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American Hardwoods for High-Traffic Areas

A natural material brings durability, cost-effectiveness and charm to busy venues

Project by Design Alliance Architects, Pittsburgh, Pa.
Photo courtesy of Ed Massery.

In order to maintain brand consistency of using hardwood flooring at their retail stores, American Eagle selected engineered maple flooring for their headquarters.

Provided by The Hardwood Council

Hardwood floors have been around for centuries, prized for their longevity, durability and wear-resistance. It's no accident that trains run on oak rail ties, or that professional basketball is played on maple courts. Because of their inherent strength, as well as the fact that they have some "give" to them and are not tiring underfoot, hardwood floors are frequently specified in high-traffic settings—from stores to hospitals to museums—that log in millions of visitors a year. Advancements in chemical technology have generated surface and penetrating treatments that add to hardwoods' natural durability. The result is floors that, with proper maintenance, can outlast most other available flooring materials. And when factors beyond initial purchase price and installation are considered, hardwoods actually prove to be one of the least expensive flooring options. This article will discuss the suitability of various hardwood species for high-traffic settings, as well as key design considerations including finishes and maintenance.

Hardwood Basics

Hardwoods are deciduous trees that have broad leaves, produce a fruit or nut and generally go dormant in the winter. America's forests grow hundreds of varieties of hardwood trees that thrive in this country's temperate climates. These varieties, or species, include oak, ash, cherry, maple and poplar. Each hardwood species has unique physical properties, and when it comes to hardness, the U.S. species vary widely. For example, the hardest commercially available hardwood is hickory, and it is five times harder than aspen, one of the "soft hardwoods."

The relative hardness of woods is measured by the Janka Rating

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Use the learning objectives below to focus your study as you read **American Hardwoods for High-Traffic Areas.** To earn one AIA/CES Learning Unit, including one hour of health safety welfare credit, answer the questions on page 8, then follow the reporting instructions or go to continuingeducation.construction.com and follow the reporting instructions.

Learning Objectives

After reading this article, you should be able to:

- Evaluate the suitability of specifying American hardwoods in high-traffic settings
- Explain how life-cycle thinking influences green building products selection
- Consider appropriate finishes for hardwoods in different settings
- Discuss economic considerations for hardwood maintenance and care

System which measures the force required to drive a .444-inch steel ball into the wood, so that half the diameter of the steel ball is embedded. The higher the number, the harder the species of wood.

Janka Scale

Typical American Hardwoods	Hardness
Hickory / Pecan	**1820**
Hard Maple / Sugar Maple	**1450**
White Oak	**1360**
Ash (White)	**1320**
American Beech	**1300**
Red Oak (Northern)	**1290**
Birch	**1260**
Walnut	**1010**
Cherry	**950**
Elm	**830**
Sycamore	**770**
Chestnut	**540**
Basswood	**410**

Partial list containing some of the most popular choices in American hardwoods.

Red oak, which has a Janka rating of 1290, is the industry benchmark for comparing the relative hardness of different wood species.

Although the higher the Janka rating, the harder the wood, don't mistake hardness for the best wood. In addition to a wood's hardness, other qualities to consider when choosing a wood floor include both aesthetic and physical properties.

Hardwoods are also graded for quality. The National Hardwood Lumber Association (NHLA) grading system, which is used by buyers and sellers of hardwood lumber, describes the amount of "usable" clear material in a board. The highest grade boards are long, wide and free of defects. There are eight hardwood lumber grades, with Firsts and Seconds (FAS) being the highest and No. 3B Common, the lowest. Generally speaking, the higher grades of lumber have more large clear area than the lower grades.

The Wood Flooring Manufacturers Association (NOFMA) has developed a grading system that describes the appearance of hardwoods according to such variables as color, grain and markings. The grade of flooring is the primary determinant of how the floor will look once it is installed, sanded, and finished. Stains can be used to alter color but wood characteristics and other marks that determine grade can remain noticeable and are likely to remain after finishing depending on the color. The grades of wood are "clear," "select," #1 common, and #2 common. The first two grades have fewer markings and are more consistent in appearance than the "common" grades, which may have a variety of markings. Unfinished NOFMA-certified flooring in any of the four grades —clear, select and two common grades—will result in a serviceable floor. The primary differentiator between the grades is the degree to which natural characteristics or manufacturing marks are allowed, and the average length.

