



Potential Hazards Associated with Environmentally Preferable ("Green") Products

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Abstract

This project examines the safety of environmentally preferable consumer products. This was accomplished through observations of product marketing and interviews with representatives at retail stores, research into the Consumer Product Safety Commission's databases, and interviews with several experts in the fields of fire safety and environmental studies. Our research concluded that environmentally preferable products generally did not present additional hazards and in some cases presented safety benefits when compared to non-green, traditional products.

Executive Summary

Since the second half of the 20th century, environmental issues have moved from a matter of secondary concern to a much more widely shared concern in science, politics, and popular culture. With the growing awareness that many industrial processes are harmful to the environment around us, resource allocation and sustainability have recently become topics of interest. The manufacturers and designers of consumer products are faced with these issues and many have offered environmentally preferable or “green” alternatives to their regular products. These green products supposedly make unique use of certain materials, manufacturing processes, and design features to reduce their overall environmental impact. But while the popularity of environmentally preferable products grows, their definition is still vague and relatively non-specific. This inexact definition may mislead consumers by deemphasizing the ultimate goal of environmentally preferable products: to lessen the environmental impact of the human population on the Earth.

In addition, there may be some unforeseen safety hazards related to certain environmentally preferable products. Many third party organizations certify products as environmentally preferable. Other products are marketed and sold as green, even though they are not necessarily environmentally preferable. Due to the infancy of the market and the general confusion about what exactly constitutes an environmentally preferable product, not much is known about the potential safety issues that could be associated with the materials of which green products are made, their functionality, and their operation.

To understand if environmentally preferable products presented more of a safety hazard than traditional products, we first needed to comprehend how traditional (i.e. non-green) products are regulated. Many common household products such as textiles, furnishings, home maintenance products, and building materials have some standards associated with them and are

regulated accordingly. The Consumer Product Safety Commission enforces mandatory standards and regulatory acts, such as the Federal Hazardous Substance Act and Flammable Fabrics Act, which outline minimum requirements for consumer products. Other organizations such as the National Fire Protection Association (NFPA) and the American Society for Testing and Materials International (ASTM International) set voluntary standards for safety. In most cases, these safety standards do not classify products according to their environmental impacts, but by their function.

Our project examines the characteristics of some environmentally preferable household consumer products to determine whether or not these products present increased safety hazards to consumers when compared to their traditional counterparts. The first step in understanding how environmentally preferable products may potentially cause safety hazards was to develop a working definition for environmentally preferable. We settled on defining a green product as any product that is certified, advertised, or claimed to be environmentally preferable, as the consumer must consider many of these promotions to be factual.

Although the popularity of environmentally preferable products was perceived to be increasing, it was uncertain whether large chain retailers were also increasing the number of products available and experiencing increasing trends of environmentally preferable product sales. Thus, we carried out a market overview, which determined that, while retailers advertise sustainability on websites, environmentally preferable products have only a small or nonexistent presence in many retail stores.

In environmentally preferable product alternatives, it is unknown whether or not certain green characteristics contribute to potential safety hazards. We searched the CPSC National Electronic Surveillance System (NEISS) database and the Injury and Potential Injury Incident

(IPII) database to determine if current voluntary and mandatory standards properly covered environmentally preferable products. While using these databases, our group attempted to identify whether risks were inherent in the product or were the result of misuse by the consumer. The CPSC's incident reports (IPII) and hospital (NEISS) data did not provide enough information to determine if the products were marketed as environmentally preferable.

We also interviewed experts in consumer product safety testing, regulation, and fire protection to gain a better understanding of the specific product standards and current areas of concern regarding traditional, non-green products. We found that, compared to the rapid development of environmentally preferable products, the creation of amendments to the respective safety standards and codes are delayed, thus potentially causing hazardous situations. From these interviews it was also determined that, for products such as paints and home furnishings, there are no current universal standards for emission of hazardous chemicals, which may present a safety hazard to some consumers with an increased sensitivity to these compounds.

This project provided insight into whether or not there is justifiable concern for green product safety. Little evidence supported that increased safety risks exist in certain environmentally preferable products. However, areas of concern included the inclusion of engineered wood in the "lumber" category of many safety codes and the composition of paints and varnishes that may cause health effects. We recommend that existing standards continue to be performance-based, rather than amending them to treat environmentally preferable products separately. We also recommend that environmentally preferable products and traditional products continue to be regulated by function rather than environmental characteristics. Overall,

existing mandatory and voluntary standards seemed to adequately cover environmentally preferable products.

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Chapter 1: Introduction

During the 20th century, the world experienced its highest population growth rate, increasing approximately 2.04% on average each year, with a projected world population of ten billion people by the year 2200 (United Nations, 2004, p. 1). With this many people relying on the Earth's resources, the concept of environmental sustainability has become more significant and relevant in the development of renewable and non-renewable resources. Through a combination of public education by the media and marketing of environmentally friendly products, a consumer "green movement" has been established based on the idea that every individual consumer choice can sustain or deplete the environment. The economic, political, and social impacts of this green movement have had small and large-scale effects: consumers have created the demand for environmentally preferable products, and thus the design and production of environmentally preferable products has increased. However, there may be unforeseen safety issues related to certain "green" product characteristics.

Although the popularity of environmentally preferable products has increased, little research has been done in order to reveal associated fire safety risks and other potential hazards in these products (Green Confidence Index, 2010a). Most of these products are still relatively new. The Consumer Product Safety Commission (CPSC) staff has expressed concern that there may be an increased risk of fire or burn hazards in some of these environmentally preferable products due to the materials from which they are made, their functionality and operation, or a combination of both.

The CPSC (2010e) has jurisdiction over 15,000 consumer products and enforces mandatory requirements for various products. For example, under the Federal Hazardous Substances Act (FHSA, 1960), certain hazardous household products are required to have a cautionary label. Although the CPSC does not segregate traditional products from

environmentally preferable products, other independent organizations do. Organizations such as Green Seal (2010b), Energy Star (2004), and Green Guard Environmental Institute (2010) determine if certain products can be claimed as environmentally preferable. Although there are some regulations regarding whether a product can be sold as environmentally preferable, it is unclear if these products are safer or more hazardous than other traditional products. The materials, functionality, operation, manufacturing processes, and design attributes of certain products may potentially be responsible for an increased risk of fire, burn, or other hazards.

While recalls and incident reports on environmentally preferable products are available through the CPSC, it is unknown whether or not trends in potential or actual hazards exist in some products. The increasing trend of the green product led to changes in the market and a new demand; however, little research has been done to on the relative risk of environmentally preferable products.

The purpose of this project is to determine if there is any evidence indicating that certain environmentally preferable products pose increased safety hazards to consumers. Because the scope of consumer products is broad, this project will focus specifically on consumer products found in the household, specifically textiles, home furnishings, home maintenance products, and building materials. We interviewed experts in the fields of fire safety and consumer product testing, to better understand how these environmentally preferable products present a potential safety hazard. We also examined the CPSC National Electronic Injury Surveillance System (NEISS) and Injury and Potential Injury Incident (IPII) databases, which were useful in determining if and how these products present the risk of such hazards. If any concern was justified, the result was an analysis and list of recommendations to improve and reduce the risk

of safety hazards of certain products. Moreover, if the team identified certain significant trends in the safety of environmentally preferable products, then further study was recommended.

Chapter 2: Background/Literature Review

Products that claim to be environmentally preferable, or “green,” are becoming more prevalent in the homes of consumers as a result of increasing environmental awareness. However, it is unknown whether or not the reduced environmental impact of green products inadvertently changes the product in ways which might increase the probability of safety hazards occurring. As such, it is possible that tradeoffs may occur in some green products between environmental safety and consumer safety. The Consumer Product Safety Commission (CPSC) staff would like to explore potential problems and develop solutions or recommendations to reduce hazards in consumer products that are marketed as environmentally preferable. This chapter will focus on the literature on environmental preferability, as well as hazards associated with household consumer products, including textiles, home furnishings, home maintenance products, and building materials.

Environmentally preferable products are defined by consumers, manufacturers, and certification organizations. We explain the differences between traditional products and environmentally preferable products, emphasizing each product’s environmental impact. We also explain the danger of fire and the importance of fire safety. By understanding the differences between traditional products and new environmentally preferable products, we will be able to gain an insight into which products and product categories may present an unforeseen safety hazard. Finally, we present an evaluation of the safety of these products and focus on the categories analyzed in the background for further study.

To further examine green products, we studied journal articles relevant to their safety and analyzed the Material Safety Data Sheets (MSDSs) for each specific product. The articles used for the purposes of this literature review included scholarly journals, business publications, and periodicals. The MSDS is required by the Occupational Safety and Health Administration to be

available to all individuals or employees who will be exposed to a chemical (29CFR19001200). Although the MSDS for a cleaning compound, for example, does not generally contain information that is readily decipherable by consumers, it does detail the hazards associated with the compound, as well as safety precautions that can be taken by someone using the compound. A close inspection of these data sheets allowed us to better understand the specific chemical differences between environmentally preferable and non-environmentally preferable products.

2.1 Environmentally Preferable Products

In the present economic, social, and political climate, some consumers have become increasingly aware of the short-term and long-term personal costs of the products they buy. Environmentally preferable products are products marketed as offering a reduced environmental impact when used instead of the traditional product counterpart. Buying environmentally preferable products provides consumers with the option of reducing their overall environmental impact and occasionally lowering their long-term expenses. The color green has come to be associated with the Earth, indicative of a healthy environment. “Green” products are aptly named because, in comparison to the non-green or alternative products, they are marketed as environmentally preferable. For our project, we chose to use the word “green” as a reference to a product’s marketing; a green product is marketed as environmentally friendly, regardless of the product’s actual environmental impact. The term “environmentally preferable,” however, is more academic: if, by altering their processes or materials, a manufacturer is able to reduce the environmental impact of a product, then that product may be sold with a label or logo certifying it to be “environmentally preferable.” But the standards and regulations that exist to control green certification and eco-labeling may vary from country to country and organization to organization.

Eco-labeling and environmentally preferable product standardization occur on both an international and national level, but the organizations producing these voluntary standards are mostly third-party, private organizations working in cooperation with the government. While there is some overlap among the standards and regulations of these various organizations, there is no single common standard to which all products marketed as environmentally preferable can be compared. When describing products that have reduced environmental impacts, the term green is more than just a color; it describes a complex system of tradeoffs balancing cost with environmental performance.

Our project will define a green or environmentally preferable product, as any consumer product marketed as “environmentally friendly” and employs one of the three types of environmental labeling, as set forth by the International Organization for Standardization (ISO). This definition, as well as other definitions and determinants of what is “green,” will be discussed in detail in the following sections.

2.1.1 Life Cycle Assessment

A useful tool for manufacturers, designers, and third-party organizations to determine whether or not a product is environmentally preferable, is to perform a life cycle assessment (LCA). An LCA takes into account all of the various aspects of a consumer product’s life cycle, including raw material acquisition, manufacture, transport, use, and disposal (Allen and Rosselot, 2001). Figure 1 illustrates the various levels and components of a general product life cycle. In each step of the product life cycle, energy is consumed and wastes and emissions are produced. Transportation, which also occurs at almost every stage in the product life cycle, is a major factor in a product’s overall environmental impact. A product progresses through various stages of development, beginning with the acquisition of the raw materials used in the product,

through the manufacture of the processed materials, and ending with the actual product manufacturing. The stages after manufacturing focus on the consumer's use and disposal of the product. The following four actions can occur after the product is used by the consumer:

1. The consumer can reuse the product
2. The product parts can be taken apart and remanufactured
3. The product's materials can be recycled and used again in other products, or
4. The product can be disposed of permanently.

The first three of these possible stages in the product life cycle help to conserve resources and lessen the overall impact a product may have on the environment.

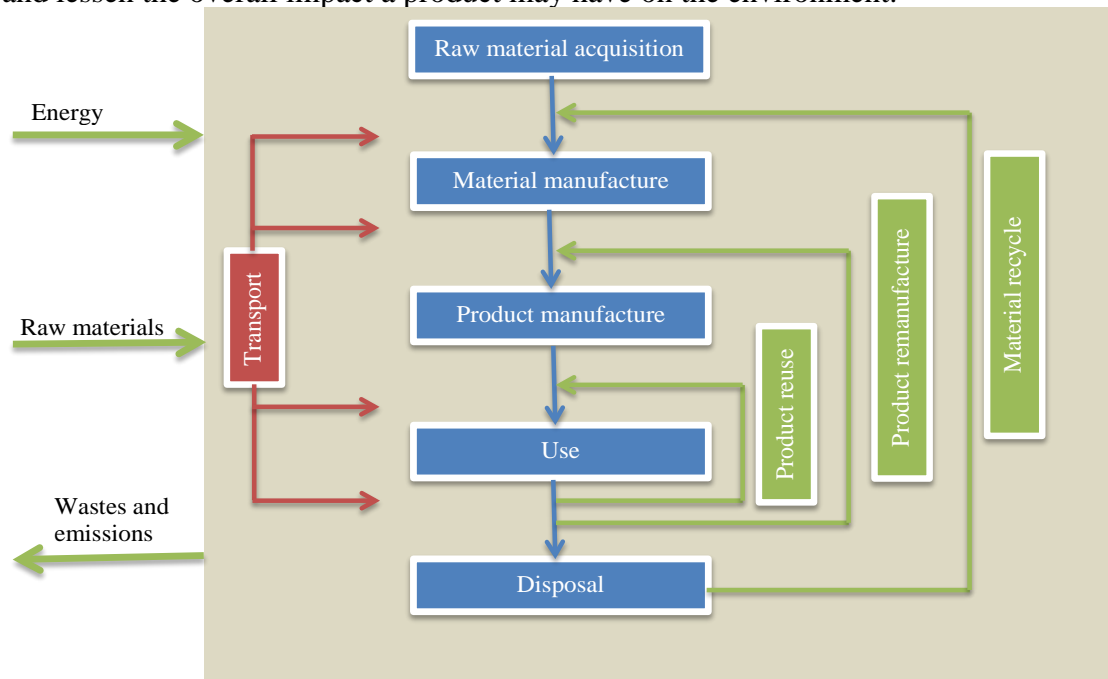


Figure 1: Product Life Cycle (Allen and Rosselot, 2001): a diagram summarizing the inputs and outputs that are incurred over a product's life cycle and the processes use or produce these inputs and outputs.

Until recently, product manufacturers and designers were involved in the product life cycle only up to the manufacturing stage, but recently some have shifted their focus to include the use, disposal, and recycling of their products. By performing LCA, a manufacturer or

designer can discover ways to lessen the amount of pollution produced by the product and conserve non-renewable resources and ecological systems associated with the product.

There are three main steps in LCA: life cycle inventory, life cycle impact assessment, and life cycle improvement analysis (Svoboda, 1995, p. 2). A life cycle inventory is a data-based list of all the inputs (e.g. energy, raw materials) and outputs (e.g. sold wastes, air emissions) which a product incurs over its life cycle within the manageable system of the product (shown in Figure 1 as the tan box). The input and output information is quantified, so that the various components of the product are comparable and a net impact can be calculated. The evaluation of these data sets leads to the life cycle impact assessment by which a product's ecological, human health, social, cultural, and economic impacts are explored. After the entire system in which the product exists is reviewed, life cycle improvement analysis of areas within the product life cycle occurs. Opportunities to reduce the environmental impact of a product include improved product design, industrial manufacturing processes, raw material usage, consumer use, transportation, and waste management.

There are some uncertainties that can arise from the results of a life cycle inventory that can render the entire life cycle assessment inaccurate. If certain assumptions are made when defining the system boundaries or choosing data sources (whether or not the data came from a regional or global source), there can be inconsistencies that arise in the input and output data. For some input and output components of a product, there may not even be any data, thus leading to more assumptions being made in the life cycle inventory. If LCA is not done correctly, a product may be inappropriately labeled and thus would be assumed by a consumer to be greener than the product actually is. While many leading third-party organizations, such as Green Seal, have adopted LCA as their primary evaluation tool, many products are evaluated by

other means, such as laboratory tests for different components of environmental impact. Variability in testing and standards makes statistical comparisons between products unreliable. And even within organizations using LCA, there are different value systems in place, and so the quantified data may not be comparable (Allen and Rosselot, 2001). Yet, despite its shortcomings, few other methods offer such a complete insight into a products' net impact on the environment.

2.1.2 Green Chemistry

The theoretical term “green chemistry” refers to product engineering that promotes sustainability and can be used in conjunction with inorganic chemistry, organic chemistry, biochemistry, physical chemistry, and analytical chemistry; and because chemicals are used in everything from the product's materials to manufacturing processes, “green chemistry” is relevant to any product. Based upon the product life cycle and life cycle assessment, green chemistry aims to reduce the overall environmental impact a product has on the environment from manufacturing to disposal. It attempts to accomplish this by specifically altering the material and chemical composition of the product during all of the stages of its life cycle. Manufacturers and designers can use the twelve principles of green chemistry, developed by Anastas and Warner (1998) of the U.S. Environmental Protection Agency, to design products that use fewer raw materials, create less waste, are fully recyclable or biodegradable, and are safer.

The first principle of green chemistry states that the prevention of waste is more favorable than the treatment of created waste, because of additional energy that must be expended in the cleanup process. One way to reduce waste, as suggested in the second principle, is to incorporate as much of the raw materials used in the manufacturing processes as possible in

the final product. The tenth principle suggests another way to reduce waste: to design products using components that will naturally degrade and will not persist in the environment. While much of green chemistry deals with sustainability, a number of the principles also pertain to product safety. Products designed using green chemistry should be designed with “inherently safer chemistry for accident prevention,” in order to reduce the number of chemical releases, explosions, and fires (Anastas and Warner, 1998, p. 54). The other principles of green chemistry deal with issues that are beyond the scope of this paper.

2.1.3 Product Marketing

Many manufacturers and product designers aim to develop products and manufacturing processes that they believe to have a lower environmental impact. Such companies or manufacturers may claim that a product is “green” or environmentally friendly, or seek certification from a third-party organization to strengthen the validity of their claim. There are many such organizations worldwide, but one organization, the International Organization of Standards (ISO) (2010b) sets standards for both environmental labeling (eco-labeling) and eco-labeling organizations.

The International Organization for Standardization (2010a) has attempted to put standards in place regarding environmental labeling and organizations that provide labels for products. As one of the world’s largest standards developing organizations, their business, government, and societal standards have begun to become widely accepted. Since 1947, the ISO has published over 16,500 international standards in areas such as agriculture, construction, medical devices and mechanical engineering. Two key international standards are ISO 14020 and ISO 14025, which outline the criteria for eco-labeling. ISO 14020 describes nine general principles to be applied to labeling schemes and environmental claims to ensure that the

consumer receives accurate, verifiable, and relevant information. ISO 14025 provides guidelines for developing programs that “verify the environmental attributes of a product with a seal of approval” (ISO, 2010b).

According to the Global Eco-labeling Network (2004), the ISO has classified three main types of voluntary environmental labeling. Type I (ISO, 1999a) refers directly to third-party eco-labeling, or “a voluntary, multiple-criteria based, third party program that awards a license which authorizes the use of environmental labels on products indicating overall environmental preferability of a product within a product category based on life cycle considerations (p. 2)”. These eco-labels are attained only when a qualified product meets certain criteria put forth by the particular eco-labeling organization. Qualification may be determined by performing a life cycle assessment, laboratory tests for certain components, and inspection of the factory where the manufacturing takes place, as well as working conditions for employees. Type II (ISO, 1999b) are first-party, self-declaration claims made by the manufacturer of a product, and could be considered simply as product marketing. Some manufacturers believe that describing a product as “green” makes it more attractive to the average consumer; whether or not the product is actually beneficial for the environment is not always considered. Type III (ISO, 2006) are first or second-party environmental declarations using informational labels or environmental impact report cards. While these labels generally supply the consumer with information regarding the environmental impact of the product, they are usually created by either the manufacturer or by an industry organization, such as the American Association of Textile Chemists and Colorists, which may have a non-objective or biased perception of the product.

2.1.4 Role of the Consumer

This project will assess the potential unforeseen hazards and risks associated with certain types of “green” products, posed to the average consumer. In order to do this, it is necessary to discover who the “average” consumer of environmentally preferable products is. Based upon the most recent results of a monthly survey conducted by Earthsense, a company that does comprehensive market research for various manufacturers of green products, the largest group of green product consumers are aged 18 to 34 (Green Confidence Index, 2010a). Studies have also found a correlation between annual household income and general attitude towards green products. Since July 2009, those with annual household incomes of greater than \$50,000 reported an increase in their feelings of responsibility to the environment, availability of information regarding green products, and their purchase of green products, while those with household incomes less than \$50,000 reported decreased interest in all three of these categories when compared to survey results from previous years. A survey taken of individuals of various educational backgrounds has also shown that consumers with a higher level of education make more green product purchases than those with a lower level of education.

The consumer’s role in the development of environmentally preferable products is obviously very important; it is the consumers who are creating the demand for and use these products. All product manufacturers ultimately want their products to be purchased and used by consumers and achieve this through effective marketing and product accessibility. One successful marketing tactic is to develop products that can be included as a part of the green movement. This can be accomplished by advertising that the product has been made with environmentally friendly materials and manufacturing processes or simply by including phrases such as “green” or “eco” in the product name (Green Confidence Index, 2010b). A consumer educated about the long-term benefits that some of these environmentally preferable products

might have may choose to buy them over the product's standard counterpart. Even though the sales of environmentally preferable products have been incrementally increasing over the years, the average consumer is not necessarily informed enough about a specific type of product to fully evaluate the claims made by the manufacturer and may take any type of eco-labeling at face value, whether the product is or is not actually environmentally preferable. Without a single, universal definition for environmentally preferable products put forth by a single regulatory body, the consumer cannot discern the true environmental impact of a product through the product marketing.

Environmentally preferable products are defined by the standards of the third-party organizations that certify them, although these third-parties do not certify every product that claims to be environmentally preferable. Some organizations may have overlapping standards, while others may have stricter standards, but ultimately all of these standards are voluntary and only pertain to that specific organization's definition of what is environmentally preferable. By attempting to meet these criteria, a manufacturer may change a product's material, operation, or manufacturing processes, which may change the way the product needs to be regulated for safety. It is unknown whether or not a trade-off between environmental preferability and consumer safety exists in some products, but the use or exclusion of certain materials or processes may change how the product should be tested and regulated for consumer safety.

2.1.5 Our Definition of "Green"

While environmental label types I, II, and III, as defined by the ISO standards, help the consumer to identify products with lowered environmental impact, the differences amongst all three types of labeling may not be clear to the average consumer. One must assume that the average consumer is not able to distinguish between which environmentally preferable product is

properly certified and which product is deemed environmentally preferable by an advertisement. This is because the information regarding standards and “green” products is not readily available without intensive research. We have defined a green product as any product marketed as “environmentally friendly” and that meets the necessary criteria for one of the three types of environmental labeling as described by the ISO (see section 2.1.3). This all-inclusive definition is based upon the perspective of the average consumer and how they purchase green products. By looking at products that fall into all of the three environmental labeling categories, we can better assess the potential associated hazards posed to the consumers of those products.

2.2 Textiles

The term *textile* typically refers to fabrics, the components used to make fabrics, or the products made from fabrics. Many consumer products are considered textiles, such as clothes, rugs and carpets, upholstery, and mattresses. A number of these products are regulated by the Consumer Product Safety Commission (CPSC) under the Flammable Fabrics Act (FFA, 1953). This Act regulates what articles of apparel and fabric can be sold based on their fire safety.

A number of companies are producing textile goods in a more environmentally friendly way so that they can market their products as environmentally preferable. Environmentally preferable textiles are often referred to as eco-textiles. These eco-textiles are considered more environmentally preferable for many reasons, which include using more sustainable material, less polluting manufacturing processes, and recycled material among other things. These environmentally preferable textiles meet the CPSC standards, as well as certain voluntary standards regarding environmental impact.

2.2.1 Voluntary and Mandatory Textile Standards

The CPSC regulates a number of textiles under the Flammable Fabric Act (1953). This Act regulates apparel textiles under four standards: 16 CFR part 1610 *Flammability of Clothing Textiles* (1610), 16 CFR part 1611 *Standard for the Flammability of Vinyl Plastic Film* (1611), and 16 CFR parts 1615 and 1616 *Standards for the Flammability of Children's sleepwear* (1615, 1616). Carpets and rugs are regulated by 16 CFR 1630 *Standard for the Surface Flammability of Carpets and Rugs* (1630) and 16 CFR 1631 *Standard for the Surface Flammability of Small Carpets and Rugs* (1631). Mattresses are regulated by 16 CFR 1632 *Standard for the Flammability of Mattresses and Mattress Pads* (1632) and 16 CFR 1633 *Standard for the Flammability (Open Flame) of Mattress Sets* (1633). Each standard describes a flammability performance test that the textile must meet, as well as any exceptions, exclusions, and interpretations. The Commission has also proposed a new mandatory standard for the flammability of upholstered furniture (Proposed 16 CFR 1634, 2008).

The United States Department of Agriculture (USDA) regulates what an organic product is through Title 7 U.S. CFR 205 National Organic Program (Organic Foods Production Act, 2000). This program details the minimum requirements that a product must meet if the product is “intended to be sold, labeled, or represented as ‘100 percent organic,’ ‘organic,’ or ‘made with organic (specified ingredients or food group(s))’ (7CFR205100, 2005).” There are also several organizations, such as Green Guard and Oeko-Tex, that define what an organic eco-textile is by listing criteria that must be met for both the textile and manufacturing processes. These third party standards may be stricter than the USDA regulations. For example, Oeko-Tex (2010) will not certify a product that uses a chemical from Oeko-Tex’s banned chemical list.

2.2.2 Eco-Textiles

Eco-textiles are textiles made from recycled or repurposed materials and redesigned manufacturing processes. A result of this is several new products including organic fiber textiles, organic textiles, bamboo textiles, coconut textiles, and upholstery fabric that may lack some traditional chemical finishes. One product type is organic fiber textiles. These textiles are made from fibers grown without the use of herbicides, pesticides, or “inhumane” labor, but are manufactured using the same methods as traditional textiles (OecoTextiles, 2008). Similar to organic fiber” textiles are organic textiles which are made from organic raw materials, however, organic textiles are made using a more environmentally preferable manufacturing process than the average traditional textile.

Several companies are using different raw materials to manufacture eco-textiles, rather than the traditional textiles. Cocona (2010) is a company that uses coconut husks to produce a “high quality” fabric. Cocona claims their products are environmentally preferable because they infuse fabrics with activated carbon made from coconut husks that would otherwise have gone into a landfill. Bamboo is also being used to create fabrics. This is done in one of two fashions. The first way is by using the bamboo to create rayon (Federal Trade Commission, 2009). Rayon is a regenerated cellulosic fiber and can be made from any plant material. Bamboo rayon has the same properties as other rayons and does not retain any of the characteristics of bamboo. Rayon processing is considered detrimental to the environment, and because bamboo rayon still uses the same manufacturing process as other rayons it is not truly environmentally preferable. The second way to produce a textile from bamboo is through a mechanical process extremely similar to the process to turn flax into linen (Green Cotton, 2007). This process retains some of the properties of the bamboo, such as bamboo’s natural anti-bacterial properties and the rounded shape of the fibers.

Environmentally preferable rugs and carpets include recycled plastic carpets and rugs, 100% wool carpets, and rugs that are made in other sustainable manners. Recycled plastic carpets and rugs are often made from recycled bottles which contain the plastic known as polyethylene terephthalate, or PET (Bright Hub, 2010). The PET is ground into chips then melted down and extruded into the desired thread shape. There are several 100% wool carpets and rugs that are environmentally preferable, like Eco Choices' (2010) wool carpeting. This carpeting is advertised as chemical free, 100% natural, and organic. Wool is an animal product that does not require pesticides and herbicides, and is also naturally fire resistant (Kadolph and Stone, 2003).

The traditional manufacturing process of textiles involves many chemicals that are considered detrimental to the environment by several environmental groups. To produce more environmentally preferable textiles, some companies are replacing or removing these chemicals from the manufacturing process. OecoTextiles (2010) make several upholstery fabrics and claim that no harmful chemicals are used in the production of their upholstery fabrics. If this claim is true, then no chemical fire retardants are applied to these upholstery fabrics when they are sold. Some of these fabrics contain a significant amount of cotton, which is a highly flammable fiber (Kadolph and Stone, 2003).

2.3 Home Furnishings

Home furnishings cover a vast variety of products. From flooring to tables, cabinets and décor, a home furnishing is any type of furnishing intended “for use or which may reasonably be expected for use in homes or other places of assembly or accommodation (CPSA, 1972).” They are products that support human activities from sitting and sleeping to holding objects. The main categories of home furnishings include wall, flooring and ceiling treatments, furniture, and décor.

Traditional floor coverings typically include linoleum, laminate, or hardwood which can be made into tiles. Home furnishings also include furniture, like coffee tables, end stands, and chairs (though, for the purposes of our investigation, we exclude upholstered furniture). The last category of a home furnishing, décor, includes products, such as picture frames, vases, works of art, and other similar products used to accessorize the home. These products often lack any other function other than decoration. Home furnishings are essentially products that shape the aesthetic of the modern home interior. Environmentally preferable home furnishings are becoming more popular as more options become available to consumers.

Like many standard products, home furnishings have environmentally friendly counterparts. These products include flooring made of bamboo, rubber, cork, or marmoleum, carpets made of hemp, recycled plastic or wool, and furniture made of recycled wood. Environmentally preferable home furnishings can be as common as a bamboo floor or as obscure as sofas made of refrigerators (Johnson, 2010). It is uncertain if these products are really safer for the environment or if their marketing is just “green washing;” claiming a product is environmentally safe without presenting any substantiating evidence.

Organizations, such as GreenFloors and Smart Certification, describe their standards for “green” home furnishings. GreenFloors and Smart Certification comply with ISO standards and use life cycle analyses to determine whether or not a home furnishing can be considered environmentally preferable. GreenFloors (2010) lists the top ten factors in deciding if a home furnishing is environmentally preferable. Two of these factors include requirements for the manufacturer to account for the environmental impact of the manufacturing processes used. The other eight factors deal directly with the product, guaranteeing that the home furnishing is made with raw, renewable, or recycled materials. The home furnishing must not contain toxic materials

and must be able to be maintained in an environmentally friendly manner (i.e. low water consumption and low toxic cleaning chemicals).

While GreenFloors determines whether or not a floor is environmentally preferable, Smart Certification certifies a variety of green home furnishings. “Smart Certified” home furnishings claim to be safe for public health and the environment, use materials from renewable energies or recycled materials, and can be recycled after use (Knoll Life Chair, 2008). Like GreenFloors, Smart Certification complies with ISO standards and uses life cycle analyses to determine whether or not a home furnishing can be considered environmentally preferable. Environmental preferability is beginning to have a significant impact on the home furnishing industry. Specifically, one company, Kincaid Furniture, is starting to promote their new line of environmental friendly furniture called Eco3Home (AHFA, 2010a). These home furnishings claim to meet or exceed federal safety standards and other standards regulating the emission of toxic chemicals. However, the general safety of any environmentally preferable counterpart to a standard home furnishing is unknown. When using recycled or new materials, an in-depth analysis must be performed to investigate whether or not these products present not only a fire or burn hazard, but a health hazard.

2.3.1 Voluntary and Mandatory Standards for Home Furnishings

Home furnishings are generally the first items to be ignited in the majority of building fires (Fowell, 1994). The severity of a residential fire is dictated by the flammability of each furnishing. The creation of standards under NFPA and ASTM International led to methods to control the ignition of furnishings and the spread of fires. By setting standards for products such as wall, floor and ceiling coverings, the threat of flame spread between the furnishings is reduced. A home furnishing can go through a variety of testing depending on its different

components and use. For example, if a material is painted, it must comply with section 101 of the Consumer Product Safety Act (1972), which establishes a regulation concerning the level of lead paint, as well as NFPA 261 (2009), which focuses on cigarette ignition of upholstered furniture. However, there are currently no mandatory standards for the fire rating of un-upholstered furniture.

Other than fire related hazards, health hazards are also associated with home furnishings. Some home furnishings are painted, stained or have some kind of adhesive applied to them. Finishers used in home furnishings often off-gas chemicals known as volatile organic compounds (VOCs) that may cause symptoms such as sore throat or nausea. These compounds are usually associated with paints. Although the EPA enforces some mandatory standards for VOC content in products under the Clean Air Act (2004), there are currently no state-wide standards for VOCs in non industrial settings (EPA, 2010b).

2.3.2 Environmentally Preferable Home Flooring

Alternatives to home flooring are becoming more numerous. Though still popular, traditional flooring such as hardwood or laminate is being replaced by products such as cork or bamboo. This section will describe in detail two types of environmentally preferable alternatives to traditional flooring. The section will also provide areas of potential hazard associated with each type of flooring.

Marmoleum

Selling approximately \$900 million dollars in 2009 in flooring alone, Forbo claims to be the leading manufacturer of linoleum flooring (For more information on Forbo please see Appendix H). In their vision statement, Forbo expresses their concern for creating better environments and more rewarding opportunities for all consumers and industries (Forbo, 2010).

