REGULATORY POLICY LEADING TO HALOGENATED FLAME RETARDANTS IN FURNITURE AND BABY PRODUCTS: FIRE SAFETY AND HEALTH CONCERNS

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Introduction

Regulatory policies compounded by industry lobbying may be contributing to the use of untested and toxic flame retardants associated with adverse health effects in consumer products. One example is Technical Bulletin 117 (TB117), a California flammability standard requiring the polyurethane foam used in upholstered furniture and juvenile products (i.e., nursing pillows, strollers, sleep positioners) to resist ignition from exposure to a small open flame for twelve seconds[1]. An important question is whether the potential health harm from the flame retardants commonly used to meet TB117 is balanced by a measurable increase in fire safety. The regulation is currently becoming a *de facto* national standard in the U.S. and Canada, as evidenced by the detection of halogenated flame retardants in furniture foam and baby products in states outside of California[2]. Since its implementation in 1975, halogenated flame retardants have been added to furniture foam at levels of about five percent of the weight of the foam to meet the standard. Levels as high as twelve per cent have been found[3]. Many of these flame retardant are persistent organic pollutants, (POPs) and several have been globally banned by the Stockholm Convention on Persistent Organic Pollutants. Many are semi-volatile and migrate into dust and humans where they can pose a health hazard. Human biomonitoring studies show flame retardants are ubiquitous in the blood of most United States citizens[4,] with young children having the highest levels[5]. In many animal and a few human studies, these chemicals have been associated with neurological and reproductive deficits, endocrine impairment (including thyroid disruption), and cancer. These health and environmental hazards have been well documented in reviews[6] and the San Antonio Statement on Chlorinated and Brominated Flame Retardants[7]. Research on the fire safety impacts of using the chemicals to meet TB117 is less well-known and will be discussed in more detail in this paper.

Materials and Methods

Based on a survey of the relevant fire science literature and health literature, as well as interviews with industry representatives and research scientists, the authors made a determination of the major chemicals used for TB117 compliance. To evaluate the possible fire safety benefits, we ask: (1) Does the TB117 standard prevents ignition from small flame sources? (2) If ignition occurs, do these flame retardants reduce the severity of the fire? To begin to identify the costs of TB117, we present a very brief overview of human exposure and adverse health associations of the chemicals used to comply with the standard

Results and Discussion

Flame Retardant Chemicals Used for TB117 Compliance

From the implementation of TB117 until 2004, Pentabromodiphenyl ether (penta-BDE) was added to the polyurethane foam of furniture and baby products to comply with it. In 1999 and 2001, 98% and 95% respectively, of the usage of pentaBDE, was in North America, in large part to comply with TB117[2]. PentaBDE was banned in California in 2003. In 2004, Chemtura (previously Great Lakes Chemical), the sole U.S. manufacturer, voluntarily ceased production and in 2009 pentaBDE was listed under the Stockholm Convention. PentaBDE replacements currently in use in the United States and Canada include Chemtura's Firemaster 550® and tris (1,3-dichloro-2-propyl) phosphate, also called chlorinated Tris or TDCPP.

Does the flammability standard prevent ignitions from small flame sources?

While foam treated to meet the standard can by itself resist a *small* open flame, such as a candle or lighter, for 12 seconds, most furniture has fabric covering the foam. After the furniture fabric is ignited by a small flame, the fire can become many times larger than the original flame. Materials that can withstand small flame ignition cannot resist a larger flame[8,9]. For example, Talley[10] tested 15 different upholstery fabrics, each covering untreated and flame retardant treated foams of matched density, and concluded that the treated foam made no significant, consistent difference in either ignition or flame spread.[13] Talley also showed that flame-retardant treated foams did not have increased resistance to smoldering ignition from cigarettes. In addition, the U.S. Consumer Product Safety Commission (CPSC) investigated whether adopting the California standard as part of a national furniture standard would be likely to reduce fire-related deaths and concluded reducing the flammability of foam did not reduce the flammability of foam covered by fabric in a piece of furniture, and "TB117…would not, if federally mandated, ensure a substantial reduction in the risk of small open flame ignition of finished articles of furniture." [11] These results indicate that foam to meet TB117 does *not* serve to prevent ignitions from small flame sources.

Is fire severity reduced by flame retardant foam?

The severity of a fire is quantified by its peak heat release rate, which is the maximum amount of heat generated per second during the combustion of the product[12]. Babrauskas[13] found no measurable difference between the peak heat release rates of different pieces of furniture containing cushioning foam that was and was not TB117-compliant. Also, the spread of the fire in flame-retardant-treated versus untreated furniture was visually identical. Schuhmann and Hartzell similarly found the use of foam that met the TB117 did not reduce the peak heat release rate.[14] Babrauskas et al.[15] later compared a room containing furniture made with non-flame retarded foams with another room containing foams with flame retardants 50% or more by weight (versus about 5% by weight required to meet TB 117). The study concluded: "The average available escape time was more than 15-fold greater" when all of the products in a room were 50% or more by weight flame retardant compared to a room containing non-flame retarded furniture. This statement has been misquoted by the chemical industry, implying that the use of TB117 compliant furniture, with much lower levels of flame retardants, would create such a difference in escape time[16]. In addition, the earlier study by Babrauskas[16] found no difference in the time-to-peak heat release (a measure of escape time) for treated and untreated furniture foams. The preceding studies indicate that the severity of the fire *is not* significantly reduced by the use of foam that meets the California furniture standard.