Types of Wood Flooring

Solid Wood Flooring

"Solid wood" means that each flooring piece is made from a single piece of wood. Each exposed part is made of pieces of genuine hardwood and nothing else.

Solid wood flooring comes in three basic types:

- Strip flooring accounts for the majority of installations. Strips usually are 2-1/4 inches wide, but also come in widths ranging from 1-1/2 inches to 3-1/4 inches. They are installed by nailing to the subfloor.
- Plank flooring boards are at least 3 inches wide. They may be screwed to the subfloor as well as nailed. Screw holes can be covered with wooden plugs.
- Parquet flooring comes in standard patterns of 6-inch x 6-inch blocks. Specialty patterns may range up to 36-inch square units. Parquet often achieves dramatic geometric effects of special design patterns.

Solid wood flooring expands with changes in a facility's relative humidity—which can be addressed during installation by proper acclimation, environmental control and field expansion, if necessary. In addition, expansion gaps between the floor and the wall are necessary in the event of excess water.

Engineered Wood

Engineered wood is made of several layers of different woods or different grades of the same wood stacked and glued together under heat and pressure to form a single plank. Several layers of veneers can be stacked with every other piece placed in opposite directions—an arrangement that makes the engineered wood resistant to expansion and contraction to the same extent as solid wood. The finished plank is more dimensionally stable in width than solid wood. The top piece of wood can be made of any wood variety and will be less expensive than a solid wood plank from that same wood species. Engineered floors can be mechanically fastened, glued, or floated. Most products are pre-finished by the manufacturer. Engineered wood flooring reacts less to changes in humidity than solid wood, except for length changes.

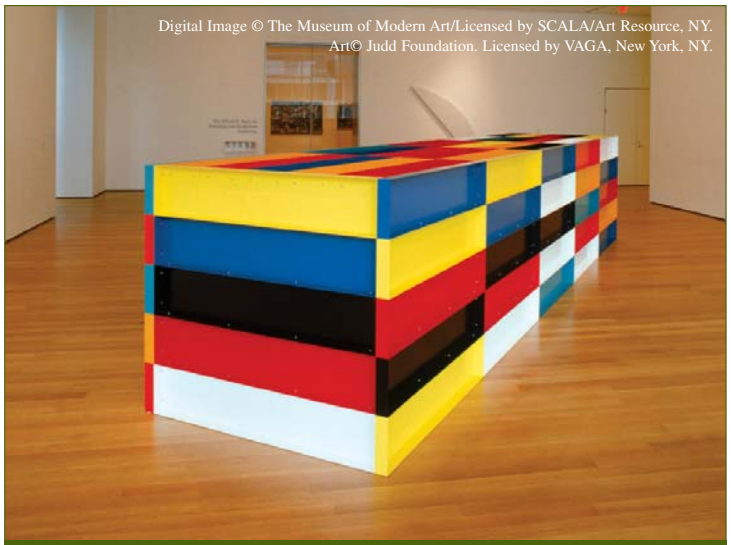
Hardwood floors are frequently specified in high-traffic settings—from stores to hospitals to museums—that log in millions of visitors a year.

Popular Species

Because of their durability and ability to withstand heavy wear and tear, certain hardwood species are a better choice for high-traffic flooring applications. Some of the most popular American hardwood flooring choices include:

Red Oak. The heartwood of red oak is a pinkish reddish brown and the sapwood is white to light brown. The wood is similar in general appearance to white oak, but with a slightly less pronounced figure due to the smaller rays. The wood is mostly straight-grained, with a coarse texture. Red oak machines well, nailing and screwing are good, although pre-boring is recommended, and it can be stained to a good finish. It can be stained with a wide range of finish tones.

White Oak. White oak heartwood is impervious to liquids, and has been used extensively for ship timbers, barrels and casks. The sapwood is generally light-cream colored and the heartwood is light to dark brown. White oak is mostly straight-grained with a medium to coarse texture, with longer rays than red oak.



White oak floors at the Museum of Modern Art are comfortable underfoot for millions of gallery visitors, and easily support massive objects.

