TEXTILES for RESIDENTIAL and COMMERCIAL INTERIORS

5th Edition

MaryPaul Yates • Adrienne Concra

FAIRCHILD BOOKS

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PREFACE

The fifth edition of *Textiles for Residential and Commercial Interiors* reflects the suggestions of professors who used earlier editions of the book, and benefits from the expertise of numerous generous professionals in all segments of the interior fabric industry. Many of these professionals read sections of the manuscript related to their expertise and contributed comments, updates, and corrections. Some of the college instructors and professors shared invaluable comments offered by their students. The organization, pedagogy, and scope of the book reflects all this input.

The book is written as a textbook, directed to interior design students and educators in higher education, but it is also a useful reference for practicing interior designers, architects, retailers, and consumers with a professional or personal interest in textile furnishings.

Changes for the fifth edition include:

- New illustrations that feature current market trends
- Outline of current performance and sustainability standards, guidelines, and codes for multiple products
- Simplified organizational structure, minimizing redundancy
- Examination of current and new finishes and fiber preferences
- More illustrations of and performance information about fibers and fabrics suitable for outdoor use
- Extensive discussion of environmental and health issues related to the manufacture and use of interior textiles and their relationship to governmental codes, requirements, and trends

To achieve a greater understanding of interior textiles requires examining and studying fabrics as well as the information included in the textbook. This text can be used in conjunction with *Swatch Reference Guide for Interior Design Fabrics* by Deborah Young, also available from Fairchild Books. Direct access to fabric swatches can enhance understanding of essential details of woven, printed, and nonwoven fabrics.

Because readers will have different levels of knowledge about textiles, the text begins with a focus on textile fundamentals. As requested by users of the earlier editions, all aesthetic, durability, appearance retention, comfort, and health and safety properties are examined in greater depth at the end of each section that relates to the relevant end-use. All levels of manufacturing and processing, from fiber to yarn, to fabrication, to dyeing and finishing, are discussed in detail. Newly developed fibers and new processing techniques are covered.

For the benefit of the instructor and the student, key terms and review questions are offered at the end of each chapter. The appendices include a list of generic manufactured fiber names, established performance guidelines for contract fabrics, a bibliography, and an extensive glossary. The text is richly illustrated, with

line drawings and full-color, detailed photographs of fibers, yarns, fabrics, equipment used in manufacturing, coloring and finishing processes, end products and end-use settings.

The text is presented in five units, with Unit One having a focus on textile fundamentals. Units Two through Five are divided by end-product category. Unit Two includes discussion of upholstered furniture coverings and fillings; Unit Three focuses on window coverings, drapery linings, and textile wallcoverings; Unit Four covers soft floorcoverings and cushions; and Unit Five presents material on both functional and decorative bath and bedding textiles used in residential and commercial settings.

In larger institutions with extensive offerings, *Textiles for Residential and Commercial Interiors* is appropriate for a course to follow completion of introductory textiles and interior design courses. It can be used in either textiles or interior design departments. In smaller institutions where course offerings may be more limited, the text would be useful in an introductory course with an expansive scope (e.g., apparel textiles and interior textiles, or housing and interior textiles). The book's organization permits the selection of units or chapters dealing with topics in the order preferred by the instructor.

Instructor Resources

An Instructor's Guide and PowerPoint presentations for each chapter accompany the text to assist in planning, presenting, and evaluating content found in the text and in the STUDIO.

Textiles for Residential and Commercial Interiors STUDIO™

Fairchild Books has a long history of excellence in textbook publishing for design education. Our new online STUDIOs are specially developed to complement this book with rich media ancillaries that students can adapt to their visual learning styles. *Textiles for Residential and Commercial Interiors* STUDIO features online self-quizzes with scored results and personalized study tips, and flashcards with terms and definitions, to help students master concepts and improve grades. STUDIO access cards are offered free with new book purchases and also sold separately through www.fairchildbooks.com.

ACKNOWLEDGMENTS

We are pleased to have been asked to participate in the well-established franchise of *Textiles for Residential and Commercial Interiors.* For several decades, this book, in its previous four editions, has been a fixture in the educational protocol for many interior designers and textile professionals. We are both industry professionals who also teach college courses in our field and care deeply about contributing to the knowledge and professionalism of our future colleagues. We appreciate the opportunity to build on that goal through this platform.

First and foremost, thank you to all our friends and colleagues, both companies and individuals, who shared images, illustrations, and information so that we could make *Textiles for Residential and Commercial Interiors*, fifth edition, attractive, informative, and accurate. Max Concra, Judy Juracek, and Jim Koch stand out as photographers who were always willing to help us fill in missing slots with beautiful images.

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Last but not least, we would like to acknowledge each other. Partnerships are not always easy; writing books is definitely a trial. We have been close friends and mutually admiring colleagues for a long time, and this project proved to be not a wedge, but a wonderful collaboration. We enjoyed the partnership—and the shared accomplishment of completion.

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UNIT ONE

THE FUNDAMENTALS OF TEXTILES FOR INTERIORS

1

The Interior Textile Industry

Facing page: Photo © Koch Studio, Inc., www.jk-gallery.com; Photo courtesy of Fabricut Fabrics, www.fabricut.com.

Fabric for interior furnishings is produced in every corner of the world. With international trade, instant electronic communication, and increasingly efficient worldwide transportation of goods, a wider range of beautiful fabrics is available, at more reasonable prices, to the consumer than at any other time in our history. The volume and diversity of choices makes a designer's job easy—in some ways. It also makes the selection process more challenging, as the aesthetic and performance features of offerings and the sheer range of availability can be overwhelming. This text aims to offer designers parameters and considerations that are critical to making wise choices and successful specifications of fabrics for interior furnishings.

Several levels and segments make up the fabric-production industry, whether the intended market is interior furnishings, apparel, or industrial application. Each operation in the manufacturing process is an equally important link in the chain of production and distribution. These mutually dependent entities, composed of many independent firms, all need reliable suppliers and all serve the ultimate customers. Furniture producers, for example, must have a supply of fillings, linings, and finished fabrics. In turn, they depend upon product designers to guide their product offerings, distributors and sales agencies to sell their product, and interior designers and architects who are willing to recommend their upholstered products to clients and retailers who then offer their products to purchasing customers.

Sharing a common goal—to operate profitably—all members of the industry work cooperatively to ensure that the **end products** offered are widely accepted by consumers. To secure this acceptance and realize their goal, suppliers, producers, and distributors often support and seek assistance from outside consultants for product development, marketing, and branding; trade associations; independent testing authorities; and other providers. While such groups are not directly involved in the manufacturing sequence, they have a major influence on quality, awareness, and selection of the industry's goods.

Although consumer acceptance or rejection of the products available primarily determines the economic health of the industry, the fabric industry is directly affected by environmental issues and economic factors, as are all other industries. Fiber and fabric executives are aware of, and respond to, many variables in order to keep their firms financially viable.

Major Segments of the Industry

Fiber Suppliers and Producers

Fabric starts with **fiber**, the chemically distinct raw material of which fabric is made. Is it cotton? Polyester? Wool? Fiber is fabricated into yarn, or sometimes, directly into fabric. Natural fiber harvesters and processors and **manufactured fiber producers** initiate the work of the fiber industry, which culminates in products used by the residential and commercial consumer.

Natural fiber suppliers recover naturally formed fibers, principally from animal fleece (such as sheep), from silk-producing caterpillars, or from plants (such as cotton bolls and flax plants). These suppliers focus on production of high yields of quality fibers while balancing the concerns of the environment, business needs, and the marketplace. Except for silk, these materials naturally occur as short lengths called **staple**. Staple fiber is combed, cleaned, and aligned to make long lengths that can be woven or knitted. The staple fiber supplier usually handles the first part of the yarn-making process, and then ships the fiber in a loose, rope-like form called **tow** to the yarn producers.

Natural man-made fiber producers utilize natural materials such as wood chips, cotton linters, bamboo, sugar beets, glass, and corn, which they process chemically to generate fibers including rayon, PLA (polylactic acid), fiberglass, and acetate.

Synthetic manufactured fiber producers manufacture acrylic, nylon, polyester, polypropylene (olefin), and PVC (polyvinyl chloride, also known as vinyon) from synthetic polymers derived from petroleum. Synthetic fiber is extruded from a liquid (much like toothpaste from a tube) into a continuous length, which is referred to as **continuous filament** form.

Filaments also may be cut, texturized, brushed, and combed to simulate staple form for aesthetics, in order to more closely mimic natural fibers. Silk naturally occurs as a filament, other than bits of scrap silk fiber, which are typically handled as staple and are used for spinning.

Yarn Producers

Yarn producers combine fibers into usable yarn structures. **Spinners** align, spin, and twist staple-length fibers into spun yarns, and **synthetic yarn producers** combine filament-length fibers into untwisted or twisted multi-filament yarns, and add texture to the filament yarns. Yarn producers frequently employ multiple twisting or plying operations to expand the assortment of yarns available to fabric manufacturers.

Fabric Manufacturers

Fabric manufacturers use **weaving**, **knitting**, **knotting and twisting**, **braiding**, and **tufting** to form fabric structures from yarns. Others use **felting**, **spunbonding**, and **needle punching** to produce **nonwovens**, which are fabrics made directly from fiber, bypassing a need for yarn. They extrude polymer to produce **film**—or sheeting made directly from solutions—bypassing both fiber and yarn stages, thereby functioning as the fabric manufacturer.

Fabric producers and textile machinery engineers work cooperatively to develop new equipment and devise more efficient fabrication techniques, continually striving to fulfill two major goals. First, they work to engineer fabric structures that will be appealing to and perform satisfactorily for the consumer. Second, they strive to operate as efficiently as possible. Manufacturers are profitable when they work efficiently and produce desirable products at appropriate prices.

Dyers, Printers, and Finishers

Dye, which chemically bonds with fiber to change its color, can be incorporated before the fabric is made. Manufactured fiber producers may incorporate dye pigments within filaments as they are extruded (**solution-dyed**); dyers may immerse fibers (**stock-dyed**) or yarns (**yarn-dyed**) in a solution of dyestuff.

Some fabrics that are dyed using one of these three methods are ready to go to the consumer once they are woven, but other fabrics require extra processes, or **finishes**, to achieve the final result that professionals and consumers want. Additionally, some fabrics will have color applied after the fabric is woven, either through **piece-dyeing** (the entire bolt of fabric is immersed in a dye bath) or through **printing** (dye is applied only to certain areas of the surface of the fabric). Before such unfinished fabrics are dyed or printed, they are called **greige goods**. Piece-dyed fabrics and most printed fabrics need to be finished—at the least washed, dried, pressed—before they are usable.

In addition to performing simple processes like washing and drying fabric, **finishers** apply mechanical and chemical treatments to alter a cloth's appearance. For example, pile-yarn orientation and luster can be adjusted. Performance characteristics such as water- and soil-repellency, wrinkle recovery, and shape retention can be improved. By applying coatings and laminating other fabrics to the backs of carpet and to fabric wallcoverings, finishers can improve the functional characteristics and stability of these structures and facilitate their efficient installation.

It should be noted that fabric production is a **vertical** process. Producing and handling fiber, spinning yarns, weaving fabrics, applying color, converting greige goods, and constructing end products are all part of reaching the end-user. Though becoming more rare, some producers, called **vertical manufacturers**, undertake several of these processes. For example, dyers, printers, and finishers may all be parts of one company, or may be completely separate, or may also be part of a fiber, yarn, or fabric manufacturer. They may be an independent operation that simply performs a service to another operation, not ever taking ownership of the material. Whether performed under one roof or several, many steps and teams of collaborators are needed to make every fabric.

Converters and Distributors

Converters take ownership of fabric that is unfinished, add value to it, for example, by having it dyed or printed, and then resell it. These companies employ designers who create original designs and signature collections. They may also commit to large runs of fabric from mills and resell the fabric in smaller lots, usually by the **piece** (approximately 60 yards/meters). Converters do not generally cut-to-order for small quantity sales. Converters

sell to furniture manufacturers and wholesalers/distributors, functioning as a mill does. They may also act as a distributor to segments of the industry that purchase in large quantities, such as the hospitality segment.

Distributors, commonly called wholesalers, or jobbers, are the main suppliers to the interior designer and architect marketplace. Distributors work with mills all over the world to develop products that create a brand identity for the wholesaler, and conform to their clients' aesthetic preferences, serviceability requirements, and budgets. The distributors adopt these fabrics into their own lines and sell them under their own labels. These companies maintain showrooms in major design centers, produce marketing material such as brochures, advertisements, and samples, and retain a large sales staff who visit designers in their offices to show the latest product offerings. A designer may order the fabric from the distributor and resell it to a customer, or the professional may **specify** the fabric and have the customer (the end-user) purchase the fabric. Also, a firm that makes furniture, fabricates window coverings, or installs wallcoverings may purchase the material and then invoice the end-user for the finished, or installed, product. (The term *end-user* is commonly used to describe a corporate purchaser, while *consumer* refers to a retail customer.) Although distributors do not manufacture fabric, they often present themselves as "**mills**." This is a term-of-art in the industry as shorthand to the designer/specifier/customer.

Especially in small cities and remote areas, an upholstery or drapery workroom, a wallcovering installer, or an interior designer may maintain a product showroom. These businesses are often geared to the trade (to professional interior designers and architects) and also sell to retail consumers. Designers receive a **trade discount** off the price sold to retail customers.

In decades gone by, the best sources were available only to the trade. Increasingly, designers and consumers alike have a vast array of available interior products, through multiple channels. The quality and diversity of retail products at affordable prices and the general public's increasingly high level of aesthetic intelligence challenges today's interior designer to hone marketing skills, professional practices, and to offer a high level of expertise.

