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U.S. CONSUMER PRODUCT SAFETY COMMISSION  
RESEARCH ON FR MATERIALS IN UPHOLSTERED FURNITURE<sup>1</sup>

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Abstract:

The U.S. Consumer Product Safety Commission (CPSC) is an independent Federal regulatory agency whose primary mission is to protect the public from unreasonable risks of death and injury associated with consumer products. Reducing risks from fire is an important element of the Commission's product safety goal. Although national fire statistics show residential fires and fire-related deaths and injuries have declined substantially over the past two decades, residential fires killed about 3,400 people, injured nearly 18,000, and caused billions of dollars in property damage in 1997. Total costs to society associated with these losses are estimated to be over \$24 billion. Fires involving upholstered furniture remain a leading cause of fire deaths. In 1996, about 650 deaths, 1,640 injuries and \$250 million in property damage were attributable to residential fires in which upholstered furniture was the first item ignited; total societal costs were about \$3.7 billion. CPSC is considering a possible product safety standard to address one aspect of upholstered furniture flammability--ignition by small open flame sources such as lighters, matches and candles. Manufacturers that would be affected by a new flammability standard have reported that FR materials, particularly polymeric treatments for upholstery cover fabrics, would likely be used in most furniture to meet a small open flame standard. The agency's preliminary research suggested that FR fabrics could effectively improve small flame ignition resistance. A recent, Congressionally mandated study by the National Academy of Sciences of candidate FR fabric treatments concluded that, based on available data, a variety of existing compounds could be used in furniture fabrics with minimal risk to consumers, even under extreme conditions of exposure. The CPSC staff's research in the areas of technical and economic feasibility and consumer risk assessment is continuing in support of possible regulatory action to reduce furniture fire hazards. Complementary activities by other Federal agencies on worker safety and environmental issues are also ongoing.

<sup>1</sup> The author prepared this paper as part of his official duties at the U.S. Consumer Product Safety Commission. The paper is in the public domain and may be freely excerpted or reproduced. The views expressed are the author's and do not necessarily represent the official position of the Commission.

## Introduction

The U.S. Consumer Product Safety Commission (CPSC) was created in 1973 by an act of Congress (the Consumer Product Safety Act, 15 U.S.C. § 2051 *et seq.*) as an independent Federal regulatory agency whose primary mission is to protect the public from unreasonable risks of product-related death and injury. CPSC has broad jurisdiction over household products, with specific exceptions such as tobacco products, medical devices, food and drugs, motor vehicles, firearms, and pesticides. The agency has three Commissioners, who collectively set policy and vote on matters of regulatory action, and a staff of about 500. CPSC's fiscal year 2000 budget is \$49 million.

The Commission performs a variety of activities aimed at product hazard identification and reduction. The agency collects and analyzes hazard and risk data, conducts technical research on potential product hazards, develops or supports voluntary standards and--if necessary--mandatory rules, provides comparative safety and cautionary information and education to consumers, investigates and obtains recalls of defective products, and enforces existing regulations. These activities are regularly undertaken to investigate and devise remedial strategies for all kinds of product-related risks, including residential fire hazards.

## Residential Fire Hazards

In 1997, fire departments responded to an estimated 406,500 residential fires in the U.S. These fires caused an estimated 3,400 civilian deaths, nearly 18,000 injuries, and about \$4.6 billion in property damage. There has been an overall reduction in the numbers of fires, deaths and injuries since 1980, thanks in part to safer products as well as other factors like reduced smoking, better fire and emergency medical services, increased smoke alarm ownership, and heightened fire safety awareness. These numbers are still, however, unacceptably high. The U.S. still has one of the worst fire records in the world. In some cases, the numbers of product-related deaths have not kept pace with the significant downward trends in overall fire losses. These areas are of particular concern to CPSC.

The Commission has undertaken numerous fire safety activities over the years that have contributed, along with other factors, to the observed decline in fire losses. These activities include mandatory fire safety standards for mattresses, matchbooks, carpets and rugs, cigarette and multi-purpose lighters, apparel and children's sleepwear, solid fuel heating equipment, and cellulose home insulation. The CPSC staff has also supported numerous voluntary standard development efforts on almost every significant category of products associated with fire hazards.

