sustainable design trends
IN WINDOWS, DOORS + DOOR HARDWARE

BY C.C. SULLIVAN, CONTRIBUTING EDITOR

Ask fenestration experts and interior design consultants what they're looking for in windows and doors for their projects, and they won't hesitate to tick off this list: speed to the project site, a fair price, resilient and sustainable performance, and no callbacks.

"Demand for an economical solution for openings that does not sacrifice quality or performance, that's what is driving the commercial construction market," says Valerie Bevens, an Architectural Hardware Consultant certified by the Door and Hardware Institute (www.dhi.org) and a Technical Services Manager with Timely Doors. "Uniformity and simplicity also play a factor when selecting products as part of prefinished opening systems."

In fact, door and window manufacturers have been responding with increasing alacrity, thanks to the use of just-in-time manufacturing and mass customization.

As an example, Bevens recounts a large order submitted to her company for a Kaiser Permanente medical office building. "This project had numerous hardware preparations that were not available from Timely prior to 2010," she says, a fact that kept the company from involvement in other building projects by the managed healthcare giant. Instead, the company retooled and quickly launched a new line of preparations specifically to meet the need—opening the door for new business while also establishing a niche for a durable, value-driven hardware offering that would work for other institutional end users.

Window and door companies are also exploring novel approaches to lean manufacturing that parallel interest in sustainability. Waste drives cost, according to architectural door manufacturer VT Industries. To keep waste to a minimum, VT employs every various means of lean manufacturing—from reusing scraps of core materials to heating its plants with sawdust left over from the manufacturing process.

With VT, Timely, and other producers, the interest in low-impact manufacturing extends to their evolving supply chains, which are remapping operations. The new distribution models value nearness of centralized operations—in other words, plants and warehouses closer to the project site. The approach that is not only more efficient but also helps meet the U.S. Green Building Council's LEED certification criteria for regional materials in more parts of the country than ever before.

This focus on sustainable design standards reflects an industry that is keen to meet and exceed building codes as well as new performance criteria, both voluntary and prescriptive.

COURTESY NANAWALL SYSTEMS

The HKS-designed Salt River Fields at Talking Stick, near Scottsdale, Ariz., spring training facility for the Arizona Diamondbacks and the Colorado Rockies, and one of the first LEED Gold-certified sports venues. The sliding glass wall systems can be used as doors or to open up the training facility to the outdoors and allow natural ventilation.

LEARNING OBJECTIVES

After reading this article, you should be able to:

+ LIST the sustainability and performance benefits of a wide selection of window and door products.
+ DISCUSS green building standards, labeling programs, and new codes affecting window and door specifications and designs.
+ DESCRIBE the variables of window/door selection that impact sustainability and occupant/tenant health, safety, and welfare, including productivity and comfort effects.
+ EXPLAIN the impact of sustainability advances, such as environmental product declarations, on window and door selection.

KEEPING UP WITH CODES + STANDARDS

Codes and standards related to window and door technology, however, are like a thousand moving targets, which the Building Team has to hunt down and wrestle with, one at a time. For interior doors, for example, the codes and standards are changing subtly and more frequently than many expect. The key language to follow applies to exit widths, the Americans with Disabilities Act, path of travel, fire barriers and separations, and security.

Among the most sweeping changes are relatively new standards from the Window & Door Manufacturers Association (www.wdma.com) for architectural wood flush doors and stile-and-rail doors. At the time of their introduction two years ago, WDMA called the new documents "a major overhaul and rewrite," which included harmonizing with the Architectural Woodwork Institute's standards and adding updated face veneer charts, factory finishing guidance, and a specification checklist cross-referenced to other standards. "The trick has been crafting the standards to allow for product innovation and environmental sustainability while at the same time preserving the high quality and performance that architects and specifiers demand," says Jeff Lowinski, WDMA's Vice President of Technical Services.

At the building perimeter, the improvements to fenestration codes are significant. According to Julie Ruth, PE, a Code Consultant for the American Architectural Manufacturers Association (www.aamanet.org), there's a raft of changes for jurisdictions adopting the 2012 International Building Code (IBC) in place of the 2009 edition. For example, there is no distinction between metal and nonmetal framed fenestration in the International Energy Conservation Code (IECC) commercial prescriptive rules, which are referenced by the IBC.

