and staff believes it to be sufficient at this time.

d. Industry Groups

Comment Summary:
CPSC received comments stating that certain industry groups, such as APA, AFSL, and suppliers of display fireworks, may have an interest in the proposed rule being adopted (by stifling small business competition or reducing the desirability of consumer devices) and that CPSC worked closely with some of these groups for this rulemaking.

Response:
CPSC received more than 2,400 written comments in response to the NPR, which CPSC staff reviewed, considered, and has summarized and responded to in this memorandum. In addition, staff considered the oral comments provided at the March 7, 2018, meeting, which was open to any interested party to participate in, and considered an additional nearly 200 written comments submitted in response to the notice of that meeting. Staff met with APA, AFSL, NFA, and SBA, the primary organizations representing the vast majority of the fireworks industry, and considered their input in developing the recommended final rule. For the reasons explained in the briefing package, staff believes that the recommended final rule provides for consumer safety and streamlines fireworks requirements by aligning with APA Standard 87-1, and DOT regulations.

Tab B – Final Regulatory Analyses

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
BETHESDA, MD 20814

Memorandum

Date: August 27, 2018

TO : Rodney Valliere, Ph.D. Project Manager, Division of Chemistry, Directorate for Laboratory Sciences

THROUGH : Gregory B. Rodgers, Ph.D., Associate Executive Director, Directorate for Economic Analysis
Robert Franklin, Senior Staff Coordinator, Directorate for Economic Analysis

FROM : Mark Bailey, Directorate for Economic Analysis

SUBJECT : Final Regulatory Analysis of the Amendments to the Fireworks Regulations

1.0 Background

The Consumer Product Safety Commission (CPSC) is considering a recommended final rule to amend the regulations concerning fireworks, 16 C.F.R. parts 1500 and 1507. The Commission published a notice of proposed rulemaking (NPR) in the *Federal Register* on February 2, 2017. The amendments are based on the recommendations that the CPSC staff developed during a review of all regulations pertaining to fireworks and are generally intended to harmonize the existing CPSC regulations with the voluntary standard established by the American Pyrotechnic Association (APA 87-1).[60] This memorandum provides a final regulatory analysis of the recommended final rule.

2.0 Recommended Final Rule

The recommended final rule includes provisions that are intended to limit the explosive force of consumer fireworks, and adds a requirement that the bases of fireworks remain securely attached to the device during handling, storage, and normal operation. The recommended final rule also includes several provisions that do not materially affect the requirements, but clarify the existing requirements. For example, the recommended final rule includes several new definitions for terms based on industry understanding and their use in the voluntary standards. These provisions are explained in greater detail below.

The recommended final rule is intended to improve consumer safety while better harmonizing the CPSC regulations with those of the voluntary standard, APA 87-1, which is

[60] CPSC Staff, Fireworks Rule Review Briefing Package (December 30, 2015)

referenced by DOT as one of the means of obtaining transport permit. Under DOT regulations, firms have four options to obtain the required approval to transport fireworks in commerce (49 C.F.R. §§ 173.56(b)(1), 173.56(f), 173.64, 173.65). Nearly all firms use only two of those options, and both of those options require certification that the devices comply with APA 87-1. The two remaining options do not require compliance with APA 87-1, but are not regularly used.

3.0 Products within Scope of Recommended Final Rule

The recommended final rule applies to consumer fireworks, which are fireworks intended to be used by consumers and are classified as 1.4G fireworks by the DOT. These include, but are not limited to, devices such as firecrackers, bottle rockets, sparklers, fountains, roman candles, wheels, and reloadable tube aerial mortars. Products not within scope of the recommended final rule are display fireworks, which are intended to be used by professionals at public fireworks displays and are classified as 1.3G by the DOT and typically include, but are not limited to, "salutes containing more than 2 grains (130 mg) of flash powder, aerial shells containing more than 40 grams of explosive compositions (including any break charge and visible/audible effect composition but exclusive of lift charge), and other display pieces which exceed the limits of explosive materials for classification as 'consumer fireworks.'"[61]

Fireworks that are subject to the recommended final rule are commonly purchased by consumers in the U.S. to celebrate holidays like the 4th of July (Independence Day) and New Year's Day (December 31st and January 1st). The devices range from handheld devices like sparklers that produce visual effects to devices like mortar kits that produce explosions with sound effects and color variations. The purchase of these products by consumers is seasonal, with a large majority of sales occurring in the months of June, July, and December.

In contrast, the import, sale, and manufacturing of display fireworks are under the jurisdiction of the Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF). Because display fireworks have larger amounts of pyrotechnic compositions and higher amounts of explosive force than consumer fireworks, a license is required to import, manufacture for commercial use, deal in, transport or cause to be transported, or otherwise receive display fireworks in the United States. CPSCs rulemaking covers only consumer fireworks devices. The transportation of both consumer and display fireworks are under the jurisdiction of the DOT. DOT regulations governing the transportation of fireworks incorporate APA 87-1 by reference. Under DOT regulations, firms must obtain approval to transport fireworks (display or consumer) in commerce. Firms have four options to obtain this approval, but only two of those options are commonly used, and both of those options require that the firms certify the fireworks comply with APA 87-1.[62] Therefore, based on the approval option the vast majority of firms use, consumer fireworks generally should comply with the requirements of APA 87-1 in order to be transported.

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[61] https://www.atf.gov/explosives/fireworks Accessed 12/12/17

[62] DOT regulations provide manufacturers with four options for obtaining approval to transport fireworks; two of which require that firms certify compliance with APA Standard 87-1.According to testimony from Julie Heckman at the CPSC public hearing on March 7, 2018, the vast majority of firms use one of the options requiring compliance with APA standard 87-1.

4.0 Market Information

4.1 Product Types and Characteristics

This section presents information on the types of consumer fireworks and their characteristics. A summary of these characteristics, by device type, can be found in APA 87-1. APA 87-1 also provides definitions and brief descriptions of the various consumer fireworks types along with total chemical composition limits, which is defined as "[a]ll pyrotechnic and explosive composition contained in a fireworks device. Inert materials such as clay used for plugs, or organic matter such as rice hulls used for density control are not considered to be chemical composition." Consumer fireworks include, among others, ground and hand-held sparkling devices, cone fountain, ground spinners, bottle rockets, aerial spinner, roman candles, mine and shell devices, reloadable aerial shell kit, firecrackers, party popper, glow worms, sky rockets, and wire sparklers.

Consumer fireworks have varying chemical compositions that create the visual and auditory effects of the firework device. APA 87-1 provides a list of standard fireworks chemicals along with their typical use in fireworks, which includes but is not limited to fuels, oxygen donor, color agent, neutralizer, binder, or whistle. Many of the metals listed can be used as a fuel but also can also be used to produce different colors or visual effects. In many cases, the metal compound is the most expensive ingredient in the firework.

4.2 Retail Prices

Consumer firework retail prices vary by device type and the type of visual and auditory effects they produce. The most recent pricing data were obtained from a CPSC staff review of online and in-store advertised prices of consumer fireworks.[63] Typically, aerial (including repeaters) and mine/shell devices are the most expensive and snaps are the least expensive on a per device basis. Snaps retail price ranges from $0.50 to $2.00 for a small box that can contain up to 50 of the devices. Aerial devices have a large variety of effects and range in price from $4 to $600 with the more expensive devices being multi shot devices.[64] Aerial devices can range from less than $1 to $37 per device shot into the air. The lowest cost aerial devices per shot are aerial repeaters that can contain hundreds of individual shots and the highest cost are aerial tube devices typically called finale racks, which generally contain 9 shots at most.[65]

[63] The advertised prices could differ significantly as staff was unable to review prices of small retailers who have no online presence and only sell fireworks during the typical busy firework season of May to July. The number of small retailers with no online presence is believed to be under 1,000.
[64] Multi shot fireworks are devices that shoot more than one pyrotechnic device into the air after ignition of the fuse. Aerial repeaters are an example of a multi shot device.
[65] Review of retailer offerings by CPSC staff at retailer websites and physical locations.

4.3 Firms Involved in Fireworks Market

The majority of the fireworks in the current U.S. market are imported, with domestic production accounting for approximately 2.5 percent of U.S. consumption in 2016.[66] Firms involved in fireworks manufacturing are classified under North American Industry Classification System (NAICS) code 325998, "All Other Miscellaneous Chemical Product and Preparation Manufacturing." This is a broad category, which includes both display and consumer fireworks manufacturers, as well as manufacturers of antifreeze preparations, lighter fluids, matches, sugar substitutes, and swimming pool chemicals. Most of the 937 firms classified in this category are not involved in the manufacture of fireworks.[67] The Small Business Administration (SBA) size guidelines define manufacturers categorized under this code as small if they have fewer than 500 employees. All of the three domestic fireworks manufacturers that we identified and obtained employment information for would be considered "small" according to the SBA employee criteria.

Fireworks importers and retail sales firms are classified under NAICS codes 423920 and 453998, "Toy and Hobby Goods and Supplies Merchant Wholesalers" and "All Other Miscellaneous Store Retailers," respectively. However, the majority of the 2,009 and 15,648 firms classified in these two categories, respectively, are not involved in the sale of fireworks, and NAICS codes 423920 contains both display and consumer fireworks wholesalers.[68] The SBA defines importers as small if they have fewer than 150 employees (for wholesalers, NAICS code 423920) or less than $7.5 million in sales (for retailers, NAICS code 453998). The American Fireworks Standards Laboratory (AFSL), which conducts testing and certification for a substantial portion of the industry, maintains a public list of U.S. importers and Chinese manufacturers that participate in its programs, including both display and consumer fireworks manufacturers. Its list includes 165 importers, of which 6 are large, 121 are small, and the remaining 38 are of unknown size, though likely small. AFSL states its members represent between 85-90 percent of U.S. importers, implying a total of 183-194 fireworks importers. In 2016, approximately 94 percent of the imported products came from Chinese manufacturers, with U.S. firework importers representing the largest share of sales for Chinese exporters.[69]

4.4 Annual Shipments and Sales of Fireworks

According to data from the APA, sales of consumer fireworks almost doubled from 1998-2016.[70] In real terms, sales of consumer fireworks increased from roughly $416 million in 1998

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[66] APA Facts and Figures. *American Pyrotechnics Association.* Accessed December 12, 2017. http://www.americanpyro.com/industry-facts-figures

[67] U.S. Census Bureau, 2015 County Business Patterns (release date 9/29/2017).

[68] U.S. Census Bureau, 2015 County Business Patterns (release date 9/29/2017).

[69] Thirty-eight percent of Chinese fireworks exports were to the U.S. Germany was the next largest market for Chinese fireworks exports, accounting for 13 percent (International Trade Centre. *Trade Map* Accessed on December 18, 2017).

[70] APA Facts and Figures. *American Pyrotechnics Association.* Available at http://www.americanpyro.com/industry-facts-figures Accessed December 12, 2017.

to roughly $825 million in 2016 or about 198 percent.[71] A substantial majority of consumer fireworks are imported, with APA estimates of domestic production equating to 2.5 percent of total annual production in 2016. The U.S. International Trade Commission (ITC) reported that total imports for 2014, 2015, and 2016 for consumer fireworks (in pounds) were 202.6 million, 262.4 million and 245.2 million, respectively, which averages to about 236.7 million pounds a year.[72] In comparison, the ITC reported display firework import quantities for 2014, 2015 and 2016 as relatively unchanged at 17.1 million pounds in both 2014 and 2015, and 17.2 million pounds for 2016.

Measured in pounds, U.S. consumption of consumer fireworks increased by 139 percent between 2000 and 2016, from 102 million pounds in 2000 to 243.9 million pounds in 2016.[73] Consumer fireworks are single use products that are disposed of after use. Due to the disposable nature of fireworks, the seasonal cycle of sales, and the costs associated with storing these products, a reasonable estimate for the number of fireworks in use during any given year is equal to the number of fireworks imported plus the number of fireworks produced by domestic manufacturers.

5.0 Societal Costs of Consumer Fireworks Deaths and Injuries

Based on estimates from the National Electronic Injury Surveillance System (NEISS), a national probability sample of U.S. hospital emergency departments (ED), the Directorate for Epidemiology estimated an annual average of 11,200 non-fatal ED injuries involving consumer fireworks that were treated in EDs from January 1, 2014 to December 31, 2016.[74]

In addition to injuries treated in hospital EDs, many product-related injuries are treated in other medical settings, such as, among others, physicians' offices, clinics, and ambulatory surgery centers. Based on estimates from the CPSC's Injury Cost Model (ICM) (Miller et al, 2017), there were another 14,400 medically attended injuries annually involving consumer fireworks that were treated outside of hospital EDs during 2014 to 2016.[75] Consequently, there was an estimated annual average of about 25,600 medically treated injuries involving consumer fireworks (including 11,200 initially treated in hospital EDs plus 14,400 treated outside of hospital EDs) during the 2014-2016 time frame.

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[71] In nominal terms, sales of consumer fireworks were $284 million in 1998. The reported sales revenues for 1998 were inflated to 2016 dollars using the consumer price index.

[72] The ITC data report import value as "value of first sale" and are not comparable to APA sales data. The concept of "value of first sale" allows importers to report the value of goods as the first sale price recorded for those goods in a series of sales from manufacturer to middleman to importer.

[73] Data from the American Pyrotechnics Associations, available at http://www.americanpyro.com/assets/docs/FactsandFigures/Fireworks%20Consump.%20Figures%202000-17.pdf (accessed on March 7, 2018).

[74] Tu, Y, 2016 CPSC Fireworks Annual Report: Firework Related Deaths and Emergency Department Treated Injuries During 2016. Bethesda, MD, CPSC.

[75] The appendix provides a description of the methodology used by the ICM to estimate product-related injuries treated outside of hospital EDs.

As described in detail in the appendix, the estimated societal costs of these nonfatal injuries amounted to about $1.45 billion a year (in 2014 dollars), or about $56,600 per injury ($1.45 billion ÷ 25,600 medically attended injuries).[76]

In addition to nonfatal injuries, the Directorate for Epidemiology reports an average of 7.1 fireworks-related deaths annually from 2001-2016.[77] The annual societal cost of consumer firework deaths is estimated to be $61.8 million in 2014 dollars, using a value of a statistical life (VSL) of $8.7 million.[78] When combined with the nonfatal injury costs, the total societal costs associated with fireworks-related deaths and injuries amounts to roughly $1.52 billion annually.

6.0 Regulatory Analysis

The regulatory analysis consists of a discussion of the benefits and the costs of the recommended final rule. The analysis is conducted from a societal perspective, considering all of the significant costs and health outcomes. As described below, one of the benefits of the recommended final rule is related to the harmonization of requirements from existing fireworks safety rules. The benefits could also include some reduction in deaths and the frequency and severity of injuries. The costs include the added cost, if any, associated with producing consumer fireworks that conform to the new standard, as well as any potential reduction in consumer utility that might be related to the requirements, such as a loss in the sound quality or visual display of fireworks. The majority of these costs and benefits are expected to be small but not quantifiable, with quantified costs at approximately one cent per aerial device.

In the next section we describe each of the major provisions of the recommended final rule, and their expected impacts, both the potential benefits and potential costs.

6.1 Requirements Intended to Limit the Explosive Force of Aerial Fireworks Devices

The recommended final rule changes the method by which CPSC would limit the explosive force of consumer fireworks and align the CPSC regulations with APA 87-1 requirements. The first set of requirements would amend the current CPSC regulation at § 1500.17(a)(3), which limits the chemical composition in the burst charge of devices intended to produce audible effects to 130 milligrams (or 2 grains). The draft rule does not change the two grain limit, but replaces the determination of "intended to produce audible effects" with a quantitative limit on fine mesh metal in the burst charge. The second set would amend § 1500.17 to establish limits on total chemical composition in certain firework types. Each of these sets of requirements are discussed below.

[76] The appendix provides a description of the methodology used to estimate the societal costs of these injuries.
[77] Tu, Y, 2016 CPSC Fireworks Annual Report: Firework Related Deaths and Emergency Department Treated Injuries During 2016. Bethesda, MD, CPSC.
[78] The estimated value of a statistical life (VSL) of $8.7 million (in 2014 dollars) is a revision of the VSL estimated by the Environmental Protection Agency (EPA, 2010) and is generally consistent with other estimates based on willingness-to-pay. Kneiser et al. (2012) suggested that a reasonable range of values for VSL was between $4 million and $10 million (in 2001 dollars), or about $5.3 million to $13.3 million in 2014 dollars (BLS 2015).

6.1.1 Limit on Fine Mesh Metallic Powder in the Burst Charge of Aerial Devices

The draft rule would amend § 1500.17(a)(3) to replace the current regulation, which limits the pyrotechnic material in fireworks "intended to produce audible effects" to two grains (130 milligrams), with the APA 87-1 requirement that prohibits fine mesh metallic powders (less than 100 mesh) in the burst charge, if the burst charge contains more than 130 milligrams of chemical composition. The recommended final rule retains the two grain (130 milligram) limit, but changes the initial step of the current requirement. Both the existing CPSC standard and APA 87-1 are intended to address hazards associated with higher explosive force per volume in fireworks. In addition, the staff-recommended preamble would explain that the Commission will exercise enforcement discretion to allow up to 1.00 percent fine mesh metal powder in a burst charge before applying the 2 grain limit.

Chemical materials that contain fine mesh metallic powders are frequently used by fireworks manufacturers to produce sharp, clear audible effects in aerial devices. Although all devices will produce audible effects, in most cases the audible effect is a byproduct of the explosion of the break charge required to disperse the visual elements of the firework, and is not the primary intended effect of the device. However, fireworks using fine mesh metallic powders have up to three hundred percent more explosive force per volume of chemical material than fireworks using only black powder.[79] Although it is difficult to link any particular injury associated with fireworks to the amount of explosive force contained in the device, as the Division of Chemistry memorandum in staff's briefing package indicates, the most highly explosive types of consumer fireworks are associated with the majority of consumer fireworks deaths and many of the most severe consumer fireworks injuries. As a result, reducing the explosive force of fireworks could potentially reduce the propensity of the device to cause serious injury or death.

To enforce the current requirements, CPSC staff uses what is often referred to as the "amount" test or the "ear" test (for further details on this testing, please refer to the Division of Chemistry memorandum in staff's briefing package). The "amount" test involves a technician listening to the device during field testing and determining whether or not the sound heard was intentional or a byproduct of the functioning of the device. If staff determines that the sound is intentional, the device is considered to be "intended to produce an audible effect." The recommended final rule would adopt the method used in APA 87-1, which considers any burst charge that contains metallic powder of less than 100 mesh as being intended to produce audible effects. Therefore, the draft requirement can be enforced by testing pyrotechnic material for the presence of metal powders, which can be accomplished using various techniques, including x-ray fluorescence spectroscopy (XRF). This method of enforcement is more objective and more easily repeatable, and is therefore more likely to produce identical results for different testers, than the current CPSC test method (or "ear" test).[80]

[79] Tang, Andrew. A New and Fast Method of Evaluating Powder Energy. *Journal of Pyrotechnics*. Issue 28, 2009, pp 51-64.

[80] Roemer, Matthew, Priscilla Verdino, and Jason Howe, 2018 CPSC Memorandum to Rodney Valliere, "Fireworks Final Rule – Laboratory Sciences Analysis," Consumer Product Safety Commission, Bethesda MD (August 27, 2018).

Testing by CPSC and others suggests that adopting the recommended final rule would effectively result in a marginally more stringent rule. The NPR reported that random testing of compliance samples by CPSC staff found detectable levels of fine mesh aluminum in 84 percent of the break charges tested and that all of the break charges that contained detectable levels of fine mesh aluminum contained more than 2 grains of chemical composition. However, using current testing methods, the NPR reported that only 17 percent of the same devices "were intended to produce audible effects and exceeded the 2-grain limit." The joint public comment provided by the APA and AFSL reported that their testing conducted in 2017 found that 8 percent of the mine and shell devices tested and 22 percent of the reloadable aerial tube devices tested would have failed to comply with the limit on fine mesh metallic powders in the recommended final rule and the 1.00% enforcement discretion allowance. However, they note that "none of the devices were found non-compliant using the current methods."

***Costs of Limiting Fine Mesh Metallic Powder in the Burst Charge*:** The costs of the draft requirement limiting fine mesh metallic powders in burst charges would consist of the costs to manufacturers and importers of bringing their products into compliance with the recommended final rule and the lost utility to consumers if compliant fireworks do not provide as much enjoyment or pleasure as noncompliant fireworks. In order to estimate the cost to manufacturers, staff analyzed the rate of compliance with the limits imposed in the recommended final rule, testing costs associated with firework devices, and material costs associated with switching from the use of flash and hybrid powders, which contain fine mesh metallic powders, to strictly black powder in firework burst charges. Thus, we are able to quantify the approximate costs to manufacturers. Although we acknowledge that there could potentially be some cost to consumers in terms of a loss of enjoyment or utility, we have no basis for quantifying those costs.

Costs to Manufacturers/Importers: The recommended final rule would prohibit fine mesh metallic powders in the burst charge if the burst charge contains more than 2 grains of pyrotechnic composition. However, the staff-recommended preamble would state that the Commission will exercise its enforcement discretion to allow the burst charge to contain up to one percent fine mesh metallic powders to allow for contamination from the visual effects or environmental contamination, and to accommodate differences in instrument readings. Staff expects industry to comply with the recommended regulation by eliminating fine mesh metallic powder from the formulations used in fireworks break charges, which in most cases would result in burst charges that consist solely of black powder.

Based on a comparison of the wholesale prices of ingredients used to make flash powder and the ingredients used to create black powder, the costs of switching from metallic and hybrid powders to black powder should not significantly impact firms that have to change formulations.[81] The wholesale prices for aluminum, magnesium and potassium perchlorate powders, which are widely used in flash powders, averaged to $1.75, $2.04, and $0.67 per pound, respectively.[82] This suggests a typical flash powder wholesale price range of $0.99 per pound (based on a flash powder composition of 30 percent aluminum and 70 percent potassium

[81] Some flash powder formulations are aluminum and perchlorate, aluminum and chlorate (which is currently a prohibited chemical), magnesium and nitrate with varying compositions depending on the desired effect.
[82] Estimates are based on online wholesale prices for one metric ton, collected from November 2017 to April 2018.

perchlorate) to $1.42 per pound (based on a flash powder composition of 34 percent magnesium, 26 percent aluminum, and 40 percent potassium perchlorate).

Given the observed online wholesale prices for the ingredients used to make black powder, we estimate that the wholesale price of black powder would be about $0.36 per pound.[83] Additionally, mixing of black powder may require more labor as extra milling and preparation of the ingredients is needed to produce an efficient explosion, which may increase the cost due to labor and time needed to produce a good quality black powder. For the purpose of this analysis we assume that an additional two hours of labor per 10 pounds of black powder are needed to account for the additional preparation, which equates to an additional labor cost of about $0.69 per pound.[84] Therefore, the cost of a pound of black powder may be about $1.05 including the cost of the ingredients and labor. The explosive qualities of black powders are greatly affected by the quality of the materials used in the mixture, which can also affect cost.[85] For example, higher quality charcoal made from maple trees will typically command a slightly higher price over other soft wood charcoals.

Flash powders are typically three times more powerful than black powders. Therefore, to produce an explosive force equivalent to what could be obtained with flash powder, a manufacturer might have to use three times as much black powder.[86] Using that assumption, the material costs of a flash powder burst charge can potentially be lower than a black powder charge with an equivalent explosive force.[87]

The cost of eliminating fine mesh metallic powders from the burst charge of firework devices will be very low on a per unit basis. A typical burst charge for a reloadable tube aerial device weighs approximately 9 grams and of those burst charges in which the aluminum content

[83] Black powder is generally made with 75 percent potassium nitrate (saltpeter), 15 percent charcoal, and 10 percent sulfur and is typically mixed using a ball mill and/or a screen using a technique called "ricing." For the purpose of the wholesale cost estimate a 75/15/10 composition is used with price per pound of potassium nitrate, charcoal, and sulfur equating to $0.41, $0.31, and $0.14, respectively.

[84] Estimate assumes that the manufacturing is located in China and an hourly wage of $3.91 based on annual compensation data published by the National Bureau of Statistics of China and an estimate of average annual hours worked in Bannister 2005.

[85] Maltitz I, 2003 Black Powder Manufacturing, Testing & Optimizing. Dingmans Ferry, PA, American Firework News.

[86] Roemer, Matthew, Priscilla Verdino, and Jason Howe, 2018 CPSC Memorandum to Rodney Valliere, "Fireworks Final Rule – Laboratory Sciences Analysis," Consumer Product Safety Commission, Bethesda MD (August 27, 2018).

[87] Some devices that currently have close to the maximum limit on pyrotechnic material in the burst charge (15, 50, and 125 grams for mine and shell devices, 60 g single devices, 200 g cakes and 500 g cakes respectively) and have large amounts of fine mesh metallic (or flash) powders would not be feasible if the recommended final rule is promulgated because the limits of total pyrotechnic weight in the recommended final rule would prevent manufacturers from substituting sufficient black powder in the amounts to produce equivalent explosive force. However, these devices would also likely fail to comply with the current regulation regarding devices intended to produce an audible effect and would therefore be prohibited now and may be available now only because consistent enforcement of the current regulations is difficult.

exceeds one percent, the average aluminum content is 8 percent.[88] A 9 gram burst charge that contains 8 percent aluminum content would mean that it contains approximately 2.4 grams of flash powder.[89] The equivalent explosive force in black powder equates to approximately 7.2 grams (*i.e.*, three times the 2.4 grams). Given these parameters, the cost increase to bring this average device into compliance is approximately $0.011, or about 1 cent.[90]

This compliance cost would apply to only a subset of aerial devices.[91] According to compliance rates provided by the APA/AFSL in its joint public comment only 14 percent of aerial devices would require changes to comply with the rule (assuming a 1 percent contamination allowance).[92] A report provided by the NFA with its comment found that a higher percentage (55 percent) would require modification to comply.[93] Therefore, the impact of this component of the recommended final rule on the total revenue of any manufacturer or importer would actually average far less than one cent per aerial device.

Section 14 of the Consumer Product Safety Act (CPSA) requires manufacturers or importers to certify that their products comply with all applicable testing rules based on a test of each product or a reasonable testing program. Testing products for compliance with the limit on fine mesh metallic powders could be accomplished using XRF technology or inductive coupled plasma (ICP) technology. XRF testing costs approximately $15 per scan and ICP testing costs about $50 per test.[94,95] Both of these testing methods are more reliable, objective, and repeatable than the current "ear" test conducted on aerial devices to determine whether they are "intended to produce an audible effect."[96] Using the testing protocol described in APA 87-1, which requires testing of 15 to 25 devices per test (as an example of a rigorous testing protocol) at a cost of $15 per test equates to a range of $225 to $375 per firework batch tested.[97] On a per production unit basis, the testing costs would equate to a range of $0.01875 to $0.0625 for an

[88]Roemer, Matthew, Priscilla Verdino, and Jason Howe, 2018 CPSC Memorandum to Rodney Valliere, "Fireworks Final Rule – Laboratory Sciences Analysis," Consumer Product Safety Commission, Bethesda MD (August 27, 2018).

[89] Calculated as: [(burst charge size (grams) * Aluminum percentage in burst charge) / proportion of aluminum in flash powder formula]. The flash powder formula used in the calculation is the 0.3 aluminum to 0.7 potassium perchlorate. (i.e., 9 * 0.08 / 0.3)

[90] Calculated as: [(Black powder increase in weight (grams) * price per gram of black powder) – (Flash powder weight * price per gram of flash powder), or [(7.2 grams * ($1.05/453.592 grams)) – (2.4 grams * ($0.99/453.592 grams))] The 453.592 in the denominator represents the number of grams per pound.

[91] According to testimony from John Rogers at the CPSC public hearing on March 7, 2018, aerial devices account for between 60 and 65 percent of consumer fireworks on the market.

[92] Based on the data for all aerial devices tested in 2017 provided by APA/AFSL in their joint public comment on the NPR.

[93] A report summarized in the public comment on the NPR submitted by the NFA reported that 55 percent of devices tested exceeded 1 percent aluminum in the burst charge.

[94] Based on price data provided by AFSL, Bureau Veritas, and price quotes from U.S. based testing laboratories.

[95] NFA obtained quotes for XRF testing of fireworks from two labs which were provided to CPSC in a comment for the public hearing on the amendments to the fireworks regulations held at CPSC headquarters on March 7, 2018. The quotes were approximately $100 for XRF testing of firework devices which is 6.6 times greater than the quote provided by BV.

[96] Roemer, Matthew, Priscilla Verdino, and Jason Howe, 2018 CPSC Memorandum to Rodney Valliere, "Fireworks Final Rule – Laboratory Sciences Analysis," Consumer Product Safety Commission, Bethesda MD (August 27, 2018).

[97] APA 87-1 calls for 15 devices per test and an additional 10 devices if at least 1 sample fails.

average batch size between 6,000 and 12,000 devices, respectively.[98,99] Manufacturers would also have the option of certifying compliance with the requirements by testing the raw materials for the presence of fine metallic powders using the principles of component part testing, which could substantially reduce the testing costs on a per unit basis.[100]

Note that the requirement to certify compliance with all product safety rules is a requirement of the CPSA and not of the draft rule. The certification requirement also applies to the current regulation concerning devices intended to produce an audible effect and manufacturers and importers should be certifying compliance to the current regulations, based on a reasonable testing program. Moreover, because the "amount test" is susceptible to environmental and design factors that influence the sound a device produces, devices of the same type can produce inconsistent results, which one could argue necessitates testing a large number of samples to ensure that a "loud report" could not be detected. Therefore, the cost of properly conducting certification tests for compliance with the recommended final rule is likely lower than the cost of properly conducting certification tests with the current regulations,.

Reduced Utility to Consumers: The limit on fine mesh metallic powders in the burst charges could result in an unquantifiable cost to consumers in terms of reduced utility or enjoyment from fireworks.[101] Fine mesh metal commonly is used in fireworks burst charges for two reasons, to produce a particular sound and because aluminum contributes to the symmetry of visual effect detonations. Metallic fuels in the burst charge produce a different sound during detonation than a black powder only burst charge device due to the pressure wave that a metallic fuel produces.[102] A device with metallic fuel produces a sharp and loud sound with overpressure determining the loudness.[103] Fireworks consumers may have a preference for these louder, sharper sounds or a preference for the more symmetrical visual effect. Consequently, if consumers were able to discern this difference, the requirement could reduce utility and potentially sales. We also note that black powder cannot create the bright white flash that is characteristic of flash powder. Other visual effects within the firework will ignite with black powder formulations but it is possible that some fireworks requiring specific dispersal patterns may be affected by limitations on pyrotechnic/explosive load.

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[98] Based on average aerial device lot size data for 500 g and 200 g cakes and mine and shell devices provided by AFSL.

[99] Using the XRF testing cost of $100 would indicate a range of testing costs from $0.125 to $0.42.

[100] For example, if a manufacturer tested one metric ton of black powder, which can produce approximately 27,000 burst charges of average weight, the testing cost per device could be substantially less than $0.01 per unit. In order to use component part testing to certify compliance under a reasonable testing program, the manufacturer would also have to ensure it had procedures in place that would prevent the raw materials from being contaminated by fine mesh metallic powders. This might require ensuring that devices that use fine mesh metallic powders are not manufactured in the same areas in which the burst charges for consumer fireworks are manufactured.

[101] Utility is a measure of preference of a good, typically defined as happiness or satisfaction received from the consumption of a good.

[102] Tang, Andrew. A New and Fast Method of Evaluating Powder Energy. *Journal of Pyrotechnics*. Issue 28, 2009, pp 51-64.

[103] Kosanke, K.L, Kosanke, B.J. Flash Powder Output Testing: Weak Confinement. *Journal of Pyrotechnics*. Issue 4, 1996, pp 384-393.

Because we do not have information on the extent to which consumers derive utility from the sound or visual effects created by fine metallic powders and the extent to which it could be reduced under the recommended final rule, we cannot quantify any potential utility losses or the extent to which such losses would reduce sales. However, utility losses may be small. Devices that contain sufficient flash powder to produce a more concentrated explosion and a louder report are likely to fail the current requirement limiting devices intended to produce an audible effect. Testing indicates that the vast majority of devices on the market contain more than 2 grains of pyrotechnic composition, so devices that produce this sharp, loud sound, would be noncompliant with the current regulation. Moreover, the fact that many of the devices that contained fine mesh metallic powders that would exceed the limits in the recommended final rule were not found to violate the current regulations, using the current testing methods also suggests that the impact on consumer utility will be low. If it is difficult for trained technicians to identify these devices using the current test methods *(i.e.*, the "ear" test), the ability of untrained consumers to differentiate between the effects of a device containing fine mesh metallic powders and those containing only black powder is doubtful.

In addition, Bureau Veritas' testing of more than 1,700 aerial devices (reported in the joint comment from APA and AFSL) in 2016 and 2017 indicates that approximately 47 percent of devices had no detectable level of fine mesh aluminum in the break charge and approximately 77 percent of devices had less than 1.00 percent fine mesh aluminum in the break charge. This suggests that a large number of devices on the market already comply with the recommended regulation, and, although we do not know the demand for these devices, we can presume that they provide some utility for consumers, since they are on the market. There are also some factors that may counterbalance the potential loss of utility to consumers. Some of this loss in utility could be offset by a reduction in a negative externality to non-users of the fireworks.[104] The consumer of a firework device may receive utility from the noise, but a neighbor woken up from sleep by the device suffers a loss of utility.