In accordance with their vision, Forbo created renamed and revamped linoleum into a new flooring called marmoleum.

In 2002, Forbo requested a life cycle assessment of linoleum, a product first developed in England during the 1800s. Linoleum is a floor covering made up of mainly linseed oil, wood flour, and jute. During the manufacturing process, linseed oil, wood flour, and other raw materials are heated and mixed together then pressed into jute backing to form a sheet. Linoleum sheets are then hung to dry to allow them to cure and to acquire flexibility and resilience. The life cycle assessment aimed to gain insight into the environmental impact of linoleum, the effects of the different processes in making linoleum, and the possible improvement options (Gorree, 2002). Forbo's ultimate goal in requesting the life cycle assessment was to improve upon linoleum and create a new, more environmentally preferable product. The conclusion of the life cycle assessment was that linoleum is generally already environmentally preferable, though the drying process off-gassed harmful chemicals and improvements could be made to the distribution or transportation process. The completion of the linoleum's life cycle analysis led to the production of "new" linoleum product, called marmoleum. Marmoleum is composed of the same ingredients and is manufactured in a similar way to linoleum. Because they are composed of the same materials, for technical purposes, the terms marmoleum and linoleum can be used interchangeably. The difference is that Forbo markets marmoleum in a variety of bright colors, patterns and faux finishes not found in traditional linoleum.

Upon first examination of the composition of marmoleum (linoleum), one notices that the main ingredient is linseed oil. Extracted from the flax plant, a renewable resource that sprouts every year, linseed oil is prepared by crushing the seeds of the flax plant (Abraham, 1996). Here, the first possible safety hazard may arise; the growing of flax may involve the use of pesticides

that can be released when the product is installed into the home. After the seeds are compressed they are then made into oil and used in the manufacturing process of the flooring. During this process it is possible that marmoleum flooring could emit toxic compounds into the air. Not only can the linseed oil emit toxic chemicals, it may also be responsible for some fire related hazards.

Linseed oil, in itself, is highly flammable and combustible; however, the manufacturer claims that marmoleum is resistant to burning. Linseed oil is made of up three fatty acids, in which one, linolenic acid, is of interest due to its potentially dangerous properties (Abraham, 1996). In the liquid state, the double bonds in linolenic acid are located much closer together than in the other two fatty acids. Because the molecules are compact, oxidation of the acid occurs easily. The heat released from one bond undergoing oxidation results in a release of energy which heats up the next bond, which in turn heats up the next. This chain reaction can lead to spontaneous combustion and thereby cause a fire. However, it is more likely that such a reaction will occur in raw linseed oil and rarely occurs when the oil is absorbed into a material, like marmoleum. Linseed oil in marmoleum oxidizes and causes the flooring to harden as it is exposed to air. This process involves both auto-oxidation and polymerization. The hardening of marmoleum as it ages also accounts for its antibacterial properties (Kujawski, 2010). As the flooring hardens, germs, mold, or other types of bio-hazards cannot soak into the material and therefore remain on the surface. This also accounts for the marmoleum's anti-static properties as dust and dirt do not absorb into the flooring.

Although the hardening of marmoleum may present some positive effects, the oxidization of linseed oil may provide some adverse indoor air quality effects. One important environmental concern is health effects related to indoor air quality (Knudsen, 2007). In general, natural materials, like linseed oil, are more susceptible to degradation than synthetic or man-made

materials. In a study done by Knudsen for the Danish Building Research Institute, emissions from products with and without linseed oil were tested. The experiments tested emissions from two types of linoleum against two types of synthetic flooring (PVC). The results (shown in Figure 2) illustrated that products with linseed oil negatively influenced the perceived indoor air quality and was persistent over a period of 51 weeks. These emissions were concluded to be due to volatile organic compounds (VOCs). Although the comfort level is altered when VOCs are emitted, it is uncertain whether or not the product is labeled as a health hazard. A possible error exists in this study; consumer sensitivity is not uniform and the emissions of VOC can cause allergic reactions to some consumers but be completely benign to others.

Odor Intensity and Acceptability for Products with/without Linseed Oil

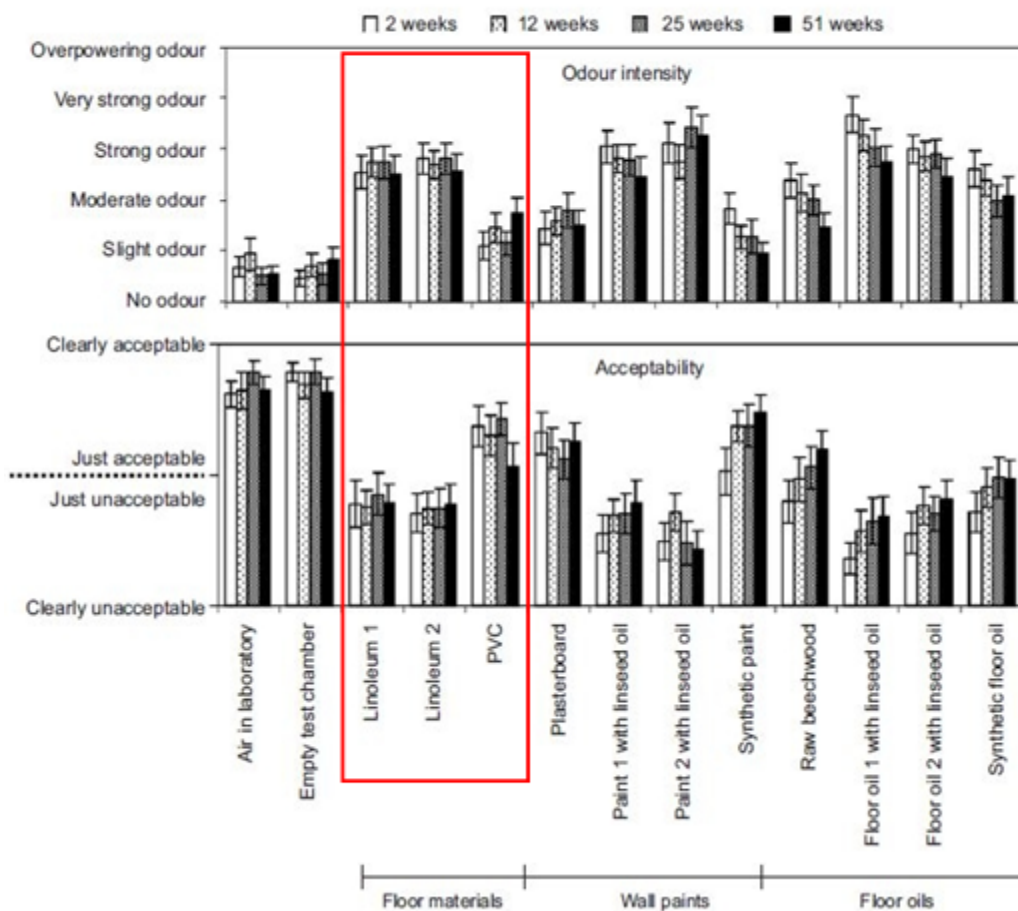


Figure 2 Perceived odor. (Knudsen, 2007). The important products to note are the floor materials. When compared to PVC, linoleum emitted more odor than standard flooring. Linoleum for this purpose is interchangeable with marmoleum.

Aside from possible hazards, marmoleum is recognized for its ecological benefits and is claimed to resist burning, have anti-static properties, and emit no toxic compounds. One of Forbo's marmoleum products, marmoleum easy loc, is rated in its technical specifications as a having no health danger, is cigarette and chemical resistant, and will have no toxicological effects on humans (Forbo, n.d). Marmoleum is also resistant to flame, as it will have to be exposed to open flame for over 10 minutes before it flashes (Forbo, 2005). Used in any space, marmoleum is becoming widely popular.

Cork

Although used for many centuries, cork is now becoming a popular commodity for home flooring. Known as an environmental counterpart to traditional home floorings, cork is made from a renewable resource and is found in areas such as Portugal and the west Mediterranean (Capri Cork, 2010). Cork, the material used in the manufacture of cork flooring, comes from the bark of the cork oak tree. Unlike most trees, the bark of the cork oak tree is only a protective layer and is not essential to the tree's survival; therefore, the harvesting of cork is done without harming the tree. In fact, it is this characteristic of cork flooring, which defines it as an environmentally preferable product.

Unlike products such as marmoleum, cork is manufactured and sold by a variety of companies, such as Zandur and Ecohaus (for more information on companies please see Appendix H). These companies claim that cork floorings are natural heat and acoustic insulators, hypoallergenic, static resistors, and provide a softer floor to relieve human joint pain. Each of these claims relies on the natural physical properties of cork. Cork is a porous material that contains approximately 40,000 cells per square centimeter that are filled with air, allowing for thermal and acoustic insulation (Pronto Kork, 2010). The air filled bark also accounts for the softer, more cushion-like floor. Although cork does have many built in positive effects, depending on its manufacturing process, the product may present a health hazard.

The manufacturing of cork begins with the removal of bark with an axe (Capri Cork, 2010). After the bark is removed from the tree, it is dried and boiled. Most cork is made into stoppers whose waste is usually ground up and made into composite material for cork tile. Composite cork is then mixed with appropriate binders such as phenolic, cardolic, and polyurethane resins, and then compressed and heated to temperatures as high as 130°C for two hours (Horn, 1998).

The binding resins used in the manufacturing process could account for a percentage of emissions of harmful toxins in the air. A study done by Horn (1998) for the Federal Environmental Agency in Berlin, tested the VOC emissions from cork products to address frequent complaints that composite cork products emit unpleasant odors. The actual toxicity of such odors was unknown and therefore tested. After obtaining cork from commercial stores and testing it, the results showed that organic compounds furfural and phenol were emitted and should be reduced. The exact source of the emissions from the composite cork was unknown though it is known that furfural, an organic compound, is formed if untreated cork is heated between 100°C and 150°C. During the manufacturing process, natural cork is heated to high temperatures and emits such toxins. The toxins could then be trapped inside the porous bark and be released into the home when installed.

Composite cork is only one type of possible flooring or layer in the product category of cork flooring. Cork flooring can even be mixed with other types of flooring like rubber. One manufacturer of rubber cork flooring is Zandur. Other than the claims already mentioned, Zandur specifically declares that their products are of high quality, are environmentally preferable, and do not involve any sort of “greenwashing” (Zandur, 2009a). In product specifications, rubber cork is resistant to certain chemicals, cigarette burns, and mold/mildew growth (Zandur, 2009b). The MSDS’s of Zandur products further establish the safety of their products by claiming that they do not create any health hazards (Zandur, n.d). Zandur is also a manufacturer of solid cork flooring that contains both raw and recycled cork..

In general, cork products are heat and acoustic insulators, which are naturally fire, mold, and mildew resistant. Depending on the binding or finishing products used, cork products may emit volatile organic compounds into the air.

2.3.3 Environmentally Preferable Paints

Environmentally preferable paints are those that claim to emit no or low amounts of VOCs or are made from all natural products. According to the EPA, organic compounds can average two to five times higher indoors than outdoors (EPA, 2010b). Chemicals that emit VOCs are those used for drying and coloration. High levels of VOCs can cause health effects like sore throat, nausea, or headache. Environmentally preferable paints claim to benefit the consumer by reducing the frequency or severity of these health effects.

No VOC

Paints labeled as containing no VOCs are those that contain 5 grams/ liter or less of VOC content (EarthEasy, 2010). These paints can still contain colorants and chemicals used for drying. Companies such as Olympic, Sherman Williams, and Yolo are marketing paints that claim to have zero or no VOCs (for descriptions on manufacturers see Appendix H). These paints are said to allow the customer to breathe easily as they makeover their home (Olympic, 2010).

Low VOC

Paints containing less than 200 grams/liter of VOC content are labeled as low VOC paints (EarthEasy, 2010). Although most paints do not exceed 200 grams/liter of VOC, many environmentally preferable products labeled as low VOC contain approximately 50 grams/liter of VOC. Unlike traditional paints, low VOC paints or varnishes contain no or very low levels of formaldehyde, as they use water as base rather than petroleum based solvents. Benjamin Moore claims to manufacture a low VOC paint that covers surfaces in one coat, is durable, and able to be scrubbed (Benjamin Moore, 2010). Other manufactures include Miller Paints and Cloverdale (for information of manufactures, please see Appendix H).

Natural

Made from raw ingredients, such as plant oils and dyes, clay, chalk and milk, natural paints are those that are said to give off almost no smell (EarthEasy, 2010). Natural paints claim to include no toxins, are non-allergenic, and safer for human health and the environment.

EcoDesign's BioShield is just one manufacturer of all natural paints among many. The BioShield collection of paints and stains are primarily made from natural raw materials including essential oils, seed oils, tree resins and citrus peels. These paints and finishes also claim to not only eliminate harsh odors, but also release a mild fragrance to enhance painting experience.

Although BioShield paints claim to be environmentally friendly, emit no toxin, no VOC and provide optimum breathability, they may create adverse effects if dispersed into the environment. (BioShield, 2003)

2.4 Home Maintenance

“Home maintenance products” are identified as products that are used in cleaning the household or aid in chores and daily tasks. Household cleaning supplies include, but are not limited to, products such as liquid drain cleaners, detergents, soaps, glass cleaners, personal hygiene products, chemical deodorizers, and bleach. This specific grouping of products as “home maintenance” products follows the categorization used by the CPSC databases.

Cleaning compounds are both ubiquitous in American households and cheap. This makes it easy for a consumer to switch brands from a more traditional cleaner to a “green” alternative. Therefore, the categories of home maintenance products we have created for the purposes of our research are those that replace common household cleaners, detergents, and

bleaches. These alternative green products have the potential to affect a large amount of consumers if they are indeed hazardous.

Many cleaning supplies are already known to be irritants and slightly toxic. It has been shown that individuals employed as professional residential cleaners have an increased risk of asthma (Anto, 2005). The cause of many forms of asthma is believed to be associated with chlorine and ammonia vapors, which are both found commonly in standard cleaning chemicals. Due to these concerns, environmentally conscious organizations often advise people to avoid buying home maintenance products containing certain chemicals (Green Living, 2010a). Manufacturers of environmentally preferable home maintenance products tend to change the products to exclude petroleum-derived components and other substances they consider to be toxic or hazardous.

One of the reasons for researching home maintenance products is because they have been one of the many product categories targeted by manufacturers of environmentally green products. Products made for everyday use in the home are generally cheap and simple to modify, and as such it is easy to transition from one brand to another. For this reason, home maintenance products made using “green chemistry”, such as soaps and detergents, have existed in markets for some time. More complex green chemical products are relatively new (Poliakoff, 2002).

One interesting aspect of the green movement is the number of small companies that have, in effect, been created by it. Numerous, if not countless, companies are now marketing environmentally preferable products to consumers. As a result, it is difficult to ascertain which companies or products to study, and reviewing all possible combinations would be impossible. The following sections attempt to provide an accurate overview on both the important large and

small companies and on a wide as possible variety of the different types of home maintenance products available.

2.4.1 Voluntary and Mandatory Standards for Home Maintenance Products

The Federal Hazardous Substances Act of 1960 and the Poison Prevention and Packaging Act of 1970 are statutes enforced by the CPSC and regulate products that are bought, stored, or brought into a living space at any given time, such as cleaning products. These Acts outline how each cleaner or related product should be labeled according to its contents. Mandatory standards under these acts include having a label on the product container indicating the name of the manufacturer and the distributor, the common name of each ingredient, storage instructions, and instructions for first aid. These labels also include signal words such as “danger” if the product is extremely flammable, corrosive, or highly toxic, “warning” for all other products, and an affirmative statement such as “harmful if swallowed”. Each cleaning product that is flammable, toxic, or corrosive must also contain, in large letters, “keep out of reach of children” (Federal Hazardous Substance Act, 1960, p.6). The Poison Prevention Packaging Act (1970) requires that hazardous chemicals have childproof caps.

Concerns about eutrophication spurred a voluntary industry ban on phosphates greater than 8.7% by weight in 1970 (Litke, 1999). Phosphates have been banned by law in laundry detergents since the U.S. signed the 1972 Great Lakes Water Quality Agreement with Canada (International Joint Commission, 2009). This agreement was adopted state-by-state in order to reduce the eutrophication process on the Great Lakes. Although the detergent industry initially fought the ruling, eventually all laundry detergents had their phosphate content reduced to at least 0.5% by weight (Knud-Hansen, 1994). A less benign result of this was the manufacture

and use of nitrolacetic acid (NTA) in laundry detergents, which initial data suggested was toxic to humans (EPA, 1977). This compound was eventually phased out, and in the meantime a lesson about exchanging environmental health for human safety should have been learned. The important goal for the CPSC will be to make sure that a similar trade-off does not occur.

Although states have been individually banning the use of phosphorous in dish detergents since the 1970's, it was not until 2010 that the industry voluntarily banned the compounds from all dish detergents (American Cleaning Institute, 2010). This was done in response to several new state bans that had already set strict standards on phosphate content in detergents. Previously, companies that manufactured environmentally friendly dish detergents had already removed phosphorous from their products (Cascade, 2010). Since the ban, all members of the American Cleaning Institute have removed phosphates from their detergents.

Although the CPSC has standards on what should be indicated on the labels of each household cleaning product, it does not regulate exactly what kinds of chemicals or substances are contained in each cleaner. The CPSC has banned certain chemicals, such as liquid drain cleaners containing 10% or more of sodium hydroxide and potassium hydroxide (Federal Hazardous Substances Act, 1960, p. 4). But because there are few safety standards on what kinds of chemicals can be used in cleaners, it is possible that some could be more flammable, corrosive, or toxic than others. Other agencies that regulate cleaning products include the Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA), and the Food and Drug Administration (FDA); however, the CPSC generally regulates all chemical cleaning products readily available to consumers and described as hazardous.

One organization that regulates both product safety and environmental preferability is the Environmental Protection Agency. These voluntary standards are created by the EPA's Design

for the Environment (DfE) program. The webpage for DfE lists numerous home cleaners that have achieved their certification (EPA, 2010c). Although most of the certified chemical products are used for primarily industrial applications, the Dfe does certify home maintenance products intended for consumer use. An example of products that have received the certification would be the Clorox company's "GreenWorks" line of products.

2.4.2 Environmentally Preferable Detergents

Detergents can be described as a compound that has similar cleaning properties when compared to soap. Detergents generally contain several compounds, such as solvents, surfactants, and builders. Surfactants are generally used to emulsify inorganic and organic compounds. Some surfactants foam in order to increase their dissolving powers. Builders act to remove hardness from the water so other cleaning agents can be more effective (Litke, 1999).

The exclusion of sodium triphosphate builders in detergents made a significant impact on the detergent industry. Phosphates have been used in detergents for decades. Unfortunately, when phosphates from detergents are discharged into local water sources, rivers and lakes are artificially fertilized (Hanrahan, 2004). This fertilization process results in algal blooms and eutrophication, which is when a water source becomes choked with plants and aquatic animals suffocate from the lack of oxygen (EPA, 2010d). There is currently a consumer concern that phosphate-free cleaners do not perform as well as those with phosphates, but companies are continuing to phase the phosphates out (Navaro, 2010).

Seventh Generation (2010e) makes an environmentally preferable laundry detergent, among other products. Most of the surfactants appear to be plant-based and the MSDS lists that the product may be an irritant (Seventh Generation, 2010c). The first aid measures appear to be benign, requiring rinsing with water for eye exposure and drinking a glass of milk for ingestion.

Seventh Generation (2009c) also makes a powdered detergent, which is listed as toxic if ingested. As the powdered version is more concentrated, it presents more of a hazard if exposed to the eyes or ingested. The main ingredient is sodium carbonate, which is not that hazardous a compound. Method is another company which makes an environmentally preferable laundry detergent. Although Method (2010) does not make the MSDS available on their website, they do advertise the solvents and surfactants as being plant-based compounds and enzymes. One last laundry detergent is made by Green Works, which is a brand name created by the Clorox Company. This detergent advertises its several plant and enzyme based cleaning agents heavily, although they use the more complicated chemical names on the ingredient list (Clorox, 2010b). Green Works detergent does not have any hazardous compounds listed by the International Agency for Research on Cancer (IARC), the Occupational Safety and Health Administration (OSHA), or the National Toxicology Program (NTP). The product is considered an eye irritant.

One popular brand of traditional laundry detergent is Tide, which is owned by Proctor & Gamble. Tide offers a variety of detergents, but in general the active ingredients do not change often. The MSDS lists ethanol, borax, and ethanalamine as hazardous compounds according to OSHA regulations (Proctor & Gamble, 2007). Gain is also made by Proctor & Gamble and appears similar to Tide. The MSDS sheets list several more hazardous compounds listed under OSHA regulations than Tide, such as alcohol ethoxylate and linear benzene sulfonic acid (Proctor & Gamble, 2009b). Wisk is a laundry detergent made by JohnsonDiversey. The detergent contains amines, sodium borate, and other compounds as hazardous (JohnsonDiversey, 2008). All of these detergents use some amount of ethanol.

Aside from the phosphate ban, dishwashing detergents have . Clorox's Green Works brand makes an environmentally preferable dishwashing liquid. The compound is an eye and

skin irritant, but none of the ingredients are considered toxic (Clorox, 2010a). Seventh Generation owns a brand of automatic dishwasher detergent that comes in a gel form. The MSDS lists one fragrance as a mild irritant, but another is considered a moderate irritant (Seventh Generation, 2009a). The safety precautions are similar to other common first aid procedures, with immediate rinsing upon exposure to eyes and skin. Ecover is a Belgium company that makes dishwasher detergent in a tablet form. The MSDS lists the compound as a serious hazard to the eyes (Ecover, 2006). Unlike other detergents, the first aid procedures require the afflicted consumer to seek medical attention upon ingestion or eye exposure instead of suggesting it.

Cascade is a popular brand of dishwashing detergent used in automatic dishwashers. Although Cascade has recently gone phosphate-free, the brand is not as environmentally preferable as those previously mentioned. The first aid procedures for Cascade generally include rinsing the affected area with water, or drinking water if the product is ingested (Proctor & Gamble, 2010). The product is stable and is only a slight health and flammability hazard. Dawn is another product owned by Proctor & Gamble, and is produced as a liquid detergent. P&G's (2009a) Ultra Dawn is the most chemically intensive of all their Dawn products, although the MSDS lists ethanol as the only hazardous compound. Finish is a detergent made by Rickett Benckiser (2010a) and the powdered form is classified as a moderate health hazard. This is more severe than most of the other brands, which are generally classified as slight or moderate health hazards.

2.4.3 Environmentally Preferable Bleach Alternatives

Bleaches are used in most households to remove stains from white clothing. Most modern bleaches use chlorine, which is well known to be a skin and eye irritant (Clorox, 2009).

Environmentally conscious individuals tend to use alternative bleaches that contain no chlorine. There are several variations of alternative bleach, which utilize hydrogen peroxide, citric acid, carbonate compounds, and different types of salt. Although these products are all aimed at environmentally conscious consumers, many green websites post the benefits of using a single product, such as hydrogen peroxide, instead a particular brand named product.

Tide currently makes a liquid laundry detergent which contains a bleach alternative (Tide, 2010). OXO-Brite is a brand of powdered bleach by Earth-Friendly Products (2010) that utilizes sodium percarbonate and sodium carbonate in place of sodium hypochlorite. Ecover (2010b) also makes an environmentally preferable bleach based on sodium percarbonate. The brand is available in both liquid and powder forms, with the liquid form being in an aqueous solution with small amounts of hydrogen peroxide. Seventh Generation (2010a) makes a product that uses cosmetic-grade hydrogen peroxide in deionized water, without any other ingredients.

The MSDS for Tide's bleach alternative detergent lists few hazards (Proctor and Gamble, 2009). Precaution information for bleach-alternative exposure to the eyes, skin, ingestion and inhalation is not included, and for each of these hazards the bleach "may be an irritant". Rinsing with water is recommended for every form of exposure. Oxo-Brite is considered reactive, but only in extremes of temperature or moisture (Earth Friendly Products, 2003). Oxo-Brite's powder is concentrated and as such any exposure requires immediate rinsing with water. The substance appears to be most dangerous to the eyes, and the MSDS advises contacting a physician immediately should the bleach be exposed to them. Ecover's (2008) MSDS for liquid bleach is more direct, identifying the product as a serious danger to the eyes, possibly to the point of inflicting blindness. The powdered form of bleach appears to be safer, and is listed as a mild irritant (Ecover, 2010a). Both the liquid and powder forms pose a fire danger if mixed with

combustible fluid. Seventh Generation's chlorine-free bleach is slightly more benign. Although the eye and ingestion hazards still have first-aid procedures, the inhalation and skin exposure hazards are listed as not applicable (Seventh Generation, 2009b). All of these manufacturers require their bleach to be kept out of reach of children.

Clorox regular bleach appears to have a monopoly on the chlorine bleach market; few other brands were easy to find on an extended internet search. Chlorine bleach's active ingredient, sodium hypochlorite, is well-known to be caustic and corrosive. Any eye or skin contact with Clorox (2009) regular bleach requires rinsing the exposed area with water for 15-20 minutes. Clorox bleach is listed as stable under normal storage conditions, but is considered a "strong oxidizing agent". Cloralex is chlorine bleach made by AIEn Americas, a division of the Mexican company Industrias AIEn. It is currently the #1 bleach in Mexico, and is actively exported to the United States (AIEn Americas, 2010). Cloralex's bleach is listed as an unstable compound, whereas Clorox's MSDS makes no comment of the bleach's chemical stability (AIEn Americas, 2004). It uses the same chlorinated compounds as Clorox bleach.

2.4.4 Environmentally Preferable All-Purpose Cleaners

One major area where manufacturers of environmentally preferable products have a strong market demand is in home cleaning chemicals. Many chemical cleaners now use compounds such as calcium ascorbate and citric acid in place of more traditional chemicals, which often included formaldehyde and ammonia (Green Depot, 2010). Another significant area of focus for manufacturers has been to leave out any chemicals derived from petroleum. Although the resulting products are considered non-toxic, whether or not they present unidentified inherent risks is still unstudied.

All-purpose or multi-purpose cleaners are used around the household to clean up soiled surfaces and stains. Because they are all-purpose, these cleaners must generally be stronger than a specialized cleaner due to the large variety of messes they must clean, which usually include grease, grime, soil, and stains. Generally these products work on most common hard surfaces and cannot be used for carpets or upholstery. The opinion that some of these compounds may be worse than merely “irritants” has resulted in environmentally preferable alternatives to be produced.

The green movement has created opportunities for both existing and new businesses, as well as for ambitious entrepreneurs. One company that sells environmentally preferable household cleaners is Sunshine Makers, which sells the Simple Green brand of cleaning chemicals. More information about Sunshine Makers can be found in Appendix H. Green Depot (2010) is both a manufacturer of “green” all-purpose cleaning products as well as a supplier of other brands. Seventh Generation (2010b) carries an all-purpose cleaner called Free & Clear that uses plant-derived cleaning agents. Better Life (2010b) is a newer company which has created several cleaning products based on natural ingredients. Their products are sold at Walgreens and other retail stores. Countless other retailers of cleaning products doubtlessly exist as small businesses. The lasting demand created by the green movement has created and sustained this market niche.

Some larger companies have also created product lines that claim to be “green” cleaners. The Clorox Company’s Green Works brand claims to use plant and mineral-based biodegradable ingredients (Green Works, 2010a). Staples (2010) owns the Sustainable Earth brand of products which claims to have less toxicity and perform better than the leading brands of cleaners.

Although other large companies have also entered the “green” market, it appears as though small-scale manufacturers are more prevalent.

The only hazard listed for Simple Green All-Purpose Cleaner in the provided MSDS is that the product is a mild eye irritant (Simple Green, 2010b). Yet unlike other cleaners, there are no safety issues listed with accidentally inhaling or ingesting the cleaner. Green Depot’s cleaner appears to be similarly benign, stating standard first-aid procedures under the safety section of the MSDS (Green Depot, 2009). One possible point of concern would be that the compound is not listed with OSHA, and all of the health hazard data lists that the cleaner “may be an irritant”. While these statements suggest the active ingredient, alcohol ethoxylate, is unstudied and therefore suspect, it is more likely that the compound is harmless enough not require safety certifications. The cleaner used by Green Works (2010b) is listed simply as an irritant, with basic first aid instructions to flush any irritated area with water. Seventh Generation’s natural all-purpose cleaner is listed as a minimal irritant, yet the first aid procedures demand immediate attention if the cleaner is spilled onto the eyes or ingested (Seventh Generation, 2010d). Seventh Generation’s cleaner also bears a label that states “KEEP OUT OF REACH OF CHILDREN AND PETS”. Better Life (2010a) does not have an available MSDS sheet available on their website, but they list the ingredients in their what-EVER! brand of cleaner to be coconut, vegetable, and amino-acid based surfactants.

Competing non-green products appear to have similar hazards. Formula 409 is made by Clorox (2007) and appears to be similar to the Green Works brand also manufactured by Clorox. The MSDS lists first aid for irritation and the product is considered a mild eye irritant. Fantastik, which is manufactured by SC Johnson (2008), is listed as a moderate eye irritant. Reckitt Benckiser (2010b) makes the popular Lysol brand of all-purpose cleaner. Lysol is an eye and

skin irritant. The cleaner is also considered hazardous as per the definition given in 29 CFR 1920.1200. Both Lysol and Fantastik have a rating of “2” (Moderate risk) in the health section of the NFPA fire diamond, whereas most other cleaners have a rating of “1” or “0” (slight or minimal risk).

Although many environmentally preferable cleaning chemicals exist on the market, many homeowners chose make their own home maintenance compounds. Since the best “green” products are meant to be local and natural, the “greenest” product is one that is grown in a garden and then made by hand. Although few consumers go to such extremes, it does appear that a significant number of people do purchase store-bought natural products and mix their own cleaning chemicals. Several professional websites offer tips on how to make effective mixtures of natural chemicals for the best, non-abrasive cleaner (Martha Stewart, 2010). A few of these organizations give highly detailed guides with safety instructions included, such as the one found on the Consumer Reports (2010) website.

2.5 Building Materials

The materials used to construct a building, whether residential or commercial, play an important role in how that building may be affected or damaged by natural disasters, fire, and even time. As many new materials have been developed within the last century, it is imperative that the long term and short term effects of these building materials are studied. Companies manufacturing environmentally preferable building materials seek to reduce adverse health effects, if they exist, as well as reducing the strain on the environment and natural resources created by the production of traditional building materials. While these products were created to offer consumers a “green” alternative, the overall safety of the products, as well as their potential

hazards, may not be well documented. However, all of the products discussed in this section have met the safety standards that apply to all consumer products.

There are several qualities that can allow a building material to be marketed as green (Ryan, 2006). Some products may have environmentally conservative properties, such as being made out of recycled or rapidly renewable materials, reducing waste or preventing pollution, saving water, and being durable. A product may also be considered green if it has a less adverse impact on human health than its standard counterparts. Many green building materials are non-toxic, non-allergenic, have no or almost no volatile organic compounds, have no combustion gasses, and exhibit mold resistance. Green building materials usually also promote energy efficiency by utilizing a renewable energy source or are designed with energy conservation in mind. There are also some qualities of green building materials that may have nothing to do with their design or function. Materials manufactured locally provide an economic stimulus to small businesses, which is beneficial to the environment in which certain individuals live. Products manufactured by factories with worker protection may also be called green according to some standards. A building or construction material with one or more of the characteristics listed above may be believed to be beneficial to the environment, but each characteristic is not equal, and therefore some products may be greener than others. However, how green a product is measurable only with a high degree of inaccuracy.

Some of the major categories of construction and building materials include insulation, structural materials, and roofing. These three categories make up the main components of every building and depending on what materials they are made out of or how they are constructed, can alter how a building is affected by fire or natural disasters. The following sections will provide

background information about two specific categories of building materials and some of the products that fall within these categories.

2.5.1 Voluntary and Mandatory Standards for Building Materials

Most of the existing safety standards occur at the level of the building or structure, rather than at the level of their building material components, in order to regulate how different materials are used in conjunction with one another. The Nation Fire Protection Association (NFPA) has numerous building codes to help reduce the risk of fire spreading in residences and commercial structures alike. However, all building materials must be tested in accordance with the proper NFPA (2009) standard before being used in any kind of construction. Testing done to meet the NFPA standards must determine the ranking of flame speed and smoke development. In addition to passing the laboratory tests, each material must be in accordance with the building construction and safety codes detailed in NFPA 5000 (NFPA, 2009).

Engineered wood products follow the same voluntary building and material fire standards that regular solid wood lumber materials follow. UL 263: Fire Tests of Building and Construction Materials provides an outline of different fire tests, as well as outcomes and their respective ratings. These tests cover all structural materials, which include walls and other kinds of partitions. The results of the standard fire tests describe the burning characteristics of the tested material, including rate of flame spread, ignition temperature, and measurement of the transmission of heat and gasses through the material. The load bearing ability of the material is also tested with and without end support conditions (Underwriter Laboratories, 2010). Other American National Standards Institute (ANSI) certified standards organizations, such as the Engineered Wood Association, have voluntary industry standards for engineered wood products regarding performance and quality.

