Fire Safety and Interior Textiles

by

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(ABSTRACT)

The role of the interior designer in providing for fire safe interiors is an important one. The textile end-products they specify play an important part in the start and/or spread of interior fires. Furthermore, the rate of developments in textile testing and products makes it difficult for designers to keep abreast of the latest information. This thesis provides a program for updating interior designers on fire safe interior textiles. A one hour update program was developed as part of the thesis and delivered to members of the Southwest Regional Chapter of ASID in Roanoke, Virginia.

An analysis of data from a survey showed that participants believe there is a need for an educational program such as this course and that they would attend a five hour CEU course developed on this subject. Responses to questions on textile fibers, standard tests, and new products on the market supported the perceived need for

continuing education on the subject of fire safe textiles. The course evaluation in turn, determined that some areas of the program needed to be revised. This thesis provides a packaged program which can be easily updated. Furthermore, anyone with a textile background can use this program in preparing and delivering a CEU course on fire safety and interior textiles.

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Chapter I

INTRODUCTION

Over the past few decades, interior textiles have played a significant role in the start and/or spread of fires in interior spaces. There has been a growing awareness concerning the role that textile products and finishes play on the public safety and welfare as related to interior fires. Specifying furnishings and finishes that are safe from fire hazards is among one of the most important responsibilities of the interior designer. Hence, designers are required to be aware of the flame resistance, toxicity, and smoke emission properties of various interior textile products. In the event of a fire, to avoid loss of lives or potential lawsuits, designers need to have specified the appropriate flame resistant textile products and finishes. Therefore, they also need to be up-to-date concerning interior textile codes, standards, flammability testing methods and recent textile developments.

Most choices that an interior designer makes concerning textile end-products used in furnishings, walls, floors, or ceilings, have a direct bearing on the health and safety of building occupants. Also, with the implementation of laws regulating interior designers in several states, Virginia

being one, selection of fabrics and finishes by interior designers takes on legal ramifications. Hence, in order to make the most knowledgeable decisions concerning fire safe textiles for interiors, designers need to be aware of characteristics and finishes, as well as the most recent product developments in the textile industry.

There are a number of sources for interior designers to obtain the necessary information on current developments in the textile industry. Some of the sources for information concerning interior textiles include (but are not limited to) professional meetings, research journals, trade magazines, newspaper articles, and related Continuing Education Unit (CEU) courses.

For interior designers continuing education is the preferred method of gaining necessary educational information (ASID, 1988). CEU courses have the advantage of organizing a wide variety of important and current information on a particular subject, making them a more time efficient method of communicating substantial amounts of information in a short period of time. However, CEU courses, though being a preferred method of gaining educational information, also can be costly to attend. The cost per participant can be as much as ninety-five dollars or more. This is primarily due to the fees instructor's

charge, which could typically cost $1000 per day plus air fare, hotel, and meals.

Due to the growing need for interior designers to stay abreast of developments related to the fire safe issue in the textile industry, this thesis focused on developing a program for interior designers on the flammability aspects of textiles. Furthermore, this course was developed in such a way that others with textile expertise could easily adapt the program for presentation in other regions. Providing course materials and instructions for use by local or regional instructors would eliminate costs associated with bringing in a nationally recognized instructor. By providing listings of resources the course materials could be continually kept current.

Justification

In order to serve their clients adequately and maintain their own professional standing in an increasingly competitive field, interior designers need to be up-to-date on the latest developments in the textile industry, as related to flammability. Increased awareness of the role of textiles in interior fires has placed additional responsibilities on interior designers to specify fire safe textiles; therefore, an efficient and economical method which could be easily adopted in other regions of the

country by others with textile expertise is needed. Furthermore, the lower the cost, the more designers that would probably attend the course.

Statement of the Problem

The performance of textiles within a fire may either help feed or help contain the fire. Improper specification of interior textiles may put the occupants at risk. The interior designer's role in specifying interior textiles requires that he or she have an adequate amount of knowledge of textile flammability properties. With proper specification, interior designers could substantially reduce the risk occupants face in case of fire. Awareness of the flammability problem concerning textiles is essential for the public's safety. Therefore, a means to update interior designers is needed, if these professionals are to be kept abreast of the most current developments related to the specification of fire safe textiles.

Objectives

1. To provide an efficient method for professional interior designers to gain updates on developments in the textile industry on fire safe textile products, which have implications for the health and safety of building occupants.

2. To develop a one-hour preliminary program for professional interior designers which could be developed into a five-hour course
3. To investigate the need for the development of a five-hour CEU course.

Limitations

1. Only a portion of the program has been completely developed and presented to practicing professional designers and industry foundation members.
2. The results of the questionnaire and course evaluation may not be generalizable to other regions of the state or country.
3. The participants may not be representative of all professional interior designers in the region or in other parts of the state or country.

Chapter II

LITERATURE REVIEW

There are many factors specifically relating to textiles and textile finishes which contribute to flammability. In the event of a fire, the performance of a textile end-product can feed or delay a fire. This critical time of potential fire development may, respectively, lead to a loss or saving of lives. Hence, the specification of textile end-products may effect the health, safety, and welfare of the public. It is important for designers to become knowledgeable about the nature of some textiles as potential fire hazards, and to apply this information when specifying textile materials. Additionally, by understanding fire-related terms, and flammability test methods for textiles, interior designers will be better able to widen the margin of personal safety, minimize structural damages, and lessen economic losses in the event of a fire (Yeager, 1988).

This chapter covers some of the major causes of concern with regard to flammability of interior textiles, and the role of the interior designer. The topics begin with the importance and benefits of licensing, including the health, safety, and welfare issue of fire safe interior textiles.

Statistical data regarding the fire problem in the United States are then presented. The effect of flammability and toxicity on the general public are also covered. The following section includes a description of some of the tests being performed on textile products today, current flammability standards used in the industry, flame resistant textile products and finishes, and the toxicity of textile products as well as their behavior in fire situations. Finally the role of continuing education units as a means of imparting information are discussed.

Licensing/Certification

Currently there are twelve states plus the District of Columbia and Puerto Rico, who have adopted either licensing or certification laws for interior designers. The basic difference between the two is that licensing is a legal recognition of the profession, and it regulates individuals within the profession. Certification on the other hand, is referred to as a level of legal recognition, and is generally defined as a voluntary form of recogniton, granted by an organization or agency which is non-governmental.

The basis for adopting licensing laws for interior designers in such places as Alabama, Connecticut, Florida, Illinois, Louisiana, New Mexico, Tennessee, Texas, Puerto Rico and Washington D.C. is for the health, safety and

welfare of the public. Licenses are granted to those who have met predetermined qualifications, generally including education and experience requirements, and those who have successfully completed an examination for minimum competency within the profession. Licensing may limit the use of a title associated with the profession, as in the case of title act legislation or, in the case of practice of a profession to those individuals who have become licensed under the legislation. Both Puerto Rico and Washington D.C. have enacted a title practice act prohibiting unlicensed people from working as interior designers (Bakin, 1991).

The certification laws in states such as California, Maryland, New York, and Virginia are generally defined as voluntary forms of recognition for individuals. In other words, in these states, interior designers fulfilling the stipulations of the law can add "certified interior designer" to their title, indicating professional knowledge and experience. According to certification laws, a "certified interior designer" is a design professional who meets the criteria of education, experience, and testing in the rendering of interior design services. In Virginia, the specific requirements in order to become a certified designer include:

1) A four-year minimum professional degree, accredited by the Foundation for Interior Design Education Research (FIDER) or the equivalent.
2) Two years of monitored experience in the performance of interior design services.
3) Passing the National Council for Interior Design Qualification (NCIDQ) examination or the equivalent (Virginia House bill no. 645, 1990).

The certification law in Virginia does not take anything away from or restrict uncertified interior designers, interior decorators or others rendering interior design services. A grandfather clause is also included, which permits qualified people to apply for certification without taking the exam. Qualified individuals include those who have used the title or have been identified as interior designers or college-level design teachers for at least five years and also meet the education and practical requirements. Hence, certain basic qualifications have to be fulfilled before an interior designer can be considered certified. Since certified interior designers can be assumed to have the necessary skills for performing their tasks, consumers could thus have more confidence in their ability to make appropriate decisions.

Many of the arguments in support of licensing and certification were related to protecting the health, safety,

and welfare of the public. Professionals who brought licensing and certification before the legislature identified the ways in which interior designers make decisions regarding the selection of furnishings and finishes. These decisions could potentially affect the well being of those who occupied the space. Of all the selections made by interior designers, textiles offer some of the greatest hazards, especially concerning the specification of fire safe textile end-products and finishes.

The challenge to designers in making responsible choices concerning textile furnishings is two fold. New textile products continually enter the market, making it difficult for practitioners to stay abreast of the performance qualities of each new item. At the same time, testing methods for measuring the performance qualities of interior textiles exist, but few have been universally adopted. The same problem of non-uniformity exists in codes and standards. In considering matters of fire protection, designers and educators face a constant chore of keeping abreast of new technological developments. New test methods and products seem to be emerging everyday. However, some of the best lessons in life are learned by looking at some of the lessons of the past. In the case of fires, we can learn

a great deal by looking at the fire statistics (in the U.S.) of the recent past.

The Fire Problem in the United States

Despite the legislative actions that have taken place over the years, fire continues to be a major problem in the United States. The National Institute of Standards and Technology (formerly the National Bureau of Standards) estimates that there are 12,000 fire related deaths annually in the United States. The bulk of these fires are residential in character. Residential fires include 31% of all structure fires, cause 76% of the deaths, 67% of the injuries, and about 40% of the direct property loss. The remaining percentage of fires involve the following categories: public assembly, institutions, and commercial structures (see Table 1).

The public assembly category which includes restaurants, theatres, courtrooms, and museums, has received the greatest consideration in developing fire codes. In fact, the number of fires occurring in this category has decreased in the last few years as a result of the growing restrictions against smoking in public places. These structures are involved in about four percent of the fires, less than one percent of the deaths, only four percent of the injuries, and about eight percent of the dollar loss.

Table 1

Structure Fires

CATEGORY	% FIRES	% DEATHS	% INJURIES	% DIRECT PROPERTY LOSS
RESIDENTIAL	31	76	67	40
PUBLIC ASSEMBLY	4	1	4	8
INSTITUTION	4	1	3	2
COMMERCIAL	23	6	19	36
OTHER	38	16	7	14

Source: Emergency Education Network, 1989.

At the same time, institutions, including hospitals, schools, detention homes, and prisons, account for another four percent of the fires, less than one percent of the deaths, three percent of the injuries, and some one and a half percent of the dollar loss. Lastly, commercial property, including stores, offices, factories, and warehouses, are the site of 23% of the fires, 6% of the deaths, 19% of the injuries, and 36% of the dollar loss. Codes and standards must constantly be adjusted in these commercial structures due to the fact that they are growing in number, also housing more people, contents, and valuables than ever before (Emergency Educational NETwork, 1989).

According to Reznikoff (1979), a large percentage of these fire related deaths are a direct result of design and construction deficiencies. Interior textiles have also been a contributing factor in many of these fires. In fact, fires due to textile ignition sources account for more fire deaths than any other combustible material (NFPA, 1986). An analysis of 1980-82 fatal structure fires in the National Incident Reporting System (NFIRS) operated by the U.S. Fire Administration, identified that for fires where both the type of material and the form of material first ignited were known, 51% of the fatal incidents involved a fabric. A similar analysis of multiple death fires in the NFPA's Fire Incident Data Organization identified textiles as the

primary fuel involved in 41% of the multiple death fire studies with known types and materials first ignited (NFPA, 1986, p. 5-17).

Interior Designers' Role in Textile Specification

One of the most vital topics concerning public safety today centers on the flammability of textiles and finishes. Many of the choices interior designers make, concerning textile products, can lead to life or death situations in interior fires. Floor and wallcoverings, drapery, and furnishings, are the primary elements providing fuel in the early phases of a fire. According to the ASID code of ethics, a designer should at all times consider the health, safety, and welfare of the public in spaces that he or she designs. Interior designers should, whenever possible, notify property managers, landlords, and/or public officials of conditions within the built environment that endanger the health, safety, and welfare of occupants (ASID, 1989).

Fire protection experts agree that the first five or ten minutes of a fire are the most critical (Reznikoff, 1989, p.27). Fires can grow five times in the first minute, 25 times in the second minute, and as much as 125 times in the third minute (Emergency Education NETwork, 1989).

The scenario described above concerning the rapid spread of fire is not always the case. Fires do not always

grow so fast in the first minute, they can grow more slowly or even be contained. However, whether a fire spreads quickly or not depends on many factors. Among the factors contributing to the outcome is the fuel response (the combustible interior finish materials such as interior textile products). The fuel response depends on the material, mass, surface characteristics, etc. The initial materials ignited can either contribute to the growth of the fire or prevent its spread to other areas of the building. Therefore, some of the interior finishes that designers specify may become crucial elements in the early phase of a fire.

Many times proper textile material selection can prevent or reduce the outbreak of a fire. In the case of fire, the interior furnishings and finish materials should be adequate in reacting to the emergency and suppressing or containing it. Such materials take the form of fire resistant fibers/barriers, and flame resistant finishes placed on textile end products. Another technique which could be used in suppressing or containing a fire includes limiting the fuel packages which are the combinations of the finishings, furnishings, contents, and the arrangement of these in a space (here the fuel is seen in terms of its actual distribution in a space). A fuel package is defined

as any discrete amount of fuel in the compartment, whose operational potential for consumption and spread is either:

a) through a continuity of fuel, or

b) where the discontinuity of material is so slight that the proximity between materials allows the fire to spread across the discontinuity of surfaces and ignite adjoining material because of thermal radiation (Lerup, Cronrath, and Liu, 1977, p. 46).

Translating preventative fire concepts into nuts and bolts of practical design requires a comprehensive knowledge of fire behavior. The ability to evaluate the impact of material alternatives on the occurrence and behavior of fire is also necessary. This is a tall order, especially since a designer rarely has an opportunity to observe or study fire first hand. Nonetheless, the designer has an obligation to provide a safe design. No matter what other redeeming features an interior textile product might have in terms of economics, aesthetics, and/or function, if the interior materials specified are not safe, the designer has failed in his or her first obligation to the public, and that is safety.

Textile Flammability

Some of the major fire hazards associated with interior textiles include , flame spread, smoke development, and

toxicity. The primary flammability hazard associated with textile products such as carpeting, textile wallcoverings, drapery, and furniture upholstery, is accidental exposure to an open flame ignition source. However, the ease of ignition, rate of flame spread, smoke development, toxicity, and amount of heat produced by a textile product, will not solely depend on the textile material. Flammability of a textile product also depends on the construction and finish of the textile, as well as on the design of the finished product. For instance, cotton is considered highly flammable in its natural state, and is usually among the first textile items to ignite in a fire (See Table 2). However, a very tightly woven, heavy cotton fabric such as duck, would resist flaming when a match is applied to it; eventually, it would glow, smoke, and slowly be completely consumed (Hilado, 1974).