***Benefits of Limiting Fine Mesh Metallic Powder in the Burst Charge*:**

As discussed in Tab D , burst charges that contain fine mesh metallic powders have greater explosive force than burst charges of the same weight that consist of only black powder and the potential for injury increases with explosive power. Whereas the DOT and the APA attempt to limit the use of fine mesh metallic powders directly, the current CPSC regulations attempt to do so indirectly by placing a two grain limit on the burst charges of devices that are "intended to produce an audible effect." Thus, there are three primary benefits to the limit on fine mesh metallic powders. These are harmonizing CPSC requirements with those of the DOT and APA, providing an objective test that would replace the subjective "ear" or "amount" test now used by CPSC, and, because the recommended final rule is effectively more stringent than the existing regulation, potentially reducing fireworks-related injuries. Each of these possible benefits is discussed in turn.

First, the draft rule would align the CPSC requirements with the requirements of APA 87-1 and DOT requirements. Currently, consumer fireworks manufacturers and importers certify that their products comply with both the requirements of APA 87-1 (as it is incorporated by

[104] A negative externality is an economic activity that imposes a negative effect on an unrelated third party.

reference into the DOT regulations and is the option that nearly all firms use to obtain DOT approval to transport fireworks) and the CPSC requirements pertaining to devices intended to produce audible effects. Although both sets of requirements are intended to address the same hazard, currently manufacturers and importers must meet two different sets of requirements that have two very different tests for assessing compliance. Under the recommended final rule, the CPSC requirements would be the same as those in APA 87-1, including the tests for compliance.

Second, manufacturers would no longer be required to conduct the ear screen or amount test to determine if their devices were subject to the two grain limit. In contrast to the ear screen, the test method in the recommended final rule is more objective, simpler, more reliable, and repeatable, and could result in fewer fireworks shipments being found in violation of the requirements after being imported. As discussed above, to test for audible effects, technicians listen for a "loud report" during field testing. However, different technicians may make different judgments regarding whether the device made such a report. Moreover, the sound quality may be affected by environmental conditions during the test, such as the humidity level, wind, other sources of ambient noise, or design factors such as shell construction and packing density. Therefore, under the "amount" test, even if an importer required that the fireworks be tested in China before importing the products, there is still a possibility that a technician testing the product in the United States could judge the product to be intended to produce an audible effect and be found noncompliant with the current regulation. Because the testing for compliance with the limit on fine mesh metallic powders is simpler and more repeatable than testing for compliance with the current standard, manufacturers and importers should be able to more reliably determine whether the device complies with the requirements before they attempt to introduce it into commerce in the United States.

Finally, because (as described above) the recommended final rule is, in effect, marginally more stringent than the current rule (as indicated by the fact that based on testing of devices currently on the market more devices would fail the recommended final rule than fail the current regulations), it could potentially result in some reduction in injuries or the severity of injuries. However, because the extent to which this requirement would reduce the number or severity of injuries, if any, is uncertain, we cannot compare the potential injury reduction benefits to the costs of the provision.

We can, however, show that a relatively small number of injuries would need to be prevented for the injury reduction benefits to equal the costs of modifying devices to comply with the requirements. Above, we estimated that the cost of modifying devices to comply with the requirement would be approximately one cent per shell or shot. According to the APA, consumer fireworks revenues in 2017 amounted to about $885 million.[105] We estimate that aerial devices account for about 70 percent of this amount.[106] CPSC staff review of retailer

[105] American Pyrotechnic Association (https://www.americanpyro.com/industry-facts-figures) accessed on September 11, 2017.

[106] According to the public comment from the NFA, aerial devices account for *more than half* of revenue associated with consumer fireworks. According to statements made by a representative from the AFSL at the public hearing on the amendments to the fireworks regulations on March 7, 2018, aerial devices account for approximately 60 percent of imported consumer fireworks. Because the prices of aerial devices on average are higher than those for other types of fireworks, we believe that 70 percent is a reasonable estimate for the portion of revenue from sales of consumer fireworks that is accounted for by aerial devices.

websites indicates that average costs per shell is approximately $5.60. Using data from APA/AFSL (for 2017), approximately 14 percent of the devices would need to be modified. Therefore, the cost of the provision at 0.01 cent per shell would amount to about $155,000 (($885 million × 0.70) ÷ $5.60 × $0.01 × 0.14). Given the average cost per medically attended fireworks injury of about $56,600 described in section 5.0, the provision would need to prevent about 3 medically attended injuries annually for the benefits to equal the costs.

6.1.2 Limit Total Chemical Composition for Certain Fireworks Types

Another provision of the recommended final rule that is intended to limit the explosive force of consumer fireworks would amend § 1500.17 to limit the total amount of pyrotechnic and explosive material in certain types of aerial firework devices. Currently, apart from the 2 grain limit discussed above for devices that are "intended to produce audible effects," the CPSC regulations do not contain any limits on the chemical composition of any fireworks devices. The limits in the recommended final rule generally align with APA 87-1 with minor changes to provide clarification related to the burst charge provisions, and are high enough to allow sufficient explosive force for a viable fireworks device, even accounting for switching from flash powder and hybrid formulations to exclusively black powder.[107] The limits do not preclude the existence of any device types based on an inability to function with the limited amount of pyrotechnic/explosive material, and only represent a limit on the size.

The recommended final rule would limit the total chemical composition of Sky Rockets, Bottle Rockets, Missile-Type Rockets, Helicopters (Aerial Spinners), and Roman Candles to 20 grams. Mine and shell devices would be limited to 60 grams of total chemical composition in any shell, and the lift charge would be limited to no more than 20 grams of black powder. Under the recommended final rule the lift charge must contain only black powder. Multiple-tube devices could contain up to 200 or 500 grams total, depending on the base structure.

The recommended final rule would limit the burst charge of any component to no more than 25 percent of the total chemical composition weight of the component, excluding any lift charge. Aerial shells with reloadable tubes would be limited to no more than 60 grams of chemical material per shell, 20 grams of black powder in the lift charge, and 400 grams per device total, with the burst charge limited to no more than 25 percent of the total chemical composition weight of the shell, excluding any lift charge.

Overall, most devices comply with the limits on total chemical composition. However, there is evidence that a substantial number of devices on the market might not comply with the limits on the ratio of the burst charge to the chemical composition of the device, exclusive of the lift charge. Testing of sample mine and shell devices collected by CPSC staff shows 8 percent were over the total chemical composition limit and 17 percent exceeded the burst charge limit.[108]

[107] Roemer, Matthew and Priscilla Verdino, 2016 CPSC Memorandum to Rodney Valliere, "Fireworks NPR Preliminary Regulatory Analysis," Consumer Product Safety Commission, Bethesda MD (December 14, 2016).
[108] Roemer, Matthew, Priscilla Verdino, and Jason Howe, 2018 CPSC Memorandum to Rodney Valliere, "Fireworks Final Rule – Laboratory Sciences Analysis," Consumer Product Safety Commission, Bethesda MD (August 27, 2018).

CPSC testing of sample reloadable tube aerial devices shows that none exceeded the total chemical composition limit but 55 percent exceeded the burst charge limit.

The benefit of the requirement limiting the total chemical composition and the burst charge to 25 percent of total chemical composition (excluding the lift charge) is that it would allow CPSC to remove fireworks with what could be considered excessive chemical material from the consumer market or prevent such fireworks from entering the U.S. market, if discovered at the port, without having to make findings in each case that the product poses a substantial hazard to consumers. There could also be some unquantifiable benefit in terms of reduced injuries. As the Division of Chemistry memorandum explains, increased pyrotechnic content increases the explosive power of a device, even when the device contains only black powder (no fine mesh metal powder). As noted, most devices currently on the market already comply with the limits on total chemical composition contained in APA 87-1, which are the same as those in the recommended final rule. However, based on the CPSC testing, a substantial number of devices could exceed the limit on the ratio of the chemical composition of the burst charge to the combined chemical composition of the burst charge and effects. Applying a mandatory limit on the break charge content should limit the explosive power of devices, which may provide benefits in terms of reduced injuries. However, this benefit is not quantifiable because it would be difficult to trace the cause of any specific injuries to the burst charge exceeding 25 percent of the combined chemical composition of the burst charge and effects.

Although we cannot quantify any costs of this provision, staff assesses that the cost to manufacturers of bringing any noncompliant product into compliance with the draft rule would be low. Most manufacturers that find that some of their devices exceed the limits would need to institute better quality control procedures to ensure that they do not use more chemical materials than allowed. Given the handmade production methods of most firework production, a quality control system to comply with the recommended regulation could consist of changes such as a one-time adoption of smaller measuring devices for filling fireworks with chemical material. In addition, we again note that this requirement is already part of the current voluntary standard (APA 87-1), which nearly all firms certify compliance with to obtain required DOT approval to transport fireworks in commerce. Therefore, firms should (and may) already have procedures in place to assess or control the amount of composition in devices, which would mean the recommended final rule would not create any new costs for these firms. As already mentioned, the limits contained in APA 87-1 are thought to be sufficiently high and do not greatly restrict manufacturers from their preferred levels of chemical materials in consumer fireworks.

6.2 Require Bases to Remain Attached During Storage, Handling, and Operation

The recommended final rule includes a requirement for bases to remain attached to fireworks during storage, handling, and operation. This is a requirement in APA 87-1. While the current CPSC regulations only specify the required size of base attachments, improper attachment of the base or base detachment can lead to tip over upon use. Fireworks not launched at the intended launch angle pose a hazard to consumers by exploding too low, or even launching horizontally, directly at consumers.

The benefits of this requirement would be the reduction in injuries that might result from fewer fireworks tipping over during operation or being launched at the wrong angle because the base had become detached. We are unable to quantify the impact of this addition to the rule because CPSC epidemiological data do not provide sufficient detail for identifying which incidents fitting the hazard pattern are associated with base detachment, as opposed to more general tip-over incidents that might be caused by launching fireworks on a sloped or un-level surface or intentionally being launched at an angle. An analysis of the NEISS injury incidents from 2014 to 2016 involving consumer firework tip over incidents found an average of approximately 130 nonfatal injuries a year possibly addressed by the requirement for attached bases during storage, handling, and operation. However, which of these incidents, if any, would have been prevented by the requirement in the recommended final rule is not known.

Therefore, although it is not possible to estimate the number of injuries caused by fireworks whose base has detached, a firework device with a firmly attached base is less likely to tip over or be launched at an unintended angle than one whose base has detached. Moreover, there seems little justification for the inclusion of a requirement for the size of base attachment if the actual attachment to firework device is not required.

Although Staff cannot quantify any potential costs, it is expected that the costs of this requirement will be minimal. CPSC does not test for base attachment when testing samples of fireworks, but on occasions where bases were not attached, a note is typically made in the testing record. In fireworks tested from fiscal year 1999 through 2016, out of 4,554 relevant samples, the reports regarding only 111 samples (2.4%) contained notes that bases were either missing or functioned improperly during operation. More recent data collected by CPSC staff from October 2014 through May 2018 indicate that approximately 9 percent of devices that required bases to operate had no base, a detached base, required base assembly, or tipped over during testing.

For devices not currently meeting the requirements, staff expects firms to comply by either adapting the firework design so the device and base are all one piece, or securing the base to the rest of the device with an adhesive. The potential costs of complying with the recommended regulation include additional time in affixing the base to the firework (seconds per device), adhesives or other materials for affixing the base to the device (also a very low cost per device), and possibly higher shipping costs if, in some cases, the packaging takes more volume when the bases are shipped attached rather than separate. For devices that are initially produced with bases attached, but the bases detach during storage, handling, and operation, some measure of quality control may be necessary to ensure this does not take place.

6.3 Provisions Intended to Clarify Existing Requirements

The recommended final rule includes several provisions that are not intended to change existing regulations, but rather to clarify the meaning or scope of the requirements. The benefits of these draft changes would be those that result from increasing the clarity of the regulations and improving the understanding of the requirements by the regulated community. Because these changes do not substantively change existing requirements, any resulting costs or benefits would be negligible. These changes are discussed briefly below.

***Define "Aerial Bomb" and Clarify the Regulations Using the Term*:** Currently the regulations mention the term "aerial bomb" as both subject to the limits described in § 1500.17(a)(3) and subject to the ban described in § 1500.17(a)(8). The recommended final rule would remove the term from § 1500.17(a)(8) to clarify the applicable regulation for such devices is § 1500.17(a)(3), and would define the term to clarify which devices are subject to the ban.

***Modify the Exemption for Firecrackers from 16 C.F.R. part 1507*:** The recommended final rule would define the term "firecracker" and would replace the current global exemption for firecrackers in § 1507.1 (Scope) with exemptions for firecrackers in §§ 1507.2 (Banned Chemicals) and 1507.3 (Fuses). The remaining subsections of part 1507 apply to devices that by definition are not firecrackers.

***Define Several Terms in the C.F.R.*:** The recommended final rule would add several definitions for terms used in the regulations, but are not defined. CPSC staff believes that the draft definitions are consistent with industry use and understanding of these terms, and are consistent with the definitions used in the CPSC test manual. The terms for which the recommended final rule would include regulatory definitions include "break charge," "blowout," "burnout," "chemical composition," "explosive composition," "firecracker," "lift charge," and "pyrotechnic composition."

6.4 Effective Date

The recommended final rule would be effective one year after the final rule is published in the *Federal Register*. The proposed effective date in the NPR was one month after the promulgation of a final rule. Staff's analysis of the consumer firework market, and public comments indicate that a one-month effective date would be unnecessarily burdensome. Commenters stated that additional time, ranging from six months to several years, would be necessary to adjust fireworks production to meet the new requirements, obtain necessary testing, sell existing inventory, and acquire compliant inventory before the next season. Staff concluded that a one year effective date is reasonable given the retail cycle of consumer fireworks. Most fireworks are sold and used around July 4th of each year. Manufacturers and importers begin planning for the 4th of July sales in August of the previous calendar year. A one year effective date will allow sufficient time to make any necessary adjustments to comply with the requirements.

7.0 Alternatives to the Recommended Final Rule that CPSC Considered

Staff considered several alternatives, which are discussed below. Among the alternatives considered were the different limits for fine mesh metallic powder in the burst charges and whether these should be in the form of a contamination allowance discussed in the preamble or in the form of an explicit regulatory limit. Staff also considered several alternatives or tests to limit the explosive power without limiting the metallic fuel content, including tests using sound level meters, black powder equivalency tests, and tests based on over-pressure measurements. Staff considered an alternative limit on total chemical composition of the burst charge. Additional alternatives considered included several provisions that were in the proposed rule but

are not included in the recommended final rule. These include prohibiting additional chemicals from fireworks, allowing trace contaminates of prohibited chemicals, establishing a regulatory test for evaluating side ignition, and prohibiting fireworks that expel fragments. Finally, staff considered taking no regulatory action, which would retain the existing regulations unchanged.

7.1 Increase the allowance for contamination for fine mesh metallic powders to three percent

Justification for Alternative in the Recommended Final Rule: The recommended final rule contains a prohibition on the use of fine mesh metallic powders in the burst charge if the burst charge contains more than 130 milligrams or 2 grains of pyrotechnic composition. However, as in the NPR, the recommended preamble to the final rule would state that the CPSC will use its enforcement discretion to allow minimal contamination of up to, but not exceeding 1.0 percent of metallic powder in the burst charge. Staff received a number of comments on the proposed contamination allowance, most of which stated a preference for a higher contamination allowance. In developing the recommended final rule, Staff considered higher contamination allowances including 2.0 percent, 3.5 percent, and 5 percent.

The contamination allowance of 1.0 percent in the recommended preamble to the final rule is intended to reflect a balance between the intended safety purpose and the realities that impact the level of fine mesh metal powder detected in a break charge. The intent of the rule is to limit the use of flash powders, which contain fine mesh metallic powders and have more explosive force per volume than black powder. As the Division of Chemistry memorandum in Tab D explains, increasing the amount of fine mesh metal powder increases the explosive power produced. Staff analysis and BV comments indicate that there is a 3 percent increase in energetic potential for every 1 percent increase in metallic fuel. Devices with greater amounts of energetic potential or explosive power could potentially increase the severity of fireworks injuries. Furthermore, given the relationship between explosive force and standoff distance as described in the Division of Chemistry memorandum, reducing the explosive force also reduces the range at which injuries can occur, and therefore the likelihood of occurrence. However, staff cannot quantify an increase in the likelihood of injury or injury severity that would result from allowing a higher contamination level. All aerial devices, including those that would meet the requirements of the recommended final rule, are capable of causing severe injury or death if they misfire at ground level or are misused. We cannot identify which injuries were more severe because of the presence of metallic powders or would not have occurred in their absence. However, as discussed previously, if the recommended final rule reduces the number of injuries by about 3 (out of an estimated 25,600 medically attended injuries annually), the benefits of replacing the metallic powders with black powder will exceed the costs.

In addition to the argument that keeping the contamination allowance at 1 percent may potentially reduce injuries by reducing explosive power, the Division of Chemistry memorandum states that a 1 percent contamination limit is sufficient to address reasonable contamination levels and test equipment variability, as long as metallic powders are not intentionally added to the burst charge. CPSC staff found that potential environmental contamination and migration of fine mesh metal from other components within a device, into the break charge, are extremely low, if they occur at all. For example, staff found environmental contamination and migration

likely account for no more than 0.5 percent fine mesh metal in the break charge. In addition, the Bureau Veritas (in the joint comment from APA and AFSL) provided some relevant data on potential testing variation. According to that comment, instrument readings may vary, on average, by about 0.15 percent. Consequently, inadvertent contamination and instrument variation is expected to produce far less than 1.00 percent fine mesh metal in a break charge. Staff believes that fine mesh metallic powders being present at above one percent is indicative of intentional use.

Increase the Allowance to 2 Percent: In their joint comments, AFSL and APA advocated a 2 percent contamination limit. They stated that at levels between zero and two percent of metal powder there is no significant increase in the energetic/explosive force of the device. They provided data that an increase from a 1 percent to a 2 percent metallic fuel allowance would result in a 1-2 percent increase in the "pass" rate with approximately 94 percent of MSDV and 79 percent of RTAS devices meeting a 2 percent allowance.

Staff considered a 2 percent allowance but did not include it in the recommended final rule. Staff notes that APA 87-1, with which the draft rule is intended to harmonize, does not make any allowance for contamination. As discussed above, staff believes that a 1 percent allowance is sufficient to allow for any environmental contamination or migration of metallic powders from other components, if metallic powders are not intentionally being used and to accommodate any potential variation in instrument reading when testing for compliance. Therefore, staff believes that a 2 percent allowance would result be a slightly less stringent standard than recommended final rule, and could result in the potential for a 3 to 6 percent increase of explosive force in the devices. Although any increase in injuries or injury severity would be small and unquantifiable, such a change would only result in a 1-2 percent increase in the pass rate. Thus, any marginal decrease in costs would be very small. On the other hand (as discussed in the next paragraph), a 2 percent allowance would more closely replicate the stringency of the current requirements.

Increase the Allowance to 3 or 3.5 Percent: Another alternative is to allow a higher discretionary limit of up to 3 or 3.5 percent. As discussed in the analysis of the alternatives in the briefing memo and Tab D, this alternative would replicate the stringency of CPSC's current requirement. Of the 98 devices CPSC tested using the both the current audible effect test and the metal content test, all of the devices that did not produce audible effects contained 3.14 percent aluminum or less, with 48 of the 50 "no audible effect" devices containing less than 3 percent aluminum. This indicates that a 3 percent allowance would replicate the results of the current test method about 95 percent of the time. However, increasing the discretionary allowance to 3 or 3.5 percent would result in an explosive energy increase of about 10-12 percent over that would be allowed under the recommended final rule. As noted, an increase in explosive energy increases the probability of and potential severity of injuries. Adopting a 3 to 3.5 percent allowance would slightly decrease the cost to manufacturers for modifying devices to comply with the requirements. However the cost reduction to manufacturers would be low. As discussed in section 6.1.1, a break-even analysis showed that the costs associated with replacing metallic powders with black powder would equal the benefits if about 3 injuries were prevented. If a 3 percent contamination allowance were allowed, the break-even point would be about 2 prevented injuries. Current product market compliance data provided by APA and AFSL indicate that

approximately 96 percent of MSDV and 81 percent RTAS devices on the market would comply within the 3-3.5 percent allowance range. About 92 percent of the MSDV and 78 percent of the RTAs would comply with the recommended final rule.

Although a 3 to 3.5 percent requirement would somewhat decrease the cost to manufacturers associated with modifying devices to comply with the rule, it would also potentially increase the number or severity of injuries over that which would be expected from the recommended final rule. Because an allowance at this level would essentially replicate the current CPSC requirements, there would be no potential benefit from an increased level of safety as there is with the recommended final rule. The benefits associated with the requirements limiting explosive force on objective measurement of fine mesh metallic powders in the burst charge than the more subjective methods used to enforce the current "audible effects" requirements would still apply to this limit.

Increase the Allowance to 5 Percent or Higher: Some commenters suggested considering a 5 percent or even higher allowance for metallic fuel content. However, as noted, while an allowance at 3.5 percent would essentially replicate the level of stringency associated with the current CPSC regulation, CPSC test data indicates that above 3.5 percent, all devices produce an audible effect as shown in Figure 1 of the briefing memo and discussed in Tab D. That is, providing an allowance above 3.5 percent would mean that some devices that are currently prohibited would be permitted. Therefore an allowance of 5 percent or higher for metallic content would likely reduce the level of safety from its present level.

Incorporate the Contamination Allowance as a Regulatory Limit: The text of the recommended final rule does not provide any specific contamination allowance for metallic fuel content but the recommended preamble would state that the Commission would exercise enforcement discretion to allow up to 1 percent of metallic fuel. Alternatively, the Commission could state a specific metallic fuel limit in the regulation. Some commenters advocated that the limit be stated in the rule. They stated that this would provide greater transparency, certainty and predictability to regulated entities. They observed that an enforcement discretion limit could be changed at any time without notice.

In contrast, staff notes that to provide the greatest safety, the regulation should not allow any metallic fuel. Providing some allowance through enforcement discretion appropriately recognizes that due to variability in instruments and possible contamination from metals in the environment or parts of the device other than the burst charge, attaining a zero level may not be possible. Enforcement discretion serves this purpose. Staff also notes that if instrument detection capabilities and inadvertent contamination levels change in the future, as technologies improve, modifying an enforcement discretion level to reflect these changes is easier than amending the regulation.

7.2 Revise Current Testing Method to Use Sound Level Meters

CPSC considered alternative test methods using sound level meters (SLMs) to assess the explosive force of fireworks. The European Standard EN 15947-4 currently requires that a consumer fireworks device not produce a noise level above 120 dB but the standard is intended

only to limit the sound and not intended to be a means to limit the explosive force of a device. CPSC staff has conducted SLM testing and is not aware of a test method using SLMs that would measure the force generated from a fireworks device independent of environmental factors (e.g., humidity, altitude, temperature, physical or geographic surroundings), instrumentation (e.g., type and quality of SLM instruments vary widely and affect test procedures and results), device design, and testing (e.g., distance from fireworks device, height of functioning, orientation to instrument). Therefore, CPSC staff cannot recommend a SLM testing protocol that would accomplish the same goal as intended by the draft requirements regarding fine mesh metallic powders. Moreover, even if a method were developed that accurately used sound as a proxy for explosive force, the costs of such testing would not necessarily be lower than simply excluding flash powders from the burst charge. Such a test may involve the purchase of equipment, such as an SLM, and would almost certainly involve field testing the devices, with various controls needed to eliminate variation from the factors listed above.

7.3 Adopt a "Black Powder Equivalency" Test

Staff considered adopting an option allowed by the AFSL voluntary standard that requires break charges to consist of black powder or a fuel that is demonstrated to be equivalent in performance to black powder through empirical testing. As discussed in the LSC memorandum, the required empirical test would involve placing one gram of the break charge in a plastic vial that is then placed inside a steel mortar launch tube on which a 600 gram steel ball is placed.[109] The charge is then exploded and the displacement of the ball is measured. Staff concluded that this alternative would be more costly to execute (for both industry and CPSC) than the requirement in the recommended final rule in which the presence or absence of metallic fuel can quickly be determined by XRF or ICP-OES analysis.

7.4 Adopt a Test Method Based on Overpressure Measurements

CPSC staff attempted to develop a requirement that would be based on overpressure measurements. These efforts are discussed in the LSC memorandum.[110] However, staff found that virtually all aerial devices it tested using these methods would fail and would, therefore, be banned. Therefore, staff rejected this alternative as nondiscriminatory.

7.5 Limit the Burst Charge to No More Than 25 Percent of the Chemical Composition of the Shell, Including the Lift Charge

The recommended final rule would adopt the limits on the burst charge from APA 87-1, 3.1.2.5. Mine and Shell Devices, which CPSC staff interprets as limiting the maximum quantity

[109] Roemer, Matthew, Priscilla Verdino, and Jason Howe, 2018 CPSC Memorandum to Rodney Valliere, "Fireworks Final Rule – Laboratory Sciences Analysis," Consumer Product Safety Commission, Bethesda MD (August 27, 2018).
[110] Roemer, Matthew, Priscilla Verdino, and Jason Howe, 2018 CPSC Memorandum to Rodney Valliere, "Fireworks Final Rule – Laboratory Sciences Analysis," Consumer Product Safety Commission, Bethesda MD (August 27, 2018).

of the burst charge to no more than 25 percent of the total weight of the chemical composition of the firework device, excluding the device's lift charge.[111]

Alternatively, the maximum chemical quantity of the burst charge could be limited to no more than 25 percent of the weight of the chemical composition in the tube or shell of a device, including the lift charge. This alternative would seem to align with APA 87-1, 3.1.2.6, Aerial Shell Kit, Reloadable Tub, which says that "Each aerial shell is limited to a maximum of 60 g of total chemical composition (lift charge, burst charge, and visible/audible effect composition,). In addition, the maximum quantity of lift charge in any shell shall not exceed 20 g, and the maximum quantity of break or bursting charge in any shell shall not exceed 25% of the total weight of chemical composition in the shell." This alternative would also seem to align the requirements of the recommended final rule with the draft revision of the voluntary standard, which explicitly states that the lift charge should be included in the denominator when calculating the maximum lift charge weight. The draft revision of the voluntary standard is designated "APA 87-1A" and is currently awaiting approval by the DOT. This alternative would result in a somewhat less stringent rule and one that would result in lower failure rates for some manufacturers or devices. This is suggested by LSC testing, which found that 55 percent of reloadable aerial tube devices do not comply with the ratio limit in the recommended final rule, but only 5 percent of the same devices do not comply with this alternative requirement.

Adopting this alternative requirement could potentially reduce costs because fewer devices might fail the limit on the ratio of burst charge to chemical composition and need to be destroyed. It is also possible that larger burst charges could increase consumer enjoyment of the firework burst effects. On the other hand, if producers are aware of the requirement, and they are aware that the requirement will be enforced, producing complying fireworks devices should not be difficult. It is also possible that a reduced burst charge could potentially reduce injuries, though such an impact, if any, cannot be quantified.

CPSC staff did not recommend this alternative because CPSC staff believes that limiting the burst charge to 25 percent of the combined weight of the chemical composition of the burst charge and effects, excluding the lift charge results in a somewhat less hazardous device than would be allowed if the lift charge were included in the calculation.

7.6 Prohibit Hexachlorobenzene, Lead, and Lead Compounds in Fireworks

The proposed rule included a ban on the use of hexachlorobenzene, lead, and lead compounds in consumer fireworks. This ban is not included in the recommended final rule. The toxicity of both HCB and lead compounds is well documented.[112] Both chemicals were once

[111] Roemer, Matthew, Priscilla Verdino, and Jason Howe, 2018 CPSC Memorandum to Rodney Valliere, "Fireworks Final Rule – Laboratory Sciences Analysis," Consumer Product Safety Commission, Bethesda MD (August 27, 2018).
[112] Hooker, Eric. CPSC Memorandum to Priscilla Verdino, "Toxicology of Hexachlorobenzene and Lead Compounds in Fireworks," U.S. Consumer Product Safety Commission, Bethesda, Maryland (May 13, 2015).

prominent in fireworks formulations, but have since largely fallen out of use and are not usually present in fireworks beyond a trace amount.[113]

The proposed ban on the use of hexachlorobenzene, lead, and lead compounds is not included in the recommended final rule because although these are toxic chemicals, the available evidence suggests that they are not frequently used in fireworks beyond a trace amount. Moreover, APA 87-1 prohibits the use of lead tetroxide and other lead compounds (except in trace amounts), while the AFSL standard prohibits the use of HCB (except in trace amounts), lead, and lead compounds. In addition, the Stockholm Convention which the United States signed but did not ratify, and which China has signed and ratified requires parties to take measures to eliminate the production and use of HCB.[114] Therefore, whether the Commission included the provision or not in the recommended final rule likely would have little impact on either injuries or illnesses associated with fireworks or upon the costs associated with the manufacture of fireworks to minimize the presence of these chemicals.

7.7 Allow for Trace Contaminants of Prohibited Chemicals

The proposed rule included an amendment to § 1507.2 to allow for trace amounts of up to 0.25 percent of the chemicals prohibited in fireworks. This provision is not included in the recommended final rule. Instead, the recommended preamble of the final rule would state that CPSC will use enforcement discretion as appropriate to allow for trace contamination from the prohibited chemicals.

A means of allowing for trace contamination would be of some benefit to the industry without causing harm to consumers because, since this section of the CPSC regulations was developed, testing equipment has become much more advanced and capable of detecting increasingly lower concentrations of banned chemicals in fireworks. As a result, banned chemicals can now be detected where the concentration of the chemicals likely pose little to no hazard to consumers.

From fiscal year 2000 to 2015, CPSC compliance officers reported 41 violations of § 1507.2. Of these violations, four came from samples which contained banned chemicals in concentrations below the proposed allowances. The total lot value of the four lots was $7,109. Over 15 years, this comes to less than $500 per year, which represents the theoretical reduction in cost to industry from allowing trace amounts of the prohibited chemicals.

Hence, the proposed allowance could provide some small burden reduction if the nonconforming products contained only trace levels of the prohibited chemicals. However, whether the allowance is explicitly incorporated into the regulations, or whether it is provided in the form of enforcement discretion, will make little (if any) difference in either the health risks to the general public or the costs to the manufacturers.

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[113] A study by Schwartz, et al, found hexachlorobenzene present beyond a trace amount in 3 of 220 (1.36 percent) fireworks samples tested in Europe.

[114] A list of countries that have signed and/or ratified is available at: http://chm.pops.int/Countries/StatusofRatifications/PartiesandSignatoires/tabid/4500/Default.aspx.

7.8 Establish a Test Method for Evaluating Side Ignition by Regulation

The proposed rule included a provision amending the regulatory language in § 1507.3 to include a test to assess side ignition of fuses. The test was the same test specified in the CPSC testing manual, which requires placing the lit end of a cigarette directly against the side of a fuse and observing how much time elapses before it ignites. The test manual specifies that testing should last up to five seconds, but CPSC considers a device to have failed if it ignites within three seconds. As stated in the NPR, CPSC has found that 99.5 percent of devices tested successfully resist ignition for 3 seconds.

This provision is not included in the recommended final rule. Instead, the recommended preamble to the final rule would explain how CPSC staff conducts testing and what timeframes they use to determine compliance. In addition, staff will add the 3-second threshold to the CPSC testing manual when updating it in the future. As stated in the NPR, because CPSC testing for side ignition of fuses is currently done in accordance with the method that was included in the proposed rule, staff expected to see little change in societal costs from the addition to the regulation. At most, by incorporating the requirements from the test manual into the regulation, staff hoped to eliminate any confusion between the voluntary and mandatory standard requirements for side ignition of fuses. However, any such confusion should already be minimal because the CPSC testing manual is publicly available.

7.9 Prohibit Fireworks from Expelling Fragments

The proposed rule included a provision to ban fireworks that expel or disperse fragments such as pieces of metal, glass, or brittle plastic upon operation, similar to the provisions in APA 87-1 and the AFSL voluntary standard. This provision is not included in the recommended final rule.

CPSC Laboratory Sciences staff has observed fragments falling from detonated fireworks during testing. According to LS staff, the proportion of tested fireworks expelling or dispersing fragments may likely be less than 10 percent of devices. Additionally, a special study of 27 fireworks incidents in 2016 indicated that 1 of the cases involved fragments dispersed from an aerial firework (though no detail was obtained on the type or size of fragment that caused the injury or whether it involved a consumer or display firework).

However, staff does not have information on compliance rates with the ban proposed in the NPR, has not been able to adequately define fragments for purposes of compliance testing, and has not kept testing data related to fragments. Moreover, whether such fragments (of metal, glass, concrete, or brittle plastic) being expelled from consumer fireworks are associated with consumer injuries is uncertain. Although some injuries appear to involve fragments, the injury records are not detailed enough to determine if the fragment was expelled from a consumer firework.

Because CPSC staff has little information on the incidence of injuries associated with fragments expelled from consumer fireworks or the compliance rates with the voluntary standard, the provision prohibiting the expelling of fragments from fireworks is not included in the recommended final rule.