Cellulose insulation is regulated by the Interim Safety Standard for Cellulose Insulation written by the CPSC and enacted by Congress in 1979 (16 U.S.C. § 1290). The standard focuses on the flammability and corrosiveness towards aluminum, copper, nickel, and steel of cellulosic insulation products and outlines the testing procedures for these characteristics. The American Society for Testing and Materials (ASTM) also has a series of voluntary standards regarding cellulosic thermal insulation, but specifically ASTM C739 – 08: Standard Specification for Cellulosic Fiber Loose-Fill Thermal Insulation sets the testing procedures and standards specific to the kind of insulation discussed in the section below (see section 2.6.3).

2.5.2 Environmentally Preferable Engineered Wood

Engineered wood is a kind of composite material that is made from a combination of adhesives and wood particles, fibers, or veneers (Einsaphr et al., 1984). Engineered wood is also a wood derivative product, meaning that it retains some of the qualities of solid wood and can be used as a wood substitute for certain purposes. It is often manufactured for a specific purpose and it may not be suitable for other unintended uses. For example, a certain kind of fiber board may be designed to be used as the back piece of shelving unit: it would not be very strong, because it would mostly be decorative, rather than load bearing. But if a consumer were to purchase this type of fiberboard and use it for load bearing purposes, it would most likely break. The density of the wood board and the types of adhesives used to make the board are also major determinants in how the board burns (Einsaphr et al., 1984). The chemicals used during manufacturing and in the final product also may have an impact on human health in the form of emissions.

There are many different kinds of engineered wood products, but the following sections will focus on particleboard and homasote. Both of these products have been advertised as being “green” and have some qualities that help to reduce their environmental impact.

Particleboard

Particleboard is made from wood waste products, like sawdust and wood chips, and a synthetic resin or chemical binder. It was first created in Germany during World War II, to address the growing lumber shortage during wartime. Since then, particleboard has been a popular wood substitute for flooring, furniture, décor, and building adornments. It is usually fire resistant (with the addition of flame retardants) and mold resistant (Einsaphr et al., 1984).

Particleboard can be considered an environmentally preferable product because it is composed of waste materials. According to a study done by Oregon State University, (Currier, n.d.), particleboard makes use of 95% of a tree, whereas solid-wood lumber makes use of only 63%. Solid-wood lumber requires wood pieces of a certain length or width, ruling out the use of small branches or tree limbs. Particleboard is made by a manufacturing process called “dry-forming,” where wood scraps are reduced to a specific size, dried, sorted, blended with adhesives and waxes, and then hot-pressed to the desired size and density (Einsaphr et al., 1984). While particleboard is made from a waste material, it does require a much more energy-intensive manufacturing process in comparison to solid-wood lumber.

One area of concern for particleboard is the use of urea formaldehyde, which is included as a component in adhesives. Formaldehyde is emitted from particleboard and can reduce indoor air quality. The rate of emission of formaldehyde can change based on room temperature and humidity, but formaldehyde emission rates tend to decrease as the product ages (US EPA & CPSC, 1995). Acute (short term) symptoms of formaldehyde exposure include: increased

sensitivity, nausea, and difficulty breathing, as well as asthma attacks in people who have asthma. These symptoms may arise from exposure to formaldehyde gas at as little as 0.2 ppm (parts per million). There is currently not enough conclusive evidence to identify the chronic (long term) symptoms of formaldehyde exposure (Sierra Pine Composite Solutions, 2009). The World Health Organization (WHO) (Beauchamp et al., 2002) has examined the results of multiple experiments on the carcinogenic effects of formaldehyde through meta-analysis, and has found that in high concentrations, formaldehyde can be carcinogenic for model organisms. Despite this, the WHO has determined that the data from these experiments are inconclusive as to whether or not formaldehyde is a human carcinogen. However, formaldehyde is classified as a human carcinogen by the National Toxicology Program (NTP) and International Agency for Research on Cancer (IARC). At levels greater than 0.5 ppm formaldehyde gas, the Occupational Safety and Health Administration (OSHA) considers formaldehyde to be carcinogenic (Flakeboard America Limited [FAL], 2008).

There have been many recently developed “green” alternatives to particleboard, including Acadia’s DuraCane, Hawaiian’s DuraGreen, and Sierra Pine particleboard, all of which claim to be formaldehyde-free and meet the American National Standards Institute (ANSI) standard ANSI-208.1-1999 for particleboard. This standard restricts particleboard flooring emissions to 0.2 ppm and 0.3 ppm for all other particleboard products, as measured by the ASTM large chamber test (Green Seal, 2001).

While these products may protect consumers from formaldehyde exposure, the wood dust by-product created by the sawing, sanding, or hand assembly of composite wood products, like particle board, poses a serious health and fire hazard to consumers (Health and Safety Executive [HSE], 2003). People are most commonly exposed to wood dust through inhalation, skin

absorption, and eye exposure. Acute symptoms of exposure to wood dust include: eye irritation, allergic contact dermatitis, respiratory irritation, nasal dryness, coughing, sneezing, and wheezing due to inhalation. Prolonged and repeated exposure to wood dust may lead to increased sensitivity, irritating the skin, the respiratory system, or both. Both IARC and NTP consider wood dust to be a human carcinogen, based on the significant amount of conclusive research linking wood dust to adenocarcinoma of both the nasal and paranasal cavities (FAL, 2008).

Wood dust is also highly combustible, with a lower flammability limit (LFL), or lower range of volume for ignition, at 40 grams per cubic meter of air. Auto-ignition occurs at 400-500°F, similar to the flash point of wood (Universal Forest Products, 2010). Wood dust in the air is a combustible mixture that can undergo deflagration at a certain concentration and temperature. Deflagration refers to a kind of combustion where the flame is propagated by burning materials igniting adjacent cold materials and that has a flame spread slower than the speed of sound (Marshall, 2000). As illustrated in Figure 3, combustion can occur only after five factors are present: fuel, ignition, oxygen, dispersion, and confinement. In this particular case, the wood dust serves as the fuel for the fire. Wood dust may be ignited by any heat source, such as a cigarette, wood burning stove, badly maintained heating units, and overheated electric motors (HSE, 2003).

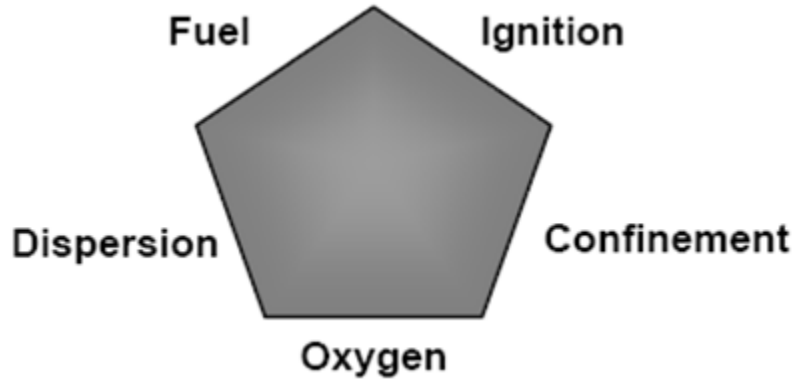


Figure 3 Dust Explosion Pentagon. This illustration shows the five elements necessary for wood dust combustion to occur (Marshall, 2000, pp.237).

Dispersion of the wood dust in the air, the source of oxygen, at a certain concentration is also necessary for flame spread to occur. Confinement provides a pressurized environment in which the combustion will take place. Sometimes, a wood dust explosion will disturb even more dust that may have accumulated inside wall spaces and other gaps, resulting in a secondary explosion (Marshall, 2000). Mandatory standards regarding wood dust safety hazards have already been developed by the NFPA and OSHA, but the regulations pertain only to commercial buildings. NFPA 654 (2000) provides characterizations of hazardous dust and requires factory inspections. Inspectors look for dust layers greater than 1/32 of an inch on or around equipment, floors, and structural members. An OSHA (2007) directive was also released in order to raise awareness of the dangers of combustible dust in the workplace, as well as procedures for inspection and ways to handle combustible dusts. No similar body of regulations exists to safeguard the consumer against wood dust inhalation or combustibility in their own home.

Homasote

Homasote is a type of cellulose based fiberboard made from recycled materials.

Manufactured exclusively by the Homasote Company (2010), homasote has been in use since the early 1900's and is considered to be one of the earliest advertised "green" products. Originally

used for automobile tops and railroad car siding, homasote was eventually expanded to include specific paneling products for wall surfaces, flooring, and thermal and acoustical insulation. Similar in composition to paper mâché, homasote is manufactured by treating recycled paper under high temperature and pressure, as well as combining the paper with some kind of adhesive chemical.

During the 1930's through the 1950's, homasote fiberboard became a popular, economical building material primarily used for the lining of wall surfaces and ceilings. After a number of avoidable fire-related incidents occurred, further research and testing was done on the homasote products to ensure improved consumer safety. Homasote is a Class C fire rated material under the standard UL263, and because of its low fire rating, it must be covered by dry wall in most interior applications (J. Clunan, personal communication, November 17th, 2010).

2.5.3 Environmentally Preferable Insulation Materials

Different kinds of insulation serve different functions, though the most common types are acoustic and thermal insulation. Acoustic insulation provides sound-proofing by damping the resonance of a room either by absorbing or reflecting sound waves (National Institute of Building Sciences [NIBS], 2010). Thermal insulation reduces the rate of heat transfer through spaces, allowing rooms or buildings to be temperature controlled or consistent. The R-value of this kind of insulation is a measurement of thermal resistance, or how well the insulating medium insulates. All different kinds of insulation are often marketed as “green” products, because they help to reduce energy costs for heating, regardless of what material it is made out of or how it is manufactured.

Blow-in Cellulosic Insulation

Loose fill cellulosic insulation can be made from a variety of cellulose materials or products, including newspaper, cardboard, sawdust, and cotton. Cellulosic insulation has been in

use for over a hundred and fifty years, but the most common form of loose-fill cellulosic insulation found today is made from ground recycled newspaper and was developed in the 1950's. There are four main kinds of loose-fill cellulose insulation products: spray applied cellulose, stabilized cellulose, dry cellulose, and low-dust cellulose. Spray-applied cellulose is applied to new wall constructs and acts as a sealant in the insulated cavity. It usually contains chlorine to resist moisture and some type of adhesive (Turret Group, 1991). Stabilized cellulose is commonly used in attic or roof insulation and is applied using a small amount of water, which activates the adhesive in the product and reducing settling problems. Dry cellulose is blown into the insulating cavities using a pump and temporary net retainers, which are taken down after the insulation reaches the desired density and R-value. Dust masks are usually worn during installation because of the large amount of dust generated by the product. Low-dust cellulose contains a kind of oil or dust dampener to reduce the amount of dust generated during installation (Turret Group, 1992).

Blow-in cellulose insulation often has a Class I fire rating due to the addition of a fire retardant during manufacturing, which makes up about fifteen percent of the overall product weight. This fire retardant is usually a combination of borate and ammonium sulfate, two compounds that effectively resist fire. However, certain companies may choose to replace borate with ammonium sulfate entirely, which helps to lower the cost of their product, but also results in a product that has less moisture and insect resistance, and is more corrosive to metals when damp (Murrel, 1991).

Two examples of loose-fill cellulosic insulation products that are advertised to be environmentally friendly are National Fiber Cel-Pak Cellulose Insulation and Green Fiber Insulation. National Fiber Cel-Pak Cellulose Insulation is made from 100% post consumer

recycled newspaper and a borate fire retardant. Because the borate compound contains boric acid, over-exposure through inhalation or ingestion may result in serious symptoms including: nausea, vomiting, diarrhea, drowsiness, headache, renal injury, cyanosis, coma, and death (National Fiber, 2009). Green Fiber Loose-fill Insulation is made from 85% recycled newspaper and contains a fire retardant mixture of boric acid, ammonium sulfate, and zinc sulfate. The symptoms listed above for Cel-Pak Insulation also apply to over-exposure to Green Fiber Insulation. The product will also off-gas carbon monoxide, boric acid, and other harmful airborne particulates during thermal decomposition (Green Fiber, 2010).

Chapter 3: Methodology

The goal for our project is to present the U.S. Consumer Product Safety Commission with recommendations to identify and address, if necessary, potential safety issues affiliated with certain environmentally preferable products. This chapter outlines the methodologies used to achieve our goal in relation to our objectives:

- ▶ Perform a market overview for environmentally preferable products;
- ▶ Identify the specific potential hazards of these products by comparing the specific characteristics of environmentally preferable products to the standard non-green products;
- ▶ Determine if existing federal and voluntary standards adequately address green products and if additional requirements are needed;
- ▶ Produce recommendations for the CPSC based on our findings about the general safety of the chosen specific consumer products.

We conducted interviews with experts in the fields of consumer product safety and fire protection, and examined the CPSC incident report database for supporting evidence to develop our recommendations. The exact procedures we used to achieve these objectives are detailed in the following sections.

3.1 Objective 1: Perform a Retail Market Overview

A market overview illustrates the consumer buying trend of the current market, future market, and trends that are associated with both. By performing a market overview of environmentally preferable products, we were able to identify which stores promoted environmentally preferable products the most actively. Through these store visits, we also were able to gain an insight into which environmentally preferable products were the most actively sold. When we compared this data to expert interviews, we were able to identify recent

developments in consumer buying trends and which populations of consumers are increasing their demand of such products.

To perform a market overview of environmentally preferable products, we first determined which retailers were of particular interest. These retailers are popular among consumers and have store locations throughout the country. The retailers we contacted were generally chain stores that either sold a wide variety of products or specialized in selling a large amount of products with a similar use. To further investigate the current and future markets, we interviewed sales and marketing representatives from each of these retailers. The primary way we contacted these representatives was by obtaining one or two expert contacts of chain stores from the CPSC staff. We also called the companies through the general phone numbers given to the public. We asked these contacts questions concerning the popularity of the “green” products carried in their stores and the retailer’s stance on green products and green product marketing.

We asked the following questions to each representative:

- Do you have your own criteria for what is green?
- Do you do additional advertising (beyond what the manufacturer does) for environmentally friendly products?
- What green products are currently popular?
- What is the least popular?
- Have any products been unexpected successes? Have any completely failed?
- What green products have gained and/or lost popularity?
- Do you have any reports on the trends of green product sales for your store?
- What do you see the future market for green products?
- Have any green products that your store sells ever been recalled?

The conclusion of the market overview led to an understanding of how these mass retailers view the “green” product movement and what trends the green product movement is currently experiencing. This data allowed us to address the most popular environmentally preferable products in our own research and determine which consumer population is most likely to buy such products.

3.2 Objective 2: Identifying the Specific Potential Hazards

There are many ways to conduct a full-scale laboratory test for the purpose of determining whether or not an environmentally preferable product presents a greater hazard than a non-environmentally preferable product. Our team had neither the time nor the proper resources to conduct and analyze such experiments therefore, we traveled to local branches of national chain stores to study samples, like eco-paint, and to observe how certain products were sold and packaged. This allowed us to determine whether or not a manufacturer conveyed the relevant safety information concerning certain products which were being tested and sold with protective coatings, chemicals, and finishes. We also tried to determine if the product that was passing safety tests was in fact the end product that was actually being sold to consumers. Some green product manufacturers do not use protective chemical coatings on their final products because the chemical coatings are considered to be harmful to the environment. Yet, when testing an unfinished product, a protective chemical may be applied to pass. We were concerned that if products were sold without such coatings, the product could present more of a safety hazard to consumers, who may not be aware that they must apply the protective coatings themselves.

The CPSC maintains a database of hospital reports describing injuries or other incidents which were related to, but not necessarily caused by, a consumer product. This database, called

the National Electronic Injury Surveillance System (NEISS), contains patient information from hospitals all over the United States. The medical information included in this database is not very detailed and required extensive sorting and analysis by the team. We also had access to the Injury or Potential Injury Incident (IPII) database, which is a database of incident reports. We searched both databases using the product codes provided in the table in Appendix G. We searched records dated from January 1, 2010 to December 1, 2010.

We first searched the CPSC's hospital database by product code for injuries caused by consumer products. We began by looking at these hospital reports and tried to identify whether or not the incident was due to human error during use, the product's operation, or a malfunction. Next, we examined the specific products that began showing patterns of incidents or an increased risk for a particular hazard. This allowed us to broaden our search to investigate the safety and hazard risks of an entire field of products. We also used the database to observe whether or not comparable non-environmentally preferable products have resulted in similar injuries. From these results, we were able to analyze the extent of the threat that an environmentally preferable product poses, based on its environmentally friendly qualities and characteristics. The patterns that we observed between products and hazards may not imply causal relationships, but they helped to identify certain "green" attributes of specific products that may contribute to increasing the risk of fire hazards or other injuries.

After we determined what fire hazards or other unintended hazards environmentally preferable household products could present, we identified characteristics of these products that led to such hazards. This research allowed us to make recommendations for improving consumer education concerning the safety of these environmentally preferable products and the effectiveness of regulations already in place. To do this, we used two techniques. First, we

researched both In-Depth Investigations (IDIs) and manufacturer information, and secondly, we interviewed experts from different organizations, including the Consumer Product Safety Commission, the U.S. Environmental Protection Agency, and the National Association of State Fire Marshalls (see Appendix C).

Having identified environmentally preferable products that present a possible hazard, we investigated them further through IDIs. IDIs are incident reports of consumer products conducted by the CPSC whenever they receive notice of a product failing and resulting in injury, death, or after a consumer files a complaint about a product he or she feels is unsafe. Whenever the CPSC receives news of a death or injury that the CPSC believes to be caused by a consumer product, an IDI is initiated. The resulting IDI report contains information about the source of the incident, the product failure or misuse that occurred, any resulting hospital reports, and an overall assessment of the hazard associated with that product. This information helped us determine what product characteristics present a hazard.

Lastly, we conducted interviews with experts from different fire safety oriented agencies and organizations such as the National Association of State Fire Marshalls (see Appendix C). We also interviewed more general product safety experts at the CPSC and environmental safety experts at the U.S. Environmental Protection Agency. By asking questions about the flammability of specific materials, common problems that lead to fires, techniques in making products fire resistant, and products that have well documented adverse health effects, we have identified possible solutions and recommendations for the consumer products in question.

3.3 Objective 3: Determine if Environmentally Preferable Products Are Fully Covered by Existing Regulations

The Consumer Product Safety Commission writes and enforces regulations over 15,000 types of products. Other agencies such as NFPA and ASTM International also have codes for consumer products. Standards and regulations include requirements on flammability, chemical content, and labeling amongst other categories. Each regulation or standard does not discriminate against products; standard and environmentally preferable products are treated in the same manner.

The assessment of potential hazards and hazardous characteristics associated with specific environmentally preferable products led to the analysis of the sufficiency of existing regulations. If certain environmentally preferable products presented hazards not regulated under existing standards and regulations, we provided recommendations for new or amendments to existing regulations. However, if environmentally preferable products did not present such hazards and complied with existing regulations, we provided recommendations for continuing the use of existing regulations, with few alterations.

Chapter 4: Results

This chapter will present the results we obtained from research, interviews, and data analysis. Included in this chapter are sections discussing a market overview for “green” products, specific environmentally preferable products, and potential associated hazards. The results presented below were the basis for the recommendations made to the Consumer Product Safety Commission concerning the safety of environmentally preferable products.

4.1 Market Overview

To complete a general market overview of “green” products, we visited national mass retailers and interviewed representatives from each of these stores. The stores we visited were chosen not only based on their popularity, but on their proximity to Washington D.C. At each store we visited we talked with sales associates or managers, took pictures of examples of green promotions, and examined informational product tags. We were also able to interview a few representatives from some of these companies using the set of questions listed in the methodology (see Section 3.1). The following sections will review our findings for each retailer, also summarized in Table 1, below.

Table 1: Retailers. The table below summaries market overviews of seven mass market national retailers. Some information was gathered through phone or in store interviews while other information was gathered at the actual store.

	Retailers						
	<i>DIY Store A</i>	<i>DIY Store B</i>	<i>Supplier A</i>	<i>Furniture Store A</i>	<i>Furniture Store B</i>	<i>All Purpose Store A</i>	<i>All Purpose Store B</i>
Products sold:	Textiles, home furnishings, home maintenance products, and building materials	Textiles, home furnishings, home maintenance products, and building materials	Home furnishings, home maintenance products, and building materials	Textiles and home furnishings	Textiles and home furnishings	Textiles, home furnishings, and home maintenance products	Textiles, home furnishings, and home maintenance products
Has own criteria for “green products”	Yes	No	Yes	Yes	Yes	No	No
Advertises “green” products in stores	Yes	Yes	Yes	No	No	No	Yes
Advertises “green” products on store website	Yes	Yes	Yes	Yes	Yes	Yes	No
Does market research for “green” products	Yes	No	Yes	n/a	n/a	No	No

DIY Store A is a nationwide retailer of textiles, home furnishings, home maintenance products, and building materials. The term “DIY” stands for “Do-It-Yourself”, a reference for the stereotypical consumer who shops there and is likely to be knowledgeable in home repair and renovation. This reflects the products DIY stores sell, which mostly consist of building materials and other home improvement products. To determine what is environmentally friendly, DIY Store A follows national standards, including Environmental Protection Agency programs like Design for the Environment, and third party testing. DIY Store A utilizes in-store promotions and displays to draw consumer attention to the various green products that they sell. DIY Store A also has a very detailed website, called “Eco Options,” which includes categorizations of all the green products they sell, as well as energy and water use calculators. Natedra Baks, senior manager of environmental innovation at DIY Store A, explained that DIY Store A has been conducting market research specifically for green products since 2006 due to the steadily increasing trends of consumer interest and demand for green products. DIY Store A plans to continue emphasizing these products as consumers become increasingly aware of them and more educated about environmental impact (N. Baks, personal communication, November 30, 2010). Notes from the interview with Natedra Baks can be found in Appendix E.

DIY Store B is another nationwide retailer of textiles, home furnishings, home maintenance products, and building materials and is a competitor of DIY Store A. DIY Store B sells Energy Star rated appliances and electronics, as well as Water Sense rated kitchen and bathroom fixtures. DIY Store B also utilizes in-store promotions and displays to draw attention to and educate the consumer about particular green products. Olympic paint, shown in the picture below, is marketed as environmentally preferable (Figure 4). According to a paint technician at

DIY Store B, although Olympic paints are more expensive, they are popular among consumers because they emit no harmful toxins or fumes.



Figure 4 DIY Store B: Paint. Olympic paint is a popular paint brand at DIY Store B stores. The can itself informs the consumer that it is a “green” product by its half green can and that it is certified environmentally preferable. The label on the right side of the can claims zero VOC emissions and uses the term environmentally preferable rather than eco-friendly or green.

Another large display of environmentally preferable products at DIY Store B included carpets.

The picture below illustrates the process a carpet made of P.E.T plastic chips or polyethylene terephthalate, a plastic resin and a form of polyester. The display, provided by the manufacturer and displayed in store, gives the consumer information on the environmental impact of this specific carpet (see Figure 5).

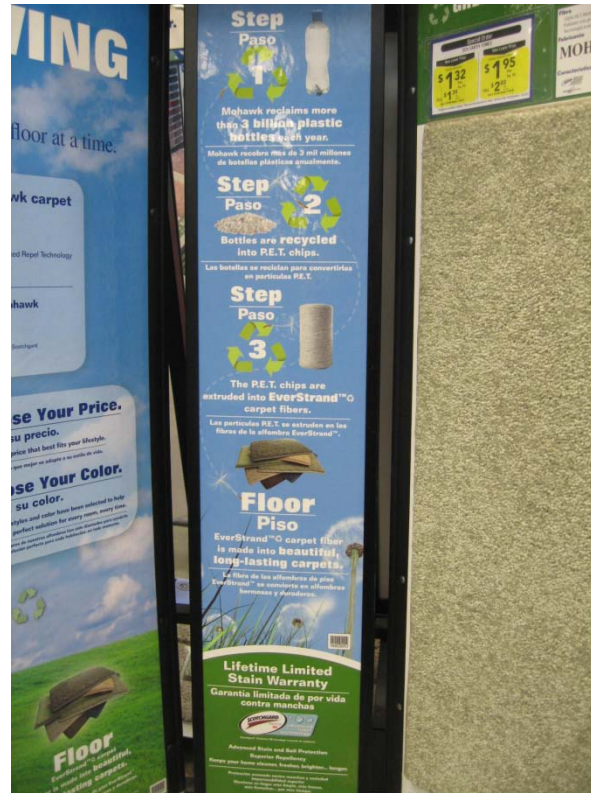


Figure 5 DIY Store B: Carpet. Green Living carpet, as shown above, is made of recycled P.E.T plastic. Plastic is formed into chips then into a thread that is made into carpet. The information provided by the manufacturer related to the consumer that this is a green product.

The DIY Store B website further promotes these products. Every October, DIY Store B publishes a newspaper insert advertisement encouraging environmentally conscious behavior and product use. Even though the company is aware of the growing consumer interest and popularity of green products, Michael Schnard, a DIY Store B representative, revealed that DIY Store B does not conduct any kind of market research specifically on green products. Michael Schnard believes that, in part, this is due to the nation’s current economic status; green products are often priced higher than their standard counterparts and have not necessarily fostered enough consumer confidence to be tracked as an individual product categorization (M. Schnard, personal communication, November 30, 2010). Notes from the interview with Michael Schnard can be found in Appendix E.

Supplier A is one of the largest nationwide retailers of exclusively environmentally preferable textiles, home furnishings, home maintenance products, and building materials. Supplier A has extensive criteria for the products they sell, which they refer to as their “Green Filter.” The “filter” contains criteria under the categories of conservation, location, energy, air quality, and responsibility. While we were not able to visit the Supplier A’s retail store, we were able to closely examine the Supplier A’s online shop, which actively promotes an environmentally friendly lifestyle through advertising and product information. After speaking with an anonymous sales representative, we were also able to discern that the most popular products at Supplier A are products that are not only made from environmentally friendly materials, but also claim to be safer for human health: VOC-free paint and Bonded Logic recycled cotton insulation (Anonymous, personal communication, December 1, 2010).

All Purpose Store A emphasizes the importance of sustainability on their website. However, when we visited the local store, we found no instance of additional marketing for environmentally preferable products. There were no signs or special aisles dedicated to green products. Several of their clothing products were environmentally preferable in that they were made of organic fibers or recycled materials (see Figure 6). While we were there, we asked the manager where the green products were located. He led us to the all-purpose cleaner aisles, where he was surprised to find that All Purpose Store A no longer carried the GreenWorks brand of cleaner. All Purpose Store A did not carry any environmentally preferable home maintenance products, home furnishings, or building materials. Attempts to contact All Purpose Store A representatives directly about their green product marketing failed to result in any useful information. Further attempts at using their customer service line failed.



Figure 6 All Purpose Store A: Clothing. Right: Clothing at All Purpose Store A advertised that this product is made of 100% organic cotton. The product itself has only a small label to promote the product as “green.” **Left:** A shoe made of recycled material advertised as “green”. With either product shown above, the consumer must be looking for an environmentally preferable product, because All Purpose Store A did not promote this product any further.

All Purpose Store B proved to be more active than All Purpose Store A in promoting green products. Although they had no advertisements promoting environmentally preferable products on their website, the local store had large banners promoting the benefits of such products (seen in Figure 7). In general, environmentally preferable products were isolated from their surrounding products and displayed with a banner overhead. These banners showed a picture of a leaf and explained that the products below were eco-friendly. Home maintenance products and health & beauty products were the most prominently displayed.



Figure 7 All Purpose Store B: Banners. In the home maintenance department, All Purpose Store B displays products that are environmentally preferable. Banners are set above products claiming natural or earth-friendly.

All Purpose Store B had a large number of environmentally preferable home furnishings, but these were not specially identified or promoted via in-store graphics and the only way to identify them was by an eco-label on the factory packaging. We could not find any green building materials or clothing, although they did have rugs made of recycled plastic. We spoke to the storefront manager, who informed us that she sees a lot of environmentally preferable products go through the checkout, but was unsure as to how they sold in relation to other products. When we contacted a representative from All Purpose Store B, we were unable to find information on how the corporation markets green products. We tried their customer service lines with the same result.

Furniture Store A produces and sells textiles and home furnishings, among other products, internationally. Furniture Store A sets its own environmental standards for

environmentally preferable products using analytical tools like the e-wheel. This tool takes raw material, manufacturing, distribution, product use and the end of the product's life into consideration during the design process. On their web site, Furniture Store A actively promotes their products as environmentally preferable by applying a set of 77 improvements listed on Furniture Store A's website. In the Furniture Store A local retail outlet, we visited in College Park, Maryland, we observed that there was no promotional material about the green product, on the products, or in the product displays. Promotions of environmentally preferable products were found on information panels next to the product, though no large panels were displayed (see Figure 8). Overall, Furniture Store A did not have a lot of specific product marketing of environmentally preferable products inside the local store.



Figure 8 Furniture Store A: Mattress Pad. Furniture Store A displays an environmentally preferable product. Information on the product is found on the side of the packaging, however, the promotion is on a small label that the consumer must look for.

Furniture Store B was the last retailer that we interviewed and visited. From kitchen goods to bed and bath and storage, Furniture Store B manufactures and sells a vast variety of products in their 160 stores located nationwide and in Canada. On their website, Furniture Store B promotes environmentally preferable products extensively. Many products are described as

eco-friendly or being made of natural materials. However, in the local store, Furniture Store B does not promote environmentally preferable products. Information about environmentally preferable products was shown on panels provided by the manufacturer next to the product (see Figure 9).



Figure 9 Furniture Store B: Chest. Bamboo chest found in the local Furniture Store B retail outlet. The store displayed information about the product provided by the manufacturer.

When interviewing sales associates, little knowledge was displayed about such products. Information gathered in an interview with Natalie Levy, public relations personnel, contradicted observations made in Furniture Store B. According to Levy, Furniture Store B is trying to have all retail stores inform consumers which products are eco-friendly, although consumers will sometimes have a “different perspective” of what is green (N. Levy, personal communication, November 30, 2010). It is unclear if Furniture Store B chooses which environmentally preferable products are sold in stores, although Levy suggested all products must comply with eco-labeling standards. Levy did not convey a clear definition of what eco-labeling standards Furniture store B abides by, only that some products may be certified according to the materials they are made from and how the final product is manufactured. The local retail outlet of Furniture Store B that

we visited in the surrounding area did not actively promote environmentally preferable products, the same cannot be said for other, larger or newer stores.

All of the retailers that we visited promoted environmentally preferable products to some extent. There tended to be more environmental information and advertising online rather than at store locations. In addition, sales personnel and managers at the store locations were not very well informed about environmentally preferable products in their stores. Most of the contacts listed in Appendix E reported that they did see an increase in the sales of their environmentally preferable products and that the increase has been continuing steadily. Many stores reported a surprising increase in sales including low and no VOC paints and kits for fitting toilets with water saving flush mechanisms. Despite the market for environmentally preferable products, most companies are not categorizing environmentally preferable products as anything more than fulfilling the products base function.

4.2 Identifying the Potential Hazards

In the following sections, we present the data we found in both the NEISS database and the IPII database. The data from the NEISS database reported in the following sections are not an accurate assessment of hazard risk nationwide and do not include a sample spanning all age groups and genders. The databases contain a collection of data which categorize incidents that might be reported by a hospital, and as result cannot provide a statistically significant sample of the U.S. population. Each hospital report was filed after an actual incident took place, but only a small selection of hospitals from across the country participates in this system. The data also cannot be generalized to apply to the entire population due to other reasons, such as the number of cases not reported or the accuracy of the report, which is generally brief and provides minimal details. However, the quantitative data retrieved from the database allowed us to create some

descriptive graphs, illustrating the trends evident in the sample sizes used. Unfortunately, due to the brevity of the descriptions in the database reports and the fact that product brands were often not reported, we were unable to separate “green” products from “non-green” products.

4.2.1 Textiles

We searched through both the hospital (NEISS) and incident report (IPII) databases to determine what hazards textile products present. The majority of the hospital database reports were of consumers tripping over clothes, towels, and rugs. As tripping over textiles is not likely to be a hazard inherent in the product, the hospital database reports were unhelpful and are not included in the following discussion. On the other hand, the IPII database was an excellent source of reports documenting what happened to the consumer. The IPII data has revealed the most common hazards associated with non-green textiles.