Among other significant changes for exterior windows and doors:

- Updates to the 2011 North American Fenestration Standard (NAFS) Standard/Specification for windows, doors, and skylights.
- Elimination of separate energy-conservation provisions for residential construction in the IECC.
- New mandatory daylighting requirements combined with automatic daylighting controls in the IECC for certain large, open public spaces.
- New strength design-based wind speed maps from ASCE 7-10 Minimum Design Loads for Buildings and Other Structures (from the American Society of Civil Engineers), used for calculating design wind pressures.
- A new exception to the minimum windowsill height requirements for windows equipped with opening-control devices.
- Revised minimum sill heights for operable windows.
- Removal of the distinction between metal and nonmetal framed fenestration in the IECC's commercial prescriptive rules.

In addition, there are life safety matters to address for both interior and perimeter opening products, and new designs and features are geared specifically to those challenges, too. Special situations, such as cross-corridor fire separations or areas where occupant traffic control is desired or mandated by code, may call for double-egress doors. What's different today is that some manufacturers have made it possible to match the double-egress openings with all other interior doors, allowing a more unified look.

COURTESY ASSA ABLOY

Door security packages for metal doors like the ones used for the National Renewable Energy Laboratory can come with documentation of material contents, such as with a Health Product Declaration, or HPD.

Many building codes relating to egress doors are based on National Fire Protection Association (www.nfpa.org) standards. The most basic is NFPA Standard 101, which determines how an egress door should be designed, installed, and operated. Exit door hardware, on the other hand, may be listed by UL (www.ul.com, formerly known as Underwriters Laboratories) as well as the Builders Hardware Manufacturers Association (www.buildershardware.com), which serves North American manufacturers of commercial builders hardware and publishes standards under the auspices of the American National Standards Institute (www.ansi.org). The published ANSI/BHMA standards must be updated every five years.

NFPA 80 regulates assemblies and devices that protect openings in walls, floors, and ceilings against the spread of fire and smoke, except fire-safety fabric curtains, fire-resistive glazing, and sliding- or folding-glass wall assemblies. (Walls, including opening glass partitions, are tested to NFPA 251, which covers building construction and materials.) Other requirements pertain to specific types of openings, such as power-assist doors that include a blow-open feature for smoke ventilation, covered by NFPA 92B.

UL also certifies windows and doors as systems for structural fire resistance and separation of spaces to safeguard against the spread of fire and smoke. (See http://ulstandardsinfonet.ul.com/scopes/ for details.) UL fire ratings include UL 9, a standard for fire tests of window assemblies; for means of egress, the key standards include UL 10B for testing door systems as well as UL 10C, which certifies the positive-

pressure fire tests required for door assemblies. Door ratings vary, but typical requirements might be a 45-minute fire rating for an acoustical wood veneer door, while a hollow metal door might be expected to carry a rating up to three hours for critical opening applications. The same three-hour label could be offered by a specialized life-safety product, such as a blast-rated, pressure-resistant door assembly.

Some life-safety standards are based on equipment testing protocols. For bullet resistance, for example, the standard UL 752 covers specialized materials and devices suitable to protect against armed robbery, yet it also covers construction materials, window assemblies, and walls and other barriers. Windows and doors may be tested and certified with UL 752, typically for levels 1 through 8, with higher numbers describing the escalating potency of ammunition that the assemblies can thwart.

DOOR AND WINDOW ACOUSTICS

Acoustics is an essential aspect of window and door assembly design, because it directly impacts occupant comfort, health, and productivity.

"Often the wall is specified but the door opening is overlooked in acoustical control," says Whitney Vitale, with ASSA ABLOY Door Security Solutions. "Now it is possible to get an opening tested to meet sound control requirements." This step is also required to meet the privacy rule in HIPAA, the federal Health Insurance Portability and Accountability Act.

With these considerations in mind, manufacturers have introduced products with better acoustic performance across both standard and premium lines.

Consider standard dual-pane windows, with a sound transmission class (STC) rating of around 27 but which, according to manufacturer Jeld-Wen, can be improved to STC 34. One way to do that is to use dissimilar glass panels on the insulated glazing unit; for example, using one pane that is 1/8-inch thick and another that is ¼-inch thick. One pane targets lower-frequency sounds, while the other handles higher frequencies.

COURTESY TIMELY INDUSTRIES

Increasingly, doors are being specified with interior glass, sidelights, and vision panels to bring daylight deeper into the floorplate and, in some cases, earn LEED, Green Globes, and other green certification credits.

Each pane in a dissimilar glass unit blocks different sound frequencies, according to window maker Jeld-Wen, which states that dual-pane windows with dissimilar glass can achieve STC ratings nearly as high, if not as high, as triple-pane or laminated glass.

