FOAM PLASTICS AND FIRE RETARDANTS:

A Practitioner's View of a New Code Change Proposal

By Dr. James L. Hoff

INTRODUCTION

Fire safety is a critical concern for building designers and occupants, and building codes play a vital role in reducing and managing the risks of fire in buildings. In order to comply with modern building code requirements, manufacturers of building materials frequently include fire retardants in their products. Although they typically account for only a small part of overall product formulation, fire retardants deliver a number of important functions: preventing fires from starting, slowing the burning process, increasing fire escape time, and reducing risks for first responders.

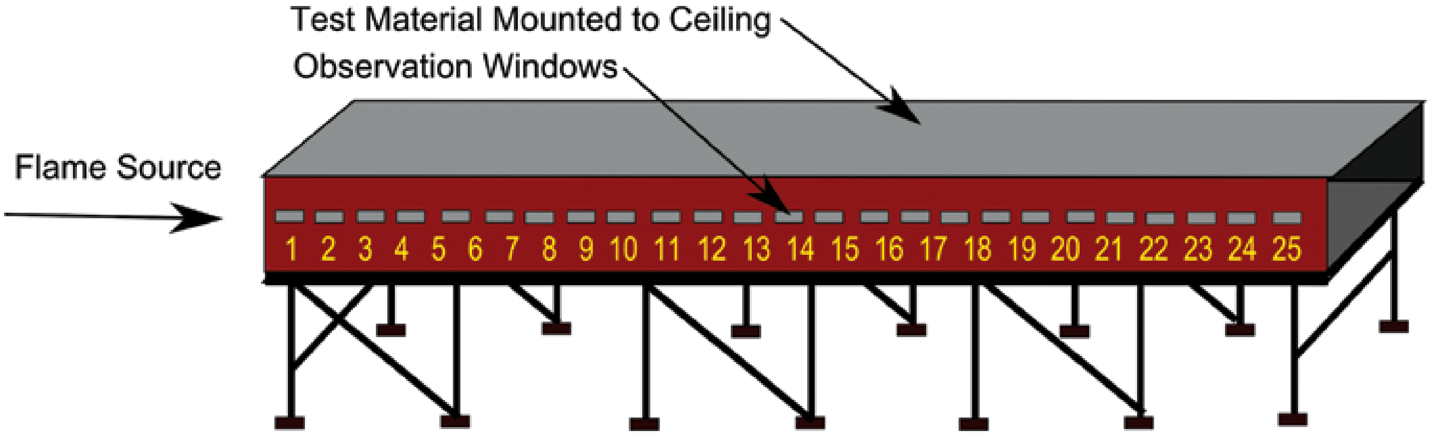
A recent study conducted by Babrauskas and others[1] and referenced in the January 2013 edition of *Interface* ("Study Finds Health Risk in Flame Retardants Added to Foam Insulation," page 41) suggests that an existing small-scale test used to evaluate and qualify foam plastics in residential building codes is unnecessary and should be removed from these codes. Currently, this small-scale test is used as a qualification criterion for a variety of foam plastic materials, including expanded polystyrene (EPS), extruded polystyrene (XPS), polyisocyanurate (polyiso), and spray polyurethane foam (SPF). Because building designers and consultants may have questions and concerns regarding this study and its recommendations, this article seeks to provide a comprehensive overview of the critical issues involved, including the role of fire testing in building codes, the economic and environmental benefits of fire-rated walls and roofs using foam plastic insulation, and a global health hazard assessment status of fire retardants currently used in foam plastic building insulation.

BACKGROUND: THE PROPOSED CODE CHANGE

Residential Code Only

Currently, building codes adopted across the United States require foam plastics to meet a minimum flame spread rating in the E84 Steiner Tunnel test for both residential and nonresidential applications. However, the Babrauskas study targets a proposed change only in the residential building codes. Although the exact language may vary among the different adopting code authorities, typically the wording is based on Section R316 of the International Residential Code (IRC) or Section 2603 of the nonresidential International Building Code (IBC):

> "... all foam plastic or foam plastic cores used as a component in manufactured assemblies used in build-



The Steiner Tunnel (ASTM E84) test consists of a 25-ft. vented tunnel lined with firebrick. Test material is mounted to the top of the chamber. At one end of the chamber, the sample is subjected to a high-energy flame for ten minutes. Flame spread is viewed through windows in the tunnel. An optical cell mounted at the tunnel exhaust measures smoke density. Illustration by TEGNOS Research, Inc.