Some of the performance standards issued or encouraged by the CPSC staff have resulted in increased use of flame retardant (FR) polymeric materials. These standards include: portable electric appliances, for which an upgraded Underwriters' Laboratories (UL) voluntary standard was recently proposed; mattresses and bedding, for which a new mandatory or voluntary flammability standard may be developed; and upholstered furniture, for which a possible flammability standard is currently under development by the CPSC staff.

## Upholstered Furniture Flammability

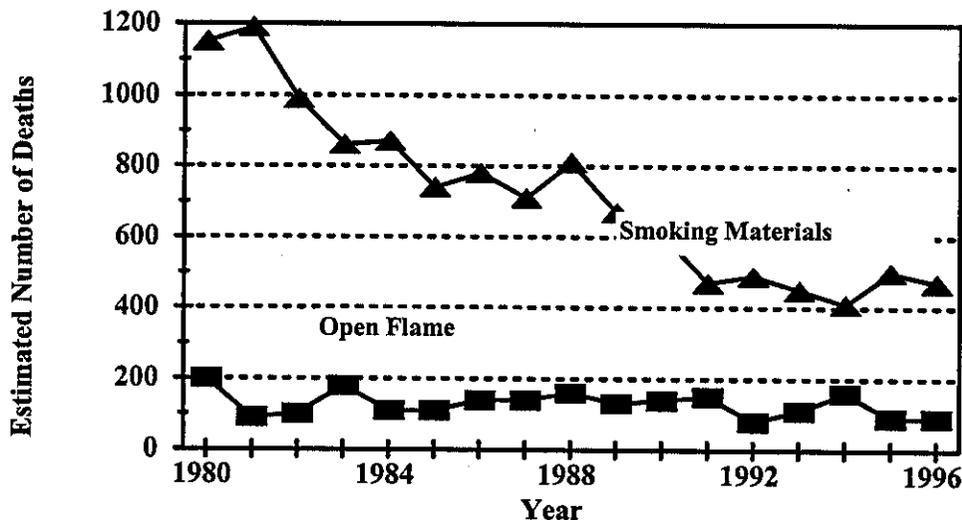
Upholstered furniture fires are a leading cause of fire deaths among products under CPSC's jurisdiction. In 1996, these fires accounted for an estimated 650 deaths, 1,640 injuries and \$250 million in property damage. Smoking material-ignited furniture fires--virtually all involving cigarettes--accounted for most furniture fire losses (470 deaths in 1996). The other principal furniture fire risk involves ignition by open flames, predominantly small flame sources like lighters, matches and candles. Since 1990, small open flame-ignited furniture fires caused an estimated annual average of 90 deaths, 440 injuries, and about \$50 million in property loss. Most of these are childplay fires; about two-thirds of the fatalities are children under five.

CPSC's furniture testing conducted over the past two decades shows a steady increase in cigarette resistance, attributable to the rising popularity of smolder-resistant polymeric materials such as thermoplastic fabrics and polyurethane foam fillings. The cigarette ignition criteria of existing voluntary guidelines established by the Upholstered Furniture Action Council in 1978 encouraged the use of cigarette ignition-resistant materials and constructions. The vast majority of currently produced furniture is cigarette ignition-resistant.

Most furniture currently produced or in use will not, however, resist ignition from a small open flame. Smolder-resistant polymeric materials do not reduce open flame ignition propensity; in fact, many fire safety experts have expressed concern about the potential for polymeric, once ignited, to burn more rapidly and intensely, and to produce more toxic combustion products. There is no nationwide standard in the U.S. addressing the open flame risk.

The figure below illustrates how this situation is reflected in the national fire loss data. Despite a substantial decline in cigarette-ignited fire deaths, there has been no statistically significant change in the number of deaths from open flame ignitions since 1980.