Fabrics composed of glass fibers are considered to be the least hazardous due to the fact that they are inherently flame resistant (they will not burn). Textile products made of protein fibers such as wool and silk will burn with great difficulty and will not normally sustain a fire. About the only effect of exposing protein fibers to ignition is to char a hole in it without producing flames. Other animal fibers and feathers share the same general properties since they are all of similar composition. The nitrogen found in

Table 2

Type of Fiber First Ignited in Fatal Structure Fires

FIBER TYPE	% FIRES	% DEATHS
Cotton, rayon	25	22
Synthetic fibers	16	16
Wool, wool mixture	1	1
Type not reported	9	9

* Based on 2,534 fatal structure fires accounting for 3,277 civilian deaths, where the type and form of material first ignited was known. Percents in this data-set refer to only fabric related incidents

Source: National Fire Protection Association, 1986, p. 5-18.

these materials make them non-flammable, and incapable of supporting combustion. When burned in the flame of another material, they will char, decompose, and form combustion products with a characteristic unpleasant odor. On the other hand, fabrics composed of natural cellulosic fibers such as cottons and linens, or man-made fibers such as rayon (regenerated cellulose) are considered highly flammable. A flame retardant finish would have to be applied to them in order for textile products made from these fibers to be fire safe. The other group of textile products which are classified as thermoplastic fibers or synthetics, include such fibers as polyester, acrylic, nylon, and polypropylene. None of these thermoplastic fibers are especially flammable (they do not pose as dangerous a threat as some of the natural fibers), although they can burn when subjected to an open flame source. Synthetic fibers tend to shrink or melt away in an applied flame. This action of melting or shrinking away from the flame, will expose flammable contents (the cushion/batting underneath) to the fire, creating a dangerous and potentially deadly fire situation (Kirk, 1969).

Table 3 lists the various textile fibers that are presently used in the production of interior textile end-products. Also shown are some of the characteristic reactions associated with these fibers when exposed to heat

Table 3

Reaction of Fibers to Heat and Flame

FIBER	NEAR FLAME	IN FLAME	REMOVED FROM FLAME	ODOR AND RESIDUE
COTTON	no shrinkage,ignites on contact	burns quickly	continues to burn, afterglow	burning paper odor: light, ash
FLAX	no shrinkage, ignites on contact	burns quickly	continues burning	burning paper odor; light, ash
WOOL	curls away from flame	burns slowly	self-extinguishing	burning hair; small bead
SILK	curls away from flame	burns slowly sputters	usually self-extinguishing	burning hair crushable bead-like residue
RAYON	no shrinkage, ignites on contact	burns quickly	continues burning	burning paper odor; very little ash
ACETATE	fuses & melts away from flame, ignites quickly	burns quickly	continues rapid burning	acrid odor; irregular hard, bead
TRI-ACETATE	as acetate	as acetate	as acetate	as acetate
ACRYLIC	fuses away from, melts, ignites quickly	burns rapidly with hot flame sputters melts	continues burning	acrid odor; irregular hard, black bead
MOD-ACRYLIC	fuses away from, melts	burns slowly	self-extinguishing	acrid odor; irregular hard, black bead
NYLON	fuses, melts & shrinks from flame	burns slowly with melting	self-extinguishing	celery-like odor; hard, tough grey or brown bead
OLEFIN	fuses,shrinks from flame	melts & burns	continues burning	paraffin wax odor tough brown bead
POLYESTER	fuses, melts &shrinks from flame	burns slowly with melting	self-extinguishing	chemical odor; dark, tough bead
SARAN	fuses, melts & shrinks from flame	melts, yellow flame	self-extinguishing	chemical odor; dark, tough bead
GLASS	will not burn	softens, glows red	hardens, may change shape	no odor; hard white bead
VINYON	fuses, melts & shrinks from flame	burns, melting	self-extinguishing	acrid odor; irregular hard, black bead

Source: Yeager, 1988 pp. 17-18.

and flame. However, the descriptions of burning are based on small scale tests and for this reason may be misleading. For instance, some of the synthetic fabrics will give the appearance of being flame retardant when tested with a small flame source, such as a match. On the other hand, when the same fabrics are subjected to a larger flame or full-scale test, they may burst into flames and consume themselves while generating large quantities of black as well as toxic smoke.

History of Textile Flammability Legislation

As a result of several deaths involving apparel fires, in 1953 the United States Congress passed the Flammable Fabrics Act requiring textile products intended for use in apparel, to meet mandatory standards. This legislation was enacted in an effort to reduce the threat to life and property caused by flammable fabrics. In 1967, the Amended Flammable Fabrics Act gave the Secretary of Commerce the authority and duty to set mandatory flammability standards as needed, in order to protect the public against unreasonable risk. It authorized the investigation of deaths and injuries caused by fires. Research and development of test methods and devices, along with studies to show the feasibility of reducing flammability, were also authorized. The amendment was applicable to wearing apparel

as well as to residential and commercial interior furnishings (with the exception of vehicles of transportation). In 1972, Congress directed the Consumer Product Safety Commission (CPSC) to monitor the involvement of textile products in burn accidents. The Commission, in conjunction with industry, was given the power to issue standards that protected the public from unreasonable hazards (Schultz, 1985). As a result, Federal flammability performance standards have been established for carpets, rugs, mattresses, and a standard has been proposed but not applied for upholstered furniture. Since no flammability standards had been established for upholstered furniture, the furniture industry formed the Upholstery Furniture Action Council (UFAC) in 1974. Its primary goals, even to this day, are to make safer furniture and to educate the public on fire safety (Yeager, 1988).

The UFAC Voluntary Action Program, which officially started in April 1979, has four aspects: fabric classification, construction criteria, a labeling plan, and a compliance procedure. Fabric classification divides upholstery fabrics into two categories of ignition propensity, based on their ability to resist ignition when exposed to a burning cigarette. The UFAC has established five construction criteria to which manufacturers must adhere in order to qualify for participation in the program.

Each criterion is paired with a standard test method to ensure proper compliance. The labeling plan centers on a hangtag that identifies furniture meeting UFAC criteria. Under the compliance procedure an independent laboratory verifies that materials used in making the items carrying the compliance hangtag meet the performance criteria set forth in the program (Yeager, 1988).

Although a mandatory standard for furniture upholstery has not been implemented, flammability regulations do exist for transportation fabrics and other textile products used in certain applications, including passenger cars, trucks, buses, and commercial airliners. Unlike the voluntary program dealing with upholstered furniture, these regulations are mandatory and are under the jurisdiction of the United States Department of Transportation.

The following is a listing and a description of some of the current flammability standards. Any one of these standards can be examined further in the ASTM Fire Test Standards Handbook (1990) as well as the NFPA Fire Protection Handbook (1986).

The standard governing the flammability of mattresses, and mattress pads, DOC FF 4-72, was established in order to protect the public against unreasonable risk of mattress fires. The mattress test uses a lighted cigarette, the most common mode of bedding ignition, as the ignition source. At

least nine ignited cigarettes (measuring 85 millimeters long and with no filters) are placed on top of the ticking product and allowed to burn completely. These locations are also tested by placing nine additional cigarettes between two cotton percale bed sheets that cover the mattress. Individual cigarette test locations pass the test if the char length of the mattress surface is not more than two inches in any direction from the nearest point of the cigarette. All eighteen cigarette locations must pass the test in order for the mattress or pad to be marketed (Yeager, 1988).

Carpets and rugs are currently federally regulated in the United States by the Consumer Product Safety Commission. The test method which is required for all carpets and rugs to meet federal standards is FF 1-70 (large carpets and rugs) & FF 2-70 (small carpets and rugs), or more commonly known as the Methenamine Pill Test. Other test methods required in some jurisdictions after the pill test has been performed include: ASTM E-84 Steiner Tunnel Test, UL 992 Chamber Test, NBS IR 75-950 NFPA 253 Flooring Radiant Panel Test, and NBS 708 Smoke Density Chamber (Reznikoff, 1989).

Curtains and draperies are not currently federally regulated. However, curtains and draperies covering large expanses of wall (more than 10 percent of wall area) in public occupancies, are usually classified among interior

finishes and are often regulated by state or city fire authorities. Interior finishes normally comprise those materials or combination of materials that form the exposed interior surface of walls, ceilings and floors in a building. In regulating the textile materials found on many of these surfaces, the city or state authorities specify certain standards and specifications. Various tests are used to observe conformity with these standards. For instance, in the case of curtains or draperies, one of the most widely used tests for regulating interior finish specifications is the NFPA 701 Vertical flame test. Other test standards which are frequently used are those required in the City of New York, the City of Boston, and the State of California (Reznikoff, 1989).

Generally, wallcoverings not exceeding 1/28 inch in thickness are not included as interior finish material, except where deemed to be a hazard by the authority having jurisdiction. Chicago, IL, and Boston, MA, for example, have established stringent wall covering criteria in areas of public assembly, fire exit stairs and passageways, and in lobby egress areas.

Interior floor finishes are the exposed floor surfaces of buildings and include floor coverings such as carpets and floor tiles which may be applied over a concrete/sub-floor. Many local building regulations have been expanded to

include provisions regulating floorings and floor coverings, either by including them as interior finish or by requiring that they meet other criteria based on one or more test methods. NFPA 701 (Life Safety Code), however, does not regard floorings and floor coverings to be interior finishes. Thus, unless the authority having jurisdiction determines that a material poses an unusual hazard, floorings and floor coverings are excluded from interior finish requirements. Hence, where required, floor coverings must comply with special "interior floor finish" provisions (NFPA, 1986).

Textile Flammability Testing

By testing a completed product, as a composite of materials rather than testing each component of the product separately, the flammability test results are significantly more accurate since real life fire situations involve the entire finished product. This is why more confidence should be placed on composite testing rather than component (singular product such as a fabric) testing. Examples of composite tests include: California Technical Bulletins 121 and 133, Boston regulatory Notice (2-7-83), and Underwriters Laboratories Proposed Standard 1895. Component flammability testing can be used as a guide, but composite testing must be considered when one realizes the potential for death,

property damage, and the resultant liability associated with building fires.

Flammability testing has shown that by protecting the foam and fiber filling found in seating a potentially destructive and lethal fire situation can be avoided. If a covering can be burned or melted away, it exposes flammable cushioning and batting products to the fire which can take the room involved to flashover in a few short minutes. Flashover is a deadly phenomenon that occurs when an individual room fire approaching 900-1000 degrees Fahrenheit actually explodes, igniting every combustible item in the room. The now intense fire proceeds to hallways and adjacent rooms, quickly creating a flashover domino effect that has been known to consume entire buildings with catastrophic results (Fisher, 1984).

The National Institute of Standards and Testing (NIST) has created a highly sophisticated computer model that is able to accurately predict the behavior of a fire in building. By entering the room dimensions, furnishings, and laboratory fire test data, the model can predict the time the fire takes to spread and reach flashover, the heat and toxic fumes given off, the temperature and height of the combustion gases, the amount of carbon monoxide, and the level of danger as the fire and smoke spread (Fisher, 1984).

This model has determined that through the use of barrier materials (such as fire safe textile products) for protecting the flammable fiber fills and foams in a typical room, it is possible to contain the fire within the room. This averts a flashover situation, and also protects the building and its occupants from the ravages of fire or smoke. NIST's computer model predictions have been confirmed with full room burn testing. With flammable materials involved in a room fire, flashover can occur in as few as seven minutes. Thus, state of the art barrier furnishings could be critical in preventing a flashover situation.

Future creativity on the part of designers will be challenged in the face of increasing restrictions on materials which can be specified. This task is further complicated by varying flammability codes across the U.S., with more than 300 different fire code regulations presently in effect (Fabric Flammability, 1983).

Frequently Used Interior Textile Tests

Fire codes for interior textiles are determined by individual state and local governments. The following is a description of some of the more frequent tests used in examining the flammability of most textile end-products. An indepth description of these tests can be found in the ASTM

Fire Test Standards Handbook (1990) as well as the NFPA Fire Protection Handbook (1986).

NFPA 701 Small Scale. The National Fire Protection Association component test measures the vertical flame spread of fabrics intended for use as curtains or draperies. A ten inch strip of cloth is suspended over an open flame from a bunsen burner and ignited. The sample is then measured for both after flame and length of char (burn) of the warp (lengthwise yarns) and of the filling (crosswise yarns). The maximum afterflame for any one specimen is two seconds. The length of char maximum is dependent upon the fabric weight, with a maximum value for both average and individual specimens. Residues that drip or break cannot continue to flame after reaching the test chamber floor.

The NFPA 701 tests were revised in 1989 allowing fabric to be folded during testing, and it can be retested if it fails the first time. The chamber for these tests is somewhat different for measuring the char length on drapery fabrics. Since it was discovered that man-made fabrics shrink from the heat source, fabrics intended for use as curtains and draperies are required to retain 95 percent of their weight after ignition.

Methenamine Pill Test (ASTM D-2859) (DOC FF 1-70 carpets & DOC FF 2-70 rugs). This test seeks to prevent the use of highly flammable fiber floorcoverings by evaluating

the ease of surface ignition and surface flammability. Eight nine-inch square sections of moisture free carpet specimens are placed on the bottom of a one foot enclosed cube, which is open at the top, and held in place by a nine-inch square metal plate having an opening eight inches in diameter. A methenamine tablet formulated to burn for two minutes, is placed in the center of the specimen and ignited. A specimen meets the standard when the char area does not extend to within one inch of the metal ring in the hold down plate. At least seven of the eight specimens must pass the test to meet the established criteria. All carpets made in the U.S. must pass this test.

Steiner Tunnel Test (ASTM E-84) (NFPA 255) (UL 723). The test was devised to compare surface burning characteristics of building materials and interior finishes. Specifically, the test is designed to simulate the growth stage, or fully developed stage of a fire and provide data on flame spread, fuel contribution, and smoke density. A twenty-five feet by one foot eight inches floor covering specimen is mounted pile surface down on the ceiling of the tunnel chamber. Jet flames and heat are applied to the sample for ten minutes. Time and flame spread distance values are obtained and compared with those recorded for asbestos-cement board (assigned a flame spread rating of 0) and select-grade red oak flooring (assigned a flame spread

rating of 100) to arrive at a flame spread classification. A value of 0-25 is Class A; 26-75 is Class B; 76-200 is Class C; and above 200 is not rated.