ing construction shall have a flame spread index of not more than 75 and shall have a smoke-developed index of not more than 450 when tested in the maximum thickness intended for use in accordance with ASTM E84 or UL 723." (2012 IRC Section R316.3; 2012 IBC Section 2603.3)

The targeting of residential building codes in the Babrauskas study is based on findings that suggest that the flame spread characteristics measured in the E84 test have little bearing on the performance of foam plastics when covered by a thermal barrier. And because foam plastic in residential construction is covered by a thermal barrier such as gypsum board in almost all cases, the Babrauskas study suggests that E84 testing requirements serve no relevant purpose in meeting the intent of current residential fire codes.

With Limited Consequences

In addition to the proposed code change to eliminate E84 testing requirements, the Babrauskas study suggests that many of the original concerns behind the requirement are not modeled reliably by current E84 test apparatus and procedures. Examples of concerns addressed by Babrauskas include:

1. Fire propagation into a cavity constructed in violation of codes (with holes, gaps, or other discontinuities)
2. Fire propagation of directly exposed foam insulation installed in violation of codes

In the case of plastic foam installed behind a compromised thermal barrier, Babrauskas cites research findings that suggest the flame spread rating of the materials is not a significant factor in slowing fire propagation into the wall cavity. In the case of directly exposed foam insulation, Babrauskas cites research findings suggesting that foam plastic insulation not protected by a thermal barrier has an unacceptable level of fire hazard, irrespective of the use of flame retardants. In conclusion, Babrauskas states:

> "...the research presented shows that for plastic foam insulations protected by a thermal barrier, there is no added fire safety benefit from flame retardants." (Babrauskas *et al.*, 2012, p. 7)

ANALYSIS: IMPLICATIONS OF THE PROPOSED CODE CHANGE

Unaddressed Consequences

Although the literature review in the Babrauskas study discusses several potential implications, including fire propagation into a cavity constructed in violation of codes and the fire behavior of foam directly exposed within a building, several equally important consequences are not addressed. These include fire hazards during construction or job-site storage, when foam plastics may be left exposed, as well as fires ignited by electrical sparks or other heat sources within code-approved wall and ceiling cavities. The concern about ignition from electrical sparks may be especially important, given the increasing quantities of electrical and electronic cables installed within the walls and ceilings of modern buildings. Firefighters also may have concerns about the behavior of non-FR-treated foam plastics during fires.

The Potential for Misapplication

In addition to technical aspects of fire performance, the code change proposed by Babrauskas opens up a new and potentially disturbing area of concern. Because the code change applies only to foam insulation used in residential construction, it is likely that the code change will drive the development of two different types of foam insulation materials: one without fire retardants for use in residential construction, and one with fire retardants for use in commercial construction. In fact, the development of a two-tiered market for foam plastics is a stated goal of the Babrauskas study.

However, as will be discussed in more detail later in this article, the potential for misapplication of untreated residential products in nonresidential applications may expose material manufacturers, building professionals, and building occupants to unanticipated dangers. This is especially important because the fire tests associated with nonresidential construction tend to be much more rigorous than the simple E84 Steiner Tunnel and because a number of popular nonresidential wall and roof assemblies can achieve fire ratings without the use of additional thermal barriers. And if the inclusion of fire retardants is a critical factor in the achievement of these fire ratings, the misapplication of a non-FR-treated foam insulation could pose a significant danger—in terms of both occupant safety and practitioner liability.

Overreliance on One Type of Foam Plastic

The bulk of the research cited in the Babrauskas study was conducted using only one type of foam plastic insulation (polystyrene, either expanded or extruded) while omitting other types, including polyiso and SPF. This is important because thermoplastic foams such as EPS and XPS behave very differently than thermoset foams such as polyiso and SPF when exposed to flame. The study also fails to address the benefits of reducing flame spread when a variety of facers are applied to all plastic foams.