7.10 No Regulatory Action

CPSC staff considered taking no regulatory actions, which means the status quo would be maintained. However, staff believes that some amendments to the CPSC fireworks regulations are needed. In particular, staff believes that current requirements that limit the composition of devices intended to produce an audible effect should be replaced by the requirements of the recommended final rule that would replace them with the requirements of APA 87-1, that prohibits metallic fuels in the burst and can be measured directly using techniques such as XRF. As discussed, both requirements are intended to address the same hazard, but the one in the recommended final rule uses a more objective and repeatable method for evaluating compliance. Additionally, by aligning the CPSC requirements with those of the DOT, industry compliance with the requirements would be simplified. This option would also not align with changes that have occurred in the fireworks industry including new types of devices and changes in the use of different types of pyrotechnic materials.

8.0 Significant Issues Raised By the Public Comments in Response to the Preliminary Regulatory Analysis

CPSC received comments from the public that discussed the Preliminary Regulatory Analysis or other issues relating to the economic impact of the proposed rule on businesses. These comments and CPSC staff's responses are discussed below.

Comment Summary:

Many commenters expressed a concern that the price of aerial devices will increase as a result of the rule. Some also expressed concerns that prices of all fireworks will increase as businesses will try to recover the cost of destroyed noncompliant products through increases in the prices of all product lines and types.

Response:

CPSC staff expects cost increases that could occur as a result of the recommended final rule and any resulting price increases to be small. Staff's analysis of the provisions of the recommended final rule concerning base attachment, and total composition limits show no expected cost increase. Such a price increase would generally be related to increases in materials costs and the cost of testing for metallic powders in aerial devices. Staff expects these costs to be small because substituting black powder for flash powder would increase costs by about $0.01 per product.[115] *This is likely a high estimate of the cost because staff assumed an additional two hours of labor would be needed to manufacture and mix black powder. Additionally, compliance with the recommended final rule can be assessed using XRF technology, which, as discussed in this regulatory analysis, might cost two to six cents per device based on typical lot sizes. We do not estimate the cost savings associated with removing the CPSC's previous regulatory regime, which ostensibly industry had to test to in order to ensure*

[115] Staff analyzed sample devices and estimated the cost to switch from flash powder to all black powder.

compliance. We note that aerial firework devices typically retail for between $4 and $600 per device.

The commenters also said that prices would increase to recover the cost of destroyed noncompliant products. CPSC staff does not expect that the recommended final rule will result in an increase in noncompliant products being imported and destroyed. Compliance with the rule can be assessed with inexpensive methods, such as XRF, that provide consistent and repeatable results. Therefore, importers could require test results showing that the products comply with the requirements before accepting the products. This should reduce the number of imported products that are found to be noncompliant. More recent test results provided by APA/AFSL that are thought to be more representative of the devices now on the market, indicated that between 73 and 84 percent of the devices on the market would now comply with the draft requirements on fine mesh metallic powders if a one percent contamination allowance were allowed. CPSC staff expects that the compliance rate will increase as manufacturers become increasingly aware that they should ensure that the burst charges of consumer fireworks do not contain fine mesh metallic powders.

Comment Summary:

Commenters expressed concern over the potential indirect effects of the rule on state and local entities' revenue from taxes and permits, and projects affected by that revenue, such as fire departments, emergency responders, schools, transportation funding, and community programs. Commenters also cited indirect impacts on companies that transport fireworks, landlords renting to fireworks suppliers, and insurance companies that cover fireworks suppliers.

Response:

The draft rule could only have even a noticeable impact on the revenue of state and local governments if (1) tax revenue from fireworks sales constituted a significant source of revenue for a jurisdiction and (2) the draft rule would very significantly reduce sales of fireworks. Neither of these conditions is likely. First, total revenue from the sales of consumer fireworks is less than $900 million annually while state and local tax revenue nationally exceeds $1.3 trillion.[116] Thus, tax revenue from sales of consumer fireworks is unlikely to be significant for any locality. Moreover, the recommended final rule is unlikely to significantly affect sales of fireworks. The most significant impact of the draft rule would be on aerial devices due to the provision in the recommended final rule that would replace the current CPSC regulations on devices intended to produce an audible effect with the requirements from APA 87-1 regarding fine mesh metallic powders and pyrotechnic limits. A significant proportion of aerial devices already comply with these requirements and so sales of these devices would not be impacted by the draft rule. As discussed in the above regulatory analysis, the current devices that were found not to comply could be made to comply with minor changes. Moreover, the vast majority of manufacturers are certifying compliance with APA 87-1 in order to obtain the EX number from the DOT required to transport fireworks. Therefore, we do not expect a significant impact on the sales of fireworks as a result of this

[116] U.S. Census Bureau, "2017 Quarterly Summary of State & Local Tax Revenue Tables," available at: https://www.census.gov/data/tables/2017/econ/qtax/historical.html, Accessed on September 13, 2018.

rule. Therefore we do not expect any of the indirect impacts of the rule described in these comments to be significant.

Comment Summary:

Commenters expressed concern about the percentage of devices that will be banned by the proposed change to 16 C.F.R. § 1500.17(a)(3) because they contain detectable fine mesh metallic powder in the burst charge.

Response:

This rule will not result in the ban of any type of fireworks device; it simply limits fine mesh metallic powders in the burst charge of aerial devices. Although the NPR reported tests results that indicated that 84 percent of the devices tested would not comply with the limit on fine mesh metallic powders, more recent data submitted by APA and AFSL in their joint public comment on the NPR suggested that 92.4 percent of mine and shell devices and 78.4 percent of reloadable tube devices collected in a market survey conducted in 2017 would comply with the draft final regulation, if a contamination allowance of up to 1.00 percent were allowed. For the fireworks with more than 1 percent fine mesh metallic powders, CPSC staff expects firms to simply replace hybrid powder mixtures with black powdered mixtures.

Comment Summary:

One commenter expressed concerns about the research and development costs to identify substitutions or modify devices to comply with the limitation on fine mesh metallic powders in burst charges.

Response:

Because many of the formulas used in the construction of firework burst charges have existed for well over two decades, we expect there to be little to no research and development cost to modify devices to meet the limitations on fine mesh metallic powder. According to testimony provided to the Commission during the public hearing on March 7th 2018, nearly all fireworks before 2003 contained all black powder burst charges.[117] Moreover, as the data supplied by APA and AFSL indicate, 73 to 86 percent of devices currently on the market comply with the draft requirement regarding fine mesh metal content, suggesting that research and development efforts are unnecessary to meet the requirement.

Comment Summary:

Commenters expressed concern about the cost to CPSC of enforcing the draft rule. One stated that "enforcement agencies would be required to spend large amounts of money to track down these offenders and prosecute them."

Response:

The recommended final rule should reduce the costs of enforcement to CPSC. Currently, the CPSC regulations ban fireworks that are intended to produce an audible effect if the effect is produced by a burst charge that contains more than 2 grains of pyrotechnic material. To enforce this test, CPSC technicians first apply a test, operating the devices and

[117] Comments made by Joel Anderson at the public hearing on the amendments to the fireworks regulations held at CPSC headquarters on March 7, 2018.

listening to the report made to determine if the sound was intentional or incidental to the operation of the device. If it is determined to be intentional, a similar device is examined to determine if the break charge contained more than 2 grains of pyrotechnic material. This method is subject to some variation because different technicians in different environmental conditions can come to different conclusions as to whether the sound made was intentional. The recommended final rule, on the other hand, considers that any device that contains fine mesh metallic powder in the burst charge to be intended to produce audible effects and banned if the audible effect is produced by a charge of more than 2 grains of pyrotechnic composition. This is a more objective test for which compliance can be directly and easily assessed using XRF or ICP testing and should be easier for CPSC to enforce.

Comment Summary:

A few commenters expressed concern about the costs of manufacturing devices with sufficient purity to conform to the proposed limitations on fine mesh metallic fuels in burst charges.

Response:

Although APA 87-1 standard (and by extension the DOT regulations) does not include any allowance for contamination, the recommended preamble to the final rule would state that the Commission will exercise its enforcement discretion to allow up to 1.00 percent contamination of fine mesh metallic powders in the burst charges. This should reduce or eliminate most costs associated with manufacturing devices that conform to the limitations on fine mesh metallic powders. CPSC staff believes that if flash powders are not intentionally being used, a one percent allowance is sufficient to allow for all inadvertent contamination. Sample data on aerial device lift charges (which are composed entirely of black powder) collected by CPSC staff show contamination levels well below one percent.[118] Instrument variation data provided by BV indicates that instrument readings vary on average 0.15 percent. Taken together, these sources of potential variation or contamination amount to less than 1.00 percent.

9.0 Summary

The recommended final rule is intended to improve consumer safety and align several CPSC regulations pertaining to consumer fireworks with the voluntary standard APA 87-1, which is incorporated by reference into the DOT regulations. The recommended final rule would, among other things, replace the current CPSC regulations concerning devices intended to produce audible effects with a limit on fine mesh metallic powders in the burst charges of aerial devices, limit the total pyrotechnic/explosive composition weights for several types of devices, and require bases to remain attached during storage and operation. Although the NPR preamble stated that a significant number of devices tested by CPSC staff were found not to comply with these requirements (especially the limits on the fine mesh metallic powders and total pyrotechnic/explosive composition weights), more recent data supplied by the industry indicate

[118] Roemer, Matthew, Priscilla Verdino, and Jason Howe, 2018 CPSC Memorandum to Rodney Valliere, "Fireworks Final Rule – Laboratory Sciences Analysis," Consumer Product Safety Commission, Bethesda MD (August 27, 2018).

greater compliance. Furthermore, CPSC staff found that the costs associated with bringing these devices into compliance with the recommended final rule would be small.

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Appendix: Estimates of nonfatal injuries and the societal costs of fireworks injuries

Nonfatal firework-related injuries. Based on estimates from the National Electronic Injury Surveillance System (NEISS), a national probability sample of U.S. hospital emergency departments (ED), CPSC Epidemiology staff estimated an annual average of 11,200 non-fatal ED injuries involving consumer fireworks that were treated in EDs from January 1, 2014 to December 31, 2016.[119]

In addition to injuries initially treated in hospital EDs, many product-related injuries are treated in other medical settings, such as, among others, physicians' offices, clinics, and ambulatory surgery centers. Some injuries also result in direct hospital admission, bypassing the hospital ED entirely. The number of firework-related injuries treated outside of hospital EDs is estimated with the CPSC's Injury Cost Model (ICM), which uses empirical relationships between the characteristics of injuries (diagnosis and body part) and victims (age and sex) initially treated in hospital EDs and the characteristics of those initially treated in other settings. A detailed discussion of the ICM and these methods is given in Miller et al. (2000), Bhattacharya et al. (2012), and Lawrence (2013). The ICM estimate of injuries treated outside of hospitals or hospital EDs (*e.g.*, in doctors' offices, clinics) is based on data from the Medical Expenditure Panel Survey (MEPS).

The MEPS is a nationally representative survey of the civilian, non-institutionalized population that quantifies individuals' use of health services and corresponding medical expenditures. It combines data from a panel of participants interviewed quarterly over a two-year time period with data from the respondents' medical providers. The MEPS is administered by the Agency for Healthcare Research and Quality (AHRQ). The ICM uses the MEPS data, in combination with a classification tree analysis technique, to project the number and characteristics of injuries treated outside of hospitals.

To project the number of direct hospital admissions which bypass hospital EDs, the ICM uses data from the Nationwide Inpatient Sample of the Healthcare Cost and Utilization Project (HCUP-NIS), which was also analyzed using a classification tree analysis technique. HCUP is a family of healthcare databases and related software tools and products developed through a federal-state-industry partnership and sponsored by AHRQ. The HCUP-NIS provides information annually on approximately 3 to 4 million in-patient stays from about 1,000 hospitals.

The classification tree analysis technique (also called decision tree) is a statistical tool that divides and sorts data into smaller and smaller groups for estimating the ED share of injuries until no further gains in predictive power can be obtained. This technique allows for more precise estimates of injuries treated in doctor visits or injuries admitted directly to the hospital than other regression techniques. For example, where data permits, the age and sex of the victim can have an influence on the estimates of the number of injuries treated outside the ED. When we combine the national estimates of the NEISS with the non-ED estimates from the ICM using classification tree techniques, we obtain total medically treated injuries.

[119] Tu, Y, 2016 CPSC Fireworks Annual Report: Firework Related Deaths and Emergency Department Treated Injuries During 2016. Bethesda. MD CPSC.

Based on the annual estimate of about 11,200 firework injuries initially treated in hospital EDs, the ICM projects approximately 14,400 firework injuries treated in other treatment settings. Combined with the ED-treated injuries, there were an estimated annual total of about 25,600 medically treated firework injuries.

Injury Costs of firework-related injuries. The societal costs of the firework injuries are quantified with the ICM. The ICM is fully integrated with NEISS, and, in addition to providing estimates of the societal costs of injuries reported through NEISS, it also estimates the costs of medically treated injuries that are initially treated outside of hospital emergency departments. The major aggregated societal cost components provided by the ICM include medical costs, work losses, and the intangible costs associated with lost quality of life or pain and suffering.[120]

Medical costs include three categories of expenditures: (1) medical and hospital costs associated with treating the injury victim during the initial recovery period and in the long run, including the costs associated with corrective surgery, the treatment of chronic injuries, and rehabilitation services; (2) ancillary costs, such as costs for prescriptions, medical equipment, and ambulance transport; and (3) costs of health insurance claims processing. Cost estimates for these expenditure categories were derived from a number of national and state databases, including the Medical Expenditure Panel Survey, HCUP-NIS, the Nationwide Emergency Department Sample (NEDS), the National Nursing Home Survey (NNHS), MarketScan® claims data, and a variety of other federal, state, and private databases.

Work loss estimates are intended to include: (1) the forgone earnings of the victim, including lost wage work and household work, (2) the forgone earnings of parents and visitors, including lost wage work and household work, (3) imputed long term work losses of the victim that would be associated with permanent impairment, and (4) employer productivity losses, such as the costs incurred when employers spend time juggling schedules or training replacement workers. Estimates are based on information from the, HCUP-NIS, NEDS, Detailed Claims Information (a workers' compensation database), the National Health Interview Survey, U.S. Bureau of Labor Statistics, and other sources. The intangible, or non-economic, costs of injury reflect the physical and emotional trauma of injury as well as the mental anguish of victims and caregivers. Intangible costs are difficult to quantify because they do not represent products or resources traded in the marketplace. Nevertheless, they typically represent the largest component of injury cost and need to be accounted for in any benefit-cost analysis involving health outcomes (Rice et al., 1989; Haddix, Teutsch, and Corso, 2003; Cohen and Miller, 2003; Neumann et al, 2016). The ICM develops a monetary estimate of these intangible costs from jury awards for pain and suffering. While these awards can vary widely on a case-by-case basis, studies have shown them to be systematically related to a number of factors, including economic losses, the type and severity of injury, and the age of the victim (Viscusi, 1988; Rodgers, 1993; Cohen and Miller, 2003). Estimates for the ICM were derived from regression analysis of jury awards in nonfatal product liability cases involving consumer products compiled by Jury Verdicts Research, Inc.

[120]A detailed description of the cost components, the general methodology and data sources used to develop the CPSC's Injury Cost Model, and Injury Cost Model Updates, can be found in Miller et al. (2000), Lawrence (2008), Lawrence (2013), Lawrence (2014), Bhattacharya, et al., (2012), Lawrence (2015a, 2015b, 2015c).

Tab C –Regulatory Flexibility Analysis

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
BETHESDA, MD 20814

Memorandum

Date: August 27, 2018

TO : Rodney Valliere, Ph.D., Project Manager,
Division of Chemistry, Directorate for Laboratory Sciences

THROUGH : Gregory B. Rodgers, Ph.D., Associate Executive Director,
Directorate for Economic Analysis
Robert Franklin, Senior Staff Coordinator,
Directorate for Economic Analysis

FROM : Mark Bailey, Directorate for Economic Analysis

SUBJECT : Fireworks FR Regulatory Flexibility Analysis

Background

The Consumer Product Safety Commission (CPSC or the Commission) is considering a recommended final rule that would amend the regulations concerning fireworks (16 C.F.R. parts 1500 and 1507). The amendments would more closely align CPSC's fireworks regulations with voluntary standards such as the American Pyrotechnics Association Standard 87-1, which is also incorporated by reference in U.S. Department of Transportation (DOT) regulations. The Commission commenced this rulemaking proceeding with a notice of proposed rulemaking (NPR) that was published in the Federal Register on February 2, 2017 (82 Fed. Reg. 9012-9034).

Generally, when an agency publishes a final rule, the Regulatory Flexibility Act (5 USC 601 – 612) requires that the agency prepare a final regulatory flexibility analysis (FRFA) that describes the impact that the rule would have on small businesses and other entities. The FRFA must contain:

1. a statement of the need for, and objectives of, the rule;
2. a statement of the significant issues raised by the public comments in response to the initial regulatory flexibility analysis, with the agency's assessment of such issues, and a statement of any changes made to the proposed rule as a result of such comments;
3. the response of the agency to any comments filed by the Chief Counsel for Advocacy of the Small Business Administration (SBA) in response to the proposed rule, and a detailed statement of any change made to the proposed rule in the final rule as a result of the comments;
4. a description of and an estimate of the number of small entities to which the rule will apply or an explanation of why no such estimate is available;

5. a description of the projected reporting, recordkeeping and other compliance requirements of the rule, including an estimate of the classes of small entities which will be subject to the requirement and the type of professional skills necessary for preparation of the report or record;
6. a description of the steps the agency has taken to minimize the significant economic impact on small entities consistent with the stated objectives of applicable statutes, including a statement of the factual, policy, and legal reasons for selecting the alternative adopted in the final rule and why each one of the other significant alternatives to the rule considered by the agency, which affect the impact on small entities, was rejected.

This report provides the FRFA of the recommended final rule which would apply to consumer fireworks manufactured or imported in the United States. Consumer fireworks are fireworks intended to be used by consumers and include many different varieties, including firecrackers, bottle rockets, sparklers, fountains, roman candles, wheels, and several others. Consumer fireworks are distinct from display fireworks, which are intended for professional use, based on intended use and amount of chemical composition. Although consumer fireworks are under the jurisdiction of the CPSC, the import, sale, and manufacturing of display fireworks are under the jurisdiction of the Bureau of Alcohol, Tobacco, Firearms, and Explosives.

Need for and Objectives of the Rule

The objective of the recommended final rule is to protect consumers from hazards associated with consumer fireworks and harmonize CPSC regulations with the other federal and voluntary standards for consumer fireworks (removing a redundant regulatory regime with CPSC utilizing the same requirements as does DOT) and to clarify and streamline certain provisions in the C.F.R. in order to reduce the burden on industry by reducing the number of different regulations or standards with which firms must comply. It is also intended to provide firms with objective means of ensuring that their products comply with the regulations.

Comments of the Chief Council for Advocacy, SBA

The Office of Advocacy of the SBA (Advocacy) states that it contacted several small businesses that would be impacted by the proposed rule and submitted several comments on the proposed rule. CPSC staff evaluated these comments and based on this evaluation recommended a change to the proposed rule to extend the effective date. Advocacy's specific comments along with our responses are discussed below.

Comment Summary:
Advocacy noted that CPSC relied on AFSL membership data to estimate the number of importers in the U.S. market. The NPR noted that AFSL currently has 165 fireworks importers on its membership list, of which at least 121 (73 percent) are considered small businesses, according to SBA guidelines. According to AFSL, its membership represents 85 to 90 percent of the U.S. market, suggesting a total market size of 183 to 194 importers. Advocacy stated that "this means that the proportion and number of small businesses impacted by the rule may be even higher than estimated above. Depending on the magnitude of cost impacts, the number of affected small firms may be substantial."

Response:
As discussed in the IRFA, CPSC staff's estimate of the number of small firms that could be impacted by the rule was already based on the estimate from AFSL that its 165 members represent 85 to 90 percent of the U.S. market for consumer fireworks. Thus, the IRFA suggested a total of about 183 to 194 manufacturers or importers. Staff has not found any other source that provides a more comprehensive directory of consumer fireworks manufacturers or importers that would allow CPSC to improve this estimate. The Census Bureau estimates the number of firms by size by North American Industrial Classification System (NAICS) categories. Unfortunately NAICS categories for consumer fireworks manufacturers or importers are very broad and include many firms not involved with fireworks. For example, fireworks manufacturers are classified in NAICS category 325998, "All Other Miscellaneous Chemical Product and Preparation Manufacturing," which would encompass firms that manufacture products other than fireworks, including products such as antifreeze preparations, lighter fluids, matches, sugar substitutes, and swimming pool chemicals. However, CPSC staff agrees with Advocacy that the number of firms that would be impacted by the rule is substantial.

Comment Summary:
Advocacy stated that the small businesses it spoke with said that "their biggest concern was with the portion of the rule relating to limitations on the amount of metallic 'fuel' powder allowed in the burst charge, and specifically with the methodology for testing this limitation." The proposed rule "would allow for a margin of less than one percent metallic 'fuel' in the burst charge and would test for this limitation using X-ray fluorescence (XRF) technology." The small businesses "indicated that the new proposed threshold is simply not feasible, and that it will substantially alter the product in a way that makes it unmarketable. The businesses indicated that at the one percent level, using XRF technology, the CPSC product failure rate increases from the current rate of 17 percent to a rate of 84 percent. The businesses are proposing that CPSC increase this level to at least three to four percent."

Response:
The provision Advocacy referred to would amend § 1500.17(a)(3) to replace the reference to "fireworks intended to produce audible effects" with a reference to devices that "contain a burst charge containing metallic powder less than 100 mesh in particle size," thereby applying the existing 2 grain limit on burst charges to devices containing fine mesh metal powder in the burst charge. As indicated by the commenter, in the NPR, the Commission proposed to exercise its enforcement discretion to allow a margin of up to 1.00 percent metallic powder in the burst charge to allow for possible contamination and variability in instrument detection.

CPSC staff agrees that tests conducted by CPSC and reported in the NPR indicated that many of the aerial mine and shell devices would fail this requirement. As the commenter noted, the NPR reported that in random testing of samples collected from the Office of Compliance 84 percent of the devices tested failed the proposed requirement, whereas only 17 percent failed the current requirement. CPSC staff understands that, based on these reported results, firms supplying fireworks may be concerned that a substantial portion of consumer fireworks would be prohibited by the rule and their sales could be significantly decreased. However, we note that the CPSC data reported in the NPR consisted of fireworks collected by the Office of Compliance and

may not be representative of the fireworks available on the consumer fireworks market in general. More recent data suggest that fewer devices would fail to comply with the proposed requirement if the Commission exercised enforcement discretion to allow up to one percent contamination. In its joint comment, the APA and AFSL presented data from a market survey in 2017 that indicated 8 percent of the mine and shell devices and 22 percent of reloadable tube aerial devices contained fine mesh metallic powders in excess of one percent. This data suggest that it is feasible to meet the requirements of the draft proposed rule because 78 percent of reloadable tube aerial devices and 92 percent of mine and shell devices tested in these two studies would not violate the draft rule with the enforcement discretion allowing for one percent contamination.[121] *Moreover, these failure rates are unlikely to be representative of the failure rates that would be observed if the requirement goes into effect, as manufacturers would attempt to meet the requirement resulting in lower overall failure rates. Currently, fireworks with more than 2 grains of pyrotechnic material in the burst charge may contain metallic fuel if they are not determined to be "intended to product audible effects," which CPSC staff determines by listening to the device in a screening test. CPSC staff expects that if the recommended final rule is promulgated, manufacturers will stop using metallic fuel in the burst charges in consumer fireworks bound for the United States and will make more of an effort to ensure that it is not present as more than a minor contaminant. This can be accomplished by simple quality control measures by the manufacturers. Therefore, CPSC staff does not expect significantly more devices to violate the revision to § 1500.17(a)(3) than have failed the current requirements for devices intended to produce audible effects in recent years.*

Additionally, CPSC staff does not believe that these changes "will substantially alter the product in a way that makes it unmarketable." As noted above, the APA/AFSL data indicate that between 78 of reloadable tube aerial devices and 92 percent of mine and shell devices on the market would already comply with the proposed requirement (in combination with the discretionary contamination allowance); consequently, sales of these fireworks would be unaffected by the change to the rule. CPSC Division of Chemistry staff notes that a device with a burst charge containing only black powder will still ignite the "stars" and other visual effects, but the sound might be noticeably different. Consequently, if some consumers have a high preference for the sound produced by devices with metallic powders in the burst charges and receive little utility from fireworks that do not produce this sound, it is possible that there could be some loss in sales due to the limit on metallic fuels. This presumes that the consumers know which devices produce the sound that they desire and which ones do not at the time they make their purchase decisions. CPSC currently has no data with which it could estimate any potential sales loss.

In addition, CPSC staff and Bureau Veritas (on behalf of AFSL, as indicated in the joint APA/AFSL comment) assessed the extent to which fine mesh metals may be detected in a break charge because of environmental contamination, migration from other components within a device, or variation in screening instruments. Overall, this testing indicated that there is little to no environmental contamination and migration and, when it does occur, it is at levels well below 1.00 percent (roughly 0.06 percent to 0.4 percent). In addition, this testing indicated that screening instrument readings differ by about 0.15 percent. Taken together, enforcement discretion up to 1.00 percent is enough to accommodate these potential variables. Increasing

[121] The National Fireworks Association stated that its data showed that 55 percent of the devices would fail the draft requirements on fine mesh metallic powders in the burst charges. However, it did not provide that data to the CPSC.

this level to 3 percent or higher is unnecessary, and increases the explosive power of devices, which would increase the hazard to consumers. As noted in the BV assessment, every 1 percent increase in metallic fuel increases the explosive power of a device by 3 percent.

Comment Summary:
Advocacy stated that in order to prepare for the high demand for products preceding the 4th of July holiday, "companies often purchase their stock of fireworks from China up to one year in advance. The products are sometimes tested before shipment, but more often than not, they are shipped directly to the small businesses that are then subject to Commission testing once the product is in the U.S. If a product does not comply with testing, the company must incur the costs to destroy the product, and will not be reimbursed by the manufacturer for any defects."

Response:
The recommended final rule extends the effective date from the 30 days proposed in the NPR to one year. The effective date of one year in the recommended final rule will provide sufficient time for suppliers to conform to the rule's requirements or to allow fireworks importers to switch to suppliers that can provide conforming products. Products imported before the effective date will not be subject to the new standard. Any new standard promulgated by the Commission will be prospective and only apply to products that are manufactured or imported after the effective date. With respect to the metallic fuel requirements, because the test for metallic powders is objective and is reproducible, importers should be able to require that their Chinese suppliers conduct the testing in China and provide them with passing test reports from qualified laboratories or from a reasonable testing program conducted by the manufacturer before they accept the shipments. If importers require passing test results before accepting shipments, the promulgation of the recommended final rule could result in the destruction of fewer noncomplying products after they have been imported.

Comment Summary:
Advocacy stated that the majority of the businesses it spoke with agreed "that the current testing method, the sound/ear/amount test, is both subjective and inaccurate at determining whether a case of fireworks is compliant with the 'audible effects' standard" and that an evaluation with an XRF device would be a "more accurate method for determining pyrotechnic composition; however, they also indicated that the new testing method would make it impossible for them to be able to test their own products for compliance, as purchasing one of the XRF devices is cost prohibitive to small businesses." As a compromise, businesses suggested using a sound level meter (SLM) that "would accurately test 'audible effects' but not produce such a high failure rate."

Response:
The rule would not require that manufacturers or importers purchase an XRF device (although they would have that option). The rule would simply consist of content limits for certain materials; it does not require a particular method of assessing compliance with those limits. The certification requirements in CPSA section 14 allow certifications to be based on either a test of each product or a "reasonable testing program." In order to certify that their fireworks meet the regulations, importers could rely upon tests conducted by the manufacturer or by a qualified laboratory. Note that certification is not a new requirement; manufacturers (or importers) are

currently required to certify compliance with existing requirements. A manufacturer of consumer fireworks could probably spread the cost of the testing over more units than a single importer could, which would reduce the cost of testing on a per unit basis. Alternatively, importers that wish to conduct their own tests could send samples of their fireworks to a qualified domestic laboratory for testing or rent an XRF device for a few days while they conducted their own testing. Importers likely would not purchase an XRF machine unless they were planning to conduct a very large number of tests.

CPSC is not aware of a test method using an SLM that would measure the force generated from the shell while controlling for confounding variables including environmental factors (e.g., humidity, altitude, temperature, physical or geographic surroundings), instrumentation (e.g., type and quality of SLM instruments vary widely and affect test procedures and results), device design, and testing parameters (e.g., distance from fireworks device, height of functioning, orientation to instrument). Therefore, CPSC staff does not consider tests using SLMs to be a viable option for assessing the explosive force of a fireworks device.

Comment Summary:
Advocacy stated that in the IRFA, "CPSC alludes to a certification that the rule will not have a significant economic impact on a substantial number of small entities in several sections, by using certification language in place of an IRFA and stating that there will not be a cost of compliance to small business. Advocacy urges CPSC to first acquire enough information that would provide a factual basis for certification including cost analysis under the RFA, and only after it makes this determination use certification language that is consistent with the statue [sic]."

Response:
The Commission did not certify that the proposed rule would not have a significant impact on a substantial number of small entities, and the IRFA did not recommend certification. We agree that CPSC lacked a sufficient factual basis for such a certification. The IRFA provided the results of the staff's analysis, which concluded that the impact of the proposed rule probably would not be significant for a substantial number of firms. For example, bringing noncompliant devices into compliance with the fine mesh metal limits, and pyrotechnic composition and weight provisions could be achieved by eliminating metal powders from the burst charges and using smaller measuring devices for filling fireworks with pyrotechnic material. Nevertheless, the IRFA did not recommend certification, but rather requested comments from businesses that believed that they would be significantly impacted by the proposed rule (particularly on the fine mesh metal limits, and pyrotechnic composition and weight requirements, which CPSC staff believed would be the most controversial requirements of the proposed rule). The IRFA properly discussed the requirements of the proposed rule, and discussed the evidence that CPSC had of the potential impact on small firms and requested comments. The fact that CPSC has received over 2,400 comments, many from small entities, is evidence that the IRFA provided sufficient information to provoke comment from small businesses that believed that they would be impacted by the rule.

Comment Summary:
Advocacy stated that it "spoke with several small businesses who indicated that the proposed rule [would] have such a high cost of compliance [that] it could cause them to stop selling the class of fireworks being regulated altogether. In its RFA analysis, CPSC does not include information regarding the cost of compliance, and instead in more than one instance states that it does not have this information and is seeking public comment on the issue. In one case, the Commission even suggests that the new requirements will result in a 'theoretical reduction in burden for the fireworks industry.' The Commission's conclusions about cost impacts differ significantly from what Advocacy heard from the small entities with which it consulted."

Response:
Importing firms will likely purchase from suppliers that will certify that their products conform to the standard and, because of the added testing, may incur slightly higher costs per imported firework. Although a number of the fireworks currently on the market might not comply with the metallic fuel requirement, it should be reasonably easy to make these products comply. As discussed later in this analysis, staff estimates that the material cost to bring a noncompliant product into compliance would probably amount to an average of one cent per product to replace break charge content with all black powder if the break charge contained some nonconforming levels of flash powder. Moreover, confirming compliance could be accomplished with XRF testing, which, if performed by a manufacturer, would spread the cost over a large volume of fireworks, making the cost very low on a per production unit basis. Importers may rely upon testing conducted by a foreign supplier to certify compliance with the requirements and would no longer have to conduct the current "ear" test to determine if the device was intended to produce an audible effect.

The only reference in the IRFA to a "reduction in burden on industry" was in the discussion of a very specific provision of the proposed rule that would establish allowances for trace contaminants of banned chemicals. The recommended final rule does not include this allowance; instead, CPSC will use enforcement discretion, as appropriate. Nevertheless, the following explains CPSC's use of the quoted phrase in the IFRA. Currently, if any of the chemicals prohibited in fireworks (arsenates, mercury salts, boron, chlorates, gallates, magnesium, white phosphorus, picric acid, titanium, and zirconium) is detected at any level whatsoever, the fireworks do not comply with § 1507.2. Adding allowances for trace contamination, which the NPR proposed to set at 0.25 percent for most of the prohibited chemicals, would reduce the burden on manufacturers. The IRFA noted that the CPSC had identified 4 lots over a 15 year period that violated § 1507.2, and the levels of the prohibited chemicals detected were below what would be allowed under the proposed rule. The IRFA noted that on an annual basis, the "theoretical reduction in burden" from this change would total about $500, based on the value of the lots, thus indicating that the reduction in burden would not be significant.

Comment Summary:
Advocacy stated that "The Commission failed to include the relevant NAICS codes and revenue data for the industries likely to be impacted by the rule. Without this information, neither the Commission nor the commenting public can properly assess whether compliance costs will represent a significant proportion of regulated firms' annual revenues."