Fire data

In alignment with the studies above, an analysis of fire data by the National Fire Protection Association (NFPA) shows that the rate of reduction of fire deaths in California is similar to that of states that have no furniture flammability standard.[17].

PentaBDE has been found at significantly higher levels in house dust and human serum in California compared to other states [18,] suggesting that more TB117-compliant furniture was sold in California. Concentrations in the North American population and household dust are 10 to 40 times higher than those measured in other regions of the world[19,20]. In addition the organohalogen flame retardants commonly used to meet TB117 are known upon ignition to increase the fire effluent toxicity which is the carbon monoxide, irritant gases (HCl or HBr) and particulates such as soot and smoke particles produced during a fire. Most fire deaths and most fire injuries result from inhalation of such fire effluents [21,]. More effective fire safety strategies have included decreased smoking[22], the introduction of fire-safe cigarettes[23] and fire-safe candles[24], and the increased use of sprinklers and smoke detectors[25].

Exposure Associated with TB117 Compliance

Additive organohalogen flame retardants commonly used to meet TB117 are not chemically bound to their substrate. They are semi-volatile, migrate out of products and accumulate in indoor dust which is ingested by humans and animals[4]. Biomonitoring studies have detected pentaBDE congeners in the body fluids of nearly all Americans tested,

Recent studies show that TDCPP and Firemaster 550® components similarly migrate from foam products into indoor house dust[7]. Components of Firemaster 550®, TBB and TBPH, have been detected in blubber of dolphins and porpoises near flame retardant production facilities in South China[9] as well as in seven arctic species[10].

Health Effects Associated with TB117 Compliance
Adverse reproductive, endocrine, neurodevelopmental, and carcinogenic effects of pentaBDE have been well documented in animal studies[11, 12]. There is also a growing body of human epidemiological literature finding associations between increased pentaBDE body burdens and health problems such as reduced IQ in children[13], endocrine and thyroid disruption[14], changes in male hormone levels and reduced fertility[15], increased time to pregnancy in women[16], adverse birth outcomes like low birth weight and premature delivery[17, 18], cryptorchidism19, and impaired cognitive and motor development[20].
TDCPP or chlorinated tris, which was removed from children's panamas in the 1970s is mutagenic and carcinogenic in rats[21] and the Consumer Product Safety Commission (CPSC) has declared TDCPP a probable human carcinogen [22]. The U.S. EPA considers TDCPP a moderate hazard for cancer and reproductive and developmental problems[23]. A recent human epidemiology study found that men living in homes with high amounts of TDCPP in household dust had reduced sperm counts and altered levels of hormones related to fertility and thyroid function[24].
Two Firemaster 550 components are genotoxic in fish[25] while another component TPP has shown to be toxic in several aquatic species[26] and a reproductive and developmental toxin in rats[27]. In the only human epidemiological study investigating a Firemaster 500 component, TPP was shown to be associated with substantial reductions in sperm concentrations and an increase in prolactin levels (a marker of decreased neuro-endocrine activity) in men[28].

With a lack of proven fire safety benefit and potential for harm to human health, why do we continue to add organohalogen flame retardants to furniture foam?
The profits from the sale of these chemicals appear to be a major driver for their use. The three major chemical manufacturers who produce halogenated flame retardants employ lobbyists and spend millions of dollars[26] to initiate and maintain flammability standards favorable to their industry. One company's quarterly earnings more than quadrupled in 2009 compared to 2008 "powered by an increase in the sales of brominated flame retardants." [27]

At present no regulatory agency has the authority to ensure that flame retardant chemicals used in consumer products are safe. Current legislation in Congress would authorize the U.S. Environmental Protection Agency to require manufacturers to provide health information about new chemicals and prioritize the regulation of chemicals of high concern such as halogenated flame retardants.

Conclusion
Since 1975, a California furniture flammability standard has led to the use of hundreds of millions of pounds[28],[29] of pentaBDE and halogenated replacements without a proven fire safety benefit. These chemicals could be contributing to such health problems in our population. California furniture flammability standard needs to be re-evaluated in light of the fire science and health information discussed above. Prior to implementing new flammability standards, decision-makers should evaluate the potential fire safety benefit versus the health and environmental impacts of the chemicals, materials, or technologies likely to be used. Requiring toxicity information **before** chemicals are used in consumer products could help prevent a wide range of health problems.