California Technical Bulletin 121. A composite test for mattresses that subjects the completed product to an open flame from ten double sheets of newspaper burning in a metal wastepaper basket. This ignition source is placed under the bed in a test chamber that is equipped to monitor weight loss, ceiling temperature, concentration of carbon monoxide, and smoke capacity. If any one of the first three test criteria is not met, the product does not pass. This test is mandatory for products to be used in the state of California in high risk occupancy buildings such as prisons and healthcare facilities.

California Bulletin 117.(section E). This test is conducted on upholstery fabrics in which both the face and back of samples are subjected to direct flame impingement for one second. If the fabric ignites, it does not meet the standard.

UFAC Test. This test has a classification for cigarette ignition, which is determined by the vertical char and ignition of the substrate. If samples produce a char less than 1.75 inches and if the substrate does not ignite, it is a Class I fabric. If the char of any one specimen is

equal to or greater than 1.75 inches or if the substrate ignites, it is a Class II fabric.

Toxicity

One of the major causes of concern in the area of flammability of textiles centers on toxicity of fabrics and finishes. In fact, toxic fumes which are emitted from many burning textile end-products are one of the primary causes of death for many people during a fire.

Every combustible material emits toxic fumes in the process of burning. However, certain materials emit less toxic fumes compared to others. In the specification of interior textiles, care should be taken to avoid materials which tend to emit unusually high amounts of toxic fumes. For instance, wool yields significant amounts of hydrogen cyanide, and cotton produces large quantities of carbon dioxide (see Table 4). On the other hand, Trevira for FR (produced by Hoechst Celanese Corporation) does not give off any cyanide, nitric oxide, sulfur dioxide, hydrogen chloride or hydrogen fluoride under either smoldering or flaming conditions, making it a safer choice. Another safe textile choice in terms of limiting the amount of toxic smoke generated during combustion, is a fabric called Sandel (made by Burlington Industries). Like Trevira for FR, it also emits no hydrogen cyanide or hydrogen chloride.

Table 4

Gases Identified with Combustion of Textile End Products

TOXICANTS	SOURCE MATERIALS	TOXICOLOGICAL EFFECTS
Aldehydes	Polyester fabrics & fibers	Potent respiratory irritants
Ammonia	Wool, Silk, Nylon, (Nitrogen containing material)	Pungent, unbearable odor, irritant to the eyes & nose
Carbon Dioxide	Cotton (All carbon containing materials)	Increases respiration
Carbon Monoxide	Cotton (All carbon containing materials)	Reduces oxygen carrying capacity of blood, asphyxiation
Halogen Acids	Halon fire retardant Brominated fire retarded polyesters	Respiratory irritants
Hydrogen Cyanide	Wool, Silk, Nylon, (Nitrogen containing material)	A rapidly fatal asphyxiant poison, reduces normal cell metabolism
Nitrogen Oxides	Nylon	Strong pulmonary irritant, can cause immediate death or delayed injury

Source: Fisher, 1984, p. 150.

Perhaps the best choice of textile fibers that an interior designer could specify are those which contain predominantly inert fibers, such as materials produced from glass or metal fibers. In fact, manufacturers have developed drapery and liners, mattress tickings and bedspreads, and wallcoverings using glass fibers. Incidentally, textile fabrics made from glass fibers can be treated to give them the hand and feel of traditional fabrics (Hoechst Celanese, 1988).

In recent years there has been much speculation as to whether fabrics with finishes, such as certain flame retardants, produce more toxic fumes than fabrics without them. In a study conducted by the National Institute of Standards and Technology (NIST), researchers reported that those products treated with a fire retardant did not burn as quickly, and released significantly less heat and toxic gases as compared to untreated products. Tests ranged from burns of various household items to complete furniture items. In the NIST full-scale room burns, the researchers found the average time to flashover with the untreated products was less than two minutes. By contrast, in the room with fire retarded products, flashover never occurred. After about 30 minutes, however, the room was considered untenable because of toxic gases (Research Proves, 1988).

According to Dr. Vytenis Babrausdas, leader of the NIST research team, "This study shows that fire retardants can improve the fire safety of products without increasing the hazard of combustion toxicity." However, he cautions that not all fire-related products can automatically be expected to perform the same. "As new interior furnishings and new fire-retardant chemicals are developed, each new combination should be tested and evaluated," he said (Research Proves, 1988, p. 19).

In the major fires that have occurred in the past few years, where people have died from the inhalation of toxic gases, suits have named everyone including the building owners, product manufacturers, architects, and interior designers. Interior designers are particularly at risk of liability suits due to the amount of interior textile products that they specify in any given project. However, there are ways for interior designers to reduce their liability. For instance, before specifying a certain textile product, manufacturers should be contacted for the combustion toxicity of their products and combustion test results of every product should be kept on file. Another avenue for obtaining the toxicity content of a certain textile product is to contact the New York State Department in, Albany, New York. New York State has a toxicity law that no drapery, wall fabric, ceiling material, and

carpeting may be used in any installation, unless fire gas toxicity tests have been conducted. The results of the tests are filed in a computerized Building Material and Finishes Fire, Gas and Toxicity data file. Additionally, a New York City regulation requires that a product covered by the building code must not be more toxic than wood.

Proper textile specification alone cannot stop a fire and nothing can prevent lawsuits. However, being aware of the flammability and toxicity of textiles and keeping abreast of the latest textile fire safe materials can give the interior designer the confidence needed to specify the state-of-the-art in fire safe as well as toxic-safe textile products.

Toxicity Tests

The following is a description of the only toxicity test currently available.

LC-50 Test Measures the biological impact of carbon monoxide, carbon dioxide, fluorine, chlorine, bromine and iodine on Swiss Webster mice when fabrics are burned in their environment. LC-50 stands for the lethal concentration for 50 percent of the test animals (Bitter, 1989).

Current Flame Resistant Products and Treatments

Over the years the lack of fire safe products has led many interior textile manufacturers to begin developing new fibers and treatments to ensure that their products pass, or even exceed, the toughest toxicity and flammability tests on record. Hence, the increasing emphasis on the importance of fire safety has led to the availability of a wide array of code-complying styles and materials from which to chose. Some of the materials and treatments popular with manufacturers and designers include:

1) Hoechst Celanese's Trevira FR. A polyester fiber that contains a substance within the fiber which allows for a lower melting-point. This enables the fabric to shrink away from the flame and to self-extinguish. In addition, since the molecular structure of the fiber has been modified, neither sunlight, washing, or dry cleaning can deprive the fabric of its flame resistance. The product also offers 35% less smoke generation than topically treated fabrics (Hoechst Celanese, 1988).

2) Monsanto's SEF (Self-Extinguishing Modacrylic Fibers). This product which resembles wool, can be spun in its pure state or blended with other fibers to create fabrics with inherently flame resistant features. The most recent breakthrough with SEF is the fibers' ability to blend with wool. While wool in general, will not support combustion, the lighter weight and construction of

upholstery fabrics made of wool will often ignite under vertical upholstery testing conditions. By blending the SEF fibers with wool fibers, light weight-wool fabrics can thus pass vertical flame tests (Monsanto, 1987).

3) Zirpro. A zirconium-based treatment (applied to fiber and/or fabric) developed by the Wool Bureau that is effective on protein fibers such as wool and silk. This finish which is widely used for furnishings, chars rather than burns, and can be applied in varying degrees to match specific application needs (The Wool Bureau, 1989)

4) Uniroyal's Naugahyde 2-200 Flame Blocker. A vinyl-coated fabric that works in conjunction with foam underpaddings to resist flame penetration of seat-cushion material (Uniroyal, 1990).

5) Du Pont's Thermablock. A collection of fire-blocking fabrics using aramid film (inherently flame resistant polymer). These aramid films are designed to surround flammable material such as foam seat cushions, in order to slow the spread of flames (Dupont, 1990)

6) Springs' Firegard. A family of flame barrier textile fabrics. This flame barrier is achieved by combining a fiber glass matrix within a cotton covering that is both durable and soft to touch (Spring, 1990).

Continuing Education

"There will be a shift to a lifetime of learning, rather than knowing. There is a revolution ready to break," says James W. Botkin (1979, p. 122), author of No Limits to Learning and research director at the Alliance for Learning in Santa Fe, New Mexico. According to Botkin, corporations today spend more money educating employees than is spent by all U.S. colleges and universities and they are expected to outspend the schools by a factor of 2:1 by the end of the century (Botkin, 1979).

Among the many sources that interior designers have for staying abreast of current developments in their field, is Continuing Education Unit (CEU) courses. The Continuing Education Unit (CEU) is defined as a nationally recognized unit of measurement of non-credit formal education and/or training activities. One continuing education unit is defined as, "ten contact hours of participation in an organized continuing education experience, under responsible sponsorship, capable direction and qualified instruction" (ASID, 1989, p. a). The minimum hours of study on a subject, according to professional development guidelines, vary from five to six hours. In addition, sources which approve CEU courses include professional organizations such as ASID and IBD.

Several professional organizations in the field of interior design offer CEU courses, including the American Society of Interior Designers (ASID), the Institute of Business Designers (IBD), and the Interior Design Educators Council (IDEC). Incidentally, most courses at the national level are offered during the time of each organization's national convention or conference. Other courses conducted by these organizations are offered at the local chapter levels. At the same time, programs are also offered through educational institutions such as universities. In using their continuing education centers, universities are able to establish their own education course standards, criteria for granting CEU's, and review procedures. Independent groups or individuals are a third source for interior design continuing education. A good example of an independent group is design trade magazines. Many times they offer programs relating to topics such as computers, lighting, and management (Fowles, 1984).

Data compiled by the independent research firm of Moore and Symons reveals that 67% of all ASID members rank continuing education as their preferred method among other means for gaining necessary educational information (ASID, 1988). More and more design professionals have accepted the idea that in today's world, to stay in the same place is to fall behind. And in accepting this notion they have

embraced the concept of continuing and continual education (ASID, 1989).

Continuing Educational Units have become an important part of the interior design profession. Currently, only Washington D.C.'s licensing board impose mandatory CEU credit as a condition of license renewal. However, the demand for CEU courses should increase as more states adopt licensing laws.

A survey (conducted in March 1989) sent to all Virginia American Society of Interior Designer (ASID) members requesting preferences on continuing education courses revealed the following top five preferences (ASID, 1989):

1. Regulations/Codes
2. Marketing
3. Lighting
4. Historic Preservation
5. Computer Aided Design

Interestingly, the topic of textiles received a very low preference rating. The low rating could possibly indicate a lack of awareness of the importance of textiles, especially as they affect the health and safety of the public. Therefore, more needs to be done in the area of recognizing the importance of the role that textiles play in interiors, particularly as interior designers assume more legal responsibilities.

A national survey concerning textile competencies for interior designers reported different findings. This survey indicated a need for information related to textile usage in interiors (Myers, 1982; Hernecheck, Rettig and Sherman, 1983, Baker and Sondhi, 1989). Furthermore, in a recent national ASID/IBD (Institute of Business Designers) survey (Fowles, 1987), designers expressed interest in textiles as a continuing education topic at the basic or intermediate level of instruction.

Awareness is increasingly becoming more important to interior design professionals, especially with the implementation of licensing for interior designers and the increased liability risk that goes along with it (Baker and Sondhi, 1989; Hernecheck, Rettig, and Sherman, 1983; Myers, 1982). In fact, Fowles (1987) found that the topic of fire safe design was considered as a high interest category among other CEU course topics. At the same time, the topic of interior finish materials (materials commonly used for wall, ceiling, and floor finishes) was also considered as being a topic of interest among the most popular CEU topics listed.

To date, there have been two CEU courses developed, relating to interior textile flammability. The first one entitled Fire Safe Design presents the participant with a comprehensive picture of the flammability design problem in interior spaces. The role of the interior designer is also

analyzed in terms of specification and code compliance. The second one entitled Fire Safe Textiles and Furnishings, addresses the role of the interior designer in making responsible specifications of textiles and furnishings on an advanced level. Other topics covered in the course center on codes, liability suits, flammability testing, and hazard potential of various occupancies. Both of these courses generally give the participants a picture of the overall fire problem in interior spaces. In addition, both of these courses could cost each participant as much as $95 to attend.

There have not been any CEU courses, however, which have focused entirely on interior textiles. In addition, neither of the two previously offered CEU courses have concentrated on textile properties and characteristics as related to their performance in fire situations. Additionally, the cost associated with making the above CEU courses available locally would involve considerable expense in bringing the instructor to the area.

The interior design profession could benefit from having a CEU course readily available and affordable. By developing the format for such a program and identifying the necessary resources, someone at the local or regional level with adequate preparation could administer a CEU course offering an update on the topic of fire safe textiles.

The breadth and complexity of today's textile choices, along with issues concerning flammability and the licensing or certification of designers, has created a real need for increased textile information. A continuing education program in this area could thus keep professionals abreast of the latest interior textile developments.

Summary

In order to perform their jobs effectively, interior designers are required to be knowledgeable with the wide array of interior textile products and be up-to-date with recent developments in the textile industry. They are also required to be aware of the ability of different textile products to perform satisfactorily under a particular set of end-use conditions. A designer selects the appropriate textiles and finishes not only for the best performance and appearance, but also for safety. The pace of recent developments in textile technology emphasizes the need for interior designers to take active steps in educating themselves about the products and finishes they specify. Additionally, licensing and certification of interior designers further emphasizes the need for updating their knowledge of textiles, by adding a legal aspect to their job functions. Education must be regarded as a continuing process. A CEU course on this subject would serve to

fulfill interior designers' needs to keep abreast of the latest developments, and also to update them on the health and safety aspects of the textiles/finishes they specify.

Chapter III

METHODOLOGY

The purpose of this study was to develop a one-hour program on the topic of flammability as related to interior textiles. More specifically, an outline for a five-hour CEU program was developed which focused on the flammability hazards of textiles, as well as on the role interior designers play in the specification of fire safe textiles. Thus, using the five-hour CEU course outline, a condensed one-hour version of the five-hour program was developed. The course consisted of an experiment, lecture, slides, and a video tape. The hour long course provided an update on textile fibers, end-products, and finishes related to fire safe textiles.

This one-hour course was designed for licensed and non-licensed interior designers and others who worked in related fields, such as architects and textile sales representatives. By participating in such a course, professionals would receive up-to-date information concerning codes, standards, interior textile testing, and new fire safe textile/finish developments.

Using the instructor's manual along with the slides and video tape, any designer with adequate preparation could

develop and present a five-hour version of this program. The one-hour program serves as a framework and provides a base for others to build upon the course. This program also provides for increased flexibility and cost reduction in the preparation and presentation for a future five-hour CEU course. Another advantage of this program is that it provides for increased access to the subject of fire safe textiles since almost any designer could present it.