Response:
The relevant NAICS codes were provided in the IRFA, but the categories are very broad and included many other non-firework related firms. For example, the IFRA included NAICS code 325998, "All Other Miscellaneous Chemical Product and Preparation Manufacturing." Additionally, importers and retail sales firms were included under NAICS codes 423920 and 453998, "Toy and Hobby Goods and Supplies Merchant Wholesalers" and "All Other Miscellaneous Store Retailers." The vast majority of firms in these categories are not involved in the manufacture or importation of consumer fireworks. (See, for example, the discussion at page 2 of Tab D of Fireworks Notice of Proposed Rulemaking Briefing Package dated December 14, 2016.[122)] Consequently, even if we did report the revenue for these NAICS categories, it would be unlikely to shed light on the revenue of the small proportion of producers or importers of fireworks.

Comment Summary:
Advocacy stated that "under the RFA, CPSC has an obligation to consider feasible alternatives" that further the agency's goal of reducing injuries. It stated that "the Commission should therefore consider feasible alternatives, and provide a cost analysis of the alternatives and an explanation as to why they were not chosen over the current proposed requirements." Alternatives Advocacy suggested include:

> "(a) allowing a higher percentage of metallic 'fuel' in the burst charge;
> (b) better assistance with destruction of non-compliant products including consistency in destruction requirements, and assistance with costs associated with destruction;
> (c) ability to sell the product at a commercial level if it does not meet consumer standards;
> (d) exemptions for businesses who self-test using the approved methodology, or elect to pay for testing from a certified provider;
> (e) front-end testing at the manufacturer's point of sale in China, rather than the importer's point of sale so as to reduce the burden to U.S. small business importers;
> (f) testing products during non-peak sales seasons only so as not to substantially interfere with small businesses revenue;
> (g) requiring consumers to complete safety training courses and/or other requirements that are more punitive for misuse of the products;
> (h) using a sound meter rather than an XRF."

Response:
Our responses to each of the alternatives Advocacy suggested are below.

a) CPSC staff did consider alternatives that would allow a higher percentage of metallic fuel in the burst charge when it was developing the NPR, but failed to discuss these alternatives in the RFA. Staff again considered alternative allowance levels in preparing the recommended final rule, after considering written and oral comments, and relevant data. Both the FRFA and the final regulatory analysis now discuss an alternative that would allow a higher percentage of metallic fuel in the burst charge. (See regulatory alternatives below.)

[122] https://www.cpsc.gov/s3fs-public/ProposedRuleAmendmentstoFireworksRegulations.pdf Page 173

b) CPSC provides guidelines on how to dispose of noncompliant fireworks but does not set destruction requirements. This allows firms more flexibility to destroy their products in a manner that imposes the least burden on themselves, so long as it meets Environmental Protection Agency and state, and local jurisdiction requirements related to the disposal of hazardous chemicals. The costs of destroying non-compliant fireworks are the responsibility of the importer and CPSC does not have the authority to subsidize the destruction of noncompliant fireworks.

c) CPSC generally does not allow noncompliant consumer fireworks to be sold as display fireworks because the fireworks are already marked and labeled as intended for consumer use. Consequently, it would be difficult to monitor the market to ensure that the noncompliant fireworks did not re-enter the consumer market. In order to be sold as display fireworks they would have to be relabeled and repackaged according to display fireworks requirements, which would usually be more costly than simply destroying the fireworks.

d) It is not clear what Advocacy means by "exemptions for businesses who self-test." Section 14 of the CPSA requires that manufacturers or importers certify compliance based on a test of each product or a reasonable testing program. Hence, self-testing and/or paying a qualified third party to conduct the testing are already available alternatives that firms can use to satisfy this requirement. However, the fireworks would still have to comply with the requirements and if subsequent testing by the CPSC found that some fireworks did not conform, the fireworks would be subject to a recall or other corrective action.

e) Again, section 14 of the CPSA requires only that manufacturers or importers certify that all consumer products subject to a product safety rule comply with all applicable product safety rules based on a test of each product or a reasonable testing program. Therefore, importers already have the option of relying upon front-end testing by Chinese manufacturers for this purpose.

f) Manufacturers and importers will have substantial discretion or flexibility in establishing their own testing program, including the flexibility to time their own tests (or third party tests) to coincide with their nonpeak season. There is nothing in the recommended final rule that would preclude testing during nonpeak seasons.

g) CPSC's regulatory authority over fireworks derives from the requirement to keep certain hazardous substances "out of the channels of interstate commerce." 15 U.S.C. § 1261(q). As such, the FHSA authorizes CPSC to deem a hazardous substance to be a "banned hazardous substance," which may not be introduced or delivered for introduction into interstate commerce. Id. 1263(a). Accordingly, CPSC's regulations address the manufacture, import, and distribution of hazardous substances. CPSC cannot adopt requirements applicable to consumers themselves, such as completing training courses. Any punitive requirements applicable to consumers for misusing fireworks would be within the authority of local jurisdictions, not CPSC.

h) CPSC staff considered the alternative of using sound meter testing. The LSC memorandum discusses this alternative and why staff recommends against adopting it. CPSC is not aware of a test method using SLMs that would measure the force generated from the shell that would be independent of environmental factors (e.g., humidity, altitude, temperature, physical or

geographic surroundings), instrumentation (e.g., type and quality of SLM instruments vary widely and affect test procedures and results), device design, and testing (e.g., distance from fireworks device, height of functioning, orientation to instrument). In short, CPSC staff is unaware of a test methodology using SLMs that would effectively assess the explosive force of a fireworks device.

Significant Issues Raised By the Public Comments in Response to the IRFA

CPSC received several comments from the public that discussed the IRFA or other issues relating to the economic impact of the proposed rule on businesses, including small businesses. These comments and CPSC staff's responses are discussed below.

Comment Summary:
CPSC received comments that expressed concern that if the limit on the use of fine mesh metallic powders significantly decreases the performance of fireworks, there could be a negative effect on the entertainment value, quality, and overall interest in fireworks, which could decrease the demand for these fireworks. This might happen, for example, if a limit on the use of fine mesh metallic powders results in stars that do not travel far enough apart or that require the use of stars with "diminished visual qualities." The NFA states that aerial devices account for 50 percent of the total sales of many of its members.

Response:
According to CPSC Division of Chemistry staff, a device with a burst charge containing only black powder will still ignite the "stars" but the sound might be noticeably different (i.e., not have the sharp "crack" associated with the higher energy explosion that is the focus for the audible effects screening test) and there could be some effect on the symmetry of the visual effects. Consequently, it is possible that there could be some loss in sales related to a change in auditory and visual effects due to the limitations imposed on metallic fuels. Such a reduction in sales is unquantifiable but would depend on the loss of consumer utility related to changes in the combined auditory and visual effects. However, the fact that many of the devices currently in the market were not found to violate the recommended final rule requirements suggests that the impact of the difference in sound quality on consumer utility will be low. If it takes trained technicians to identify these devices using the current test methods (i.e., the "ear" test or the "amount" test), the ability of untrained consumers to differentiate between the effects of a device containing fine mesh metallic powders and those containing only black powder is doubtful.

Comment Summary:
The NFA states that "There has been no analysis of the inevitable cost to business of struggling to comply with the Metals Ban using expensive equipment that does not produce reliable results." According to the NFA, "the testing methodologies that would be used for the Metals Ban are unreliable, error-prone, and expensive." The NFA states that there are flaws in the CPSC's testing methods that would produce inconsistent results, which could cause some fireworks to fail some tests even though the businesses took some efforts to comply with the standards. NFA states that, "CPSC has acknowledged in response to a FOIA request that it has no documents to show its cost-benefit analysis of the Metals Ban, or an analysis of the likely costs from false positives due to (i) inability of XRF and/or ICP-OES based testing to distinguish

metals from their compounds and (ii) contamination that does not affect the explosivity of a burst charge. These costs must be considered in weighing the merits of the Metals Ban."

Response:
In response to the NPR, Bureau Veritas (BV) submitted a description of testing and test results in the joint comment from APA and AFSL concerning the relative accuracy of XRF and Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES) screenings for 100 mesh aluminum powder in mine and shell devices and reloadable tube devices. The test results indicated that XRF results for screening metal fuel in break charges are reliable and comparable to the ICP-OES testing of the same samples. BV found an average difference in XRF and ICP-OES readings of about 0.15 percent (~1500 ppm). Seventy-nine percent of the time the XRF reading was higher than the ICP-OES results. This mimics the CPSC finding that around fifty-three percent of the time, XRF reading will be greater than the quantified result. This indicates that when screening for metallic powders, it is unlikely that there will be metallic fuel present in the sample if the XRF does not detect it.[123] These data confirm that the XRF is a reliable and effective screening tool for metallic fuels in the break charge powder.[124] The LSC memorandum also discusses the accuracy of XRF and ICP-OES, including with respect to metal compounds and contamination. We also note that the draft rule does not require use of XRF.

As discussed later in this analysis, testing fireworks devices for the presence of fine mesh metallic powders might cost about one to six cents per device assuming typical lot sizes. Therefore, CPSC staff do not expect that the draft requirement on fine mesh metallic powders will result in significant costs to firms either from inconsistent test results or the cost of the testing itself.

Comment Summary:
According to the NFA, in many states the sale of consumer fireworks is limited to only a few weeks out of the year and "businesses that plan to sell fireworks must place their orders from factories abroad well in advance (often a full year ahead) of this narrow sales window to ensure on-time delivery." The NFA asserts that businesses would have difficulty replacing noncompliant devices and potentially suffer significant sales losses due to the short time frame in which fireworks may be sold in a given year. The NFA points out that these businesses have costs, many of which are fixed, including the cost of permits and retail space. The NFA states that the "severity of the financial harm would be magnified for small businesses, many of which import only a few containers of fireworks each year. If those fireworks fail CPSC's testing, the importers lose their entire investment and have no means of replacing that inventory in time for the fireworks season" which could "put a small importer out of business."

Response:
The recommended final rule would become effective one year after it is published in the Federal Register and would apply to products manufactured (if domestically produced) or

[123] Roemer, Matthew, Priscilla Verdino, and Jason Howe, 2018 CPSC Memorandum to Rodney Valliere, "Fireworks Final Rule – Laboratory Sciences Analysis," Consumer Product Safety Commission, Bethesda MD (August 27, 2018).
[124] A device that fails an XRF screening for metallic powder can be tested using ICP-OES to confirm the results of the XRF scan.

imported after that date. The percentage of fine mesh metallic powders in burst charges can be measured objectively and accurately using several testing methods, including XRF and ICP. The reliability of these testing methods is discussed elsewhere in this memorandum and the LSC memorandum in this briefing package. Therefore, if importers obtain test results showing that the product complies with § 1500.17(a)(3) before importing the product, they should not have to be concerned that the products would fail CPSC testing. The 1-year effective date should give manufacturers sufficient time to adjust their processes to the new requirements or for importers to locate manufacturers that offer products that comply with the requirements.

Comment Summary:
Commenters expressed concerns about the impact of the rule on devices already purchased by retailers. The concern is that suppliers would not be able to sell, and would have to destroy, any non-compliant fireworks that have already been purchased and are in their inventory.

Response:
All new requirements in the recommended final rule would be prospective and apply to products manufactured or imported after the effective date of the rule. Products already manufactured or imported before the effective date would not be subject to the requirements and could still be sold after the effective date.

Comment Summary:
Some commenters (consumers, retailers, and NFA members) expressed the concern that product shipments to retailers will be delayed, resulting in lost sales and reduced product availability to consumers as a result of the rule.

Response:
The one-year effective date allows time for manufacturers to adjust their manufacturing procedures to ensure that their products intended for the U.S. consumer market comply with the requirements of the rule. It should also allow time for importers and retailers to locate manufacturers and distributors who can supply complying products. Because of the extended effective date, a disruption to the supply chain is unlikely.

Comment Summary:
Several commenters expressed the concern that Chinese manufacturers will no longer supply fireworks to the U.S. market as a result of the requirements in the rule with one commenter stating that manufacturers will not supply the U.S. market due to “oddball” requests.

Response:
Because burst charges consisting of all black powder are not unusual, we assume the commenters are concerned about the testing and potential testing costs related to the limit on fine mesh metals in burst charges. Based on testing costs supplied by Bureau Veritas, the cost of XRF testing in China is approximately $15.00 per sample. Using the testing protocol described in APA Standard 87-1, which requires 15 to 25 devices per test as an example of a rigorous testing protocol, at a cost of $15 per test, this equates to approximately $225 to

$375 per firework type tested.[125] On a per production unit basis, the testing costs would equate to a range of $0.019 to $0.063 for an average batch size between 6,000 and 12,000 devices.[126] Should a manufacturer instead choose to use a component part testing strategy and test the raw materials used in the production of burst charges, the costs would be substantially less, perhaps as low as $0.0004 per production unit.[127] Consequently, because testing costs are likely to be small, it is unlikely that many Chinese manufacturers would exit the U.S. market due to testing costs alone. Also, the United States is the largest importer of Chinese made fireworks, making it unlikely that a Chinese manufacturer would forgo supplying the U.S. market.

Comment Summary:
CPSC received a comment addressing the assertion that importers may find new suppliers to mitigate the cost burden associated with the proposed rule. The commenter stated that many importers have contracts with manufacturers and may not be able to find new suppliers. The commenter also suggested that importers may produce their own products, and that there are not enough factories to produce devices to meet demand.

Response:
It is unlikely that manufacturers will be unable to meet the demand for compliant products as the only provision in the rule that requires potentially significant changes to the construction of an aerial firework device is the limit on fine mesh metals (under 100 mesh) in burst charges. Manufacturers will switch from using flash powder in burst charges to all black powder, which is currently used in the construction of the lift charges of aerial devices.[128] As manufacturers already have the required materials to make compliant products, we expect little to no disruptions in the supply of firework devices. The rule may increase the demand for black powder material, which could conceivably affect the supply of firework devices in the short run but the effective date in the recommended final rule is one year after its publication in the Federal Register (as opposed to the 30 day effective date in the proposed rule) and should provide suppliers enough time to adjust.

Small Entities to Which the Recommended Final Rule Will Apply

Domestic fireworks manufacturing is covered under North American Industry Classification System (NAICS) code 325998, "All Other Miscellaneous Chemical Product and Preparation Manufacturing." Importers and retail sales firms are counted under NAICS codes 423920 and 453998, "Toy and Hobby Goods and Supplies Merchant Wholesalers" and "All Other Miscellaneous Store Retailers," respectively. However, these are broad categories and

[125] APA 87-1 calls for 15 devices per test and an additional 10 devices if at least 1 sample fails.
[126] Based on average aerial device lot size data for 500 g cakes, 200 g cakes, and aerial shell devices provided by AFSL.
[127] Estimate based on testing of one metric ton of black powder, which can produce approximately 27,000 burst charges of average weight.
[128] Black powder in firework lift charges is typically larger than 100 mesh but can be reduced in size using various techniques of which component milling in a ball mill is one example.

only a small percentage of firms in these categories are involved in the manufacture, import, or sale of consumer fireworks.

The American Fireworks Standards Laboratory (AFSL), which conducts testing and certification for a substantial portion of the industry, maintains a public list of U.S. importers and Chinese manufacturers that participate in its programs. Its list includes 165 manufacturers or importers. AFSL claims its members represent between 85 and 90 percent of U.S. importers, implying a total market size of 183-194 importers. We have identified three U.S.-based firms that manufacture fireworks, but the vast majority of the market is represented by imported products.

According to criteria established by the Small Business Administration (SBA), fireworks manufacturers would be considered to be "small" if they have fewer than 500 employees. All three domestic manufacturers that we have identified would be considered "small" under these criteria. Importers are considered to be small if they have fewer than 150 employees (wholesalers) or less than $7.5 million sales (retailers). Applying these criteria to the firms that we have identified as importers, we believe that 6 importers would be considered to be large, 118 would be considered small and the rest are of unknown size, though likely small.[129]

Fireworks are typically manufactured overseas and imported into the United States. Most of the potential impact will be felt by small domestic importers, rather than small domestic manufacturers. The recommended final rule includes changes intended to harmonize CPSC regulations with voluntary standards, especially APA Standard 87-1, which is also incorporated by reference into DOT regulations that apply to the transportation of consumer fireworks. In order to obtain DOT approval for transporting consumer fireworks in this country, the vast majority of fireworks manufacturers certify that they products comply with the requirements of APA 87-1.[130] Therefore, manufacturers and importers should already be complying with these requirements to transport consumer fireworks in the U.S.

Requirements of the Recommended Final Rule and Potential Impact on Small Entities

The recommended final rule includes the following provisions which will impact small entities:

- banning fireworks with greater than two grains (130 mg) of pyrotechnic material in the burst charge when fine mesh metallic powder (less than 100 mesh in particle size) is used in the break charge,

- limiting total pyrotechnic/explosive weight and chemical composition of aerial devices, by firework type,

[129] CPSC staff made these determinations using information from Dun & Bradstreet and ReferenceUSA, as well as firm websites.

[130] DOT regulations provide manufacturers with four options for obtaining approval to transport fireworks; two of which require that firms certify compliance with APA Standard 87-1.According to testimony from Julie Heckman at the CPSC public hearing on March 7, 2018, the vast majority of firms use one of the options requiring compliance with APA standard 87-1.

- requiring bases for fireworks be attached to the device, and remain attached through storage, handling, and use.

These provisions are explained in greater detail below.

Provisions Banning Fireworks with Greater Than Two Grains (130 mg) of Pyrotechnic Material When Metallic Powder is used in the Break Charge

The recommended final rule would amend § 1500.17(a)(3) to replace the current regulation, which bans fireworks "intended to produce audible effects" if "the audible effect is produced by a charge of more than 2 grains (130 milligrams) of pyrotechnic composition," with the requirement in the APA Standard 87-1, which limits the total chemical material in the burst charge to two grains (130 milligrams) if fine mesh metallic powders (less than 100 mesh in particle size) are present. The NPR reported that random testing of samples collected by the Office of Compliance found detectable levels of fine mesh aluminum in 84 percent of the break charges tested and that all of the break charges that contained detectable levels of aluminum contained more than 2 grains of pyrotechnic composition. Using current testing methods (*i.e.*, listening to the sound produced), the NPR reported that only 17 of the same devices "were intended to produce audible effects and exceeded the 2-grain limit." However, more recent data provided by the APA and AFSL in their joint public comment reported that their own test results, of a much larger sample size, indicated that 47 percent of devices had no detectable level of fine mesh aluminum in the break charge. Moreover, if a trace allowance of one percent were allowed, APA/AFSL's results indicated that approximately 22 percent of devices exceed the 1.00% allowance. However, the percentage of fireworks tested by the APA/AFSL that would fail according to the current testing methods (*i.e.*, the "ear" test) is not clear.[131]

Manufacturers or importers of fireworks that do not currently comply with the limit on fine mesh metallic powders in the burst charge would incur some costs to comply with the new regulation. As described below, manufacturers that have intentionally included some fine mesh metallic powders may do so because they believe that the use of metallic fuels is slightly less costly as well as necessary to produce the desired visual and auditory effects that they believe consumers desire.

According to CPSC Laboratory Sciences staff, the amount of explosive power necessary to produce an effect in aerial fireworks is higher than the explosive power derived from two grains (130 mg) of metallic or hybrid powder, the limit on pyrotechnic load. Therefore, staff expects industry to comply with the regulation by eliminating fine mesh metallic powder from the formulations used in fireworks, rather than comply through a reduction in the total amount of pyrotechnic material in the device.

[131] The APA/AFSL data consists of tests conducted in 2016 and again in 2017. In the 2017 report, Bureau Veritas (the test laboratory that conducted the tests) reported that "none of the devices were found non-compliant using the current methods." However, this note was not included in the 2016 report.

The costs of switching from metallic and hybrid powders (usually referred to as "flash powder") to black powder should not create a significant impact for firms that have to change formulations. Staff compared wholesale prices of ingredients used to make flash powder to ingredients used to create black powder.[132] Wholesale prices for aluminum (Al), magnesium (Mg) and potassium perchlorate ($KClO_4$) powders, the ingredients used to make flash powder, averaged to $1.75, $2.04, and $0.67 per pound, respectively.[133] Combining these metallic powders to make flash powder suggests a typical flash powder wholesale price range of $0.99 to $1.42 per pound.[134]

Wholesale prices for black powder ingredients average $0.36 per pound.[135] Mixing of black powder may require more labor as extra milling and preparation of the ingredients is needed to produce an efficient explosion, which may increase the cost due to labor and time needed to produce a good quality black powder. For the purpose of this analysis we assume that an additional two hours of labor per 10 pounds of black powder are needed to account for the additional preparation, which equates to approximately $0.69 per pound.[136] Adding this labor cost to the $0.36 per pound estimate above for the wholesale prices of the ingredients in black powder, suggests that a pound of black powder for use in fireworks could cost as much as $1.05 per pound. The explosive qualities of black powders are greatly affected by the quality of the materials used in the mixture, which can also affect cost.[137] For example, higher quality charcoal made from maple trees will typically command a slightly higher price over other soft wood charcoals.

Flash powders are typically three times more powerful than black powders, so the cost of replacing one pound of flash powder with sufficient black powder to equal the explosive force of the flash powder could be $1.73 to $2.16 per pound of flash powder replaced.[138] Therefore, the material costs of a flash powder burst charge to manufacturers can be lower than a black powder charge on the basis of explosive power. Some devices with large amounts of metallic powder that might currently be available on the market would no longer be feasible because the limits on total chemical weight would prevent substituting black powder for the metallic powders in the

[132] Some flash powder formulations are Aluminum and perchlorate, aluminum and chlorate, and magnesium and nitrate with varying compositions depending on the desired effect.
[133] Wholesale online quotes for one metric ton.
[134] For the purpose of the wholesale cost estimate a 30/70 to $Al/KClO_4$, and 34/26/40 to $Mg/Al/KClO_4$ composition was used.
[135] Black powder is generally made with 75 percent potassium nitrate (saltpeter), 15 percent charcoal, and 10 percent sulfur, and is typically mixed using a ball mill and/or a screen using a technique called "ricing." For the purpose of the wholesale cost estimate, a 75/15/10 composition is used.
[136] Based on an estimate of average hourly wage of manufacturing employees in China using data published by the National Bureau of Statistics of the People's Republic of China, an estimate of annual average hours worked in Bannister 2005, and yearly average currency exchange rates published by the U.S. Internal Revenue Service.
[137] Maltitz I, 2003 Black Powder Manufacturing, Testing & Optimizing. Dingmans Ferry, PA American Firework News.
[138] The cost of replacing a pound of flash powder with sufficient black powder to produce the equivalent explosive force is calculated as follows: Three pounds of black powder at $1.05 per pound would cost $3.15, less the cost of one pound of flash powder at $0.99 to $1.42 per pound, which includes additional labor costs associated with black powder production.

amounts that would be necessary to produce the equivalent explosive force.[139] However, these devices would also likely fail to comply with the current regulation regarding devices intended to produce an audible effect and would probably technically be prohibited now, if tested using the current testing methods.

The cost of eliminating fine mesh metallic powders from firework devices is very low on a per unit basis. A typical burst charge for a reloadable tube aerial device weighs approximately 9 grams and of those burst charges in which the aluminum content exceeds one percent, the average aluminum content is 8 percent.[140] A 9 gram burst charge that contains 8 percent aluminum content would mean that it contains approximately 2.4 grams of flash powder.[141] The equivalent explosive force in black powder equates to approximately 7.2 grams (*i.e.*, three times the 2.4 grams). Given these parameters, the cost increase to bring this average device into compliance is approximately $0.011, or about 1 cent.[142]

Note that this compliance cost applies to only a small subset of aerial devices.[143] According to compliance rates provided by the APA/AFSL in its joint public comment only 14 percent of aerial devices would require changes to comply with the rule (assuming a 1 percent contamination allowance).[144]A report provided by the NFA with its comment found that a higher percentage (55 percent) would require modification to comply.[145] Therefore, the impact of this component of the recommended final rule on the total revenue of any manufacturer or importer would actually average far less than one cent per aerial device.

Section 14 of the Consumer Product Safety Act (CPSA) requires manufacturers or importers to certify that their products comply with all applicable testing rules based on a test of each product or a reasonable testing program. Testing products for compliance with the limit on fine mesh metallic powders could be accomplished using XRF technology or inductive coupled plasma (ICP) technology. XRF testing costs approximately $15 per scan and ICP testing costs about $50 per test.[146,147] These testing methods are more reliable, objective, and repeatable than

[139] Non-metallic formulations, known as "whistle mixes," may prove to be an acceptable substitute in these cases.
[140] Roemer, Matthew, Priscilla Verdino, and Jason Howe, 2018 CPSC Memorandum to Rodney Valliere, "Fireworks FR Regulatory Analysis," Consumer Product Safety Commission, Bethesda MD (March 1, 2018)
[141] Calculated as: [(burst charge size (grams) * Aluminum percentage in burst charge) / proportion of aluminum in flash powder formula]. The flash powder formula used in the calculation is the 0.3 aluminum to 0.7 potassium perchlorate. (*i.e.*, 9 * 0.08 / 0.3).
[142] Calculated as: [(Black powder increase in weight (grams) * price per gram of black powder) – (Flash powder weight * price per gram of flash powder), or [(7.2 grams * ($1.05/453.592 grams)) – (2.4 grams * ($0.99/453.592 grams))] The 453.592 in the denominator represents the number of grams per pound.
[143] According to testimony from John Rogers at the CPSC public hearing on March 7, 2018, aerial devices account for between 60 and 65 percent of consumer fireworks on the market.
[144] Based on the data for all aerial devices tested in 2017 provided by APA/AFSL in their joint public comment on the NPR.
[145] A report summarized in the public comment on the NPR submitted by the NFA reported that 55 percent of devices tested exceeded 1 percent aluminum in the burst charge.
[146] Based on price data provided by AFSL, Bureau Veritas, and price quotes from U.S. based testing laboratories.
[147] NFA obtained quotes for XRF testing of fireworks from two labs which were provided to CPSC in a comment for the public hearing on the amendments to the fireworks regulations held at CPSC headquarters on March 7, 2018. The quotes were approximately $100 for XRF testing of firework devices, which is 6.6 times greater than the quote provided by BV.

the current "ear" test conducted on aerial devices to determine whether they are "intended to produce an audible effect."[148] Using the testing protocol described in APA 87-1, which requires testing of 15 to 25 devices per test (as an example of a rigorous testing protocol) at a cost of $15 per test equates to a range of $225 to $375 per firework batch tested.[149] On a per production unit basis, the testing costs would equate to a range of $0.01875 to $0.0625 for an average batch size between 6,000 and 12,000 devices, respectively.[150,151] Manufacturers would also have the option of certifying compliance with the requirements by testing the raw materials for the presence of fine metallic powders using the principles of component part testing, which could substantially reduce the testing costs on a per unit basis.[152]

Note that the requirement to certify compliance with all product safety rules, based on a reasonable testing program, is a requirement of the CPSA and not of the recommended final rule. The certification requirement applies to the current regulation concerning devices intended to produce an audible effect and manufacturers and importers should be certifying compliance to the current regulations, based on a reasonable testing program. Because the "ear test" is influenced by environmental factors and design variations in devices, it does not produce consistent results, and one could argue that one would have to test a large number of samples to ensure that a "loud report" could not be detected by other technicians testing the product under possibly somewhat different environmental conditions or variations inherent in handmade products. Therefore, the cost of properly conducting certification tests for compliance with the recommended final rule is likely lower than the cost of properly conducting certification tests with the current regulations.

Limit Total Chemical Composition for Certain Fireworks Types

The recommended final rule includes a provision to add a new requirement at § 1500.17(a)(14) to limit the total amount of pyrotechnic material in aerial fireworks, not only those which are intended to produce an audible effect. Under the recommended final rule, the following limits would apply to aerial devices:

Sky Rockets, Bottle Rockets, Missile-Type Rockets, Helicopters (Aerial Spinners), and Roman Candles:

- are limited to 20 grams of total chemical material.

[148]Roemer, Matthew, Priscilla Verdino, and Jason Howe, 2018 CPSC Memorandum to Rodney Valliere, "Fireworks Final Rule – Laboratory Sciences Analysis," Consumer Product Safety Commission, Bethesda MD (August 27, 2018).
[149] APA 87-1 calls for 15 devices per test and an additional 10 devices if at least 1 sample fails.
[150] Based on average aerial device lot size data for 500 g and 200 g cakes and mine and shell devices provided by AFSL.
[151] Using the XRF testing cost estimate of $100 provided by NFA would indicate a range of testing costs from $0.125 to $0.42.
[152] For example, if a manufacturer tested one metric ton of black powder, which can produce approximately 27,000 burst charges of average weight, the testing cost per device could be substantially less than $0.01 per unit. In order to use component part testing to certify compliance under a reasonable testing program, the manufacturer would also have to ensure it had procedures in place that would prevent the raw materials from being contaminated by fine mesh metallic powders. This might require ensuring that devices that use fine mesh metallic powders are not manufactured in the same areas in which the burst charges for consumer fireworks are manufactured.

Mine and shell devices:

- are limited to 60 grams of chemical composition in any tube and shell.
- the lift charge cannot contain more than 20 grams of black powder. The lift charge must contain only black powder.
- Multiple-tube devices can contain up to 200 or 500 grams total, depending on the base structure.
- The burst charge of any component cannot exceed 25 percent of the total chemical material weight of the component, excluding any lift charge.

Aerial shells with reloadable tubes:

- are limited to 60 grams of chemical material per shell.
- the lift charge cannot contain more than 20 grams of black powder. The lift charge must contain only black powder.
- Reloadable aerial shells can contain up to 400 grams per device total.
- The burst charge in each shell is limited to 25 percent of the total chemical material weight in the shell, excluding the lift charge.

This provision is intended to align the CPSC requirements with the limits imposed by APA 87-1. The limits specified in APA 87-1 are high enough to allow sufficient explosive force for a viable fireworks device, even accounting for switching from flash powder and hybrid formulations to exclusively black powder.

The Laboratory Sciences memorandum in the FR package describes testing by CPSC staff that found 5 out of 59 (8 percent) mine and shell device samples were non-compliant with the limit on total chemical weight and 10 out of 59 (17 percent) were non-compliant with the burst charge provisions.[153] Staff's sample data on reloadable tube aerial devices show that 0 percent were non-compliant with the limit on total chemical composition and 22 out of 40 (55 percent) were non-compliant with the burst charge provisions. These data are indicative that a significant number of firms are in compliance with the draft final regulations concerning total chemical composition. However, a large percentage of reloadable tube aerial devices do not comply with the draft burst charge requirements.

To comply with the limit on total chemical weight and composition requirements, non-compliant fireworks producers would likely need to implement some quality control to their production to ensure their devices do not exceed the allowed limits. The draft limits would not cause any device types to be unable to function; rather, the draft requirements only represent a limit on the amount of pyrotechnic material. Given the handmade production methods, a quality control system to comply with the regulations could consist of changes such as a one-time

[153] Roemer, Matthew, Priscilla Verdino, and Jason Howe, 2018 CPSC Memorandum to Rodney Valliere, "Fireworks Final Rule – Laboratory Sciences Analysis," Consumer Product Safety Commission, Bethesda MD (August 27, 2018).

adoption of smaller measuring devices for filling fireworks or changes in assembly protocol for products with chemical material, and are not likely to be significant for manufacturers or importers, regardless of firm size. CPSC did not receive any public comments asserting that this provision would have a significant impact on small businesses.

Require Bases to Be Attached, and Remain Attached During Storage, Handling, and Operation

The recommended final rule includes a requirement for bases on devices that operate in an upright position to remain attached to fireworks during storage, handling, and operation. Currently the regulations only specify the required size of base attachments. Staff expects minimal impact to manufacturers from the draft final requirements. CPSC does not test for base attachment when testing samples of fireworks, but on occasions where bases were not attached or detached, a note is typically made in the testing record. In fireworks CPSC tested from Fiscal Year 2015 to May 30, 2018, staff reports identified 873 devices that should or would have bases to function, and noted that 59 devices had no base, a detached base, or required base assembly, and 17 devices tipped over during field testing (which can occur from improper base attachment).

For devices not currently meeting the requirements, staff expects firms to comply by either adapting the firework design so the device and base are all one piece, or securing the base to the rest of the device with an adhesive. The potential costs of complying with the draft final regulation include additional time in affixing the base to the firework (seconds per device), materials for affixing the base to the device, and potential shipping costs associated with higher volume per device when the base is attached rather than separate. Potentially, some additional quality control effort might be required to ensure that the bases are attached correctly so that they do no detach during storage, handling, and operation. Because there are only a small proportion of products not meeting the draft final requirements, and the potential activities necessary for compliance are not costly, staff does not expect this provision to cause a significant impact on a substantial number of small firms. CPSC did not receive any public comments asserting that this provision would have a significant impact on small businesses.

Other Provisions in the Draft Final Standard

The recommended final rule would add definitions for “aerial bomb,” “blowout,” “burnout,” “explosive composition,” “firecracker,” and “pyrotechnic composition.” These definitions are based on what staff believes is the industry’s existing understanding of the terms and their use in the voluntary standards. Therefore, adding these definitions should have no impact on the costs of fireworks suppliers. The recommended final rule would also clarify the exemptions that apply to firecrackers, but would not substantively change the requirements for firecrackers.