Textiles present a number of hazards including deadly fire, fire, scorching, piercing or cutting, chemical burns, allergic reaction, nauseating odor, suffocation, and death by suffocation. Deadly fire refers to a fire that started at the product and ended in one or more fatalities. Fire refers to any sustained flame on the product that does not end in a fatality. Scorching occurs when the product does not ignite but instead blackens, shrivels, and/or show signs of fire damage without sustaining a flame. Piercing or cutting occurs when the consumer’s skin is broken. Chemical burns are defined as burns caused by a corrosive chemical reaction on the consumer’s skin. Allergic reactions are defined as responses by the consumer’s body such as rashes, hives, sore throat, difficulty breathing, and/or puffy eyes. Nauseating odor refers to an odor reported to cause illness such as nausea, vomiting, headache, chest pain, and/or burning sensations in the airways. Suffocation refers to the occurrence of, or concern of a person experiencing trouble breathing. The cause of suffocation is mechanical rather than chemical. Death by suffocation

occurs when a consumer cannot breathe due to a mechanical rather than chemical problem with the textile and ends in a fatality.

The most common hazard represented in the database with wearing apparel is deadly fire, as seen in Figure 10 below. In wearing apparel 30% of the incidents are about deadly fires with the second largest hazard in wearing apparel being fire at 25%. Third most common incident is of allergic reactions with 24% of the complaints followed by suffocation at 11%, chemical burns at 6%, scorching at 2%, and piercing and cutting at 2%.

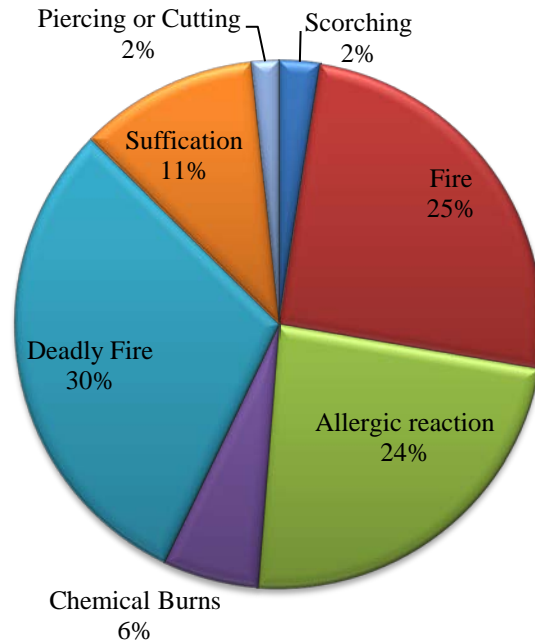


Figure 10 IPII Results for Wearing Apparel. Injury reports on all wearing apparel dating from 1/1/2010 to 11/29/2010. This data was taken from the IPII, the injury and potential injury database (N=119).

For organic fiber textiles it is unlikely that they will present any additional or greater risk. Organic fiber textiles still go through the traditional manufacturing process so there is negligible difference in the end product of a natural fiber textile compared to a similar traditional textile.

This means that an “organic fiber” textile will present the same hazards as a non-environmentally preferable product.

Figure 10 shows that 24% of complaints are of allergic reactions. These reactions are in part due to some of the chemicals used in the processing of the fabric (Washington State Department of Labor and Industries, 2001). If new chemicals or fewer chemicals are used in processing fabric, such as organic, bamboo, and coconut textiles, then people who have allergic reactions to synthetic chemicals are likely to have fewer or no reactions to these environmentally preferable fabrics. So organic, bamboo, and coconut wearing apparel should decrease the amount and severity of allergic reactions experienced by consumers.

Different age groups have different tendencies and some are more prone to injury than others. As Figure 11 suggests, according to the IPII database, people between the ages of 51 and 65 are more prone to deadly fires. People over the age of 66 become increasingly vulnerable to deadly fires according to the IPII database. Figure 11 also suggests that people between the ages of 21 and 35 are less likely to report these hazards. Figure 12 suggests that males are more likely to experience deadly fire and females are more likely to experience allergic reactions.

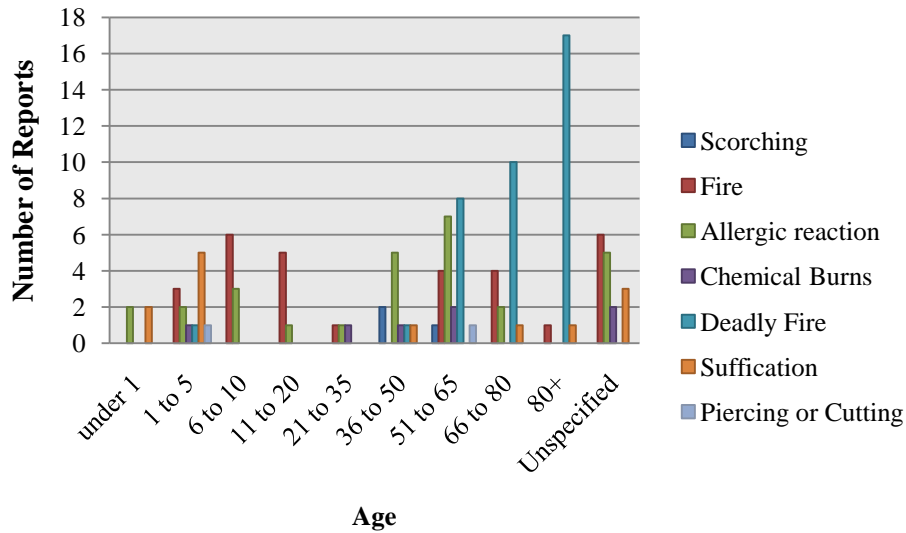


Figure 11 IPII Results for Wearing Apparel By Age. Number of injury reports about all wearing apparel dating from 1/1/2010 to 11/29/2010 by age group. This data was taken from the IPII, the injury and potential injury investigation database (N=119).

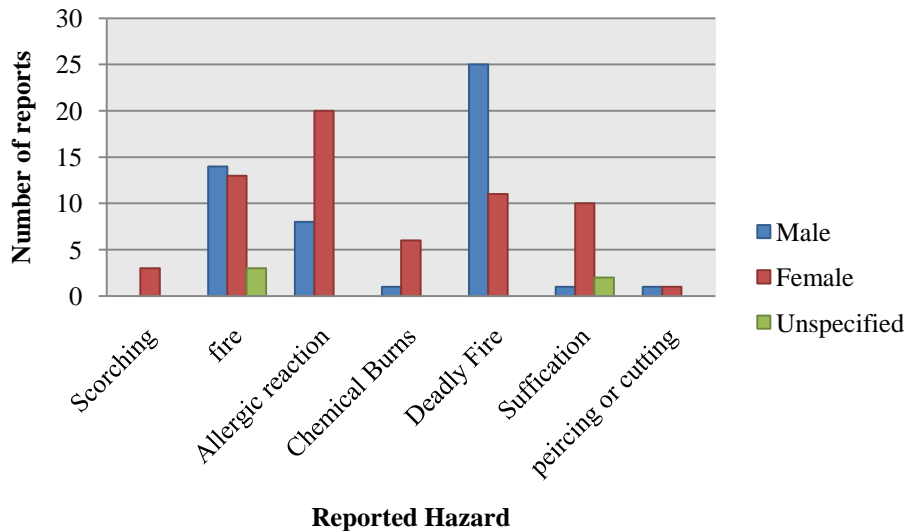


Figure 12 IPII Results for Wearing Apparel by Hazard. Number of injury reports from all wearing apparel dating from 1/1/2010 to 11/29/2010 by gender. This data was taken from the IPII, injury and potential injury database (N=119).

Figure 13 demonstrates that, of the reported incidents from the IPII database, the greatest hazards are scorching and fire. The only other reported hazards are nauseating odor consisting

7% of the reports and allergic reactions consisting 5% of the reports. Figures 14 and 15 suggest that most of the incident reports about rugs and carpets provide no information on the age and gender of the injured consumers.

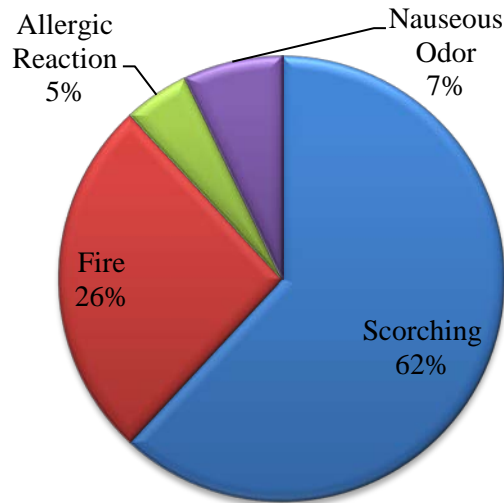


Figure 13 IPII Results for Carpets and Rugs. Incident reports (N=42) on carpets and rugs dating from 1/1/2010 to 11/29/2010. This data was taken from the IPII, incident and potential incident report database (N=42).

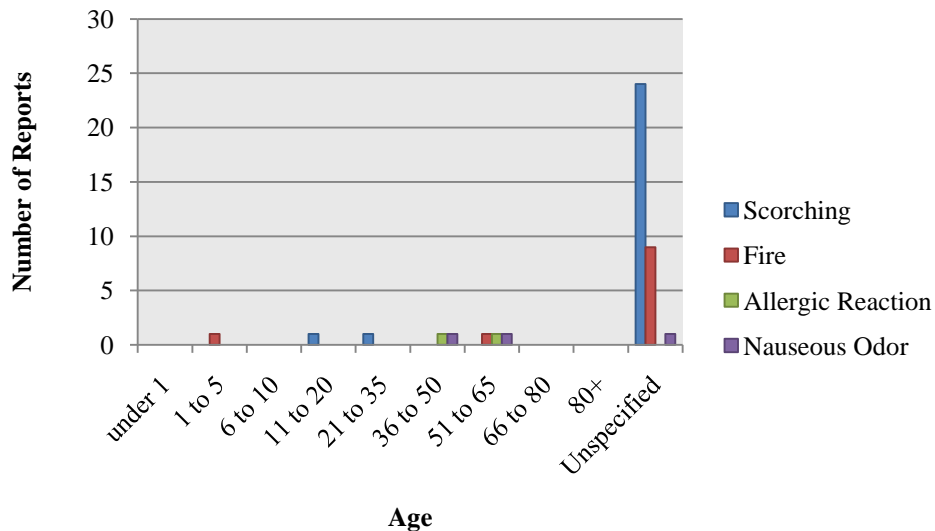


Figure 14 IPII Results for Carpets and Rugs by Age. Injury and potential injury reports from carpets and rugs dating from 1/1/2010 to 11/29/2010. This data was taken from the IPII, injury and potential injury database. The numbers represent how many incidents of each hazard are occurring in each age group.

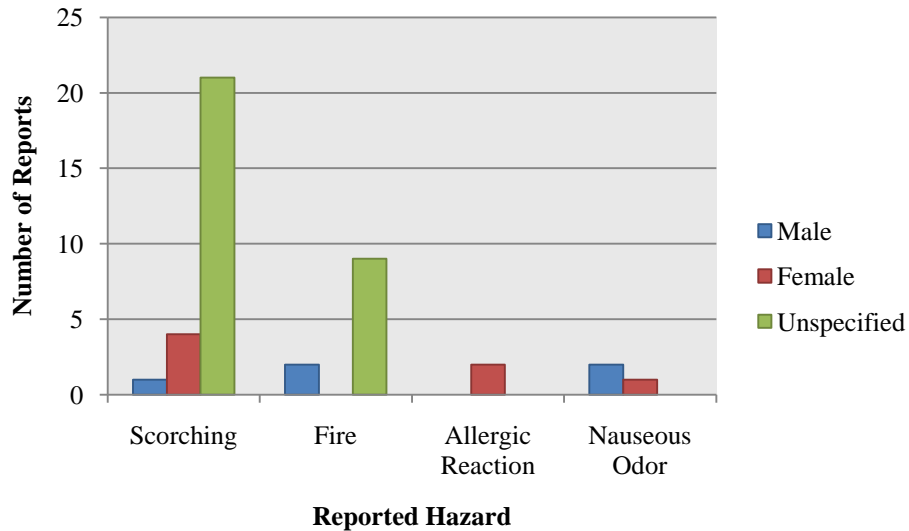


Figure 15 IPII Results for Carpets and Rugs by Hazard. Incident reports from carpets and rugs dating from 1/1/2010 to 11/29/2010. This data was taken from the IPII, injury and potential injury database.

Environmentally preferable rugs are made from wool and recycled plastic (PET). As both these materials are resistant to fire they should lessen the number of scorch and fire hazards (Kadolph and Stone, 2003). In addition some wool carpets are made using no chemicals so that less VOCs are released. It is reasonable to believe that the lessening of VOCs will most likely cause a drop in the allergic reactions and nauseating odors. For these reasons it is likely that environmentally preferable rugs and carpets are less hazardous than their non-green counterparts.

Couches, sofas, and davenports have three major hazards associated with them; deadly fire, fire, and death by suffocation. Deadly fire and fire are a large problem for couches, sofas, and davenports, as shown by Figure 16. Deadly fire makes up 34% of couches, sofas, and davenports related hazards closely followed by fire at 30%. Death by suffocation is also a problem at 19% of the reported incidents. The other hazards are allergic reactions at 12%, scorching at 4 %, and nauseating odor at 1%.

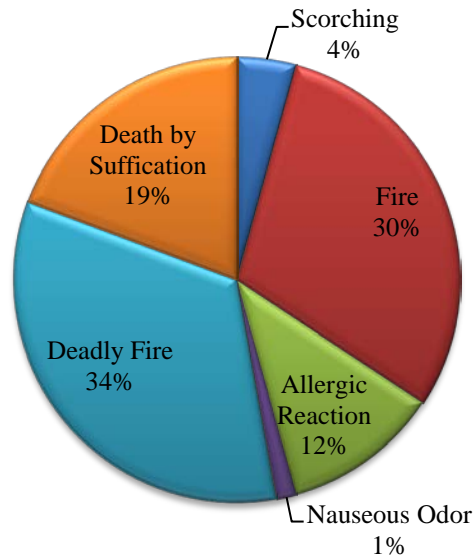


Figure 16 IPII Results for Couches. Incident reports on couches, sofas, davenports dating from 1/1/2010 to 11/29/2010. This data was taken from the IPII, injury and potential injury database. The numbers represent the percentage of the total accidents that were the specified hazard. A total of 140 reports were analyzed. N=140

Figure 17 displays the total number of these hazards as found in the IPII database.

Children under one are particularly vulnerable to death by suffocation, but other than that there does not appear to be a trend in age relating to the associated hazards. As well as lacking a trend in age Figure 18 shows that there is no trend between the hazards and gender as both genders are equally likely to experience a hazard with couches.

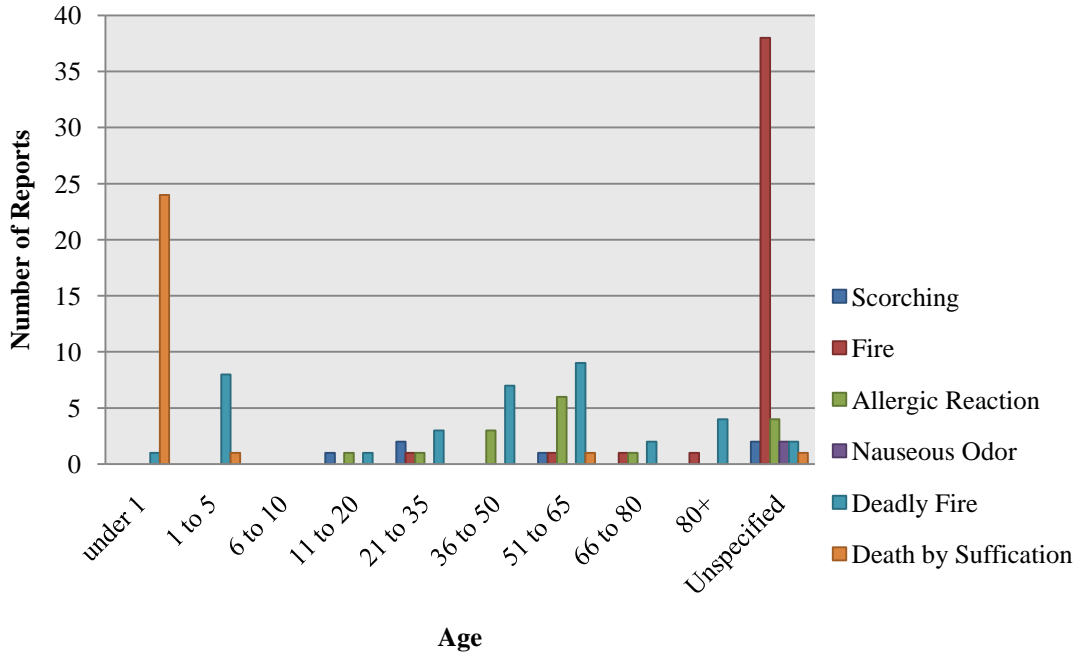


Figure 17 IPII Results for Couches by Age. Incident reports from couches, sofas, davenports dating from 1/1/2010 to 11/29/2010. This data was taken from the IPII, injury and potential injury database.

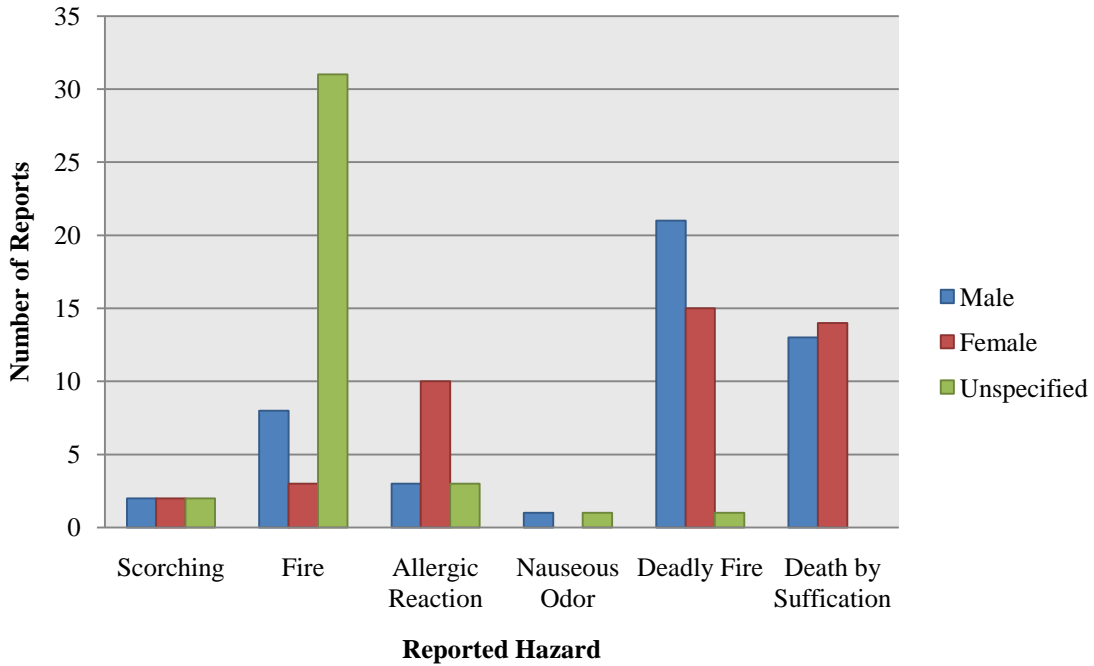


Figure 18 IPII Results for Couches by Hazard. Incident reports from couches, sofas, davenports dating from 1/1/2010 to 11/29/2010. This data was taken from the IPII, incident report database.

The major hazards with couches, sofas, and davenports are fires and deaths by fire. Since there are currently no mandatory standards for flammability of these products, the large number of fires in these products is not surprising. Some companies are selling upholstery fabric that is not treated with chemicals such as fire retardants. This is then sold with the purpose of reupholstering furniture. Furniture reupholstered with this unfinished fabric may present a greater fire hazard than traditional upholstered furniture.

4.2.2 Home Furnishings

Home furnishings, in general, did not present a significant number of safety hazards. Using the product codes listed below in Appendix G, hospital and incident report databases, common hazards associated with furnishings were determined. CPSC hospital database, however, did not highlight safety concerns with specific products. Approximately 2,000 hits occurred from the date range of January 1, 2010 to December 1, 2010. Recurring issues consisted of sprains or strains to the body from moving or lifting furniture. Another common issue was slipping, tripping or falling on the floor causing contusions, lacerations or hematomas. A significant number of falling-related injuries occurred in the age range of 60-80+. Thus, old age is a possible explanation for this trend.

Although the CPSC hospital database did not provide other safety hazards other than falling, IPII databases did. Incident reports that we examined were filed in dates ranging from January 1 to December 1, 2010, and were broken up into three categories: flooring; paints and varnishes; and furniture. Out of 1,235 complaints for flooring and flooring materials, 46 were related to fire or burning due to a nearby appliance malfunction. Figure 19 shows which type of flooring caught on fire most often. Most reports did not specify the type of flooring that caught on fire or charred, although appliances used in such cases were either refrigerators or space

heaters. This could indicate a vinyl-based tile or hard surfaced flooring, rather than a carpeted one due to the location of such appliances. The database also did not specify the make or manufacturer of each type of flooring, though one report indicated that linoleum (which is considered environmentally preferable) caught on fire.

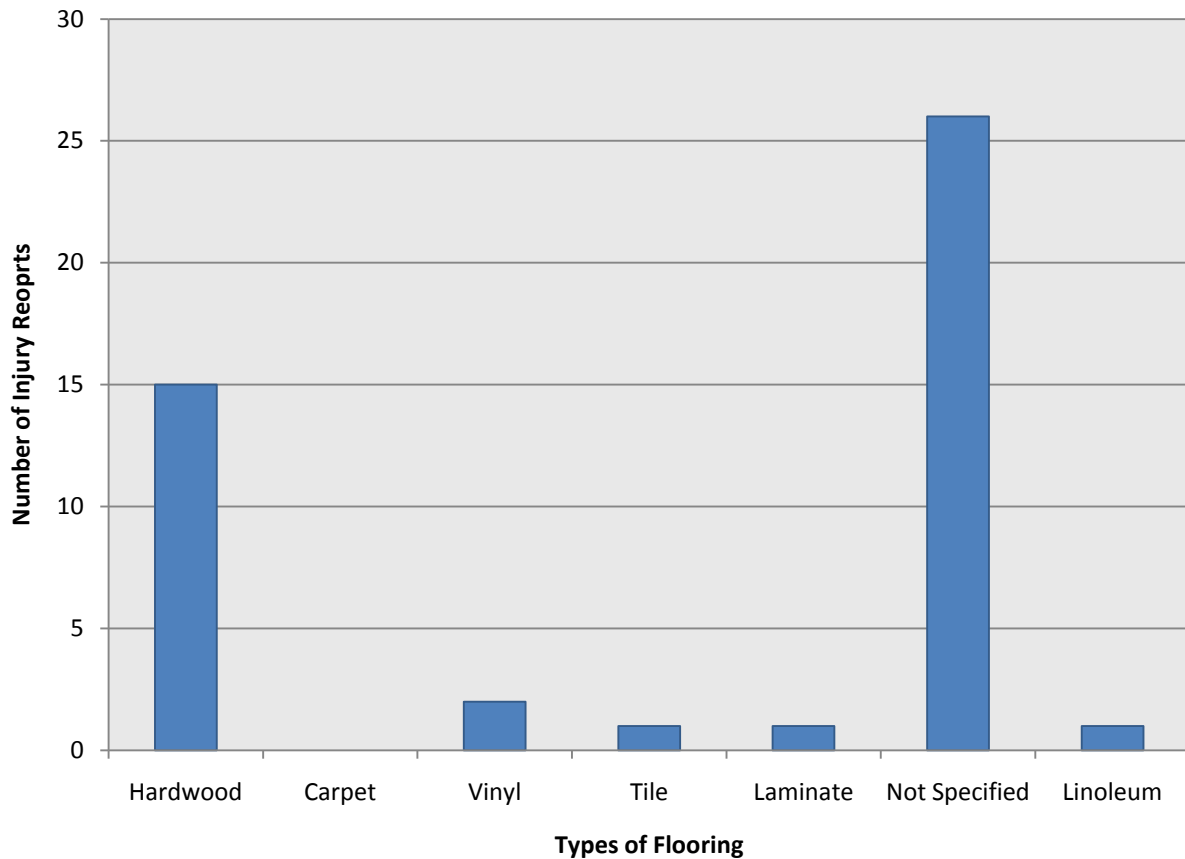


Figure 19 IPII Results of Floor Burning due to Other Appliance Malfunction. The graph above illustrates that hardwood and non-specified flooring caught on fire more often due to appliance malfunction. This is because appliances that tended to malfunction included refrigerators or space heaters, usually found in hard surfaces. One report concerned linoleum flooring that can be considered as environmentally preferable. Reports were analyzed from the CPSC IPII database and ranged from dates January 1, 2010 to December 1, 2010.

Seven reports indicated an allergic reaction to new flooring. One injury report named one industry that manufactures vinyl flooring, detailing that it out-gassed chemical vapors. This industry does manufacture one type of environmentally preferable vinyl-type flooring; however,

it is not clear if this product was the cause of the allergic reaction. Other reports were similar to the hospital databases in that the victims were either elderly or infants who fell on the floor, receiving injuries which ranged from minor or intermediate injuries to death. Those who died from falls were mainly elderly people who broke a hip or experienced head trauma. One report, not specifying product type, explained an explosion after new flooring installation. The cause may have been a spontaneous combustion of wood dust.

Injury incident reports regarding paints, varnishes, and shellacs included allergic reactions, poisonings, fire, and other hazards not found in the home (as shown in Figure 20 below). Allergic reactions and poisonings from paints or finishes included itchy or burning throat symptoms or severe headache and nausea. Out of 36 reports, 28% or ten incidents reported an allergic reaction or poisoning due to off gassing. Only one report declared an environmentally preferable, zero VOC paint, being the cause of headaches and nausea. A larger portion of complaints consisted of fire caused by rags soaked with finishers. One severe report claimed \$42,000 property damage after the house burned down.

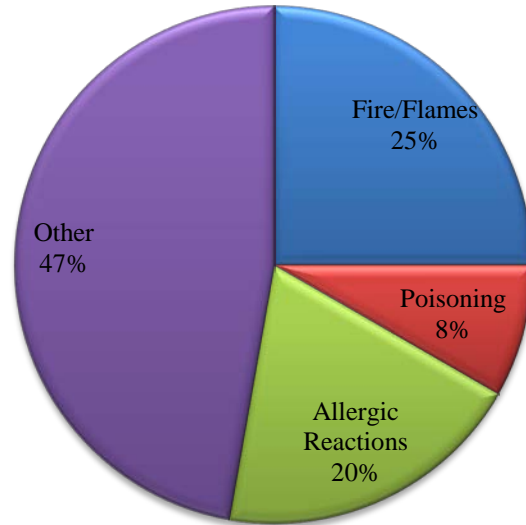


Figure 20 IPII Results from Paints, Varnishes & Shellacs. Incident reports regarding paints and varnishes provided potential health and fire related hazards. Spontaneous combustion was the reasoning for fire and flames and paint or varnish fumes contributed to poisoning and allergic reactions. One environmentally preferable paint was the cause of a poisoning that caused burning throat. Data was collected from January 1, 2010 – December 1, 2010 from the CPSC IPII database (N=36).

Furniture complaints fell into four categories- malfunction, allergic reactions, poisonings, fire/flames (as illustrated in the Figure 21 below). Malfunctions occurred mostly in chairs or tables where the legs broke or overlying glass shattered. Allergic reactions and poisonings were due to off gassing of chemicals in furniture. Symptoms included watery eyes, bad tastes in mouth or trouble breathing. In most cases manufacturer information was not provided. Furniture was the source of ignition in fires. Reports included cigarette fire starters or furniture catching of fire after a product had malfunction. In one case property damage resulted in \$30,000.

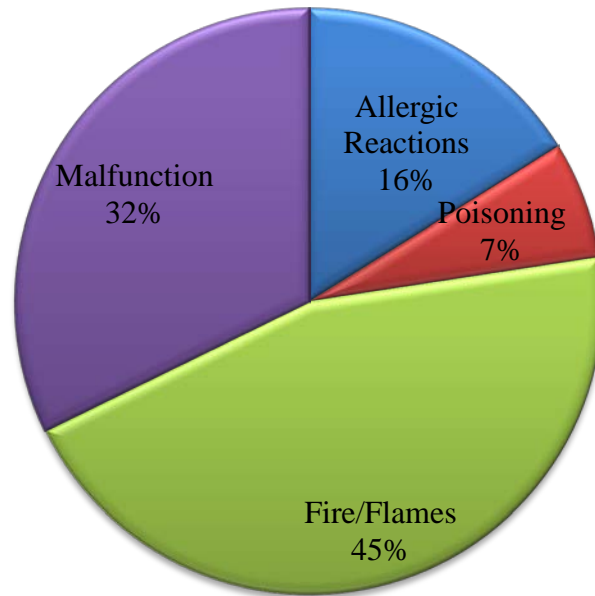


Figure 21 IPII Results from Furniture. Incident reports regarding furniture were usually due to a fire after a nearby appliance malfunctioned. These fires caused large property damage. Other hazards included irritations due to fumes that disappointed into the surrounding environment. Data was collected from January 1, 2010 to December 1, 2010 from CPSC IPII database (N=31).

Although not represented in the graph, other incident reports regarding furniture included strain or sprain due to lifting or moving furniture, or stubbed toes or other body parts.

While analyzing injury reports about allergic reactions and poisonings a trend appeared. Injury reports due from off gassing of hazardous toxins usually occurred in two main age groups, young toddlers and older, more mature people (as seen in Figure 22 below), though a greater number did not specify age. Young children mostly fell victim to off gassing from flooring. Their relative small size (and hence their proximity to the flooring) and sensitivity to gasses are two possible reasons for their heightened risk in this category. Irritation due to paint was more prevalent among older people. Possible reasoning may include more exposure to substances due to home improvement or general sensitivity; however a clear explanation for the increased prevalence amongst older adults.

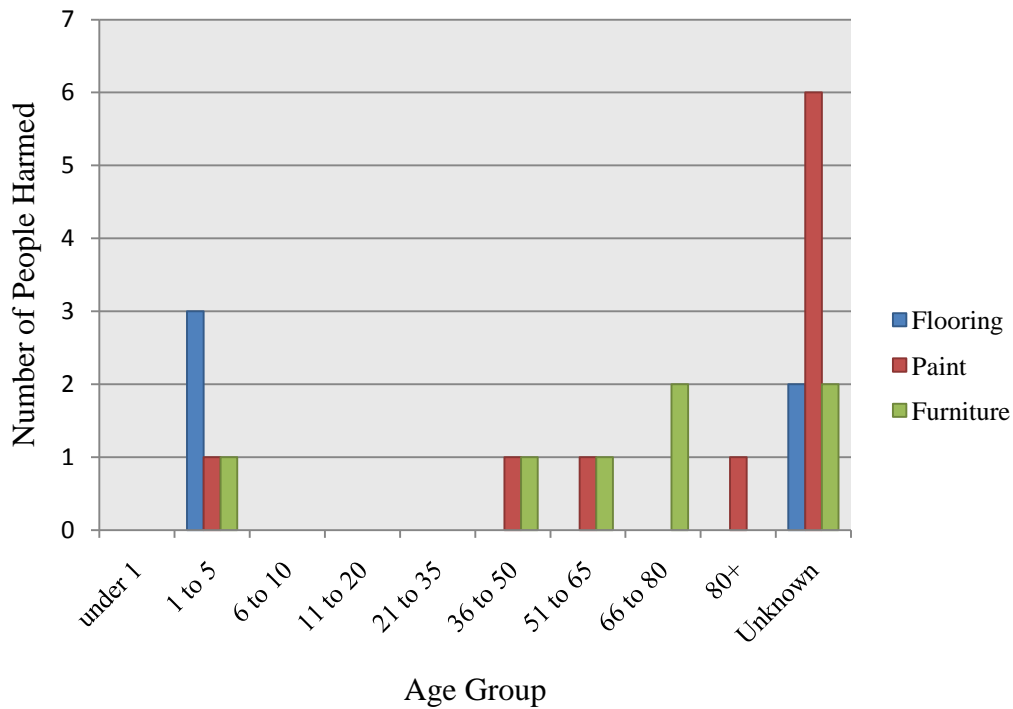


Figure 22 IPII Results of Irritation from Furnishings. Incident reports regarding irritation due to harmful chemicals was separated into age groups. The groups at most risk are young children or people other than 38. Young children are at risk because they are more sensitive to smell and irritation. Older people may experience more irritation due to home improvement options. Many injury reports did not specify an age. Data was collected from January 1, 2010 – December 1, 2010 from CPSC IPII database.

Many reports in the IPII database indicated situations of fire or flames, every home furnishing product category reported some irritation due to chemicals in the paint, flooring, or furniture. In many cases, the IPII database did not specify the product or manufacturer name, however, reports that indicated an allergic reaction or poisoning could be alleviated if the product was environmentally preferable.