FOAM PLASTIC INSULATION AND FIRE SAFETY

Other Fire Tests

It is important to recognize that E84 testing represents only one test within a much larger body of testing protocols used to determine the fire safety of building components and assemblies. Other important tests for evaluating building fire safety include:

- UL 790/ASTM E108, *Standard Test Methods for Fire Tests of Roof Coverings*
- NFPA 285, *Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Nonload-Bearing Wall Assemblies Containing Combustible Components*
- FM/ANSI 4880, *National Standard for Evaluating Insulated Wall and Roof/Ceiling Assemblies*
- ASTM E119, UL 263, and NFPA 251, *Standard Test Methods for Fire Tests of Building Construction and Materials*

It is also important to note that all of these tests employ significantly higher temperatures for a much longer duration than the E84 Steiner Tunnel. In addition, these tests involve a wide variety of building components combined into many different wall, ceiling, or roof assemblies. Because of the rigor and complexity of such tests, the contribution of a single test element or an ingredient such as a fire retardant is difficult to determine. As a consequence, it is possible that fire retardants may play a much more important role in these tests as compared to the simple Steiner Tunnel test of a flame applied to an exposed piece of foam plastic.

Foam Plastics and Class A Roofing Systems

The current test protocol for external

fire resistance of roofing systems provides a useful example of the complex role of fire retardants in building roof and wall assemblies. This test (UL-790/ASTM E108) subjects roofing assemblies to a variety of external fire sources, including a continuous flame, an intermittent flame, and a burning brand. Based on performance in this test, approved roofing systems are classified as Class A, B, or C, depending on the degree of fire resistance demonstrated. Although some foam plastic insulations require one or more thermal barriers to achieve a Class A or B rating, others, such as polyiso and SPF formulated to meet Steiner Tunnel test requirements, are frequently able to achieve a Class A or B rating without the use of external thermal barriers. Because a Class A or B fire rating typically is required by code for nonresidential roofing installations, such insulations have become very popular in the commercial construction market. And, when formulated to meet E84 test criteria, these insulations provide this critical fire rating without the need for one or more thermal barriers, offering significant economic savings and design flexibility for building owners and designers.

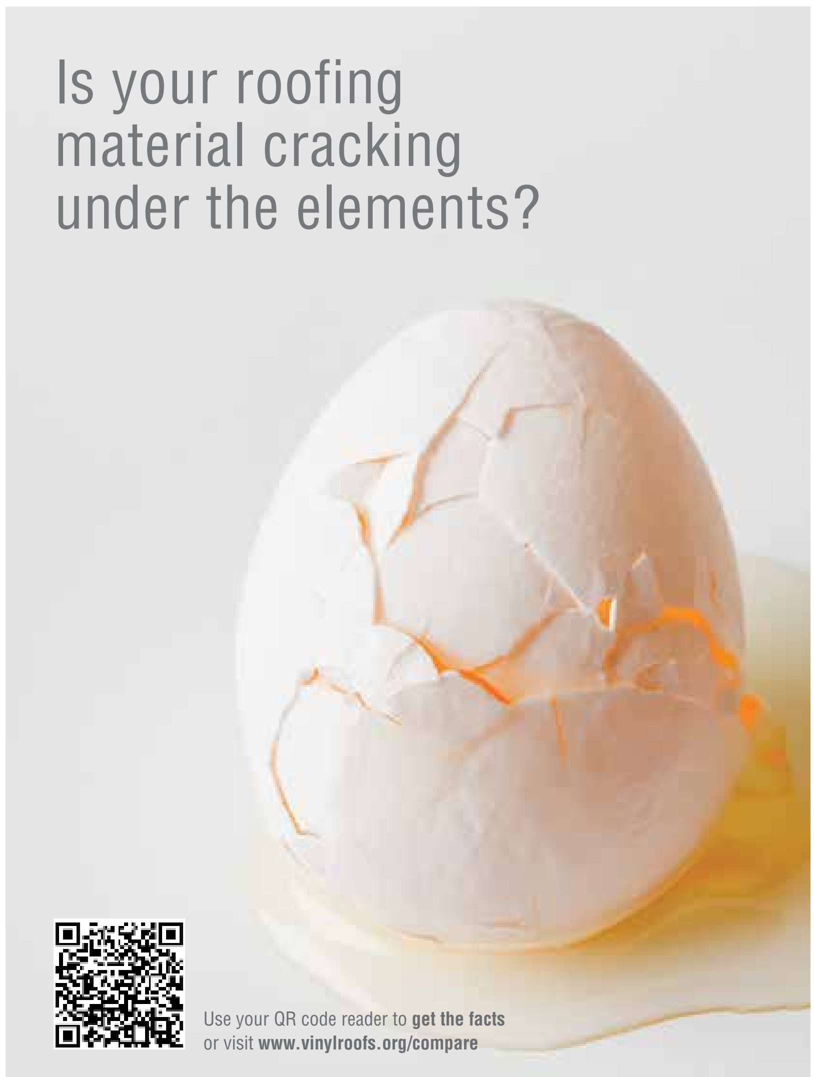
Foam Plastics and FM Class 1 Roofing Systems