Provisions in the Proposed Standard That are Not Included in the Final Rule

The proposed rule included several provisions that are not included in the recommended final rule. These include:

- a provision that would have added hexachlorobenzene, lead, and lead compounds to the list of chemicals banned in fireworks,

- a provision that would have established by regulation a test method for assessing side ignition resistance of fuses,
- a provision limiting overall device content for ground devices, and
- a trace contamination allowance for prohibited chemicals.
- a provision that would have aligned CPSC regulations with those of the voluntary standards prohibiting fireworks, upon functioning, from projecting or dispersing any metal, glass, or brittle plastic fragments.

As these provisions are not included in the recommended final rule, they will not have impact on small manufacturers or importers.

Steps Taken or Alternatives Considered to Reduce or Minimize the Economic Impacts on Small Entities

Extend the effective date: The proposed effective date in the NPR was one month after the promulgation of a final rule. However, based on staff's analysis of the public comments, which included comments from small businesses, the effective date in the recommended final rule is one year after the promulgation of the final rule. The extended effective date should allow manufacturers and importers sufficient time to make any adjustments to comply with the requirements. A one year effective date is reasonable given the planning and retail cycle in fireworks sales. Most fireworks are sold and used around July 4th of each year. However, manufacturers and importers begin planning for the next July 4th by August.

Increase the allowance for contamination for fine mesh metallic powders: CPSC received many comments, many from small businesses, that limit on fine mesh metallic powders could have an adverse impact on manufacturers and importers. The recommended final rule would prohibit the use of fine mesh metallic powders in the burst charge if the burst charge contains more than 130 milligrams or 2 grains of pyrotechnic composition. However, the NPR stated that the CPSC would use its enforcement discretion to allow minimal contamination of up to, but not exceeding 1.00 percent of metallic powder in the burst charge. As discussed more thoroughly in the regulatory analysis of the recommended final rule, staff considered increasing this allowance to 2.00 3.00 and 5.00 percent.

The contamination allowance is intended to reflect a balance between the intended safety purpose of the recommended final rule and the realities that impact the level of fine mesh metal powder detected in a break charge. The intent of the rule is to limit the use of flash powders, which contain fine mesh metallic powders and have more explosive force per volume than black powder. As the Division of Chemistry memorandum explains, increasing the amount of fine mesh metal powder increases the explosive power produced, and devices with greater amounts of explosive power could potentially increase the severity of fireworks injuries. However, staff cannot quantify an increase in the likelihood of injury or injury severity, if any, that would result from allowing a contamination level of 3 percent rather than 1 percent. Moreover, because the burst charge ignites high in the air, the only likely increase in injury or injury severity would occur if the device misfires at ground level or is misused.

In addition to the explanation that keeping the contamination allowance at 1 percent may potentially reduce injuries by reducing explosive power, the Division of Chemistry memorandum states that a 1 percent contamination limit is adequate as long as metallic powders are not intentionally added to the burst charge. CPSC staff found that potential environmental contamination and migration of fine mesh metal from other components within a device, into the break charge, are extremely low, if they occur at all. For example, staff found environmental contamination and migration likely account for no more than 0.5 percent fine mesh metal in the break charge. In addition, the Bureau Veritas (in the joint comment from APA and AFSL) provided some relevant data on potential testing variation. Based on that comment, instrument readings may vary, on average, by about 0.15 percent. Consequently, inadvertent contamination and instrument variation is expected to produce far less than 1.00 percent fine mesh metal in a break charge. Staff believes that fine mesh metallic powders being present at above one percent is indicative of intentional use. Additionally, as discussed earlier in this analysis, even if manufacturers are currently adding small amounts of metallic powders to their burst charges, there will be very little cost to reformulate the devices to contain only black powder (even allowing for the greater amount of black powder that could be required).

Additionally, we note that based on the 2017 testing data provided by the APA and AFSL, increasing the contamination to 3 percent would result in a difference of only two to three percent in the number of devices that would comply with the requirements of the recommended final rule. According to data provided by AFSL and APA in their joint public comment, based on their testing in 2017, about 94 percent of the mine and shell devices and 81 percent of the reloadable aerial tube devices would comply with a three-percent contamination allowance, versus 92 percent and 78 percent, respectively, that would comply with the one percent contamination allowance in the recommended final rule. Therefore, increasing the contamination allowance would create, at most, a minimal reduction in costs.

In sum, staff believes a 1.00 percent allowance for metallic powder contamination is a reasonable limit, as long as such powders are not intentionally added. However, possible increases in injuries or injury severity if the allowance for contamination were increased to 2 or 3 percent cannot be quantified and are probably small.

Using sound level meters instead of fine mesh metallic powders to identify highly explosive devices: Another alternative staff considered, suggested in public comments, including comments from representatives of small businesses, was sound level meter testing (SLM) to assess explosive force. The European Standard EN 15947-4 currently requires a consumer fireworks device to not produce a noise level above 120 dB, but the standard is not intended to measure metallic content or explosive force. CPSC staff performed testing with SLM to assess the viability of this alternative. CPSC is not aware of a test method for SLM that would measure the force generated from the shell while removing various variables including environmental factors (*e.g.*, humidity, altitude, temperature, physical or geographic surroundings), instrumentation (*e.g.*, type and quality of SLM instruments vary widely and affect test procedures and results), device design, and testing (*e.g.*, distance from fireworks device, height of functioning, orientation to instrument). Even if we were aware of a testing methodology using SLMs that could be used, it is not clear that it would be less expensive than testing fireworks for

the presence of fine mesh metallic powders. Testing fireworks for the presence of fine mesh metallic powders can be done in a laboratory setting using relatively inexpensive technologies, such as XRF. Testing using SLMs would likely involve the use of one or more SLMs and functioning the devices in an open area under certain environmental conditions. Therefore, at this time it is at best uncertain whether a test method using SLMs even could be developed that would reduce the impact on small businesses

Limit the Burst Charge to No More Than 25 Percent of the Chemical Composition of the Shell, Including the Lift Charge: The recommended final rule would adopt the limits on the burst charge from APA 87-1, 3.1.2.5. Mine and Shell Devices, which CPSC staff interprets as limiting the maximum quantity of the burst charge to no more than 25 percent of the total weight of the chemical composition of the firework device, excluding the device's lift charge.[154]

Alternatively, the maximum chemical quantity of the burst charge could be limited to no more than 25 percent of the weight of the chemical composition in the tube or shell of a device, including the lift charge. This alternative would seem to align APA 87-1, 3.1.2.6, Aerial Shell Kit, Reloadable Tub, which says that "Each aerial shell is limited to a maximum of 60 g of total chemical composition (lift charge, burst charge, and visible/audible effect composition,)….In addition, the maximum quantity of lift charge in any shell shall not exceed 20 g, and the maximum quantity of break or bursting charge in any shell shall not exceed 25% of the total weight of chemical composition in the shell." This alternative would also seem to align the requirements of the recommended final rule with the draft revision of the voluntary standard, which explicitly states that the lift charge should be included in the denominator when calculating the maximum lift charge weight. The draft revision of the voluntary standard is designated "APA 87-1A" and is currently awaiting approval by the DOT. This alternative would result in a somewhat less stringent rule and one that would result in lower failure rates for some manufacturers or devices. This is suggested by LSC testing, which found that 55 percent of reloadable aerial tube devices do not comply with the ratio limit in the recommended final rule, but only 5 percent of the same devices do not comply with this alternative requirement.

Adopting this alternative requirement could potentially reduce costs because fewer devices might fail the limit on the ratio of burst charge to chemical composition, thus forcing producers to destroy the noncomplying fireworks or incurring the cost to bring them into conformance. It is also possible that larger burst charges could increase consumer enjoyment of the firework burst effects. On the other hand, if producers are aware of the requirement, and they are aware that the requirement will be enforced, producing complying fireworks devices should not be difficult. It is also possible that a reduced burst charge could potentially reduce injuries, though such an impact, if any, cannot be quantified.

CPSC staff did not recommend this alternative because CPSC staff believes that limiting the burst charge to 25 percent of the combined weight of the chemical composition of the burst charge and effects, excluding the lift charge, results in a somewhat less hazardous device than would be allowed if the lift charge were included in the calculation.

[154] Roemer, Matthew, Priscilla Verdino, and Jason Howe, 2018 CPSC Memorandum to Rodney Valliere, "Fireworks Final Rule – Laboratory Sciences Analysis," Consumer Product Safety Commission, Bethesda MD (August 27, 2018).

No Regulatory Action: CPSC staff considered taking no regulatory actions, which means the status quo would be maintained. However, staff believes that some amendments to the CPSC fireworks regulations are needed. In particular, staff believes that current requirements that limit the composition of devices intended to produce an audible effect should be replaced by the requirements of the recommended final rule that limit the use of fine mesh metallic powders. As discussed, both requirements are intended to address the same hazard, but enforcement of the requirements in the recommended final rule is based on a test that is objective and repeatable, while enforcement of the current regulations is based on a subjective and less repeatable test. Additionally, by aligning the CPSC requirements with those of the DOT, industry compliance with the requirements would be simplified.

Tab D – LSC Memorandum

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
4330 EAST WEST HIGHWAY
BETHESDA, MD 20814

Memorandum

Date: August 27, 2018

TO : Rodney Valliere, Ph.D., Project Manager

THROUGH: Andrew G. Stadnik, P.E., Associate Executive Director for Laboratory Sciences
Aaron S. Orland, Ph.D., Division Director, Laboratory Sciences – Chemistry

FROM : Matthew Roemer, Chemist
Priscilla Verdino, Chemist
Jason Howe, Chemist

SUBJECT : Fireworks Final Rule - Laboratory Sciences Analysis

I. Introduction

The U.S. Consumer Product Safety Commission (CPSC or Commission) regulates consumer fireworks devices under the Federal Hazardous Substances Act (FHSA).[155] The division of Laboratory Sciences-Chemistry (LSC) tests consumer fireworks under CPSC's compliance testing program. CPSC staff has developed a testing manual to facilitate industry compliance with the various fireworks regulations.[156] The CPSC staff has prepared a recommended final rule to revise the regulations concerning fireworks in 16 C.F.R. parts 1500 and 1507. The requirements in the recommended final rule are based on the recommendations that CPSC staff developed during a review of all regulations pertaining to consumer fireworks, the requirements the Commission proposed in the notice of proposed rulemaking (NPR), and comments CPSC received in response to the NPR.

II. Draft Requirements

A. Definitions: Draft Additions to 16 C.F.R. §§ 1507.1, and 1507.6

In the NPR, the Commission proposed to adopt definitions to provide clarity and consistency in interpreting and applying regulatory requirements. Many of the clarifications and regulatory changes proposed in the NPR involved specific terms that require precise definitions

[155] 15 U.S.C. §§ 1261-1278.
[156] Consumer Product Safety Commission, "Consumer Fireworks Testing Manual" (Aug. 17, 2006). https://www.cpsc.gov/PageFiles/121068/testfireworks.pdf.

to be clear about the requirements. These terms include “aerial bombs,” “lift charge,” “burst charge,” “expelling charge,” “break charge,” chemical composition,” “pyrotechnic composition,” “explosive composition,” “firecracker,” “burnout,” and “blowout.” With respect to “burnout” and “blowout,” specifically, according to § 1507.6, fireworks devices must be constructed to allow functioning in a normal manner without blowout or burnout because blowouts often create a large explosion, low to the ground, where debris can injure spectators. Burnouts can cause fires, leading to property damage and injury.

In the NPR, the Commission proposed to incorporate by reference the APA 87-1 definitions of these terms, with the exception of “aerial bomb,” which is not defined in APA 87-1. Staff believes that the APA definitions accurately express CPSC staff’s and industry understanding of these terms. Additionally, because the DOT incorporates by reference APA 87-1, by extension, the DOT also incorporates APA 87-1 definitions. Adding the definitions would clarify the regulations and harmonize with the DOT.

For these reasons, staff recommends including the same definitions in the final rule. CPSC received comments regarding the definitions proposed in the NPR, which are summarized and addressed in the comment summary and response memorandum in the briefing package for the recommended final rule. Staff believes that the definitions in the recommended final rule are appropriate, will provide clarity regarding regulatory requirements, and adequately address the comments received.

The specific definitions the Commission proposed in the NPR, which staff believes are accurate and has included in the recommended final rule, are as follows:

Aerial bomb: a tube device that fires an explosive charge into the air without added visual effect.

Lift charge: pyrotechnic composition used to propel a component of a mine or shell device into the air. Lift charge is limited to black powder (potassium nitrate, sulfur, and charcoal) or similar pyrotechnic composition without metallic fuel. (Section 2.10 of APA 87-1.)

Burst charge, Expelling charge or Break charge: Chemical composition used to break open a device after it has been propelled into the air, producing a secondary effect, such as a shower of stars. (Section 2.5 of APA 87-1.)

Chemical composition: All pyrotechnic and explosive material contained in a fireworks device. Inert materials, such as clay used for plugs, or organic matter, such as rice hulls used for density control, are not considered to be chemical composition. (Section 2.6 of APA 87-1.) This includes lift charge, burst charge, and visible/audible effect materials.

Pyrotechnic composition: A chemical mixture, which upon burning, and without explosion, produces visible or brilliant displays or bright lights, or whistles, or motions. (Section 2.6.2 of APA 87-1.)

Explosive Composition: Any chemical compound or mixture, the primary purpose of which is to function by explosion, producing an audible effect (report) in a fireworks device. (Section 2.6.1 of APA 87-1.)

Firecracker: Small, paper-wrapped or cardboard tube containing not more than 50 mg of explosive composition, those used in aerial devices may not contain more than 130 mg of explosive composition per report. Upon ignition, noise and a flash of light are produced. (Section 3.1.3.1 of APA 87-1.)

Burnout: The unintended escape of flame through the wall of a pyrotechnic chamber during functioning of a fireworks device. (Section 2.4 of APA 87-1.)

Blowout: The unintended release of a pressure effect from other than the intended orifice of a fireworks device. Examples include expulsion of the bottom plug of a roman candle, expulsion of the clay choke of a fountain, or the rupturing of the wall of a mine or shell. (Section 2.3 of APA 87-1.)

B. Explosive Power: Draft Revisions to 16 C.F.R. § 1500.17(a)(3) Regarding Devices "Intended to Produce Audible Effects" and Draft Addition of 16 CFR § 1500.17(a)(14) Regarding Chemical Composition and Pyrotechnic Weight Limits

Staff recommends two revisions in the recommended final rule to address the explosive power of fireworks devices. One modifies the existing regulation in § 1500.17(a)(3), and the other adds a new regulation to more comprehensively address the hazard § 1500.17(a)(3) addresses. Staff is covering these recommendations in this combined section because both provisions aim to address the hazard presented by highly explosive fireworks devices.

. Each of these two changes addresses one of two components that contribute to the explosive power of a device—namely, fine mesh metal content, and a large quantity of pyrotechnic composition. First, staff recommends modifying the portion of § 1500.17(a)(3) that is used to identify highly explosive devices, to focus on fine mesh metal content, rather than the sound a device produces. Fine mesh metal content is a better and more reliable indicator of explosive power (this is discussed in *4. Fine Mesh Metal Powder*). Second, to more comprehensively address the hazard of highly explosive devices, staff recommends adopting limits on the total chemical composition and the ratio of break charge to total chemical composition weight of aerial fireworks devices (discussed in *5. Chemical Composition and Pyrotechnic Weight*). Staff has conducted and researched testing regarding the two recommended revisions (discussed in *6. Staff Testing*) and considered alternative methods of addressing the hazard presented by highly explosive devices (discussed in *8. Alternatives*).

1. Current Regulatory Requirement

a. Regulation and Test Method

Section 1500.17(a)(3) bans a fireworks device that is "intended to produce audible effects" if the audible effect is produced by a charge of more than 2 grains (130 milligrams (mg)) of pyrotechnic composition. Determining compliance to this requirement is essentially a two-

part test. First, a fireworks device must be one "intended to produce audible effects." In this screening test, a technician determines whether a device is subject to a 2 grain limit of pyrotechnic content by evaluating the type of sound the device makes. Second, if the technician determines the device is intended to produce an audible effect, then the amount of pyrotechnic content in the device is measured to determine if it exceeds the permissible limit. Fireworks devices that are determined to be not "intended to produce audible effects" have no restriction on pyrotechnic composition.

To determine whether a device is "intended to produce audible effects" and, if so, whether it meets the pyrotechnic content limit, staff field tests fireworks devices in accordance with the "Consumer Fireworks Testing Manual."[157] Although all devices potentially produce an audible effect, not all audible effects are the result of designed intent to produce audible effects, as stated in the regulation. For example, fireworks devices such as tube mortars and mine shells may produce visual effects and the audible effect heard is a byproduct of the break charge, burst charge, or expelling charge, required to disperse those visual effect elements, rather than an intended sound effect. As such, determining whether an aerial device is "intended to produce an audible effect" requires training and expertise.

Over the years, CPSC staff has extensively trained the fireworks industry to help improve the consistency of this testing protocol.[158] However, because most fireworks devices produce a sound, the tester must determine if the sound is an audible effect that is an intentional design feature, or if the sound is merely a byproduct of the functioning of the device. One other factor in making this determination is that fireworks devices tend to be handmade, so devices that are intended to be identical often are not, and thus, do not produce the same audible effect. The amount of powder, effects, shell width and height, often vary greatly within devices from the same manufacturer and lot. As a result, the quality of sound a device produces may differ from the sound other devices of the same type, from the same manufacturer, and same lot, produce. Thus, multiple devices may be tested to assess this potential variability.

To determine whether a device is "intended to produce an audible effect," CPSC staff listens to the device during field testing, and based on the sound, determines whether there was a "loud report."[159] If staff hears a "loud report," staff considers the fireworks device to be "intended to produce an audible effect" and the break charge (which causes the audible effect) is limited to 2 grains (130 mg) of pyrotechnic composition.[160] If staff determines that a device is "intended to produce an audible effect," then staff examines the shells of ten devices from the sample, screens the report charges through a 100-mesh sieve, and weighs the break charges to determine compliance with the regulatory limit.

[157] Consumer Product Safety Commission, "Consumer Fireworks Testing Manual" (Aug. 17, 2006). https://www.cpsc.gov/PageFiles/121068/testfireworks.pdf.
[158] Christopher Musto & Andrew Lock, Consumer Product Safety Commission, "FY 2012 Fireworks Safety Standards Development Status Report" (2013).
[159] Section IV(C)(11)(e) of the Consumer Fireworks Testing Manual.
[160] Consumer Product Safety Commission, "Consumer Fireworks Testing Manual" (Aug. 17, 2006).

b. Purpose of the Regulation

The requirement in § 1500.17(a)(3) was adopted in 1973 (although it was first adopted in a different section). The Food and Drug Administration (FDA) and subsequently, the Commission intended to prohibit the sale to the general public of "dangerously explosive" devices, such as M-80s, silver salutes, aerial bombs, and cherry bombs.[161] Although the regulation uses the phrase "intended to produce audible effects," limiting the content of such devices was not intended to protect consumers from loud sounds; rather, it was intended to limit the total powder content of the more powerful devices.

The preamble expressly stated that devices that use black powder (typically a mixture of charcoal, sulfur, and potassium nitrate) as the break charge, would not be considered to be "designed to produce audible effects," and therefore, would not be subject to the 2 grain limit. Rather, the goal of the rule was to ban devices using large quantities of flash powder (typically a mixture of sodium or potassium perchlorate and aluminum or magnesium), also referred to as salute powder.[162]

CPSC has not updated § 1500.17(a)(3) since its adoption many decades ago, and the content of fireworks devices has evolved since then, which has impacted the effectiveness of the regulation at addressing the hazard it was intended to address. The fireworks industry has moved away from using just black powder as the break charge in some fireworks devices. The industry sometimes uses hybrid powders, which vary greatly in composition. Although flash powder traditionally contained perchlorate as the oxidizer, formulations that add metallic chemicals to black powder have been created and the energy of such modified flash powder can generate a much greater effect than black powder on its own.[163] Depending on the construction of the shell, packing density, the type of powder, and quantity of powder, these shells might produce an audible effect; in other cases, the sound produced is incidental to the necessary function of dispersing the visual effects. When the sound is incidental to dispersing visual effects, the limit in § 1500.17(a)(3) does not apply, and no CPSC regulation limits the quantity of explosive composition. In other words, highly explosive devices that present the hazard the regulation was originally adopted to address may not produce a sound that indicates it is "intended to produce an audible effect," in which case there is no limit on the pyrotechnic content of these devices. Thus, some devices on the market fall outside the reach of § 1500.17(a)(3) because of design and content factors that influence the sound they produce. This is cause for concern, since many hybrid powders are much more powerful than black powder.[164] The addition of fine mesh metallic fuels, in particular aluminum metal, creates an explosive force that is more energetic per volume, and therefore more dangerous, than the explosive force without metallic fuel. [165]

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[161] 35 Fed. Reg. 7415 (May 13, 1970).
[162] Conkling, J. (2017) Boom, America's Ever- Evolving Fireworks Industry. Alabama: Whitman Publishing, LLC
[163] Tang, A. (2009). "A New and Fast Method of Evaluating Powder Energy" Journal of Pyrotechnics. Issue 28, Pages 51-64
[164] Tang, A. (2009). "A New and Fast Method of Evaluating Powder Energy" Journal of Pyrotechnics. Issue 28, Pages 51-64
[165] Akhavan, J. (2011). The Chemistry of Explosives. Cambridge, UK: The Royal Society of Chemistry.

CPSC test data, as well as data from testing conducted by Bureau Veritas (BV) on behalf of AFSL and submitted as part of APA's and AFSL's joint comment on the NPR, indicate that there is not substantial compliance with the provisions in APA 87-1 regarding fine mesh metallic fuel use, even though the requirement has been in place to meet DoT regulations since 1987. According to BV's results, only 47 percent of multiple-tube and reloadable shell device break charges contain no detectable level of aluminum less than 100 mesh in particle size.[166] CPSC staff also tested devices and found that all of the devices tested contained some detectable level of fine mesh aluminum in the break charge.[167] Devices that contain detectable levels of fine mesh aluminum would have to contain less than 2 grains of pyrotechnic composition to comply with APA 87-1. CPSC staff found that all of the devices tested contained more than 2 grains of pyrotechnic composition in the break charge, and BV found that nearly all of the devices it tested contained more than 2 grains in the break charge. Therefore, it appears that there is not a high degree of compliance with this provision in APA 87-1.

Finally, the current regulations include no limits on the amount of pyrotechnic composition in a device, or its components, other than this 2 grain limit on devices "intended to produce audible effects" and a similar 50 mg limit on firecrackers. There is currently no limit on the total chemical composition or pyrotechnic weight of devices, to account for large amounts of black powder in devices.

2. Hazard Associated with Explosive Power

The hazard that § 1500.17(a)(3) and the recommended regulatory changes aim to address is the hazard to consumers from high levels of explosive power in fireworks devices. Although testing cannot be performed to determine the direct relationship between the amount of explosive power in a fireworks device and the likelihood and severity of injuries, it is clear that a more energetic explosion creates greater potential for injury if the fireworks device functions in close proximity to a person. The preamble to the final rule issued in 1970 stated that the goal of the regulation was to prevent "dangerously explosive fireworks" from reaching the general public because these products had caused 8 deaths (including 6 children and teenagers) and a "large number of serious injuries ranging from puncture wounds to broken bones and shattered hands."[168] In a similar rulemaking that limited the pyrotechnic composition in firecrackers, the Commission explained the relationship between explosive power and injuries, stating:

> Although no definite conclusion can be drawn as to what size firecracker causes a specific type of injury, the information contained in the in-depth reports demonstrates a correlation between the degree of injury and the explosive power of the firecracker which was involved in the injury. Most cases involving

[166] This represents the aggregated results of BV's testing in 2016 and 2017 for multiple-tube and reloadable shell devices, totaling 1,723 devices. The testing and results are detailed in Attachments 2 and 3 of APA's and AFSL' joint comment, available in regulations.gov under the docket for this rulemaking.
[167] The full results of CPSC staff's testing are in the LSC memorandum in this briefing package.

> severe injuries and deaths were caused by firecrackers or homemade devices with large powder accumulations.[169]

Similarly, although fireworks devices that were involved in deaths and injuries cannot be tested to determine their explosive power, fireworks incident data indicates that the most severe fireworks-related injuries and deaths involved devices that are generally the most highly explosive and subject to § 1500.17(a)(3). Specifically, reloadable aerial devices and multiple tube mine and shell devices are the most common devices on the market that are highly explosive and commonly identified as "intended to produce audible effects," and therefore, subject to the 2 grain limit in § 1500.17(a)(3).

Reloadable aerial devices and multiple tube mine and shell devices are responsible for some of the most severe fireworks-related incidents. The 2015 Annual Fireworks Report[170] indicates that 9 of the 11 fireworks-related deaths in 2015 involved reloadable aerial devices (this represents a minimum number of deaths because reporting for 2015 was not complete at the time of the report). These deaths occurred when the device went off near the victim. One victim was a 12-year old male.

The 2015 Fireworks Annual Report also indicates that during a one-month special study regarding fireworks incidents surrounding the 4th of July holiday in 2015, there were an estimated 1,200 injuries treated in U.S. hospital emergency departments (EDs) that involved multiple tube mine and shell devices (400 incidents) and reloadable aerial devices (800 incidents). To collect more detail about incidents, staff conducted in-depth investigations (IDIs) by telephone of 31 cases that occurred during the one-month period, of which 12 involved multiple tube mine and shell devices (2 incidents), reloadable aerial devices (9 incidents), and M-80s (1 incident). These 12 IDI cases resulted in severe injuries, including burns to a victim's groin area; second-degree burns and thermal burns to victims' hands, feet, arm, leg, or abdomen; a thigh hematoma; a fractured hand and 4 broken fingers; eye lacerations or abrasions (possibly resulting in loss of one victim's eye); temporary hearing loss; and a ruptured eardrum. Of the 31 total IDIs staff conducted, these 12 incidents were among the most severe, including 3 cases that required admission to the hospital (lasting 1 month, 4 days, and 3 days, respectively); 1 case that required 3 surgeries; and lengthy recovery periods (most incidents required 1 month or more to recover).

The 2016 Annual Fireworks Report[171] indicates that 3 of the 4 fireworks-related deaths in 2016 involved reloadable aerial devices (like the 2015 data, this represents a minimum number of deaths because reporting for 2016 was not complete at the time of the report). These deaths resulted from injuries sustained when the fireworks device struck the victim. In one case the device malfunctioned, exploding through the side of the launch tube; in one case the device exploded out of the bottom of the launch tube, when placed in the tube upside down; and in one case the victim may have been holding the device when it exploded.

The 2016 Fireworks Annual Report also indicates that during a one-month special study regarding fireworks incidents surrounding the 4th of July holiday in 2016, there were an

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[170] Available at: https://cpsc.gov/s3fs-public/Fireworks_Report_2015FINALCLEARED.pdf?

[171] Available at: https://cpsc.gov/s3fs-public/Fireworks_Report_2016.pdf?t.YHKjE9bFiabmirA.4NJJST.5SUWIQJ

estimated 1,400 injuries treated in U.S. EDs that involved multiple tube devices (300 incidents) and reloadable shells (1,100 incidents). To collect more detail about incidents, staff conducted telephone IDIs of 27 cases that occurred during the one-month period, of which 17 involved multiple tube devices (6 incidents) and aerial shells (11 incidents). Six of the 27 IDIs incidents resulted in hospital admission, and all of these incidents involved multiple tube devices or aerial shells. These 17 incidents resulted in severe injuries, several of which required surgery, including amputations of multiple fingers; first-, second-, and third-degree burns; lacerations; ruptured ear drums; shrapnel injuries; a scratched cornea; internal bleeding; retinal swelling; a corneal abrasion; knocked out teeth; and tissue avulsion. Several of these incidents involved substantial recovery time, including multiple cases that required 2-3 months and 1 incident, which involved a 1 year recovery. Three of the 17 incidents involved children, including a 7-month old male, 4 year-old male, and 8-year old male. Nearly all of the 17 incidents involved devices falling over, tipping over, failing to launch before exploding, errant flight paths, or devices firing too quickly, not giving the victim time to move away.

The 2017 Annual Fireworks Report[172] indicates that 4 of the 8[173] fireworks-related deaths in 2017 involved reloadable aerial devices. The 2017 Fireworks Annual Report also indicates that during a one-month special study regarding fireworks incidents surrounding the 4th of July holiday in 2017, there were an estimated 1,200 injuries treated in U.S. hospital emergency departments (EDs) that involved multiple tube mine and shell devices (200 incidents) and reloadable aerial devices (1,000 incidents). To collect more detail about incidents, staff conducted IDIs of 29 cases that occurred during the one-month period, of which 11 involved multiple tube mine and shell devices (4 incidents) or reloadable aerial devices. These 11 IDI cases resulted in severe injuries, including an eviscerated abdomen with internal organ injuries, a concussion, second- and third-degree burns, embedded shrapnel, ruptured ear drums, eye abrasions, and lacerations. Of these 11 incidents, 5 involved child victims, aged 5, 7, 10, 11, and 13 years old.

In addition to the severity of injuries and high proportion of fireworks-related deaths that involve the most-highly explosive devices on the market, we also note that the addition of fine mesh metal, such as aluminum, to an energetic material increases the sensitivity to impact, spark, and friction.[174] This increase in sensitivity could result in accidental ignition, which could likely lead to injury or death. In 2013, a 25-year-old male sustained injuries to his left hand and two fingers in addition to lacerations in the thigh, side, and wrist when a "cherry bomb" (typically consisting of flash powder) exploded in his hand, allegedly due to the heat of the kitchen at the residence.[175]

[172] Available at: https://cpsc.gov/s3fs-public/Fireworks_Report_2017.pdf?Jr0lMG0Z5QYQMTyUtYr_3GR.991BKn4l

[173] It is possible that one additional fatal incident in 2017 involved a reloadable aerial device. The incident involved a firework device that was in a "PVC pipe." Without more detail it is not certain whether the device was a reloadable tube device or another type of device that was placed into the pipe.

3. Voluntary and International Standards

The European Standard, Pyrotechnic Articles – Fireworks Category 1, 2, and 3, EN 15947-1-5 ("European Standard"), the American Fireworks Standards Laboratory ("AFSL") Standard, and the American Pyrotechnics Association ("APA") Standard 87-1, all include requirements to address the explosive power of fireworks devices, including audible effects (analogous to "reports"), through limits in the chemical composition of break charges as well as limits in total pyrotechnic composition. The limits in the standards address both the metallic content (flash powder as well as newer hybrid powders) and total mass of the break charge. By limiting the chemical composition in the break charge and the total pyrotechnic material of all devices, as is done in the standards listed, CPSC would address the hazard of highly explosive power in all fireworks devices that have a break charge, not just those "intended to produce audible effects." The AFSL and APA 87-1 standards also limit the ratio of break charge to chemical composition. This is important because if a shell consists of too much break charge relative to effects, the effects could potentially disperse farther and cause flaming debris to reach ground level.

The following provides the provisions in the three voluntary and international standards that address explosive power, through audible effects, metal content, and chemical composition and pyrotechnic weight limits.

European Standard:

The European Standard limits the total pyrotechnic composition of all fireworks devices. Fireworks are subdivided into 3 categories where category 3 fireworks present the most hazard and Category 1 fireworks present the least hazard. The limits for chemical composition and total pyrotechnic material vary based on device type and category. These limits include a total pyrotechnic weight limit of the device, a maximum limit per tube (if applicable) and a limit on the net explosive content of report charges (if applicable). The total mass of the report charge is limited based on the composition of the pyrotechnic powder. Metal based compositions have a stricter limit than black powder compositions. Metal compositions are differentiated based on the oxidizer (nitrate vs. perchlorate). Perchlorate/metal compositions (traditional flash powder) have the strictest limit. Generally, nitrate/metal based compositions are limited to 40% of the black powder limit and perchlorate/metal based compositions are limited to 20% of the black powder limit. Any report or bursting charges with a compositions other than black powder, nitrate/metal, or perchlorate/metal have the same upper limit as that of perchlorate/metal. As an example, the limit for a Category 2 rocket is: Net explosive content shall not exceed 75 g; report and/or bursting charge, if any shall be not more than 10 g of black powder or 4.0 g of nitrate/metal based composition, or 2.0 g of perchlorate metal based composition.

AFSL Standard:

The AFSL Standard limits the total pyrotechnic and chemical composition for all devices and those limits vary based on device type. The break charge must consist of black powder (defined in the standard as a mixture of potassium nitrate, sulfur and charcoal intended to produce a pyrotechnic effect), or "Black Powder Equivalent" defined in the standard as "A

mixture containing potassium nitrate and non-metallic fuel." The use of any other mixture as break charge requires empirical test data demonstrating that the mixture is equivalent in performance to black powder. Any aerial report must not contain more than 130 mg of explosive composition.

The AFSL Standard further limits the amount of break charge, relative to effects for large (greater than 1 inch) mine and shell devices at "25% by weight of the chemical composition of the tube or 10 grams, whichever is less." Small devices (1 inch or less) are limited to "50% by weight of the chemical composition of the tube or 10 grams, whichever is less." Aerial shells are limited to "25% by weight of the chemical composition of the shell or 10 grams, whichever is less." The standard also has specific limits for lift charges depending on device type and total pyrotechnic weight for each tube in a device, when applicable.