Fabric Designers, Colorists, and Creative Directors

Every stage in the sequence of making fabric necessitates aesthetic choices. Fabric designers are responsible for ensuring that the company's line is ready, on time, in the proper form, starting from a scrap of yarn, a few colors (Figure 1.1), and some ideas, all the way to having samples ready to ship on the date of the product's release.

Well in advance of production, **fabric designers** identify and forecast the aesthetic features preferred by current and future consumers. By studying sales reports, company records, and the general market patterns, they remain alert for slight shifts in the selection of fashion-related qualities such as color, fabric weight, textural characteristics, and drapability. Designers tally the relative popularity of woven patterns and printed patterns; simple or elaborate design motifs; small-scale or large-scale patterns; and fiber, yarn, and fabric color

Figure 1.1 Designers research future color trends. Photo courtesy Color Association of the United States, www.colorassociation.com.

choices. They interpret and forecast trends and anticipate variations and evolution of the ideas, while considering suitability for production operations.

Additionally, each fabric must meet requirements and expectations for quality, price, performance, suitability for being produced efficiently, and environmental impact. To these ends, designers work closely with all operations, whether outside vendors or in-house production, in order to engineer the best possible qualities through yarn choices, structural development, and finishing.

Fabric designers may focus on structure (weave, knit, how the fabric is made), surface pattern, or color, or in several areas of the process. **Design directors**, or **creative directors**, manage the entire creative team. **Colorists** are designers who specialize in color development of patterns in process, but the term can also describe personnel of dyers who develop dye formulas and match colors.

In some market segments, design personnel are termed **stylists**, which can carry a variety of job descriptions. A stylist may be a creative director in some companies, or someone who arranges displays for photo-shoots, or one who merchandises, purchasing products from a variety of sources to build a product line. European designers, merchandisers, and wholesaler/distributors are often referred to as **editors**.

End-Product Producers and Market Segments

End-product producers fabricate and construct items that are ready for immediate use or for installation in an interior setting. Fibers, yarns, and finished fabrics are among the many materials used to make upholstered furniture, drapery and window treatments, wallcoverings, carpet and padding, and household and institutional textiles.

Some interior products are specifically produced for use in privately owned (**residential**) interiors. Other products are specifically designed and constructed to withstand the higher levels of anticipated use in public (**contract**) interiors—offices; hospitals and other medical facilities, including nursing homes and other long-term care facilities (healthcare); hotels, motels, and restaurants (hospitality); schools, colleges, and dormitories (education); stores and shopping centers (retail); libraries and public buildings; religious buildings; high-traffic public spaces (such as airport terminals); and theaters.

The upholstered furniture market includes chairs, sofas, ottomans, and the like, each covered by a fabric, vinyl, or leather; most have a combination of fiber, foam, or feather filling. Window coverings range from sheer curtains to blinds and shades containing grasses or metal slats. Wallcovering offerings range from elegant moiré taffetas to rough burlap cloths made of jute, vinyls, and high-performance woven fabrics. Floorcoverings range from scatter rugs to wall-to-wall carpet to exquisite Turkish or Persian rugs. Carpet backing can be jute or olefin, and rug padding may be animal hair, rubber, or polyurethane.

Household textiles (**domestics**) used in residential interiors include beddings, towels, and tabletop accessories; similar such products designed for use in hospitality or healthcare facilities are referred to as **institutional textiles**, which are required to conform with performance criteria and life-safety codes.

Among the assortment of products included in each of these categories, fiber content, yarn features, fabric structure, color styling, finishes, and product design differ. In most cases, fabric and **end-product designers** work cooperatively with producers and marketing specialists to plan necessary combinations that meet a variety of consumer desires and that conform with specific requirements set by the design professional and agency with jurisdiction over a given installation.

At every level, producers must continually refine products and develop new and unique items. They must offer design, composition, and performance characteristics that spark enthusiasm from interior designers, architects, end-users, and consumers.

Design Professionals

Design professionals, who are primarily licensed, registered, or certified interior designers and architects, select fabrics for many categories of installation, as previously discussed. Professional interior designers have endeavored to require that designers be licensed, registered, or certified by passing, for example, the National Council

for Interior Design Qualification (NCIDQ) examination. Design professionals may operate their own firms, partnerships, or be employed by independent firms, schools, banks, or many sorts of large corporations. They normally provide services in accordance with the terms of a contractual agreement made with their clients. Most importantly, contracts establish legal responsibility between client and design professional.

Interior designers and architects serve as critical links between the industry and end-users and consumers. These professionals have a positive economic effect on the industry by selecting new products and by recommending and specifying products that are consistent with their clients' selection criteria. To do their jobs well, they must be familiar with the industry's array of products in order to assess the anticipated aesthetics and performance features needed for specific end-use conditions. Distributors' representatives play a critical role in providing information to the designer and architect who are specifying products. Designers and architects must be aware of codes governing the selection and installation of products in a facility or in a particular location within a facility. Ultimately, the accuracy with which interior designers and architects recommend or specify products helps determine their professional reputations and that of their suppliers. Customers will ultimately return to the designer, and to the product suppliers, only if they are satisfied with completed jobs.

Consumers and End-Users

The **consumer** or end-user pays for the end product; thus, the consumer may be a person, a group, a corporation, an agency, or an institution. Consumers may prefer to use their own talents and judgment when selecting products, or they may elect to contract for the services of an interior designer or architect for this task. In the latter case, functioning as consultants, the professionals select, recommend, or specify products; their clients, who pay for the merchandise, are the consumers.

An end-user is, likewise, the party that pays for, and uses, the product, but, as previously noted, the term **end-user** is also specifically used to refer to corporate purchasers. For example, a hotel chain, a large corporation, or a hospital may be the purchaser and end-user, and is a corporate entity rather than an individual.

Selecting Interior Textiles

In most cases, the residential or commercial consumer determines the relative importance of several fabric attributes, personally deciding which compromises can be made. For certain commercial products, however, the fabric is expected to meet specific product standards, and, in some cases, compliance with certain regulations and building codes is required.

Challenges to Design Professionals and Consumers

In order to provide the best solution for the function and aesthetics of the interior, consumers and design professionals, such as interior designers and architects, should be informed when making their interior textile product selections. They must, for example, consider the factors affecting the apparent color of textiles to ensure that the color characteristics chosen will look the same when seen in the interior setting. A basic understanding of fiber properties, yarn and fabric features, factors affecting color retention, and finishing treatments is helpful. The designer should consider the environment where the fabric will be installed and any unusual needs the fabric will need to fill, as well as the maintenance that will be needed. These several product and end-use variables will be discussed in detail throughout this book.

The task in design is especially challenging because residential and commercial consumers have widely varying and constantly changing aesthetic preferences and performance needs. Designers, architects, and suppliers must be knowledgeable of market trends. They must be aware of the resources available for reliable information, including trade publications, professional journals, and the Internet, and especially from valued, reputable suppliers.

When contract designers and architects are selecting interior textile products for commercial use, they must ascertain which, if any, agency has jurisdiction over the project, and they must identify all applicable codes affecting their selections. In turn, they must confirm that their planned product selections conform to all mandated selection criteria. Interior designers and architects are,

in fact, legally and ethically responsible for choosing textiles that meet all applicable industry and government standards and codes, particularly performance standards and life safety codes. It may be necessary for the design professional to educate the consumer, explaining that codes and safety requirements may preclude the choice of certain aesthetic or structural features with a textile product.

Aesthetic Considerations

Several aesthetic or sensory characteristics are considered in the selection of interior textile products (see Table 1.1). These include **design elements** such as color, line, texture, and form, and **design principles** such as emphasis, rhythm, contrast, and harmony. Although the initial visual impact of these features is a primary concern, consideration must also be given to variables such as the effects of end-use lighting on the apparent color, the availability of matching items, and the life expectancy of the fashion features.

Performance and Safety Factors

Among the selection criteria held by consumers are several variables pertaining to performance (see Figure 1.2 and Table 1.2). For some consumers, functional attributes such as indoor air quality, glare reduction, and acoustic control may be critical; for others, texture retention may be of paramount importance; and for still others, durability and wear-life may be high on the list. At the same time, many consumers are increasingly demanding fabrics that are highly stain resistant and very easy to clean. For some applications within a commercial interior, certain flame resistance codes may be mandated.

Maintenance Considerations

Products are selected for their appropriateness for an environment, as well as for the enjoyment they will provide during their expected use-life. The most common reasons that an end-user replaces fabric is that the current item in use has become dirty. Moreover, the

TABLE 1.1
AESTHETIC PRODUCT SELECTION CRITERIA: SOME EXAMPLES

	Variable Characteristics
Design Elements	Form: 3D form of upholstered furniture, pillows
	Color characteristics: hue, value, and intensity
	Texture: smooth or rough resulting from the fiber, yarn, or fabric structure or from an applied finish
	Pattern: detail, size, and repetition of motifs
	Light: level of reflectance, level of transmittance
Design Principles	Scale: size of motifs, fullness of window coverings
	Emphasis: dominant visual characteristic
	Rhythm: repetition of elements
	Contrast: differentiates items in the visual field
	Harmony: pleasing arrangement of parts
Styling Features	Color styling: heather, multicolored, solid-colored
	Texture styling: nonpile, cut pile, uncut pile, level, multilevel
	Hand: warm, cool, smooth, rough, soft, harsh
	Drapability: fluid, stiff
	End-product styling: trimmed, plain, traditional, contemporary
	Availability of matching and/or coordinated items
	Coordination with existing interior and current furnishings
	Life expectancy of fashion features

Figure 1.2 Color development tools. Photo courtesy Color Association of the United States, www.colorassociation.com.

most common complaints that suppliers hear about field failures (when the fabric no longer looks good) turn out to be that the fabric is dirty, or that it was improperly cleaned. Therefore, the type and level of maintenance required is a critical aspect of a satisfactory specification or selection. Proper maintenance of textiles affects their serviceability, in terms of appearance retention, wear, durability, and safety. Dirt that is not removed from carpet, for example, will facilitate an abrasive action between traffic and the carpet fibers, as well as affect the apparent color. Concomitantly, the aesthetic value of the floorcovering will be diminished.

Both the end-user and design professional should be aware of proper maintenance, including the cleaning agents and equipment needed (Table 1.3). Maintenance procedures should be examined prior to installation to determine that the practices are both feasible and affordable. With commercial installations, interviews with the maintenance personnel are helpful in determining any deficiencies in equipment. Insufficient or incorrect maintenance may lead to premature replacement of a product and greatly add to the long-term cost. Careful consideration should be given to the selection of nontoxic cleaning products that contribute to improved indoor air quality and that do not require dumping contaminants or chemicals into the wastewater system. Together with the cost of utilities, the energy efficiency of a product will result in long-term savings or long-term expense.

Cost and Installation Factors

Product costs for a given project may be categorized by **initial cost** and **life-cycle cost**. Initial cost starts with the cost of the product, as well as the cost incurred for installation, including site preparation, labor, and any accessories that are needed (see Table 1.4). A detailed **project bid** provides prices for each of the products chosen, together with the installation charges, thus

TABLE 1.2
PERFORMANCE AND SAFETY PRODUCT SELECTION CRITERIA: SOME EXAMPLES

	Variable Characteristics
Functional Properties	Insulation, glare reduction, static reduction, fatigue reduction, acoustic control, mobility improvements, safety enhancement
Appearance Retention	Color retention, texture retention, resistance to pilling and snagging, soil hiding, soil repellency, soil shedding, soil release
Durability and Wear-Life	Resistance to tear and surface disturbance, dimensional stability, fuzzing, fiber loss, repairability, warranty availability
Structural Stability	Tuft bind strength, delamination strength, stability of yarn twist
Flame Resistance	Natural characteristics, chemically manipulated in fiber state ("inherent") or in yarn/fiber state ("applied"), treatment durable to cleaning
Design and Performance Mandates	Flame resistance, indoor air quality, structural stability, colorfastness, wear resistance, functional properties (acoustical value, static reduction)

TABLE 1.3
MAINTENANCE PRODUCT SELECTION CRITERIA: SOME EXAMPLES

	Variable Characteristics
Cleanability	Washable, dry-cleanable, need for vacuuming, need for brushing, ease of stain removal, appearance after cleaning
Cleaning Location	On-site versus off-site cleaning
Level of Ironing Required	None, touch-up, extensive
Frequency of Cleaning	Daily, weekly, monthly
Cleaning Products Required	Toxic, biodegradable, readily available

enabling the client and designer to determine affordability of the project. If necessary, the project can usually be completed in phases.

Life-cycle cost is comprehensive and is listed in a formal **project specification**. Consideration is given to several factors, including the initial cost, installation expenses, ongoing maintenance costs, and the anticipated life-span of the product. With life-span in mind, the initial costs may be amortized; for example, an expensive textile product that is expected to be serviceable for ten years could, in fact, be less costly than one whose initial cost was less but whose life expectancy was shorter.

Challenges to the Industry

As in any industry, interior products businesses must offer desirable product to their customers in order to generate the necessary volume of sales to support cash flow, cover their operating expenses, pay their suppliers, and realize an adequate profit. End-product producers and fabricators will not survive without a flow of viable fabric and fiber supply. Likewise, reductions in end-product sales result in reductions in the quantity of fiber, yarn, and finished fabric needed, and thereby threaten the financial stability of upstream firms. Moreover, low profit margins limit the ability of firms at all level to expand and develop new product.