4.2.4 Home Maintenance

Searching the NEISS database using the product codes in Appendix G for home maintenance products resulted in hundreds of hits for some product categories and none for others. No records were attached for the product categories of home and family maintenance products, cleaning agents and compounds, chemical deodorizers, unspecified deodorizers, and

general household cleaners. In addition, the database had a duplicate code: product code 947, “Detergent, not Specified”. No records were found under this code, even though several records were found under product code 976, “Detergent, not Specified”. Figure 23 demonstrates the number of hits per category. The vertical blue line represents the 100-record cutoff that was used to reduce the time it took to analyze records.

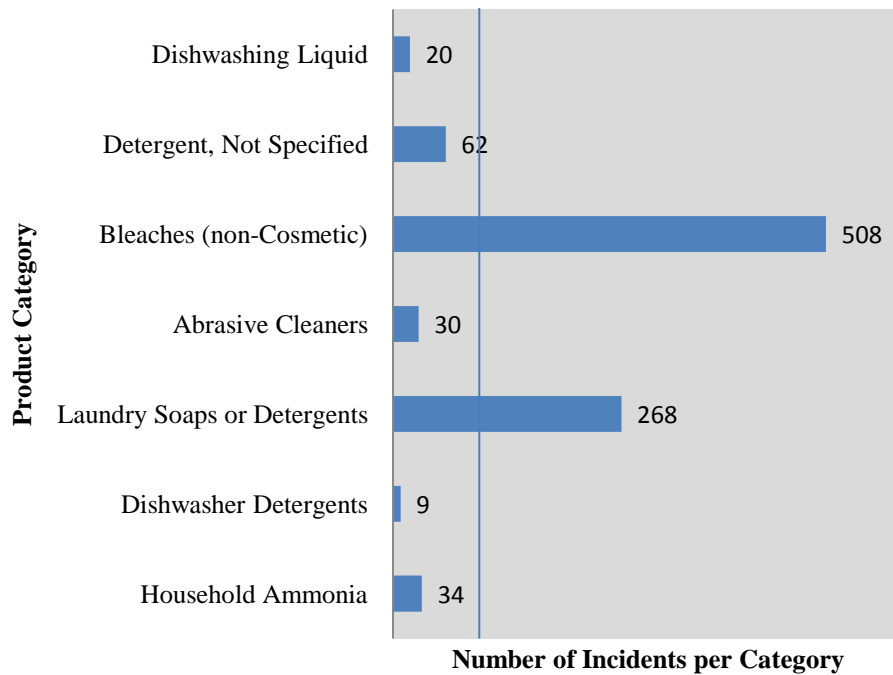


Figure 23 Number of Incidents for each Category of Home Maintenance Products. The graph above displays data from the NEISS database of hospital record from 01/01/2010 through 12/01/2010. There were 931 cases but due to the limit of 100 per category (represented by the vertical blue line) only 355 incidents were studied.

Many injuries included in the NEISS database resulted from home maintenance products being used both as intended and in ways not intended. Home maintenance products generally had many routes of exposure, such as ingestion, inhalation, allergic reactions, irritation, or chemical burns to the skin or eyes. Injuries resulting in consumers straining their backs to pick up heavy boxes of home maintenance products were also highly prevalent.

Figure 24 shows the diagnoses from the 355 cases considered. The “Chemical Burns” category contains both cases involving a chemical burn to the skin or eyes (dermatitis or conjunctivitis). Poisonings include both ingestion and inhalation, while the “Other” category includes fractures or sprains involving dropping or slipping in a chemical cleaner as well as the cases where the diagnosis was not reported. “Allergic Reactions” indicates that the consumer suffered an allergic reaction, which was common for detergents.

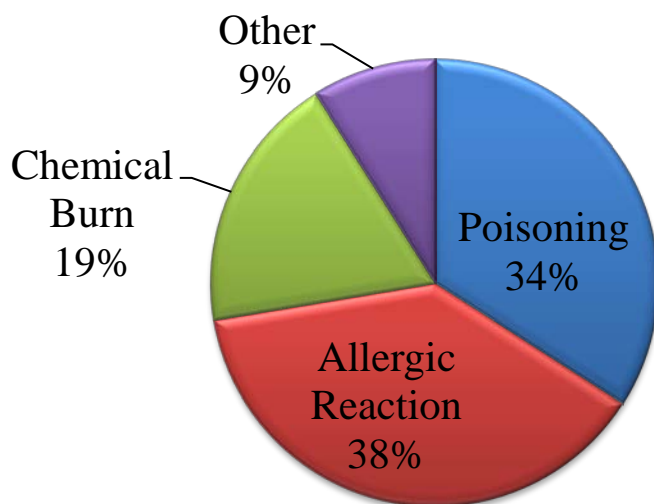


Figure 24 NEISS Results for Home Maintenance Products by Hazard. The diagnosis of home maintenance product incident studied. (N=355) from 01/01/2010 through 12/01/2010. The graph above displays data retrieved from the NEISS database of hospital records.

Unfortunately, the diagnoses of “poisonings” and “chemical burns” were far too broad. This diagnosis did not differentiate between poisonings due to ingestion and poisonings due to inhalation. The CPSC database also did not differentiate between injuries resulting from the normal use of the product and injuries resulting from the misuse of the product. As a result, it was difficult to find the true cause of why the consumer was injured, which impeded our search for whether or not hazards were inherent with the product. For these reasons, further categories

describing the cause of the incident were created based on the short descriptions provided by the database. These categories included the following:

1. Overexposure – an injury resulting from being exposed to the chemical for a long period of time;
2. Misuse – the act of grossly misusing the product. Almost every incident in this category was caused by mixing bleach with ammonia and inhaling toxic chlorine gas. A few other injuries resulting from misuse were also put into this category, such as using concentrated bleach as the sole ingredient to wash and cleanse exposed skin;
3. Unintended Use – This category refers exclusively to injuries resulting from unattended children exposing and injuring themselves to home cleaning chemicals through ingestion or a chemical burn;
4. Allergic/Asthma – This category can be when the consumer used the product properly and took the necessary safety precautions, but suffered an allergic reaction from being minimally exposed to the chemical. It can also be when the product causes a consumer's asthma to flare up despite precautions. In both situations, the injury was unlikely to be preventable;
5. Specified Use – accidental injuries that resulted during the normal use of the product after taking all of the recommended precautions. In other words, this injury was unavoidable given the configuration of the product and its accompanying labels;
6. Unknown – an injury in which the description provided by the hospital was too vague or incomplete to determine a cause for the injury;
7. Intentional – The intentional injury by purposely misusing the product, e.g. a suicide attempt. Only one instance of such an injury was found in the database search;

8. Invalid – This category reflects an error in recording in the database, and as such cannot be used to quantify results.

Nearly every instance of accidental injury involving home maintenance products was considered to be a poisoning, although a few chemical burns appeared from time to time. The cause of injury by ammonia products was usually a blatant misuse of the product, which amounted to over 53% of all records. Overexposure, unintended uses by children, and unknown causes of accidents were each the cause of around 15% of all injuries. There were very few accidental injuries that resulted from a consumer taking the proper safety precautions but still being harmed. Laundry soaps and detergents were another category of products that caused a large number of incidents, yet nearly all of these (89%) were caused by an allergic reaction to that specific product. Since hypoallergenic products readily exist on the market, this problem is probably fixed by switching brands.

Abrasive cleaners resulted in a small number of hits, but the method in which consumers were injured was varied. 14 of the 30 causes resulted from an unintended use by children. Misuse was another common source of injury, contributing to 6 hospitalizations, while 3 injuries resulted each from allergies and asthma, the normal use of the product, and unknown causes. Overexposure only resulted in one case.

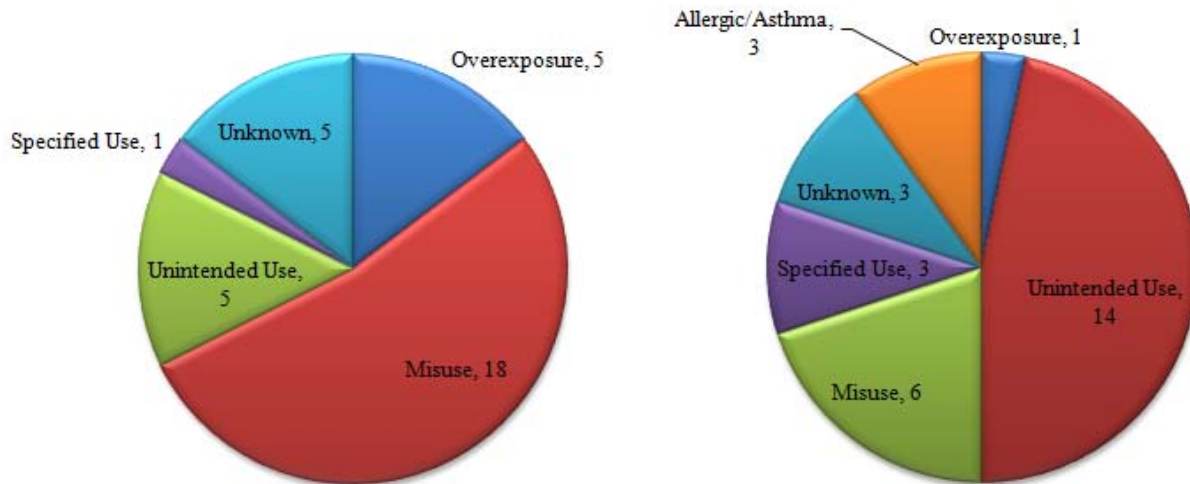


Figure 25 NEISS Results of Ammonia and Abrasive Cleaners. Number for each cause of injuries from household ammonia (left) and abrasive cleaners (right) from 01/01/2010 through 12/01/2010. The graphs above displays data retrieved from the NEISS database of hospital records. There were 34 injuries from ammonia and 30 injuries from abrasive cleaners.

Chlorine bleach resulted in the most hazards of all the home maintenance products that were examined by far. In a period of 11 months, the use and misuse of bleach generated over 500 hospitalizations in hospitals submitting records to the NEISS database. No instance of environmentally preferable bleach ever appeared in the 100 records that were examined. A large number of incidents (28%) fall under the “Unintended Use” category, which means children are often victims of bleach improperly stored or left within their reach despite the warning labels. A similar number of injuries occurred when a consumer used bleach as intended, and another 25% of incidents occurred with an unknown cause. Misuse, which was a common injury in household ammonia products, was less prevalent in chlorine bleaches.

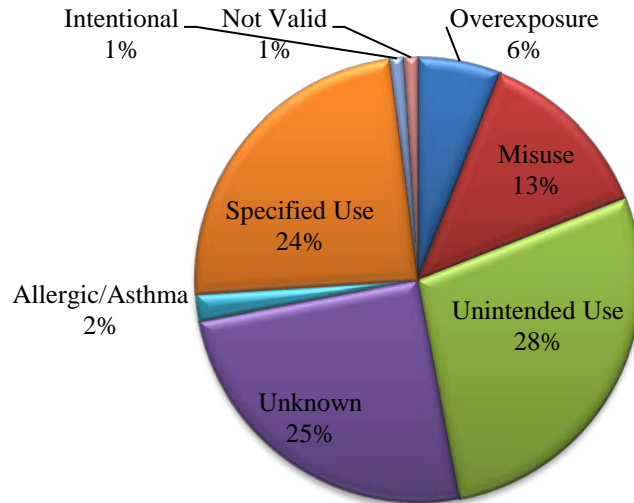


Figure 26 NEISS Results for Bleach. Number for each cause of injuries from bleach. Data was searched from 01/01/2010 through 12/01/2010 (N=100). The graph above displays data retrieved from the NEISS database of hospital records. There were 508 injuries from bleach, but only the first 100 starting from 01/012010 were considered for the purposes of this graph

Accidental injuries from household dishwashing detergents generated only 9 incident reports over the last year. 5 incidents resulted from unattended children, 4 from the normal use of the product, 1 from the misuse of the product, and only 1 was unknown. Reports for dishwashing liquids were also sparse. 5 out of 20 incidents resulted from the normal use of the product, 5 incidents from children accidentally ingesting the product, and 4 incidents from unknown accidents. The rest of the incidents fell to allergic reactions, misuse, and invalid errors. The “Unspecified Detergent” category generated a large number of allergic reactions. Over 80% of the 62 cases were allergic reactions, with the rest being caused by unintended, specified or unknown accidents.

The age range of those injured varied from product type to product type. The sample sizes were so different for each category that displaying a graph using the total number of victims for each category would be of little use. In the graph below, the age ranges of the

victims of injuries were analyzed as a percent of the total sample of the product category they were hurt by.

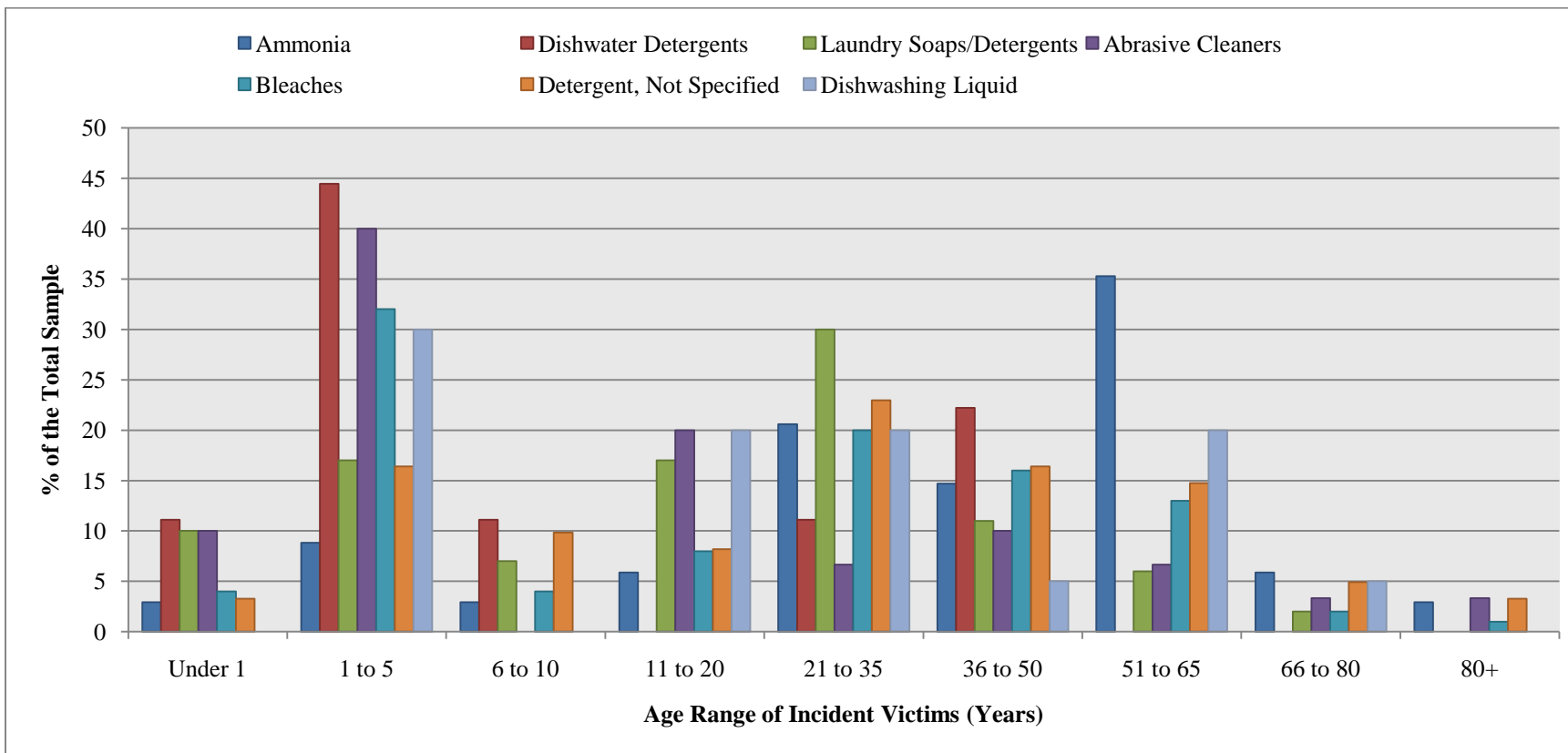


Figure 27 NEISS Results for all Home Maintenance Products by Age. Incidents involving all of the home maintenance product categories by age group. The database was searched from 01/01/2010 through 12/01/2010 (N=354). The graphs above display information from the NEISS database of hospital records. The number of incidents for each age group were categorized by the type of hazard and are displayed here as a percentage of total sample size for each respective hazard.

According to the information obtained from the database and as shown in Figure 29, the most at-risk group for injuries caused by home maintenance products is very clearly children between the age of 1 and 5. Over 40% of all victims injured by dishwasher detergents are children, although this is put in a different perspective when considering the small sample size of that area. Between 30 and 40 % of all incidents involving abrasive cleaners, bleaches and dishwashing liquids affect this age group. Interestingly, 35% of all injuries from household ammonia are sustained by people between the ages of 51 and 65 years of age. Those above the age of 80 are probably less likely to use these products due to old age, and as a result sustain few injuries.

The difficulty with using the hospital database is that it can only give an overview of the entire product market. It is not often that the hospital database includes brand information, so determining which products are more dangerous from this data is impossible. It is equally difficult to see if environmentally preferable products are more or less hazardous. The lack of information regarding the brand of products is an oversight which may need to be corrected in the future, especially if a new compound slips past existing regulations.

The IPII database was much less useful for home maintenance products. Most of the reports were either due to factory defects in packaging that were improperly screened out, consumers using products past their expiration date, or incidents similar to the ones described in the hospital base. As a result, most reports were due to careless errors. Those that were not generally brought forth information already found and analyzed in the hospital database.

4.2.4 Building Materials

To better understand what hazards affiliated with wood paneling and particleboard were most commonly reported in the NEISS database, we examined each hospital report and

reorganized the information into the following graphs, Figures 28 and 29. There were only two major reported hazards, re-categorized as “Injury (General)” and “Injury to Eye.” The “Injury (General)” category includes data from any hospital report describing a case where the patient obtained any kind of physical bodily injury. In the case of wood paneling and particle board, this includes wood splinters in skin, any kind of laceration obtained from cutting oneself on the wood product or working with the wood product, or injuries obtained when a wood product fell on the patient. There were a few cases pertaining specifically to wood dust debris entering the patient’s eye, which is considered to be a hazard inherent in the product, and so emphasize its significance, the hazard type was given its own category, referred to as “Injury to Eye.”

Based on the data presented in Figure 28, the age group of 36 to 50 years old seemed to have the highest number of reported cases of incidents involving wood paneling or particle board during the last year. The age group with the second highest number of reported cases was between the ages of 21 and 35. These two age groups comprise of over half of the reported general injuries and all of the reported eye injuries. Figure 29 organizes the same NEISS hospital report data by specified gender. From the graph, it is clear that a majority of the reported hospital cases were male patients. From reading the actual case descriptions in addition to graphing the factual data (age and gender), one can infer that one group of consumers that is at high risk for experiencing hazards affiliated with wood paneling and particles board, are males, aged 36 to 50. Many of the cases were the result of injuries obtained during home improvement projects.

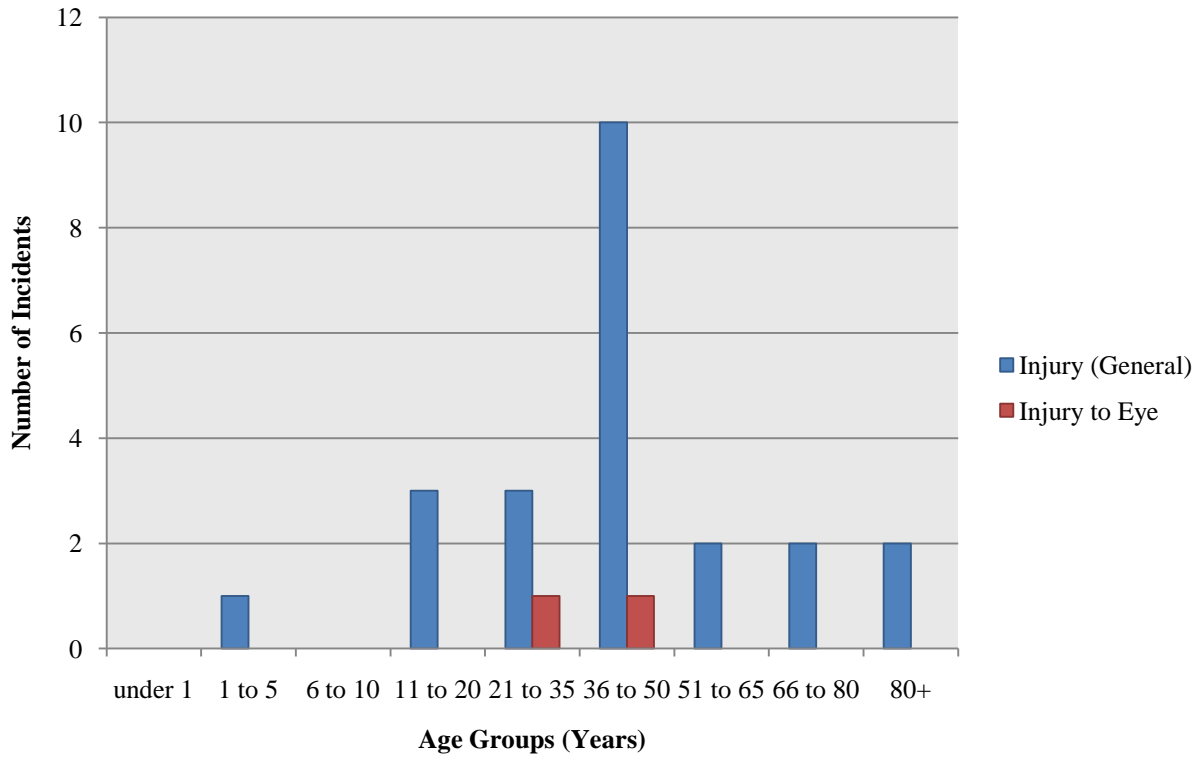


Figure 28 NEISS Results for Wood Paneling/ Particleboard by Age. Incidents involving wood paneling/particleboard from 01/01/2010 through 12/01/2010 by age group. The graph above displays data retrieved from the NEISS database of hospital reports.

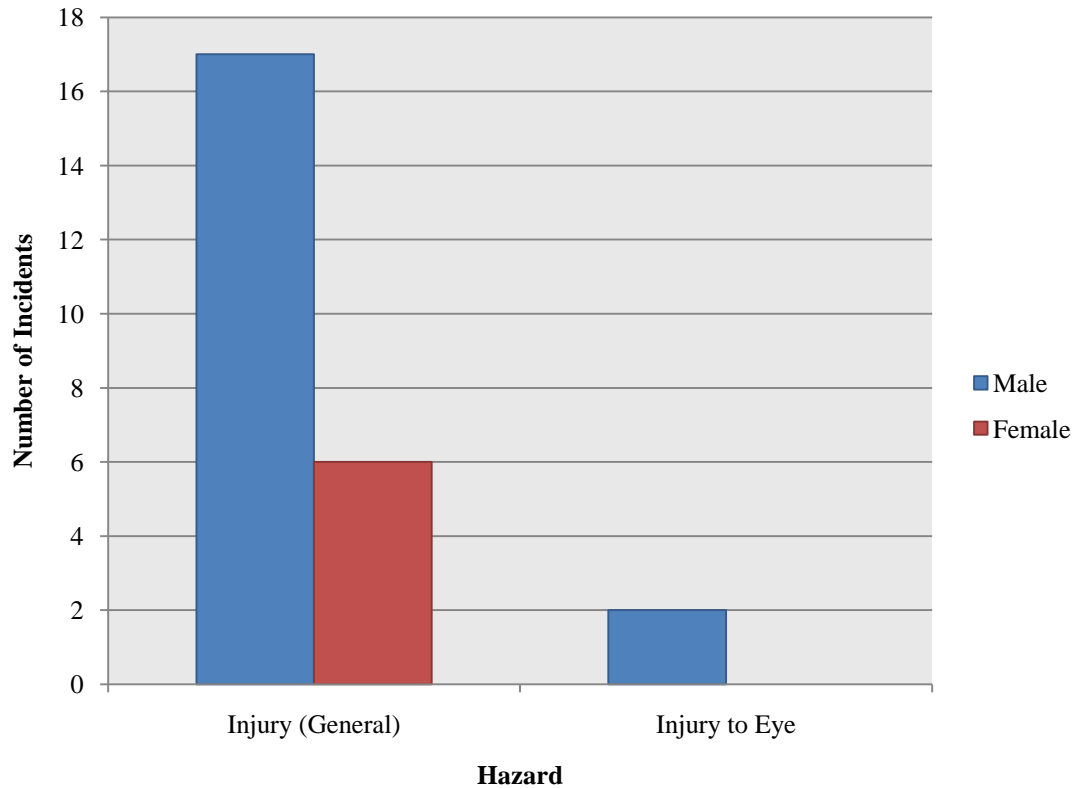


Figure 29 NEISS Results for Wood Paneling/ Particleboard by Gender. Incidents involving wood paneling/particleboard from 01/01/2010 through 12/01/2010 by gender. The graph above displays data retrieved from the NEISS database of hospital reports.

The two most commonly reported hazards in the NEISS database are injuries involving skin lacerations from wood paneling or particle board or foreign bodies penetrating the skin or eyes. The frequency of the two types of hazards described by the figures above are not less likely to or more likely to occur in green, alternative products. Green particleboard is still made from wood chips and sawdust like its standard counterpart, and so injuries that involve wood dust entering the eye or splinters penetrating the skin are just as likely to happen. Skin lacerations are also just as likely to occur, because they are caused more by consumer carelessness than by the product itself.

The green particleboard products, like Acadia’s DuraCane, are commonly formaldehyde-free, resulting in lower formaldehyde gas emissions from the product over time. None of the

hospital reports described cases of formaldehyde gas exposure, and so one might be able to infer that the population of people who experience the symptoms of formaldehyde gas exposure from wood paneling products or particle board is very small. Another possibility is that an exposed consumer does not experience symptoms severe enough to warrant a trip to the hospital. There were also no reports in the IPII database for the wood paneling and particle board product code.

Both the NEISS and IPII databases were used to gather data concerning the commonly reported hazards affiliated with thermal or sound insulation materials during the last year. The information obtained from the two databases was reorganized into the graphs in the following Figures 30, 31 and 32. The hazards identified in the hospital reports were categorized by type and included in the graphs of Figures 30 and 31 as follows: fumes, burn, injury to eye, respiratory, injury to skin, skin exposure, and ingestion. The “fumes” hazard includes all cases where a patient was hospitalized for dizziness, vertigo, nausea, vomiting, and loss of consciousness due to the fumes released from insulation. The “burn” hazard includes all cases where a patient was hospitalized for burns obtained from an insulation fire. The “injury to eye” hazard category included all cases where a patient was hospitalized due to insulation debris in their eye. The “respiratory” hazard category includes all cases where a patient was hospitalized due to respiratory symptoms, such as trouble breathing, chest pain, and dyspnea (shortness of breath), likely to be caused by inhalation of insulation particles. The “injury to skin” hazard category includes all cases where a patient was hospitalized for lacerations on the skin due to handling or being around insulation materials. The “skin exposure” hazard category includes all cases where a patient was hospitalized for skin conditions due to overexposure to insulation materials. Lastly, the “ingestion” hazard category includes all cases where a patient was hospitalized for symptoms caused by the ingestion of insulation materials.

Figure 30 organizes the number of hospital reports by hazard and age group. The age group of 36 to 50 had the highest number of reported incidents involving thermal or sound insulation materials. The age group with the second highest number of reported incidences is 21 to 35, with most cases involving an injury to the patient's eye or skin for both age groups. Figure 31 organizes the same hospital report data by gender. The majority of cases involved male patients, and similar to the results for wood paneling and particle board, both figures illustrate quite clearly that one possible group of consumers that are at high risk for experiencing hazards associated with thermal or sound insulation materials are males, aged 36 to 50. Based on the written descriptions included with many of the hospital reports, a great majority of these incidents occurred while the patient was working on a home improvement project involving insulation installation or repair.

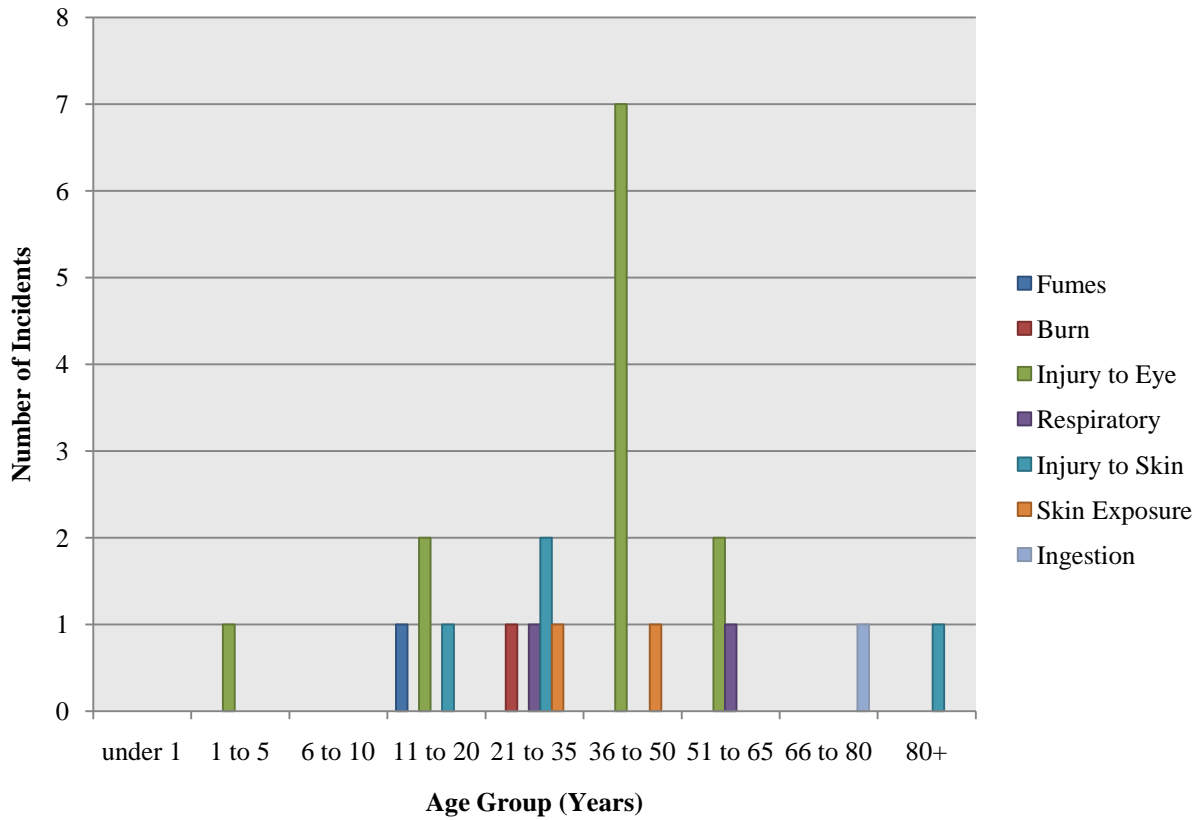


Figure 30 NEISS Reports for Thermal or Sound Insulation by Age. Incidents involving thermal or sound insulation materials from 01/01/201 through 12/01/2010 by age group. The graph above displays data retrieved from the NEISS database of hospital reports. The numbers of incidents for each age group were categorized

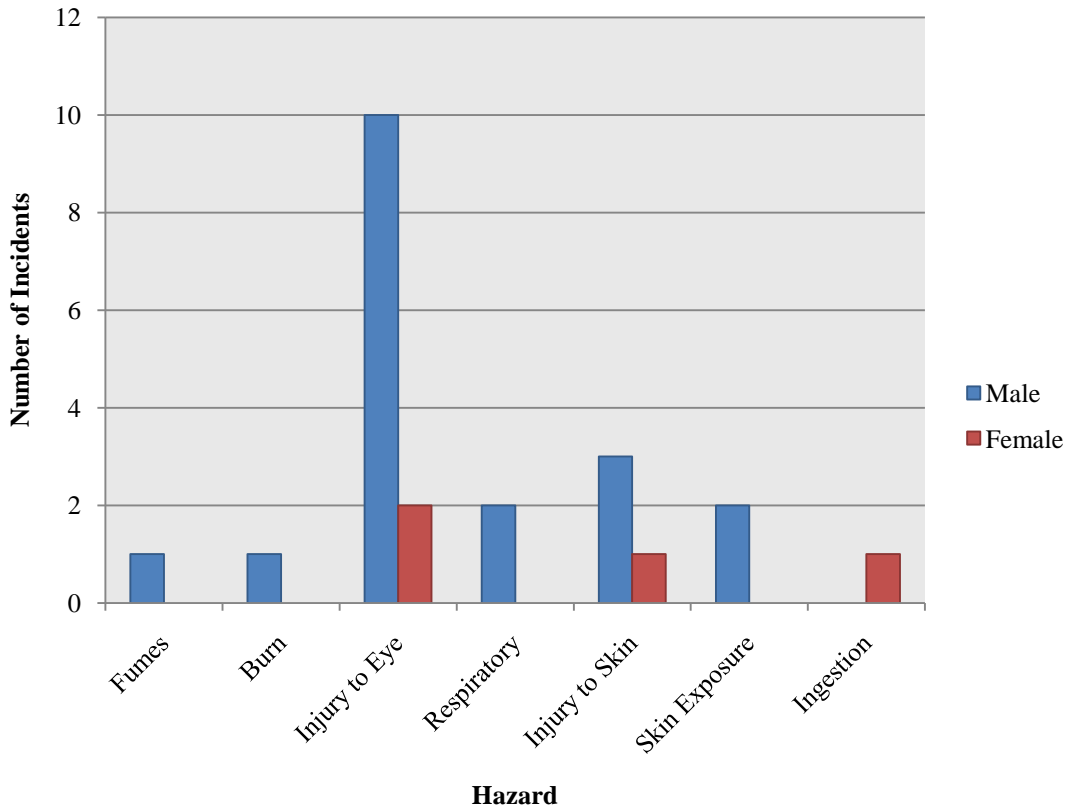


Figure 31 NEISS Reports for Thermal or Sound Insulation by Gender. Incidents involving thermal or sound insulation materials from 01/01/2010 through 12/01/2010 by gender. The graph above displays data retrieved from the NEISS database of hospital reports. The numbers of incidents for each hazard were categorized by gender.