At the Museum of Modern Art in New York, (MoMA) which averages some 2.5 million visitors a year, the choice for aesthetic, durable flooring was 120,000 feet of American white oak that blends with the glass and granite in the galleries. "With museums in general, the floor should be a backdrop, not call attention to itself. The less active the grain, the better," notes Roger Berk of Haywood-Berk Floor Co., which worked with MoMA on the floors. The oak was FAS grade ("first and second"), NHLA's clearest grade, which bears few if any knots or other natural marks.

The flooring used at MoMA was a 4-inch face by random 3-foot to 16-foot lengths, and 3/4-inch thickness, conventionally tongue-and-grooved. "Length was a major issue, because the gallery sizes are so large that, without the length, it would look very choppy and full of joints—very unattractive," says Berk, noting that one of the galleries is 17,000 square feet. After a year in service and two-and-a-half million visitors, not counting special events, Berk reported that the floor was "holding up quite well."

Cherry. The heartwood of cherry varies from rich red to reddish brown and will darken with age and on exposure to light. In contrast, the sapwood is creamy white. The wood has a fine uniform, straight grain, satiny, smooth texture, and may naturally contain brown pith flecks and small gum pockets. Cherry is easy to machine, nails, and glues well and, when sanded, it produces an excellent smooth finish. Cherry is softer relatively speaking than some of the other hardwood species.

Hard Maple. The sapwood is creamy white with a slight reddish brown tinge and the heartwood varies from light to dark reddish brown. The amount of darker brown heartwood can vary significantly according to growing region. Both sapwood and heartwood can contain pith fleck. The wood has a close fine, uniform texture and is generally straight-grained, but it can also occur as "curly," "fiddleback," and "birds-eye" figure, which is generally only available in commercial volumes as veneer. The wood is hard and heavy with good strength properties, in particular its high resistance to abrasion and wear.

While hardwoods are often associated with a certain formal, elegant design aesthetic, certain species and cuts can work to achieve a more untailored look. Mainstream retailer American Eagle Outfitters, for example, uses hardwoods in all its 949 stores. "We have used oak, ash, and maple," says John Bezek, Vice President of Construction. "We typically are looking for a 'casual' feel in our stores and the rustic or lesser grades of these species seem to fit the bill."

Subflooring

A solid hardwood floor is only as good as its subfloor. The construction of the hardwood floor, as well as the type of subfloor will determine the method of installation. Options available for subflooring include: floating floor systems, mechanically attached subflooring systems, and wood framed subflooring systems. The requirement of any subfloor is that it be clean, dry and flat.

At MoMA, a special subfloor incorporating small synthetic rubber cushions (a floating floor system) was required for strength and resilience. "One of the things we always recommend very strongly in museums—partially so people will spend more time in the museum and not complain about getting tired feet—is to put in a floating floor," says Berk. "It's basically a very sturdy version of a basketball or athletic floating floor, resilient but stiff enough to support major works of art. Berk notes the likeness to a dance floor. "But dance floors are much springier," he says. "You can actually see a dance floor deflect under the weight of a dancer. We never want that to happen here, because of the art the floor must support. But the same principle applies."

Hardwoods in Other High-traffic Applications

Hardwood applications in high-traffic areas are not limited to flooring, with designers opting to specify a variety of species for ancillary uses. Pennsylvania State University's department of forest resources celebrated its centennial in 2007 with a new $27.5 million facility for its almost 600 faculty, staff, undergraduate and graduate students in the program. The 96,000-square-foot building fully utilizes hardwood species native to the region. "Due to the nature of the project, we were very spoiled as to the amount and the quality of local hardwoods we were able to use," explains Kevin Aires, AIA LEED®, project architect at BLT Architects in Philadelphia. "Even though we had so many species available to us, we limited the wood use to three main species—cherry, ash and red oak."

The Penn State University Forest Resources Building is a LEED® Silver, 96,000-square-foot building. Exposed structural elements of the building, such as beams, trusses and columns, demonstrate the uses of wood and the beauty of natural elements. Ash, cherry, red oak, panel and trim, are used throughout.