This chapter includes the steps followed in completing this study, the various teaching techniques, visual aids used, and a description of how the course was organized. Following that, the questionnaire and course evaluation, as well as the course manual are described.

Steps Followed in Completing the Proposed Study:

- Developed complete outline for .5 CEU credit course.
- Developed and planned materials for a one hour program to include:
  - > Text for one hour presentation
  - > Course manual for one hour program
  - > Visuals for course
  - > List of fire safe products and treatments
  - > List of federal agencies and their addresses
  - > List of references for further reading,

- Presented a one hour program to professional designers on fire safe textile products and finishes.
- Developed a questionnaire and course evaluation to be administered at the one hour program.
- Measured the need of a CEU course on fire safe textiles by analyzing data collected in the questionnaire.
- Measured the success of the one hour program by analyzing data collected in the course evaluation completed by the participants.
- Made corrections and additions to the course plan based on participants responses to the questionnaire and course evaluation.

Five Hour Outline

A complete outline for a .5 CEU course (see Appendix A) was developed prior to the development of the one hour course. The five hour course is broken down into five sections, each being one hour in duration. In the first hour, following the completion of a pre-course summary, an overview of the fire problem in the United States is given, including statistical fire data related to textile products and a short video which demonstrates some of the recent fires which have occurred involving textiles as a primary fuel source. During the second hour, some of the flammability hazards associated with textile end-products

are discussed. Two participants from the group are asked to demonstrate some of these flammability hazards by performing an experiment in front of the class. Flammability characteristics associated with certain fibers are also discussed in this section. In the third hour of the course, some of the flammability test methods which apply to interior textiles are addressed. Slides, diagrams, and videos serve to further explain their significance as well as how these flammability tests are performed. The fourth hour discusses textile products which are currently regulated by the Federal Government. A brief discussion of the Virginia codes and standards which apply to interior textiles is addressed, as well as some of the BOCA fire prevention model codes which the state of Virginia follows. In the final hour of the course, participants are split up into groups and given a case study concerning textile properties and characteristics. In this case study, participants are to discuss the problem and how they came up with a solution. Later, some of the flame retardant and toxic-safe textile product developments are reviewed and analyzed (samples will be made available for observation). Finally, a video tape depicting the performance qualities of some of these new products is shown. The course is concluded by asking participants to complete the course evaluation form.

Development of One Hour Program

A one hour program to serve as a preliminary testing of the five-hour CEU course was planned. It included a questionnaire to collect data on participant background as well as textile background. An evaluation form was developed to determine the success of the one hour presentation and to gather suggestions for additions and changes that would improve the course. The major content of the one hour program included a condensed version of the material described in the outline for the five hour CEU course (see Appendix B).

Participant Selection

Members of the Southwestern Regional Chapter of the American Society of Interior Designers (ASID), and Industry Foundation members were invited to participate in the one hour program. Participants were notified through the mail.

Teaching Aides and Techniques

A variety of teaching aides were planned for the one-hour course, such as an experiment, video tape, slides, and manuals. A review of recent fire safe textile product developments used in interiors, and test methods which apply to interior textiles are examples of topics discussed. An experiment was also conducted which demonstrated the effects of different fiber construction types when submitted to

flame tests. In addition, video clips as well as slides, covering most of the issues involved in fire safe textiles were shown in order to clarify each point which might be difficult to envision (ie. showing flammability test methods, etc.). A manual of support materials was developed for all course participants. The course manual served both as a tool in allowing participants to follow the delivery, and as a reference guide after the course.

The materials for this course were collected from a variety of sources. Interior design trade and research journals, various related federal and private agencies (NFPA, NIST, etc), newspaper articles, etc., were all sources of information. The primary focus for the selection of materials from these sources centered on information relating to fire safe textiles and finishes.

Development of Video Tape

A video was compiled taking excerpts from different product videos. These product videos, obtained from manufacturers, demonstrate the properties and performance characteristics of their latest fire safe textiles. The video clips compare the performance characteristics of different products to demonstrate what should be expected of a fire safe textile product. The video also serves to help

the audience fully understand some of the flammability test methods which are being used today.

Development of Slides

A series of slides prepared for the presentation included pictures, tables and notes on the flammability aspects of textiles. The slides served as an outline and a guide in delivering the presentation. They also could serve as a visual aid for the audience to see actual fire situations, interior settings, and test apparatus. The tables were included to demonstrate how certain textile fibers performed in comparison to others in fire situations. Finally, notes describing certain points (such as flammability standards, etc.) were to serve as introductions to the sections being discussed.

Instructor's Manual

The instructor's manual (see Appendix C) was written to serve as an instructional guide to be used in setting up a five-hour CEU course concerning fire safety and interior textiles. It primarily focuses on the text to be followed in delivering the one-hour presentation. The first section of the manual contains some background information on the topic presented. The background information not only serves as an introduction, but also as a tool to acquaint the

participant with some of the information to be covered in the course. Following that is a discussion on the fire problem in the United States, along with an explanation of the different stages of an interior fire. Some of the flammability hazards associated with fibers are also covered. A brief overview of the Hazard 1 computer model is then presented. The manual continues with an explanation of the various federal standards, and textile flammability and toxicity tests. Finally, an appendix is included which contains a list of the equipment required for conducting the course, the sources for further information on the textile tests, and the product videos that are available along with addresses.

Questionnaire

A questionnaire was developed to be administered prior to the one hour course in order to identify participant understanding of the interior textile flammability problem. The instrument is for collecting data on the extent of knowledge with regard to flammability test methods and fire safe textile specification. The survey form also included questions to collect demographic data (see Appendix D).

Course Evaluation

A course evaluation was developed to be administered at the end of the course to obtain a measure of success of the program. The evaluation was also developed to be used in making further modifications to the CEU course, so that the course could more successfully fulfill its objectives. Furthermore, the course evaluation was to identify additional recommendations offered by participants for incorporation into this CEU course (See Appendix E).

Course Manual

A course manual was developed which outlined information contained within the one-hour course. The manual was to be used by the participants, both within the course as a learning aid to follow the delivery and after the course as a reference. Topic sections included in the manual are the following: nature of textiles as potential fire hazards, fire-related terms participants should be familiar with, some flammability test methods used for interior textiles, and fire safe developments in the interior textile industry. Also, the manual includes a reference section for further reading, tables indicating characteristic fiber properties of textiles when exposed to a flame, a chart comparing the relative ease with which fibers ignite, and addresses and telephone numbers of

federal agencies and other organizations where participants can seek additional information (See Appendix F).

Summary

The completed instructional packet contains helpful teaching aids such as an experiment, slides, manuals, and a video. It also includes an instructor's manual which serves as a guide in setting up a five-hour CEU course on fire safety and interior textiles. The packet has been designed so that it is easy to follow, and gives a potential instructor helpful guidance in seeking current materials to keep the course up-to-date.

Chapter IV

Results and Discussion

The one hour course was delivered at the Southwestern Regional meeting of ASID held in Roanoke Virginia on August 21, 1991. A total of 125 invitations were mailed for the presentation, most of them to ASID and Industry Foundation (IF) members from the Southwest Association. Some invitations were also sent to various other people who were not ASID or IF members but were invited as guests by ASID members and the author. More specifically, 85 invitations were sent to ASID members, 25 were sent to IF members, and 15 were sent to other guests. Twenty-six participants attended the presentation, of which twenty filled out the questionnaire and course evaluation. The responses of these twenty participants were then used for the data analysis.

Questionnaire

At the beginning of the presentation, course participants were asked to complete a survey form containing nineteen questions. The questions included demographic data on participant's educational and employment background, other questions sought to identify the extent of knowledge concerning textile specification and testing, and the last

set of questions addressed awareness of new fire safe textile products. The following sections are a report of the findings from the data obtained from the questionnaire.

Educational Background of the Participants

Ninety-five percent of the sample had an undergraduate degree, and five percent had a master's degree (see Table 5).

Employment Background of the Participants

The majority (30%) of the course participants had been practicing for less than two years (see Table 5). A substantial number (25%) had been practicing between five to ten years. The rest were equally split between working for two to five years (20%) and more than ten years (20%).

Most of them (45%) worked for interior design firms. An equal number were either self employed (20%) or worked for retail firms or dealerships (20%). Two participants (10%) worked for architectural firms. One respondent was a professor in an academic institution.

The predominant type of design work handled by the participants fell into the category of commercial work. Most of them (75%) did only commercial work while four of the respondents (20%) reported that at least 75 percent of their business was commercial work. Only one participant

Table 5

Participant Background Information

(N=20)

Variable	No.	%
Last Degree Completed		
Undergraduate	19	95
Masters	1	5
Years of Experience		
0-2 years	6	30
2-5 years	4	20
5-10 years	5	25
more than 10 years	4	20
no answer	1	5
Type of Employment		
Self-employed	4	20
Architectural Firm	2	10
Interior Design Firm	9	45
Retail Firm/Dealership	4	20
Other	1	5
Type of Work		
At least 75% Residential	1	5
At least 75% Commercial	4	20
100% Commercial	15	75
Professional Organization		
ASID members	15	75
IF members	1	5
Other	3	15
No answer	1	5

indicated that most of their business was residential.

The majority (75%) of those who attended were ASID members. The remaining few (25%) who attended were either IF members or others who came as guests of one of the ASID members.

Magazines/Journals Read Regularly

The list of related magazines and journals read by the participants on a regular basis is presented in Table 6. Interior Design (55%), Contract (45%), Designer (45%), Architectural Digest (20%), Hotel & Restaurant Design (20%), and Interiors (20%) were the most often read by the participants. Most of these magazines provide, among other things, the latest information on various products related to interior design. Hence, they provide an excellent source of information on the latest in fire safe interior textile products and finishes.

Sources for Textile Information

Participants' sources for textile information were equally split. When asked to identify sources they relied upon for information in specifying textiles, they reported relying equally on sales representatives and labels on samples (75% & 60%), and their own textile background (personal experience 70% and previous textile knowledge

Table 6

Magazines Read Regularly (N=20)

Title of Magazine Read	No.	%
Interior Design	11	55
Contract	9	45
Designer Specifier	9	45
Architectural Digest	4	20
Hotel & Restaurant Design	4	20
Interiors	4	20
Builder Magazine	2	10
Metropolitan Home	2	10
Architectural Record	1	5
Art Business News	1	5
Business Interiors	1	5
Decor	1	5
Design Management	1	5
Framing	1	5
Hotel & Motel Management	1	5
Log Homes	1	5
Progressive Architecture	1	5
Southern Accents	1	5

Note: Number of responses in this category do not total 20 because participants could make several choices

65%).

Textile Flammability Knowledge of Participants

None of the respondents claimed to be completely confident in specifying fire safe textile products and finishes (see Table 7). However, most of them (60%) claimed to be confident. Some of them (35%) claimed to be not very confident while one person claimed to have no confidence in specifying fire safe textile products.

Most of the participants (70%) were aware of the difference in the fire resistance of wool and silk. Also, most participants (85%) knew the effect of the fabric construction/characteristic on its burn rate. They (65%) were also aware of simple flammability terms such as flashover (see Table 8).

Most commercial designers do not specify mattresses, except for those specializing in the healthcare field, therefore most of the participants (65%) were not aware that mattresses were required to meet federal flammability standards. They (70%) were also not aware of the of certain fibers. Almost all of the participants (90%) did not know of the new fire safe textile product, Thermablock, by DuPont (see Table 8).

Table 7

Participant Confidence Level in Specifying Textile End-Products as they Relate to Fire Safety and Toxicity

(N=20)

Confidence in Textile Spec.	No.	%
Very Confident	0	0
Confident	12	60
Not very confident	7	35
Not confident	1	5

Table 8

Participant Textile Knowledge

(N=20)

Question? Answer(s)	No. Correct	% Correct
A mandatory federal flammability standard has been established for? Mattresses	7	35
Which fabric const. would be more likely to speed the rate of burning? Loose and/or fuzzy weave	17	85
Which would be the most fire resistant fiber for an upholstery fabric? Wool	14	70
In same environment which would you expect to ignite first? Rayon	6	30
A new product on the market by DuPont related to fire safe fabrics is? Thermablock	2	10
Flashover is a particularly dangerous situation because? Fire reaches its approximate maximum potential	13	65

Note: Number of responses in this category do not total 20 because participants could make several choices.

Flammability and Toxicity Test Method Knowledge

Over half (55%) of the participants were not familiar with the test method required for carpets to meet federal flammability standards (see Table 9). Furthermore, although the Steiner Tunnel test is one of the most widely used tests in the industry, a majority of the participants (60%) were not aware of its purpose. Also, a majority of the participants (70%) were not aware of the test method for determining the toxicity of fumes released by certain fibers when burning.

Course Manual

The manual included as part of the one hour course was designed to serve as a resource during the course and as a reference after the course. A description of the manual content is given in Chapter III, and the complete manual can be found in Appendix F.

A few changes were made to the course manual after the course was delivered. These changes were based on the suggestions given by the participants. The changes made included adding more flammability terms, a table on the type of fibers most readily ignited, and a section on textile flammability standards. A section covering the toxic properties of certain interior textiles was also added. Included in this toxicity section is a table on the type of

Table 9

Test Method Knowledge

(N=20)

Question? Answer	No. Correct	%correct
Steiner Tunnel Test measures all the following except? Ease of Ignition	8	40
Which test method is required to meet Federal flammability tests? Methenamine Pill Test	9	45
Which test method would you choose if you wanted a measure of the impact of toxic fumes released by certain fabrics? LC-50 Toxicity Test	5	30

Note: Number of responses in this category do not total 20 because participants could make several choices.

toxicants emitted with the combustion of certain textile fibers and a brief description of the LC-50 toxicity test.

The content of the course manual was reorganized so that the same sequence was followed as was used in the review of literature. It also helped to organize the manual so that the material was presented more systematically, with current flame resistant products and treatments being addressed last. Another point noted by the author was that most people did not realize that they could use the course manual as a reference during the course. Therefore, a reminder was added to the instructor's manual to make this point during the introductory statement.

Instructor's Manual

The instructor's manual was developed to assist the person delivering the one-hour program. The manual primarily details the text used in the program. An instructor could use the manual as a guide in conducting and developing a future five-hour CEU course on fire safety and interior textiles (Appendix C). Included in the instructors' manual are a set of 36 slides, along with a script. The slides demonstrate important points, tables, fire scenes, interior settings, and testing apparatus. Slides were selected as a more appropriate format for a professional presentation. If the slides were to be

duplicated, copyright permission would have to be obtained from the NFPA, ASTM, Hoechst Celanese, The Wool Bureau, Springs Industries, NIST, etc. A complete listing of the sources are provided in Appendix C

In addition to background information and the text for the slides, the manual also lists the physical materials required for delivering the course. References of the various flammability and toxicity tests as well as contacts for the video clips used within the presentation are provided as an appendix.