To remain profitable, firms in the industry must constantly monitor consumer selections and quickly respond to changes in consumer preferences. Products must offer desirable aesthetic features, meet any mandated design and performance specs, and be functional within available maintenance and service guidelines. Additionally, installation procedures must be practical, and the price of the product, along with any charges for assembly, delivery, and installation, must not exceed the ability or willingness of the consumer to pay.

TABLE 1.4
COST AND INSTALLATION PRODUCT SELECTION CRITERIA: SOME EXAMPLES

	Variable Characteristics
Initial Cost	Product price, accessories prices, fees for design professional, delivery charges, installation charges
Life-Cycle Cost	Maintenance costs, including equipment, cleaning agents, and labor Warranty costs, insurance costs Energy costs Interest charges Disposal
Installation Factors	Site preparation Labor, tools, and level of skill needed; permanence: movable, removable, permanent

Economic Factors Affecting the Industry

All businesses must cope with the variable economic climate. When consumers' wages are high and unemployment is low, business for discretionary spending on items such as furniture or carpet is obviously more robust than when consumers are missing paychecks. Likewise, furnishing purchases increase during cycles of robust commercial and residential building. The cost and availability of components impact pricing and sales opportunities, as do the number and success of competitors. Rising costs of labor and workers' compensation; maintaining appropriate working conditions; surviving shifts in cost of goods, equipment, utilities, and in transportation; and changing tastes of customers create unpredictability and challenges for every enterprise.

Challenges to Fiber and Fabric Producers

Fiber and fabric producers face additional financial and environmental hurdles that would not be of direct concern to, say, a retail business. Growers and producers of natural materials are at the mercy of weather, pests, and plant and animal diseases. Commodity markets dictate raw material costs and availability. Fabric manufacturers must respond to environmental concerns such as water pollution and consumption, avoid pesticide and fertilizer runoff into water supplies and depletion of nonrenewable resources (such as oil), utilize renewable resources, and create and utilize recycling opportunities for their products. Animal-fiber suppliers must use humane treatment for the fiber-producing animals in their care.

Imports and Tariffs

As previously mentioned, fabrics are produced all over the world. Manufacturers in specific countries and areas specialize in particular types of fabrics or techniques. Often, the component parts of a fabric—from the fiber to the dyestuff to the weaving—are sourced from many countries. The United States' fabric-making capabilities have been increasingly diminishing for many decades; labor is in short supply and expensive for factory jobs. But low tariffs and strong currency have led to offerings of diverse product in both high-priced and volume interiors markets. American manufacturers import yarn and machinery, and export interior furnishing fabrics to many countries. Prices and availability of materials and labor at all points along the supply chain impact the end product.

Government Regulations and Consumer Protection

Businesses must also satisfy national and regional governmental requirements, put in place to protect the environment and the health and safety of the populace from overzealous business practices. Companies must pass the costs incurred on to consumers. These protections dictate working conditions, compensation restrictions, waste disposal, and environmental protection, among other issues. For example, in the United States and Europe, textile producers are legally required to minimize utilization of water and purify what is used before returning it to the environment. In most of Asia this is not required, thereby reducing manufacturing costs in those areas.

Associate Members of the Industry

Trade associations, publishers, advertising and public relations firms, and service organizations provide valuable assistance to the interior furnishings industry. Some are for-profit and others nonprofit; in either case, to be viable, they must be profitable for themselves and for the industry. Many of these firms focus on education and dissemination of news related to the industry.

Publishers

Writers and publishers provide members of the industry, students, educators, practicing professionals, retailers, and consumers with a wide assortment of books, websites, newsfeeds, print and online magazines, and technical journals that focus on products for and other developments relevant to interiors. Some of these publications are for the professional preparation of students; some apprise industry professionals of new techniques, new products, research findings, marketing plans, and consumer preferences; some exist to inform the consumer.

Media exposure of styles, materials, and decorating trends, as seen in print, television, and cyberspace, impacts the demand for goods and services provided by the fabric industry. Although magazines related to the decorative arts have been around since the early twentieth century, especially since the advent of online publications a proliferation of material directed toward the consuming public has flooded the market. Magazines targeting specific styles, regions of the country, socioeconomic levels, housing types, materials, and even well-known personalities have raised the consumer's aesthetic awareness and expectations.

Television has brought building and furnishing products into even more homes. The popularity of television programming about home construction, remodeling, and decorating has increased rapidly, resulting in the introduction of entire television networks devoted to home decor, gardening, and lifestyle.

Trend Services

Various color and trend forecasters offer color and trend information via presentations, conferences, online services, access to reference material, and actual samples of color and material. Color Association of the United States (CAUS), Color Marketing Group (CMG), Trend Union, Pantone, WGSN, and Fashion Snoops are a few examples.

Advertising and Public Relation Firms

Industry members use advertising firms and advertisements to promote their brands and corporate identity. They utilize the media to introduce and promote new products, new equipment, and new materials. Upstream firms direct their advertisements to downstream firms and to end-users and consumers; end-product producers direct their advertisements to members of the trade, to retailers, and to consumers; retailers direct their advertisements to retail consumers. In some cases, the cost of a promotional campaign is shared; for instance, a fiber producer shoulders a portion of the charges assessed for promotions run by an end-product manufacturer.

Service Organizations for Maintenance

In contrast to promoting the sales or improving the safety of a fabric product, some organizations focus on the efficient, proper, and economical maintenance of the goods. The Association for Linen Management (ALM), for example, has members in textile care and environmental services (e.g., hospitals, nursing homes, educational institutions, hotels, motels, and so on), and it also has member businesses such as chemical manufacturers and textile manufacturers. The Dry Cleaning and Laundry Institute International provides education, research, legislative representation, and industry-specific information to its members on dry-cleaning and care procedures related to dry-cleaning.

Trade Associations

Trade associations are organized to represent, protect, and promote the interests of their members, who provide financial support for the operation and activities of the association. Trade associations in this field usually have very few paid personnel, and most of their work is done by volunteers from the associations' member firms. The personnel establish liaisons between their members and various federal and state agencies and often lobby legislative bodies. They maintain websites that offer detailed educational material and technical literature. They devise marketing programs and conferences that increase the recognition and acceptance of their members' products. Some associations even maintain testing laboratories to evaluate and certify the quality of these products.

Some trade associations are composed of firms that compete with one another in the marketplace but also share a common goal. The American Fiber Manufacturers Association, for example, is supported by several independent firms, each of which is competing for sales orders for raw fiber. At the same time, however, these producers recognize the value of cooperating to provide information about manufactured fibers and to extend their use. Other trade associations are made up of firms belonging to different segments of the industry but having a vested interest in the marketing and widespread use of a particular category of products. The Textile Exchange, for example, operates internationally and is committed to expansion of textile sustainability.

The Carpet and Rug Institute works to increase the use of soft floorcoverings, Cotton Incorporated strives to increase the use of products containing cotton,

Australian Wool Innovation works to increase the long-term success of Australian woolgrowers, and the Business and Institutional Furniture Manufacturers Association (BIFMA) represents business and institutional furniture manufacturers.

Trade organizations often establish guidelines or standards to help their memberships' customers better understand the materials in which they specialize. For example, the Upholstered Furniture Action Council (UFAC) is made up of upholstered furniture industry firms that collaborated to establish a test that would measure an upholstered furniture's resistance to catching fire from burning cigarettes, which is the top cause of fires in the United States.

The Association for Contract Textiles (ACT) (Figure 1.3) was established to address a variety of issues related to contract fabric manufacturing and distribution of fabric for commercial building interiors. Among many other endeavors, the organization developed the ACT Voluntary Performance Guidelines to make specification easier for designers. ACT's icons on a contract fabric's marketing materials indicate that the cloth meets or exceeds these guideline requirements. (These registered certification marks are shown in Appendix B, p. 427.) Furthermore, ACT's **Facts**, based on the NSF/ANSI 336 standard, is the definitive sustainability certification program for contract fabrics (see Chapter 3).

act®

association *for* contract textiles

Figure 1.3 A service mark registered with the U.S. Patent and Trademark Office and owned by the Association of Contract Textiles, Inc. Courtesy the Association of Contract Textiles, Inc.

Interior designers form the core membership of American Society of Interior Designers (ASID) and International Interior Design Association (IIDA), organizations that strive to advance the interior design profession, primarily through education, outreach, and advocacy.

Key Terms

braiding
colorists
consumer
continuous filament
contract (commercial) interiors
converter
design director
design elements
design principles
design professional
end product
end-product designer
end-product producer
end-user
fabric designer
Facts
felting
fiber
film
finishers
finishes
filament
greige goods
initial cost
institutional textiles
knitting
knotting and twisting
life-cycle cost
manufactured fiber producer
mill
natural fiber supplier
natural man-made fiber producers
needle punching
nonwovens
piece
piece-dyeing
printing
project bid
project specification
residential interiors
solution-dyed
specify
spinner
spunbonding
staple fiber
stock-dyed
stylists
synthetic manufactured fiber producers
synthetic yarn producers
tow
trade associations
trade discount
tufting
vertical
vertical manufacturers
weaving
yarn-dyed

Review Questions

1. Identify the major segments of the interior textile industry and discuss their interconnectedness.
2. Discuss the environmental challenges that face natural fiber suppliers and manufactured fiber producers.
3. Why is it critically important that members of the industry monitor slight shifts in both the aesthetic features and the functional expectations of interior textile products?
4. Identify several interior textile products used in residential and commercial interiors. What interior textile products are used in hospitality settings, for example?
5. What challenges face design professionals in selecting and specifying interior fabrics?
6. What challenges face fabric and fiber producers, and why must they meet these challenges?
7. Discuss the consequences of offering interior textile products that do not coincide with the wants and needs of the consumer.
8. Discuss the role of interior designers and architects in choosing textiles. What legal ramifications are associated with their decisions?
9. Why would competing firms work cooperatively in a trade association?
10. Discuss the external factors that affect the economic health of the industry.

Trade Association Links

American Association of Textile Chemists and Colorists (AATCC)
http://www.aatcc.org

American Fiber Manufacturers Association (AFMA)
http://www.afma.org

American Institute of Architects (AIA)
http://www.aia.org

American Society of Interior Designers (ASID)
http://www.asid.org

American Society of Testing and Materials (ASTM)
http://www.astm.org

Association for Contract Textiles (ACT)
http://www.contracttextiles.org

Business and Institutional Furniture Manufacturers Association (BIFMA) International
http://www.bifma.org

Decorative Fabrics Association (DFA)
http://www.dfa.info

Industrial Fabrics Association International (IFAI)
http://www.ifai.com

Institute of Inspection, Cleaning, and Restoration Certification (IICRC)
http://www.iicrc.org

International Code Council (ICC)
http://www.iccsafe.org

International Interior Design Association (IIDA)
http://www.iida.org

Merchandise Mart Properties, Inc. (MMPI)
http://www.mmart.com

National Association of Decorative Fabric Distributors (NADFD)
http://www.nadfd.com

National Council of Textiles Organizations (NCTO)
http://www.ncto.org

National Fire Protection Association (NFPA)
http://www.nfpa.org

NSF International
http://www.nsf.org

International Casual Furnishings Association
https://www.icfanet.org/

Wallcovering Association
http://www.wallcoverings.org

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Fabric Performance and Evaluation

Manuel Canovas fabric courtesy of Cowtan & Tout, Inc. www.cowtan.com.

Standards, Certifications, Ratings, and Guidelines

Specifiers hear a lot about performance features, ratings, and standards for fabrics coming across their desks. Most of this data is driven by marketing efforts, in attempts to offer information that might suggest one product is better than another, or that a given product has unique features. In the process, our industry has unintentionally made performance data more muddled.

When the design-driven contract market was first evolving in the 1950s, innovative suppliers felt an imperative to convince users that the newer, more attractive fabrics they were offering would perform as well as the less-attractive, but very durable, fabrics that were then successful in the market. In the process, suppliers barraged the architect and design community with test data, standards, and ratings, with suppliers trying to outdo one another with higher test data. Specifiers began asking for higher and higher ratings, under the misconception that higher test result ratings would ensure additional protection.

Please note that very few codes or standards apply broadly to interior fabrics; the codes that do apply almost entirely apply to commercial interiors, and generally to flammability ratings, many of which are applicable only to certain states, cities, or specific types of buildings. *The simple fact is that fabrics from reputable suppliers, if used for the application of the normal use for which they are marketed, are unlikely to need additional performance assurance or extra test data.*

Furthermore, established suppliers stand behind their products. Fabric and furniture marketers offer up-front information on their products, are willing to answer endless questions, and can suggest products that are designed for a specific situation or unusual code. Manufacturers pretest their fabric to be sure it is appropriate for the intended market, and to maintain lot-to-lot quality control. They test yarns and dyestuffs to be sure the quality is maintained. By the time fabric from an established supplier crosses the specifier's desk, labeled with its intended market, it is very well vetted.

For these reasons, understanding test data on soft materials is virtually irrelevant for interior designers and architects. Nonetheless, the current climate dictates that design professionals now customarily expect performance and sustainability features to be verified. Since designers and specifiers will come across this data, it is important to highlight the differences between standards, certifications, and ratings, although its detail is of limited relevancy to the design community.

While understanding the difference between standards, codes, and ratings related to fabrics provides context for information that crosses designers' desks every day, delving into fabric test methodology and precise processes that leads to ratings on a given standard is the fabric producer's realm, and is outside the scope of a specifier's work. Additionally, specifications for standards are constantly evolving. For these two reasons, this text refers to only the most common standards, and in simple terms as to the performance feature to which each refers. Specific details for any standard can be found on the internet, or in the voluminous books of standards published by the standard-setting organizations.