APA 87-1:

APA 87-1 (section 2.5) states: "any burst charge containing metallic powder (such as Magnalium or aluminum) less than 100 mesh in particle size, is considered to be intended to produce an audible effect, and is limited to 130 mg in 1.4G [consumer] fireworks devices." It should be noted that the 130 mg limit (2 grains) is the same as the CPSC limit. The difference is that the language in APA 87-1 spells out how to identify devices that are "intended to produce an audible effect," specifically addressing the fact that some chemical compositions of explosives (those containing metallic fuel) are more energetic per volume than those that do not contain metallic fuel. Additionally, APA 87-1 states: "burst charge consisting of black powder or equivalent non-metallic composition is not considered to be intended to produce an audible effect when it is used to expel and ignite a secondary effect in a fireworks device."

APA 87-1 also limits the total pyrotechnic and chemical composition, as well as the ratio of break charge to effects, regardless of chemical composition and provides quantifiable limits for all devices, not solely those intended to produce audible effects. The APA 87-1 limits for aerial devices are listed below:

A) *Sky Rockets, Bottle rockets, Missile-type rockets, Helicopter (aerial spinners), Roman Candles*: The chemical composition (which includes all pyrotechnic and explosive composition in the fireworks device) is limited to no more than 20 grams (section 3.1.2).

B) *Mine and Shell Devices*:

- Total chemical composition (which includes lift charge, burst charge, and visible/audible effect composition) is limited to no more than 60 grams per shell (section 3.1.2.5).

- Total chemical composition of multiple-tube devices must not exceed 200 grams unless the tubes are securely attached to a wood or plastic base and the tubes are separated from each other on the base by a distance of at least 0.50 inches (12.7 mm), in which case no more than 500 grams of total chemical composition is allowed (sections 3.1.2.5, 3.5).

- Lift charge is limited to a maximum allowance of 20 grams per shell (section 3.1.2.5).

- Lift charge is limited to black powder (potassium nitrate, sulfur, and charcoal) or similar pyrotechnic composition without metallic fuel (section 2.10).

- The maximum amount of burst charge must not exceed 25% of the total weight of chemical composition in the component (i.e., burst charge + effects) (section 3.1.2.5). APA 87-1 section 3.1.2.5 applies the ratio limit to the total chemical composition of the "component," which is the portion of the device that bursts open in the air. Although not explicitly clear in APA 87-1, because the "component" consists of only the burst charge and effects (not a lift charge), CPSC staff considers that the 25 percent limit excludes the lift charge because it is not part of "the component" that subsequently bursts in the air.

C) *Aerial Shell with Reloadable Tube*:

- Total chemical composition (which includes lift charge, burst charge, and visible/audible effect composition) is limited to no more than 60 grams per shell (section 3.1.2.6).
- Lift charge is limited to a maximum allowance of 20 grams per shell (section 3.1.2.6).
- Lift charge is limited to black powder (potassium nitrate, sulfur, and charcoal) or similar pyrotechnic composition without metallic fuel (section 2.10).
- The maximum amount of burst charge in each shell must not exceed 25 percent of the total weight of chemical composition in the shell (section 3.1.2.6). Although not explicitly clear in the APA standard, to be consistent with requirements noted above for Mine and Shell devices, CPSC staff considers that the 25 percent limit excludes the lift charge because it is not part of "the component" that subsequently bursts in the air.
- The total chemical composition of all the shells in the kit must not exceed 400 grams (section 3.1.2.6.).

CPSC staff considers the 25 percent limit to exclude the lift charge because it is not part of "the component" that subsequently bursts in the air. Although one can interpret APA 87-1 to mean the lift charge is included in the calculation, when considering the interpretations of the indefinite text and how aerial devices are described in 3.1.2.5 where a delineation is clearly made between the shell and the component. CPSC staff concludes that it is appropriate to limit the break charge to effects ratio to 25 percent for all shell devices, as proposed in the NPR.

The recommended final rule includes the APA 87-1 requirements for identifying devices that are subject to the 2 grain limit and the aerial device limits (including total chemical composition, the ratio of burst charge to total weight of chemical composition, and lift charge content). To summarize, the recommended final rule replaces "intent to produce audible effect" with a quantifiable method of identifying devices, consistent with APA 87-1, such that any burst charge containing metallic powder (such as Magnalium or aluminum) less than 100 mesh in particle size is limited to 130 mg. This effectively removes the sound screening test and instead

focuses directly on composition tests. Revising the current regulation would make testing quantifiable and repeatable, while potentially reducing the economic burden on the fireworks industry (see Tab B for further analysis).

Staff also recommends adopting pyrotechnic and chemical composition limits, consistent with APA 87-1 with clarifications noted above for the lift charge composition and break charge ratio 25% limit based on the aerial component excluding the lift charge, for all aerial fireworks devices, since all highly-explosive devices cause injuries, not solely those intended to produce audible effects. Under APA 87-1, each type of device has its own pyrotechnic and chemical content limit. Depending on the type of device, a different limit applies. This is important because the energetic power of the device is directly related to the amount of pyrotechnic material in the device. Staff believes that a limit on the total pyrotechnic weight in all devices is an important component missing in the CPSC regulations because fireworks that are intended to produce audible effects are not the only type that pose a hazard to consumers—all highly-explosive fireworks, like those for which device limits are provided, have the potential of creating an injury, and present the risk of more severe injuries and death since they have particularly high explosive power.

Additionally, staff recommends allowing enforcement discretion to be described in the preamble for a contamination limit of 1.00 percent for metal powder under 100 mesh in particle size present in break charges exceeding 2 grains (130 mg). The need for, safety implications of, and appropriate level for the contamination limit is discussed below in *7. Contamination Allowance for Fine Mesh Metal*.

The U.S. Department of Transportation (DOT) has incorporated APA-87-1 by reference into its regulations as one of the options for obtaining EX number approval. An EX number approval is required to transport fireworks in commerce in the United States. Companies may obtain an EX number approval from DOT through one of four methods, two of which involve the applicant certifying that the fireworks comply with APA 87-1 (the other two methods do not require conformance to APA 87-1 but according to testimony at the CPSC public hearing on the fireworks rulemaking, few companies, if any, use it). Companies currently must adhere to APA 87-1 to transport display and consumer fireworks in the United States if they use one of those two options to obtain their EX approval, and the majority of companies currently use adherence to APA 87-1 to obtain EX numbers. Therefore, in addition to providing an objective and repeatable method for addressing the hazard associated with highly explosive fireworks, using the particular language in APA 87-1 in CPSC regulations provides clarity to industry and harmonizes the language used by different agencies to regulate the same products. Because the majority of companies use adherence to APA 87-1 to obtain EX numbers, staff believes that adopting the APA 87-1 provisions would create a minimal burden on the fireworks industry.

4. Fine Mesh Metal Powder

Pyrotechnic materials that contain metallic powders less than 100 mesh in particle size are frequently used by fireworks manufacturers to produce sharp, clear audible effects in aerial

devices.[176] Aluminum is the most common metallic fuel currently used in fireworks. The addition of aluminum increases the heat of explosion (Q) of energetic materials. Aluminum metal has a high heat of combustion (ΔHc) and makes for more geometrically symmetrical detonations. Other metals such as titanium, magnesium, and zirconium also have high ΔHc and are already prohibited by existing regulations.

The oxidation of aluminum is highly exothermic, producing a heat of combustion of -1590kJ, as shown by the following reaction.

$Al_{(s)} + 1½O_{2(g)} \rightarrow Al_2O_{3(s)}$ $\Delta Hc = -1590kJ$[177]

In an oxygen-deficient explosive composition, the aluminum reacts with the gaseous products, particularly in compositions where no free oxygen exists as shown in the following reactions.[9,178]

4) $3CO_{2(g)} + 2Al_{(s)} \rightarrow 3CO_{(g)} + Al_2O_{3(s)}$ $\Delta Hc = -741kJ$
5) $3H_2O_{(g)} + 2Al_{(s)} \rightarrow 3H_{2(g)} + Al_2O_{3(s)}$ $\Delta Hc = -866kJ$
6) $3CO_{(g)} + 2Al_{(s)} \rightarrow 3C_{(s)} + Al_2O_{3(s)}$ $\Delta Hc = -1251kJ$

The volume of gas does not change in Reactions 1 and 2. Consequently, the increase in the output of heat from the oxidation of aluminum prolongs the presence of high pressures.[179] However, there is a limit to the amount of aluminum that can be added to an explosive composition before competing reactions begin to dominate.

In Reaction 3 the addition of aluminum increases the heat of explosion (Q), but the volume (V) of gas decreases (Table 1). To obtain the explosive power, the heat of explosion and the volume of gas are multiplied (Column 4 in Table 1).[23] Table 1 demonstrates that as aluminum is increased, so is the amount of explosive power, where it reaches a maximum at 18 percent aluminum content. Trinitrotoluene (TNT) is the standard for comparing explosive power of different explosives, so research into the effects of explosives is often compared with TNT. The term "Relative Effectiveness Factor," or RE factor, is a normalization technique for equating the energy of an explosive to TNT. The greater the RE Factor, the more powerful the explosive.

Chart 1 displays the quadratic fit of energy versus percent aluminum data found in Table 1. As can be seen in Chart 1, a 1 percent addition of aluminum will increase the energy by a noticeable amount of 3 percent, and this increase in energy is attributable only to the reaction of aluminum to gaseous products of the detonation of TNT. The same effect can be observed for other explosive compositions containing aluminum, where a maximum value for the power can be achieved by adding 18 percent to 25 percent aluminum. At an aluminum content of about 23

[176] Metal particles larger than 100 mesh may be used in fireworks for other purposes, such as to produce colors, and are not impacted by the recommended final rule.
[177] Chetah, ASTM computer program for chemical thermodynamic and energy release evaluation, ver. 7.3
[178] Knock, C., Lecture Notes "Explosive Ordinance and Engineering Thermodynamics", Department of Environmental and Ordinance Systems, RMCS, Cranfield University, 2004.
[179] Akhavan, J. (2011). The Chemistry of Explosives. Cambridge, UK: The Royal Society of Chemistry.

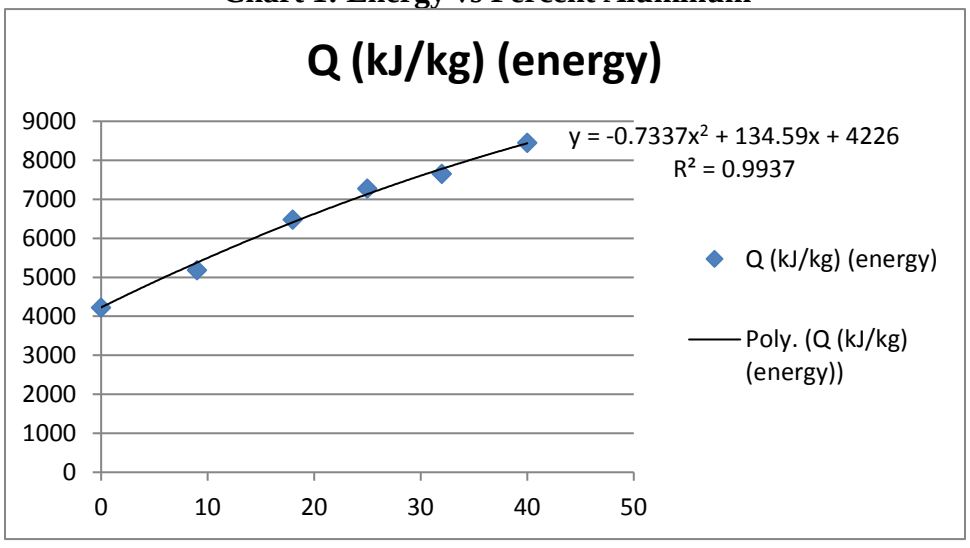
percent, the explosive power begins to diminish as the explosive becomes too fuel-rich, thus quenching the reaction. This can be seen in Chart 2.

When aluminum is added to black powder, the aluminum and carbon will compete for the oxidizer and will result in an oxygen deficiency.[180] The reactions that transpire during the afterburn, as described above in Reactions 1-3, are identical to that of the mixtures of TNT/Aluminum in Table 1. Therefore, trends found in TNT/Al mixtures will be identical to trends found in black powder/aluminum mixtures.

Table 1
Effect of the addition of aluminum on the heat of explosion and volume of gaseous products for TNT/Al[181]

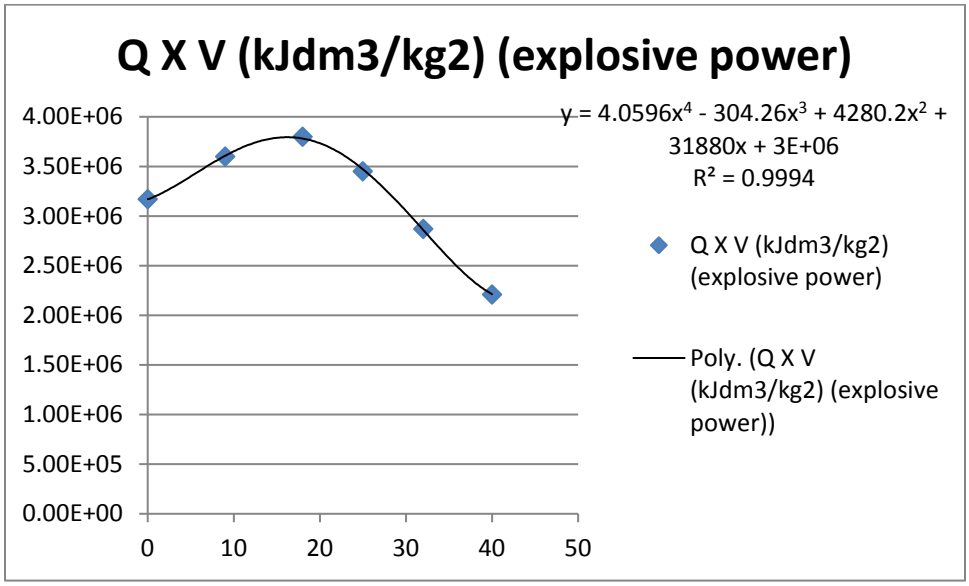
Al % weight	*Q (kJ/kg) (energy)*	*V (dm^3/kg) (volume)*	*Q X V (kJdm^3/kg^2) (explosive power)*
0	4226	750	3170000
9	5188	693	3600000
18	6485	586	3800000
25	7280	474	3450000
32	7657	375	2870000
40	8452	261	2210000

Chart 1: Energy vs Percent Aluminum



[180] Myatt, S, G, Davies M. L. (2005). Explosive output from black powder/metal compositions.
[181] Akhavan, J. (2011). The Chemistry of Explosives. Cambridge, UK: The Royal Society of Chemistry.

Chart 2: Explosive Power vs Percent Aluminum



Fireworks using metallic fuels with metal particles below 100 mesh (0.0059 inch or 149 micron) in size have greater explosive force per volume of pyrotechnic material than fireworks using only black powder. A given mass of large pieces (greater than 100 mesh) of metal would not necessarily increase the explosive power of the device because the overall surface area is smaller. A smaller surface area produces a slower rate of reaction. However, the same mass of small pieces (under 100 mesh) would burn at an increased rate of reaction, thus increasing the explosive power and injury potential at a close proximity.

CPSC staff has compiled data comparing the percent of aluminum content in the break charge of devices to the determination of audible reports in the field. Staff analyzed shells from various samples for aluminum content by carefully opening the shell and separating the break charge powder from the effects by passing the contents of the shell through a 100 mesh sieve. The break charge was then analyzed by ICP-OES for aluminum content following a nitric acid digestion. Staff tested similar shells from the same sample set to determine whether the device was "intended to produce audible effects" in accordance with the Consumer Fireworks Testing Manual.[182] During field testing, CPSC staff determined whether each device was intended to produce an audible effect (yes) or was not intended to produce an audible effect (no). Table 2 provides the complete results, and Graph 1 demonstrates the relationship between the sound produced and the fine mesh metal content of the device.

[182] Consumer Product Safety Commission, "Consumer Fireworks Testing Manual" (Aug. 17, 2006).

Table 2: Devices tested for audible report and aluminum content

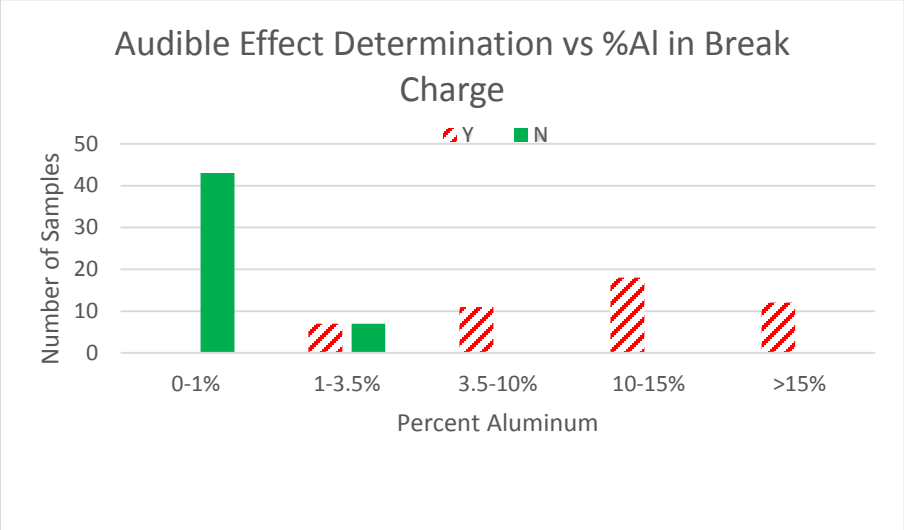
Sample #	Audible Reports detected Y/N	Break Charge (%Al by ICP-OES)
18-1	N	0.16
18-2	N	0.45
18-3	N	0.57
18-4	N	0.19
18-5	N	0.24
18-6	N	2.98
18-7	N	3.14
18-8	N	3.03
18-9	N	2.06
18-10	N	2.80
18-11	Y	6.54
18-12	Y	5.56
18-13	Y	5.89
18-14	Y	5.99
18-15	Y	6.54
18-16	Y	6.60
18-17	Y	13.55
18-18	Y	14.09
18-19	Y	14.18
18-20	Y	14.48
18-21	Y	13.37
18-22	Y	14.24
18-23	N	0.26
18-24	N	0.20
18-25	N	0.49
18-26	N	0.33
18-27	N	0.10
18-28	N	0.14
18-29	N	0.10
18-30	N	0.15
18-31	N	1.26
18-32	N	0.90
18-33	N	0.17
18-34	N	0.25
18-35	N	0.13
18-36	N	0.16

18-37	N	0.11
18-38	N	0.16
18-39	N	0.43
18-40	N	0.32
18-41	N	0.44
18-42	N	0.42
18-43	N	0.19
18-44	N	0.22
18-45	N	0.71
18-46	N	0.72
18-47	N	0.41
18-48	N	0.38
18-49	N	0.32
18-50	N	0.41
18-51	N	0.86
18-52	N	0.25
18-53	N	1.85
18-54	N	1.00
18-55	N	0.28
18-56	N	0.28
18-57	N	0.13
18-58	N	0.21
18-59	N	0.22
18-60	N	0.17
18-61	N	0.80
18-62	N	0.65
18-63	Y	2.05
18-64	Y	2.00
18-65	Y	2.27
18-66	Y	2.98
18-67	Y	3.55
18-68	Y	1.89
18-69	Y	1.49
18-70	Y	1.68
18-71	Y	15.23
18-72	Y	15.25
18-73	Y	15.09
18-74	Y	15.70
18-75	Y	15.38
18-76	Y	14.20
18-77	Y	7.42

18-78	Y	7.38
18-79	Y	7.20
18-80	Y	8.01
18-81	Y	13.33
18-82	Y	14.77
18-83	Y	13.65
18-84	Y	12.58
18-85	Y	14.74
18-86	Y	15.55
18-87	Y	14.50
18-88	Y	14.77
18-89	Y	14.45
18-90	Y	15.48
18-91	Y	14.97
18-92	Y	13.81
18-93	Y	16.81
18-94	Y	15.69
18-95	Y	14.11
18-96	Y	16.28
18-97	Y	15.74
18-98	Y	15.80

The graph below shows a direct correlation between audible effect and the percent of aluminum.

Graph 1: Audible Reports vs. %Aluminum in Break Charge



In Statistical Hypothesis testing there are two types of errors: Type 1 and Type 2. A Type 1 error is a rejection of the null hypothesis, or a "false positive." A Type 2 error is failing to reject a

null hypothesis or a "false negative." Shells containing less than 1% aluminum were never found to produce audible effects. Shells containing aluminum between 1 and 3.5% were found to produce reports in the field 50% of the time and shells containing greater than 3.5% of aluminum were found to contain reports 100% of the time. The shells containing between 1 and 3.5% aluminum that were found to have no audible effect were the result of Type 2 error. If the shells between 1 and 3.5% aluminum that had an audible effect were because of Type 1 error, then all of the shells below 1% and above 3.5% would be incorrectly characterized. What this means is that for example at 1% and below there would be a 100% correlation with the intent to produce and audible effect test approach whereas at 3.5% there would be only and 85% alignment with the current test method.

As the information in this section demonstrates, increasing the amount of fine mesh metal powder in a break charge increases the explosive power a device produces (up until the quenching point). For this reason, limits on fine mesh metal content in fireworks are necessary for consumer safety. However, limits on fine mesh metal powder alone are not sufficient, because that would address only one factor that contributes to increased explosive power—namely, fine mesh metal content. Another factor that contributes to increased explosive power is increased amounts of pyrotechnic composition in a fireworks device and its components, even if the composition does not contain fine mesh metal. To address these highly explosive devices, the next section discusses limits on chemical composition and pyrotechnic weight.

5. Chemical Composition and Pyrotechnic Weight

Under APA 87-1, each type of device has its own pyrotechnic and chemical content limit. Staff recommends the addition of these specific limits into the CPSC regulation. Depending on the type of device, a different limit applies. This is important because the energetic power of the device is directly related to the amount of pyrotechnic material in the device. A device with more pyrotechnic material has more explosive power. Staff believes that a limit on the total pyrotechnic weight in all devices is an important component missing in the CPSC regulation because all fireworks have the potential of creating an injury, not just fireworks intended to produce an audible effect. Staff believes that the limits in APA 87-1 for each device are appropriate. These limits are current industry standard and allow for proper functioning. The addition of metallic fuel creates a greater explosive force, as does the addition of more pyrotechnic composition. Thus, total limits on devices are also necessary. The ratio of break charge to effects is important because if a shell consists of too much break charge relative to effects, the effects could potentially disperse farther and cause flaming debris.

6. Staff Testing: Analyses of proposed test method and pyrotechnic limits

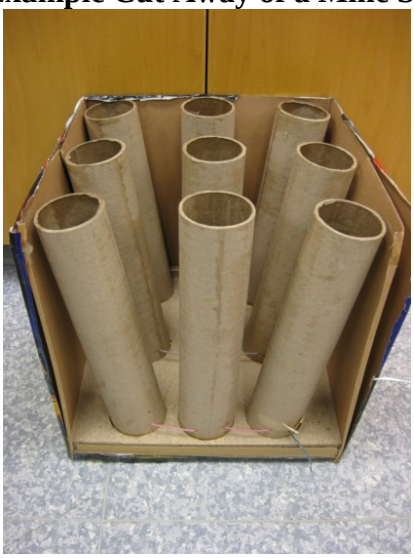
To assess the recommended final rule requirements for the total pyrotechnic weight in devices, and metallic fuel in devices, LSC performed random testing of fiscal year (FY) 2018 fireworks samples collected by the Office of Compliance. Staff performed this testing to assess compliance with APA 87-1, and to assess other possible variables or issues that could impact the reliability of the requirements in the recommended final rule. The process and test results are described below.

a. Description of Samples

Staff chose fireworks samples of various sizes and types from several manufacturers, based on availability from existing CPSC compliance samples. The two types of devices staff chose for evaluation were reloadable tube aerial shell devices (RTAS) (Figure 1) and mine and shell devices (MSDV) (Figure 2). These two types of products represent the majority of fireworks devices sampled for compliance evaluation.

Figure 1: Example of a Reloadable Tube Aerial Shell Device

Figure 2: Example Cut Away of a Mine Shell Device



b. Analysis of Pyrotechnic Composition Mass for Individual Components and Ratio of Effects to Break Charge

Staff carefully dissected and subsequently analyzed 63 (40 RTAS (Table 4) and 23 MSDV (Table 3)) uniquely labeled “sample devices” to obtain the mass of each lift charge, break

charge, and effect for each device. Following CPSC staff's testing protocol,[183] staff separated the break charge from the effects by passing the pyrotechnic composition of the shell through a 100-mesh sieve.

To determine the total chemical composition per shell, staff separately measured the mass of the lift charge, break charge and effects contained in multiple devices (Tables 3 and 4). According to APA 87-1 and the recommended final rule:

- the lift charge in any one RTAS or MSDV is limited to 20 grams per shell,
- the break charge is limited to 25% of the total weight of chemical composition in the component (break charge and effects), and
- individual shells are limited to 60 grams of total chemical composition (lift charge, break charge, and effects).

To determine the ratio of the break charge to the total weight of chemical composition in the component, the mass of the break charge powder is divided by the total mass of the break charge and effects. To determine the total mass of the device, staff multiplied the number of tubes in the mine and shell device by the average total mass of the tube.

Table 3 provides the results of staff's testing for the MSDV samples and Table 4 provides the results for the RTAS samples. Any devices that do not comply with the APA 87-1 limits and the recommended final rule are highlighted in gray.

Table 3
Mass and Ratios of Mine and Shell Devices

Sample # (Total allowed)	Tube	Lift Charge mass (g)	Effects mass (g)	Break Charge mass (g)	Break Charge Ratio (%)	Total chemical comp. per tube mass (g)	Total Device mass (g)
2018-1 (500g)	1	3.7189	11.5297	2.0407	15.04%	17.2893	
	2	3.5408	13.7449	1.5252	9.99%	18.8109	433
2018-2 (500g)	1	4.7830	11.6328	3.5085	23.17%	19.9243	
	2	5.0071	9.6455	2.9282	23.29%	17.5808	
	3	5.5694	9.1963	2.7818	23.22%	17.5475	294
2018-3 (500g)	1	1.6050	2.0960	0.7020	25.09%	4.4030	
	2	1.7260	2.6850	0.6900	20.44%	5.1010	
	3	1.5940	2.3458	0.7216	23.52%	4.6614	76
2018-4 (500g)	1	1.6568	3.0702	0.8690	22.06%	5.5960	
	2	1.6150	3.1902	0.5300	14.25%	5.3352	87
2018-20 (500g)	1	3.7741	18.8194	2.2059	10.49%	24.7994	
	2	3.6976	17.6776	2.251	11.30%	23.6262	581
	1	7.3498	31.7088	1.5077	4.54%	40.5663	368

[183] Consumer Product Safety Commission, "Consumer Fireworks Testing Manual" (Aug. 17, 2006).

2018-56 (500g)	2	7.5593	32.5532	1.1414	3.39%	41.2539	
	3	7.6817	32.1029	0.9031	2.74%	40.6877	
2018-5 (500g)	1	2.4814	8.9814	2.4193	21.22%	13.8821	
	2	2.3625	6.0523	2.4692	28.98%	10.8840	
	3	2.3846	7.5862	2.7688	26.74%	12.7396	
	4	2.0975	7.2524	2.4026	24.88%	11.7525	
	5	2.3446	7.8812	2.6625	25.25%	12.8883	249
2018-6 (500g)	1	2.1269	6.4751	2.1495	24.92%	10.7515	
	2	2.253	6.966	1.8338	20.84%	11.0528	
	3	2.2416	7.5871	1.8575	19.67%	11.6862	
	4	2.0226	7.0718	2.3531	24.97%	11.4475	
	5	2.0198	7.9421	2.3317	22.70%	12.2936	229
2018-7 (500g)	1	4.1137	9.6477	3.1035	24.34%	16.8649	
	2	4.1664	9.8967	3.6794	27.10%	17.7425	
	3	3.4445	10.3144	3.7581	26.71%	17.5170	
	4	4.0282	10.3784	3.4274	24.83%	17.8340	
	5	3.8371	10.5944	3.2733	23.60%	17.7048	386
2018-57 (500g)	1	14.1065	52.7150	2.6132	4.72%	69.4347	
	2	14.0417	51.5156	3.2770	5.98%	68.8343	622
2018-58 (500g)	1	5.6932	14.7797	6.6027	30.88%	27.0756	
	2	5.3940	15.9323	6.6526	29.46%	27.9789	193
2018-59 (500g)	1	3.8156	16.7894	3.4050	16.86%	24.0100	
	2	3.6893	15.2226	3.2089	17.41%	22.1208	577
2018-60 (500g)	1	5.4970	9.3305	0.0000	0.00%	14.8275	
	2	3.8409	7.3099	0.0000	0.00%	11.1508	
	3	3.7717	8.5630	0.0000	0.00%	12.3347	383
2018-61 (500g)	1	4.7685	17.7184	6.4857	26.80%	28.9726	
	2	5.0440	17.7253	6.6250	27.21%	29.3943	350
2018-62 (500g)	1	2.1175	7.8691	2.4504	23.75%	12.4370	
	2	2.0578	8.4795	2.0832	19.72%	12.6205	251
2018-63 (500g)	1	6.4318	30.3185	1.0110	3.23%	37.7613	
	2	6.8588	26.4597	1.0694	3.88%	34.3879	433
2018-64 (500g)	1	3.5118	11.1096	2.4713	18.20%	17.0927	
	2	3.8645	13.1350	1.8716	12.47%	18.8711	216
2018-65 (200g)	1	2.8265	7.4878	1.6190	17.78%	11.9333	
	2	2.7533	7.4996	1.8010	19.36%	12.0539	144
2018-66 (500g)	1	7.3917	26.7320	2.7830	9.43%	36.9067	
	2	7.9723	27.7389	1.6448	5.60%	37.3560	446
2018-67 (500g)	1	9.9381	33.3128	2.3198	6.51%	45.5707	
	2	9.8545	34.0182	3.0814	8.31%	46.9541	555
	1	6.9567	31.8950	1.8286	5.42%	40.6803	462

2018-68 (500g)	2	7.1862	27.3960	1.8166	6.22%	36.3988	
2018-69 (500g)	1	3.1965	13.0250	2.2154	14.54%	18.4369	
	2	3.2424	12.4432	2.2329	15.21%	17.9185	545
2018-70 (500g)	1	4.9166	13.7290	3.4387	20.03%	22.0843	
	2	4.6693	14.7070	2.3080	13.56%	21.6843	350

Table 4
Mass and Ratios of Reloadable Tube Aerial Shell Devices

Sample #	Shell	Lift Charge mass (g)	Effects mass (g)	Break Charge mass (g)	Break Charge Ratio (%)	Total chemical comp. per tube mass (g)	Total Device mass (g)
2018-8	1	10.2725	33.5245	3.8465	10.29%	47.6435	48
2018-9	1	10.2726	26.7166	5.3542	16.69%	42.3434	42
2018-10	1	10.3463	30.1370	6.8444	18.51%	47.3277	47
2018-11	1	10.4734	33.1345	6.1578	15.67%	49.7657	50
2018-12	1	10.2014	25.9914	8.1535	23.88%	44.3463	44
2018-13	1	9.8046	31.6397	5.4845	14.77%	46.9300	47
2018-14	1	7.7283	27.0958	7.4075	21.47%	42.2316	42
2018-15	1	7.3745	31.8645	10.8243	25.36%	50.0633	50
2018-16	1	7.3411	27.5012	9.0516	24.76%	43.8939	44
2018-17	1	7.5132	23.7111	11.1017	31.89%	42.3260	42
2018-18	1	7.7250	27.5019	9.6715	26.02%	44.8984	45
2018-19	1	8.1275	25.6700	9.4180	26.84%	43.2155	43
2018-27	1	6.8873	32.7924	11.2953	25.62%	50.9750	51
2018-29	1	7.1254	26.5582	8.6439	24.56%	42.3275	42
2018-30	1	7.9021	30.3478	9.4297	23.71%	47.6796	48
2018-31	1	7.1479	28.3075	8.5372	23.17%	43.9926	44
2018-32	1	10.0582	30.1991	4.5033	12.98%	44.7606	45
2018-33	1	10.3838	32.7483	7.2954	18.22%	50.4275	50
2018-34	1	9.9953	32.4821	6.9427	17.61%	49.4201	49
2018-35	1	9.9971	24.6483	8.4489	25.53%	43.0943	43
2018-36	1	7.5064	24.8304	10.3768	29.47%	42.7136	43
2018-37	1	7.4623	23.5772	11.1136	32.04%	42.1531	42
2018-38	1	7.4646	26.6883	9.6924	26.64%	43.8453	44
2018-39	1	8.0128	25.1750	9.6393	27.69%	42.8271	43
2018-40	1	7.7465	28.4692	10.7974	27.50%	47.0131	47
2018-41	1	7.6024	28.0202	10.0500	26.40%	45.6726	46
2018-42	1	7.6398	24.0681	10.1238	29.61%	41.8317	42
2018-43	1	7.4149	29.3827	8.5627	22.57%	45.3603	45
2018-44	1	7.3850	31.5331	8.9576	22.12%	47.8757	48

2018-45	1	7.6712	29.3925	10.1040	25.58%	47.1677	47
2018-46	1	7.6819	21.9278	9.6150	30.48%	39.2247	39
2018-47	1	7.9064	22.7244	9.6390	29.78%	40.2698	40
2018-48	1	7.7250	28.9612	9.7290	25.15%	46.4152	46
2018-49	1	7.5626	27.6316	10.6400	27.80%	45.8342	46
2018-50	1	7.1746	28.9225	9.8410	25.39%	45.9381	46
2018-51	1	7.3743	28.3674	8.9903	24.07%	44.7320	45
2018-52	1	7.5156	27.2051	8.9323	24.72%	43.6530	44
2018-53	1	7.3860	28.7072	10.1214	26.07%	46.2146	46
2018-54	1	7.2651	27.2148	10.2960	27.45%	44.7759	45
2018-55	1	7.4025	27.9042	10.4201	27.19%	45.7268	46

The recommended final rule aligns with APA 87-1 section 3.1.2.5, which states that if the break charge is composed of black powder or equivalent non-metallic composition, consumer fireworks may have a maximum break charge of 25 percent by weight of the device's total pyrotechnic composition in each component. If the break charge contains a fine particulate metal fuel (for example, aluminum or the aluminum-magnesium alloy called Magnalium), the charge is, by definition, "intended to produce an audible effect" and the limit for the break charge is 130 mg.