The bulk of wood used in the high-use public spaces is cherry, which was specified for paneling, allied seating, trim and millwork throughout the facility. While ash and red oak were used for trim and paneling in the conference areas, cherry makes up most of the visually evident hardwood. "Cherry is very attractive and popular, so that's why we used so much of it in the public areas," says Aires, noting that every piece of paneling used was solid wood. Aires explains, "In terms of the solid cherry, there were really no obstacles or hang-ups other than educating ourselves as to the differences between veneer and solid wood." Since the design team was working with all-natural, non-engineered wood, the wall panels could only be as large as nature would allow. Aires contends that the limitations of the panel dimensions were not an issue. "Because all of the wood was solid, you can really see the grain. In order to highlight this aspect of the design, we went with a clear natural finish," says Aires.

Life Cycle Cost

If other factors are considered beyond initial purchase price and installation of hardwood floors, hardwoods have been shown to be actually less expensive overall than sheet vinyl, linoleum, carpet and other alternatives. Broadloom and tile carpeting, because of its four-to-six-year life span, needs to be replaced three times more frequently over a 15-year lifespan than a hardwood floor. After 15 or 20 years of use, hardwood flooring can gain a fresh, new appearance with refinishing for roughly half the cost of replacing carpet or other flooring options. Hardwood floors can last 25, 30, even 50 years or more. As American Eagle's Bezek puts it, "The hardwood itself is forever if you don't mind staying with the same look and refinishing. We have had some floors down for 20 to 30 years but this doesn't happen often because the architects want to change the look."

Several studies point to the favorable life cycle cost implications of natural materials, and hardwood floors in particular, over synthetic materials. For example, in her life cycle cost comparison of a dozen frequently used synthetic and natural flooring products, Sue Tartaglio, Interior Designer, Burt Hill, Butler, Pennsylvania, shows that in facilities with a lifetime use of more than 15 years, hardwood flooring, while it may have higher upfront costs, has life cycle costs that are significantly lower. These findings were based on manufacturers' published maintenance data/life cycle costs, and conversations with manufacturers' representatives.

A study by Ducker Research Company, Inc., comparing the life cycle cost of maple gymnasium flooring to that of PVC and poured urethane, found that maple flooring shows a significant advantage. According to the study, the life cycle cost of PVC is 42 percent higher than maple flooring. In addition, the life expectancy of one maple floor is two and one half times that of a PVC floor. Assuming a 38-year life span, one maple floor is the equivalent of more than two PVC floors. Likewise, the life cycle cost of poured urethane flooring is 40 percent higher than that of maple flooring.

A 1997 study by Jönsson et al., which examined the environmental impacts of linoleum, vinyl, and untreated solid wood flooring in Sweden using life-cycle assessment, found that because linoleum and vinyl both require extensive material inputs relative to wood, solid wood flooring was more environmentally sound. In their 2006 study of the flooring industry in Germany, Nebel, Zimmer, and Wegener examined the whole life cycle of four wood floor coverings, including solid parquet, multilayer parquet, solid floor boards, and wood blocks. The authors point out that, compared with all German gross domestic products, wood flooring contributed significantly less (factors of 5 to 50 lower) to impact categories including climate change, acidification, eutrophication, photo-oxidant formation, and ozone depletion. The authors further note that substituting water-based glues for those made from solvents could reduce photo-oxidant formation by nearly 70 percent. Storage of carbon inherent in wood flooring coupled with energy production alternatives to fossil fuels realized by residual wood and post-consumer wood streams, claim the authors, represent significantly reduced, perhaps even negative, global warming potential for these products.

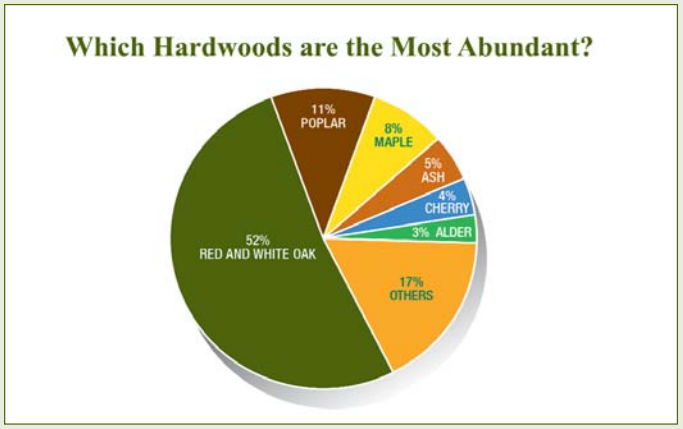
In 2004 research, the Consortium for Research on Renewable Materials (CORRIM), a U.S. non-profit corporation of 15 research universities, concluded that steel framing used 17 percent more energy than wood construction for a typical house in Minnesota, while concrete construction used 16 percent more energy than a wood construction house in Atlanta. In both situations, the consortium found that the use of steel had 26 percent more global warming potential than wood, and concrete had 31 percent more.