**Estimated Upholstered Furniture Fire  
Deaths 1980 -1996**



In 1993, the National Association of State Fire Marshals (NASFM) petitioned CPSC to initiate a regulatory proceeding to address all fire risks associated with upholstered furniture. NASFM suggested that CPSC adopt California or other existing standards. The Commission granted the petition in part, with respect to small open flame ignition, denied the petition with respect to large open flame ignition, and deferred action on cigarette ignition pending further evaluation of the level of cigarette ignition resistance among currently produced furniture.

Pursuant to the Commission's decision, the CPSC staff developed a draft small open flame performance standard. This draft standard contains two basic tests, for seating area composites (using a bench scale test method and seat/back cushion mockups) and for dust covers. In each test, a 35-millimeter butane flame (simulating a lighter or match) is applied for 20 seconds. The test sample must exhibit no continued flaming or other combustion for more than 2 minutes after removal of the test flame. Further, flaming may not extend beyond any edge of the test sample. The CPSC staff's draft standard is similar to certain "match test" provisions of the existing United Kingdom furniture flammability regulations, which have been in effect for over a decade. This composite test approach for seating areas is different from (and more stringent than) the component test approach taken in California's small open flame requirements.

In mockup tests, fabrics appeared to be the most important determinant of flammability performance. Some FR fabrics that are widely used in the United Kingdom were observed to perform well in the CPSC staff's tests. Certain barrier materials, such as interliners incorporating intumescent FR chemistry, also may yield good mockup performance in some instances. The CPSC staff also tested a variety of foam fillings, including FR foams used in California and the U.K.; the choice of foams had little effect on mockup ignition behavior.

#### FR Chemical Issues

The CPSC staff's draft standard specifies only performance criteria; it allows but does not require any particular approach to achieve compliance. Furniture and textile manufacturers have reported, however, that FR fabrics would likely be used to meet such a standard. These may include fabrics with FR backcoatings, immersion or topical FR finishes, or inherently FR fibers. The likelihood of FR use led the staff to investigate whether FR treatments could pose chemical risks.

The CPSC staff became concerned about the lack of toxicity, exposure and bioavailability data for a number of FRs that might be used in fabrics. In 1998, the Commission deferred regulatory action pending an evaluation of potential toxic health effects associated with possible consumer exposure to FR fabric treatments. CPSC held a two-day public hearing in May 1998 to gather additional information on human toxicity, ecotoxicity, and other risk-related issues.

The Fire Retardant Chemicals Association identified 16 chemical compounds or classes as the most likely candidates for use in fabrics to meet a small open flame standard. Some of these, including certain bromine- and phosphorus-based compounds, are currently used in upholstery fabrics, either in the U.K. or in other U.S. textile applications; none is used in U.S. residential furniture.

The 16 compounds or classes are:

- Decabromodiphenyl oxide
- Hexabromocyclododecane
- Phosphonic acid
- Tetrakis hydroxymethyl hydronium salts
- Zinc borate
- Alumina trihydrate
- Magnesium hydroxide
- Ammonium polyphosphates
- Antimony trioxide
- Tris (2-chloropropyl) phosphate
- Tris (1,3-dichloropropyl-2) phosphate
- Calcium and zinc molybdates
- Antimonates
- Chlorinated paraffins
- Aromatic phosphate plasticizers
- Organic phosphonates

In response to the public hearing, data and studies were provided on many of these compounds. The CPSC staff is using this information in its evaluation of potential FR chemical risks.

#### Chemical Hazard Assessment Under the FHSA

The Commission is guided in its evaluation of chemical hazards by provisions of the Federal Hazardous Substances Act (FHSA). The FHSA defines a "hazardous substance" as:

"Any substance or mixture of substances which (i) is toxic, (ii) is corrosive, (iii) is an irritant, (iv) is a strong sensitizer, (v) is flammable or combustible, or (vi) generates pressure through decomposition, heat, or other means, if such substance or mixture of substances may cause substantial personal injury or substantial illness during or as a proximate result of any customary or reasonably foreseeable handling or use, including reasonably foreseeable ingestion by children."  
{15 USC 1261 (f)(1)(A)}.