This may surprise many designers, but the physics is straightforward. One reason is that the triple-glazed units have smaller air spaces between the glass panes, which may increase reverberation. Laminated glass also has less airspace, and in the best cases provides only an incremental acoustical improvement of about 1 point toward the STC. Other factors in window selection include the materials (for example, wood generally outperforms aluminum), glass-to-frame/sash ratio (higher is better), and air infiltration (tighter is better).

Sound transmission class (also called sound reduction intensity, and expressed in decibels, or dB) is not the only acoustical rating to consider in window or door selection, but it is easily the most important. STC summarizes the product's efficacy at blocking and isolating sound in a single, memorable number. Testing for STC involves placing the door or window into a void connecting the openings into two acoustical chambers. A controlled sound generated on one side is measured on the other side, and the dB reduction is essentially the rating. For example, if the noise source is 74dB and the measured sound through the opening assembly is 36dB, the difference is the STC: 38.

In this example, the STC of 38 is typical of ratings for standard large windows with storm sash and air space that might be found in typical residential projects. A standard hollow-core door may have a rating of only 20, in part due to the "leaking" of sound between the door and frame. A simple gypsum board wall with an air space and a sound attenuation blanket easily exceeds these values, with a typical STC of about 45. Density helps also: A concrete masonry unit wall achieves STC 49 without any added insulation.

The poor acoustical values inherent to the components of windows and doors are worsened by leaking (also known as flanking), in which noise is transmitted through areas within or adjacent to an impervious, solid assembly. Recent door designs have focused on minimizing the gap between the swinging or sliding door and the wall to cut sound transmission—and, not incidentally, to provide improved aesthetics, says Jessy Servol, Architectural Business Manager for Klein, a maker of interior glass doors. Improvements in gaskets, damping pads, and absorptive layers, as well as the use of heavy, solid materials, will benefit doors and windows with opaque areas or spandrels.

In fact, recently introduced specialty door assemblies have achieved some of the highest ratings ever for both wood and metal doors, including swinging and sliding types, which are used in performance centers, recording studios, industrial facilities, and high-security locations such as defense installations, according to Krieger Specialty Products. The products are tested and certified according to ASTM E-90, which measures sound transmission loss (STL), as well as ASTM E413, which rates sound insulation. Many manufacturers also offer field installation and testing for projects that require precise performance.

DESIGN TRENDS AND OPENING ADVANCES

Good acoustics is a critical variable influencing today's best building enclosures, core designs, and interior fitouts. Acoustical comfort is seen as essential to a positive, productive occupant experience.

There is growing sense among designers that enhanced interiors can improve organizational effectiveness, market leadership, and even bottom-line growth, especially among clients who value visual transparency in the work environment. This has led to more use of glass interior doors and vision panels, as well as glazed partition systems, storefront-style openings, and operable glass walls. "Workplace clients have more overall connectivity with their staff, or they can expand their visual experience and make environments more spacious," says Servol. Sliding doors can also save interior space.

Space-saving openings are increasingly used where conventional swinging doors and sliders have been used in the past, adds Matt Thomas, Marketing Manager at NanaWall, which makes operable glass systems. "Folding glass walls, single-track sliding systems, and frameless glass wall systems are now engineered with such precision and durable components that they last longer than some of the wall systems around them," he says. "The key is to specify for the expected use and proper exposure, climate, and weather events."

Glass openings also enhance security and safety in a variety of settings. At schools and police stations, for example, officials like the ability to monitor lobby activity or see who is lingering at an entry. Glass openings also allow for a better view during emergency egress or fire drills.

COURTESY DORMA

All-glass sliding door systems can be tested to meet life-safety standards such as NFPA 251, which covers building construction and materials.

At sports stadiums, horizontal sliding wall systems that have been associated with retail entries are increasingly used to allow space for sufficient movement as well as ease of access for large numbers of people, according to DORMA, which makes automatic door operators. Recent projects include the Moses Mabhida Stadium, in Durban, South Africa, which served as a host stadium for the 2010 soccer World Cup, which uses a powerful, fully automatic swing door mechanism. Closing sequence coordinators are also employed in its box suites for fire- and smoke-check double doors.

The new $487 million Amway Center Orlando, designed by architecture firm Populous (populous.com), includes a value-conscious fitout of luxury interior spaces by local design firm Baker Barrios Architects (www.bakerbarrios.com). The 18,500-seat basketball arena's luxury boxes are fitted with frameless, all-glass walls that can be open or closed. The concept, which has recently become a common choice for stadium owners, affords suite occupants some measure of acoustical and physical privacy when desired but with a completely unobstructed view at all times, says NanaWall's Thomas. The operable glass walls ensure high functionality and appeal along with a way to maximize the drama and excitement of professional sports.