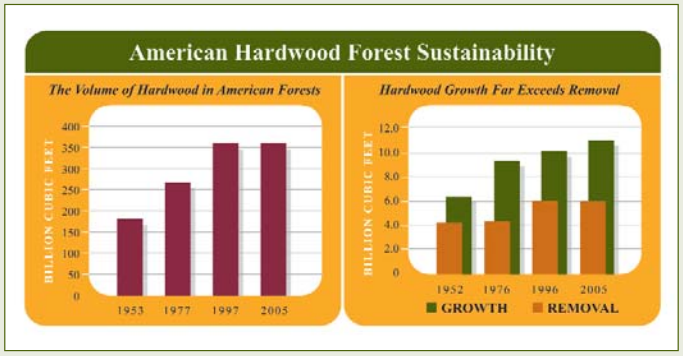
The Athena Model, developed by the non-profit Athena Sustainable Materials Institute, compares the cradle-to-grave ecological quotient of wood, steel and concrete across the six stages of a material's life expectancy: resource extraction, manufacturing, on-site construction, facility occupancy, and demolition and ultimate reuse or recycling. The Athena Model found wood to have the lowest environmental impact in each of these categories, and that wood exceeds the other materials in terms of environmental soundness and energy use; production of greenhouse gases; air and water pollution; production of solid waste; and overall ecological resource use.

A Renewable Resource

Hardwoods are one of the original renewable resources. Today's hardwood forests grow far more wood than is harvested from them every year—a situation that ensures that, at current volumes, American hardwoods will be around for generations to come. In fact, the U.S. Forest Service states that the hardwood volume in American forests increases by about 10 billion cubic feet yearly, while annual removals total only 6 billion cubic feet. Consequently, the volume of American hardwoods is 90 percent larger than it was 50 years ago.

Each hardwood species requires a particular set of conditions to thrive—soil, nutrients, moisture, warmth, sunlight or shade. That's why most species distribution varies by region. For example, natural forces have determined that the oaks grow from New England to Mississippi in more abundance than any other hardwood species.





Hardwood Finishes

Manufacturers offer a wide selection of finishes designed to enhance and protect the wood floor, each with its own distinct benefits and appearances.

Surface Finishing

Surfaces finishes involve applying a stain to achieve a particular color, followed by a top coat of polyurethane or varnish to give a protective coat. Surface finishes are durable, they resist moisture, and are easy to maintain. There are four options for the top coat, and each has its own benefits:

Oil-based Urethane is a commonly used floor finish. Available in gloss, semi-gloss, and satin sheens, oil-based urethane is generally applied in two or three coats, with drying time of up to eight hours for each coat. This type of finish dries by evaporation of petroleum-based solvents, so adequate ventilation is important. The finish will also amber as it ages.

Water-based Urethane, another commonly used finish, provides a clear, non-yellowing finish and produces fewer odors than other choices. This product dries quickly. There are a number of choices of water-based finishes, which include different blends of acrylic and urethane resins and one component, or those requiring different additives.

Moisture-cured Urethane is a solvent-based polyurethane that is more durable and more moisture-resistant than other surface finishes, and is ideal in commercial, high-traffic settings. This finish is available in a satin or gloss non-yellowing formula, as well as one that will take on an amber hue with age. The finish relies on humidity to cure and is generally unsuitable for use in very dry areas. It should only be used by a professional familiar with the product.

Conversion Varnish is a product which resists yellowing. It produces a "rich" pleasing patina. It is flammable, and like moisture-cured urethane produces a very strong odor and should only be applied by a skilled wood flooring professional.

Knowing the species is a prerequisite to choosing the surface finish.

"Cherry will actually deepen in color over time and its natural state has many variations, so we actually stained it to get a more uniform initial color. Then it will deepen with a similar darkness as opposed to letting it change naturally," says Katrina Barnett, AIA, Radelet McCarthy Architects and Interior Designers in Pittsburgh, which has used hardwoods in several local hospitals, reflecting a growing trend to incorporate natural materials in health care settings.