Video Used in Presentation

A video was used in the presentation to demonstrate various new fire safe textile products as well as to demonstrate some of the flammability tests available in the market. The video was a collection of clips obtained from different product tapes acquired from five manufacturers of current fire safe products. Permission was obtained from the manufacturers to use clips from their product videos and a compiled tape was made which ran for approximately 20 minutes. The video tape helped to show the actual performance of the new products in fire situations. Primarily the compiled tape provided a comparison of non-fire safe and fire safe products to demonstrate how textile

products may help feed or contain the start and/or spread of a fire.

Course Evaluation

A course evaluation was distributed to the participants at the end of the presentation. It consisted of ten questions to determine the participants' response to the effectiveness of the course and any suggestions for improving the course.

On a scale of one to seven, with one being very helpful to seven being not helpful, the participants were asked to rate the effectiveness of the course. A score was then assigned to each response. A check in the first space indicated that the respondent found the class very helpful and was assigned a value of seven. A check in the second space was given a value of six, and so forth up to the last space (not very helpful) which was assigned a value of one. The higher the score, the more helpful the participants found the course (see Table 10).

An average of the ratings showed that twenty respondents rated the one-hour course above average at 5.05. The participants indicated that an expanded five hour course covering the same topic would be helpful to interior designers. The average rating of their responses was 5.1. Also, after taking the one hour course, most people

Table 10

Evaluation of One-Hour Class

(N=20)

Questions 1 & 2	SCALE: Number/Percentage						
	7	6	5	4	3	2	1
Rate how helpful you found this class.	3/15	8/40	2/10	4/20	0/0	3/15	0/0
Ave. Rating 5.05							
Based on the one hour class, how helpful would an expanded 5 hr. class be?	4/20	6/30	2/10	5/25	2/10	1/5	0/0
Ave. Rating 5.1							

indicated an increase in their confidence in specification of fire safe textile products (see Table 11), with an average response score of 5.4. The majority of them (65%) stated that they would attend such a course if available in the New River Valley (see Table 12). Forty-five percent of the respondents were willing to pay as much as $50, while forty percent indicated that they would pay $25. Only one participant reported to be willing to pay as much as $75 to attend such a course (see Table 13).

When asked to rank order topics they would be interested in for a CEU course, the following were their top three choices. A value of three was assigned to their first choice, two to their second choice, and their third choice was assigned a value of one. The weighted scores revealed their first choice to be fire codes and standards, fire safe design was their second choice, and their third choice of interest was fire safe textiles.

Question number six in the course evaluation addressed a number of points dealing with interior designers and the subject of fire safe textiles. On this question participants were given an opportunity to check all the choices possible. As a result, many (45%) stated that they were keeping up with current developments in the industry. However, almost all of the participants (85%) felt that interior designers need more information on the topic of

Table 11

Confidence Level After Taking One-Hour Course

(N=20)

Question #8	SCALE: Number/Percentage						
	7	6	5	4	3	2	1
After taking this course, would you feel more confident in specifying fire safe textile products?	5/25	6/30	4/20	4/20	0/0	0/0	1/5
Ave. Rating 5.4							

Table 12

Attendance of CEU Course in New River Valley

(N=20)

Question #3	No.	%
If a CEU course on fire safe textiles were offered in the New River Valley, would you attend?	13 Yes 7 No	65 35

Table 13

Cost of CEU Course

(N=20)

Question #4	Number	Percentage
How much would you be willing to pay for a CEU course on fire safe textiles?		
$25	8	40
$50	9	45
$75	1	5
$100	0	0
$150	0	0

fire safe textiles for interiors. In fact, very few (5%) felt that they were well informed on the subject. Many of them (75%) were also especially concerned now that licensing is a possibility (see Table 14).

In question number seven participants were asked to rank three important considerations for enrolling in a course on fire safe textiles for interiors. A value of three was assigned to their first choice, two to their second choice, and one to their third choice. The weighted scores revealed their first three choices to be: requirement to maintain state licensing, need to update/increase knowledge, and speaker/presenter of course has particular expertise.

Many of the suggestions given in the course evaluations stated that more opportunity to have hands on demonstrations would be beneficial. They suggested that samples of different types of construction characteristics, fibers and finishes, with an explanation of the differences in their performance in fires, be made available to the class participants. Moreover, participants demonstrated an interest in seeing actual samples of the latest products and finishes concerning fire safe textiles. As a result of these suggestions the course was altered to include more demonstrations and more samples of state-of-the-art products on the market.

Summary

The one hour program supported the perception that a five-hour CEU course would be beneficial to professional interior designers. The data obtained from the questionnaire and course evaluation, and the experience gained in delivering this course, helped meet the objectives of this study. An analysis of the data collected during the one hour course supports the view stated in existing literature (Fowles, 1987), which stressed the importance of interior designers being up-to-date on fire safe textiles and finishes. This study also indicates that designers' knowledge appears to be limited to basic textile flammability.

Chapter V

Conclusions and Recommendations

The role of textiles in interior fires is an important one. The behavior of textile end-products used in interior spaces can have a direct effect on the start or spread of fires. The role of the specifying interior textile products is primarily that of the interior designer. Hence, interior designers are required to be knowledgeable of the properties of the materials they specify, as they can have a direct bearing on the safety and welfare of the public.

The rate of developments in the industry is such that interior designers may have difficulty in keeping up-to-date on the latest and best options available with regards to fire safe textiles. A means for helping interior designers keep current on developments in the textile industry is needed. Such an update would assist designers in making more informed decisions as well as help protect them from liability suits.

This study presented a one hour course to aid future course instructors in developing a CEU course on fire safety and interior textiles. The results of the study reinforced existing literature which states, that interior designers need to be aware of relevant and current knowledge on

interior textile properties as related to fire situations (Fowles, 1987).

The objectives this study were: 1). To provide an efficient method for professional interior designers to gain updates on developments in the textile industry on fire safe textile products, which have implications for the health and safety of building occupants. 2). To develop a one-hour preliminary program for professional interior designers which could be developed into a five-hour course 3). To investigate the need for the development of a five-hour CEU course.

A one-hour course presenting a condensed version of the five-hour CEU course was delivered. The one-hour packaged program could be adapted by anyone with adequate preparation in the development and delivery of it as a .5 CEU course.

This author recommends the formulation of a five-hour CEU course on the topic of fire safety and interior textiles. The process of developing such a course can be an easy task, especially since many helpful resources are provided in this study.

Additional topics to be addressed could include focussing on the residential market. One aspect of this could involve updating store buyers on the importance of selecting fire safe textile products for the furniture they retail. The author feels there is a lack of understanding

among retail furniture buyers concerning the potential effect of the products they sell on the safety and welfare of the public. Many residential textile products do not have to pass flammability tests, neither at the federal or local/city level. A substantial amount of textile furniture products can thus be very flammable and may pose a hazard to residential properties. Therefore, a similar course for retail furniture buyers would be beneficial to them.

Another related topic relevant to flammability is that of toxicity. The topic of toxicity could focus on flame retardant finishes which are placed on many textile end-products that outgas toxic fumes into indoor air

Finally, this study provided a packaged program for updating interior designers on fire safety and interior textiles. The package is designed to be easily adaptable and anyone with sufficient preparation can use it for developing and delivering a five-hour course on fire safety and interior textiles.

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Appendix A: Outline for Five Hour CEU Course

Outline for Five-Hour Course

First Hour

1) Ask participants to complete course questionnaire.

2) Give an overview of recent fires (within the last ten years) which could have been confined if the proper specification of interior textile materials would have been specified. The MGM Grand Hotel is one example where textile products contributed to the spread of the fire.

3) Give examples of other fires in which people have died as a result of toxic fumes which were emitted from textile materials.

4) Show a video which demonstrates as well as explains some of the steps involved leading up to these fires.

Second Hour

1) Discuss the role of fiber, fabric construction, and finishes in decreasing the flammability potential of textiles. Supply sample of textiles with loose and tight

weave, different fibers types, and finishes to show the difference in flammability characteristics.

2) Have two participants from the group show some of the hazards associated with textile materials, by having them give a demonstration to the rest of the group. For example, have them demonstrate the effects of a flame retardant finish on a fabric versus one that does not have one.

3) Go over the flammability characteristics associated with some fibers (near a flame, in a flame, away from a flame).

4. Go over the toxicity problem. Show chart depicting the different toxicants associated with the combustion of certain textile fibers.

<u>Third Hour</u>

1) Review flammability test methods which apply to some interior textiles such as the Steiner Tunnel test, Methenamine Pill test, and the NFPA 701 vertical large-scale test..

2) Show slides and a video tape of the flammability tests performed on some textile products to further explain their significance as well as how they are performed. The slides prepared for the one-hour course can be used here. These slides include pictures of actual test apparatus such as the test apparatus for the Steiner Tunnel test or the Radiant Flooring Panel test, etc. The slides also depict flammability tests being performed.

3) Explain the toxicity test which is currently performed on interior textiles (LC-50 Toxicity Test).

4) Word search exercise of common flammability terms as related to textile products. This will aid in keeping the participants involved in the presentation and also help them retain more information.

Fourth Hour

1) Review Federal government.regulations currently in place.

2) Discuss some Virginia codes and standards which apply to interior textiles.

3) Review some of the BOCA fire prevention model codes.

4) Crossword puzzle to solve. The solutions will be related to material covered in this hour of the presentation. This will assist in the participants' retention of the material covered.

Fifth Hour

1) Case Study. The participants will be broken up into groups and presented with a problem they will have to solve. For example, one case study could deal with Federal codes and standards, in which case participants would have to be familiar with some of these codes in order to solve the problem correctly.

2) Review some of the interior textile product developments concerning flame retardant and toxic-safe materials. For instance, show samples of some of the state-of-the-art textile products which are currently on the market. Discuss the good and possible bad points of these products.

3) Show video tape of new products.

4) Distribute course evaluations for participants to complete.

Appendix B: Outline for One-Hour Course

Outline for One Hour Course

First Half Hour

Introduction

Stages of an Interior Fire

Flammability Hazards Associated with Textiles

(construction, fiber, finish)

Fiber Flammability Characteristics

Demonstration

Second Half Hour

Hazard 1 Computer Model

Federal Standards

Flammability & Toxicity Test Methods

Interior Textile Product Developments

Conclusions\Summary

Appendix C: Instructor's Manual

Instructor's Manual

In order to serve their clients adequately and maintain their professional standing in an increasingly competitive field, interior designers need to be up-to-date on the latest developments in the textile industry, as related to flammability. It is important for designers to become knowledgeable about the nature of some textiles as potential fire hazards, and to apply this information when specifying textile materials. Additionally, by understanding fire-related terms, and flammability test methods for textiles, interior designers will be better able to widen the margin of personal safety, minimize structural damages, and lessen economic losses in the event of a fire.

This manual serves as an instructional guide to be used in setting up a CEU course concerning fire safety and interior textiles. The manual primarily focuses on the text to be followed in delivering the presentation. The following section details the text for the slides, to be used in the presentation. The numbers represent the number of the slide.

Note: Tell course participants they can refer to their manuals to follow the outline of the presentation. Also tell them the manual can be used as a reference guide after the course.

Text for Slides

Slide 1: (Picture of a building fire)

Over the past few decades, interior textiles have been found to have played a significant role in the start and/or spread of fires in interior spaces. There has been a growing awareness concerning the role that textile products and finishes play on the public safety and welfare as related to interior fires. The specification of interior textiles normally falls in the interior designers domain. Hence, the responsibility for specifying furnishings and finishes that are safe from fire hazards is up to the interior designer. Source: NFPA, 1991.

Slide 2: (Title of topic written out)

The subject I will be discussing with you all today concerns the role that textiles play in interior fires, as well as the role of interior designers in specifying fire safety and interior textiles.

Slide 3: (Picture of a building fire)

Despite the legislative actions that have taken place over the years, fire continues to be a major problem in the United States. The National Institute of Standards and Technology (formerly the National Bureau of Standards) estimates that there are 12,000 fire related deaths annually in the United States. Source: NFPA, 1991.

Slide 4: (Structure fires chart)

The bulk of these fires (31 percent) are residential in character. Commercial property, including stores, offices, factories, and warehouses, are the next frequent in number, accounting for 23 percent of all fires which occur in the United States. The least frequent number of fires occur under the categories of public assembly (including restaurants, theatres, courtrooms, and museums) and institutions (including hospitals, schools, detention homes, and prisons), each accounting for 4 percent of all fires. Source: NFPA, 1986.

Slide 5: (Three stages of a fire in list format)

First, I would like to begin by addressing the different stages of an interior fire. The occurrence of a fire normally follows three stages; ignition, growth, and spread. Source: Yeager.

Stage 1

This stage consists of three steps: smoldering, ignition, and initial growth. Only the smoldering or ignited item is burning. In other words the fire is localized to the one item which has caught fire.

Stage 2

This is considered the flame spread and buildup stage. The fire has spread from the item of origin, igniting other items in its path. As the fire spreads and grows, heat is generated and the air in the room becomes very hot.

Slide 6: (Flashover definition)

It is at this stage that every combustible item in the room has the potential to ignite spontaneously. This phenomena is known as flashover and it usually occurs when the temperature of the burning room reaches approximately 900-1000 degrees Fahrenheit. Source: Yeager, 1988.

Slide 7: (Description of stage three and preventive stages of a fire)

At this stage, flashover has occurred and the flames have spread beyond the room of fire origin. In addition to the flames, a significant amount of heat, smoke, and toxic fumes may be radiating into other areas of the building making it a life-threatening situation for persons who remain within the building. Source: Yeager, 1988.

The first two stages are considered to be the fire preventive stages, i.e. where the fire can be controlled before it reaches its full potential. These two stages, ignition and spread are therefore of primary concern to interior designers since this is where the textiles they specify may control the behavior of a fire. For instance,

if a burning cigarette were to be dropped on an upholstered couch, the textile fabric should be able to resist ignition. Thus, designers should be aware of, and consider the preventive stages of fire growth while specifying textile materials.

Slide 8: (Picture showing an example of a stage 1 fire)

This is an example of a Stage 1 fire. The fire is just starting out and is limited to the source. Here, the behavior of the fire is heavily influenced by the materials present within the room. The fire spreads by feeding on the combustible materials present on or near the chair. Incidentally, the smoke produced from the burning chair can travel many feet from the room of fire origin and pose a threat to human life. Source: Hoechst Celanese, 1990.