In addition to minimum fire code requirements, insurance organizations such as FM Global require testing to higher levels of fire resistance in order to underwrite hazard insurance, especially for commercial buildings. An example of such an above-the-code test is FM 4450, *Fire Hazard Test Procedure for Class 1 Insulated Steel Deck Roofs*. This test is used to classify roof systems as Class 1 or 2. Roof systems that pass the test are rated Class 1, while all other roofs are rated as Class 2. Although this test is based on the same large-scale fire investigation as the E84 Steiner Tunnel test,[2] the FM 4450 test takes a more rigorous look at overall fuel contribution rather than the simplistic measurement of flame spread used in the E84 test. The test apparatus is called the FM Calorimeter, and it measures the overall fuel and gas escape from an entire roofing assembly when heated from the underside. Because FM 4450 looks at overall fuel contribution instead of surface flame, organizations such as the National Association of Fire Marshalls historically have favored this test over the E84 Steiner Tunnel.

Although some foam plastic insulations require one or more thermal barriers to achieve FM Class 1, both polyiso and SPF insulation as currently formulated with small amounts of fire retardant frequently are able to achieve a Class 1 rating without the use of thermal barriers. Because a Class 1 rating frequently is required by commercial building underwriters, these have become popular insulations of choice for owners of FM-insured buildings. And as formulated, they offer significant economic savings and design flexibility for building owners and designers seeking underwriting approval from organizations such as FM.

Foam Plastic and NFPA 285

NFPA 285 testing provides a method of determining the flammability characteristics of exterior wall assemblies of nonresidential buildings that contain foam plastic insulation. The NFPA 285-2006 testing apparatus is a two-story wall assembly that includes a framed window opening on the first floor. The pass/fail criteria are that flame propagation must not occur either vertically or laterally with the integral drainage plane beyond an acceptable distance from the area of flame plume impingement.



You want a tested and trusted roofing material – not one that cracks under pressure. Why specify roofing materials that age prematurely, unable to withstand the elements? Roofing membranes should perform for decades – **are you settling for less?**

Thermocouples are placed throughout the wall, and the defined temperature limits cannot be exceeded; otherwise, the test is considered a failure.

Wall assemblies using a variety of foam insulations have passed NFPA testing and are approved for use in nonresidential construction. In addition, many of these assemblies do not require an external thermal barrier between the foam insulation (typically applied continuously on the exterior of the wall structure) and the wall finish. Because many foam insulations formulated to meet E84 test criteria provide this critical fire rating without the need for exterior thermal barriers, they provide significant economic savings and design flexibility for building owners and designers.

Summary: Foam Plastic and Fire Safety

As demonstrated in the review of the performance of polyiso, SPF, and other foam plastic insulations in numerous critical fire code test approvals, these products deliver significant economic benefits by reducing the need for additional thermal barrier layers in many roof and wall system assemblies, especially in nonresidential construction applications. Although some of the fire test contributions of these products may be attributed to the inherent fire resistance of thermoset chemistry, which promotes charring rather than active flame, much of the safety and economic benefit may also be attributed to the addition of small quantities of fire retardants required to meet Steiner Tunnel test criteria.

It should be noted that this economic benefit is sizable. In roofing alone, over 3 billion square feet of code-rated nonresidential roofing assemblies are installed each year in the United States, and over 70% of these roofs use Steiner Tunnel-tested foam insulation that eliminates the need for additional thermal barriers, both above and below the insulation.[3] This implies that the elimination of Steiner Tunnel-tested foam plastic insulation would require the installation of billions of square feet of additional thermal barriers at a cost of hundreds of millions of dollars annually in construction costs. And in addition to the initial economic costs, the related environmental and health impacts of such an immense amount of construction material should be considered as well. (See "Thermal Barriers: No Risk-Free Lunch" later in this article for additional information.)