Penetrating Finishes

These finishes actually penetrate the wood to form a protective seal. The stains soak in to provide color, and a wax coating gives a low-gloss satin sheen that can be maintained with additional thin applications. These finishes require special care—water-based products should never be used to clean or maintain the floor, only solvent-based waxes, buffing pastes, or cleaning liquids specifically made for wax-finished wood floors.

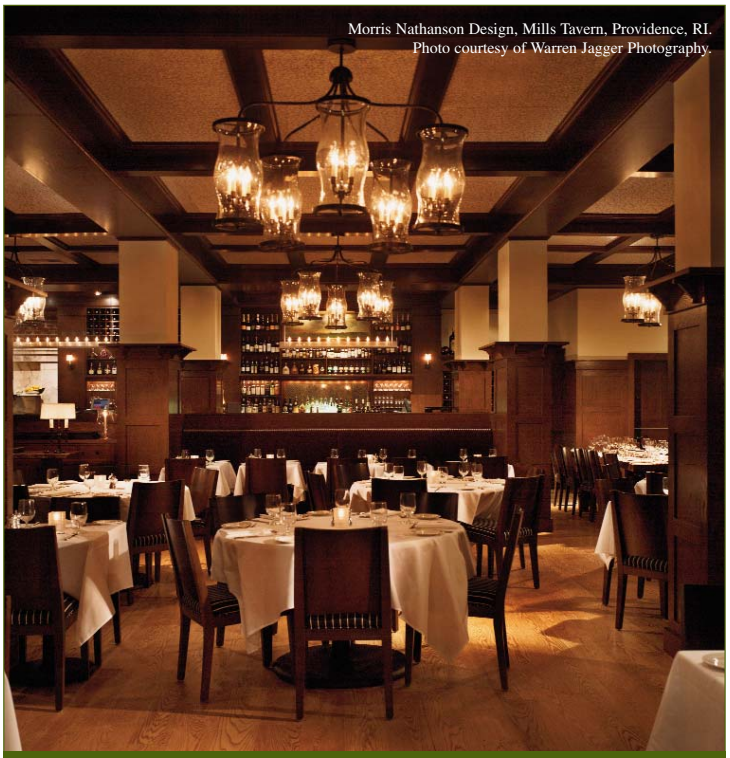
Particularly in high-traffic settings, the latest trends in finishes include products designed to further extend the life of hardwood floors.

Factory-finished and site-finished floors can be equally durable in high-traffic areas. Some factory-applied finishes contain aluminum oxide to enhance the abrasion-resistance qualities of the floor.

Acrylic-impregnated floors, in which acrylic and color are forced into the pores throughout the wood through a high pressure treatment, are extremely resistant to abrasion and moisture. They are among the most expensive and are used in very high-traffic commercial settings. Scott McFadden, Vice President and Director of Design at Maregatti Interiors, reserves acrylic impregnated products for ultra-high-use settings in hospitals andcorporate environments. To demonstrate its

durability to a client, McFadden had samples of various flooring materials put to a "wear" test. "The acrylic-impregnated floor held up slightly better than even the terrazzo floor," he says.

Particularly in high-traffic settings, the latest trends in finishes include products designed to further extend the life of hardwood floors and make them more durable than ever.



Morris Nathanson Design, Mills Tavern, Providence, RI. Photo courtesy of Warren Jagger Photography.

White oak flooring was chosen for its light color and the control of the grain in this 4,700-square-foot restaurant.

On-site versus Factory Finishes

Because flooring is subject to minute inspection and must withstand substantial wear and tear, a thorough consideration of all factors involved is advised in the decision of whether to use on-site finishing or a factory-finished application.

A high-quality, site-applied finish requires planning, adequate time and careful attention to detail. That deep, glossy, finished look involves repeated sanding, proper cleaning and multiple finish coats. Finishing floors on site requires more time and skill than installing factory-finished materials. Finishing a hardwood floor in the field can tie up a work site for five or more days and requires extensive preparation. Other work that could jeopardize the quality of the finish will have to stop, adding time to any construction schedule. Many designers prefer the rich look of flooring finished on site and the consistent finish that can be uniformly applied across the entire installation.