Slide 9: (Picture showing an example of a stage 2 fire)

This is an example of a Stage 2 fire. The rest of the combustible materials within the room are starting to catch fire. The primary source of combustible materials are the textiles present within the room, and they help cause other materials within the room to catch fire. This stage is considered the growth stage where the fire spreads beyond the original item ignited. The potential for flashover can also occur in this stage. Source: Hoechst Celanese, 1990.

Slide 10: (Picture showing an example of a stage 3 fire)

This is a Stage 3 fire. Here flashover has already occurred and the fire is spreading beyond the room of origin. The room is uninhabitable, and everything within the room which can burn is burning. As you can see from this picture the fire is spreading out from the room of fire origin and into the corridor of the building. Source: Hoechst Celanese, 1990.

Slide 11: (Picture of a stage three fire)

This shows a fire in its full potential, where flames have engulfed the entire building. The textile products interior designers specify may help in preventing the occurrence of such situations. Source: Hoechst Celanese, 1990.

Slide 12: (Flammability hazards written in list format)

Designers are required to be aware of the flammability hazards associated with many textile products. These hazards include tendency of ignition, flame spread, smoke development, and toxicity. Tendency of ignition refers to the ability to catch fire or to begin to burn; flame spread is the rate at which flames spread; smoke development is the rate/amount of smoke released by burning material; and toxicity is the poisonous fumes released by a burning material or finish. Source: Hilado, 1974.

Slide 13: (Other flammability hazards associated with textile products written out in list format)

Now, all of these hazards do not only depend on the finished product, they also depend on the textile construction, type of fiber, and finish. For instance, in the case of textile construction, if all other parameters are held the same, a fabric made in a loose weave construction will ignite faster than a fabric made in a tight weave construction. Even though they are made from the same fiber, a loose weave cotton fabric will ignite more readily than a tight weave cotton duck fabric. Likewise, in the case of the type of fiber used in a fabric, a 100 percent rayon fabric would ignite more readily as compared to a fabric constructed of 100 percent wool fibers. The same rules also apply in the case of a fabric containing an FR finish versus one that does not. Obviously the one without the FR finish would ignite more readily. Source: Hilado, 1974.

Slide 14: (Chart of different fiber flammability characteristics)

This chart depicts the relative flammability of selected fibers. The chart begins with the most fire resistant fibers down to the least fire resistant (from left to right). A fireproof fiber is unaffected by fire. Asbestos is a fireproof fiber, and may glow if heated to a sufficiently high temperature. However, asbestos in the

form of textile end-products is no longer used, since it has been found to be a carcinogen. Fabrics composed of glass fibers are the next least hazardous fibers due to the fact that they are noncombustible. When exposed to a fire condition, the fiber may melt but it will remain the same material chemically, although it may change in physical form. Protein fibers, that is those deriving from animal hairs are quite fire resistant. About the only effect of exposing them to ignition is to char a hole in them without producing flames. Fabrics composed of natural cellulosic fibers such as cottons and linens, or artificial cellulosic fibers such as rayon are considered highly flammable. A flame retardant finish would have to be applied to these fibers in order for them to be considered safe. Thermoplastic fibers such as acetate, nylon, etc.. also fall under the category of flammable, although they are not as flammable as the cellulosic fibers. However, they do tend to shrink or melt away in an applied flame. Source: Kirk, 1969.

Slide 15: (Picture of a lounge/lobby area)

Many times the first items to ignite in a room are usually those surfaces where a lit cigarette may have been dropped. A prime example of this phenomena usually tends to occur where people congregate, or where people usually tend to smoke, such as in living rooms. For instance, if a lit

cigarette is accidentally dropped unnoticed on an upholstered furniture the start of a fire depends on the behavior of textile materials on the furniture. Source: Wool Bureau, 1989.

Slide 16: (Picture of a carpet with a match lit on it)

Another item which may ignite is carpeting. A dropped cigarette or match may go undetected and the carpet could smolder for hours before catching fire. Source: Wool Bureau, 1989.

Slide 17: (Picture of a mattress on fire)

Another textile item which often ignites first is mattresses. Source: Springs Industries, 1989.

Slide 18: (List of items which must meet federal flammability standards)

The items which must meet federal flammability standards are carpets, rugs and mattresses. Both of these items were established in the early seventies (1970 & 1972) and are regulated by the Department of Commerce. Source: NFPA, 1986.

Slide 19: (Goals of UFAC listed)

However, since no federal flammability standard was established for upholstered furniture, the furniture industry formed the Upholstered Furniture Action Council

(UFAC) in 1974. The UFAC is a voluntary testing program for upholstered furniture which many manufacturers follow. Its primary goals are to make safer furniture and to educate the public on fire safety.

The UFAC Voluntary Action Program, which officially started in April 1979, has four aspects: fabric classification, construction criteria, a labeling plan, and a compliance procedure. Fabric classification divides upholstery fabrics into two categories of ignition propensity, based on their ability to resist ignition when exposed to a burning cigarette. The UFAC has established five construction criteria to which manufacturers must adhere in order to qualify for participation in the program. Each criterion is paired with a standard test method to ensure proper compliance. The labeling plan centers on a hangtag that identifies furniture meeting UFAC criteria. Under the compliance procedure an independent laboratory verifies that materials used in making the items carrying the compliance hangtag meet the performance criteria set forth in the program. Source: Yeager, 1988.

Slide 20: (List of transportation textile items)

There is one exception to not having federal flammability standards for upholstered furniture. Regulations exist for transportation fabrics and other textile products used in certain applications, including

passenger cars, trucks, buses, and commercial airliners. Unlike the voluntary program dealing with upholstered furniture, these regulations are mandatory and are under the jurisdiction of the United States Department of Transportation. Source: NFPA, 1986.

Slide 21: (Picture of subway train which has upholstery fabric that had to meet federal regulations)

Here is an example of a subway train in which along with the carpeting, the upholstery fabric present also has to meet federal standards. Source: Wool Bureau, 1989.

Slide 22: (Description of the Hazard 1 computer model)

An innovative device in the fire industry which was developed a few years ago by the National Institute of Standards and Technology is the Hazard 1 computer model. This highly sophisticated model is able to accurately predict the behavior of a fire in a building. By entering the room dimensions, furnishings, and laboratory fire test data, the model can predict the time the fire takes to spread and reach flashover, the heat and toxic fumes given off, the temperature and height of the combustion gases, the amount of carbon monoxide, and the level of danger as the fire and smoke spread. Source: NIST.

Slide 23: (Characteristics of the Hazard 1 computer model)

More specifically, the computer model is able to predict: 1) the time fire takes to spread and flashover, 2) the heat and toxic fumes given off, 3) the temperature and height of combustion gases, 4) the amount of carbon monoxide, and 5) the level of danger in the burning room. Source: NIST.

Slide 24: (Picture of Hazard 1 computer model)

Here is an example of the computer model depicting the toxic hazard level as well as the level of danger present in each room. As you can see here, the levels of danger are color coded, where blue is considered safe, green is warning, yellow is unsafe, and red areas are considered deadly.

Most people who use this computer model are either fire investigators, fire engineers, and/or manufacturers. Fire investigators and engineers may use it to determine the cause of fires as well as to determine the cause of deaths in fires. Manufactures on the other hand, may use it to evaluate the behavior of their products and determine the need to develop better and safer products. Source: NIST.

Slide 25: (Picture of fabrics undergoing a small-scale vertical flame test)

Many interior textile products undergo flammability testing procedures in order to determine their performance

in smoldering or fire conditions. Here for instance, is a picture of several fabrics (which are composed of different fibers) undergoing a vertical flame test (similar to the NFPA 701 small-scale test). As you can see, of the fabrics pictured here, the one made out of wool is the most flame retardant while the acrylic is the least retardant. Source: Wool Bureau, 1989.

Slide 26: (Picture of two draperies undergoing a large-scale vertical flame test)

This slide shows a vertical test similar to the NFPA large-scale fire test, where the test specimen is hung as a drapery fabric would be (with folds). The lower edge of the specimen is four inches above the burner tip and an 11-inch flame is held under the specimen for two minutes. For a specimen to pass this test the char length must not exceed thirty-five inches. As you can see the fabric on the left falls within the standard while the fabric on the right does not meet the standard. Source: Hoechst Celanese, 1990.

Slide 27: (Picture of Steiner Tunnel Test)

This is the Steiner Tunnel Test or otherwise known as the ASTM E-84 test. This test was devised to compare surface burning characteristics of building materials and interior finishes. Specifically, the test was designed to simulate the growth stage, or fully developed stage of a fire and provide data on flame spread, fuel contribution,

and smoke density. A twenty-five foot by one foot eight inches textile specimen is mounted on the ceiling of the tunnel chamber. Jet flames and heat are applied to the sample for ten minutes. Time and flame spread distance values are obtained and compared with those recorded for asbestos-cement board (assigned a flame spread rating of 0) and select-grade red oak flooring (assigned a flame spread rating of 100) to arrive at a flame spread classification. A value of 0-25 is Class A; 26-75 is Class B; 76-200 is Class C; and above 200 is not rated.

This test basically measures flame spread, smoke generation, and textile fuel contribution. It is also one of the most widely used test in that it can be used to measure many different textile end products such as carpets/rugs, upholstery fabric, and textile wallcoverings. Source: ASTM.

Slide 28: (Picture of Methenamine Pill Test)

This is the Methenamine Pill Test. It is the test method required to meet federal flammability standards for carpets and rugs. It is used for evaluating the ease of surface ignition and surface flammability. Eight nine-inch square sections of moisture free carpet specimens are placed on the bottom of a one foot enclosed cube, which is open at the top, and held in place by a nine-inch square metal plate having an opening eight inches in diameter. A methenamine

tablet formulated to burn for two minutes, is placed in the center of the specimen and ignited. A specimen meets the standard when the char area does not extend to within one inch of the metal ring in the hold down plate. At least seven of the eight specimens must pass the test to meet the established criteria. All carpets made in the U.S. must pass this test. Source: ASTM.

Slide 29: (Picture of Flooring Radiant Panel Test)

This is an example of the Flooring Radiant Panel Test which is performed on many carpets and rugs. This test was devised to measure the flame spread in a corridor or exitway which is under the influence of a fully developed fire in an adjacent room. The fully developed fire within the room transmits heat and radiant energy to the ceilings and walls of the corridor, which ignites the carpet, thus blocking the only means of escape. The sample size used in this test is 39 in. long by 8 in. wide and is mounted horizontally. The sample receives radiant energy from an air gas-fueled radiant panel mounted above the sample at an angle of 30 degrees. After the sample is preheated, a gas-fired pilot burner ignites the flooring system. The radiant energy flux decreases along the length of the carpet; therefore, the pilot flame is placed at the end closest to the source of the radiant energy. Once the carpet sample is ignited, the flame is allowed to travel along the carpet until it is no

longer reinforced by the radiant energy force and self-extinguishes. The point where the burning carpet self-extinguishes is called the point of critical radiant flux (CRF). Critical radiant flux is defined as the minimum amount of radiant energy needed to sustain the flame. The CRF is determined by converting the distance of flame spread into watts per square centimeter. The higher the distance the lower the CRF in watts per square centimeter. Hence in the test, the higher the number of watts per square centimeter, the more resistant the carpet to flame propagation. The lower the number, the greater the tendency of the carpet to spread flame. Source: ASTM.

Slide 30: (Description of composite testing)

The flammability tests which I just described were all component tests, meaning that only the textile material was tested (eg. carpet sample). In composite testing however, the entire textile product is tested (eg. a sofa or chair). Composite testing is considered to be more stringent than component testing, and the state of California is one of the states leading the way in requiring this type of flammability testing. These two tests, the California Technical Bulletin 121 and 133 are both composite tests.

Slide 31: (Picture of California Technical Bulletin 133 composite test)

Here is an example of the Technical Bulletin 133 test where a chair is undergoing the test. This test restricts the heat release rate of upholstered furniture, meaning that only a certain amount of heat can be released from the burning of the chair to pass the test. Source: California State Bureau of Home Furnishings.

Slide 32: (Picture of smoke coming out of a house)

One of the major causes of concern in the area of flammability centers on toxicity of fabrics and finishes. Toxic fumes which are emitted from many burning textile end-products are one of the primary causes of death for many people during a fire. Every combustible material emits toxic fumes in the process of burning. However, certain materials emit less toxic fumes compared to others. In the specification of interior textiles, care should be taken to avoid materials which tend to emit unusually high amounts of toxic fumes. Source: NFPA, 1991.

Slide 33: (Chart depicting toxic properties with the combustion of certain fibers)

This table has a listing of some of the gases given off with the combustion of certain textile fibers. Designers should be familiar with some of these toxicants given off by many of these textile materials. For instance, wool yields significant amounts of hydrogen cyanide, which is a

poisonous asphyxiant and it also reduces normal cell metabolism. When cotton burns, it produces large quantities of carbon dioxide, which increases respiration and could thus possibly lead to heat attacks. Source: Fisher, 1984.

Slide 34: (Description of the LC-50 toxicity test)

The LC-50 test is the only toxicity test currently available for measuring the impact of toxic fumes released by a certain fabric. The test measures the biological impact of carbon monoxide, carbon dioxide, fluorine, chlorine, bromine and iodine on Swiss Webster mice when fabrics are burned in their environment. LC-50 stands for the lethal concentration for 50 percent of the test animals. This test is a state law in New York. No drapery, wall fabric, ceiling material, and carpeting can be used in any installation, unless fire gas toxicity tests have been conducted. The results of the tests are filed in a computerized Building Material and Finishes, Fire, Gas and Toxicity data file. Additionally, a New York City regulation requires that a product covered by the building code must not be more toxic than wood. Bitter, 1989.

Slide 35: (Picture of person performing flammability test)

With further and advanced testing, researchers will be able to develop better textile products. In addition, by predicting a textiles burning behavior, they will also be

able to develop safer end-products. Source: Wool Bureau, 1989.

Slide 36: (List of some current textiles and finishes)

These are some of the state-of-the-art interior textiles and finishes currently on the market. The first product on the list is Hoechst Celanese's Trevira for FR. Trevira for FR is a polyester fiber that contains a substance within the fiber which allows for a lower melting-point. This enables the fabric to shrink away from the flame and to self-extinguish. In addition, since the molecular structure of the fiber has been modified, neither sunlight, washing, or dry cleaning can deprive the fabric of its flame resistance. The product also offers 35% less smoke generation than topically treated fabrics.

The second product on the list is Monsanto's SEF (Self-Extinguishing Modacrylic Fibers). This product which resembles wool, can be spun in its pure state or blended with other fibers to create fabrics with inherently flame resistant features. The most recent breakthrough with SEF is the fibers ability to blend with wool. While wool in general, will not support combustion, the lighter weight and construction of upholstery fabrics made of wool will often ignite under vertical upholstery testing conditions.