The two most commonly reported injuries in the NEISS database of hospital reports for thermal and sound insulation materials were eye injuries and skin injuries. While the skin injuries were mostly due to consumer carelessness and could not be prevented through product choice, the eye injuries suffered in these cases might have been preventable. All of the incidents involving an eye injury specified that the type of insulation causing the eye irritation was fiberglass insulation. Fiberglass insulation is not usually considered to be an environmentally friendly product because of the health risks associated with installing the insulation. To prevent eye injuries, skin exposure, and respiratory symptoms caused by fiberglass insulation exposure, one must wear goggles, a face mask, and heavy duty clothing for skin protection. While these precautions may effectively protect the consumer from the possible health risks listed above,

choosing a different kind of insulation may be more beneficial, but will not necessarily alleviate all of conditions and symptoms suffered by the patients described in the hospital reports.

Because loose-fill cellulose insulation is made from recycled paper it still generates a large amount of dust, but the symptoms experienced by someone who ingests, inhales, or whose eyes are exposed to insulation will be less severe.

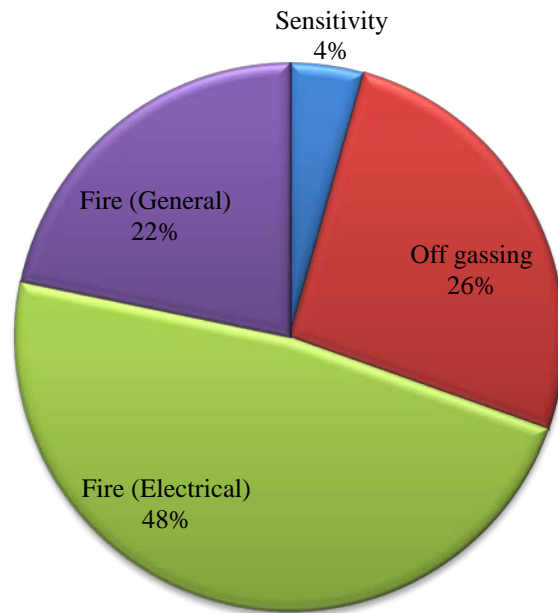


Figure 32 IPII Results for Thermal or Sound Insulation. Percentage of the subject of complaints for thermal or sound insulation materials from 01/01/2010 through 12/01/2010. The graph above displays data retrieved from the IPII database of Injury reports. There were 25 total incident reports regarding thermal or sound insulation materials. (N=25)

Figure 32 illustrates the different subjects of incident reports found in the IPII database. The largest two largest categories of complaints were “Fire (General)” and “Fire (Electrical).” The electrical fire category included any complaint of a fire started with electrical wiring as the ignition source and insulation as the fuel for the fire. The general fire category included all other non-electrical insulation fires. Even though both fiberglass insulation and loose-fill cellulosic insulation are Class A fire rated materials, some studies show evidence that cellulosic insulation may be more fire-resistant, due to its greater density (Murrel, 1991). The other reports included

incident reports about insulation off gassing and increased sensitivity to the insulation. Many consumers found that after they had new insulation installed in their home, fumes were released containing a strong smell, causing the consumer's possessions to be contaminated and making it difficult for the consumer to breathe. Cellulosic insulation from Green Fiber advertises that their insulations will only off gas if the water used to install the insulation is strongly acidic (Green Fiber, 2008). Based on manufacturing claims and the data obtained from the databases, we can infer that it is likely that "green" alternative insulation may have some safety benefits, but more research may need to be done on these claims, including product testing, to fully determine whether or not these products provide a safer alternative in addition to a greener one.

4.3 Determine if Environmentally Preferable Products Are Fully Covered by Existing Voluntary and Mandatory Standards

The main goal of our project was to see if the CPSC needed to account for safety hazards presented by the growing market of environmentally preferable products. Our analysis does not indicate that the majority of these products pose an elevated safety risk, though further analysis, particularly in textiles, home furnishings, and building materials, would result in stronger inferences. At this time, we feel that existing mandatory and voluntary standards that apply to all products are sufficient to regulate products that are marketed as environmentally preferable. This section will analyze the existing standards detailing if they adequately address environmentally preferable products. .

4.3.1 Textiles

Textiles are regulated by parts 1610, 1615, 1616, 1630, and 1631 of the federal code of regulation. These codes set the mandatory standards of fabric flammability for consumer products. Parts 1610, 1615, and 1616 of the federal code of regulations cover all serious hazards

that are possible to regulate for wearing apparel, including the newer eco-textile products. Parts 1630 and 1631 of the federal code of regulations include all serious hazards that are possible to regulate for carpets and rugs and these mandatory standards are also sufficient for the newer environmentally preferable carpets. There are currently no mandatory standards for the flammability of upholstered furniture although the CPSC staff has a federal proposed rule, 1634, that would regulate upholstered furniture and that would cover the new eco-textile products.

4.3.2 Home Furnishings

Although there are few voluntary or mandatory standards for home furnishings, the IPII database results outlined that existing standards are relatively sufficient. When considering fire hazards, furniture that is not upholstered does not have any associated standards. Results from database research proved that furniture is most likely to cause strain or sprains when being lifted than any fire related hazard. Sprain or strain due to moving furniture is not a fault of the product, but rather that of improper use by the consumer. Although the IPII database did not differentiate between environmentally preferable and traditional home furniture, hazards associated with home furniture were not that of the product. Therefore, environmentally preferable furniture is covered under any existing standard for un-upholstered furniture, though there is not one for fire.

Other hazards associated with home furnishing included allergic reactions or poisoning mainly in paints. Out of the 37 reports examined in incident reports, 10 described some kind of irritation due to fumes. In general, there is no universal standard for VOC content in non-industrial settings. As described by Kent Carlson, a CPSC staff member specializing in VOC emissions, many factors are taken into consideration when determining if the VOC content of a consumer product may potentially be hazardous. Some of these factors include concentration, room size, and available ventilation. From the interview, it was concluded that VOC

standardization may be an area of further research (Interview notes can be found in Appendix D). However, in terms of environmentally preferable products, paints and varnishes are claimed to have little to no VOC content and therefore may not cause irritation.

4.3.3 Home Maintenance

The Poison Prevention Act, the Federal Hazardous Substances Act, and regulations from Occupational Health and Safety Administration all appear to be adequately protecting the consumer from unreasonable risks presented by home maintenance products. It does not appear that “green” home maintenance products present an increased hazard to consumers when compared to non-green counterparts. In actuality, most environmentally preferable cleaners are safer for consumers to use, as the principles of green chemistry predict. The use of cleaners, detergents, and bleaches in the household is something that must exist if cleanliness standards are to remain high. In fact, rather than presenting a hazard to consumers, it appears that home maintenance products may prevent more health hazards from filth than they cause via irritation. It does not appear that extra attention is needed in this area.

It does not appear that dish or laundry detergents present much hazard to the consumer. The MSDS analysis revealed that all widely marketed detergents comply with existing federal regulations, and very few chose to use truly abrasive or caustic chemicals. When concentrated, dish detergents may present an increased hazard to consumers, but when compared to the hospital database results, it does not appear that detergents cause many injuries. So long as they are kept out of reach of children, detergents appear to be largely safe.

Under initial inspection, alternatives to chlorinated bleaches do not present an increased hazard to consumers. On the contrary, it appears as though bleach alternatives lack a number of the caustic effects of chlorinated bleach. Hydrogen peroxide is considered to be generally safe

for household use when used at between 3 and 10 percent dilution (Department of Health and Human Services, 2008). The compound is available as a cosmetic product although using it as alternative bleach may require a different concentration, as it would be diluted in the washing water. Sodium percarbonate is merely sodium carbonate (washing soda) dissolved in hydrogen peroxide, and as such presents a similar level of risk. It seems more likely that alternative bleaches are safer to handle than chlorinated bleaches, although this view is not completely supported by empirical data. Many instances of someone misusing bleach were recorded in the database. On the contrary, no records of oxygen-based bleach or other bleaches ever appeared to present a hazard. Although this may indicate that chlorine bleach is a dangerous product, it is important to remember that this compound is less expensive than oxygen bleach. It is quite possible that fewer consumers purchase oxygen-based bleaches and as a result the average consumer injured by bleach is much more likely to have been injured by chlorine bleach.

Despite the use of new, lesser-known chemicals, environmentally preferable all-purpose cleaners do not appear to pose any increased hazard to consumers. Many “green” all-purpose cleaners advertise the health benefits of using natural compounds, although this claim is unsupported. According to an interview with Kevin Tibbs of Better Life, natural cleaning chemicals derived from plants such as coconuts function as an acceptable replacement for traditional petroleum-based compounds (K. Tibbs, personal communication, November 8, 2010). All-purpose cleaners are almost always mild irritants, no matter the type of cleaner. Although chronic effects are still unknown, it is reasonable to assume that green All-purpose cleaners pose a similar risk when compared to their non-green counterparts. For all these reasons it does not appear that existing standards need to be modified.

4.3.4 Building Materials

Because environmentally preferable building products must meet the mandatory standards already in place, they, like their traditional counterparts, are safe for consumer use. The voluntary standard fire tests used for testing the load-bearing capabilities and fire performance of engineered wood products, as outlined in UL263, are sufficient because they apply to all building and construction materials and hold them to a single standard of fire safety. There are also a number of voluntary standards from ASTM that test these same properties of engineered wood and solid wood products. However, in an interview with Karen and Roy Deppa, we learned that NFPA model building codes, which deal more with the design of the structure as a whole, rather than the individual components, may not cover certain aspects of lightweight construction using engineered wood. In many cases, the fire safety standards of solid wood lumber are also used for engineered wood compliance. Buildings built using lightweight construction may burn differently from buildings built using more traditional construction, but the fire safety building codes treat them as though they were the same product. NFPA 5000 does have a placeholder for a standard regarding engineered wood, so new standards may be currently in development stages (personal communication, November 19, 2010).

Cellulosic insulation is regulated by the mandatory standards found in the Interim Safety Standard for Cellulosic Insulation (CFR 16 §1209) written by the CPSC. This standard sufficiently covers the testing procedures for settled density, corrosiveness, and critical radiant flux. However, the test for smoldering combustion uses a cigarette as the ignition source, while the database results indicate that a majority of insulation-related fires have an electrical ignition source, such as wiring malfunction. The standard should be amended to include another testing procedure for insulation-related fires with an electrical ignition source. This standard still

applies to “green” alternative cellulosic insulations because the only difference between green insulation and the standard counterpart is the source of the paper fibers used to make the product.

Chapter 5: Conclusions and Recommendations

The purpose of this project was to examine the safety of environmentally preferable household consumer products. We have researched environmentally preferable products by visiting stores, interviewing professionals, and speaking with retail company personnel. We also examined the hazards associated with standard household consumer products by searching the CPSC hospital (NEISS) and incident (IPII) databases. We analyzed the results in regards to the environmentally preferable counterpart. From this study, we have arrived at the following conclusions and recommendations for the Consumer Product Safety Commission.

5.1 Conclusions

Searching through the CPSC hospital (NEISS) and incident (IPII) report databases, we found many reports of the different hazards associated with household consumer products. However, the databases did not contain sufficient detail to allow us to distinguish between a “green” product and a traditional product. A small number of the reports did include brands or product names and of these we were able to identify one incident of a green product causing irritation. Besides that one instance, all of the data collected from the databases was unspecified as to whether or not the product was considered environmentally preferable. The data does not support or refute any safety claim for environmentally preferable products.

From our review of the databases, we identified the hazards associated with household consumer products. When we analyzed the data in consideration of our research on environmentally preferable household consumer products, we were able to infer what hazards, if any, might increase or decrease the frequency and severity with green products in comparison to the traditional product. A summary of our conclusions can be found in Table 2 below. It is unknown whether green textiles may present a greater risk of a fire hazard. Some green textiles

may decrease the frequency of allergic reactions in consumers compared to traditional textiles. In green home furnishing products, we expect the number of allergic reaction and poisoning cases to decrease in comparison to traditional home furnishings. We also concluded that green home maintenance products will have fewer cases of allergic reactions, poisonings, and chemical burns than the standard home maintenance products due to chemical changes within the product. In comparison to traditional building materials, green building materials may cause fewer cases of poisoning in consumers. In general, we concluded that green household consumer products are likely to cause fewer incidents than their non-green counterparts.

Table 2 Our Hazard Score Sheet. The table displays which hazards we think will increase or decrease if the product was made environmentally preferable. Some categories are unknown.

<i>Comparing Traditional Product Hazards to Environmentally Preferable Products</i>				
Product Category	Common Hazards for Traditional Products	May Decrease Safety Performance if Green	May Increase Safety Performance if Green	Unknown
<i>Textiles</i>	Fire/Flames Allergic Reactions Suffocation		✓	✓
<i>Home Furnishings</i>	Allergic Reactions Poisonings Fire/Flames Malfunction		✓ ✓	✓ ✓
<i>Home Maintenance Products</i>	Allergic Reactions Poisonings Chemical Burns		✓ ✓ ✓	
<i>Building Materials</i>	Fire/Flames Laceration Poisonings		✓	✓ ✓

Mandatory standards regulating consumer household products are performance based, and the green products we researched are submitted to the same level of testing as any other product. The mandatory standards regulating the products we examined are presented in Table 3 below, with either no recommendation or a recommendation to amend the mandatory standard. Our reasons why the cellulosic insulation should be revised are explained in more detail in our fifth recommendation.

Table 3 Summary of results from the evaluation of mandatory standards. The table includes all relevant mandatory standards and a recommendation of no action or a recommendation to amend the mandatory standard

<i>Sufficiency of CPSC Mandatory Standards and Statutes</i>		
CPSC Mandatory Standards	To Cover Potential Hazards Presented by Green Products:	
	Amend	No Action
Flammable Fabrics Act		✓
Poison Prevention Packaging Act		✓
Federal Hazardous Substances Act		✓
Interim Safety Standard for Cellulosic Insulation	✓	

5.2 Recommendations

The following section expresses the recommendations that we are making to the Consumer Product Safety Commission. Recommendations are based upon overall conclusions that we drew from research through the market overview and results from the NEISS and IPII database. Recommendations are also based upon what we know about CPSC jurisdiction and the hazards associated with environmentally preferable products when compared to traditional, non-green products.

5.2.1 Existing Mandatory Standards

Recommendation 1: The current mandatory standards for textiles, home furnishings, home maintenance products and building materials should not be amended because they are sufficient and cover any hazard associated with environmentally preferable products.

Based on results obtained from research and incidents from CPSC hospital (NEISS) and injury (IPII) databases, existing mandatory standards are sufficient for environmentally preferable products. Textiles are regulated under parts 1610, 1615, 1616, 1630, and 1631 of the federal code of regulation. These codes set standards for all serious hazards associated with both traditional and environmentally preferable wearing apparel, rugs, and carpets. Although there currently is no mandatory standard for upholstered furniture, CPSC staff is currently working on code 1634 that will set standards for the flammability of upholstered furniture, both traditional and environmentally preferable. Results from NEISS and IPII databases demonstrated that injuries that did occur were due to carelessness on the part of the consumer or misuse of the product. The Poison Prevention Act, Federal Hazardous Substance Act and regulations from the Occupational Safety and Health Administration adequately address environmentally preferable home maintenance products. Typically, environmentally preferable or “green” home maintenance products are safer than the traditional home maintenance products. Mandatory standards for traditional building materials adequately address any hazard associated with environmentally preferable counterparts. Results from NEISS and IPII database did not indicate serious hazards caused by environmentally preferable products.

5.2.2 Further Research on Environmentally Preferable Products

Recommendation 2: In order to conduct further research, an environmentally preferable product identification field on the forms of CPSC report systems should be created.

CPSC hospital (NEISS) and injury (IPII) database do not differentiate between environmentally preferable products and traditional, non-green products. In many instances, manufacturers of products that were believed to have caused a hazard were not stated, making it

difficult to determine if the product was environmentally preferable or not. Out of the approximately 2057 reports analyzed, only one case indicated that the product that created the hazard was in fact environmentally preferable. If the CPSC wishes to continue researching environmentally preferable products, an identification field should be created in order to obtain proper data collection for the assessment of environmentally preferable products. A difficulty with this recommendation is that the identification of an environmentally preferable product will be at the discretion of the consumers filing complaints or the hospital staff entering data into a form. A solution to this problem would include the additional identification of the manufacturer. Based on the difficulty to assess the environmental preferability of products in CPSC database, our second recommendation aims to address this dilemma.

5.2.3 Market Overview

Recommendation 3: A well developed, comprehensive strategy to examine multiple product categories may be necessary to perform a market sketch of environmentally preferable products.

The market for “green” products is currently a niche market that is growing, despite the current economy (Green Confidence Index, 2010). As such, the market for “green” products may grow to the point where the CPSC deems it necessary to conduct a market sketch of green products. A market sketch of green products would not be accurate without an assessment of a large number of different product categories. Usually, a market sketch is only performed on a specific product and a market sketch on green products would have to cover a broad range of products. One strategy for conducting a multiple product market sketch would have to be created in order to conduct a market sketch of green products.

5.2.4 Additional Labeling

Recommendation 4: Products that have lower material fire ratings should require an informational label.

Products with lower fire ratings should be sold with an informational label detailing the intended usage of the product to better protect the consumer from hazards resulting from using the product incorrectly.

Some environmentally preferable textiles are sold without a protective finish or chemical fire retardant, but claim to pass certain voluntary fire tests with the application of a chemical fire retardant. These textiles should be sold with an informational label, informing the consumer that they may need to apply a protective finish to the fabric to achieve the minimum level of safety guaranteed by the fire test performed on it. This risk may be greater for textiles used in upholstery, rather than apparel, due to the nature of upholstered objects acting as sources of fuel in a fire.

There was also a specific example of a type of fiberboard made from recycled paper with a Class C material fire rating, limiting its applications to thermal and acoustic insulation. While the product is not advertised for usage in applications deemed unsafe, such as wall surfacing or load bearing applications, there is no information provided to the consumer to make them aware of the products specific intended usage. This particular product is sold without any kind of packaging in order to reduce waste; however the lack of packaging and labels may reduce the amount of information about the product being conveyed from the manufacturer to the consumer.

5.2.5 Interim Safety Standard for Cellulosic Insulation

Recommendation 5: The Interim Safety Standard for Cellulosic Insulation should be revised to include electrical sources of ignition.

The Interim Safety Standard for Cellulosic Insulation outlines various testing procedures and requirements necessary to ensure that a particular cellulosic insulation product meets a minimum level of safety. The testing procedures detailed in the standard examine determined settled density, corrosiveness, critical radiant flux, and smoldering combustion.

The IPII database results show that a large majority of insulation related fires are caused by an electrical ignition source, such as malfunctioning wiring. However, this is not reflected in the section, “Test procedures for smoldering combustion” (16 CFR § 1209.7). This section outlines a testing procedure for smoldering combustion that uses a cigarette as the ignition source, but does not account for an electrical ignition source. The Interim Safety Standard for Cellulosic Insulation may need to be amended in some way to address this discrepancy.

5.3 Recommended Areas of Research

The following section will define further research areas recommended to the Consumer Product Safety Commission. Further research areas were determined based on research and results from NEISS and IPII database. Further research areas concern VOC content in products, the flammability of cellulosic insulation, and the fire structural properties of engineered wood.

5.3.1 VOC Emissions

When examining CPSC IPII database, it was evident that VOCs in paint caused irritation. Each home furnishing categories- paints, flooring materials, and furniture- illustrated irritation due to off gassing in the material. In paints, out of 37 reported incidents, ten declared poisoning or allergic reactions due to chemicals. Currently, there is no universal standard for VOC content in paint or varnishes. Although environmentally preferable products may be safer because they claim to be low VOC or no VOC, green and traditional products may still cause irritation.

Further research on VOC content in paints and varnishes used on furniture and flooring could lead to the development of a new standard.

5.3.2 Engineered Wood

Under current NFPA fire codes engineered wood and solid-wood lumber are considered the same. However, buildings erected using lightweight construction may present more of a safety hazard to residents and fire fighters, due to a faster burning and collapse time. More research should be conducted to identify the different structural and flammability characteristics of engineered wood in comparison to solid-wood lumber.

5.4 Summary

In summary, safety hazards cannot be directly correlated with a product's environmental preferability. The current mandatory standards appear to be adequately protecting the consumer through performance-based requirements. Currently, there is no perceived problem with environmentally preferable products based on current information, but future research is necessary to find conclusive evidence. If future research is to be conducted using the CPSC databases, identification fields for environmentally preferable products must be added to any incident report form. Finally, the innovations and new products being marketed as "green" alternatives present a wide variety of new products. The usual market sketch employed by the CPSC may be too in-depth to analyze the overall market trends. A broader approach would be necessary to research the changes in the marketing of environmentally preferable products.

References:

- Abraham, C.J. (1996). A solution to spontaneous combustion in linseed oil formulations. *Polymer Degradation and Stability*, 54(2-3), 157-166.
- AlEn Americas. (2004). *Material safety data sheet: Cloralex Bleach*. Retrieved November 17, 2010, from <http://www.alen.com.mx/alenamericas/MSDS/Cloralex/MSDS%20Cloralex%20%20Regular%20Bleach%20%20.pdf>
- AlEn Americas. (2010). *Company History: AlEn United States*. Retrieved November 17, 2010, from <http://www.alen.com.mx/alenamericas/history.htm>
- American Cleaning Institute. (2010). *Changes in automatic dishwasher detergents*. Retrieved November 28, 2010, from http://www.cleaninginstitute.org/clean_living/cm_novdec2010_changes_in_automatic_dishwasher_detergents.aspx
- Allen, D.T. & Rosselot, K. (2001). Life-cycle concepts, product stewardship, and green engineering. In Allen, D.T. & Shonnard, D., *Green engineering: environmentally conscious design of chemical processes* (pp.539 - 584). Englewood Cliffs: Prentice Hall.
- Amatruda, J. (2010). *Evaluation and selecting green products*. Retrieved on November 3, 2010, from National Institute of Building Sciences, <http://www.wbdg.org/resources/greenproducts.php>
- American Home Furnishings Alliance , Initials. (2010a). Kincaid's "homecoming" is eco3home pilot. *The Furniture Executive* , 27(10), Retrieved on November 1, 2010, <http://www.ahfa.us/uploads/documents/furnexec.pdf>
- American Home Furnishings Association. (2010b). *Product standards*. Retrieved on November 1, 2010, <http://www.ahfa.us/publications/publications.asp>
- Anastas, P. and Warner, J. (1998). *Green chemistry: theory and practice*. Oxford University Press: New York.
- Anastas, P.T., Farren, T.R., Fitzpatrick, J.M., and Poliakoff, M. (2002) Green chemistry: science and politics of change, *Science*, 297, 807-810.
- Anto, J.M., Barrell A., Burgos, F., Kagevinas, M., Medina-Ramon, M., Sunyer, J., Torralba, Y. and Zock, J.P. (February 16, 2005) Asthma, chronic bronchitis, and exposure to irritant agents in occupational domestic cleaning: a nested case-control study. *Occupational and Environmental Medicine*, 62. pp.598-606.
- Babrauskas, V., and Peacock, R.D. (April 25, 1991) Heat release rate: the single most important variable in fire hazard. *Fire Safety Journal*, 18 (3). pp. 255-269

- Beauchamp, M.E., Chenier, R., Liteplo, R.G., & Meek, M.E. (2002). *Concise international chemical assessment document 40: formaldehyde*. Geneva: World Health Organization.
- Benjamin Moore. (2010). *Aura interior* . Retrieved on December 2, 2010, from http://www.benjaminmoore.com/bmpsweb/portals/bmps.portal?_nfpb=true&_pageLabel=fh_aura_hiddenPage&NodeUUID=/BEA+Repository/51803
- Better Life. (2010a). *what-EVER:! green all-purpose cleaner*. Retrieved November 11, 2010, from <http://www.cleanhappens.com/products/whatever/>
- Better Life. (2010b). *What we're about*. Retrieved November 8, 2010 from <http://www.cleanhappens.com/whatwereabout/>
- Beroes, C.S. (1977), Expert testimony in flammable fabric litigation. *Proceedings of the 1977 symposium on textile flammability*, East Greenwich, Rhode Island: LeBlanc Research Corporation, pp. 4-13
- BioShield Paint Co. (2003) *Material safety data sheet: BioShield Clay Paint #12*. Retrieved on December 2, 2010, from <http://www.greenbuildingcenter.net/MSDS/ClayPaint.pdf>
- Bloomberg Businessweek. (2010). *Cocona, Inc.* Retrieved on December 2, 2010, from <http://investing.businessweek.com/research/stocks/private/snapshot.asp?privcapId=37345177>
- Bright Hub. (2010). *Benefits of carpet made out of recycled plastic*. Retrieved on December 2, 2010, from <http://www.brighthub.com/environment/green-living/articles/62035.aspx>
- CabelSystems. (2007). *Fire triangle* . Retrieved on November 1, 2010, from <http://www.cablesystems.co.uk/fire-triangle.ph>
- Campbell, J.M., and Cramer, P.L., (1949). Combustion of hydrocarbons: free radical chain reactions. *Industrial and Engineering Chemistry*, 41(5), pp. 893-897.
- Capri Cork. (2010). *Cork's "green" story (EC301A)*. Retrieved on November 11, 2010, from http://www.capricork.com/uploadedFiles/Document_Library/Eco-Clicks/EC301A_The_Cork_GREEN_Story.pdf.pdf
- Cascade. (2010). *Phosphate free cascade faq's*. Retrieved November 9, 2010 from http://www.cascadeclean.com/en_US/phosphatefreefaq.do
- Chapter II – Consumer Product Safety Commission. 16 U.S.C. §§ 1610-1670.
- Clean Air Act of 2004. U.S.C. §§

- Clorox. (2007). *Material safety data sheet: Formula 409*. Retrieved November 17, 2010, from <http://www.thecloroxcompany.com/products/msds/409products/formula409antibacallpurposecleaner807.pdf>
- Clorox. (2009). *Material safety data sheet: Clorox regular bleach*. Retrieved November 8, 2010, from http://www.thecloroxcompany.com/products/msds/bleach/cloroxregularbleach0809_.pdf
- Clorox. (2010a). *Material safety data sheet: Green Works naturally derived dishwashing liquid*. Retrieved December 3, 2010, from <http://www.thecloroxcompany.com/products/msds/greenworks/greenworksnaturallyderiveddishwashingliquid08-13-2010.pdf>
- Clorox. (2010b). *Material safety data sheet: Green Works naturally derived laundry detergent*. Retrieved December 1, 2010, from <http://www.thecloroxcompany.com/products/msds/greenworks/greenworksnaturallyderivedlaundrydetergent08-13-2010.pdf>
- COCONA. (2010). *COCONA home page*. Retrieved on December 2, 2010, from <http://www.coonafabrics.com/>
- Commission Organization and Functions. 16 U.S.C. § 1633.
- Consumer Product Safety Act of 1972. 16 U.S.C. §§ 1101–1406.
- Consumer Product Safety Commission . (2003). *Strategic Plan*. Washington, DC: Government Printing Office.
- Consumer Product Safety Commission . (2010a). *2011 Performance budget request*. Washington DC: Government Printing Office.
- Consumer Product Safety Commission. (2010b). *2004 to 2006 Residential fire loss estimates*. Washington DC: Government Printing Office.
- Consumer Product Safety Commission. (2010c). *Consumer Product Safety Improvement Act: frequently asked questions*. Retrieved on September 25, 2010, from <http://www.cpsc.gov/about/cpsia/faq/faq.html>
- Consumer Product Safety Commission. (2010d). *List of accredited testing laboratories*. Retrieved September 19, 2010, from <http://www.cpsc.gov/cgi-bin/labsearch/>
- Consumer Product Safety Commission. (2010e). *Recalls and product safety news*. Retrieved October 2, 2010, from <http://www.cpsc.gov/cpscpub/prerel/prerel.html>
- Consumer Product Safety Commission. (2010f). *Revised residential fire loss estimates*. Washington, DC: Government Printing Office.

- Consumer Product Safety Commission. (2010g). *Your home fire safety checklist*. Retrieved September 9, 2010, from <http://www.cpsc.gov/cpscpub/pubs/556.pdf>
- Consumer Reports. (2010). *7 ways to go green – and cut costs*. Retrieved on November 29, 2010, from <http://blogs.consumerreports.org/health/2009/03/better-ways-to-green-cleanand-cut-costs.html>
- Currier, R.A. (n.d.). *Energy from forest biomass – some potential benefits and problems*. Corvallis, OR: Oregon State University.
- Department of Health and Human Services. (2008). Medical management guidelines for hydrogen peroxide (H₂O₂). *Agency for Toxic Substances and Disease Registry* p.19
- Earth Friendly Products. (2003). *Material safety data sheet: oxo-brite*. Retrieved November 15, 2010, from http://www.ecos.com/pages/msds/9751_MSDS_OxoBrite.pdf
- Earth Friendly Products. (2010). *OXO-Brite non-chlorine bleach*. Retrieved November 12, 2010, from <http://www.ecos.com/oxo.html>
- EarthEasy . (2010). *Non toxic paints*. Retrieved on November 20, 2010, from http://eartheasy.com/live_nontoxic_paints.htm
- Eco Choices. (2010). *Pure All Natural Chemical Free Untreated Wool Carpet (Wall to Wall & Rugs)*. Retrieved on December 2, 2010, from <http://www.ecobydesign.com/shop/carpet/>
- Ecover. (2006). *Material safety data sheet according to regulation (EC) 1907/2006: dishwasher tablets*. Retrieved on December 3, 2010, from <http://www.ecover.com/NR/rdonlyres/20046BE0-F78F-413B-B522-59139D561618/5197/MSDS.pdf>
- Ecover. (2008). *Material safety data sheet*. Retrieved November 15, 2010, from <http://www.ecover.com/NR/rdonlyres/24C32289-BC66-4401-B051-14AF4E974BD4/5275/MSDS.pdf>
- Ecover. (2010a). *Material safety data sheet: laundry bleach*. Retrieved November 15, 2010, from <http://www.ecover.com/NR/rdonlyres/03D8F441-74C3-4FB8-89B8-468BAA2EA26F/6318/MSDS1.pdf>
- Ecover. (2010b). *Non-chlorine bleach: 14 oz. powder*. Retrieved November 12, 2010, from <http://www.ecover.com/us/en/Products/Laundry/Non-Chlorine+Bleach+Powder.htm>
- Einspahr, D., Foil, R. R., Haygreen, J., Johnson, J., Kirk, T. K., Koning, J., Nissan, A.H., Sacman, J., Sanyer, N., Setterholm, V., Skog, K, Stone, R. N., Thoman, B., White, J. (1984). *Wood use: U.S. competitiveness and technology – volume II – technical report*. Washington D.C.: Government Printing Office.