At MoMA, the wood flooring was finished on site. "That involved the standard Museum of Modern Art practice, which is to put on two coats of linseed oil and then wax the floor. No urethane," says Berk. "Many museums—the ones that have a lot of wood floors—have something like that. They use some kind of traditional finishes like oil and wax—this is partially because the off-gassing of certain chemicals is a problem."

To address any potential off-gassing problems, BLT Architects' Aires says, "All adhesives, sealants, paints and wood finishes used in the Penn State construction were specified to meet LEED's low-VOC requirements. Because this project was a university-funded venture, an open spec was necessary. Wood finishes and polyurethanes specified included low-VOC products."

In contrast to on-site finishing, factory finish is a trend that is gaining in popularity. With factory-finished flooring, the manufacturer applies a finish at the factory, typically at least four coats of ultraviolet-cured urethane resin. Manufacturers say these finishes are more consistent and durable because they are applied under strict controls. Factory-finished floors can be installed straight out of the box, which can make the job easier. Factory-finished hardwood products can offer consistent quality and quick installation due to the following factors:

- **Controlled Environment.** Manufacturing takes place in a controlled environment without the need to contend with the effects of other building trades working nearby. Dust, traffic, temperature and humidity are out of the picture.
- **Consistency.** Factory-finishing operations work with low-pressure, high-volume spray guns and spray booths, and roll-coating techniques, so uniformly good appearance from piece to piece comes much more easily. Maintaining consistency across a whole installation is another matter—when cutting and mitering expose fresh wood, a factory finish is difficult to match, and touch-ups are tricky if there's damage on a busy jobsite. Finish-matching is easier, however, if you ask the supplier for a touch-up kit. Most manufacturers will supply stains and coatings from the same batch used on your materials, with instructions. A factory-finished floor will not be as flat as a site-finished floor. Some "overwood/underwood" should be expected.
- **Additional Steps.** On-site finishing is generally a process consisting of three steps—stain, seal, and finish coat. But a manufacturer can go through four, seven, even 13 or more steps with additional sanding and extra finish coats that add richness and depth. However, if both processes are completed professionally, a site-applied or factory finish can be the same.
- **Cost.** Per linear foot, factory-finished hardwoods can cost substantially more than unfinished products. But despite high upfront costs, installation is quicker and less expensive, without the need to be concerned about regulations for stain and finish material waste disposal.

Says Terry Jackovic, Senior Manager, Facilities and Real Estate Development at American Eagle Outfitters, "We have done both finished in-place and pre-finished over the years. Depending on the look, costs, durability, installation time, etc., we think there is no substitute for the authentic feel of a finished-in-place floor. But quality control and installation time can be a challenge. Although the finish-in-place products are excellent these days, pre-finished allows us to move a little quicker, control the finished product better and maybe gain a little in durability. We typically use pre-finished except on rare occasions."

Atwater Commons dining hall floor at Middleburry College in Vermont is 6,500 square feet of hard maple, entirely harvested from campus-owned forests. Serving 700-900 students daily, the floor holds up well. Once yearly, it is buffed down to the bare wood and a low-VOC, water-based sealer is applied.

Maintenance

For the most part, hardwood floors can be maintained with simple, routine cleaning measures.

The main damage to a wood floor comes from debris. Dirt, dust and grit can dull a floor's finish and cause scratches that can only be repaired by refinishing. Regular sweeping with a broom that features exploded tips to trap dust and dirt, not simply spread it around, is recommended. Vacuums with beater bars can cause dents in the floor's finish. Regularly cleaned matting systems at the building entrances help trap dirt and grit.

Regardless of its finish, a hardwood floor will quickly lose its luster if exposed to excessive water, and may even warp. Some steam cleaners are appropriate for use on wood floors, but if the finish is worn or scratched, steam could seep into the wood, eventually causing damage.

Another concern is ultraviolet radiation in sunlight which can cause discoloration over time. The ultraviolet rays that can burn and age skin will affect any organic material, including wood. Prolonged exposure to sunlight will change the color of virtually any wood floor, regardless of the stain or finish. Some woods lighten when exposed to sunlight. Others, like cherry and oak, tend to darken. Some finishes feature sunscreens to help block the penetration of ultraviolet rays, extending the time it will take the wood to change.