Standards describe specific material performance, behaviors, and attributes. Some record the product's reaction to a specific event, such as having a cigarette left on it. Together with other informed and interested persons, many members of the textile industry participate in the work of trade associations, nonprofit, and governmental scientific and technical associations that develop standards pertaining to areas such as definitions, recommended practices (including for life cycle analysis), methods of testing, classifications, design specifications, or performance specifications. Participants in these groups share their expertise and opinions, usually on a voluntary basis, to help establish standards that are fair and meaningful. Producers throughout the industry may elect to use these standards when they evaluate their components and end products. A standard that is adopted by a governmental **regulatory agency** becomes legally binding and is called a **code**. Codes refer to the standard that was adopted in order to define the requirements for meeting the code.

Certifications are given to products, processes, and services (even entire buildings) that have met criteria based on standards. Some certifications identify safety features; others signify environmentally desirable features within single or multiple life-cycle assessment categories. Some certifications are based on evaluation of a single property or attribute, such as the release of a certain chemical, and others are based on multiple attributes

and analysis of several criteria. In particular, products that meet certification requirements are often awarded a mark or label. Certification claims by manufacturers and service providers may provide useful information, but **third-party certification** is the gold standard of evaluations, because it requires results from an impartial third-party tester that has no connection to the product or service being tested and receives no benefit from the sale or use of the product or service. Some certification agencies also develop standards.

Ratings refer to how a product, service, or method ranks based on a given scale, guidelines, or standards. For example, a higher lightfastness rating would logically be desirable for a fabric to be used outdoors compared with one that will be used indoors. Ratings are also measurements used in evaluations of a fabric's or building's sustainability attributes.

Guidelines are not codes, and are not mandated in any way, but are recommendations established by a professional organization or other entity that suggest helpful standards. A code, which is a legal mandate, is, for example, something a physician must do to legally practice medicine, whereas a guideline might be adopted by the American Medical Association, in which case physicians will probably comply as members in good standing.

Similarly, the Association for Contract Textiles (ACT) suggests that if a fabric meets or exceeds all of its Voluntary Guidelines (which reference various standards) for general contract upholstery, it should perform satisfactorily in a typical contract application for a reasonable period of time. The ACT Guidelines are highly regarded as meaningful, though they are in no way legally required, warrantied, or mandatory. They are a recommendation for satisfactory end-use performance. (See http://contracttextiles.org/performance-guidelines/.)

Standard Methods of Testing

A **standard test method** prescribes specific procedures to be followed when making a given measurement. A test method details the selection, size, number, and preparation of the test specimens; describes the test apparatus; specifies test conditions, including the controlled atmospheric conditions required; sets forth test procedures; lists the observations and calculations to be made in analyzing and reporting the test results; and is carried out in a controlled atmosphere. Test methods attempt to simulate the conditions to which materials may be subjected in actual use. Such small-scale laboratory techniques minimize the need for large-scale, long-term, and more expensive evaluation procedures so that producers can efficiently and economically check quality control, and attempt to predict their products' viability for a given end-use. In order to produce reproducible results, textile researchers and quality-control personnel must strictly adhere to all details included in a standard test method, as performance comparisons can be made only among specimens tested in a like manner. As mentioned previously, the full text of standard test methods is available online or in the publications of the entity that established the standard.

Manufacturers use standards to assure lot-to-lot continuity of their own product, and that of their own suppliers. Manufacturers may also use test results as the basis for claims that their products exhibit specific functional and use-life characteristics, and may analyze test results to determine whether or not to put their name or other identifying mark on the product label.

Suppliers provide assurance that marketed fabrics comply with stipulated specifications, and may also provide evidence of its performance on a given test. Sometimes specifiers or end-users request samples so that they may test them on their own initiative.

Organizations That Establish Standards

Among the many scientific and technical associations involved in establishing standards, only a few are of particular interest to producers and consumers of furnishing fabric. The following are some of the better-known textile-related organizations that provide standards, certification/labeling (some use their own standards, others use outside standards), and whole-building rating programs.

ISO (International Organization for Standardization, www.iso.org), based in Geneva, Switzerland, is the world's largest nongovernmental developer and publisher of international standards. ISO is composed of national standards institutes from 157 countries (one member

per country). Some member institutions are part of their countries' governments; others are from the private sector. The ISO 9000 standard, for example, attempts to define, establish, and maintain an effective quality assurance system for manufacturing and service industries, while its 14000 series of standards pertains to ways in which an organization can minimize its operation's negative impact on the environment.

ANSI (American National Standards Institute, www.ansi.org) is a private, nonprofit organization that oversees the development of voluntary standards for products, services, processes, and systems. ANSI undertakes the development of standards only when commissioned to do so by an industry group or a government agency, and accredits standards developed by organizations, government agencies, consumer groups, and businesses. ANSI and ISO work together to develop and publish American and international standards.

ASTM International (formerly the American Society for Testing and Materials, www.astm.org) is a global standards organization that develops and publishes voluntary consensus technical standards covering a wide range of products, systems, and services for any imaginable material, from fabric to metals, concrete, and acoustical board, and beyond. Standards developed at ASTM International are the work of more than 30,000 members. The Society publishes the ***Annual Book of ASTM Standards***, which consists of 72 volumes and is divided among l6 sections, with each focusing on a limited variety of materials, products, or processes. Included in each volume are all proposed, tentative, and formally adopted standards, guidelines, and performance specifications developed for use with the specific materials or processes covered.

ASTM International's 132 committees carry out its work. Each major committee is given a letter and number, followed by a general product designation. For instance, D-13 is the Committee on Textiles. Further numerical designations are used for subcommittees, for example, D-13.21 Subcommittee on Pile Floor Coverings or D-13.56 Subcommittee on Performance Standards for Textile Fabrics. Standards developed by ASTM International committees are described as **full-consensus** standards; that is, ASTM International members and nonmembers who have an interest in a standard or who would be affected by its application are encouraged to participate in the development of the standard. Each committee and subcommittee has the participation of both producers and users of the products in question, to ensure a balanced representation of all biases and opinions.

Most of the physical property standards to which the ACT Guidelines refer are ASTM standards. For example, pilling, breaking strength, abrasion resistance, and seam slippage are commonly measured with ASTM standards, and ASTM E84 offers a standard for one of the most common flammability tests (used primarily in direct-glue wallcoverings). Environmentally related ASTM standards relate to various aspects of building systems, though not to interior materials.

AATCC (American Association of Textile Chemists and Colorists, www.aatcc.org), along with ASTM, has established the most frequently cited standards relevant to interior fabrics. Founded in 1921, AATCC is an international technical and scientific nonprofit society that establishes standard methods of testing dyed and chemically treated fibers and fabrics. Fabric makers, dyers, and dyestuff manufacturers use AATCC standards to measure and evaluate colorfastness—to light, washing, shrinkage, water resistance, flammability, and other exposures. AATCC does not set standard performance specifications, but producers and retailers use the test methods to help predict performance of fabrics' colorfastness.

AATCC maintains a technical center that serves as a test demonstration and training center and laboratory equipped with all of the testing apparatus used in AATCC test methods. The organization publishes the ***AATCC Technical Manual***, which includes all of its standard test methods, and a monthly journal, the ***AATCC Review***, which covers recent developments in dyeing, finishing, equipment, and current research in the field of textiles.

Revisions of Standards

As mentioned, standards are revised periodically. An organization's publication will list the year of original adoption or of the last revision of every standard, along with the year of the last re-approval. The latest edition of a standard is used in quality-control and research activities.

Standards developed by one scientific association are often shared with, and cross-listed by, other associations. For example, several ASTM flammability tests are cross-referenced by the NFPA (National Fire Protection Association.) Cross-listing may indicate widespread acceptance of a standard, but it does not change its voluntary status. Only when adopted by a government agency does a standard become mandatory.

Codes

Codes are governmental regulations; that is, they are mandatory practices and performance specifications. Code writers and champions aim to assure the safety and well-being of the general population. Codes are laws—or regulations—enacted by federal, state, and local governments. Individual jurisdictions may write their own laws or rely on the work of government agencies or on model building codes. Frequently, a regulatory agency will adopt a **standard performance specification** as a code, in effect turning a recommendation into a requirement. Several state-level fire marshals' offices, for example, have adopted selected NFPA standards as code.

Because codes are legally dictated, the design professional is legally responsible for selecting products that comply with all applicable codes. This is a fairly straightforward requirement, since quality suppliers are also liable for claims that they make about the features of a product that they market.

Facilities and installations usually follow consistent requirements. For example, requirements for a health-care facility, corporate office, or a residence rarely deviate from the standard for its category. However, any end-user can decide to require a particular code that is not typically mandated. Designers must check with the architects/code compliance expert on every job to determine relevant requirements, and with suppliers to assure that all specified materials meet or exceed the customer's needs.

Building Codes and Regulations

In an effort to protect citizens, local, state, and national governments adopt standards into law. For example, building codes specify standards for plumbing design, mechanical features, quantity of sprinklers needed for fire safety, and many other requirements. Each state, city, or county could have different codes, which makes an architect, builder, or engineer's job very complicated. In an effort to establish some uniformity from region to region, several organizations establish **model codes**. That is, they develop a list of standards set by the organizations previously discussed, and they lobby to have the model code adopted, perhaps with slight variations, in many jurisdictions.

Organizations That Establish Model Building Codes

Of codes that apply to interiors, the International Code Council and the National Fire Protection Association have developed those that are most widely used in the United States. The relevant codes for soft materials focus on fire safety.

In 1994, the three regional model codes organizations joined forces to create the **International Code Council (ICC)**. The U.S. government has no national building codes, but the goal of the ICC is to develop a single, nationally recognized, coordinated set of codes that address all aspects of building construction. The ICC is also responsible for updating (on a three-year cycle) and publishing these international codes, or I-codes. (Although they are called *international* codes, they are the most widely used set of model building codes in the United States.) States, counties, or city governments adopt and then modify the adopted codes to better serve their communities, and are responsible for enforcing the building codes within their jurisdictions.

ICC's **International Building Code (IBC)** has been adopted and is used as a base code standard throughout the United States. Individual states' building codes are typically listed as IBC, with the year of the version in use, and with a suffix connoting the state's specific amendments. The ICC's **International Energy Conservation Code (IECC)** addresses the design of energy-efficient buildings and their mechanical, lighting, and power systems. Generally speaking, these codes relate to the building envelope (mechanical and electrical systems, window ratings, insulation) and not to fabric and interior furnishings.

The **National Fire Protection Association (NFPA)** is an international nonprofit organization established in

1896. Through the creation of over 300 consensus codes and standards, and through research, training, and education, the association strives to decrease the potential for the development of, and devastation from, fires. Most of the fire safety codes utilized in the interiors market are based on NFPA standards.

Regulatory Agencies

In certain circumstances, **governmental regulatory agencies** have the power to oversee the selection of interior products. Some cities have stringent flammability mandates, and virtually all states have established criteria related to the flammability of products used in commercial interiors. Again, meeting these requirements is a simple matter, because suppliers for these markets are well aware of the requirements and market their products accordingly. Nonetheless, jurisdictions, responsibilities, and mandates of all regulatory agencies change frequently. Interior designers and architects must verify current jurisdictions and requirements.

The following federal agencies proscribe requirements for fabric and surface materials in limited facilities. These generally endorse the normal requirements for the type of facility and therefore do not generally necessitate special attention. Currently, federal agencies are under extreme revision and realignment. Regulations are being abolished and revised at an astounding rate. Current status is best evaluated on each agency's website.

- FHA (**Federal Housing Administration**), a division of Department of Housing and Urban Development (HUD)
  - Jurisdiction: public areas of public housing project interiors, some structures insured by FHA
  - Use of Materials Bulletin 44d stipulates carpet specifications
- **Social Security Administration (SSA),** a division of Department of Health and Human Services
  - Jurisdiction: fire safety and acoustics regulations for hospitals and extended-care facilities that receive reimbursement from Medicaid and Medicare
- **General Services Administration (GSA)**
  - Jurisdiction: all federal facilities
  - Government facilities select from GSA preapproved products
  - Has its own body of test specifications
- **Federal Aviation Administration (FAA) and National Highway Traffic Safety Administration (NHTSA),** divisions of Department of Transportation (DOT)
  - Jurisdiction: commercial airplanes and automobiles, respectively
  - Regarding fabric and furnishings, mainly pertains to fire safety regulations
- **Consumer Product Safety Commission (CPSC)**
  - Jurisdiction: consumer products
  - Prohibits initial introduction of highly flammable products so as to prevent selection
  - Does not set standards for product selection
  - Currently working on a furniture flammability standard

Key Terms

AATCC Review
AATCC Technical Manual
American Association of Textile Chemists and Colorists (AATCC)
American National Standards Institute (ANSI)
Annual Book of ASTM Standards
ASTM International
certifications
codes
Consumer Product Safety Commission (CPSC)
Federal Aviation Administration (FAA)
Federal Housing Administration (FHA)
full-consensus standards
General Services Administration (GSA)
governmental regulatory agencies
International Building Code (IBC)
International Code Council (ICC)
International Energy Conservation Code (IECC)
International Organization for Standardization (ISO)
model codes
National Fire Protection Association (NFPA)
National Highway Traffic Safety Administration (NHTSA)
ratings
regulatory agency
Social Security Administration (SSA)
standard performance specification
standard test method
standards
third-party certification

Review Questions

1. What purposes do standard performance specifications have for manufacturers?
2. Distinguish between standard methods of testing and standard performance specifications, and between standards and codes.
3. What is a certification? A third-party certification?
4. Name some organizations that establish standards, and explain how they work. Explain the meaning of *full-consensus* standards.
5. Characterize the work (that pertains to interior furnishings) of such regulatory agencies as the EPA, the FAA, and the CPSC.
6. Explain how organizations that develop test methods for evaluating textiles function.
7. What are model building codes?