- Energy Star. (2004). *ENERGY STAR electronics: sample procurement language*. Retrieved September 24, 2010, from www.energystar.gov/ia/products/home_elec/electronics_procure.doc
- Environmental Protection Agency. (1977). Detergent phosphate ban: position paper prepared by the Region V phosphate committee. Retrieved on December 2, 2010, from National Service Center for Environmental Publications database. pp. 1-61.
- Environmental Protection Agency. (2010a). *About us*. Retrieved November 12, 2010, from <http://www.epa.gov/dfe/pubs/about/index.htm>
- Environmental Protection Agency. (2010b). *An introduction to indoor air quality (iaq)*. Retrieved on December 2, 2010, from <http://www.epa.gov/iaq/voc.html>
- Environmental Protection Agency. (2010c). *Labeled products and our partners*. Retrieved November 12, 2010, from <http://www.epa.gov/dfe/pubs/projects/formulat/formpartc.htm#consumerclean>
- Environmental Protection Agency. (2010d). *Lake Erie phosphorous*. Retrieved November 15, 2010, from <http://www.epa.gov/glindicators/water/phosphorusb.html>
- Federal Hazardous Substances Act of 1960. 16 U.S.C. §§1500–1512.
- Federal Trade Commission. (2009). *FTC Charges Companies with 'Bamboo-zling' Consumers with False Product Claims*. Retrieved on December 2, 2010, from <http://www.ftc.gov/opa/2009/08/bamboo.shtm>
- Final Rule: Standard for the Flammability (Open Flame) of Mattress Sets, 71 Fed. Reg. 13472 (2006) (to be codified at 16 C.F.R. pt. 1633)
- Fishel, Fred. (1997). Pesticides and the Environment. In University Extension, University of Missouri-Columbia, MU Guide (G7520). Retrieved November 16, 2010, from <http://extension.missouri.edu/publications/DisplayPub.aspx?P=G7520>
- Fisher, E.M., Pitz, W.J., Curran, H.J., and Westbrook, C.K., (2000). Detailed chemical kinetic mechanisms for combustion of oxygenated fuels, *Proceedings of the Combustion Institute*, 28. pp. 1579-1586.
- Flakeboard America Limited. (2008). *Material safety data sheet: flakeboard particleboard*. Retrieved on November 15, 2010 from http://www.flakeboard.com/msds/Flakeboard_PB_MSDS.pdf
- Flammable Fabrics Act of 1953. 16 U.S.C. §§ 1602-1632.
- Forbo. (n.d) Technical Specifications: Marmoleum Easy Loc

- Forbo. (2005) Material Safety Data Sheet: Marmoleum Acoustic
- Forbo. (2008). Marmoleum global 3 collection delivers on style, ecology, and economy. *Proceedings of the Press release* Hazleton, PA
- Forbo. (2010). *Vision, mission, strategy*. Retrieved on November 10, 2010, from <http://www.forboflooringna.com/Home/About-us/Vision-mission-strategy/>
- Fowell, A. J. ASTM. (1994). *Fire and flammability of furnishings and contents of buildings* (1233-1994). Philadelphia, PA: Retrieved on October 27, 2010, <http://www.fire.nist.gov/bfrlpubs/fire94/PDF/f94121.pdf>
- Global Ecolabeling Network. (2004, July). *Introduction to ecolabeling*. Retrieved September 11, 2010, from: http://www.globalecolabelling.net/pdf/pub_pdf01.pdf
- Gorree, M. Centre of Environmental Science, Section Substances and Products. (2002). *Environmental life cycle assessment of linoleum* (doi: 10.1065/lca2001.12.072). Landsberg, Germany: ecomed.
- Green Cotton. (2007). *Bamboo: Processing Considerations*. Retrieved on December 2, 2010, from <http://greencotton.wordpress.com/2007/10/02/bamboo-miracle-plant-vs-troublesome-fiber/>
- Green Confidence Index. (2010, August). *Waves and tides*. Greener World Media, Inc.
- Green Depot. (2009). *Material safety data sheet: all purpose cleaner RTU*. Retrieved on November 11, 2010, from http://www.greendepot.com/greendepot/assets/images/docs/GDAllPurposeCleanerLime_MSDS.pdf
- Green Depot (2010). *Green cleaning*. Retrieved on November 11, 2010, from http://www.greendepot.com/greendepot/dept.asp?dept_id=100
- Green Fiber. (2008) *Green fiber insulation attic installation instructions for contractors*. Retrieved on December 3, 2010 from <http://www.greenfiber.com/images/technicaldocuments/115200922146PMWI-6.19-07%20Rev%20B%20GreenFiber%20Attic%20Installation%20Instructions%20for%20Contractors.pdf>
- Green Fiber. (2010). *Material safety data sheet: green fiber loose fill natural fiber insulation*. Retrieved on December 2, 2010 from <http://www.greenfiber.com/images/technicaldocuments/616201082728AMMS-6.4-057%20Rev%20A%20Loose%20Fill%20Blended%20Formula.pdf>

- Green Guard Environmental Institute. (2010). *FAQ's*. Retrieved on November 1, 2010 from <http://www.greenguard.org/en/faq.aspx>.
- Green Living. (2010). *Six household chemicals to avoid*. Retrieved November 10, 2010 from <http://www.greenlivingonline.com/article/six-household-chemicals-avoid>
- Green Seal. (2001). Particleboard and medium-density fiberboard. In Green Seal, *Choose green report*. Green Seal: Washington D.C.
- Green Seal. (2010). *Green Seal programs*. Retrieved September 11, 2010, from, <http://www.greenseal.org/programs/government.cfm>
- Green Works. (2010a). *Green works: our name says it all!*. Retrieved November 10, 2010, from <http://www.greenworkscleaners.com/about-us/>
- Green Works. (2010b). *Material safety data sheet: Green Works naturally derived all-purpose cleaner*. Retrieved November 17, 2010, from http://www.thecloroxcompany.com/products/msds/greenworks/greenworksnaturallyderiv edall-purposecleaner1015_2010.pdf
- GreenFloors. (2010). *What makes a "green" floor? What criteria do you use?.* Retrieved November 1, 2010, from http://www.greenfloors.com/HP_What%20Makes%20A%20Green%20Floor.htm
- Hanrahan, B. and Winslow, M. (2004). Contribution of phosphorus from the automatic dishwasher detergents (ADDs) to Lake Champlain. Lake Champlain Committee Environmental Service Corps Technical Report No.4. Lake Champlain Committee, Burlington, VT. 10 pp.
- Health and Safety Executive [HSE]. (2003). *Wood dust: hazards and precautions*. Retrieved on November 14, 2010 from <http://www.hse.gov.uk/pubns/wis1.pdf>
- Horn, W. (1998). Voc emissions from cork products for indoor use. *Indoor Air*, 8, 39-46.
- IKEA. (2010). *Environmental design*. Retrieved on December 2, 2010, from <http://www.ikea.com>
- Interim Safety Standard for Cellulose Insulation. 16 U.S.C. § 1209.
- International Joint Commission. (2009). *Treaties and agreements: about the great lakes quality agreement*. Retrieved December 2, 2010, from <http://www.ijc.org/rel/agree/quality.html>
- International Organization for Standardization. (1999a). *Environmental labels and declarations – Type I environmental labeling – principles and procedures*(ISO14024:1999(E)). Switzerland.

- International Organization for Standardization. (1999b). *Environmental labels and declarations – self-declared environmental claims (Type II environmental labeling)*(ISO14021:1999(E)). Switzerland.
- International Organization for Standardization. (2000) *Environmental labels and declarations – general principles* (ISO14020:2000 (E)). (2nd ed.). Switzerland.
- International Organization for Standardization. (2006). *Environmental labels and declarations – Type III environmental declarations – principles and procedures* (ISO14025:2006 (E)). Switzerland.
- International Organization for Standardization. (2010). *International Organization for Standardization*. Retrieved September 11, 2010, from <http://www.iso.org/iso/home.htm>
- International Working Group on Global Organic Textile Standard. (2005). *Global Organic Textile Standard Version 1.1*. Retrieved November 17, 2010, from <http://www.harmonyart.com/about/global-standard.pdf>
- Johnson , A. (2010, October 25). *Fridge couch is a recycled refrigerator sofa!*. Retrieved on November 3, 2010, from <http://inhabitat.com/2010/10/25/fridge-couch-is-an-upcycled-refrigerator-sofa/>
- JohnsonDiversey. (2008). *Material safety data sheet: Wisk ultra detergent*. Retrieved on December 3, 2010, from http://msds.johnsondiversey.com/wercswv/jdiMSDS.asp?A=putHTM&RID=F_PDF%27EN%27%27NAM%27%27MS0500083%27%27MTR%27%27ANSI%27\{ts%272008-04-02+15:35:57%27\}
- Kadolph, S. and Stone, J. (2003) *Facts about fabric flammability*. Retrieved November 12, 2010 from <http://www.extension.iastate.edu/publication/ncr174.pdf>
- Knoll Life Chair. (2008) *Smart Certification No 00000001*. Washington, D.C. Retrieved on November 1, 2010, from http://mts.sustainableproducts.com/certified_products/KNOLLLifeSMaRTCertificationSummary.pdf
- Knud-Hansen, C. (1994). Historical perspective of the phosphate detergent conflict. *Fall 1993 Natural Resources and Environmental Policy Seminar*. Boulder, Colorado: University of Colorado.
- Knudsen, H.N. (2007). Sensory and chemical evaluation of odorous emissions from building products with and without linseed oil. *Building and Environment*, 42(12), 4059-67.
- Kujawski, R. (2010). Marmoleum . *Living Green Magazine* , Retrieved on November 9, 2010, from http://www.livinggreenmag.com/archives/natural_home_garden/marmoleum.html

- Litke, D.W. (1999). Review of phosphorous control measures in the United States and their effects on water quality. *U.S. Geological Survey: Water-Resources Investigations Report 99-4007*. National Water-Quality Assessment Program.
- Marshall, G. (2000). Chapter eleven. In Marshall, G. *Safety engineering* (3rd ed.) (pp. 233-243). United States: American Society of Safety Engineers.
- Martha Stewart. (2010). *Clean green: natural cleaning products*. Retrieved November 12, 2010, from <http://www.marthastewart.com/article/clean-green-natural-cleaning-products>
- Method. (2010). *Method laundry detergent – 25 loads*. Retrieved December 2, 2010, from <http://www.methodhome.com/product/method-laundry-detergent-25-loads/?fresh-air>
- Moussa, Moustafa S. (2010). *Process Analysis of Textile Manufacturing*. Retrieved on November 1, 2010, from <http://www.e-textile.org/textileprocess.asp>
- Murrel, J. (August 1991). Assessing fire performance (insulation materials). *Insulation Journal*, 2 (8). Retrieved on November 23, 2010 from http://find.galegroup.com/gtx/infomark.do?&contentSet=IAC-Documents&type=retrieve&tabID=T003&prodId=ITOF&docId=A11426082&source=gale&srcprod=ITOF&userGroupName=mlln_c_worpoly&version=1.0
- National Fiber. (2009). *Material safety data sheet: cel-pak cellulose insulation*. Retrieved on December 2, 2010 from <http://www.nationalfiber.com/docs/MSDS%20NF%20Cel%20Pak%202009.pdf>
- National Fire Protection Association. (2000) *NFPA 654: Standard for the prevention of fire and dust explosions from manufacturing, processing, and handling of combustible particulate*. National Fire Protection Association: Quincy, MA.
- National Fire Protection Association. (2009). *NFPA 5000: building construction and safety code*. Quincy, MA: National Fire Protection Association, 604 pp.
- National Fire Protection Association. (2010). *About NFPA* Retrieved September 19, 2010, from <http://www.nfpa.org/categoryList.asp?categoryID=143&URL=About%20NFPA>
- Navaro, M. (2010, September 19). Cleaner for the environment, not the dishes. *The New York Times*, p. A1
- Occupational Safety and Health Administration. (2007) *Combustible Dust National Emphasis Program* (CPL 03-00-008). Retrieved on November 15th, 2010 from http://www.bsbipd.com/PDF/OSHA%20NEP%2011Mar08%20CPL_03-00-008.pdf
- OecoTEXTILES. (2008). *Why – and how - to green your textile choices*. Retrieved on October 26, 2010, from <http://www.oecotextiles.com/mission.php>

- OecoTEXTILES. (2010). *Oecotextiles*. Retrieved on December 2, 2010, from <http://www.oecotextiles.com/index.php>
- Oeko-Tex. (2010). *Oeko-Tex Standard 100*. Retrieved November 2, 2010, from http://www.oeko-tex.com/xdesk/ximages/470/16459_100def.pdf
- Olympic. (2010). *Go green*. Retrieved on December 2, 2010, from http://www.olympic.com/Paint/Go_Green/go_green.aspx
- Organic Foods Production Act of 1990, 7 U.S.C. § 205.
- Patterson, Phil. (2010). A burning issue. *Excotextile News*, 10, 20-22.
- Poison Prevention Packaging Act of 1970, 16 U.S.C. §§ 1700–1702.
- Potlatch Forest Products Corporation. (2008). *Material safety data sheet: particleboard – all types*. Retrieved on November 15, 2010 from <http://www.potlatchcorp.com/files/Downloads/Particleboard/particleboardMSDSsheet.pdf>
- Proctor & Gamble. (1999). *Material safety data sheet: liquid Tide with bleach alternative*. Retrieved November 10, 2010, from <http://www.monsterjanitorial.com/msds/cleaningmsdssheets/docs/47/4773/4773041.pdf>
- Proctor & Gamble. (2007). *Material safety data sheet: Tide liquid laundry detergent*. Retrieved on December 1, 2010, from http://www.pg.com/productsafety/msds/fabric_and_homecare/detergents/Liquid_Tide_1X.pdf
- Proctor & Gamble. (2009a). *Material safety data sheet: liquid hand dishwashing detergents and antibacterial hand soaps*. Retrieved on December 3, 2010, from http://www.pg.com/productsafety/msds/fabric_and_homecare/dishwashing_products/Ultra_Dawn.pdf
- Proctor & Gamble. (2009b). *Material safety data sheet: liquid laundry detergent*. Retrieved on December 3, 2010, from http://www.pgpro.com/Portals/0/images/msds/GainLiq_2X_Laundry_Deter_msds_0309_eng.pdf
- Proctor & Gamble. (2010). *Material safety data sheet: automatic dishwashing detergent powder phosphate free finished product*. Retrieved December 3, 2010, from http://www.pg.com/productsafety/msds/fabric_and_homecare/dishwashing_products/Cascade_Base_Complete_Powder_Phosphate_Free.pdf

- Pronto Kork. (2010). *Products* . Retrieved on November 17, 2010, from http://www.lico.ch/en/pronto_kork
- Rickett Benckiser. (2010a). *Material safety data sheet: FINISH® powder*. Retrieved December 3, 2010, from <http://www.rbnainfo.com/MSDS/CAN/FINISH-Powder-Canada-English.pdf>
- Rickett Benckiser. (2010b). *Material safety data sheet: LYSOL® Brand (Kills 99.9% of Viruses & Bacteria) Multi-Surface Cleaner Complete Clean (Pourable), All Scents*. Retrieved November 16, 2010, from <http://www.rbnainfo.com/MSDS/US/LYSOL-Brand-Multi-Surface-Cleaner-Complete-Clean-Pourable-US-English.pdf>
- Ryan, B. (2006). *Green consumers: a growing market for many local businesses*. Retrieved on November 3, 2010, from <http://www.uwex.edu/ces/cced/downtowns/lrb/lrb/LTB1106.pdf>
- S.C. Johnson. (2008). *Material safety data sheet: Fantastik antibacterial heavy duty all-purpose cleaner*. Retrieved November 16, 2010, from http://www.scjohnson.com/Libraries/Download_Documents/350000004769_Fantastik_Antibacterial_Heavy_Duty_All_Purpose.sflb.ashx
- Seventh Generation. (2009a). *Material safety data sheet: automatic dishwashing gel*. Retrieved on December 3, 2010, from http://www.seventhgeneration.com/files/assets/pdf/msds/English/Automatic_Dishwashing_Gel_MSDS.pdf
- Seventh Generation. (2009b). *Material safety data sheet:chlorine free bleach*. Retrieved November 15, 2010, from http://www.seventhgeneration.com/files/assets/pdf/msds/English/Chlorine_Free_Bleach_MSDS.pdf
- Seventh Generation. (2009c). *Material safety data sheet: natural powdered laundry detergent*. Retrieved December 2, 2010, from http://www.seventhgeneration.com/files/assets/pdf/msds/English/Laundry-Powder-Detergents_MSDS.pdf
- Seventh Generation. (2010a). *Chlorine-free bleach*. Retrieved November 12, 2010, from <http://www.seventhgeneration.com/Chlorine-Free-Bleach>
- Seventh Generation. (2010b). *Free & Clear all-purpose natural cleaner*. Retrieved November 10, 2010, from <http://www.seventhgeneration.com/Free-and-Clear/All-Purpose-Cleaner>
- Seventh Generation. (2010c). *Material safety data sheet: natural 2x concentrated laundry liquids*. Retrieved December 2, 2010, from http://www.seventhgeneration.com/files/assets/pdf/msds/English/Laundry-Liquids-2X_all_MSDS.pdf

- Seventh Generation. (2010d). *Material safety data sheet: natural all-purpose cleaner*. Retrieved November 12, 2010, from http://www.seventhgeneration.com/files/assets/pdf/msds/English/All_Purpose_Cleaners_MSDS.pdf
- Seventh Generation. (2010e). *Material safety data sheets*. Retrieved December 2, 2010, from <http://www.seventhgeneration.com/material-safety-data-sheets>
- Sierra Pine Composite Solutions. (2009). *Material safety data sheet: sierra pine particleboard*. Retrieved on November 15, 2010 from <http://www.sierrapine.com/Media/MSDS-SierraPine-Particleboard.pdf>
- Simple Green. (2010a) *The Simple Green history*. Retrieved November 9, 2010 from http://www.simplegreen.com/about_us_history.php
- Simple Green. (2010b). *Material safety data sheet: simple green® all-purpose cleaner; simple green® scrubbing pad*. Retrieved November 11, 2010, from http://www.simplegreen.com/pdfs/MSDS_EN-US_AllPurposeCleaner-Pad.pdf
- Standard for the Flammability of Children's Sleepwear. 16 U.S.C. §§ 1615-1616.
- Standard for the Flammability of Clothing Textiles. 16 U.S.C. § 1610.
- Standard for the Flammability of Mattresses and Mattress Pads. 16 U.S.C. § 1632.
- Standard for the Flammability of Vinyl Plastic Film. 16 U.S.C. § 1611.
- Standard for the Flammability (Open Flame) of Mattress Sets. 16 U.S.C. § 1633.
- Standard for the Surface Flammability of Carpets and Rugs. 16 U.S.C. § 1630.
- Standard for the Surface Flammability of Small Carpets and Rugs. 16 U.S.C. § 1631.
- Staples. (2010). *Sustainable earth*. Retrieved November 10, 2010, from <http://www.staplesadvantage.com/facility-solutions/environment/sustainable-earth.html>
- Svoboda, S. (1995, March). *Note on life cycle analysis*. Retrieved September 11, 2010, from <http://www.utexas.edu/research/ceer/che302/greenproduct/dfe/PDF/CORPlca.pdf>
- Tide. (2010). *Tide plus bleach alternative liquid laundry detergent*. Retrieved November 11, 2010, from <http://www.tide.com/en-US/product/tide-with-bleach-alternative.jsp>
- Turret Group. (June 1991) Building for the future...(energy-efficient buildings). *Insulation Journal*, 2 (5). Retrieved on November 23, 2010 from <http://find.galegroup.com/gtx/infomark.do?&contentSet=IAC->

Documents&type=retrieve&tabID=T003&prodId=ITOF&docId=A118822226&source=gale&srcprod=ITOF&userGroupName=mlln_c_worpoly&version=1.0

- Turret Group. (February 1992). The 'green' case for insulation (environmental concerns). *Insulation Journal*, 3 (2). Retrieved on November 23, 2010 from http://find.galegroup.com/gtx/infomark.do?&contentSet=IAC-Documents&type=retrieve&tabID=T003&prodId=ITOF&docId=A12410819&source=gale&srcprod=ITOF&userGroupName=mlln_c_worpoly&version=1.0
- Underwriters Laboratories. (2010). *UL263: fire tests of building construction and materials*. Retrieved on November 11, 2010 from <http://ulstandardsinfonet.ul.com/scopes/0263.html>
- United Census Bureau. (2000) *Resident population of the 50 states, the District of Columbia, and Puerto Rico: census 2000*. Retrieved October 1, 2010, from <http://www.census.gov/population/www/cen2000/maps/files/tab02.pdf>
- United Nations. (2004). The world at six billion. Retrieved September 23, 2010, from <http://www.un.org/esa/population/publications/sixbillion/sixbilpart1.pdf>
- United States Environment Protection Agency and United States Consumer Products Safety Commission. (1995). *The inside story: a guide to indoor air quality*. EPA Document #402-K-93-007.
- United States Fire Administration, National Fire Incident Reporting System. (2008). *Statistical reports: fire incident summaries* Emmitsburg, MD: Retrieved on November 1, 2010, from http://www.usfa.dhs.gov/statistics/reports/estimate_summaries.shtm
- Universal Forest Products. (2010). *Material data safety sheet: wood dust*. Retrieved on November 15, 2010 from <http://www.ufpi.com/literature/wooddust-165.pdf>.
- van Esch, Dr. G.J. (1997). Environmental health criteria for flame retardants. *Proceedings of the international programme on chemical safety*. Retrieved on October 27, 2010, from <http://www.inchem.org/documents/ehc/ehc/ehc192.htm>
- Yao, K. (2010). *U.S. Patent No. 11/133354*. Washington, D.C. Patent and Trademark Office. Retrieved on October 27, 2010, <http://www.freepatentsonline.com/7666922.html>
- Yolo. (2007). *Material safety data sheet: YOLO Colorhouse® Inside – Flat Neutral*. Retrieved on December 2, 2010, from http://www.yolocolorhouse.com/wpcontent/uploads/2010/07/MSDS_v4_InFlat_N_3.pdf
- Zandur. (2009a). *Environmental policy and mission statement*. Retrieved on November 17, 2010, from <http://www.zandur.com/downloads/PDF/Z209%20ENVIRONMENTAL%20POLICY%20AND%20MISSION%20STATEMENT.pdf>

Zandur. (2009b). *Product specifications: cork rubber flooring*. Retrieved on November 17, 2010, from <http://www.zandur.com/downloads/PDF/Z132%20Cork%20Rubber%20Specifications%20-%2011-01-09.pdf>

Zandur. (n.d). *Material safety data sheet: cork rubber flooring*. Retrieved on November 17, 2010, from <http://www.zandurdocs.com/downloads/PDF/Z150%20MSDS%20Cork%20Rubber%20Flooring.pdf>

Appendix A: Consumer Product Safety Commission

Created in 1972 by Congress under the Consumer Product Safety Act, the Consumer Product Safety Commission (CPSC, 2010) has been active for 37 years. Charged with protecting the public from products that cause fire, electrical, chemical or mechanical hazards, CPSC is committed to informing consumers about product safety through recalls and regulations. The CPSC is also dedicated to eliminating consumer products that may pose a threat to the safety of children.

The Consumer Product Safety Commission (1972) is an independent federal regulatory agency funded by the federal government. Stated in the 2011 Performance Budget Request (2010, p. vi) submitted to Congress, the Consumer Product Safety Commission applied for \$118.6 million in requests for payment increases and new program budgets. Although CPSC does not report to any department of the federal government, five commissioners, who serve staggered seven year terms, are nominated by the President of the United States and confirmed by the Senate. These commissioners are responsible for setting the Consumer Product Safety Commission's policies. The five commissioners serving their terms now are Inez Tenebaum (June 2009- October 2013), Robert S. Alder (August 2009-October 2014), Thomas Moore (October 2003-October 2010), Nancy Wood (October 2004-October 2012), and Anne Meagher Northup (August 2004-October 2011). The President then appoints one commissioner to be the Chairman, or Chief Administrator.

Nominated by President Obama on June 9, 2009, and confirmed by the Senate on June 19, 2009, Inez Tenebaum became the ninth Chairman of the Consumer Product Safety Commission (2010). Tenebaum oversees offices such as Congressional Relations, Equal

Employment and Minority Enterprise, General Counsel, Inspector General and the Executive Director. Executive Director Kenneth Hinson is responsible for the offices of Human Resources, International Programs and Intergovernmental Affairs and Hazard Identification and Reductions. Along with the Chairman and major offices at CPSC, the 500 employees manage regulations on over 15,000 kinds of consumer products. Figure 2 below illustrates where we, the WPI team fits into the grand scheme of the CPSC and its 500 employees.

The Consumer Product Safety Commission (2004, p. 2) states in its strategic plan that the organization's mission is to assess different types of consumer products under their jurisdiction to protect the public from preventable injuries and in some cases even death. Although the CPSC does not test products before they are sold, they do develop mandatory regulations, such as banning consumer products. Under the Regulated Products Handbook, the CPSC describes how regulations are enforced. First, if a product is in violation of one of their administrative acts, the Refrigerator Safety Act (RSA), Federal Substance Hazardous Act (FSHA), Flammable Fabric Act (FFA), or the Poison Prevention Packaging Act (PPPA), the manufacturer must report the product(s) to the CPSC within a 24-month period. If not, the CPSC (2005) will remove the product from the market. Manufacturers and distributors can learn about these standards and regulations through seminars and information letters. To enforce standards, surveillance is done through domestic inspections as well as placing observers at the Ports of Entry for foreign made products. Overall, once the CPSC announces a product standard that is necessary to protect consumers, firms must evaluate products for violations. The CPSC is also responsible for conducting research on hazardous products, based on previously recalled products, and developing standards with industries. If the CPSC sees that a firm is not in compliance, they do have the authority to seize the product.

One of the main reasons for the development of the Consumer Product Safety Commission (1972) is to inform and educate the general public about potential and current hazardous consumer products. Through the Freedom of Information Act and the Clearinghouse, the public can become informed, if they so choose, about previous product related injuries through electronic data sources and publications involving hazards analyses and special studies (Consumer Product Safety Commission, 2010).

While the Consumer Product Safety Commission (2003) is mandated to review the safety of a variety of consumer products, one of their strategic goals is to “reduce the rate of death from fire related causes by 20 percent from 1998 to 2013” (p. 13). Working with agencies such as the National Fire Incident Reporting System (NFIRS), National Electrical Code (NEC), National Fire Protection Association (NFPA) and National Institute of Standards and Technology (NIST), CPSC has almost reached its goal. These agencies, as well as other resources, will contribute to the success of identifying the potential safety hazards of green products.

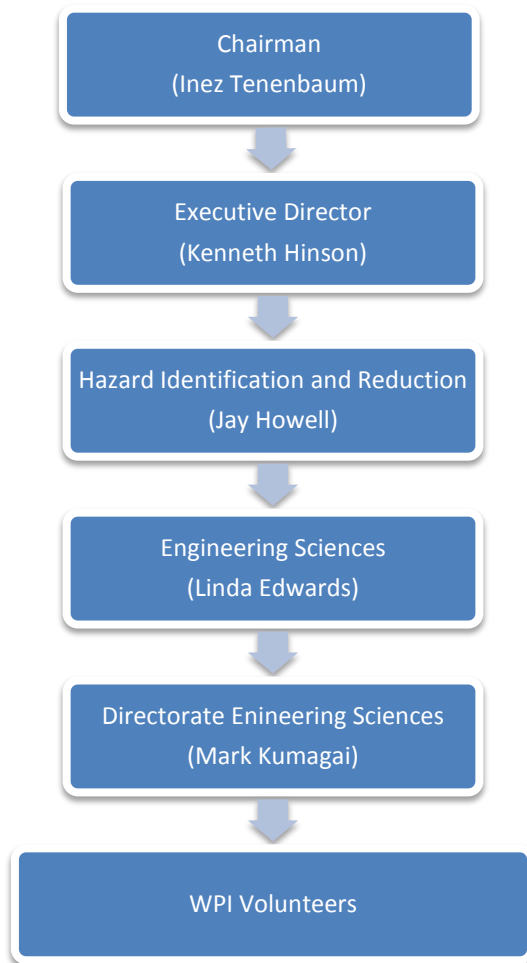


Figure 33 Where the WPI IQP group fits into the CPSC (Consumer Product Safety Commission, 2010)

Appendix B: What is an IQP?

Over 50% of Worcester Polytechnic Institute students complete their Interactive Qualifying Project (IQP) off campus. That means a majority of all projects are located in areas such as Washington DC, Namibia, and Australia, among many other locations. This allows students to work on their IQP in an environment radically different from an academic institution. But, what is an IQP and why do students do it?

To graduate with a Bachelor of Science degree, all students at Worcester Polytechnic Institute must complete and pass three projects, one of which is the IQP. As defined by WPI, an IQP is the “most distinctive academic requirement and is unique in higher education” (WPI, 2010). The IQP challenges students to examine how science and technology relate to society by addressing its needs and issues and solving real-world problems. Although these projects are researched based and are usually outside of the student’s current field of study, they help develop the student’s professional life. This allows WPI’s students to understand the significance of their decisions and how they will affect the world of which they are a part.

The Washington, D.C, Project Center is a prime location to directly relate research and recommendations to society as a whole. In our IQP, Potential Hazards Associated with Environmentally Preferable (“Green”) Products, we will be evaluating consumer products that may be a risk to society; hence, directly relating the public’s well-being to our research. By working with the U.S Consumer Product Safety Commission, our team will experience a strong professional aspect to this project. While in Washington, D.C., we will be required to produce substantial solutions and recommendations to this potential problem. In essence, our project is a real problem for a real organization.

Composed of two chemical engineers, a biology and biotechnology major, and chemistry major, our team is excited to complete this IQP. The project, which is outside of our respective fields, presents a challenge that we are ready to overcome.

Appendix C: Table of Information for Professional Interviews

Contact	Place of Work	Our Purposes
Carl Baldassarra	RJA Group	Building codes and fire protection engineering
Michael Babich	CPSC (Chemist)	Address how fire retardants work in some products and new research fields
Jonathan Barnett	Former WPI Professor	Gain insight on his history of studying products and fires
Toper Buck	GreenBlue	for perspectives in green products overall
Jacqueline Campbell	CPSC (Textile Technologist)	To fully understand how textiles are regulated and tested and if there are any new fields being researched
Kent Carlson	CPSC (Toxicology)	How different materials may emit hazardous compounds into the air. What type of VOCs and how tested
Karen Deppa	NASFM	Understand current work on Green Buildings
Roy Deppa	Consultant	Gain perspective of Green Buildings and how CPSC falls into the scheme
Emily Lavoie	EPA/DFE	Green products within the DfE's scope and their lack of fire retardants
Drummond Lawson	Method	For perspective in green cleaning products
Kathy Notarianni	WPI FPE Director	Determine fields of research to narrow scope of project
Milosh Puchovsky	WPI FPE	NFPA standing on product regulation and interior furnishing codes
Lori Saltzman	CPSC (Health Sciences)	Understand VOC's in greater detail
Alex Stone	WA State	flame retardant alternatives to decabromodiphenyl ether and WA state's ban on decaBDE
Trey Thomas	CPSC (Toxicologist)	Address how fire retardants work in some products and new research fields
Kevin Tibbs	Better Life (Chemist)	Understand how smaller companies are certified and how products that do not contain harsh chemicals work

Appendix D: Notes from Professional Interviews

Professor Puchovsky

Wednesday, September 22, 11:00am
Prof. Puchovsky's Office, WPI

The professor began the interview by asking about the scope of our project. Dan informed him, and he mentioned different strategies that might narrow down our research:

1. Fire protection products are not generally consumer-purchasable. For this reason, it may not be productive to look deeply into fire protection.
2. It would be wise to find out exactly what the CPSC means when they mention green products.
3. If the CPSC cannot answer your questions, narrow the focus to a few key products

Dan mentioned that consumer products marketed as green can be fire hazards.

Professor Puchovsky again advised that the group focus on specific products (i.e. home insulation). He mentioned that his work at the NFPA mostly dealt with fire protection systems and it was hard for him to see the link between his work and our research.

The professor then pointed out that a green product that burns are no longer green. He recommended the group pick whatever products the CPSC has identified as particularly hazardous (wallpaper, textiles, etc.) and then identify what makes these products green and why they are considered green. Many products have certain benefits but can have different fire traits than the market standard. He also mentioned it may be interesting to learn how green alternatives are repaired or trashed.

The professor informed us that a vast amount of resources on fire protection exist that are not particular to whether a product is or isn't green. The International Building Code and the Life Safety Code (NFPA 101) contain sections on interior furnishings. The NFPA Fire Protection handbook includes more information. He told us that there are standardized tests for all products nationally, and that the State of California has much more stringent standards than most of the country. The ATSM also has a standardization system.

Chapter 10 of the Life Safety Code contains information of furnishings, while Chapter 8 covers walls and insulation. Chapter 6 (specifically 6.6 and 6.5) contains fire safety of upholstery and textiles.

Professor Puchovsky was sure that the CPSC would have similar standards for green products and tests and verifications for these standards. Although companies may or may not have to meet these regulations, it would be worthwhile to check the CPSC requirements. He is interested in whether or not anyone has ever tested a green product. Do they have too? The trade-off between green properties and fire properties may be interesting.

Q: Dan asked if the NFPA had had any specific work to do with green products or consumer product fire hazards.

The professor mentioned that the NFPA has minimum standards. The federal governments, and more commonly the state governments, adopt portions of these codes, modify them and add to them. The NFPA mostly focuses on building materials and interior finishings. They create regulations and standardized tests for those regulations.