The Wool Bureau's Zirpro, unlike the first two products mentioned, is a flame retardant finish which is applied to

many wool and silk products. It is a zirconium-based after-treatment that is effective on protein fibers such as wool and silk. This finish which is widely used for furnishings promotes char-formation and can be applied in varying degrees to match specific application needs.

Uniroyal's Naugahyde 2-200 Flame Blocker is a vinyl-coated fabric that works in conjunction with foam underpaddings to resist flames and penetration of seat-cushion material.

Du Pont's Thermablock is a collection of fire-blocking fabrics using aramid film, inherently flame resistant polymer). These aramid films are designed to surround flammable material such as foam seat cushions, in order to slow the spread of flames.

The last textile product on the list is Springs Fireguard, a family of flame barrier textile fabrics. This flame barrier is achieved by combining a fiber glass matrix within a cotton covering that is both durable and soft to touch.

Introduction to Video Tape

The video tape is comprised of sections from tapes of different products, distributed by various manufacturers. It will present some of the latest, fire safe products available in the market today, and demonstrate their

performance in fire situations. Some flammability tests which are currently being used in the industry today are also presented along with types of fibers or finishes used in these state-of-the-art products. In addition, the different type of flammability tests will be demonstrated.

Follow-up Questions for the Video

1. What were some of the fibers which are used in these state-of-the-art products?
2. Why do you think Trevira for FR uses a polyester fiber in their product instead of using a different fiber?
3. Why do you think the that in the Thermablock video the California Technical Bulletin 133 flammability test was used?

Closing Statement

In the event of a fire, the performance of a textile end-product can feed or delay a fire. This critical time of potential fire development may, respectively, lead to a loss or saving of lives. Hence, the specification of textile end-products may effect the health, safety, and welfare of the public. It is important for designers to become knowledgeable about the nature of some textiles as potential fire hazards, and to apply this information when specifying textile materials. Additionally, by understanding fire-

related terms, flame resistant and toxic properties of textiles, flammability test methods, and recent product developments in the textile industry, interior designers will be better able to widen the margin of personal safety, minimize structural damages, and lessen economic losses in the event of a fire.

References/Contacts for Slides

American Society for Testing & Materials (ASTM)
1916 Race St.
Philadelphia, PA 19103; (215) 299-5400

American Society for Testing and Materials (1990). ASTM Fire Test Standards (third ed.). Philadelphia, PA.

Bitter, E.W. (1989). Fabric Toxicity Testing. Interior Design, 60(12), 252-253.

California State Bureau of Home Furnishings
3486 Orange Grove Avenue
North Highlands, CA 95660; (916) 920-6952

Fisher, T. (1984). The issue of fire. Progressive Architecture, 65(9), 149-153.

Hilado, C. J. (1974). Flammability of fabrics. Connecticut: Technomic Publishing Co.

Hoechst Celanese Corporation. (1990). Call the Specifier to the Witness Stand, Please. (company brochure). New York, NY: Author.

Kirk, P. L. (1969). Fire investigation. Berkeley, CA: John Wiley & Sons Inc.

National Fire Protection Assn. Inc.
Batterymarch Park
Quincy, MA 02269; (617) 770-3000.

National Fire Protection Association. (1986). Fire Protection Handbook (16 ed.).Quincy, MA.

National Fire Protection Association. (1991). The NFPA Catalog, vol. 1, 59.

Springs Industries. (1989). Sleepmaster Burn Test Results. (company brochure). New York, NY: Author.

Wool Bureau. (1989). The flame-retardance of wool carpets (company brochure). Atlanta, GA: Author.

Yeager, J. (1988). Textiles for residential and commercial interiors. New York: Harper and Row.

Equipment Needed for Course

1. Slide projector
2. Projector screen
3. Television
4. Video cassette recorder
5. Two candles
6. Two candle holders
7. Two metal clamps
8. Large metal tray

Updates on any of the flammability tests can be found in the latest ASTM Fire Test Standards Handbook as well as the NFPA Fire Protection Handbook. Documents describing federal test methods can also be obtained from the Consumer Product Safety Commission. The following is a list of these agencies with their addresses and phone numbers where current information can be obtained.

References

American Society for Testing and Materials (1990). ASTM Fire Test Standards (third ed.). Philadelphia, PA.

National Fire Protection Association. (1986). Fire Protection Handbook (16 ed.). Quincy, MA.

List of Contacts for Fire Tests

American Society for Testing and Materials
Department 8408
1916 Race Street
Philadelphia, PA 19103
(215) 299-5585

National Fire Protection Association
Batterymarch Park
Quincy, MA 02269
(617) 770-3000
Publication Request
Consumer Product Safety Commission
Washington, D.C. 20207
1 (800) 638-2772

List of Contacts for Toxicity Tests

New York Dept. of State Fire Protection & Control
162 Washington Avenue
Albany, NY 12231
(518) 474-6746

List of Contacts for Product Videos:

Hoechst Celanese Corporation Textile Fibers Group 1211 Avenue of the Americas New York, NY 10036 (212) 719-8823	Title: "Trevira for FR Great Performance" Year: 1991 Length: 4:30 Cost: $0
DuPont Company Nomex/Kevlar Marketing Laurel Run Building P.O. Box 80, 705 Wilmington, DE 19880-0705 1 800 453- 8527	Title: "There's no Match for DuPont Thermablock" Year: 1990 Length: 5:23 Cost: $0
Springs Protective Fabrics Firegard Textile Systems 104 West 40th Street New York, NY 10018 (212) 556-6338	Title: "Firegard" Year: 1990 Length: 12:30 Cost: $0

Uniroyal Engineered Products
Naugahyde Brand Fabrics
312 North Hill Street
Mishawaka, IN 46544-1399
(219) 256-8443

Title: "Naugahyde 2-200 Flameblocker"
Year: 1988
Length: 12:10
Cost: $0

Appendix D: Questionnaire

Questionnaire

Your responses in this questionnaire will serve as a tool in developing a five hour CEU course on fire safe textiles. Please place a check mark next to the appropriate answer(s).

1. What professional membership organization are affiliated with?

   ____ ASID ____ IBD

   ____ IDEC ____ other (specify) _____

2. What was the last college degree completed?

   ____ undergraduate ____ doctoral

   ____ master's ____ other (specify) _____

3. How many years have you been a practicing interior designer?

   ____ 0 to 2 years ____ 5 to 10 years

   ____ 2 to 5 years ____ more than 10 years

4. How would you classify your employment?

   ____ self-employed ____ interior design firm

   ____ arch.firm ____ retail firm\dealership

   ____ other (specify) _____

5. What is the predominant type of design work handled by your firm?

   ____ 100% residential ____ at least 75% commercial

   ____ at least 75% res. ____ 100% commercial

   ____ 50% res. & 50% com.

6. Have you taken the NCIDQ exam? (if No, go to question 8)

   ____ Yes ____ No

7. Which sections of the NCIDQ exam did you pass?

_____

8. What are the titles of magazines, journals, pamphlets etc. related to your work, that you read regularly?

_____

_____

9. Please select sources you rely on when specifying textile products. (check all appropriate)

____ labels on samples ____ prev. textile knowledge

____ personal experience ____ sales representatives

____ other (specify) _____

10. How confident do you feel when specifying textile end-products, as they relate to fire safety and toxicity? (check one)

____ very confident ____ not very confident

____ confident ____ not confident

11. A mandatory federal flammability standard has been established for: (check one)

____ curtains & drapery ____ upholstered furniture

____ textile wallcoverings ____ mattresses

12. Which fabric construction/characteristic would be more likely to speed the rate of burning? (check all appropriate)

____ loose weave ____ fuzzy weave

____ tight weave ____ smooth weave

(Please check off **one** answer for questions 13 through 19)

13. Which of the following would you expect to be the most fire resistant fiber for an upholstery fabric?

____ nylon ____ linen

____ silk ____ wool

14. In the same environment, which of the following fibers would you expect to ignite most rapidly?

____ polyester ____ rayon

____ nylon ____ acrylic

15. The Steiner Tunnel test (ASTM E-84) measures all of the following except

____ flame spread ____ smoke generation

____ ease of ignition ____ textile fuel contribution

16. Which test method is required to meet federal flammability standards for carpets?

____ Steiner Tunnel Test ____ Meth. Pill Test

____ Flooring Radiant Panel Test ____ Chamber Test

17. Which test method would you choose if you wanted a measure of the impact of toxic fumes released by a certain fabric?

____ Chamber Test ____ Floor Radiant Panel Test

____ Smoke Density Test ____ Toxicity Test

18. Flashover is a particularly dangerous situation because

____ flashes of flame occur sporadically throughout the room

____ combustible materials start releasing toxic fumes

____ fire reaches its approximate maximum potential

____ fire flashes over into surrounding rooms

19. A new product on the market by Dupont related to fire safe fabrics is

____ Flameguard ____ Chemblok

____ Thermablock ____ Simtex

Thank you for your time.

Appendix E: Course Evaluation

Course Evaluation

Your responses in this evaluation will assist in developing a five hour CEU course concerning fire safe textiles. (Place a check mark in the appropriate space)

1. Rate how helpful you found this class.

   very helpful ___ ___ ___ ___ ___ ___ ___ not helpful

2. Based on this one hour class, how helpful do you think an expanded five hour class would be to you on this topic?

   very helpful ___ ___ ___ ___ ___ ___ ___ not helpful

<u>Please place a check mark next to the appropriate answer(s)</u>

3. If a CEU course on fire safe textiles were offered in the New River Valley, would you attend?

   ____ Yes ____ No

4. How much would you be willing to pay for a CEU course on fire safe textiles? (check one)

   ____ $25, ____ $50, ____$75, ____ $100, ____ $150

5. Any of the following topics could be included in a CEU course on the topic of fire safe textiles for interiors. Rank order these topics according to how you see their importance, **beginning with 1 as the most important.**

   ____ toxicity

   ____ indoor air quality

   ____ fire safe design

   ____ fire safe textiles

   ____ professional liability and legal issues

   ____ codes/standards

   ____ new textile developments

   ____ others (please specify) _____

6. Do you think the subject of fire safe textiles for interiors is a subject interior designers are (check all appropriate):

____ keeping up with current developments in the industry?

____ seeking more information on the topic?

____ well-informed on the topic?

____ willing to attend a CEU course if made available?

____ willing to pay for a CEU course?

____ more concerned now that licensing is a possibility?

7. Rank **three of the following** which would be the important considerations in your enrolling in a course on fire safe textiles for interiors?
(1 = most important., 2 = important, 3 = least important)

____ requirement to maintain state licensing

____ speaker/presenter of course has particular expertise

____ course required by employer

____ course taught by university faculty

____ CEU credit

____ proximity to work or home

____ feel need to update/increase knowledge

8. After taking this course, would you feel more confident in specifying fire safe textile products? (Place a check mark in the appropriate space)

very confident ___ ___ ___ ___ ___ ___ ___ not confident

9. What suggestions would you have for improving this CEU course?

_____

_____

_____

10. How can the manual be made more helpful?

_____

_____

Appendix F: Course Manual

Course Manual

Over the past few years, the effect of interior textiles on fires in homes, hotels, office buildings, and in institutional facilities has created an increasing demand for fire safe interiors. There has been a growing awareness concerning the role that interior textile products and finishes play on the public health, safety and welfare. The responsibility for specifying interior environments that are safe from fire hazards is up to the interior designer. Hence, designers need to be aware of the flame resistance, toxicity, and smoke emission properties of various interior textile products so as to specify the appropriate flame resistant textile products and finishes. Therefore, designers also need to be up-to-date concerning interior textile codes, standards, and flammability testing methods.

This manual outlines some general information on fire safety and interior textiles. It can also be used as a reference guide. Topic sections included in the manual are: the nature of textiles as potential fire hazards, flammability and toxicity test methods, current flame resistant products and treatments, and a list of government and state agencies. A reference list for further reading and additional information is also included.

Flammability Terms

Ignitibility - Ability to catch fire; begin to burn.

Flame Spread - Rate at which flames spread.

Smoke Development - Rate/amount of smoke released by burning material.

Toxicity - Amount of poisonous fumes released by burning material/finish.

Flashover - A phenomena in which every combustible item in the room spontaneously catches fire.

Fireproof Fiber - A fiber which is not affected by fire e.g. asbestos

Noncombustible Fiber - Fiber may melt (does not burn) and change physically in flame source but will not change in chemical composition.

Fire Resistant Fiber - A fiber which has high decomposition and ignition temperatures.

Flammable Fiber - A fiber which is relatively easy to ignite and continues to burn even after flame source is removed.

Relative Flammability of Selected Fibers

Fireproof	Non-combustible	Fire Resistant	Flammable
asbestos	glass	aramid	cotton
		novoloid	linen
		wool	rayon
		modacrylic	acetate
		vinyon	triacetate
			acrylic
			nylon
			polyester
			olefin

Source: Yeager, 1988, p. 102.

Reaction of Fibers to Heat and Flame

FIBER	NEAR FLAME	IN FLAME	REMOVED FROM FLAME	ODOR AND RESIDUE
COTTON	no shrinkage,ignites on contact	burns quickly	continues to burn, afterglow	burning paper odor: light, ash
FLAX	no shrinkage, ignites on contact	burns quickly	continues burning	burning paper odor; light, ash
WOOL	curls away from flame	burns slowly	self-extinguishing	burning hair; small bead
SILK	curls away from flame	burns slowly sputters	usually self-extinguishing	burning hair crushable bead-like residue
RAYON	no shrinkage, ignites on contact	burns quickly	continues burning	burning paper odor; very little ash
ACETATE	fuses & melts away from flame, ignites quickly	burns quickly	continues rapid burning	acrid odor; irregular hard, bead
TRI-ACETATE	as acetate	as acetate	as acetate	as acetate
ACRYLIC	fuses away from, melts, ignites quickly	burns rapidly with hot flame sputters melts	continues burning	acrid odor; irregular hard, black bead
MOD-ACRYLIC	fuses away from, melts	burns slowly	self-extinguishing	acrid odor; irregular hard, black bead
NYLON	fuses, melts & shrinks from flame	burns slowly with melting	self-extinguishing	celery-like odor; hard, tough grey or brown bead
OLEFIN	fuses,shrinks from flame	melts & burns	continues burning	paraffin wax odor tough brown bead
POLYESTER	fuses, melts &shrinks from flame	burns slowly with melting	self-extinguishing	chemical odor; dark, tough bead
SARAN	fuses, melts & shrinks from flame	melts, yellow flame	self-extinguishing	chemical odor; dark, tough bead
GLASS	will not burn	softens, glows red	hardens, may change shape	no odor; hard white bead
VINYON	fuses, melts & shrinks from flame	burns, melting	self-extinguishing	acrid odor; irregular hard, black bead

Source: Yeager, 1988 pp. 17-18.