3

Fabric and Sustainability

Photo © Koch Studio, Inc., www.jk-gallery.com.

Consumers and professionals in many industries are increasingly conscious of environmental concerns; with awareness, consumers and manufacturers alike are voluntarily reducing the consumption of components and finished goods, reusing materials, and recycling resources. Most consumers are accustomed to recycling common materials such as glass, plastic, paper, and consumer electronics. Awareness of the environmental impact of human action is at an all-time high.

The American fabric industry, which has routinely exceeded governmental regulations and guidelines related to health, safety, and resources, has much to be proud of in prioritizing and protecting our environment; for example, heavy metals that are used in massive quantities in electronics were eliminated from fabric manufacturing decades ago. Fiber producers have been successfully recycling post-consumer product—such as drink bottles becoming yarn—for over two decades. Carpet producers, leaders in reclamation of their product at the end of its normal life, continually evolve new ways to recycle the material and use manufacturing byproducts. (One example: shredded carpet fibers used in a concrete mixture for reinforcement.) Preserving available raw materials and eliminating landfill waste is a major, industry-wide, and industry-driven goal.

Nonetheless, consumers and textile industry professionals are seeking additional ways to reduce the consumption of raw materials and processing agents, to recycle existing products into a second product, and to reuse existing products in alternative ways. More manufacturers have, for example, increased their use of recycled materials for product packaging. In the industry, every aspect of production and processing is frequently evaluated and refined, from minimizing or eliminating pesticides in the growing of natural fibers and improving treatment of fleece-producing animals, to the recycling of plastic for fiber conversion. Some practices are industry-wide and some are quality practices developed by individual companies. Numerous companies have made sustainable practices the focus of their missions.

Sustainability

Many products are advertised as being "green, "sustainable," or "environmentally friendly" in order to attract environmentally conscious consumers. What do these terms mean, anyway?

Sustainability requires that three pillars—the environment, social, and economic facets of a product or process—are all in good order so that our biological systems are able to remain diverse and productive indefinitely. "Environmentally friendly" is a casual term; for example, pesticide-free crops are less harmful to the environment than are pesticide-laden crops, but the overall question of sustainable farming is not addressed simply by eschewing insecticides. "Green" colloquially characterizes an action, or a product that results from an action, that reduces environmental impact.

The goal of environmentally sensitive manufacturing is to create a **cradle-to-cradle**, or *closed-loop*, system, in which all materials are reclaimed and reused. A closed-loop system is currently perceived to be the highest bar, rarely attainable with current systems, and therefore **cradle-to-grave** is more than likely the assessment used to evaluate how an item or method affects the environment throughout its life, from the time of creation to disposal. With closed-loop as the goal, manufacturers, consumers, regulators, and trade organizations strive to create environmentally preferable products and services.

Environmentally Focused Design Considerations

International Environmental Awareness

In order to make sensitive product decisions with regard to environmental concerns, a specifier or purchaser must consider that the manufacturing cultures of countries varies considerably. Some countries have rules and regulations about water use and waste water disposal, use of carcinogenic and hazardous materials in manufacturing, treatment of workers, and the like. Other cultures and countries do not prioritize these factors in their manufacturing.

This section focuses on the issues at stake, and on U.S. governmental structure and regulations. However, most product offered to the interiors market is made abroad. EU nations, largely, have an admirable record in environmental concerns and regulations; some are more rigorous than those of the United States. Many Asian

manufacturers do not prioritize conservation-minded natural resource use, although this is rapidly changing. Therefore, when making a product selection, a critical issue related to environmental impact is to understand the maker's standards, and whether they were met or exceeded.

Finishes and Aftertreatments

Fabrics are often treated with flame retardant, antimicrobial, and stain resistant agents, as well as with other compounds for a wide variety of aesthetic and functional purposes. Natural fibers, even those that are organically grown, may have chemicals applied during cleaning, and for conveniences such as mothproofing and stain resistance. Some of the chemicals that provide these added performance features are considered possible carcinogens and toxic to varying degrees. Consequently, push-back and controversy surrounds their use in fabrics, but the finishes, and the performance features they provide, are nonetheless in demand. Furthermore, certain finishes may limit or inhibit recyclability or reuse of the material.

Indoor Air Quality

Some finishes, and the material itself, may emit toxic fumes, which reduce **indoor air quality (IAQ)**. With regard to cleaning agents, water-based products offer lower toxicity than do petroleum-based products, and the problem of IAQ is reduced when fewer chemicals are used in the growth of fibers or in fabric production**.** Nonetheless, IAQ is a serious issue and is consistently ranked in the top five concerns by the EPA. Because the average American spends 90 percent of his or her time indoors, sufficient fresh air circulation throughout interior spaces and limitation of indoor pollutants is a critical public health issue. Pollution, in gas form, may be generated from new furnishings and finishes and the chemicals with which they are treated. For this reason, most manufacturers recommend an **off-gassing** period, which allows the gases emitted from furnishing materials to be dissipated through the air while the space is still vacant. These gases are referred to as **volatile organic compounds (VOCs)**.

VOCs are chemicals that contain carbon, which, during evaporation, give off gases, and can cause health problems. The rate at which the materials off-gas depends on their molecular makeup and how quickly they vaporize. The amount of volatile material emitted is given a VOC number, VOC rating, or description of VOC content, either in pounds per gallon or grams per liter or as a percentage by mass. Some of the thousands of natural and manmade VOCs have a distinct smell, while others are odorless. Many are harmful to humans and the environment. The EPA reports that the quantity of volatile material in indoor VOCs can be ten times higher than that found outdoors. Materials and finishes that contain no or low harmful VOC levels contribute to the public's health and welfare.

Carpet, wallcovering, and paint are the largest potential contributors to VOC in an interior, in part because they are present in large quantities. As a result, some manufacturers of these products have lead the way in testing for environmental impacts, exploring less-toxic materials, and pursuing recycling efforts.

Reuse of Textile Products

Reusing a product is one way to minimize material destined for a landfill. Many carpet producers, for example, are seeking new ways to use byproducts from carpet manufacturing. Any reused material reduces waste quantity and also preserves available raw materials.

Recycling of Textile Products

While **repurposing**, or *reusing*, takes an existing product and uses it in a different way (such as the carpet cut into strips and used to reinforce concrete mixtures), **recycling** returns a product to a previous state in the manufacturing cycle. That reclaimed material is then used to produce another product.

The Council for Textile Recycling (CTR) (www.weardonaterecycle.org) is a nonprofit organization dedicated to raising public awareness about the importance of textile recycling and the need to reduce the amount of used clothing and other post-consumer textile waste being sent to landfills. The organization cites the EPA statistics that textile waste occupies nearly 5 percent of all landfill space. Although nearly 4 billion pounds of post-consumer textile waste are recycled each year, 85 percent of such waste holds space in our landfills.

Many consumer-level reuse/recycling avenues are available for textile waste. For several decades, U.S. charities have worked with the recycling industry, repurposing and recycling billions of pounds of fiber material. More and more communities are setting up programs to participate in these initiatives.

Most textile manufacturers have long recycled **post-industrial** (or *pre-consumer*) materials, which are their own manufacturing waste, within their own facilities. The manufacturer can often recapture materials that end up on the factory floor, and reprocess it into the production process so that it is not wasted. An example of post-industrial fiber waste is the small amount of yarn or fiber that is left over after a large order is completed, or fibers that are too short to be processed through a given spinner's standard processing. Reprocessed wool, reprocessed polyester, and spun silk are all well-established and popular examples of yarn made from what is, essentially, post-industrial fiber waste.

Post-consumer materials are those generated by residential or commercial end-users—the final users of the products before they are disposed of. Post-consumer recycling is considered to have greater eco-benefits than recycling post-industrial content, because if it is not recycled, post-consumer waste will almost surely end up in a landfill. One of the most successful post-consumer recycling efforts is reclaiming **PET** (**polyethylene terephthalate**), better known as polyester, from plastic drink bottles into usable polyester fiber, which is extensively used in interior fabrics and in apparel.

Recycling (and reusing) carpet fiber is another success story for the interiors industry. Virtually every commercial carpet company has a recycled product platform; some offer sustainability guarantees for at least some of their product lines. Most carpet tile is recyclable. The Carpet and Rug Institute (CRI, www.carpet-rug.org) and Carpet America Recovery Effort (CARE, www.carpetrecovery.org) provide information on recycling and reuse programs in the carpet industry (refer to Unit Four). (Most commercial carpet is made of nylon.)

Whether from drink bottles or used carpet, the material must be collected and taken to a central processing location. The fibers are then identified and sorted, shredded, crushed, and converted to fiber pellets. Such recycled fibers are most often used in industrial, automotive, or building materials, but many quality fabrics containing recycled fiber are indistinguishable from those constructed of virgin fiber, and are popular in the marketplace.

While polyester and nylon are both readily recyclable, several discouraging hurdles stifle increased efforts. Some of the reasons are:

- Material must be made of 100 percent of the fiber to be recycled. This may require, for example, that the material be not only "nylon," but a specific type, or configuration, of nylon.
- Fibers may be difficult to identify once they are in the field and have been in use for a period of time, though efforts are underway to "mark" different batches of fiber distinctly.
- Fiber recovery is difficult; for example, since upholstery fabric is part of something else, the furniture may need to be disassembled to reclaim the fabric. The challenge of recycling carpet begins with collecting the bulky, heavy floorcovering and delivering it to a central collection site.
- Significant infrastructure is required for collection, storage, and processing of the reclaimed material.
- All of these steps incur costs. While virgin fiber is of known quality, recycled fiber is less consistent. Therefore, if the recycled fiber is nearly as expensive, or even higher priced than virgin fiber, few users will pay a premium for the recycled material. Note that, because these fibers are petroleum products, the value of the material, whether recycled or virgin, depends on the price of oil. When oil prices are low, virgin fiber drops in price, while recycling costs remain fixed, resulting in an even steeper challenge for recycled fiber producers.

Fiber producers, carpet and fabric manufacturers, carpet and fabric distributors and installers, design professionals, and end-users are all critically necessary to developing more successful recycling programs. With demand, more supply will evolve. Design innovations must build recyclability into a product, so that in the future more fabric—and other materials—can avoid the landfill.

Figure 3.1 American manufacturers use state-of-the-art yarn packaging to reduce waste within factories. Photo courtesy Glen Raven, Inc., www.glenraven.com.

Organic Fiber

In an attempt to reduce chemicals used to grow natural fibers, researchers are experimenting with **organically grown** cotton. In this work, the cotton is cultivated on land that has been chemical-free for a minimum of three years and is nurtured without the use of chemical fertilizers or pest-control agents. Other advances include the development of genetically colored cotton that allows subsequent dyeing processes to be eliminated and reduces the chemicals that exist on the fibers. Similarly, other plant fibers (such as linen) can be organically grown. Ethical treatment of animals is an important part of sustainability; wool and other animal fibers can be organically and conscientiously raised.

Organically grown or raised fiber is a tiny fraction of the fiber used in the market. Its application is primarily in apparel and luxury bedding. Note that even organically grown fibers may have chemicals such as pest deterrents and wrinkle-resistant finishes added in the dyeing process or after it is made into fabric.

Environmental Impact Evaluation

Governmental Agencies

The U.S. government has no standardized national policy or strategy for sustainable consumption and production. Nonetheless, numerous U.S. federal laws pertain to the environment. Those that affect the textile industry in some fashion are largely administered through the **Environmental Protection Agency (EPA)** or the **Federal Trade Commission (FTC)**. These agencies write and enforce regulations based on laws passed by Congress.

In our current political climate, these agencies, in particular the EPA, are under siege. By executive order, agencies charged with protecting air, water, land, natural resources, human health, and working conditions are being defunded, and regulations and data collection initiatives are being eliminated. Therefore, sadly, this discussion may be moot or significantly eroded in short order.

The EPA was established in 1970 to protect human health and safeguard the natural environment. Primary initiatives focus on maintaining air, water, and land quality. The EPA's sustainability programs address health and safety issues related to:

- Air, land, water
- Chemicals, substances, toxins, pesticides
- Climate change, ecosystems
- Human health and environmental emergencies
- Green living, sustainable practices
- Waste, cleanup

The FTC was established in 1914 to promote consumer protection and to eliminate unfair business practices, such as monopolies.

Agency Activities

Most federal agencies' websites provide extensive information and data on the subjects under their auspices. The EPA established and updates databases of environmental information for products and services. Anyone can check the following websites for the latest iteration of databases and endorsement, which are helpful in order to identify environmentally preferable products, services, standards, certification organizations, and environmental assessment tools.

For example, EPA's "Introduction to Ecolabels and Standards for Greener Products" (https://www.epa.gov/greenerproducts/introduction-ecolabels-and-standards-greener-products) offers extensive information on the federal government's initiatives. Its "Guidelines for the Assessment of Environmental Performance Standards

and Ecolabels for Federal Procurement" endorses standards and ecolabels for specific categories, including sustainability assessments for carpet, commercial furnishings fabric, and furniture. In 2017, the General Service Administration (GSA) announced the addition of an EPA-recommended icon to its purchasing program. All government facilities select from GSA pre-approved products, and the U.S. government has, to date, prioritized environmentally responsible products.