Thus, to be considered a "hazardous substance," a material or product must satisfy a two-part definition. First, it must be toxic, or present one of the other enumerated hazards. Second, it must pose a potential "substantial illness or injury" as a result of "reasonably foreseeable handling or use." Whether a material or product presents a hazard depends not only on toxicity, but also on exposure and risk (either acute or chronic).

The FHSA does not require manufacturers to perform any specific battery of toxicological tests to assess potential risks. The FHSA also generally does not provide for pre-market registration or approval. This places the responsibility on manufacturers to ensure that their products are either not hazardous or are properly labeled in accordance with other FHSA

provisions. An exception to this is that any product intended for use by children that contains an accessible hazardous substance is automatically banned.

In 1992, CPSC issued guidelines for assessing chronic hazards under the FHSA, including carcinogenicity, neurotoxicity, reproductive/developmental toxicity, exposure, bioavailability, risk assessment and acceptable risk. These are not mandatory rules, but are intended to assist manufacturers in complying with the FHSA. The guidelines also provide a basis for the CPSC staff analyses mentioned above. The staff prepared toxicity reviews of the 16 identified FR compounds or classes, and concluded that several (including some of those in current use) would be considered "toxic" under the FHSA. No determination has yet been made, however, as to whether these could be considered "hazardous substances" if used in upholstery fabric FR systems to meet a possible CPSC flammability standard. The staff is currently conducting dose response, exposure and dermal bioavailability assessments to contribute to an overall risk assessment for the primary candidates among the identified compounds. The staff will incorporate the results of this risk assessment into its recommendations to the Commission on upholstered furniture.

There is an important distinction to be made between FRs that do not meet the FHSA definition of "toxic" or "hazardous" because they have been shown not to present a risk, and those not meeting the definitions because the data are insufficient to evaluate chronic risks. The CPSC staff would recommend that manufacturers not use any of the latter compounds, but rather use only FRs that have been adequately studied and determined not to present a risk. Chemical manufacturers should develop the information necessary for a thorough risk assessment, in order to provide assurance that their FRs would be acceptable for use in upholstered furniture fabrics.

#### Other Federal Agency Activities

To assist the Commission in its review of FR chemicals, the CPSC is coordinating with two other Federal agencies that have complementary expertise. The CPSC staff is working with staff at the National Institute for Occupational Safety and Health (NIOSH) to examine worker safety issues associated with FR fabric production and use. The CPSC staff is also working with staff at the Environmental Protection Agency (EPA) to consider possible action regarding the use of FRs in upholstered furniture fabrics.

At CPSC's request, NIOSH is conducting a Health Hazard Evaluation study of workers in furniture, fabric and textile finishing plants where FR fabrics are made or used. This study will examine potential occupational exposures to FR compounds that may result from new or increased use of those compounds due to possible increases in demand for FR fabrics to meet a possible CPSC standard. NIOSH is developing analytical methods to determine exposure, and will conduct site visits to locations in the U.S. and the U.K. to observe work practices and take air and material samples. NIOSH has no regulatory authority of its own, but can make recommendations for potential hazard abatement if appropriate.

EPA is developing a possible Significant New Use Rule (SNUR) under the Toxic Substances Control Act (TSCA). A SNUR would require chemical companies to notify EPA of

their intent to market FRs for use in residential upholstered furniture fabrics. This would trigger a review of environmental outcomes by EPA, including consumer and worker safety. Companies could be required to provide specific data (e.g., toxicity or exposure studies) for certain compounds. Additional controls could subsequently be imposed on the use of any FRs found to present unreasonable risks.

The work of these two agencies will help CPSC ensure that any proposed upholstered furniture flammability standard would not result in adverse health risks. The studies will also help CPSC satisfy its environmental review requirements under the National Environmental Policy Act (NEPA).

#### National Academy of Sciences Study

In CPSC's fiscal year 1999 appropriation, Congress directed the agency to sponsor an independent, 12-month study of FR chemicals by the National Academy of Sciences' Committee on Toxicology. This study was to assess potential toxicological health risks associated with the use of FRs that might be used in upholstered furniture fabrics to meet a CPSC flammability standard. The Commission was prohibited from proposing any upholstered furniture regulation until it considered the NAS's conclusions. The NAS study began in January 1999. A draft report was submitted to CPSC and to Congress in April 2000. A final, published report will be available to CPSC and the public in June 2000.