FOAM PLASTIC INSULATION AND HEALTH RISK ASSESSMENT

In addition to providing an overview of fire testing research associated with foam plastics and the E84 Steiner Tunnel, the Babrauskas study also offers a discussion of potential health hazards associated with foam plastics treated with small amounts of fire retardants. Specifically, two fire retardants are discussed:

1. Hexabromo-cyclododecane (HBCD or HBCDD), currently used in EPS and XPS.
2. Tris (1-chloro-2-propyl) phosphate (TCPP), currently used in polyiso and SPF.

In both cases, Babrauskas suggests the retardants be removed from use in building materials such as foam insulation because of their high toxicity, low degradability, and high potential to bioaccumulate. However, the data cited in the study should be carefully examined interms of both timeliness and relevance to building code decisions.

HBCD: Already Regulated

Due to environmental concerns with HBCD, action to phase out HBCD from the marketplace was initiated by the European Union in 2008, and a program to encourage industry to move away from HBCD was established by the U.S. Environmental Protection Agency (EPA) in 2010. In response, the polystyrene industry has already identified alternative chemicals to provide similar levels of fire protection in foam plastics. A new polymeric fire retardant has been developed that will quickly replace HBCD in all EPS and XPS applications.[4] Therefore, the chemical in question will soon be phased out from the marketplace.[5]

TCPP: Less-Convincing Evidence

The hazard data presented for TCPP present a much less-convincing picture. Although the Babrauskas study cites several studies investigating the health hazards of this fire retardant used in polyiso and SPF, the conclusions drawn about TCPP are not endorsed by the same global authorities who have called for the removal of other fire retardants such as HBCD from the market. In fact, the leading global assessment of TCPP conducted as part of a comprehensive European Union regulation of chemicals called REACH[6] does not call for any extraordinary measures to control or eliminate TCPP. This comprehensive risk assessment study, completed for REACH in 2008, concluded, "There is at present no need for further information and/or testing (for TCPP) and no need for risk reduction measures beyond those which are being applied already."[7] In addition, the risk assessment concluded that TCPP should not be considered a persistent bioaccumulative toxin (PBT) because it does not meet all PBT criteria.[8]

Thermal Barriers: No Risk-Free Lunch

When assessing the overall health impacts of wall and roof constructions, it is important to recognize that thermal barriers do not offer a hazard-free option. Because large amounts of energy are required to extract, refine, manufacture, cure, and transport popular thermal barriers such as gypsum board—and because these energy requirements are usually met through the use of fossil fuels—identifiable amounts of hazardous materials are released into the atmosphere during the production of such thermal barriers. As a consequence, the previously discussed economic benefit of some foam plastics in eliminating thermal barriers in roofing systems also delivers an additional benefit by reducing the potential health and environmental impacts associated with their use.

Health Risks and the Building Code Process

Because the findings of a single literature review should not be considered a definitive basis for defining either public risk or policy, the Babrauskas study by itself may not be sufficient to support a significant code change, especially given the questions raised in this article. In addition, excessive dependence on the recommendations of the Babrauskas study may be especially problematic when introduced into the building code development process. Historically, the expertise of code officials has been focused on the evaluation of buildings and materials in relation to hazards such as fire, wind, hail, and other natural events rather than chemical toxicity. As a consequence, the building code development process may not be an appropriate forum for a productive discussion of chemical hazards. For individuals and organizations seeking changes in chemical hazard criteria, it is likely that the rulemaking processes of agencies such as the U.S. EPA or other similar national and international agencies provide a much more effective and productive venue. As a consequence, caution should be exercised in regard to actions within the current U.S. code development process that would require code officials to make judgments based on chemical hazard data not supported by relevant national standards or regulations.

SUMMARY

Based on this review of the Babrauskas study and its proposal to eliminate E84 testing requirements for foam plastics, the following observations are offered as a guide for building envelope professionals interested in participating in the upcoming code change process.

The elimination of E84 testing for foam plastics in the current residential building code may result in unintended consequences that reduce overall public fire safety. Additional review is especially important in regard to unintended consequences, such as possible misapplication of materials not meeting the small-scale test criteria in more complex fire-rated construction assemblies,

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as well as other fire-related hazards identified in this review.

The E84 Steiner Tunnel is only one test within a much larger body of testing protocols used to determine the fire safety of building components and assemblies. Because these other tests are more rigorous and complex than the Steiner Tunnel, it is possible that materials exempt from E84 test criteria may exhibit significantly adverse effects in more complex fire-rated construction assemblies. Although such adverse effects could be addressed through the labeling and marketing of different classes of foam insulation (some meeting E84 testing and some not), the potential for misapplication of such materials and the consequences for public fire safety should be carefully reviewed before changing current fire test requirements.