With communication and productivity benefits in the workplace, visual security enhancements in schools, and egress and entertainment boosts at performance venues, glass windows and doors create an opportunity for improving the life cycle value and return on investment for a wide range of facilities.

SPECIALTY OPENINGS AND ACCESS CONTROL

Building Teams face major project hurdles in situations that call for acoustical, blast-, and bullet-resistant doors in both wood and metal combinations. According to Krieger Specialty Products, a member of DHI and the Hollow Metal Manufacturers Association (www.naamm.org/hmma), these are typically custom openings built to fit specific wall conditions while at the same time meeting or exceeding ADA and other compliance codes.

A number of advances set the stage for expanded use of these highly protective openings with architectural finishes such as stainless steel. In the late 1980s, for example, the acoustical performance of relatively thin security doors of 1-3/4 inches depth exceeded STC 51 without using a raised sill. A few years later, an STC of 47 was achieved with a one-inch-thick wood door.

Specialty openings often use very thick wood and metal plates, as in security situations. Or they may be used for extra-large openings, as in hospitals and museums. They are often integrated with automatic operators, access-control systems, and other MEP components.

Timely Doors' Bevens notes that custom hardware preparations are now available that match very specific, even unique requirements. Thus, specifiers are no longer limited when selecting hardware for wide or heavy doors or doors with specialty electrical requirements.

"End users are faced with difficult problems when hanging, securing, controlling, and protecting doors," says Bevens. "Much of the

hardware required for doing this requires unique door and frame preparations." Some manufacturers can now prepare frames for very heavy, lead-lined doors requiring electronic access control and monitoring, as in hospital radiology suites. In this case, the maker lines the frame with lead, prepares the frame for heavy-duty pivot sets, and accommodates electrical power transfer to the lockset so that the end user can monitor door position via magnetic contacts.

COURTESY EFCO, A PELLA COMPANY

For a 1917 courthouse building in Clearwater, Fla., new replacement windows match the profiles of the original windows while meeting code requirements for hurricane hazards. The deep metal profile (left) is designed to resist thermal bridging.

Organizing the integration of access control technology and door and window systems are groups like the Electronic Security Association (www.esaweb.org), which deals with electronic life safety, security, and integrated systems. Recent areas of development for this sector include ways to protect building openings with intrusion and fire detection technology as well as novel video surveillance products. ESA recently published the *ESA Electronic Security Guidelines for Schools*, a resource for school officials considering adding or enhancing electronic security on their premises (www.ESAweb.org).

Recent code changes reflect the need for improved security and safety in schools, healthcare facilities, senior care centers, and other places where the occupants may be frail, memory-impaired, or otherwise endangered. One of the most contentious was the push to include more operable windows and glazed openings in healthcare settings—often with specialty hardware and other purpose-built protective features—for reasons ranging from evidence-based design and sustainability to occupant morale.

Life safety is paramount, according to AAMA, which notes in its Window Selection Guide (WSG.1-95), "Most deaths occur in fires because of suffocation, not because of burning." This is a special concern for occupants with limited mobility, such as hospital patient rooms. NFPA has noted, "The least desirable emergency action in a healthcare occupancy is the wholesale relocation and evacuation of patients. For this reason, a defend-in-place strategy is used." Methods to compartmentalize fire and control smoke spread are essential in designing hospital patient rooms. One such technique is the selective use of operable emergency ventilation windows, which when properly used "may relieve smoke in the immediate area without spreading it into previously unaffected areas," says AAMA.

Operable windows and glazed door openings are integral to an effective green building agenda focused on patient health and welfare. AAMA notes the importance of natural ventilation, which will be moved to a new credit area, called "Enhanced Indoor Air Quality Strategies," in the U.S. Green Building Council's LEED v4 revision.

ENERGY CODES FOR WINDOWS + DOORS

Sustainability pervades every segment of building design and construction and is essential to the selection of doors and windows for green building projects, according to window/door manufacturer Pella. Many of the green attributes of doors and windows relate to U-factor, a measure of the rate of heat transfer. U-factor is measured in Btu per hour times square feet times degrees Fahrenheit (Btu/h·sf·°F), and generally falls in a range from 0.25 to 1.25. According to the U.S. Environmental Protection Agency, "The lower the U-factor, the better the window or door insulates.