The recommended final rule and APA 87-1 limit the mass of the lift charge to a maximum allowance of 20 grams per shell in both reloadable aerial shells (APA 87-1 section 3.1.2.5) and multiple-tube mine and shell devices (APA 87-1 section 3.1.2.6). For RTAS, the maximum amount of pyrotechnic composition allowed in a single shell is 60 grams. For MSDV, the maximum amount of pyrotechnic material is 200 grams for the entire device. MSDV that contain tubes securely attached to a wood or plastic base and are separated from each other on the base by a distance of at least 0.50 inches (12.7 mm) may have a maximum amount of pyrotechnic material of 500 grams.

As can be seen by the highlighted results, in Table 3, 10 out of the 59 individual tubes tested (17%) contained an excess of break charge (greater than 25% by weight). Additionally, five samples were device styles limited to 500 grams of total pyrotechnic composition and were found to be more than 15% overloaded.

As can be seen by the highlighted results in Table 4, 22 out of the 40 shells tested (55%) contained an excess amount of break charge (greater than 25% by weight). Due to the explosive nature of fireworks devices, staff believes that a very high level of compliance is necessary to adequately protect consumers from the hazard of highly explosive devices.

It should be noted that staff obtained the mass and ratios of devices prior to analyzing the devices for metallic fuel content. If any of the devices above contained metallic fuel, the break charge would be further limited to 130 mg. All of the shells staff tested contained significantly more than 130 mg (some even 100 times more) in the break charge even though further analysis (see next section, "Break Charge Chemical Analysis") showed that many of the shells contained metallic fuel.

c. Break Charge Chemical Analysis

To determine the chemical content contained in the break charge, staff conducted analysis on a variety of MSDV as well as RTAS fireworks. Staff used Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES) to identify and quantify the aluminum content and Ion Chromatography (IC) to identify and quantify the oxidizer(s) present (Table 5). Any break charge containing metallic powder with a particle size under 100 mesh, according to the recommended final rule and APA 87-1, is "intended to produce an audible effect" (report) and is limited to 130 mg (2 grains). Sample collection was done by opening the shell and separating the break charge powder from any effects using a 100 mesh sieve. Staff analyzed the break charges separately by ICP-OES for aluminum content following a nitric acid digestion, and for oxidizer content by IC following dissolution in deionized water. Tables 8 and 9 show the results of aluminum added to black powder.

In addition, staff conducted a comparison study to determine if X-Ray fluorescence spectroscopy (XRF) is a viable screening tool for verifying metallic content in pyrotechnic powders. The break charge powders were analyzed for aluminum content by XRF and compared to the results from the ICP analysis of the same sample (Tables 6 and 7).

Table 5: Chemical Content in Break Charges for Various Mine and Shell/Reloadable Tube Aerial Shell Devices

Sample #	Shell	Break Charge mass (g)	Break Charge (%Al)	Nitrate (%)	Perchlorate (%)
2018-1	1	2.0407	0.1635	0.8954	48.2996
	2	1.5252	0.4480	1.2867	50.1957
2018-2	1	3.5085	0.5678	7.1695	34.8879
	2	2.9282	0.1869	5.5570	32.3811
	3	2.7818	0.2401	5.6487	33.5357
2018-3	1	0.7020	2.9818	0.6600	43.6366
	2	0.6900	3.1399	0.6660	43.3781
	3	0.7216	3.0347	0.6343	48.0297
2018-4	1	0.8690	2.0629	0.6516	46.8243
	2	0.5300	2.7980	0.4955	45.3118
2018-8	1	3.8465	6.5377	0.6401	46.0147
2018-9	1	5.3542	5.5593	0.7725	46.4195
2018-10	1	6.8444	5.8880	0.4187	56.9927
2018-11	1	6.1578	5.9914	4.9906	41.7872
2018-12	1	8.1535	6.5405	0.3135	46.8037
2018-13	1	5.4845	6.5960	0.3504	47.7598

2018-14	1	7.4075	13.5495	9.5086	27.8423
2018-15	1	10.8243	14.0937	9.2076	27.2618
2018-16	1	9.0516	14.1822	10.7473	30.2925
2018-17	1	11.1017	14.4787	11.3783	39.1725
2018-18	1	9.6715	13.3723	9.8941	30.0531
2018-19	1	9.4180	14.2447	NT	NT
	1	2.4026	0.2607	0.4826	47.7775
2018-5	2	2.6625	0.1980	0.7623	50.8819
	1	2.3531	0.4898	0.9224	46.4675
2018-6	2	2.3317	0.3257	0.6747	46.2727
	1	3.4274	0.0996	ND	49.7128
2018-7	2	3.2733	0.1361	0.6262	48.5148
	1	2.2059	0.0971	0.7906	51.9948
2018-20	2	2.2510	0.1454	0.8283	50.3208

Table 6: Analysis of Aluminum Content in Break Charges Using ICP-OES and XRF >2% Aluminum

Sample #	ICP- OES Al Analysis (ppm)	ICP-OES Al Analysis (%)	XRF Al Analysis (ppm)	XRF Al Analysis (%)	Difference ICP vs XRF (%)
1B	20500	2.05	30400	3.04	0.99
2B	20000	2.00	28400	2.84	0.84
3B	22700	2.27	29200	2.92	0.65
4B	29800	2.98	38400	3.84	0.86
5B	35500	3.55	33200	3.32	0.23
6B	18900	1.89	30600	3.06	1.17
7B	14900	1.49	38400	3.84	2.35
8B	16800	1.68	23500	2.35	0.67
9B	152300	15.23	145200	14.52	0.71
10B	152500	15.25	157000	15.7	0.45
11B	150900	15.09	135800	13.58	1.51
12B	157000	15.70	139500	13.95	1.75
13B	153800	15.38	153300	15.33	0.05
14B	142000	14.20	174300	17.43	3.23
15B	74200	7.42	79800	7.98	0.56
16B	73800	7.38	87100	8.71	1.33
17B	72000	7.20	82800	8.28	1.08

18B	80100	8.01	80700	8.07	0.06
19B	133300	13.33	169900	16.99	3.66
20B	147700	14.77	179300	17.93	3.16
21B	136500	13.65	171600	17.16	3.51
22B	125800	12.58	168800	16.88	4.3
23B	147400	14.74	172900	17.29	2.55
24B	155500	15.55	173300	17.33	1.78
25B	145000	14.50	194000	19.4	4.9
26B	147700	14.77	188600	18.86	4.09
27B	144500	14.45	196000	19.6	5.15
28B	154800	15.48	130500	13.05	2.43
29B	149700	14.97	138800	13.88	1.09
30B	138100	13.81	129200	12.92	0.89
31B	168100	16.81	151800	15.18	1.63
32B	156900	15.69	177900	17.79	2.1
33B	141100	14.11	185700	18.57	4.46
34B	162800	16.28	129100	12.91	3.37
35B	157400	15.74	158500	15.85	0.11
36B	158000	15.80	144500	14.45	1.35

Table 7: Analysis of Aluminum Content in Break Charges Using ICP-OES and XRF < 2% Aluminum

Sample #	ICP- OES Al Analysis (ppm)	ICP-OES Al Analysis (%)	XRF Al Analysis (ppm)	XRF Al Error (ppm)	XRF Al Analysis (%)	XRF Al 2 sigma (%)	Difference ICP vs XRF (%)
1A	12613	1.2613	3446	822	0.3446	0.0822	0.9167
2A	8983	0.8983	3427	814	0.3427	0.0814	0.5556
3A	1738	0.1738	3859	1028	0.3859	0.1028	0.2121
4A	2529	0.2529	ND	2539	ND	0.2539	0.2529
5A	1292	0.1292	2261	1068	0.2261	0.1068	0.0969
6A	1638	0.1638	4173	1030	0.4173	0.1030	0.2535
7A	1072	0.1072	ND	1907	ND	0.1907	0.1072
8A	1616	0.1616	1437	852	0.1437	0.0852	0.0179
9A	4338	0.4338	ND	1408	ND	0.1408	0.4338
10A	3213	0.3213	2562	1150	0.2562	0.1150	0.0651
11A	4359	0.4359	2434	847	0.2434	0.0847	0.1925
12A	4212	0.4212	ND	1521	ND	0.1521	0.4212
13A	1927	0.1927	2167	829	0.2167	0.0829	0.0240
14A	2223	0.2223	2256	940	0.2256	0.0940	0.0033
15A	7061	0.7061	3787	1026	0.3787	0.1026	0.3274
16A	7198	0.7198	5623	956	0.5623	0.0956	0.1575
17A	4130	0.4130	3451	962	0.3451	0.0962	0.0679

18A	3785	0.3785	2826	992	0.2826	0.0992	0.0959
19A	3237	0.3237	2016	869	0.2016	0.0869	0.1221
20A	4094	0.4094	3671	906	0.3671	0.0906	0.0423
21A	8555	0.8555	15200	1000	1.5200	0.1000	0.6645
22A	2460	0.2460	3197	906	0.3197	0.0906	0.0737
23A	18528	1.8528	5291	1118	0.5291	0.1118	1.3237
24A	9958	0.9958	4770	1080	0.4770	0.1080	0.5188
25A	2833	0.2833	ND	1331	ND	0.1331	0.2833
26A	2841	0.2841	3603	887	0.3603	0.0887	0.0762
27A	1286	0.1286	1649	841	0.1649	0.0841	0.0363
28A	2091	0.2091	2774	841	0.2774	0.0841	0.0683
29A	2242	0.2242	1457	870	0.1457	0.0870	0.0785
30A	1741	0.1741	1749	900	0.1749	0.0900	0.0008
31A	8042	0.8042	4373	816	0.4373	0.0816	0.3669
32A	6493	0.6493	3839	781	0.3839	0.0781	0.2654

Table 8: Black Powder with Fine Mesh Aluminum Powder Standards Trial 1

% Al expected	% Nitrate	% Perchlorate	% Al by ICP-OES
0.0%	50.825	0.000	0.00
0.5%	51.436	0.000	0.49
1.0%	50.664	0.540	0.89
2.0%	47.436	4.116	1.79
3.0%	49.168	1.250	2.51

Table 9: Black Powder with Fine Mesh Aluminum Powder Standards Trial 2

% Al expected	% Nitrate	% Perchlorate	% Al by ICP-OES
0.0%	51.888	0.000	0.00
0.5%	49.666	1.782	0.47
1.0%	49.030	2.213	0.84
2.0%	48.081	3.187	1.80
3.0%	48.171	2.693	2.62

As can be seen in Table 5, 17 out of the 30 shells/tubes tested (57%) contained metallic fuel in excess of 1%. All of these devices contained some amount of fine mesh metal in the break charge. Under APA 87-1, if any fine mesh metal powder is present in the break charge, this would limit the mass of the break charge to 130 mg. Under the recommended final rule, the 17 devices that contained more than 1.00% fine mesh metal in the break charge would be limited to 130 mg in the break charge. All of the devices contained well in excess of 130 mg. The extent of this overloading presents a safety hazard for consumers. Fireworks using metallic fuels with metal particles below 100 mesh in size have greater explosive force per volume of pyrotechnic material than fireworks using only black powder. A 1 percent addition of aluminum will increase the energy by a noticeable amount of 3 percent. Fifty-seven percent of these samples contained

aluminum greater than 1%.

These data also indicate that the break charges are not traditional black powder, rather they are a hybrid powder. The oxidizer(s) present were a mixture of nitrate and perchlorate. All of the samples contained a large amount of perchlorate (27-48%). The nitrate content varied between 0.3% and 11%. Each sample contains an oxidizer similar to that found in black powder (potassium nitrate) and "pure" flash powder (potassium perchlorate). However, the amount of nitrate in each sample is significantly less than the amount found in black powder. Pure flash powder contains about 30% aluminum and 70% perchlorate. The amount of perchlorate in each sample is similar to the amount found in "pure" flash powder.

Table 6 and Table 7 provide the results for the comparison study between ICP and XRF for aluminum content. Table 6 illustrates the correlation between ICP and XRF for samples containing aluminum greater than 2%. Table 7 illustrates the correlation between ICP and XRF for samples containing aluminum less than 2%. The average percent difference (ICP–XRF) at low levels (less than or equal to 2% Al content) was 0.254%. The percent difference at high levels (greater than 2% Al content) was 1.92%. Out of the 68 break charges tested, 32 (47%) yielded lower results by ICP-OES than XRF. The 0.254% difference between XRF and ICP-OES results for aluminum indicate that XRF is a viable screening tool for verifying metallic content in pyrotechnic powders at low levels. It is important to note that while storing samples for further analysis, proper explosive static control protocols should be followed.

d. Conclusion

CPSC staff believes that the recommended final rule, which is consistent with APA 87-1, is a repeatable and quantifiable way of keeping devices with greater explosive power out of the consumer market. Staff believes the recommended final rule would help the fireworks industry to attain a higher rate of compliance and improve safety through greater consistency in results by providing a clearer, more uniform, and more quantifiable identification method for powerful explosive devices. By doing so, CPSC is aligning with the DOT's regulations for consumer fireworks, which incorporate by reference the comparable method in APA 87-1. This would provide the fireworks industry with a consistent regulatory framework and reduce the burden on industry of having to comply with two different tests. The recommended test method, which relies on precise and quantifiable measurements rather than experienced observation and subsequent quantifiable measurements, greatly reduces variation of results.

e. Potential sources of aluminum contamination

Staff tested multiple aerial shell devices to investigate if the aluminum found in the break charge powder is the result of aluminum or aluminum compound migration from other various components of the device, such as the visible effects or the clay plugs. The effects from the device can contain large amounts of aluminum, and because they comingle with the break charge powder it can be a potential source of contamination. The clay "plugs" located at the top and bottom of the device can also be a source of contamination. To collect samples, staff opened the shell, separated the break charge powder from any effects (using a 100 mesh sieve) and removed the lift charge. Staff took clay samples from both the bottom (where it contacts the lift charge) and top (where it is in contact with the break charge) of the device. The break charge, effects and

lift charge were digested in nitric acid and analyzed by ICP-OES for aluminum content. The clay was microwave digested in hydrofluoric acid and analyzed by ICP-OES for aluminum content. The results can be seen in Tables 8-10.

Table 10: %Al in Effects, Lift Charge, Break Charge and Clay

Sample #	Shell	Lift Charge (%Al)	Break Charge (%Al)	Effects Small (%Al)	Effects Large (%Al)	Clay @lift (%Al)	Clay @break (%Al)
	1	0.0179	0.1635	6.2393	n/a	0.5363	0.6543
2018-1	2	0.0239	0.4480	1.6884	n/a	0.5386	0.9521
	1	0.0174	0.5678	4.1649	n/a	0.5882	0.7291
	2	0.0118	0.1869	5.1660	n/a	0.7017	0.7071
2018-2	3	0.0659	0.2401	4.1666	n/a	0.6722	0.8355
	1	0.0120	2.9818	5.6972	n/a	0.8001	0.7154
	2	0.0210	3.1399	5.4482	n/a	0.6275	0.3928
2018-3	3	0.0186	3.0347	6.1134	n/a	0.7164	0.5317
	1	0.0149	2.0629	6.3044	n/a	1.1521	0.8542
2018-4	2	0.0183	2.7980	5.8220	n/a	0.8379	0.8340
2018-8	1	0.0350	6.5377	2.6331	n/a	5.3627	0.4537
2018-9	1	0.0355	5.5593	5.0336	n/a	4.2549	0.5627
2018-10	1	0.0230	5.8880	5.8040	n/a	6.3089	0.5473
2018-11	1	0.0301	5.9914	5.1962	n/a	2.7657	0.5836
2018-12	1	0.0268	6.5405	3.5458	n/a	8.3244	0.6850
2018-13	1	0.0265	6.5960	8.0978	n/a	4.0307	0.6483
2018-14	1	0.0392	13.5495	6.3730	8.0093	0.6123	0.7620
2018-15	1	0.0403	14.0937	6.9383	14.0928	0.8826	0.5521
2018-16	1	0.0313	14.1822	9.1861	14.5465	0.7603	0.5777
2018-17	1	0.0352	14.4787	3.9336	n/a	0.3547	0.5768
2018-18	1	0.0301	13.3723	6.3022	4.9726	0.5592	0.5122
2018-19	1	0.0498	14.2447	7.1249	11.3809	0.7748	0.4660

Table 11: %Al in Effects, Lift Charge, Break Charge and Clay

Sample #	Shell	Lift Charge (%Al)	Break Charge (%Al)	Effects Small (%Al)	Clay Below Lift (%Al)	Clay Above Lift (%Al)	Clay Above Break (%Al)
	1	0.0137	0.2607	5.0842	0.5452	0.7214	0.4007
2018-5	2	0.0070	0.1980	4.4341	1.0437	0.9655	0.3034
2018-6	1	0.0008	0.4898	1.7287	0.3666	0.3309	0.2406

	2	0.0022	0.3257	1.9054	0.7173	0.4998	0.2243
	1	0.0488	0.0996	5.4392	0.9782	1.0416	0.4453
2018-7	2	0.0473	0.1361	7.3296	0.9342	0.9297	0.3191

Table 12: %Al in Effects, Lift Charge, Break Charge and Clay

Sample #	Shell	Lift Charge (%Al)	Effects @ Lift Charge (%Al)	Clay @lift (%Al)	Break Charge (1) (%Al)	Effects @break charge 1 (%Al)	Clay @break 1 (%Al)	Break charge (2) (%Al)	Effects @break 2 (%Al)	Clay @break 2 (%Al)
	1	0.0336	4.8844	0.7094	0.0971	2.2451	0.8303	0.1486	8.1446	0.7459
2018-20	2	0.0319	4.5001	0.6320	0.1454	6.0975	0.7159	0.0879	6.9385	0.7214

As can be seen from the results in Tables 10, 11, and 12, although all shells contained large amounts of aluminum in the effects (large and small), there were 13 shells (43% of shells tested) that contained small amounts (less than 1%) of aluminum in the corresponding break charge. Even though the effects are comingled with the break charge, little to no migration occurred. This confirms that migration of fine mesh aluminum powder from the effects into the break charge does not occur in large amounts.

Some shells contain effects comingled in the lift charge in order to produce a "comet" effect. The data from Table 12 is from a shell where the effects are comingled with the lift charge. These effects contained a large amount of aluminum, however small amounts (less than 1%) of aluminum were detected in the lift charges. This confirms that migration of fine mesh aluminum powder from the effects into the lift charge does not occur in large quantities. This further negates the possibility that the effects or the manufacturing environment are a major source of aluminum in break charges.

As can be seen from the results in Tables 10, 11 and 12, the majority of the clay plugs have an average of less than 1% aluminum. Break charges that contain the most aluminum (greater than 10%) do not contain aluminum in the clay. This confirms that the aluminum in the break charge is the result of intentional addition, not contamination from the clay. In addition to the aluminum in break charge, staff analyzed additional metals found in the effects to see if migration can occur (Tables 13 and 14). Strontium compounds are often used in the visual effects of fireworks to provide a red color. Similarly, copper compounds can be used to produce a blue color. Table 13 displays the amount of strontium found in both the break charge and the effects. Although, strontium appears to be present in both components, it is significantly lower in the break charge where it was found to be no greater than 0.34 percent. Table 14 shows similar results for copper. This strontium and copper analysis demonstrates the unlikeliness of the effects to contaminate the break charge. Additionally, staff found no measurable amount of residue after vigorous agitation of the effects isolated by themselves.

Table 13: ICP-OES Analysis of Strontium in Break Charge and Effects

Sample Number	Effects: %Sr	Break Charge: %Sr
1	2.21	0.31
2	5.73	0.30
3	4.67	0.28
4	9.60	0.25
5	9.97	0.34
6	4.39	0.31

Table 14: ICP-OES Analysis of Copper in Break Charge and Effects

Sample Number	Effects: %Cu	Break Charge: %Cu
1	6.94	0.25
2	3.32	0.28
3	9.72	0.25
4	14.47	0.23
5	13.59	0.38
6	12.57	0.29
7	7.97	0.18

f. Verification of elemental metals

In order to verify that the elemental metals identified via the ICP-OES are, in fact, base elements and not metal oxides,[184] staff studied representative aluminum and titanium samples with a Hitachi S3400N-II VP-SEM and Oxford INCA Energy 350 Energy Dispersive X-Ray Microanalysis system and compared them to aluminum oxide and titanium dioxide standards. Staff obtained images following a modified ASTM procedure.[185, 186] A small quantity of material was adhered to a carbon tab on a sample stub and coated with a thin layer of gold-palladium using a 30-second sputter in a Denton Desk IV sputter coater. The powders were imaged at 30kV and various magnifications using both an Environmental Secondary Electron Detector (ESED) and a Back-Scattered Electron (BSE) detector. The elemental composition of the powders was then mapped using the EDS system.

[184] Several commenters on the rule stated that screening tools, including ICP-OES cannot distinguish metals from metal compounds. This testing addresses that concern.

[185] ASTM E2809-13 Standard Guide for Using Scanning Electron Microscopy/X-Ray Spectrometry in Forensic Paint Examinations

[186] ASTM E1508-12a Standard Guide for Quantitative Analysis by Energy-Dispersive Spectroscopy

Figure 3: SEM/EDS Images of German Dark Aluminum and Aluminum Oxide

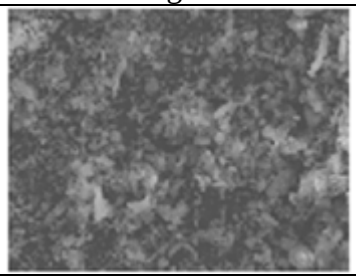
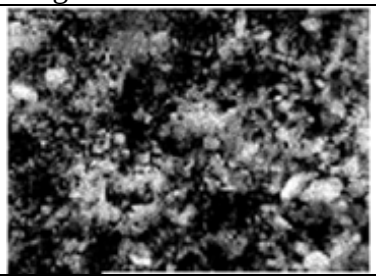
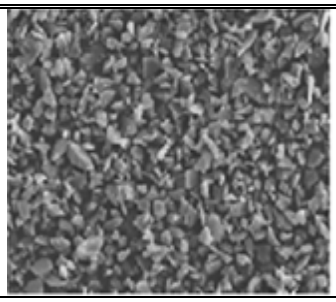
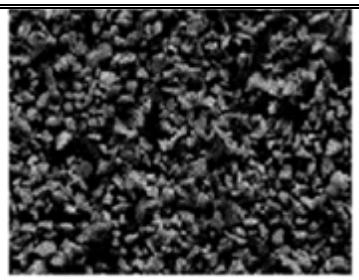
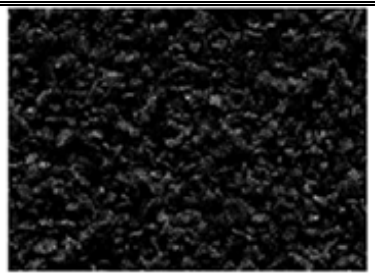
		
German Dark Powdered Aluminum	EDS Aluminum Map	EDS Oxygen Map
		
Aluminum Oxide Standard	EDS Aluminum Map	EDS Oxygen Map

Figure 4: SEM/EDS Images of Titanium and Titanium Dioxide

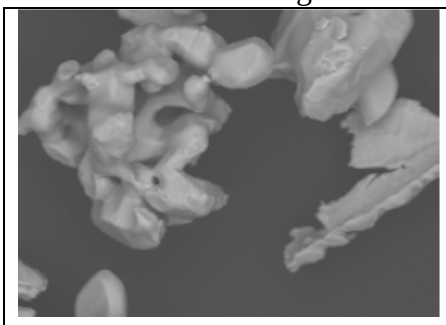
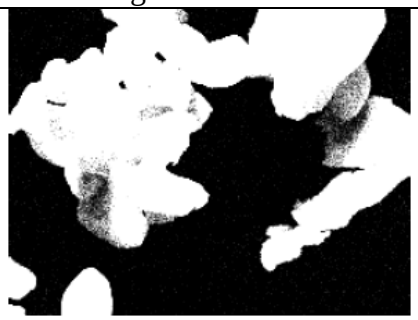
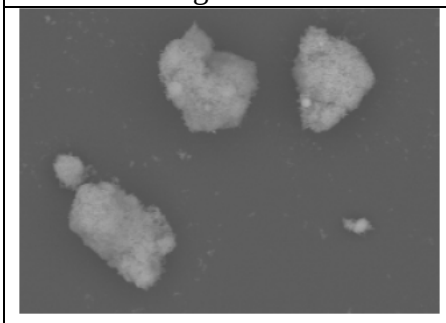
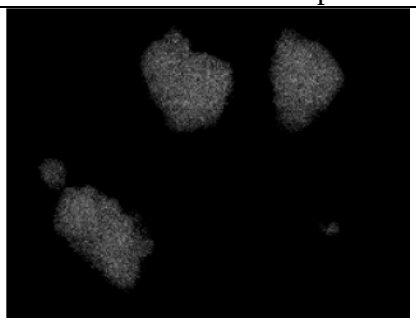
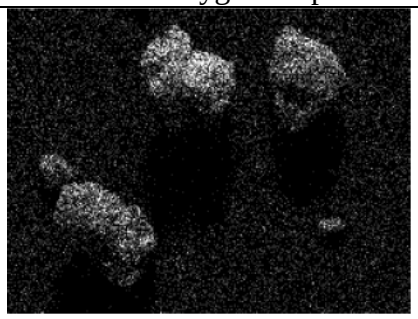
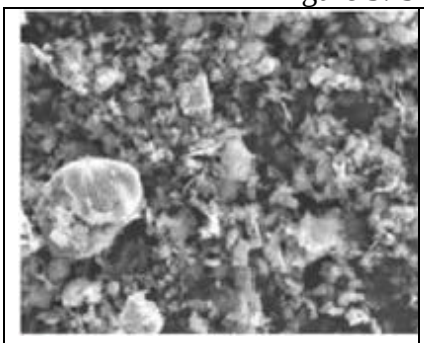
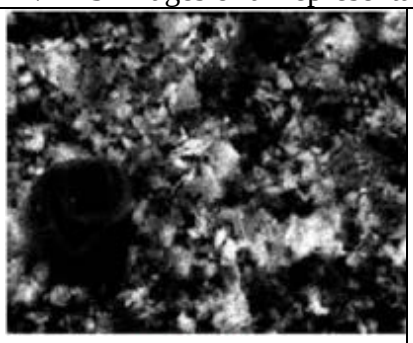
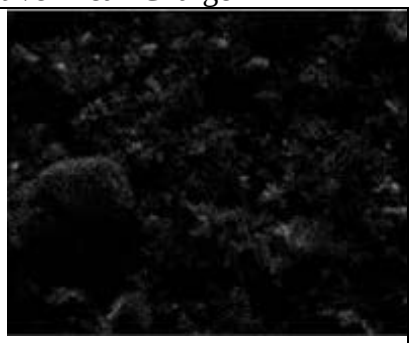
		
SEM image of Titanium	EDS Titanium Map	EDS Oxygen Map
		
SEM image of Titanium Dioxide	EDS Titanium Map	EDS Oxygen Map

Figure 5: SEM/EDS Images of a Representative Break Charge

		
SEM image of a Break Charge	EDS Aluminum Map	EDS Oxygen Map

Comparing SEM images and EDS maps of the base aluminum and titanium metals to the oxidized metal standards in Figures 3 and 4 shows that despite a thin oxide surface coating on the pure metals, they are readily differentiated from the metal oxide forms. The oxygen elemental content maps for German Dark powdered aluminum and titanium metal do not properly mirror the aluminum and titanium elemental content maps. However, the oxygen elemental content maps for the pure oxides are robust and clearly mirror the morphologies of the metal elemental content maps. The presence of metal oxides in pyrotechnic material would be shown through particle matching in the EDS maps, if present. Further, the oxide standards elemental maps provide an example of the relative contrast ratio between the elemental metal and oxygen that could be expected in a fireworks sample if it did contain aluminum oxide.

As shown by Figure 5, which is an example break charge containing a powdered aluminum metallic fuel and perchlorate oxidizer, not all particles clearly defined in the oxygen EDS map correspond perfectly to a particle in the aluminum EDS map and have the contrast ratio expected of a pure metal oxide. Therefore, it can be concluded that the aluminum present in the fireworks sample of Figure 5 is not present as pure aluminum oxide. Both the SEM and EDS portions support the presence of aluminum particles rather than aluminum oxide particles.

7. Contamination Allowance for Fine Mesh Metal

Staff recommends allowing a compliance enforcement discretion in the preamble of the recommended final rule for a contamination limit of 1.00 percent for metal powder under 100 mesh in particle size present in break charges exceeding 2 grains (130 mg). Staff believes that a minimal allowance for trace contamination may reduce the burden on the fireworks industry because it will not be necessary to use test methods capable of detecting very low levels of metals, which would require more costly equipment and test methods that have more stringent quality control to prevent contamination at very low levels. Staff believes that trace amounts of metal would not pose an additional safety risk to consumers compared to the same powder without the trace amounts of metal.

Staff believes that the presence of metal powder under 100 mesh in particle size at the level of 1.00 % is minimal, such that it would not significantly increase the amount of energy as

compared to the same powder without trace amounts of metallic fuel. At this very low level, the presence of metallic fuel would have a negligible energetic effect. Staff believes that this allowance would facilitate reasonable testing and production, while still ensuring the same safety as fuel without trace amounts of metals.

In addition to reducing testing costs and reflecting the fact that instruments can detect extremely low levels of a material, a contamination allowance would also address two potential sources of fine mesh metal contamination in a break charge as well as potential variation in readings from different screening instruments. The potential sources of fine mesh metal contamination include contamination from the environment during manufacturing, and migration from other components of a fireworks device into the break charge. The test results described in the previous section address the extent to which those are possible, indicating they occur only at extremely low levels, if at all. The test results described in the previous section also address the extent to which XRF and ICP readings of the same sample may differ, indicating this is also a minimal source of variation. One percent adequately accommodates those sources of variation and contamination, without allowing enough metal content to significantly increase explosive power.

8. Alternatives

Alternative Contamination Allowance for Fine Mesh Metal

Increases to fine mesh metal content increase the explosive power of a device; therefore, selecting an appropriate contamination level requires balancing the safety need for limiting explosive power against the practical need to account for realistic levels of inadvertent contamination and instrument variation. Staff believes strongly that levels greater than 1 percent are intentional and not associated with contamination and measurement uncertainties. The staff's recommendation aligns with the APA standard of no metallic fuel but provides for an allowance for uncertainties associated with analytical instrument variation and low level contamination.

CPSC test data shown above in Graph 1 indicates that beginning above 1% aluminum content, devices begin to show intent to produce an audible effect. Thus, the existing "intent to produce an audible effect" evaluation method shows that this aligns with the staff proposal to allow no more than 1% metallic fuel content. Above 1% levels, there appears to be a transition range, between 1 to 3.5% Aluminum metal content where audible effects are being detected about half the time. In a joint comment submitted in response to the NPR, APA and AFSL provided test results from Bureau Veritas regarding the fine mesh aluminum content in devices that are currently on the market. These results indicate that approximately 92% of MSDV and 77% of RTAS devices on the market would comply with a 1% allowance.

Staff believes that this allowance will also provide some additional safety to the current method since it will eliminate devices that produce audible effects in the transition area of 1-3.5% and would account for use of other metallic fuel constituents such as Magnesium that may be used in addition to Aluminum. A level of 1% of metallic fuel results in an increase in explosive energy of about 3% as discussed above and as shown in Charts 1 and 2.

The contamination allowance is intended to reflect a balance between the intended safety purpose of the recommended final rule and the realities that impact the level of fine mesh metal powder detected in a break charge. The intent of the rule is to limit the use of flash powder, which traditionally contains fine mesh metallic powders and has more explosive force per volume than black powder. This is consistent, in part, with the approach of the current standard to determine intent to produce an audible effect. As explained above, increasing the amount of fine mesh metal powder increases the explosive power produced, and devices with greater amounts of explosive power could potentially increase the severity of fireworks injuries.