To conduct the study, NAS selected a subcommittee of experts who reviewed all available toxicity and exposure data for the 16 identified chemicals or chemical classes. The subcommittee held three public meetings in 1999. The CPSC staff provided its toxicity reviews and other available supporting data. Since there were limited or, in some cases, no data available about how consumers might be exposed to FR chemicals in upholstery fabrics, the subcommittee made a number of assumptions about the pathways and duration of exposure. The subcommittee considered dermal exposure resulting from skin contact during normal use, ingestion by infants or young children sucking or chewing on fabrics, inhalation of particles released through wear and tear, and inhalation of vapors off-gassed from treated fabrics. As an example, for dermal exposure, the subcommittee considered the scenario of an adult sitting on a sofa with FR-treated fabric for 25% of each day, with exposure over 25% of the upper torso area, assuming that clothing provided no barrier to exposure.

By combining known toxicity information with very conservative (i.e., high) exposure assumptions, and using additional uncertainty factors to account for inadequate toxicity data, the subcommittee considered whether health effects would result from the use of FR furniture fabrics. The subcommittee estimated both cancer and noncancer effects.

The subcommittee concluded, based on the available data, that 8 of the 16 chemicals reviewed could be used in upholstered furniture fabrics with minimal risk, even under extreme conditions of exposure. These are:

- Decabromodiphenyl oxide
- Hexabromocyclododecane
- Phosphonic acid
- Tetrakis hydroxymethyl hydronium salts
- Zinc borate
- Alumina trihydrate
- Magnesium hydroxide
- Ammonium polyphosphates

No further study was recommended for these 8 chemicals.

Additional exposure studies were recommended for the remaining 8 chemicals:

- Antimony trioxide
- Tris (2-chloropropyl) phosphate
- Tris (1,3-dichloropropyl-2) phosphate
- Calcium and zinc molybdates
- Antimonates
- Chlorinated paraffins
- Aromatic phosphate plasticizers
- Organic phosphonates

NAS notes that the subcommittee's approach of using very conservative exposure assumptions tended to overstate potential exposure and, therefore, the risk to consumers. Exposure scenarios more closely related to expected household conditions would likely result in even lower human health risks than those estimated by the subcommittee.

In addition, the subcommittee based its toxicity assessment of certain FR chemicals on surrogate compounds that represent various chemical classes. Those selected surrogates were not necessarily the most likely candidates for use in furniture fabrics, but were either the most toxic chemical in the class or the class member with the most available data. Thus, the risk to consumers could be lower than the subcommittee estimated if the chemical used for the FR treatment were less toxic than the surrogate used in the NAS risk assessment.

The NAS report provides valuable information for Commission consideration of FR chemical safety issues. The NAS's conclusions show that a variety of available FR treatments for different types of fabrics could be used without posing significant health risks to consumers.

#### For More Information

Information on various CPSC activities is available on the agency's Internet web site, [www.cpsc.gov](http://www.cpsc.gov). This includes the latest (October 1997) staff briefing package on upholstered furniture flammability. CPSC documents and information are also available from CPSC's Office of the Secretary (telephone 301-504-0800, fax 301-504-0127) or through the Commission's toll-free Hotline at 1-800-638-CPSC.

**U.S. Consumer Product Safety Commission  
Research on FR Materials in  
Upholstered Furniture**



**BCC Conference on Flame Retardancy  
May 23, 2000**

**CPSC's Primary Mission:**

**To protect the public from  
unreasonable risks of death  
and injury associated with  
consumer products**

## **1997 Residential Fire Losses**

- 406,500 fires
- 3,390 deaths
- 17,775 injuries
- \$4.6 billion property damage
  
- Total societal costs > \$24 billion
- Total losses declining but still high

## **CPSC Fire Safety Rules**

- Mattresses
- Matchbooks
- Carpets & Rugs
- Cigarette / Multi-purpose Lighters
- Apparel / Children's Sleepwear
- Solid fuel Heaters
- Electric Toys