"We don't do a lot in the way of exotic maintenance," says American Eagle's Bezek, explaining that quarterly cleanings and application of a low-sheen maintenance coating are standard. "We are not adverse to some natural wear that goes with the casual feel. This is one point we feel finished-in-place wins out. The wear is more natural," he adds.

On the other hand, at MoMA, the floors are groomed virtually on a day-to-day basis and maintained with wax. "This has been something that a lot of museums insist on, which we don't always recommend to people," says Berk. "But they have the resources for continuous maintenance. It's very labor intensive, and requires a lot of money and time, and MoMA has been doing it very successfully. They wax, they clean, they remove wax, they rewax, and it's held up very well. They have a major maintenance contractor and they budget for it, which most places can't afford."

Particularly with the advent of high-strength finishes, American hardwoods are a viable choice for high-traffic settings with the added benefit of warmth, elegance and richness. Their other attributes make them economical, sustainable and healthy choices as well. ■

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Program title: **"American Hardwoods for High-Traffic Areas " (12/07).** AIA/CES Credit: This article will earn you one AIA/CES LU hour of health, safety, and welfare credit. (Valid for credit through December 2009). **Directions:** Refer to the Learning Objectives for this program. Select one answer for each question in the exam and fill in the box by the appropriate letter. A minimum score of 80% is required to earn credit. **To take this test online, go to continuingeducation.construction.com**

Learning Objectives

After reading this article, you should be able to:

- Evaluate the suitability of specifying American hardwoods in high-traffic settings
- Explain how life-cycle thinking influences green building products selection
- Consider appropriate finishes for hardwoods in different settings
- Discuss economic considerations for hardwood maintenance and care

Questions

1. The Janka Rating System measures:
❑ **a.** the quality of wood.
❑ **b.** the relative hardness of wood.
❑ **c.** character markings.
❑ **d.** manufacturing marks.

2. Engineered wood is:
❑ **a** not dimensionally stable.
❑ **b.** more expensive than solid wood.
❑ **c.** affected less by changes in humidity than solid wood.
❑ **d.** cut in 6-inch by 6-inch blocks.

3. White oak:
❑ **a.** is impervious to liquids.
❑ **b.** is a dark sapwood.
❑ **c.** contains brown pith flecks.
❑ **d.** can also occur as "curly" or "fiddleback."

4. Beyond initial costs and installation, hardwoods:
❑ **a.** slightly exceed the life cycle cost of vinyl.
❑ **b.** are very expensive to refinish.
❑ **c.** are less expensive overall than other alternatives.
❑ **d.** are equal in cost to other alternatives.

5. The water-based urethane finishes:
❑ **a.** are apt to turn yellow.
❑ **b.** accelerate color changes.
❑ **c.** dry quickly.
❑ **d.** are the most commonly used floor finishes.

6. A type of finish extremely resistant to abrasion and moisture is:
❑ **a.** oil-based polyurethane.
❑ **b.** conversion varnish.
❑ **c.** aluminum oxide.
❑ **d.** acrylic impregnated.

7. Manufacturers say factory-applied finishes are more consistent and durable because they:
❑ **a.** are applied under strict controls.
❑ **b.** can have conversion varnish applied.
❑ **c.** are dust free.
❑ **d.** contain acrylics.

8. Finishing floors on site requires more time and skill than installing factory-finished materials.
❑ **a.** True
❑ **b.** False

9. The main damage to a wood floor comes from:
❑ **a.** sunlight.
❑ **b.** high traffic.
❑ **c.** debris.
❑ **d.** scuff marks.

10. Compared to 50 years ago, the volume of hardwood in the United States today is:
❑ **a.** the same.
❑ **b.** 20 percent less.
❑ **c.** 50 percent less.
❑ **d.** 90 percent larger.

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Material resources used: Article: This article addresses issues concerning health and safety.

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The Hardwood Council

The Hardwood Council serves architects, designers and builders by providing useful information about North American hardwoods in sustainable design and building. As an independent, nonprofit organization, the Council advances better understanding of hardwood flooring, furniture, cabinetry and millwork, without bias toward specific products or manufacturers. For more information about The Hardwood Council, and North American hardwoods, please visit **www.hardwoodcouncil.com**