- NSF/ANSI 140 Sustainability Assessment for Carpet
- NSF/ANSI 336 Fabric Sustainability Standard (Facts® certification)
- ANSI/BIFMA e3 Furniture Sustainability Standard

These are among the important standards for interior that are endorsed by the EPA and included in the list of recommended standards

(see https://www.epa.gov/greenerproducts/guidelines-assessment-environmental-performance-standards-and-ecolabels-federal).

EPA's **Environmentally Preferable Purchasing (EPP) Program** was originally designed to facilitate in the mandatory purchasing of products and services with reduced environmental impact by federal and state governments (see https://www.epa.gov/greenerproducts/about-environmentally-preferable-purchasing-program). Developed in conjunction with the EPA, FTC's **Green Guides** set forth definitions of terms and outline general principles that apply to environmental marketing claims for products and services. These are a valuable resource, although furnishing materials are barely mentioned (see https://www.ftc.gov/news-events/media-resources/truth-advertising/green-guides).

Environmental Regulations

Regulations cover a variety of activities and conditions that may be detrimental to the environment or human health, including treatment of employees, raw material procurement, manufacturing processes, packaging and shipping methods, waste disposal practices, and even the construction and operation of buildings and machinery. Very few of these regulations bear on an interior designer's job of selecting, or understanding, fabric.

As noted, while federal agencies do collect data and make recommendations on "green" attributes, guidelines, and standards, governmental regulation toward nationalized policy or strategy for sustainability are few. A small number of regulations, however, do apply to the fabric industry. (It should be noted that, likewise, most of the federal government's data collection does not include fabric, just as building codes do not pertain to furnishing materials.)

The FTC, with input from the EPA, developed Part 260, "Guides for the Use of Environmental Marketing Claims" as a revision to the **Code of Federal Regulation (CFR)** Title 16, which covers federal rules and regulations regarding commercial practices. The regulations covered in Part 260 prohibit deceptive acts or practices regarding environmental attributes of products and services. Claims made in advertising, labeling, product inserts, catalogs, and sales presentations must be substantiated through an evaluation and testing process performed by an independent national or international standards setting organization[1] (see https://www.ftc.gov/enforcement/rules/rulemaking-regulatory-reform-proceedings/green-guides). Unsubstantiated or misleading marketing or manufacturing claims about the environmental benefits of a product, service, or technology are known as **greenwashing**.

The EPA works closely with various other governmental agencies and consultants in the development of environmental standards. Several other federal departments are responsible for enforcing environmental standards and laws. These relate to fabric materials in marginal ways, primarily in manufacturing and material cultivation stages. The Department of Agriculture (USDA), Department of Commerce (DOC), Department of Defense (DOD), Department of Energy (DOE), and Department of Health and Human Services (HHS) are examples.

These agencies police federal laws that relate to everything from insecticides that are used on crops (the **Federal Insecticide, Fungicide, and Rodenticide Act**) to safety standards for all work environments; the latter is regulated by the **Occupational Safety and Health Administration (OSHA)**.

Health, safety, and environmental stewardship concerns about chemicals and processes have become important considerations when selecting and specifying textiles.

Safety Data Sheets (SDS) identify hazardous chemicals and health and physical hazards, including exposure limits and precautions for workers who may come into contact with these chemicals. Any chemicals, including cleaning chemicals, used in manufacturing processes that pose a potential hazard to workers are identified in SDS. Textile manufacturers routinely review the dyes and chemicals in their factories and processes, and utilize SDS in that process.

Fabric, as an "article," is typically considered to be exempt from the requirement for SDS with regard to specifiers and end-users. (Similarly, consumers do not typically ask for an SDS when purchasing a TV.) Although the form is not actually required for fabric, the demand for this protocol is widespread today. Design professionals review product SDS when specifying materials to evaluate potential VOC off-gassing problems, for example. SDS are also required to be available to local fire departments and local and state emergency planning officials.

Note that SDS were formerly MSDS (Material Safety Data Sheets). OSHA made a change to the Global Harmonized System (GHS) so that SDS are in a common format with other like protocols worldwide, and, in so doing, dropped the "M" (Material) from the name.

Environmental Regulations

Of the extensive list of laws tangentially related to the fabric market, the **Clean Air Act** (which stipulates standards for air quality and purity with an emphasis on controlling air pollution), **Safe Drinking Water Act** (which stipulates standards for water purity and groundwater protection), and **Clean Water Act** (which stipulates standards for water quality and purity) most directly reward the industry for safe manufacturing practices.

Additionally, the **Resource Conservation and Recovery Act** (which stipulates standards management of hazardous waste), the **Toxic Substance Control Act** (which authorizes the EPA to regulate certain toxic chemicals), the **Emergency Planning and Community Right-to-Know Act** (which polices companies' release of toxic chemicals), the **Pollution Prevention Act** (which promotes pollution prevention through hazardous substance reduction and increased efficiency), the **Energy Policy Act** (which addresses energy production, energy efficiency, renewable energy, and climate change technology), and the **Energy Independence and Security Act** (which supports production of clean renewable fuels and research on greenhouse gas capture and storage options) all encourage responsible manufacturing and protect consumers and the environment.

Local Governmental Agencies

In addition to the U.S. federal laws pertaining to the environment that affect the textile industry, state laws and building codes can impact the entire life of any product, from its manufacture and use, to its end of life options. These include zoning for manufacturing facilities, use of municipal utilities, and fire codes related to end-use installation.

Environmentally Related Building Codes

Building codes, as discussed in Chapter 2, are most often developed by nationally recognized organizations (such as the **International Code Council**, or ICC) as model building codes and standards that may be subsequently adopted by state, county, or city governments, and then modified for their specific communities' needs. In addition to what might be considered "standard" building codes, green building codes address energy conservation, building component and system efficiency, sustainable products, materials and methods, and innovative technologies and design.

The **International Green Construction Code (IgCC)** and the **International Energy Conservation Code (IECC)** are model codes developed by the ICC in conjunction with other organizations as overlays to the IBC (International Building Code). These codes can apply to both commercial and residential construction for new and existing buildings, and aim to establish clear and specific requirements that promote safe and sustainable construction. These codes relate to building envelope and mechanical systems, and ongoing facility management. Interior furnishing fabric is not a part of either code.

The IgCC addresses sustainability attributes for entire construction projects and building sites, from

design phase through to facility management. The IECC addresses energy-efficient design for building envelopes and mechanical and power systems. Because these codes apply to the building itself, soft materials are not generally regulated by these codes. IgCC does refer to carpet, however.

Life-Cycle Inventory

Marketing Claims

When comparing various fabrics' overall environmental impact, as with any other overall consideration in a choice about fabric, it is important to look at a comprehensive picture. Generally, producers and marketers highlight one particular feature of a fabric as testament that the fabric is the best choice for the environment. Perhaps it is organic or recycled fiber, or it can be (hypothetically) recycled, or the production of its fiber is not deleterious to the environment.

On the other hand, perhaps it is made half way around the world and requires considerable energy to harvest the material. For example, rayon is often touted as environmentally friendly because it is made from cellulose. However, dangerous, toxic chemicals used in its production (in particular carbon disulfide) have serious health impact on workers who produce it, and the chemicals are expelled into the environment from manufacturing processes. Bamboo is considered by some to kinder to the environment than are other fibers, but in fact it is transformed to a textile fiber with the help of the exact same chemicals; bamboo also uses rayon as a cellulosic starting point, rather than cotton or wood pulp. Furthermore, although bamboo is rapidly renewable, it is an invasive plant, so farming it in areas where it is not native could be environmentally dangerous.

Life-Cycle Inventory and Life-Cycle Analysis

The **life-cycle inventory (LCI)** is an analysis of flows to and from the natural environment into the product or service that is being evaluated. That is, each aspect of a product or service's life is assessed, with attention to raw material, flows of water and energy input, and releases into the environment. The ultimate goal of environmentally sensitive manufacturing is to create cradle-to-cradle, or closed-loop, systems in which all materials—including energy and water—are reclaimed, with no degradation or harm, and can reused at the same quality level that was possible at the beginning. Cradle-to-cradle is the highest bar, and rarely met, but data accrued from the life-cycle inventory assessment process adds to a broad base of information so that relative cradle-to-grave environmental impact can be established within product categories.

Although most reputable certifications and individual interior fabric evaluations follow an LCI model, in order to complete a true **life-cycle assessment (LCA)**, databases must be available for comparative study of product performance. To date, because the fabric industry does not collect such data, the established databases have scant material on textiles. Therefore, true LCA of interior furnishing materials is not currently undertaken. Nonetheless, evaluating green product claims is simpler when viewed through the lens of a product's life cycle. (See the list of databases at the end of this chapter.)

An LCA aids in identifying products, processes, or services that are environmentally preferable, in order to compare which "have a lesser or reduced effect on human health and the environment when compared with competing products or services that serve the same purpose."[3] A range of methodologies, with slight variations, are available for use in LCAs. The EPA and numerous other environmental associations provide LCA guidelines and online programs for use by design professionals. Some can be used to evaluate products and methods, others are designed to consider entire buildings, and still others focus on specific life-cycle stage evaluation factors.

For most applications the life cycle can be divided into four stages: raw material acquisition, manufacture and transportation, use/reuse/maintenance, and recycle/waste management. Energy demands and environmental wastes associated with each stage are evaluated in the evaluation.

- Stage 1: Raw Material Acquisition
  - Extraction or removal of raw materials from mining or harvesting.
  - Transportation materials from acquisition to processing.

- Stage 2: Manufacture and Transportation
  - Converting of raw materials into a form that can be used to manufacture a finished product, including transportation.
  - Manufacturing a finished product ready for shipping.
  - Packaging and labeling of the finished product.
  - Transporting and distributing of the finished product.
- Stage 3: Use, Reuse, Maintenance
  - Product longevity and durability, taking into account frequency of necessary reconditioning, repair, or servicing, and any materials that are needed to accomplish the product's upkeep.
  - When no longer needed will the product be recycled or disposed?
- Stage 4: Recycle/Waste Management
  - Disposal or reuse.
  - Energy requirements to recycle or dispose the product.

The EPA identifies positive or negative impact based on a product's or service's LCA as "Environmental Attributes." The EPA's three basic attribute categories are natural resources use, human health/ecological stressors, and hazard factors associated with materials.[4]

- Natural Resources Use
  - Ecosystem Impacts—Adverse impacts on the ecosystem, endangered species, wetlands loss, fragile ecosystems, and erosion.
  - Energy Consumption—The total amount of energy consumed for product or service manufacture, use, and disposal. Often referred to as **embodied energy**. Different sources of energy are associated with different environmental impacts such as acid rain, climate change, air pollution, and other human health risks.
  - Water Consumption—Water resources that are consumed or used that affect water quality of aquatic ecosystems and drinking water.
  - Nonrenewable Resource Consumption—Resources that are not renewable within 200 years. Could produce acid rain, climate change, air pollution, human health risks, and risks to endangered species or ecosystems.
  - Renewable Resource Consumption—Resources that are renewable in fewer than 200 years (timber-based products) to those that are renewable in under than two years (grain-based feed stocks). In most cases the use of renewable resources is preferable to use of nonrenewable resources; however, some products made from renewable resources may also have negative environmental impacts (e.g., ethanol is derived from a renewable resource, yet its manufacture can lead to releases of VOCs).
- Human Health and Ecological Stressors
  - Releases—The release of pollutants (chemicals, gasses, biologics, particulate matter) into the air, water, or soil. An example would be ozone depleting chemicals that impact global warming.
  - Indoor Environmental Releases—Potentially hazardous chemicals released during off gassing, mold, fungi, microbials.
  - Hazardous Waste—Toxic substances with immediate health or ecological impacts.
  - Nonhazardous Waste—Non-toxic substances with health or ecological impacts.
- Hazard Factors Associated With Materials
  - Human Health Hazards
    - Acute toxicity (poisoning)
    - Cancer
    - Neurologic, developmental, reproductive toxicities
    - Immunotoxicity, immune deficiencies, allergies
    - Sensitization, irritancy, reactivity
    - Corrosivity
    - Flammability
  - Ecological Hazards
    - Aquatic, avian, terrestrial species toxicities

There are, of course, other factors that must be considered when selecting products, processes, or services. In addition to environmental impact concerns, design professionals must address issues related to aesthetics, function, safety, cost, client preferences, and codes. The LCA is one of many tools used in the design process.

Textile Related Sustainability Standards, Certifications, Ratings

It has become customary practice for design professionals to expect verification of green claims concerning products, processes, or services. Claims can be confirmed in documentation presented via standards, certifications, and the ratings. When evaluating manufacturers' green product claims, look for compliance to standards, certifications, and test ratings issued by the organizations previously noted. (Standards, certifications, and ratings are defined in detail in Chapter 2.)

Standards describe specific performance, behaviors, attributes, or results. National conformity standards used to measure sustainability attributes are developed by both government and private sector organizations. Private standard setting organizations are typically required to meet any existing federal requirements confirming their qualifications to develop standards for particular industries. Unless adopted by government or industry and mandated by law, adherence to a given standard is voluntary.

Note that most ANSI third-party certifications are structured around meeting all the standard's prerequisites in order to achieve certification. Additional points earned by meeting extra criteria, which merit higher levels within the certification.

Certifications are given to products, processes, or services that have met criteria based on standards. Certification identifies environmental preference within single or multiple life-cycle assessment categories; some evaluate a single environmental attribute, such as the release of a certain chemical, and others analyze several criteria in order to evaluate multiple attributes. Products that meet certification requirements may be awarded a mark or label from the certifying body. Third-party certification programs are considered higher caliber than those claims made by the product's manufacturer or by other parties that have a stake in the product's success. An impartial third-party testing service has no connection to the product or service being tested, and receives no benefit from the sale or use of the product or service. Some certification agencies also develop standards. A manufacturer can produce a fabric and check itself against any of the third-party certification standards. However, when a certification is performed by an outside, approved tester, the certification or mark will hold more weight.