Type of Fiber First Ignited in Fatal Structure Fires

FIBER TYPE	% FIRES	% DEATHS
Cotton, rayon	25	22
Synthetic fibers	16	16
Wool, wool mixture	1	1
Type not reported	9	9

* Based on 2,534 fatal structure fires accounting for 3,277 civilian deaths, where the type and form of material first ignited was known. Percents in this data-set refer to only fabric related incidents

Source: National Fire Protection Association, 1986, p. 5-18.

Textile Flammability Standards

Flammable Fabrics Act - 1953

Requires textile products intended for use in apparel, to meet mandatory standards.

Amendment to Fabrics Act 1967

Gave Secretary of Commerce the authority and duty to set mandatory flammability standards as needed in order to protect the public against unreasonable risk.

Authorized the investigation of deaths and injuries caused by fires.

Research and development of test methods and devices, along with studies to show the feasibility of reducing flammability were also authorized.

Amendment was applicable to wearing apparel and residential as well as commercial interior furnishings (with the exception of vehicles of transportation).

Federal Flammability Standards Established for:

- Carpets
- Rugs
- Mattresses
- Transportation fabrics (cars, trucks, buses, commercial airliners)

* A standard has been proposed but not established for upholstered furniture

Upholstered Furniture Action Council

- Formed as a result of no mandatory standard on upholstered furniture

- Primary goals: 1) To make safer furniture
  2) Educate public on fire safety

Flammability Test Methods

Interior Textile Tests

Fire codes for interior textiles are determined by individual state and local governments. The following is a description of some of the tests which are performed today in the U.S. and applied to most fabrics. A listing of these tests can be found in the ASTM Fire Test Standards Handbook as well as the NFPA Fire Protection Handbook.

NFPA 701 Small Scale The National Fire Protection Association component test measures the vertical flame spread of fabrics intended for use as curtains or draperies. A ten inch strip of cloth is suspended over an open flame from a bunsen burner and ignited. The sample is then measured for both after flame and length of char (burn) of the warp (lengthwise yarns) and of the filling (crosswise yarns). The maximum afterflame for any one specimen is two seconds. The length of char maximum is dependent upon the fabric weight, with a maximum value for both average and individual specimens. Residues that drip or break cannot continue to flame after reaching the test chamber floor. Note: NFPA 701 tests were revised in 1989 allowing fabric to be folded during testing, and it can be retested if it fails the first time. The chamber for these tests is

somewhat different for measuring the char length on drapery fabrics. Since it was discovered that man-made fabrics shrink from the heat source, fabrics intended for use as curtains and draperies are required to retain 95 percent of their weight after ignition.

Methenamine Pill Test (ASTM D-2859) (DOC FF 1-70 carpets & DOC FF 2-70 rugs) This test seeks to prevent the use of highly flammable fiber floorcoverings by evaluating the ease of surface ignition and surface flammability. Eight nine-inch square sections of moisture free carpet specimens are placed on the bottom of a one foot enclosed cube, which is open at the top, and held in place by a nine-inch square metal plate having an opening eight inches in diameter. A methenamine tablet formulated to burn for two minutes, is placed in the center of the specimen and ignited. A specimen meets the standard when the char area does not extend to within one inch of the metal ring in the hold down plate. At least seven of the eight specimens must pass the test to meet the established criteria. All carpets made in the U.S. must pass this test.

Steiner Tunnel Test (ASTM E-84) (NFPA 255) (UL 723) The test was devised to compare surface burning characteristics of building materials and interior finishes.

Specifically, the test is designed to simulate the growth stage, or fully developed stage of a fire and provide data on flame spread, fuel contribution, and smoke density. A twenty-five feet by one foot eight inches floor covering specimen is mounted pile surface down on the ceiling of the tunnel chamber. Jet flames and heat are applied to the sample for ten minutes. Time and flame spread distance values are obtained and compared with those recorded for asbestos-cement board (assigned a flame spread rating of 0) and select-grade red oak flooring (assigned a flame spread rating of 100) to arrive at a flame spread classification. A value of 0-25 is Class A; 26-75 is Class B; 76-200 is Class C; and above 200 is not rated.

Flooring Radiant Panel Test (ASTM E648, NFPA 253)

This test was devised to measure the flame spread in a corridor or exitway which is under the influence of a fully developed fire in an adjacent room. The fully developed fire within the room transmits heat and radiant energy to the ceilings and walls of the corridor, which ignite the carpet, thus blocking the only means of escape. Sample size is 39 in. long by 8 in. wide and is mounted horizontally. The sample receives radiant energy from an air gas-fueled radiant panel mounted above the sample at an angle of 30 degrees. After the sample is preheated, a gas-fired pilot

burner ignites the flooring system. The radiant energy flux decreases along the length of the carpet; therefore, the pilot flame is placed at the end closest to the source of the radiant energy. Once the carpet sample is ignited, the flame is allowed to travel along the carpet until it is no longer reinforced by the radiant energy force and self-extinguishes. The point where the burning carpet self-extinguishes is called the point of critical radiant flux (CRF). Critical radiant flux is defined as the minimum amount of radiant energy needed to sustain flame. The test is indexed in watts per square centimeter. In the test, the higher the number of watts per square centimeter, the more resistant the carpet to flame propagation. The lower the number, the greater the tendency of the carpet to spread flame.

Smoke Density Test This test measures the smoke generation of solid materials under flaming and nonflaming (smoldering) conditions. The purpose of such testing is to identify materials that would generate large volumes of dense smoke, which would hinder quick and efficient egress by obscuring exit markers and would also hamper breathing. A specimen 3 inches square and up to 1 inch thick, is suspended vertically in an enclosed test chamber. Three replicate tests are conducted by exposing the specimen

surface to an irradiance level of 2.5 watts per square centimeter; the individual tests are conducted by impinging six flamelets (small flames) across the lower edge of the specimen in combination with the radiant heat. A light beam is passed vertically through the smoke chamber. The test is completed when a minimum light transmittance value is reached or 20 minutes have elapsed, whichever occurs first. Required values vary from a low of 50 to a maximum of 450 flaming optical density. Depending on the application, there are three different classes of requirements which the specimen has to satisfy. Class A is for carpets not used in office building, Class B for unsprinklered corridors exposed to office space having a controlled equivalent fuel load of 6 pounds per square foot or less, and Class C may be installed in all office areas and in corridors protected with automatic sprinklers.

California Technical Bulletin 121 A composite test for mattresses that subjects the completed product to an open flame from ten double sheets of newspaper burning in a metal wastepaper basket. This ignition source is placed under the bed in a test chamber that is equipped to monitor weight loss, ceiling temperature, concentration of carbon monoxide, and smoke capacity. If any one of the first three test criteria is not met, the product does not pass. This test

is mandatory for products to be used in the state of California in high risk occupancy buildings such as prisons and healthcare facilities.

California Technical Bulletin 133 This test is designed to evaluate the resistance of seating furniture for use in public occupancies to open-flame ignition. The ignition source, a square gas burner, is positioned on the seat of the chair. The pass/fail criteria monitored during the burn are based on heat release rate, carbon monoxide volume, smoke and materials burned.

California Bulletin 117 (section E) This test is conducted on upholstery fabrics in which both the face and back of samples are subjected to direct flame impingement for one second. If the fabric ignites it does not meet the standard.

UFAC Test This test has a classification for cigarette ignition, which is determined by the vertical char and ignition of the substrate. If samples produce a char less than 1.75 in. and if the substrate does not ignite, it is a Class I fabric. If the char of any one specimen is equal to or greater than 1.75 in. or if the substrate ignites, it is a Class II fabric.

Toxicity

Every combustible material emits toxic fumes in the process of burning. However, certain materials emit less toxic fumes compared to others. In the specification of interior textiles, care should be taken to avoid materials which tend to emit unusually high amounts of toxic fumes. For instance, wool yields significant amounts of hydrogen cyanide, and cotton produces large quantities of carbon dioxide. Designers should be aware of some of the toxicants given off by many textile materials, the following table has a listing of some of the gases given off with combustion of certain textile fibers.

Gases Identified with Combustion of Textile Fibers

TOXICANTS	SOURCE MATERIALS	TOXICOLOGICAL EFFECTS
Aldehydes	Polyester fabrics & fibers	Potent respiratory irritants
Ammonia	Wool, Silk, Nylon, (Nitrogen containing material)	Pungent, unbearable odor, irritant to the eyes & nose
Carbon Dioxide	Cotton (All carbon containing materials)	Increases respiration
Carbon Monoxide	Cotton (All carbon containing materials)	Reduces oxygen carrying capacity of blood, asphyxiation
Halogen Acids	Halon fire retardant Brominated fire retarded polyesters	Respiratory irritants
Hydrogen Cyanide	Wool, Silk, Nylon, (Nitrogen containing material)	A rapidly fatal asphyxiant poison, reduces normal cell metabolism
Nitrogen Oxides	Nylon	Strong pulmonary irritant, can cause immediate death or delayed injury

Source: Fisher, 1984, p 150.

Toxicity Tests

The following is a description of the only toxicity test currently available.

LC-50 Test Measures the biological impact of carbon monoxide, carbon dioxide, fluorine, chlorine, bromine and iodine on Swiss Webster mice when fabrics are burned in their environment. LC-50 stands for the lethal concentration for 50 percent of the test animals.

Current Flame Resistant Products & Treatments

1) Hoechst Celanese's Trevira FR: A polyester fiber that contains a substance within the fiber which allows for a lower melting-point. This enables the fabric to shrink away from the flame and to self-extinguish. In addition, since the molecular structure of the fiber has been modified, neither sunlight, washing, or dry cleaning can deprive the fabric of its flame resistance. The product also offers 35% less smoke generation than topically treated fabrics (Hoechst Celanese, 1988).

2) Monsanto's SEF (Self-Extinguishing Modacrylic Fibers): This product which resembles wool, can be spun in its pure state or blended with other fibers to create fabrics with inherently flame resistant features. The most

recent breakthrough with SEF is the fibers ability to blend with wool. While wool in general, will not support combustion, the lighter weight and construction of upholstery fabrics made of wool will often ignite under vertical upholstery testing conditions (Monsanto, 1987).

3) Zirpro: A zirconium-based after-treatment developed by The Wool Bureau that is effective on protein fibers such as wool and silk. This finish which is widely used for furnishings promotes char-formation and can be applied in varying degrees to match specific application needs (The Wool Bureau, 1989)

4) Uniroyal's Naugahyde 2-200 Flame Blocker: A vinyl-coated fabric that works in conjunction with foam underpaddings to resist flames and penetration of seat-cushion material (Uniroyal, 1990).

5) Du Pont's Thermablock: A collection of fire-blocking fabrics using aramid film, inherently flame resistant polymer). These aramid films are designed to surround flammable material such as foam seat cushions, in order to slow the spread of flames (Dupont, 1990)

6) Springs Fireguard: A family of flame barrier textile fabrics. This flame barrier is achieved by combining a fiber glass matrix within a cotton covering that is both durable and soft to touch.

List of Agencies and Government Organizations
(for obtaining code details and fire testing information)

Scientific Organizations

American Association of Textile Chemists and Colorists (AATCC)
P.O. Box 12215
Research Triangle Park, NC 27709; (919) 549-8141

American National Standards Institute, Inc. (ANSI)
1403 Broadway
New York, NY 10018; (212) 642-4900

American Society for Testing & Materials (ASTM)
1916 Race St.
Philadelphia, PA 19103; (215) 299-5400

Business & Inst. Furniture Manufacturer's Association (BIFMA)
2336 Burton S.E.
Grand Rapids, MI 49506; (616) 243-1681.

National Fire Protection Assn. Inc.
Batterymarch Park
Quincy, MA 02269; (617) 770-3000.

Independent Testing Companies

Better Fabrics Testing Bureau
101 West 31 St.
New York, NY 10001; (212) 868-7090

Southwest Research Company
6220 Culebra Rd.
San Antonio, TX 78284; (512) 684-5111

Underwriters Laboratories
333 Pfingsten Rd.
Northbrook, IL 60062; (312) 272-8800.

York Research Corp.
1 Research Dr.
Stamford, CT 06906; (203) 325-1371

Building Codes

Building Officials & Code Administrators Intl.,
(Boca Basic Building Code)
4061 W. Flossmoor Rd.
Country Club Hills, IL 60478; (312) 799-2300

International Conference of Building Officials
(Uniform Building Code)
5360 S. Workman Mill Rd.
Whittier, CA 90601; (213) 699-0541

Southern Building Code Congress International, Inc.
(Southern Building Code)
900 Montclaire Rd.
Birmingham, AL 35213; (205) 591-1863.

Government & State Agencies

California State Bureau of Home Furnishings
3486 Orange Grove Avenue
North Highlands, CA 95660, (916) 920-6952.

Publication Request
Consumer Product Safety Commission (CPSC)
Washington, DC 20207; 1 (800) 638-2772

Federal Aviation Administration (FAA),
U.S. Department of Transportation
800 Independence Ave., SW
Washington, DC 20591; (202) 366-4000

Port Authority of New York & New Jersey
1 World Trade Center, Room B2-247
New York, NY 10048; (212) 466-8461.

State of New York Codes Division
NYS Department of State
162 Washington Ave.
Albany, NY 12231; (518) 474-4073.

Trade Associations

Upholstery Furniture Action Council (UFAC)
Box 2436
HIGH Point, NC 27261; (919) 885-5065

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Vita

Virginia Perez was born on January 24, 1965, in Washington D.C. She grew up in Northern Virginia, graduating from McLean High School in June, 1984. In August, 1988, she completed a Bachelor of Science degree (from Florida State University) in Home Economics with an emphasis in clothing and textiles. While at Florida State University, Virginia served as a member of Pi Beta Phi social sorority. She was also a member of the Collegiate Merchandising Association, and of Fashion Incorporated.

Besides earning a Bachelor's degree in Textiles and Clothing, Virginia also received a minor in Spanish. She studied through the University of Virginia/University of Valencia Hispanic Studies in Spain program during the spring semester of 1987.

In August, 1988, Virginia began a Master of Science degree in the Department of Housing, Interior Design, and Resource Management at Virginia Polytechnic Institute and State University. In January of 1990 she was awarded a graduate assistantship. Her professional development activities at Virginia Polytechnic Institute and State University included: college representative on the Investigative Board of the Graduate Honor System; member of the American Home Economics Association, and the American

Society of Interior Designers (Vice President 1990-91), and Outstanding College Students of America.

Virginia's professional career goal is to eventually have her own business. However, for the immediate future she would like to secure a position as a commercial interior designer within the healthcare field. The idea of improving the interior environment and people's well being, is something that she finds both rewarding and challenging.