Although eliminating E84 testing for foam plastics may have minimal effects on residential construction, the economic consequences in nonresidential construction are much more significant. Currently, many code-rated nonresidential roof and wall assemblies do not require the addition of a thermal barrier or cover board on the exterior side of the assembly when insulation meeting the Steiner Tunnel test is used. If insulation not meeting the Steiner Tunnel test were used in these assemblies, it is likely that billions of square feet of additional thermal barriers would be required in nonresidential construction each year in the United States.

The health risk assessment portion of the Babrauskas study may not accurately portray the risks associated with fire retardants currently used or soon to be used in foam plastics. In regard to HBCD, which is used in EPS and XPS insulation, this product is soon to be removed from the market and replaced with a newer and safer material. In regard to TCPP, which is used in polyiso and SPF insulation, the suggestions of the Babrauskas study are not supported by the most comprehensive and authoritative global review conducted by the EU in 2008.

Thermal barriers do not offer a hazard-free option compared to the use of small amounts of fire retardants. Because large amounts of energy are required to extract, refine, manufacture, cure, and transport popular thermal barriers such as gypsum board; and because these energy requirements are usually met through the use of fossil fuels, identifiable amounts of hazardous materials are released into the atmosphere during the production and use of thermal barriers.

The building code process may not be an appropriate forum for a productive discussion of chemical hazards. Historically, the expertise of code officials has centered on the evaluation of buildings and materials in relation to hazards such as fire, wind, hail, and other natural events rather than chemical toxicity. For individuals and organizations seeking changes in chemical hazard criteria, the rulemaking processes of agencies such as the U.S. EPA or other similar national and international agencies may provide a much more effective and productive venue.

The last thing building practitioners need is a two-tiered approach to foam plastics in the building code. It's hard enough to specify and police the use of code-approved materials today without the introduction of a whole new set of products. And the safety and liability risks of misapplication of foam insulations without fire retardants in assemblies calling for FR-treated insulation should not be underestimated.

FOOTNOTES

1. V. Babrauskas, D. Lucas, D. Eisenberg, V. Singla, M. Dedeo, M., A. Blum, "Flame Retardants in Building Insulation: A Case for Re-Evaluating Building Codes." *Building Research and Information*, 40, 6, 2012. http://www.tandfonline.com/doi/full/10.1080/09613218.2012.744533
2. The classic "White House" test was conducted by UL and FM in response to a devastating fire at a GM plant in Livonia, MI, in the 1950s. For more information, see *PIMA Technical Bulletin #105: Fire Test Definitions*. http://c.ymcdn.com/sites/www.polyiso.org/resource/resmgr/technical_bulletins/tb105_jun30.pdf
3. Based on market survey data prepared by TEGNOS Research, Inc.
4. "Dow Announces Development of a New Polymeric Flame Retardant Technology for Polystyrene Foam Building Insulation Products." Available: http://www.dow.com/news/corporate/2011/20110329b.htm.
5. To objectively represent the observations of the study, it is important to note that Babrauskas also questions the suitability of a new and possibly unproved fire retardant to replace HBCD. However, no experimental evidence to support such concerns is presented.
6. REACH stands for the Registration, Evaluation, Authorisation, and Restriction of Chemicals. REACH addresses the production and use of chemical substances and their potential impacts on both human health and the environment. It has been described as the most complex legislation in EU history and is the strictest law to date regulating chemical substances, affecting industries throughout the world. See Marla Cone, "European Parliament OKs World's Toughest Law on Toxic Chemicals," *San Francisco Chronicle*, December 14, 2006. http://www.sfgate.com/green/article/European-Parliament-OKs-worlds-toughest-law-on-2465418.php
7. European Union Risk Assessment Report: Tris(2-Chloro-1-Methylethyl) Phosphate (TCPP). May 2008. http://echa.europa.eu/documents/10162/13630/trd_rar_ireland_tccp_en.pdf
8. Scientific Committee on Health and Environmental Risks (2007). Risk Assessment Report on Tris(2-Chloro-1-Methylethyl) Phosphate (TCPP): Environmental part. http://ec.europa.eu/health/archive/ph_risk/committees/04_scher/docs/scher_o_064.pdf

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