An allowance of up to 1 percent provides a consistent 100 percent alignment with the current audible effect methodology. Allowance levels above 1 percent, up to 3.5 percent, provide a range of 95-85 percent alignment respectively with the current method. A level of 5 percent or higher appears to decrease the level of safety from the current method and is not at all in alignment with the current method. Staff cannot quantify an increase in the likelihood of injury or injury severity, if any, that would result from allowing a contamination level allowance greater than 1 percent. The above alternative discretionary allowance limits of up to 2 percent, 3 or 3.5 percent present a range of options the Commission could consider besides the staff recommendation of 1 percent.

Alternative Test Methods to Replace "Intended to Produce Audible Effects"

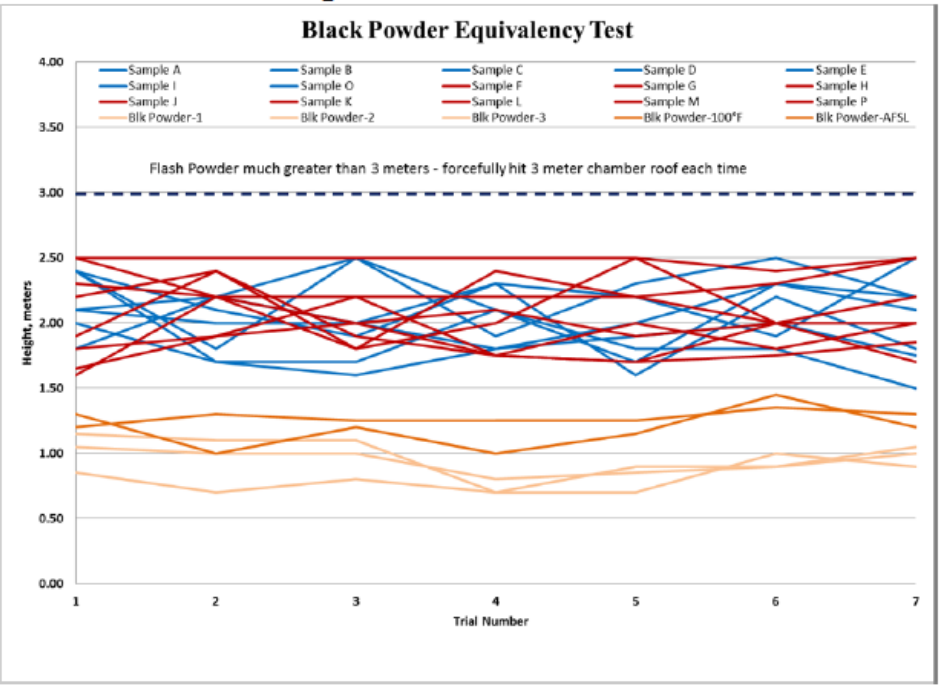
Section 1500.17(a)(3) bans a fireworks device that is "intended to produce audible effects" if the audible effect is produced by a charge of more than 2 grains (130 mg) of pyrotechnic composition. Staff investigated several alternative test methods as a possible replacement to the current test method to determine if a fireworks device was "intended to produce an audible effect." In considering replacements for the current test method, staff evaluated the potential new test methods using criteria that include the effectiveness of the new test at identifying highly-explosive devices, and reproducibility of the test results, as well as the option that would be least burdensome to industry.

a. A "Black Powder Equivalency Test"

Developed by AFSL, the "Black Powder Equivalency Test" is designed to distinguish between the energetics of black powder, hybrid powders, and flash powder. This test is conducted by removing the break charge powder from an aerial shell and exactly 1 gram of the break charge is placed in a plastic vial. The plastic vial is then placed inside a steel mortar launch tube on which a 600 g steel ball is placed. The power is tested by exploding the charge and measuring the distance the steel ball is displaced.[187] The results of this testing demonstrate the difference in power between black powder, flash powder and hybrid powders (mixtures of black powder and flash powder). This can be seen in Figure 6.

[187] Christopher Musto & Andrew Lock, Consumer Product Safety Commission, "FY 2012 Fireworks Safety Standards Development Status Report" (2013).

Figure 6: Black Powder Equivalency Test[188]



As can be seen by Figure 6, three distinct regimes can be identified. Black powder typically obtained a height below 1.5 meters. Flash powder is capable of displacing the ball much higher than 3 meters and hybrid powders clustered in the range of 1.5-2.5 meters. Similar studies on a variation of this test have been performed with good reproducibility.[189] The Black Powder Equivalency Test confirms that flash powder and hybrid powders (both of which contain metal powder) are significantly more powerful than black powder devices.

Staff believes that the Black Powder Equivalency Test is a less desirable alternative than the recommended final rule because it is less effective and potentially more costly. The Black Powder Equivalency Test, on its own, would be ineffective because it does not take into account ratios of break charge to effects, which plays a role in "intended to produce an audible effect," and presents a safety hazard, as described earlier in this memorandum. If the shell only contains break charge and no effects, the break charge is clearly intended to produce an audible effect. The recommended final rule takes into account the difference between black powder, flash powder and hybrid powders. It also takes into account the ratio between break charge and effects, which the Black Powder Equivalency Test did not. Additionally, the recommended final rule requires that metallic fuel, which is the reason flash powder and the hybrid powders were more powerful, is not used in consumer fireworks in excess of 130 mg.

In addition, staff believes that the recommended final rule is less burdensome to industry than the Black Powder Equivalency Test. First, in order to conduct the Black Powder

[188] Christopher Musto & Andrew Lock, Consumer Product Safety Commission, "FY 2012 Fireworks Safety Standards Development Status Report" (2013).
[189]Tang, A. (2009). "A New and Fast Method of Evaluating Powder Energy" Journal of Pyrotechnics. Issue 28, Pages 51-64

Equivalency Test safely, a steel ball containment chamber is necessary. Second, the tester has to construct a 1 gram device prior to testing each device. Third, the device must be ignited in order to measure if it passes or fails. In the recommended final rule, the presence or absence of metallic fuel can be quickly screened by XRF and if needed, confirmed using ICP-OES analysis.

b. Overpressure Measurements

As suggested by comments noted in Tab B, staff considered and designed a new test method based on the overall pressure released from a shell during functioning. This test method aimed to measure the energy released from an actual shell, as constructed, minus the propelling (lift) charge. Staff constructed a chamber designed to contain shell debris and device effects and 5 high-speed dynamic pressure transducers were affixed inside of the chamber. Results showed that large aerial shells, considered to meet regulations limiting explosive composition (no report) produced pressures similar to an illegal M-80 device. Therefore, this test method would result in a ban on virtually all aerial shells on the market.

Additionally, staff found that this test method would not be the least burdensome to industry, due to the cost associated with the testing. In addition to the chamber itself, the analysis requires 5 pressure transducers, the instrumentation needed to collect data, as well the complexity and prerequisite data on interpreting the data. Staff also examined ways to reduce the cost and burden of this testing (such as using a single pressure transducer and less expensive and less complex data acquisition systems) and determined that the technical reliability and reproducibility could be an issue. In contrast, staff has found the recommended final rule to be a reproducible and reliable way of limiting the explosive power of devices.

c. Sound Level Meter Testing (SLM)

CPSC received comments in response to the NPR, suggesting that SLM testing would be a better method to identify devices that should be subject to the 2 grain limit in § 1500.17(a)(3) than the proposed fine mesh metal content method. Commenters cited sound level requirements in the European Standard as an example. The European Standard EN 15947-4 currently prohibits a consumer fireworks device from producing a noise level above 120 dB (EN 15947-5, section 7.2.7) when tested using the procedures and at the distances stated in the standard (EN 15947-4).[190] The European Standard categorizes fireworks devices, in part, by how much sound they produce with the lowest-level category presenting a "negligible noise level" and the highest-level category presenting "a noise level [that] is not harmful to human health" (EN 15947-2, section 4). This suggests that the standard's requirements regarding noise levels are used to assess and limit the amount of noise generated from an exploding firework, because of the health implications or nuisance associated with loud volume, rather than any relationship the sound has to explosive force.

[190] APA 87-1 and the AFSL standard do not include requirements regarding the noise level fireworks produce.

Nevertheless, staff reviewed several SLM test methods,[191,192] and conducted some SLM testing to assess whether it may be a viable alternative for determining the explosive force a fireworks device produces. Staff tested several devices using SLM, and also compared the dB readings of devices with known amounts of aluminum content. Devices containing pure black powder, 1 percent aluminum, and 2 percent aluminum produced a variety of dB readings, all of which were less than the 120 dB limit in the European Standard. Decibel readings for devices containing 3 percent and 5 percent aluminum also varied, with some exceeding 120 dB. Devices containing 10 percent aluminum, 15 percent aluminum, and pure flash powder produced readings greater than 120 dB, and the range of readings was generally narrower than for the devices containing less aluminum, but still varied. Staff also tested multiple samples of several specific devices and, again, the dB readings varied for devices of the same type. Although the sample size was fairly small, in general, staff's testing indicated that devices with the same aluminum content did not yield consistent dB readings until there was more than 5 percent aluminum content, at which point readings became more consistent. This variation is due to several variables that impact SLM results, including environmental factors (e.g., humidity, altitude, temperature, physical or geographic surroundings), instrumentation (e.g., type and quality of SLM instruments vary widely and affect test procedures and results), device design including material amounts, thicknesses and packing density, and testing (e.g., distance from fireworks device, height of functioning, orientation to instrument). Therefore, for SLM to be a useful test method to measure the force generated from a shell, testers would have to remove all of these variables. Neither staff's own testing, nor staff's review of other's SLM testing, has identified such a test method. Therefore, the SLM method would not be an effective replacement for Section 1500.17(a)(3).

9. Summary and Recommendation

The recommended final rule modifies and adds to the current regulations to more comprehensively address the hazard presented by fireworks with high explosive power. Staff believes that updating the language the current regulation uses, in particular "intent to produce audible effects," to better reflect the current design and composition of fireworks devices would increase compliance and reduce the frequency and severity of injuries caused by these devices. The devices listed in § 1500.17(a)(3) used flash powder, which is a mixture of an oxidizer (typically potassium perchlorate) and a metallic fuel (typically aluminum or magnesium) and caused significant injuries and death at the time the rule was written.[193]

Incident data suggest that highly explosive aerial devices, which are often subject to § 1500.17(a)(3), are still associated with the vast majority of fireworks-related deaths and many of the most severe fireworks-related injuries. Incorporating a methodology that uses modern methods to evaluate the metallic content of a fuel would be consistent with the original intent of the rule. Likewise, the regulation should use a quantifiable method, rather than a method relying on the experience and training of test personnel to identify a particular sound profile. This would

[191] Page, W, Mclaren S. (2014). New Zealand Code of Practice for retail fireworks. Revision of the noise testing provisions: Experience and Findings. New Zealand.
[192] Whatron R, K, Slater H. J (1995). Further studies of the noise levels produced by fireworks. Journal of Pyrotechnics XVI.
[193] 38 Fed. Reg. 4666 (Feb. 20, 1973); 35 Fed. Reg. 7415 (May 13, 1970).

more-directly target the source of the hazard at issue (since metal content is associated with increased explosive power), and provide a more reliable way to identify devices that should be subject to the 2-grain limit, thereby improving the identification of highly-explosive devices. In addition, this would eliminate the initial screening test to determine if the device was intended to produce an audible effect, and would focus instead on the determination of whether the device falls within the limits of the regulation. This would be beneficial to industry, as the product could be manufactured to ensure compliance instead of having to check for compliance on the finished product. Staff recommends using enforcement discretion to allow up to 1.00 percent contamination with fine mesh metal powder to account for variations in screening instruments and unintentional contamination.

Additionally, limits on pyrotechnic powder should exist for all devices, not solely those intended to produce an audible effect. Staff believes that adding device limits for aerial fireworks would support the purpose of the existing regulation, which is to keep powerful explosives out of the consumer market because of the serious injuries they can pose to users.

C. Miscellaneous Clarifications: Draft Revisions to 16 C.F.R. §§ 1500.17(a)(3), 1500.17(a)(8), 1500.83(a)(27)(i), and 1500.85(a)(2)

In the NPR, the Commission proposed to modify the regulatory language in four sections of CPSC's fireworks regulations, to eliminate confusion and make the regulations clearer, without altering the substantive requirements in the regulations.

1. Eliminate conflicting requirements for "aerial bombs" (16 C.F.R. § 1500.17(a)(3))

Currently, the regulations mention the term "aerial bomb" as both subject to the limits described in § 1500.17(a)(3) and subject to the ban described in § 1500.17(a)(8). Using the term "aerial bombs" in both §§ 1500.17(a)(3) and (a)(8) is inconsistent because the former limits devices to 2 grains of pyrotechnic content, and the latter prohibits aerial bombs entirely. To clarify the requirements, in the NPR, the Commission proposed to remove the term "aerial bomb" from § 1500.17(a)(3) to clarify that the only applicable regulation for such devices is § 1500.17(a)(8).

CPSC received comments regarding this proposed change, which are summarized and addressed in the comment summary and response memorandum in the briefing package for the recommended final rule. For the regulatory requirements to be clear, it is necessary to remove the inconsistency that exists, and staff believes that § 1500.17(a)(8) is the appropriate section to address limits on aerial bombs.

2. Replace the term "audible effects" (16 CFR § 1500.17(a)(8))

This section of the CFR applies a limit of 50 mg (.772 grains) of pyrotechnic composition to firecrackers that are "designed to produce audible effects." Because firecrackers do not have any pyrotechnic effects and only produce an audible effect while functioning, all firecrackers are "designed to produce audible effects," and therefore, are limited to 50 mg of pyrotechnic

composition. Because the phrase "designed to produce audible effects" is redundant with the term "firecracker" and may be confusing because of its similarity to the phrase "intended to produce audible effects," in the NPR, the Commission proposed to remove the phrase "designed to produce audible effects" from the regulations, and instead, simply refer to "firecrackers."

Similarly, to provide consistency throughout the regulations, in the NPR, the Commission proposed to replace the reference to "audible effects" in this section with the term "explosive composition" to describe the function of the device, consistent with other sections of the C.F.R.

CPSC did not receive any comments on these proposed modifications. Because staff believes that these changes provide greater clarity and reduce potential confusion, staff has included these changes in the recommended final rule.

3. Replace the term "audible effects" (16 CFR § 1500.83(a)(27)(i))

Ordinarily, hazardous substances must meet the labeling requirements of section 2(p) of the FHSA. Section 1500.83(a)(27) provides an exemption from full labeling for the outer packaging of fireworks assortments, which generally include different types of devices, such as sparklers, fountains, firecrackers, and aerial shells. The section refers to "small devices designed to produce audible effects" and mentions the 2-grain limit for "audible effects."

As mentioned above, in the NPR, the Commission proposed to remove the phrase "designed to produce audible effects" throughout the regulations, and instead, simply refer to "firecrackers," since all firecrackers are "designed to produce audible effects." Accordingly, the Commission proposed to replace the phrase "small devices designed to produce audible effects" in this section with "small devices with an explosive composition that includes metallic fuel less than 100 mesh in particle size."

Similarly, to provide consistency throughout the regulations, the NPR proposed to use the terms "explosive composition" and "burst charge," rather than "audible effect," to describe the function of the device throughout the regulations. Accordingly, the Commission proposed to replace that term in this section as well.

CPSC did not receive any comments on these proposed modifications. Because staff believes that these changes provide greater clarity and reduce potential confusion, staff has included these changes in the recommended final rule.

4. Replace the term "audible effects" (16 CFR § 1500.85(a)(2))

As mentioned above, in the NPR, the Commission proposed to remove the phrase "designed to produce audible effects" throughout the regulations, and instead, simply refer to "firecrackers," since all firecrackers are "designed to produce audible effects." Similarly, to provide consistency throughout the regulations, in the NPR, the Commission proposed to replace references to "audible effects" with the term "explosive composition," consistent with other sections of the CFR. Accordingly, the Commission proposed those language changes for § 1500.85(a)(2).

CPSC did not receive any comments on these proposed modifications. Because staff believes that these changes provide greater clarity and reduce potential confusion, staff has included these changes in the recommended final rule.

D. Base Attachment: Draft Revision to 16 CFR § 1507.4

Section 1507.4 describes requirements for the base of a firework device—specifically, the allowable relative dimensions of the base and the height of the device. This requirement is intended to prevent devices from tipping over. Tip-overs present a serious safety hazard because a device could fire in the direction of users or bystanders, or users may return to a lit device to correct the tip-over.

Another factor that can impact device stability and tip-overs during functioning is base attachment. If the base is not attached properly, injuries can result due to unstable devices. Attaching the base to the fireworks device is a critical task to set up fireworks for safe use. There are various reasons why the base may not be attached to the device or may be inadequately attached. For example, consumers may commit a skill-based error such as slips, which are errors that are caused by lack of attention, where a simple, frequently-performed physical action goes wrong or short-term memory lapses lead to omitting a required action. Consumers may also commit a rule-based mistake, where they inadequately attach the base to the device. Requiring that fireworks devices come attached to the base would minimize the likelihood of user errors. In addition, having a base may signal to consumers that the fireworks device needs to be placed on a flat surface, rather than holding it in their hands or on other unstable surfaces.[194]

For these reasons, in the NPR, the Commission proposed to require bases to remain securely attached to a fireworks device during handling, storage, and normal operation. APA 87-1 and the AFSL standard include similar provisions, requiring bases to remain attached to devices during transportation, handling, and normal operation. CPSC received comments regarding the proposed requirement, which are summarized and addressed in the comment summary and response memorandum in the briefing package for the recommended final rule.

CPSC staff has observed, during routine fireworks testing, that several devices on the market do not have bases, or have bases that detached before or during use. For example, during routine field testing of fireworks samples, LSC staff observed multiple "tip overs" of reloadable tubes. These tubes are designed to launch single-shot mortars multiple times. These tubes are not attached to a base, but rather, they are placed in a cardboard box. Lacking any stability, the tubes fall or tip-over when the mortar is launching, which can lead to serious injury or death. Because the regulations do not currently require bases to remain attached to devices, staff may not systematically record base attachment issues. As a result, base attachment issues noted in staff's reports represent the minimum number of base attachment issues that staff has observed. Between FY 2015 and May 30, 2018, staff reports indicate that there were a total of 873 deices that should/would have bases to function properly. Staff reports indicate that during that time period, 17 devices tipped over during field testing and 59 devices had no base, a detached base,

[194] Statement provided by Engineering Sciences Human Factors staff (Balci-Sinha, R., 2016)

or required base assembly. In total, that indicates that, at a minimum, staff identified nearly 9 percent of devices (76 out of 873) with base attachment issues.

Incident data do not provide sufficient information for staff to determine whether injuries were the direct result of base attachment issues. However, incident data do indicate that certain types of incidents that are reported—specifically, tip-over incidents and errant flight paths—are the type that could occur when a base is not attached to a device. The 2015 Fireworks Annual Report indicated that one fatality may have involved a launch tube containing a mortar/artillery type shell falling over. In addition, the report states that during a one-month special study regarding fireworks incidents surrounding the 4th of July holiday period in 2015, staff conducted in-depth investigations (IDIs) by telephone to collect more information about incidents and injuries treated in U.S. hospital emergency departments (EDs) and reported through CPSC's National Electronic Injury Surveillance System (NEISS). Of the 225 fireworks-related injuries treated in EDs during the one-month period, staff completed 31 IDIs. Of those 31 IDIs, 2 cases involved fireworks devices tipping over and 4 involved errant flight paths, which can result from tip-overs. The 2 tip-over incidents resulted in first- and second-degree burns and a hematoma to a victim's thigh. The 4 errant flight path incidents resulted in second- and third-degree burns, thermal burns, an eye laceration, and burns and injuries to a 7-year old boy's legs. Staff did not receive sufficient information to determine whether the errant flight path incidents were due to devices tipping over, but that is a possible cause of errant flight paths.

The 2016 Fireworks Annual Report states that during a 1-month special study regarding fireworks incidents surrounding the 4th of July holiday period in 2016, staff again conducted telephone IDIs to collect more information about fireworks-related incidents and injuries treated in EDs during that period and reported through NEISS. Of the 199 fireworks-related injuries treated in EDs during the one-month period, staff completed 27 IDIs. Of those 27 IDIs, 6 cases involved fireworks devices tipping over and 4 involved errant flight paths. The 6 tip-over incidents resulted in 1 victim's front teeth being knocked out and a split lip, nerve damage, hearing loss, 1 victim sustaining a half-inch hole in his back, and victims suffering first-, second-, and third-degree burns, including one victim who sustained these burns over a 12 inch by 6 inch section of her chest, a 4-year old boy sustaining burns to his legs and feet, and a 10-year old girl sustaining first-and second-degree burns. The 4 errant flight path incidents resulted in second- and third-degree burns, face lacerations, and a puncture wound to a victim's leg. Again, staff did not receive sufficient information to determine whether the errant flight path incidents were due to devices tipping over, but that is a possible cause of errant flight paths.

The 2017 Fireworks Annual Report states that during a one-month special study regarding fireworks incidents surrounding the 4th of July holiday period in 2017, staff completed 29 IDIs. Of those 29 IDIs, 5 cases involved fireworks devices tipping over and 2 involved errant flight paths. The 5 tip-over incidents resulted in burns to a 9 month old child and 7 year old child, second- and third-degree burns, lacerations, and an eye injury. The 2 errant flight path incidents resulted in an eye injury and burns to a 10 year old and 11 year old child.

To address the significant safety hazard that base attachment issues and tip-overs pose, as suggested in the incident data, as well as staff's observation of base attachment and tip-over issues during field testing, the recommended final rule requires that the base of fireworks devices

that operate in a standing position to remain attached during handling, storage, and normal operation of the device.

E. Prohibited Chemicals: Proposed Revisions to 16 CFR § 1507.2

1. Addition of HCB and Lead

Section 1507.2 lists various chemicals that are prohibited in fireworks devices. For the NPR, Health Sciences (HS) staff reviewed the merits of these chemicals and recommended adding to the prohibited chemicals list lead, lead compounds, and hexachlorobenzene (HCB) (see HS memorandum in NPR BP[195]). Lead can be quickly detected via XRF and confirmed with ICP-OES, and HCB would require detection by Gas Chromatography – Mass Spectroscopy (GC-MS). As explained below, staff does not recommend including this proposed revision in the final rule.

As the Health Sciences (HS) memorandum for the NPR explained, there is some data suggesting that HCB and lead tetroxide and other lead compounds may be present in some fireworks devices, although most studies occurred in Europe. To assess the presence of these chemicals in fireworks currently on the U.S. market, CPSC staff tested some current compliance samples for the presence of lead (Table 15) and found that no samples contained lead at greater than 0.25 percent (the limit under APA 87-1). Of the 19 samples staff tested, none contained lead at more than 0.0285 percent, well below the APA 87-1 limit.

In addition to the studies cited in the NPR, LSC staff also identified a study by Schwarz et al. (2014)[196] that screened 220 samples for HCB content in fireworks in Europe. The vast majority of samples showed concentrations below 5 mg HCB/kg. Three samples out of the 220 tested gave a value above 0.01 percent (1.36%), which is the limit in the AFSL standard. This means that 98.6 percent of samples tested for HCB would comply with the limit under the AFSL standard, if the devices were available in the United States.

In the NPR, the Commission requested information about the level of compliance with the APA and AFSL requirements regarding HCB and lead compounds, the presence of these materials in fireworks on the U.S. market, and exposure data regarding the impact of these chemicals in fireworks devices. CPSC received comments regarding the proposed addition of HCB and lead compounds to the list of prohibited chemicals, which are summarized and addressed in the comment summary and response memorandum in the briefing package for the recommended final rule. However, CPSC did not receive any comments that provided the specific information requested in the NPR.

The recommended final rule does not add hexachlorobenzene (HCB) and lead/lead compounds to the list of prohibited chemicals. Staff still believes that they are dangerous chemicals. However, staff does not have information or exposure data regarding the extent to which these chemicals are present in fireworks in the United States, or the harm they pose to

[195] Available at: https://cpsc.gov/s3fs-public/ProposedRuleAmendmentstoFireworksRegulations.pdf.
[196] Schwarz S., Knorr, A., Lohrer, C. (2014). Screening of hexachlorobenzene (HCB) contents in fireworks. *Journal of Pyrotechnics*. 33:3-8, available at: http://www.jpyro.co.uk/?p=1665.

consumers when in fireworks. Although there are some studies regarding the presence of these chemicals in fireworks, the relevance of these studies is limited, because most took place in Europe (which has different fireworks), are 10 to 20 years old, or consisted of small sample sizes. Staff notes that HCB and lead/lead compounds are currently prohibited in voluntary standards, international standards, and in international treaties. Therefore staff does not anticipate that leaving this requirement out of the final rule would diminish safety.

2. Allowance of Trace Amounts

The current regulation prohibits any amount of the chemicals listed in § 1507.2 . Instrumentation used in chemical analysis has improved greatly since the rule was enacted. As a result, trace amounts of chemicals that previously went undetected are now identified in tested samples at very low levels (*e.g*., parts per million or parts per billion). For this reason, testing and manufacturing devices that comply with the regulatory limit may be difficult. Accordingly, in the NPR, the Commission proposed to allow for a reasonable amount of prohibited chemicals as impurities. The NPR requested comments about the proposed allowances, including the safety implications of allowing trace amounts of prohibited chemicals, the appropriate levels to set, and exposure data regarding the impact of trace contamination. CPSC received comments regarding the proposed allowance, which are summarized and addressed in the comment summary and response memorandum in the briefing package for the recommended final rule. However, CPSC did not receive any comments that provided the specific information requested in the NPR. For the reasons discussed below, CPSC staff does not recommend including this proposed revision in the final rule.

To evaluate how prevalent trace amounts of prohibited chemicals are present in fireworks devices, staff investigated the presence of arsenate and arsenite content and lead (Pb) in some fiscal year (FY) 2018 compliance fireworks samples. Arsenates and arenites are oxidation states of arsenic metal and currently prohibited in § 1507.2, APA 87-1, and the AFSL standard. Staff tested lead simultaneously, due to the nature of the instrumentation and the ease in doing so.

a. Test Method

Staff tested the break charge powder from multiple fireworks devices for the presence of lead, arsenates, and arsenites. Sample collection was done by opening the shell and separating the break charge powder from any effects (using a 100 mesh sieve). The break charges were digested in nitric acid and analyzed by ICP-OES for lead and arsenic content. The results can be seen in Table 15.

b. Results

Table 15 lists the quantity of lead and arsenic (As) detected in the samples.

Table 15: Elemental Composition of Break Charge via ICP-OES

Sample #	Shell/Tube	Break Charge (%As)	Break Charge (%Pb)
2018-1	1	0.0196	0.0204
	2	0.0194	0.0208

	1	0.0909	0.0285
	2	0.1122	0.0262
2018-2	3	0.1073	0.0252
	1	0.0244	0.0240
	2	0.0239	0.0250
2018-3	3	0.0169	0.0179
	1	0.0125	0.0132
2018-4	2	0.0184	0.0193
	1	0.0114	0.0145
2018-5	2	0.0133	0.0154
	1	0.0171	0.0186
2018-6	2	0.0130	0.0138
	1	0.0160	0.0168
2018-7	2	0.0117	0.0128
2018-8	1	0.0117	0.0124
2018-9	1	0.0235	0.0251
2018-10	1	0.0170	0.0182
2018-11	1	0.0154	0.0164
2018-12	1	0.0156	0.0163
2018-13	1	0.0112	0.0118
2018-14	1	0.0170	0.0194
2018-15	1	0.0238	0.0265
2018-16	1	0.0167	0.0184
2018-17	1	0.0233	0.0247
2018-18	1	0.0239	0.0264
2018-19	1	0.0232	0.0247

c. Discussion of Results

Although almost every device staff evaluated contained detectable quantities of arsenic and lead, no devices contained greater than 2,500 ppm (0.25%). The greatest concentration of arsenic staff found was at 0.1122 percent, and the greatest concentration of lead staff found was at 0.0285 percent, both far below the 0.25 percent limit proposed in the NPR. Due to the fact that arsenic was found at amounts much lower than 0.25 percent, staff concludes that arsenates and arsenites are not present in the break charge as an intended functioning component. Because lead was also detected at amounts much lower than 0.25 percent, it is also not present in the break charge as an intended functioning component. The trace quantity in a vast majority of samples was likely due to incidental contamination.

d. Conclusions

Staff's testing suggests that when prohibited chemicals are present in fireworks, it is at very low levels, far below the level permitted in APA 87-1, and these low levels are likely not

intentionally added. In addition, it is reasonable to assume that there is a trace amount that would not increase safety risks for consumers and would facilitate reasonable and cost-effective testing. However, staff does not have information to determine appropriate trace levels for each chemical. Accordingly, the recommended final rule does not amend § 1507.2 to include trace contamination allowances; instead, staff recommends that CPSC account for trace contamination through enforcement discretion, as appropriate, to reflect case-specific considerations.

F. Test Method for Assessing Side Ignition of Fuses: Proposed Revision to 16 CFR § 1507.3

Section 1507.3 details fusing requirements for fireworks. The first requirement, in § 1507.3(a)(1), aims to reduce the possibility of side ignition of the fuse. However, the regulation does not specify a test method for measuring side ignition or explain to what extent the fuse needs to reduce side ignition. Instead, this information is found in the CPSC Consumer Fireworks Testing Manual (Test Manual). The CPSC Test Manual indicates how the side of the fuse that protrudes from the device (including any tape or paper attached to the fuse) must be tested to evaluate how long it resists ignition from a cigarette. The Test Manual specifies testing for up to 5 seconds, but CPSC considers fuses that resist ignition for 3 seconds to be compliant. Both the AFSL and APA 87-1 standards' test methods and 3 second resistance times are similar to the CPSC Test Manual. To facilitate compliance with this regulation, the NPR proposed to add the test procedure stated in the Test Manual and CPSC's 3-second resistance criterion (which is not explicitly stated in the Test Manual) to the regulations. The Commission requested comments about the proposed revisions, including incidents of side ignition, the usefulness of adding the test method to the regulations, and compliance with APA 87-1. CPSC received comments regarding the proposed amendment, which are summarized and addressed in the comment summary and response memorandum in the briefing package for the recommended final rule.

CPSC does not recommend including this proposed revision in the final rule. Between October 2005 and February 2015, CPSC staff tested 2,835 fireworks samples and found 28 violations of § 1507.3(a)(1). This accounts for less than 2.5 percent of all fireworks violations during this same period.[197] This indicates significant compliance with this provision. Based on the high level of compliance, and seeming industry understanding, staff concludes it is not necessary to add the test method and 3-second criterion to the regulations. To provide transparency, as intended in the NPR, staff plans to explicitly add the 3-second criteria to in the next update to the CPSC Test Manual.

G. Projected Fragments: Proposed Addition of 16 C.F.R. § 1507.13

During routine compliance testing, CPSC staff observes large fragments of hard materials that fall or are projected from aerial fireworks devices when functioning in the air. Staff has observed fragments ranging in diameter from approximately 0.25 inches to 1.75 inches, falling from heights between approximately 40 and 100 feet, and these fragments often consist of concrete or rock, which falls to the ground intact. The NPR proposed to address this hazard by

[197] Data supplied by CPSC Compliance staff.

adopting a provision from APA 87-1. However, as explained below, staff does not recommend including this proposed revision in the final rule.

In general, staff has observed that these large, hard fragments are used as base plugs in devices and provide no function and are not necessary for the device to function properly. Often a much less potentially harmful substance, such as sand or clay, is used for base plugs, which dissipates in the air when the device functions and does not project fragments. Staff has observed these large, hard fragments projected as far as approximately 300 feet from where the fireworks device was launched, and these fragments have struck nearby objects with some amount of force. The fragments staff has observed are most commonly projected from mine and shell devices or reloadable tube devices. These fragments of hard material, and in large sizes, falling from the height of a functioning aerial firework device, pose a serious safety hazard if they strike nearby users or bystanders.

CPSC's current regulations do not address this hazard. However, the voluntary and international standards include provisions addressing the hazard of projected fragments. In the NPR, the Commission proposed to incorporate by reference section 3.7.2 of APA 87-1 to address this hazard. Section 3.7.2 of APA 87-1 states: "no component of any consumer fireworks device or novelty may upon functioning, project or disperse any metal, glass, or brittle plastic fragments." Similarly, the AFSL standard, in various sections addressing different types of devices, requires the composition and design of ground and aerial fireworks devices (including reloadable tube aerial shells, launch tubes, shell casings, and plugs in comets, mines, and shells) to be such that "no sharp fragments are produced upon functioning (or malfunctioning)" or "as a result of operation." The EU standard prohibits projected debris of metal, applies distance limits for debris that is projected from various categories of fireworks devices during functioning, and applies mass limits to debris from certain types of fireworks.

In response to the NPR, CPSC received comments regarding the proposed limit on projected fragments, which are summarized and addressed in the comment summary and response memorandum in the briefing package for the recommended final rule. Several comments stated that the proposed requirement was not specific enough and requested specific limits on the size, amount, materials, and characteristics of prohibited fragments. Although staff believes that projected fragments pose a safety hazard, additional information about the frequency of such injuries, the devices involved, and the characteristics of the fragments would be useful to determine the need for a requirement on this issue and the appropriate requirement. Staff will continue to evaluate this issue for possible future action and thus, did not include it in the recommended final rule.