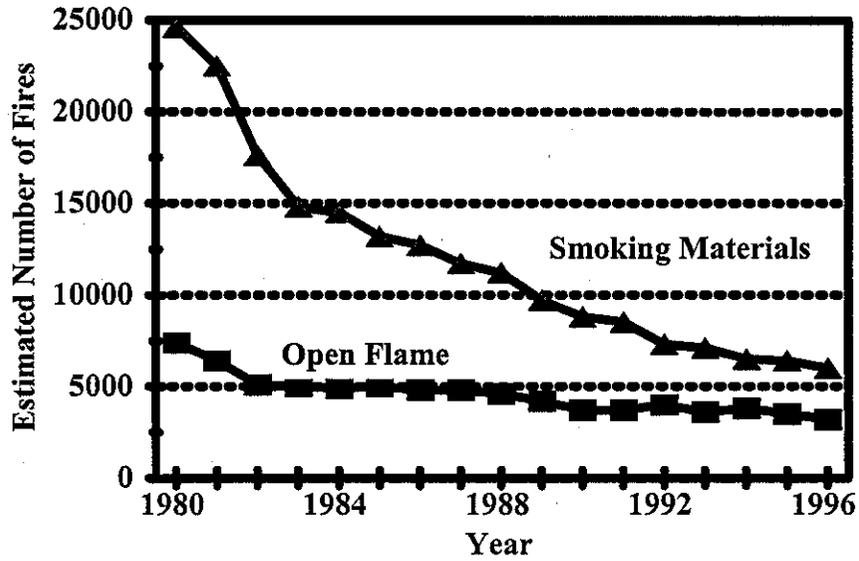
## **Current CPSC Activities Affecting FR Polymer Usage**

- **Portable Electric Appliances**
- **Mattresses & Bedding**
- **Upholstered Furniture**

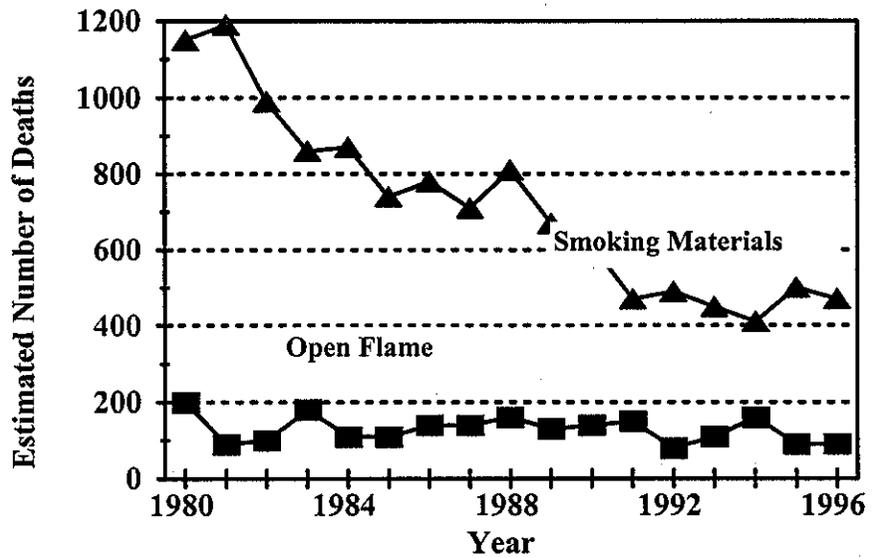
## **Upholstered Furniture**

- **Cigarette / Open Flame Ignition**
- **California, UK Regulations**
- **UFAC program addresses  
cigarette ignition; no US  
standard addresses open flame**
- **NASFM petition 1993**
- **Small Open Flame ANPR 1994**

**Estimated Upholstered Furniture Fires  
1980 -1996**



**Estimated Upholstered Furniture Fire  
Deaths 1980 -1996**



## **CPSC Staff Draft**

### **Small Open Flame Standard**

- **2 performance tests:**
  - Seating Area, Dust Cover
- **Fabric / Foam Mockup**
- **20 sec. Small flame exposure**
- **No combustion > 2 minutes;  
no flaming to sample edge**