Ratings can refer to how a product, service, or method ranks on a specific scale, based on a guideline or standard. Many sustainability standards specify several tiers, which are based on how well the product meets the standard's requirements.

Ecolabels

Certifications for sustainability attributes are commonly referred to as **ecolabels**. In addition to the EPA's list of recommended standards for sustainability, numerous other associations and consortiums identify third-party certification and labeling organizations.

Global Ecolabelling Network, which is nonprofit, (www.globalecolabelling.net) and **Ecolabel Index** (www.ecolabelindex.com) are two organizations that maintain databases of ecolabels. The periodical **Ecotextile News** (www.ecotextile.com) publishes a biennial **Eco-Textile Labeling Guide**.

It should be noted that, while the manufacturers and distributors of interior furnishings products have dedicated vast financial and personnel resources to understanding sustainability features, developing standards, and striving to meet them, the design community and end-users are not yet dedicated to requiring products that meet these standards. Products that meet specific standards are most often required for state and federal government procurement, although individual specifiers or end-users may require them. Since standards are periodically updated and revised, the best resources for current requirements are the websites for the standard-setting organizations.

Organizations Establishing Sustainability Standards

Several organizations that were introduced in Chapter 2 are also involved in developing sustainability standards.

- **International Organization for Standardization (ISO)** is the world's largest nongovernmental developer and publisher of international standards. ISO developed its 14000 series of standards, which pertain to ways in which a manufacturing organization can minimize its negative impact on the environment, to evaluate a manufacturer's sensitivity to sustainability. Factories become ISO

14000 certified; the certification does not apply to products or services.

- **American National Standards Institute (ANSI)**, the private non-profit organization that oversees the development of voluntary standards for products, services, processes, and systems, accredits standards developed by organizations, government agencies, consumer groups, and businesses, and works closely with the ISO, NSF, and other organizations in the development and publications of standards for use in the United States and internationally. Currently, the most important sustainability standards for interior furnishings are ANSI-accredited standards, assuring that they are consensus-based and transparent.
- **ASTM International** develops and publishes voluntary consensus technical standards. To date, its environmentally related standards pertain to building construction and not to soft furnishings.[5]
- **NSF International**, an independent global organization committed to protecting public health and the environment, is accredited by ANSI to develop standards and guidelines. Through its National Center for Sustainability Standards, NSF International has developed sustainability standards for building products and materials; furniture; carpet and flooring; fabrics; wallcoverings; roofing membranes; green chemicals; and drinking water quality. NSF International and ANSI worked together with the **Association for Contract Textiles (ACT)** and with the Carpet and Rug Institute (CRI) to develop sustainability standards for contract fabric and carpet, respectively. More information on NSF International's sustainability standards and protocols can be found at http://www.nsf.org/services/by-industry/sustainability-environment/sustainability-standards-protocols/.

Sustainability-Related Certifications and Certifiers

The following are some of the better-known organizations that provide certification/labeling related to fabrics for interiors and whole-building rating programs. Some developed, or collaborated on development of, the standards to which they certify; others are strictly third-party certifiers.

For example, SCS Global (https://www.scsglobalservices.com/) and UL Environment (http://industries.ul.com/environment, part of Underwriters Laboratories) are not only exclusive certifiers of the two most popular certifications (SCS Indoor Advantage and Greenguard, respectively) for levels of VOCs in interior environments, but these companies are both accredited third-party certification bodies that evaluate a wide range of nationally and internationally recognized standards. Both agencies are approved certifiers for NSF/ANSI 336 Sustainability Assessment for Commercial Furnishings Fabrics (Facts certification), NSF/ANSI 140 Sustainability Assessment for Carpet, and ANSI/BIFMA e3 Furniture Sustainability Standard. These organizations perform auditing and testing services and develop standards in the areas of environmental protection, ethical and social responsibility, product quality and safety, and life-cycle assessment services.

Numerous providers offer a wide array of services that assist manufacturers and marketers in their quests for conscientious business practices. In the discussion below, several multifaceted players' roles are described. Another example is **Intertek**, which does not certify to or develop codes, but offers comprehensive eco-testing, supply chain audits, certification, and is especially known for assisting in developing life-cycle assessment solutions for a large number of industries and customers including textile retailers, manufacturers, and suppliers. More information on industries Intertek serves can be found at www.intertek.com.

Single-Attribute Third-Party Sustainability Certifications

In the early stages of sustainability awareness, concern and testing focused around the impact a product made on the environment. This trend evolved into several standards that were developed to measure IAQ, i.e., comparative levels of materials' VOC off-gassing into interior environments. More recently, a products' environmental impact is judged more heavily by what goes into the products, from raw materials, to processes, and to manufacturers' treatment of workers.

- Greenguard and **Greenguard Gold**, developed by the **Greenguard Environmental Institute**, certify (at two rating levels) that a product does not emit harmful levels of VOCs into an interior

environment. The base-level certification, Greenguard, certifies to different standards, depending on the product type. Greenguard Gold certifies to California Department of Public Health test CA01350. Greenguard and Greenguard Gold are not specific to fabric or carpet; many interiors products can be certified to this single-attribute standard.

The Greenguard Environmental Institute was acquired by UL Environment, a division of UL (Underwriters Laboratories), in 2011, which is now the provider of the Greenguard certification program.

See www.greenguard.org for Greenguard Product Guides.

- **SCS Indoor Advantage Gold** certification, developed by **SCS Global** (Scientific Certification Systems Global Services) similarly represents that a material performs to a standard related to a single attribute, which is that the product does not emit harmful levels of VOCs into an indoor environment. SCS Indoor Advantage Gold, like Greenguard Gold, certifies to California Department of Public Health test CA01350.

  SCS Indoor Advantage Gold, like Greenguard and Greenguard Gold, is not specific to fabric or carpet; many interiors products can be certified to the standard. A complete list of SCS Global's services and standards can be reviewed at www.scsglobalservices.com.
- **Green Label** and **Green Label Plus** certification, developed and administered by the **Carpet and Rug Institute**, similarly certify to California Department of Public Health test CA01350, and aim to encourage specification of carpet, adhesive, and cushion products with the lowest possible VOC chemical emissions. UL handles testing for Green Label Plus. See http://www.carpet-rug.org/green-label-plus.html

Life-Cycle-Based Third-Party Sustainability Certifications

Facts certifies to NSF/ANSI Standard 336 (Sustainability Assessment for Commercial Furnishings Fabric), which is presently the premier standard for furnishing fabric sustainability. This assessment addresses the environmental, economic, and social aspects of furnishing fabrics, including woven, non-woven, bonded, and knitted fabrics used for commercial upholstery, drapery, wallcovering, system furniture panel fabric, and bedding applications (it excludes sheet sets and blankets). Facts certification requires a fabric to be evaluated across its life-cycle for

- Fiber sourcing
- Safety of materials
- Water
- Energy
- Air quality
- Social responsibility
- Recycling practices

Based on a point system, three levels (silver, gold, and platinum) of Facts certification are available. The maximum possible points are 100; of these, 50 percent address fabric composition and 50 percent address fabric manufacturing. To be compliant, a fabric must meet all prerequisites in the standard. If certified, manufacturers are allowed to use the NSF Sustainability Certified mark and the Facts Certified mark on the products and in related advertising. A more detailed overview of the standard is available on the Association for Contract Textiles website (http://contracttextiles.org/facts-sustainability-certification/#facts). Several independent certifiers are licensed to review compliance (see http://www.nsf.org/services/by-industry/sustainability-environment/sustainability-standards-protocols/furnishings-fabric).

NSF/ANSI Standard 140 (Sustainability Assessment for Carpet) (adopted 2007, updated 2015) is used to evaluate the sustainability of commercial carpet products for office, education, government, healthcare, and hospitality settings (see http://www.carpet-rug.org/nsfansi-140-standard.html). Again, a point system is incorporated to indicate certification level on three performance levels (silver, gold, and platinum). The rating system considers performance and quantifiable metrics in:

- Public health and environment
- Energy and energy efficiency
- Biobased or recycled materials
- Manufacturing and reclamation and end of life management

LEVEL® certifies to ANSI/BIFMA e3-2010 (Furniture Sustainability Standard), which was developed by a

joint committee of stakeholders formed by the **Business and Institutional Furniture Manufacturers Association (BIFMA)**, using the ANSI consensus process (see https://www.bifma.org/?page=e3standard for more information on ANSI/BIFMA e3 Furniture Sustainability Standard). The standard establishes performance criteria addressing environmental and social aspects throughout the supply chain, in order to promote increasingly sustainable furniture. The standard allows for multiple levels of achievement and addresses areas of

- Materials
- Energy usage
- Human and ecosystem health
- Social responsibility

NSF/ANSI Standard 342 (Sustainability Assessment for Wallcovering Products) is the current premier standard for evaluating and certifying sustainability of wallcovering products (see http://www.wallcoverings.org/?page=NSF342Info). Developed through an ANSI standards development process, the standard outlines a consistent approach to evaluating environmentally preferable wallcovering manufacturing and distribution processes. This multi-attribute standard includes relevant criteria across the product life cycle, from raw material extraction to manufacturing, distribution, use, and end-of-life reuse or disposal. Four ratings (conformant, silver, gold, or platinum) are possible, based on the point totals achieved through the third-party certification process. Certified manufacturers can use the NSF Sustainability Certified mark on products that meet the standard.

The **Cradle to Cradle Certified**™ program measures achievement in environmentally intelligent design in the following areas:

- Chemical inputs
- Energy
- Water
- Social equity
- Recyclability/compostability

Cradle to Cradle certifies to the C2C standard and is used not only for fabrics, but for a range of products. The evaluation process and the standard can be found on the **Cradle to Cradle Products Innovation Institute** website at http://c2ccertified.org. The C2C Certification mark is licensed by the Cradle to Cradle Products Innovation Institute. This certification was met with raised eyebrows in its early days because the standard was not transparent and the C2C Institute was the only certifier. This has evolved into a respected system, with multiple certifiers. Although it is not an ANSI consensus standard, it is transparent and contains valid criteria, especially in material health categories, which have been validated by LEED (see the next section). In LEED's most recent version, Cradle to Cradle certified products can earn up to two points under LEED's Materials and Resources credit system.

OEKO-TEX®, based in Switzerland, offers a range of services to textile businesses that commit to responsible, sustainable management, including overseeing and certifying products for a number of standards. It also developed **OEKO-TEX Standard 100**, which focuses on health-related issues, especially evaluation for harmful substances in processed textiles that come into direct or near contact with the skin. The focus is on levels of chemical substances that may cause skin irritations, allergies, cancer, or harm to the nervous system, internal organs, or fertility, or which are suspected of causing such problems.

OEKO-TEX's STeP (Sustainable Textile Production) certification program evaluates manufacturing processes, from fiber production to manufacture of clothing. The list of substances that are prohibited or subject to restrictions in products bearing the OEKO-TEX label can be found at www.oeko-tex.com. Although OEKO-TEX standards are more relevant to apparel, they can be used to evaluate the dyes and pigments used in furnishings fabrics and carpet. This standard is more popular in the EU than in the United States.

Global Organic Textile Standard (GOTS) is the leading worldwide textile processing standard for organic fibers. GOTS covers the entire supply chain and sets high ecological and social requirements that a manufacturer must meet for a product to be certified, including use of appropriate dyestuffs and performance additives, mandatory wastewater treatment, and assurance of safety and ethical treatment of workers. The standard covers the processing, manufacturing, packaging, labeling, trading, and distribution of any textile made from at least 70 percent certified organic natural fibers. GOTS currently certifies to Version 5, which offers two certification levels: the GOTS "organic" label must contain a minimum of 95

percent certified organic fiber, whereas the "made with organic" label must contain a minimum of 70 percent certified organic fibers. GOTS organic labeling is more widely utilized in apparel than in interior furnishings. The full standard and a list of approved testing/certification agencies can be found at http://www.global-standard.org.

Whole-Building Environmental Standards

Fiber-based materials play only a small part in current whole-building environmental standards. The focus of these standards is on construction practices that result in energy-efficient and environmentally sustainable buildings that are conducive to human health. It is important to note that a fabric cannot be LEED certified or Green Globes certified. Certain fabrics can contribute in small ways to LEED certification, but, since fabrics are not buildings, they are not candidates for whole-building certification.

A few organizations develop standards and provide certification for environmentally responsible attributes of residential and commercial building types. Currently, the most prominent voluntary green building rating and certification program is **LEED (Leadership in Energy and Environmental Design)** developed by the **U.S. Green Building Council** (**USGBC**). **Green Globes**, owned by the **Green Building Initiative (GBI)** is a strong contender in the whole-building assessment category. The **Living Building Challenge**, from the **International Living Futures Institute**, is also well recognized.

LEED

LEED (Leadership in Energy and Environmental Design) is a system created by the U.S. Green Building Council (USGBC) with the mission of encouraging sustainable building design and thereby encouraging market transformation that enables environmentally and socially responsible, healthful environments. The USGBC, a nonprofit organization, provides green building resources, educational courses, research, and statistical information. USGBC also established the World Green Building Council to offer alternative compliance pathway for projects executed overseas, allowing for regional differences and issues.

Many state and local governments utilize LEED as a desired standard for publicly owned and publicly funded buildings. LEED highlights multiple building rating system categories, such as New Construction, Existing Buildings, Operations and Maintenance, Commercial Interiors, Core and Shell Construction, Schools, Retail, Healthcare, Homes, and Neighborhood Development.