Q: Dan asked about the extent to which the NFPA works with consumers

Other than their fire protection week, the NFPA does not directly work with consumers. The NFPA is an 80,000 member organization that puts out standards. The organization does promote fire education in schools through others and publish informational pamphlets.

The Professor mentioned that many consumers today are trying to be green in whatever way they can. The NFPA has recognized this and holds a conference each year on the “green-ness” of sprinklers. He did not know whether or not the NFPA has any current program to deal with green products.

The professor then pointed out that “...making something greener increases the fire hazard”. A large part of fire safety is not “green” by certain metrics but can be considered “green” by others.

Q: Ben asked whether there is a single governing body that regulates green products, fire safety or laboratory testing. If there are many organizations which has more authority than the others?

LEED certification is a regulation agency that certifies green buildings. Although a building is certified as green, it can still burn. The International Code Council is another body which controls standards. The U.S. government writes the fire safety regulations into law, but all of the organizations that make the regulations are non-profits. As such, they have little to no direct authority. These organizations make money by selling code books which are adopted into law. Each one has a process, but none can enforce their rules.

The reason this is done is that the government saves money by not researching these areas constantly. The United States government adopts some of the standards and leaves many for the states to decide. For this reason the codes vary slightly state-by-state.

Q: Ben asked if the OSHA-certified testing labs were used by the CPSC and the NFPA.

Professor Puchovsky mentioned that the labs all adopt part of a code. The Underwriter’s Laboratories stood out in his mind as particularly preeminent. Various federal agencies may have approved a list, but it would be best to check to see if the CPSC has an overall standard.

Q: We thanked the professor for his time and explained that he had been very helpful.

Treye Thomas and Mike Babich

November 2, 2010

CPSC Headquarters, Conference Room 612

Fire Retardants

- Treye began the meeting by inquiring what green products the WPI team was looking at.
- Emily responded that the group was currently pursuing environmentally preferable textiles (Eco-Textiles) that were not using fire retardants as required by the CPSC
- Treye asked how the group how the group defined fire retardants
- Emily replied that Oco-Tex had some sort of requirement. The group's definition of fire retardant would probably be adapted from some other standard
- Ben mentioned that the group knew fire retardants were currently a controversial subject at the CPSC and wondered what it was the group could and couldn't say. Treye replied that it was not his call.
- Scott advised the group to say next to nothing about fire retardants. He wanted the group to prepare their paper's background review section as if fire retardants do not exist.
- Emily countered that eco-textiles exist because fire retardants are considered by environmentally preferable groups to be a health hazard.
- Scott said that the group should maybe mention it in on sentence of the background.
- Treye explained that fire retardants do not meet wide definitions of toxic compounds.
- Mark explained that hazards for substances like fire retardants are decided on a case-by-case basis, like any other substance.
- Treye mentioned that FHSA has specific definitions for hazardous substances. Like any other compound, the CPSC needs to remain fair and objective to fire compounds when evaluating possible hazards.
- Scott mentioned that green products are *perceived* to be important by consumers, but that doesn't necessarily mean that they are.

At this point, Mike Babich walked in and joined the discussion

Fire Retardants as They Pertain to the Project

- Mike asked if the group could inform him on what their project was.
- Dan replied that several environmentally preferable textiles were made without fire retardants, and that the group believed that this presents the consumers with hazards.
- Dan went on to say that although some eco-textiles were tested with fire retardants, they were sold without the application of fire retardants.
- Treye and Mike both asked Dan if his statement was true, which Dan assured them it was.
- Mike then asked if the products were clothing, as the CPSC did not yet regulate upholstery fabric.
- Emily answered that the product in question was upholstery and that the group was currently trying to obtain swatches.

- Mike asked if the group could identify the product.
- Emily replied that as far as she knew, the company just sells fabric.

Fiber Type

- Mike then asked about the fiber type of the sample textile. Emily responded that the textiles came in cotton, linen, and hemp.
- Mike explained that cotton usually needs a fire retardant applied in order for it to be safe for the consumer.
- Scott added that the crux of the argument is that the environmentally preferable product may not be safe. To pass the standard, the product being sold must become non-environmentally friendly. The group did not need to justify more research on this company because of their lack of fire retardants in their products. He advised the group to explain only that their advertisement is incorrect.
- Emily asked if it was okay for the group to define what the manufacture says without passing judgement. Mark, Scott, Mike and Treye all responded in the affirmative.
- Mark informed the group of the importance of not stating their personal opinions in their paper.

On the Project

- Mike mentioned that he felt the project was a good one, and that being environmentally friendly is a complicated goal despite serious motivations.
- Mark reminded the group that although the project was good, it was a bad idea to include unsupported information about toxicity.

Further Research

- Mike stated that it was interesting to know if the products passed the flammability standard without extra chemicals. He recommended this idea as a future research area.
- Scott reminded the group to accept the standard as eco-friendly and take it. It was unwise to evaluate eco-standards.
- Treye agreed with this judgement and suggested that the group do a straightforward safety test on textile samples.
- Treye also asked how valid the green standards were, to which Emily replied that the group had already gone in-depth in their background.
- Mark reminded the group to make no mention of chemicals

Liaisons Obligations

- Scott asked Mark if they needed to approve any deliverable from the group. Mark answered that the only document is a WPI document.
- Treye asked if this meant any 6b6 clearance was needed. Mark replied that this was not necessary.
- Mark stated that he was worried that the project would not have enough girth to get good grade.
- Alison stated that this was not a problem. Ben disagreed with this statement, saying that he felt a return to the original proposal would be wise.

- Scott asked if there are eco-standards for other products, and Mike suggested that the group talk to Rikki.

Future Work

- Treye explained that he was curious to see that if fire retardants were replaced, would an increase in fires be observable? He did not know of any good alternatives to the current fire retardants. Treye wondered if the market were to switch compounds with less effective compounds if any change would be observable. He wanted to know what the benefit of switching was.
- Mike told the group to make a recommendation to the commission on what to look at. He advised broadening the project and including construction materials.
- Scott explained that any tests the group wanted to do should only be a day in length, as he was unsure as to how often the group could get to the lab.
- Scott also wanted the group to evaluate claims made by manufacturers. Emily wanted to know if the group could safely identify manufactures in the paper.
- Scott advised the group to look at the broad and general claims, and then analyze the difference between them.
- Treye instruction to the group was to use the word “fire retardants” and replace it with “chemical substitutions”.
- Mike further advised the team to look at flammability standards and whether or not products meet those standards with or without chemical substitutions

Environmental Characteristics

- Mark inquired as to what the term “eco-friendly” actually means
- Emily explained that there is no universal way to tell if a product is eco-friendly. In order to deem a product eco-friendly, companies need to perform a life-cycle assessment (LCA), which is case-by-case.
- Mark asked if there were any safety assessments included in an LCA. Emily responded by explaining that only human health was considered.
- Treye verified that the health concern was only in relation to releases into the environment.
- Treye then asked if removing or replacing a fire retardant would still allow a product to be sold safely. He explained that chemicals were at the heart of green chemistry, and taken seriously by the green movement.
- Mike added that “safe” does not mean “non-toxic”
- Treye then wondered if by avoiding an eco-hazard another hazard may be created. He encouraged the group to find an answer.

Conclusion

- Treye concluded the meeting by advising the group to explain that changes may happen in products that affect their fire safety. It was beyond the scope of the project to care about what change occurred. The WPI student team should only mention that some products are no longer safe.

Kevin Tibbs

Better Life Products November 8, 2010
Electronic Communication

Tibbs: I am the chemist who developed the BETTER LIFE formulations and would be happy to try and answer your questions. If you would like to contact me feel free to use the contact numbers below or by email (I am much faster responding to email than phone however).

Regarding your general question about cleaning:

There is a wide range of “Green” cleaning products now available and it makes choosing the right one a confusing task. Definitely some products are “Greener” than others, and ingredients should be an important factor which determines how green the product is.

- Some green products contain the same chemical ingredients found in the traditional petroleum based cleaners- only at a lower level. While this allows the product to biodegrade faster, it does not eliminate the harsh ingredients.
- Some green products use a different approach to formulation of these products and utilize new plant based surfactant chemistries. This is the case for BETTER LIFE products.

Our products eliminate both petrochemical surfactants and also eliminate dyes, synthetic fragrances and solvents to achieve a product that is safe and green. Years of testing and developing cutting edge/unique formulations are the reason our products work so well while eliminating the harsh petro-chemical ingredients used by the competition.

We also take steps throughout our company to promote sustainability and environmental stewardship. A couple examples include;

- Post consumer recycled material (PCR) in our bottles as well as using the #1 recycle code
- Reducing packaging overall throughout our products
- Running our computer servers off solar generated power.
- Treating and recycling our plant water

Q: Are there any safety hazards associated with BETTER LIFE formulations?

Other than biodegradability, are BETTER LIFE products third party tested? Why/why not? and what kinds of tests?

Is BETTER LIFE formulations certified by organizations like the EPA or GreenSeal?

Tibbs: Of course all consumer products should be used properly. That said, our products are safer than most personal care products you use (shampoos, hand soap, etc.) and MUCH safer than any cleaning product on the market- green or traditional.

Yes, there have been a variety of tests done on the products and the ingredients used in

the products. Tests include; performance testing, irritation testing, aquatic toxicity, human hazard evaluation, to name a few.

Most third party seals are a “Pay to play” certification, meaning you pay a large sum of money to get the seal. Our products far surpass these third party standards. However, we are not interested in paying for a seal that allows for the use of many chemical ingredients we deem unacceptable. We also believe in merit based certifications such as the Leaping Bunny Certification (which we have).

Kent Carlson

November 10, 2010

CPSC Headquarters Conference Room 603B

Formaldehyde

- EPA categorization for VOCs in progress
- California has a hazardous emissions list (CAB50)
- Voluntary standards are VOC based, not health based standards
- Anything required to dry will emit VOCs (paints, finishes, sealants)
- Urea formaldehyde spray foams use phosphates as the fire retardant
- Craig O'Brien: contact for hospital data regarding incidents with formaldehyde (acute, not chronic symptoms known)
- Engineered wood: Carbon 2 standards for fiberboard/particleboard

What is considered when testing VOC?

- Room size
- Ventilation
- Content
- Usually have a standard room
- Many factors

Emma Lavoie

November 19, 2010 11:00am

Phone Communication

Q: Do you deal with more industrial or consumer products?

- I and I products → industrial and institutional products
- Focus on consumer product more recent (within last decade)

Q: What do you look at as a toxicologist? Emissions, chemical ingestions, irritation?

- Criteria on website “safer product labeling program)
- Exposure, dermal, and inhalation
- Biodegradability and bio-accumulation

Q: Why is the EPA interested in alternative fire retardants? Safety or health focus?

- Have not monitored shift in use
- Low, moderate, or high hazard
- Assessing for human health and ecological safety

Q: What companies are looking for DFE seal? What is the incentive?

- Want to demonstrate that their product is the environmental choice
- DFE criteria is more distinguishing and client based
- Are able to encourage companies to reformulate their product to meet criteria of DFE (prevented 500 million pounds of terrible chemicals)
- Do not put labels on products that contain fire retardants

Q: Paint VOC's:

- Have potential to react with indoor ozone
- Less volatile chemicals are likely to have chronic problems (eco-ethers)
- Difficult to find a chemical that is functional and safe for human health that is not a VOC

Q: Epa.gov/DFE

- Furniture alternative assessments
- Info about available (4-1) halogen free fire retardant alternatives
- Share paper with Emma
- Contact: trade associations (ISSA- cleaning products) (CSPA-specialty product) (American cleaning institute)

Karen and Roy Deppa

November 19, 2010

National Association of State Fire Marshalls, 2:00pm

Q: What types of building materials are becoming trendy in “green” buildings?

- Products used are generally “mundane,” or not made from novel materials, and are not too different from their standard counterparts.
- Products have good performance, are green, and economical (and may be advertised more for their economy, less for their “greenness”)
- Light weight construction and engineered wood: known hazards are formaldehyde and deterioration (building collapses faster and burns faster).
- Fire people do not like light weight materials

Q: Have more people been inquiring about green building materials?

- High percentage of architects are LEED certified
- Putting pressure on market- driving force is environmentally friendly

Q: Have building codes changed for green building materials?

- Codes generally are not keeping up with technology
- Fire- need sealants on certain wall coverings that need to be fire proof, no sealant that is 0 VOC
- Sometimes you just have to convince the code official that the building is safe
- 3yr code cycles: new materials/products held to other standards, which may not address certain attributes of the material/product

Q: Have any of these products seemed to present more safety hazards than others?

- Insulation in buildings- ignition when constructing a building.
- Green building in China burnt down during construction (Madarin Hock Hotel)
- Recycled materials may have other things in them: recycled wood is not the same as regular lumber/wood
- “green” furnishing: manufactures might be using this term to avoid regulation

FM Global: concerned about green building hazards

- Photovoltaic currents
- Plastics in skylights
- Flammable lubrication oils
- Roofs with recycled materials (polystyrene)
- Alternative refrigerants (pure propane)

Q: In the last year, how many buildings became LEED certified? Do you know of any that have been burnt down?

- China hotel that burnt down before completion
- Certification mainly depends on design, not what materials are used.

Appendix E: Retailer Interview Notes

Natalie Levy

Furniture Store B
November 30, 2010

Q: Do you have your own criteria for what is green?

A: Sure they do. Products most likely will comply with green and eco labeling standards. Does not have full information, but email to get contact for merchandising.

Q: Do you do additional advertising (beyond what the seller/manufacturer does) for environmentally friendly products?

A: The store and the manufacturer want to inform the customer of what products are eco-friendly. They are actively promoting green products. However, every customer will have a different perspective of what is green and what that means to them.

Q: Is it safe to say that Crate & Barrel, as a store and company, is becoming greener?

A: Yes. From the products we sell to the lights that are located in our stores , Furniture Store B is on the way to being entirely eco-friendly. Green is an ongoing mission for Crate & Barrel

All other questions could not be answered at this time.

Suggestions: go to eco-friendly initiative on the Furniture Store B website.

Natedra Baks

November 30, 2010

Q: Does your store have its own criteria for what is “green”?

A: Home Depot usually categorizes products by their function, not their “greenness”

- Home Depot generally follows most national standards, like Energy Star and Design for the Environment, as well as other third-party certifications
- Home Depot has been actively selling “green” products since 2006

Q: Does your store do addition promotion/advertising (beyond what the manufacturer does) for environmentally friendly products?

A: Yes

- Eco-option website

Q: What “green” products are currently popular?

A: Any product that saves the consumer money through energy or water conservation

Q: What “green” products are less popular?

A: All products are performing well, in comparison to prior years

Q: Have any “green” products had unexpected success? Have any failed?

A: Dual flush retro fit kit allows consumers to transform any standard toilet into a toilet that conserves water

Q: Do you have any reports on the trends of “green” product sales for your store?

A: Yes, Home Depot does conduct market research on “green” products specifically

Q: In what direction do you see the future market for “green” products going?

A: There will be continued emphasis on “green” products because consumers are becoming increasingly aware and educated about “green” products

Michael Schnard

DYI Store B

November 30, 2010

Q: Does your store have its own criteria for what is “green”?

A: DYI Store B mostly sells Energy Star and Water Sense products, but sells a few other “green” products with third-party certification, as well

Q: Does your store do addition promotion/advertising (beyond what the manufacturer does) for environmentally friendly products?

A: DYI Store B has an environmentally friendly products category in their online store

- Also publishes an annual newspaper insert describing environmentally friendly products and behavior in October
- Does not do much in-store advertising

Q: What “green” products are currently popular?

A: DYI Store B does not track the sales of “green” products, they are integrates into regular product categories

- Energy Star is most likely to be the most popular due to a high brand awareness of about 80%
- Water Sense products have a lower brand awareness, but are still selling well because they save consumers money

Q: In what direction do you see the future market for “green” products going?

A: Looking all different types of “green” products (not only building materials), there will increasing emphasis on organic foods

- However, “green” product adoption must wait for economic recovery due to on-average higher product pricing
- Consumer confidence in “green” products must be higher before retailers and distributors focus on “green” product sales and research specifically

Anonymous Person

Supplier Store A
December 1, 2010

Q: Does your store have its own criteria for what is “green”?

A: Yes, has very detailed criteria for the products Supplier Store A sells
- Referred to as the “Green Filter”

Q: Does your store do addition promotion/advertising (beyond what the manufacturer does) for environmentally friendly products?

A: Yes, all products sold are “green” and so all advertising promotes environmental friendliness

Q: What “green” products are currently popular?

A: Bonded Logic recycled cotton insulation
- Low or no VOC paint

Q: What “green” products are less popular?

A: All products doing very well in comparison to prior years

Q: Have any “green” products had unexpected success? Have any failed?

A: VOC free paint is extremely popular

Q: Do you have any reports on the trends of “green” product sales for your store?

A: Yes, Supplier Store A only sells “green” products

Q: In what direction do you see the future market for “green” products going?

A: What the market is currently experiencing is only the beginning of the “green” products trend
- Energy saving products are probably the next category of “green” products to expand and develop

Appendix F: Fire Safety

Under the Consumer Product Safety Act (1972), the Consumer Product Safety Commission is charged with protecting consumers against fire. To this day, this mandate remains a major focus of the agency, establishing a special interest for the flammability of consumer products. In their 2003 *Strategic Plan*, the CPSC announced three result-oriented goals. One goal was to reduce the rate of fire related deaths by 20% from 1998 to 2013. In 2008, 378,200 fires occurred in residential buildings of which 24,500 fires, 430 deaths and 1,550 injuries were unintentional (U.S. Fire Administration, 2008). Although progress has been made, it is necessary to bring the annual occurrence of these incidents even lower in order to meet this goal. This section will provide a basic understanding of the science of fire, so that it may be easier to recognize the reasons why some environmentally preferable products may present more of a fire or burn hazard than others.

Fire Triangle

The three main components to a fire – heat, oxygen and fuel – are known as the fire triangle (Beroes, 1977). The presence of all these factors will set an object or material on fire, whereas the removal of one of these elements will result in the extinguishing of the flame (Patterson, 2010). The first leg of the triangle, heat, is an essential component in starting a fire. Known as the heat of ignition, a fire will start only after a material has reached the minimum amount of heat energy needed for ignition or it will not burn. Heats of ignition are fixed amounts of energy unique to a material or product. When a material, the fuel leg of the triangle, is subjected to heat, a mixture of gasses is released into the surrounding air. If the combination of the released gasses and oxygen in the air is combustible, a material is ignited and will burn. Oxygen, the last leg of the fire triangle, allows the material to keep burning. The flame growth

will always rise vertically and can be described as a chain reaction. The ignition of a material leads to the rise of hot gasses that vacates the underside of the flame for a constant supply of oxygen. The abundance of oxygen will react with the gases released from the material and combust to keep the fire ablaze. This process will continue until one leg of the triangle is removed.



Figure 34 The Fire Triangle. As seen above, it is made up of three legs, oxygen, heat, and fuel. To have a fire, all components must be present. If one component is taken out during a fire, the result is extinguishment (CabelSystems, 2007).

Although the fire triangle is a widely known and is a useful teaching tool, it does not accurately describe all components needed to have a fire. The fire tetrahedron, however, does include all the main parts to the fire (Figure 35). Like the fire triangle, the tetrahedron establishes heat, oxygen and fuel as three important steps to making a fire. The last part of the tetrahedron is the chain reaction, which sustains the fire. A common mode of fire suppression is to stall this chain reaction, and is utilized by many chemical additives such as halogens. The chain reaction begins with combustion. Combustion occurs when an exothermic (heat-releasing) reaction between an oxidizing agent (a substance in need of electrons) and a flammable compound takes place (Campbell, 1949). For most normal fires, the agent is oxygen and the compound is some hydrocarbon-bearing substance. If the energy given off by a substance (i.e. hydrocarbon) is strong enough to split the oxygen diradical, the oxygen reacts with that substance

exothermically. The result is a release in energy in the form of light and heat, hence the flames of the fire.

Oxygen naturally exists as two atoms (a state known as “diradical”) joined together in a gaseous state (Campbell 1949). In order for a fire to occur, there needs to be a strong enough energy source to separate the two atoms in order for them to react with other atoms. A separated oxygen atom has two less electrons than usual, as the two electrons it had been sharing with its counterpart oxygen atom is no longer present. The single oxygen atom becomes reactive and is referred to as a free radical. The oxygen free radical combines with the carbon in the compound. After this, another oxygen free radical combines with the freed hydrogen, which forms a hydroxide free radical. The carbon usually combines with another oxygen free radical to form carbon dioxide, while the hydroxide free radical then combines with another hydrogen atom to form water. The mechanism for the reaction is largely the same, although variations are known to exist (Fisher, 2000). This reaction becomes a chain reaction when the heat given off by the reaction vaporizes more combustible gases, allowing for more oxygen radicals to split and combine with the gases. This explanation of the chain reaction becomes important when considering the role of fire retardants.

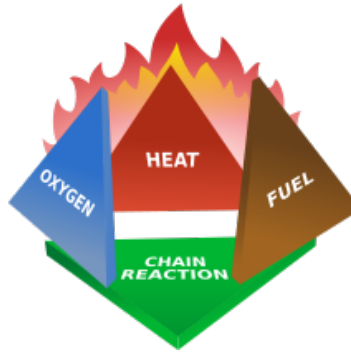


Figure 35 The fire tetrahedron accurately describes how fire is formed. Unlike the fire triangle, the tetrahedron includes the chain reaction of the fire. Many suppression systems use methods to stop the chain reaction and extinguish the fire. (CabelSystems, 2007)

Although most materials need to be exposed to an open source of flame to ignite, some materials may automatically (spontaneously) ignite. This happens when a material reaches its auto ignition temperature, or the minimum temperature that allows the gasses in the material to spontaneously ignite. For example, a bundled cloth splattered with oil can auto ignite as the temperature of the oil rise through the insulation provided by the cloth. The fire triangle and tetrahedron are models that are used to describe any type of fire, no matter how big or insignificant it is.

Characteristics of Fire

When a fire burns, it is often visible to observers in the form of flames. These flames are created by combustible vapors visibly reacting with the oxygen in the surrounding atmosphere (Beroes, 1977, p.4). Different substances at different temperatures will give off different color flames when they burn. In order for solids and liquids to ignite and burn they need to gasify, usually by reaching a high temperature, as fire only occurs in a gas-phase reaction. The temperature at which enough gasses have vaporized to sustain a flame after being exposed to an ignition source is referred to as the flash point. This differs from the auto-ignition temperature in

that for the flash point a source of ignition must be present. Without vapors, flammable substances do not ignite.

One of the dangers inherent in fires is the existence of “flash.” Flash is a when a flame front moves rapidly across a combustible surface when conditions for combustion exist (NFPA, 2010). In other words, the material will suddenly and intensely catch on fire. Many textiles, furnishings, and building materials have the ability to flash when exposed to a flame. In consumer products, flash is dangerous because it can quickly ignite surrounding combustible materials. If an indoor fire becomes large enough, the hot gasses produced from combustion rise to the ceiling and collect at the top of a room. As these gases build up and radiate heat downwards, the auto ignition temperature of materials on the ground is reached and all of the materials in the room suddenly flash. This is referred to as “flash-over”. If a product is made resistant to flash, then it has not only a reduced ignition risk, it can also reduce the destructiveness of a home fire.

Fires can burn in many ways and this can sometimes present problems for fire safety. Often textiles do not show a clean burn, but instead they char, drip, and melt (Beroes, 1977, p.7). Some textiles exhibit an “after-glow” in which they continue to burn but without any visible flame. Many home furnishings and wooden objects char and leave ash when they burn. Volatile liquids such as alcohols burn cleanly, relative to other substances, but leave a residue in the form of soot or impurities. To adequately protect a consumer product from a fire danger, the prevention method must be tailored to the materials from which the product is made.

Fire Suppression and Retardants

Each year, about 3 million fires are reported, causing approximately 4,500 deaths (van Esch, 1997). Products such as clothing or home furnishings often need additional protection from

fires in order to retard the flame spread. One popular way of increasing the flame resistance of materials is by physically adding or chemically bonding chemicals to natural or synthetic goods. When added, these chemicals use a variety of methods to reduce the advancement of fire in a material. Table 5 below gives a summarization of how different chemicals may retard a fire.

The purpose of each chemical is to prolong the time needed for each leg of the fire tetrahedron to form. One method is to use additives that reduce the amount of combustible gases in the surrounding air by increasing the amount of non-combustible gases in the surrounding air (van Esch, 1997). Typical chemicals that control fires in this way include nitrogen compounds, metal hydroxides, and metal salts. When these chemicals decompose, they release a large volume of non-combustible gases can either dilute the oxygen supply to the flame or act as a competitor and lower the fuel concentration. The non-combustible gasses will surround the material and interrupt the fuel or oxygen leg of the triangle. If there is a greater amount of non-combustible gasses than combustible gases, ignition of the fire is delayed. Nitrogen compounds, metal hydroxides, and metal salts can also retard flame spread by thermal quenching. This works by reducing the surface temperature or rate of burning of a certain material.

Forming a protective liquid layer or char barrier is a third method some chemical additives may employ (van Esch, 1997). For example, nitrogen and phosphorous compounds develop layers that limit the amount of material available for combustion by decreasing the amount of surface area exposed to the flame. The char barrier or liquid protection layer acts as a form of insulation that will limit the amount of heat transferred to the material and therefore decrease the energy needed to ignite.

A fourth method of fire suppression works through allowing the material to act as a heat sink by increasing its heat capacity (van Esch, 1997). This means that when a material treated

with this chemical is exposed to a source of heat, it is required to significantly increase in temperature before it reaches its heat of ignition. Additives that work in this manner can fall into the category of inert fillers or minerals.

Another strategy, normally employed by halogens and some phosphorous compounds, is to produce radicals that compete with the radicals in combustion. This then leads to fire termination. Table 5 below gives an overview of how each mechanism used to suppress a fire.

Table 5: Summary of fire retardants and how they work (van Esch, 1997)

<i>Part of Triangle</i>	<i>Mode of Action</i>	<i>Chemical</i>
Fuel/Oxygen	Increasing volume of non-combustibles	Metal salts & hydroxides Nitrogen compounds
Heat	Thermal quenching	Metal salts & hydroxides Nitrogen compounds
Heat/Fuel	Char/ Liquid Barrier	Nitrogen & phosphorous compounds
Heat	Act as a heat sink	Inert fillers/ minerals
Oxygen	Produce radicals	Halogens & phosphorous compounds

Traditional chemicals, noted as inorganic or organic, have been widely used to increase the flame retardance of a polymer or material. As new environmental and health concerns arise, new chemicals are being produced, although many are still in the patent processes. These new chemicals, which are being used to reduce the fire risk of materials, claim to be biodegradable (Yao, 2010). The actual performance of these new chemicals is unknown and therefore cannot be accurately compared to traditional fire retardants.

Fire Testing

Fire testing of materials was originally done to collect knowledge about how a material responds to fire, rather than for assuring product safety (Babrauskas, 1991). The earliest example of a standard fire test used for testing consumer products was an experiment developed by the British Standards Institution in 1936 for fabrics. During this test, the sample fabric was

suspended over burning alcohol contained in a cup. Soon after the development of this test, several other regulatory agencies adapted similar tests and many tests changed over the years by substituting the burning cup with Bunsen burners and probes. These changes eventually led to the fabric flammability tests the CPSC now uses.

Many products regulated by the CPSC must pass standardized fire tests. Third-party laboratories handle much of the fire safety testing and certification process for nearly all individual products. Several standards organizations, such as the American Society for Testing and Materials (ASTM), have published rules and procedures for conducting several specific standard fire tests in independent laboratories. The CPSC, however, uses the rules on fire testing as mandated in the U.S. Code of Federal Regulations.

Appendix G: Product Codes for CPSC Databases

Textiles

CODE	PRODUCT
667	Bedspreads, throws, comforters
676	Carpets, rugs
679	Couches, sofas, davenports
1644	Nightwear
1645	Daywear
1646	Outerwear
4002	Bedding
4010	Mattresses

Building Materials

CODE	PRODUCT
1803	Thermal or sound insulation
1885	Wood paneling, particle board

Home Furnishings

CODE	PRODUCT
600	Home furnishings and fixtures
604	Desks, chests
905	Furniture, polishes and waxes
907	Paints, varnishes, shelac
960	Paints, varnishes
1807	Floors, flooring materials
4013	Other furniture
4014	Furniture, not specified

Home Maintenance

CODE	PRODUCT
900	Home and family maintenance products
901	Cleaning agents and compounds
930	Ammonia (household)
934	Dishwasher detergents
935	Chemical deodorizer
946	Deodorizers, not specified
947	Detergent, not specified
949	Laundry soaps or detergents
950	General household cleaners
953	Abrasive cleaners
956	Bleaches (non-cosmetic)
976	Detergent, not specified
979	Dishwashing liquid

Appendix H: Manufacturer Information

Benjamin Moore

Benjamin Moore founded Benjamin Moore in 1883. Paints come in a variety of colors. Like other companies, Benjamin Moore has developed green products and now promotes sustainability.

Better Life

Better Life (2010b) is a newer, family-owned company which was motivated by the green movement and has since created several cleaning products based on natural ingredients. Their products are sold at Walgreens and other retail stores.

BioShield

As a subdivision of Eco Design Co. BioShield is a line of natural paints and finishes. BioShield was founded by Rudolf Reitz in 1982 in Santa Fe New Mexico. BioShield pledges to create products derived from natural and easily-renewable resources without harsh chemicals or additives. BioShield products include clay paints, solvent free wall paint, interior and exterior wood stains, color pigments for tinting and much more.

Cloverdale

Cloverdale was founded by a farmer, chemist, and paint manufacturer Rudy Henke in 1933. Committed to creating long-term trusted relationships is Cloverdale's mission. Currently, Cloverdale Paint is committed to reducing or eliminating harmful impact from their products. They have in turn developed paints that are water-based and low VOC.

COCONA

Is a company that provides natural, dry, and odor and uv managing fabrics. Based out of Boulder, Colorado, the company was originally named TrapTek, LLC, however, the name was changed in 2007 to COCONA (Bloomberg business week, 2010). The company uses its patented technology to integrate activated carbon, produced from coconut husks, into yarn to produce

Eco Choices

Is a subsidiary of Eco Planet. Eco Planet, based in Nevada, was founded in 1997 as the first online seller of environmentally preferable mattresses and bedding. Eco Planet focuses selling on creative eco-friendly products in its several online stores.

Ecohaus

A merger of two companies, Environmentally Home Center and Environmental Building Supplies, ecohaus was developed in 2006. Now led by David Silverglide (CEO) and Tamara Cihak (CFO), ecohaus is located in three states, Washington, Oregon, and California. Ecohaus

offers products ranging from flooring to paints and insulation. Its aim is to provide consumers with environmentally friendly materials.

Forbo

In 1975, Forbo evolved into a worldwide group focusing on three divisions: flooring systems, bonding systems and movement. Although based in Switzerland, Forbo owns 14 manufacturing plants and branches in 32 countries spanning 5 continents. Focusing on environmentally friendly products, Forbo's strategy is to offer a broad range of products leading in performance and design, to continuously improve their products, and to excel in customer service.

Homasote Company

The Homasote Company was founded in 1909 by Eugenius H. Outerbridge as the Agasote Millboard Company. Their original product was Agasote board and in 1916 the company started making Homasote® board. In 1925 a change in demand made Homasote the company's best selling product and so they changed the name to The Homasote Company. The Homasote Company is the oldest manufacturer in the country of building product made from recycled materials and today the company recycles over 65 million pounds of paper waste every year into engineered wood.

Miller Paints

Miller Paint was founded in Portland, Oregon by Ernest Miller, a German scenic artist and house painter. Miller Paints now has locations over the United States selling products to homeowners, contractors, and designers. Like many other companies, Miller Paints has environmentally preferable paints.

OecoTextiles

Leigh Anne Van Dusen and Patty Grossman founded the company in 2004 with the mission to "change the way textiles are made by proving that it's possible to produce luxurious, sensuous fabrics in ways that are non-toxic, ethical and sustainable" (Oecotextiles, 2010, mission).

Sherwin Williams

Henry Sherwin and Edward Williams founded Sherwin Williams in 1866. Sherwin William supplies paints for commercial and industrial uses, as well as automotive and aerospace finishes. They manufacture a variety of products including some environmentally preferable ones such as Harmony.

Sunshine Makers

Sunshine Makers began 30 years ago by selling non-toxic alternatives to industrial and residential cleaners, which at the time were toxic (Simple Green, 2010a). As environmental

awareness increased among consumers, the business began to advertise their products as being “green” because many already used natural chemicals.

Yolo

Yolo was created by Virginia Young and Janie Lowe in 2005. Considered a kind of “indie” paint, Yolo was created for healthier paint and better color purposes. Yolo interior comes in 49 colors and shades while their exterior paint comes in 36 hues. Other than sustainability, Yolo promotes creativity.

Zandur

Founded by Rob McKee and established in 2005, Zandur aims to bring environmental stewardship to commercial flooring. Zandur manufactures cork rubber flooring. Their one goal is to make green products that are not expensive.