## **Materials to Meet CPSC**

### **Draft Small Open Flame Std.**

- **FR fabric backcoatings**
- **FR fabric immersion treatments/  
surface finishes**
- **FR fiber fabrics**
- **FR barriers / laminates**
- **Non-FR fillings**

## **FR Fabric Issues**

- **Fabric treatments effective, likely**
- **Little data on potential exposure and health effects**
- **CPSC deferred action 1/98**
- **Public Hearing 5/98**
- **CPSC staff risk assessment**

## **Chemical Hazard Issues**

- **CPSC evaluation guided by FHSA**
- **“Hazardous substances”**
  - **Must be toxic**
  - **Must pose potential substantial illness or injury from reasonably foreseeable use**
- **Toxicity, exposure, bioavailability**

## **Fabric FR Candidates**

- Decabromodiphenyl Oxide
- Hexabromocyclododecane
- Phosphonic Acid
- Tetrakis Hydroxymethyl Hydronium Salts
- Zinc Borate
- Alumina Trihydrate
- Magnesium Hydroxide
- Ammonium Polyphosphates
- Antimony Trioxide
- Tris (2-chloropropyl) phosphate
- Tris (1,3-dichloropropyl-2) phosphate
- Calcium & Zinc Molybdates
- Antimonates
- Chlorinated Paraffins
- Aromatic Phosphate Plasticizers
- Organic Phosphonates

## **CPSC FY 1999 Appropriation**

- **NAS / COT FR Chemical Study**
  - Independent toxicological risk assessment
  - 12 month study
  - \$500,000 appropriation

## **NAS Study Approach**

- **Expert Subcommittee**
- **Public meetings: consider data, receive comments**
- **CPSC staff toxicity reviews for 16 chemicals**
- **Dermal, ingestion, inhalation exposures**
- **Cancer & noncancer health effects**
- **Methodology overstates exposure & risk**
- **Draft report to CPSC & Congress 4/27/00, "Toxicological Risks of Selected Flame-Retardant Chemicals," viewable at <[www.nas.edu](http://www.nas.edu)>**

## **NAS Subcommittee**

- **Donald Gardner (Chair), Inhalation Toxicology Associates, Inc.**
- **Joseph Borzelleca, Virginia Commonwealth University**
- **David Gaylor, Nat'l. Center for Toxicological Research**
- **Sidney Green, Howard University**
- **Richard Horrocks, Bolton Institute**
- **Michael Jayjock, Rohm and Haas Company**
- **Samuel Kacew, University of Ottawa**
- **James McDougal, Geo-Centers, Inc.**
- **Richard Miller, University of Rochester**
- **Robert Snyder, Rutgers University**
- **Gary Stevens, University of Surrey**
- **Robert Tardiff, The Sapphire Group, Inc.**
- **Mary Vore, University of Kentucky**

## **NAS Conclusions:**

### **Of 16 reviewed FR chemicals:**

- **8 FRs could be used in furniture fabrics with minimal risk, even under extreme exposure conditions**
- **Additional exposure studies recommended for other 8 FRs**
- **No recommendation against use of any FRs**

## **“Minimal Risk” FRs**

- Decabromodiphenyl Oxide
- Hexabromocyclododecane
- Phosphonic Acid
- Tetrakis Hydroxymethyl Hydronium Salts
- Zinc Borate
- Alumina Trihydrate
- Magnesium Hydroxide
- Ammonium Polyphosphates

## **“Further Exposure Study” FRs**

- Antimony Trioxide
- Tris (2-chloropropyl) Phosphate
- Tris (1,3-dichloropropyl-2) Phosphate
- Calcium & Zinc Molybdates
- Antimonates
- Chlorinated Paraffins
- Aromatic Phosphate Plasticizers
- Organic Phosphonates

## **Next Steps**

- **CPSC exposure / risk assessment**
- **Other supporting information**
  - Fire loss data
  - Refine draft standard
  - Economic & environmental analyses
  - NIOSH & EPA input
- **Consider regulatory alternatives**

**For Further Information:  
contact**

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