LEED certification emphasizes state-of-the-art building in numerous credit categories. Currently, these are:

- Integrative process credits
- Location and transportation
- Sustainable sites
- Water efficiency
- Energy and atmosphere
- Materials and resources
- Indoor environmental quality
- Innovation
- Regional priority

Prerequisite requirements must be met initially, and optional environmental attributes are referred to as *credits*. Points are earned for the credits. Each prerequisite and credit includes a group of preferred attributes and explanations of overall goals or intent. Evaluations are based on a combination of national standards and LEED developed requirements. To achieve certification, projects must comply with all prerequisites and a sufficient number of credits to earn 40 or more of the available certification points. LEED offers four levels of certification: certified, silver, gold, or platinum.

LEED for Homes certification starts at 45 points. In some categories bonus points are available, which can raise the total possible points over 100. In LEED for Commercial Interiors, textiles are grouped under Materials and Resources and are included with Furniture and Furnishings. Credits for this group are worth up to 8 points out of the 100 total points:

- Reuse Furniture and Furnishings: 1 point
- Recycled Content: 1–2 points
- Regional (Locally Produced) Materials: 1–2 points
- Rapidly Renewable Materials: 1 point
- Low-Emitting Materials—Flooring Systems: 1 point
- Low-Emitting Materials—Systems Furniture and Seating: 1 point

Fabrics and furnishings rarely contribute more than a tiny percentage of LEED points to a building project. For example, in order to attain the 1 point allowed for reuse of furniture and furnishings, all of the furniture and furnishings in the building would need to be previously used.

LEED Certified Professionals

In addition to the LEED standard, the USGBC accredits design and building professionals who pass exams through the Green Building Certification Institute (GBCI). **LEED Accredited Professionals (LEED AP)** have a thorough knowledge of the LEED programs and have proficiency in a particular LEED rating system. **LEED Green Associates** have a current understanding of LEED's green building practices and principles. LEED adds other certification levels periodically.

Green Globes

The Green Building Initiative (GBI) is a nonprofit organization that promotes energy-efficient, healthy, and environmentally sustainable buildings. Its Green Globes certifications, based on its **Building Assessment Protocol for Commercial Buildings**, are tailored for a wide range of buildings from large and small offices, multi-family structures, hospitals, schools, and institutional and municipal buildings.

GBI is also an accredited standards developer under ANSI/GBI 01 Green Building Assessment Protocol for Commercial Buildings, upon which the Green Globes certification is based. Under Green Globes, fabrics are grouped under Materials and Resources and are included in the Interior Fit-Out Category (interior partitions, interior finishes, doors, millwork, cabinetry, furniture, window treatments, plumbing fixtures, light fixtures, and so on). There are two basic methods that can be used when comparing sustainability of textiles and other fit-out products under Green Globes:

- Path A: Performance Path identifies performance or objectives to be achieved (10 points maximum).
- Path B: Prescriptive Path identifies exactly how to comply with specific standards (16 points maximum). Depending on the assessment method used, the total Interior Fit-Out Category is worth a maximum of 16.5 or 22.5 points out of the new construction total of 1,000 points, of which Reuse of Existing Furniture can equal 4 points and Low Floorcovering VOC (includes carpet) can achieve 2.5 points.

Green Globes Professionals

A **Green Globes Professional** is trained in the Green Globes building assessment and certification process and serves as consultants on Green Globes projects in order to facilitate the building certification process and provide project management for their own clients. A **Green Globes Assessor** is certified in the areas of GBI's sustainable design, construction, energy, and facility management protocols and requirements. After training, assessors are contracted by GBI to perform independent third-party assessments for Green Globes building projects.

Living Building Challenge

A third whole-building standard that is gaining popularity in the design community is the Living Building Challenge. Developed by the International Living Future Institute, which was founded by the Cascadia Green Building Council (a chapter of the USGBC together with the Canada Green Building Council), the system grants "Petals" for seven performance areas:

- Place
- Water
- Energy
- Health and Happiness
- Materials
- Equity
- Beauty

Living Product Challenge certification is based on LCA analysis and also synthesizes other hard data, but also measures features often deemed subjective, such as social justice and equality. To earn full program certification (Living Status), projects must meet all assigned imperatives and have proven performance through at least 12 consecutive months of operation, as the evaluation is based on demonstrated improvement

over a short history. Projects will earn partial program certification (Petal recognition) if they meet the requirements of a minimum of three categories, one of which must be water, energy, or materials.

Key Terms

Association for Contract Textiles (ACT)
American National Standards Institute (ANSI)
ASTM International
Building Assessment Protocol for Commercial Buildings
Business and Institutional Furniture Manufacturers Association (BIFMA) certifications
Clean Air Act
Clean Water Act
Code of Federal Regulation (CFR)
cradle-to-cradle
Cradle to Cradle Certified
Cradle to Cradle Products Innovation Institute
cradle-to-grave
Ecolabel Index
ecolabels
Eco-Textile Labeling Guide.
Ecotextile News
embodied energy
Emergency Planning and Community Right-to-Know Act
Energy Independence and Security Act
Energy Policy Act
Environmental Protection Agency (EPA)
Environmentally Preferable Purchasing (EPP) Program
Facts
Federal Insecticide, Fungicide, and Rodenticide Act
Federal Trade Commission (FTC)
Global Ecolabelling Network
Global Organic Textile Standard (GOTS)
Green Building Initiative (GBI)
Green Globes
Green Globes Assessor
Green Globes Professional
Green Guides
Green Label
Green Label Plus
Greenguard
Greenguard Environmental Institute
Greenguard Gold
Greenwashing
indoor air quality (IAQ)
International Code Council (ICC)
International Energy Conservation Code (IECC)
International Green Construction Code (IgCC)
International Living Futures Institute
International Organization for Standardization (ISO)
Intertek
Leadership in Energy and Environmental Design (LEED)
LEED Accredited Professionals (LEED AP)
LEED Green Associates
LEVEL certification
life-cycle assessment (LCA)
life-cycle inventory (LCI)
Living Building Challenge
NSF International
Occupational Safety and Health Administration (OSHA)
OEKO-TEX Standard 100
off-gassing
organically grown
PET (polyethylene terephthalate)
Pollution Prevention Act
post-consumer
post-industrial
recycling
repurposing
Resource Conservation and Recovery Act
Safe Drinking Water Act
safety data sheet (SDS)
SCS Global
SCS Indoor Advantage Gold
standards
sustainability
Toxic Substance Control Act
U.S. Green Building Council (USGBC)
volatile organic compounds (VOCs)

Review Questions

1. What is an example of a sustainability code for fabric? A guideline? A code?
2. What is Facts?
3. What is LEED?
4. What is greenwashing and how can it be prevented?
5. Discuss the environmental challenges that face natural fiber suppliers and manufactured fiber producers.
6. Why is it critically important that fabric manufacturers keep up to date on governmental regulations?
7. Discuss what is involved in a life-cycle assessment and life-cycle inventory. Why are LCAs not routinely undertaken for interior fabrics?
8. Explain importance of IAQ. How can the negative effects of interior textiles on the IAQ be reduced?
9. Identify ways the professional designer can strive to protect the environment when selecting textiles.
10. Discuss the benefits of building green.
11. Discuss the recycling of plastic bottles into textile applications.

Notes

1. U.S. Code of Federal Regulations (CFR) Title 16—Commercial Practices, Chapter 1, FTC Part 260—Guides for the use of Environmental Marketing Claims.
2. Executive Order 13101, Section 201—Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition, 1998.
3. Environmental Protection Agency, "Life-Cycle Assessment: Principles and Practice," May 2006, page 11.
4. Environmental Protection Agency, EPA's "Final Guidance on Environmentally Preferable Purchasing, Appendix B (1)—Menu of Environmental Attributes," as published by the EPA on August 20, 1999, http://www.epa.gov/opptintr/epp/pubs/guidance/finalguidance.htm.
5. Environmentally related ASTM standards to date relate to buildings rather than to furnishing materials. These include a Guide for Life-Cycle Assessment of Building Materials (ASTM E1991), Standard Practice for Data Collection for Sustainability (ASTM E2129), Standard Practice for Measuring Life-Cycle Costs of Buildings and Building Systems (ASTM E917), Standard Guide for General Principles of Sustainability Relative to Buildings (ASTM E2432).

Environmental Feature Databases

- EPA.
- U.S. Life-Cycle Inventory Database (https://www.nrel.gov/lci/); from NREL (National Renewable Energy Laboratory), a government-owned, contractor-operated laboratory and research institution funded through Department of Energy (DOE).
- EIE (Environmental Impact Estimator; https://calculatelca.com/software/impact-estimator/); software for LCA in the construction industry from Athena Sustainable Materials Institute, a nonprofit research collaborative.
- BEES (Building for Environmental and Economic Sustainability, https://www.nist.gov/services-resources/software/bees) established by NIST (National Institute of Standards and Technology), under U.S. Department of Commerce. For building evaluations; does not include textiles.

4

Fiber Classification and Properties

Manuel Canovas fabrics courtesy of Cowtan & Tout, Inc. www.cowtan.com

The goal of a design professional is to select a fabric that preforms well under the appropriate conditions. Fiber characteristics, along with yarn type, fabric structure or construction, and finish, impact the appearance, strength, cost, and hand (feel) of a fabric.

Fibers (Figure 4.1) are chemically distinct materials that can be manipulated in various ways. Fibers can be made into elongated forms (**yarn**), which are used to make woven and knitted fabric or melded into a film or a nonwoven. There are many different sources of fiber and cultures around the world have historically learned to harness local, natural resources that can be used in fabric production. The first synthetic fiber was invented in the 1930s and an explosion in the number of variations thereof followed. Chemists continue to manipulate these materials, striving to meet modern day demands for functional and aesthetically pleasing fabrics. In order for a fiber to have broad, modern-market appeal it must be plentiful, competitively priced, and able to be processed successfully and efficiently.

Whether a fiber is natural or manufactured, it is distinguished by its chemical composition and characterized by specific molecular structure and external physical features. Such characteristics are inherent features of natural fibers and are engineered features of manufactured fibers. In either case, these variables result in the specific appearance and performance properties of fibers. However, keep in mind that fiber is but one component of a fabric and any and all of these features can be offset in an actual fabric through construction choices and finishing. A review of fiber nomenclature will introduce the basic vocabulary for fiber labeling.

Figure 4.1 Fibers. Courtesy of Glen Raven, Inc.

Fiber Classification and Identification

Two broad categories of fiber are **natural** and **manufactured**. Natural fibers, obtained from plants, animals, or minerals, are classified according to their source. Plant, or **cellulosic**, fibers include cotton, flax, hemp, jute, and sisal. Animal, or **protein**, fibers include wool, silk, and fleece from other animals, such as **mohair** and **cashmere** from goats**.** Mineral fibers are found in the ground and include glass and asbestos. Manufactured fibers are produced from chemical compounds, are engineered for specific end-uses, and provide performance properties that cannot be achieved with natural fibers. They are versatile and quick to produce. Four subgroups of manufactured fibers are regenerated fibers, synthetic fibers, biopolymer fibers, and mineral fibers. These categories will be discussed in detail in Chapter 5.

Fiber Classification

Natural and manufactured fibers are identified by a **common name** (for natural fibers) or a **generic name** (for manufactured fibers) names for purposes of discussion and for sample and product labeling. Fibers grouped under the same name are chemically related and possess similar properties. Familiarizing yourself with these names and with the properties that typically characterize each group will assist you in making informed fabric selections.

A fiber classification system is presented in Table 4.1. Fibers are first classified on the basis of how they are produced, whether natural or manufactured. A few manufactured fibers, such as rayon, are produced from natural substances but are not categorized as a natural fiber because they are the product of an industrial process.

The Federal Trade Commission establishes **generic** names for manufactured fibers in accordance with congressional directive. Each class is defined in terms of specific chemical composition. An up-to-date listing of the generic class names set forth by the Federal Trade Commission is available at https://www.cbp.gov/sites/default/files/assets/documents/2016-Apr/icp040_3.pdf.

TABLE 4.1
TEXTILE FIBER CLASSIFICATION

Natural Fibers		
Protein (Animals)	**Cellulosic (Plants)**	**Mineral (Rock)**
Alpaca (alpaca)	Leaf	Asbestos
Angora (Angora rabbit)	Abaca (manila fiber)	
Camel (Bactrian camel)	Banana	
Cashmere (cashmere goat)	Henequen	
Cattle hair (cattle)	Piña (pineapple)	
Fur fibers (beaver, fox, mink, sable, etc.)	Sisal	
Llama (llama)	Seed	
Mohair (Angora goat)	Coir (coconut)	
Qiviut (musk ox)	Cotton	
Silk (silkworm)	Kapok	
Vicuna (vicuna)	Milkweed	
Wool (sheep)	Stem (bast)	
Yak	Hemp	
	Jute	
	Flax	
	Ramie (China grass)	
Regenerated Manufactured Fibers (Natural Polymer Based)		
Cellulosic	**Protein**	**Rubber**
Acetate	Azlon	Rubber (natural rubber)
Lyocell		
Rayon		
Triacetate		

Synthetic Fibers (Synthetic Polymer Based)				**Mineral Fibers**
Acrylic	Melamine	Olefin	Spandex	Glass
Anidex	Modacrylic	PBI	Sulfar	Metallic
Aramid	Novoloid	Polyester	Vinal	
Elastoester	Nylon	Rubber (synthetic)	Vinyon	
Fluoropolymer	Nytril	Saran		