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[1] Technical Bulletin 117—Requirements, Test Procedure and Apparatus for Testing the Flame Retardance of Resilient Filling Materials Used in Upholstered Furniture, State of California, Bureau of Home Furnishings and Thermal Insulation, West Highlands CA (current edition is 2000).

[2] Stapleton HM, Klosterhaus S, Eagle J, Fuh, JD, Meeker A, Blum A, Webster TF. (2009); *Environ Sci Technol.* 43(19): 7490
[3] Stapleton HM, Klosterhaus S, Keller A, Lee Ferguson PL, van Bergen S, Cooper E, Webster TF, Blum A. (2011); *Environ Sci Technol.* (In Press)
[4] Sjodin A, Wong LY, Jones RS, Park A, Zhang Y, Hodge C, DiPietro E, McClure C, Turner W, Needham LL, Patterson DG. (2008); *Environ Sci Technol.* 42(4):1377
[5] Windham GC, Pinney SM, Sjodin A, Lum R, Jones RS, Needham LL, Biro FF, Hiatt RA, Kushi LH. (2010); *Environ Res.*110(3):251-7
[6] Shaw SD, Blum A, Weber R, Kannan K, Rich D, Lucas D, Koshland CP, Dobraca D, Hanson S, Birnbaum LS. (2010); *Rev Environ Health.* 25(4):261
[7] DiGangi J, Blum A, Bergman A, de Wit C, Lucas D, Mortimer D, Schecter A, Scheringer M, Shaw SD, Webster TF. (2010); *Environ Health Perspect*. 34(8):1170
[8] Dembsey DA, Williamson RB (1993); *Fire Safety J.* 21: 313
[9] Babrauskas V. (2003); Ignition Handbook, Fire Science Publishers/Society of Fire Protection Engineers, Issaquah WA
[10] Talley TH. (1995); Phases 1&2, UFAC Small Open Flame Tests and Cigarette Ignition Tests, *Annual AFMA Flammability Conf.*
[11] Medford RL, Ray DR (1997); Upholstered Furniture Flammability: Fires Ignited by Small Open Flames and Cigarettes, US Consumer Product Safety Commission, Washington DC (Oct. 24, 1997).
[12] Babrauskas V, Peacock RD. (1992); *Fire Safety J.* 18: 255
[13] Babrauskas V. (1983); *J. Fire Sciences* 1: 9
[14] Schuhmann JG, Hartzell GE. (1989); *J. Fire Sciences* 7: 368
[15] Babrauskas V, Harris HR, Gann RG, Levin BC, Lee RT, Peacock RD, Paabo R, Twilley W, Yoklavich MF, Clark HM. (1988); Fire Hazard Comparison of Fire-Retarded and Non-Fire-Retarded Products (Spec. Publ. SP 749), [U. S.] Natl. Bur. Stand., Gaithersburg MD
[16] http://www.bsef.com/fire-safety-benefits/flame-retardants-fire-safety/ [Accessed 22 Jan 2011]
[17] NFPA 2008; Fire deaths in the United States. Quincy, MA
[18] Zota AR, Rudel RA, Morello-Frosch RA, Brody JG (2008); *Environ Sci Technol.* 42: 8158
[19] Pérez-Maldonado IN, Ramírez-Jiménez MDR, Martínez-Arévalo LP, López-Guzmán OD, Athanasiadou M, Bergman Å, Yarto-Ramírez M, Gavilán-García A, Yáñez L, Díaz-Barriga F (2009); *Chemosphere* 75:1215
[20] Sjödin A, Päpke O, McGahee EE, Focant JF, Jones RS, Pless-Mulloli T, Toms LML, Herrmann T, Müller J, Needham LL, Patterson Jr. DG. (2008); *Chemosphere* 73: S131
[21] Communities and Local Government Fire statistics, United Kingdom 2006. (2008);http://www.communities.gov.uk/publications/corporate/statistics/firestatisticsuk2006.
[22] Diekman ST, Ballesteros MF, Berger LR, Caraballo RS, Kegler SR. (2008); *Injury Prev.* 14: 228
[23] http://www.firesafecigarettes.org
[24] ASTM F2417-09 *Standard specification for fire safety for candles*. http://www.astm.org/Standards/F2417.htm
[25] Ahrens M. (2008); *Home fires that began with upholstered furniture*. Fire Analysis and Research Division, National Fire Protection Association.
[26] California Secretary of State Lobbying Report, 2003-2004 *Burnson-Marsteller, on behalf of the Bromine Science and Environmental Forum, also DBA Californians for Fire Safety*. http://cal-access.ss.ca.gov/
[27] C&E News, February 1, 2010
[28] Hale RC, Alaee M, Manchester-Neesvig JB, Stapleton HM, Ikonomou MG. (2003); *Environ Int.* 29(6): 771
[29] *Endocrine/Estrogen Letter* **10**(2), 1 (2004).