Another important measure is the condensation resistance factor (CRF), for which AAMA has Testing Standard 1502.3. The CRF is given as a number, usually between 30 and 80 for conventionally glazed fenestration products. Higher CRF numbers signify more robust resistance to condensation. The National Fenestration Rating Council (www.nfrc.org) tests for condensation resistance (CR) with its NFRC 500 standard, for determining the relative likelihood of condensation formation on the inside surfaces of windows. CR is expressed as a number between 1 and 100; the higher the number, the more resistance to condensation by the window or glazed door.

According to ASSA ABLOY's Vitale, there are a number of key measures in recent energy codes and green-building standards that should help guide selection of entry doors. "ASHRAE 90.1-2010 dropped the allowable air leakage for exterior doors in half, to 0.2 cfm per square foot, and states that exterior doors must be labeled by manufacturers or installers to meet operable testing," she says. "ASHRAE 189.1 and the International Green Construction Code really raised the bar for exterior doors. For example, climate zones 5 to 8 now require doors to have operable thermal testing down to a U-factor less than 0.4." This performance level is now mandatory in 15 states and municipalities across the country, says Vitale.

Manufacturers are also tracking an increased use of fiberglass and fiberglass composites for window and door assemblies in sustainable building situations. Some fiberglass materials have a closed cellular structure and a reinforced exterior skin that resist water infiltration and help prevent mold build-up. All of them share relatively

low expansion and contraction rates, a fact that helps maintain a consistent bond between sash and glass, as well as a weather-tight sash-to-frame connection. The units may also test well for U-values, air infiltration resistance, and condensation resistance.

Other frame materials, including woods and metals and hybrid components, can perform well depending on the application, occupancy, and expected use. While aluminum is a high conductor of cold and heat, recently introduced aluminum thermal entrance doors have tested to very high-performance results, according to CRL/U.S. Aluminum, which specializes in architectural glass and storefronts, entrance doors, window walls, and windows and doors. The company notes that metal fenestration can achieve thermal performance levels required for green building projects if it has thermal breaks within the frames as well as foam insulation. U-factors ranging from 0.57 to 0.31 have been recently reported, according to the firm.

Another advance is the use of light-gauge steel frames instead of hollow-metal fabrications. Some of these 20-gage products (as opposed to the traditional 16-gage systems) are paired with a novel engineered method of fastening the frame to the building structure, making them capable of supporting more weight than heavy-gauge frames using conventional installation methods.

COURTESEY KLEIN

Sliding glass doors with no floor track provide a clean look and reduce tripping hazards, while admitting exterior light through a room into adjacent spaces. Recent improvements also reduce noise transmission.

CERTIFYING ENVIRONMENTAL VALUE

Manufacturers of energy-saving, high-performance windows, doors, and hardware are also interested in providing products that promote convenience, comfort, safety, and reconfigurability.

Several manufacturers have introduced solar control options for their windows and doors. Others have added blinds between the glass panels of insulated glass units, which means there is no dust accumulation and no maintenance required for the solar blinds. Others now offer insect screens for their windows, as well as glazing that protects birds from accidental collisions.

Where energy-use concerns meet occupant comfort issues, several manufacturers have introduced low-energy power operators for swing doors, incorporating innovations in the electromechanical drive units as well as improved microprocessors for motion control, according to DORMA. Some of the swing door operators have an onboard power supply, typically delivering 1.5 amps at 24-volt DC; this capability means that a secondary power supply isn't needed. The power-assist systems are now designed to control force and door speed throughout the entire opening cycle, for leaf positions from 0° to 85°. Together, these improvements reduce the physical effort needed to operate even very heavy doors, an ideal benefit for grade schools, senior housing, hotels, and healthcare facilities, as well as any location requiring compliance with the ADA.

Options for power-assist doors are growing, too. Models have a range of programmable options, including a permanent hold-open feature for use in movie theaters and emergency services buildings.

Another trend in door and window products is the race to increase the percentage of recycled materials. The latest introduction is high-end door hardware in solid bronze, according to Rocky Mountain Hardware, a manufacturer that specializes in architectural hardware collections. Such products can contain as much as 90% recycled materials, of which about 90% is post-consumer material.

Several options for certifying recycled content in window and door products are available to Building Teams for use in project documentation for LEED, Green Globes, and other green building submittals. These include Scientific Certification Systems (www.scsglobalservices.com), which evaluates products made from pre-consumer or post-consumer material diverted from the waste stream.

Another focus for window and door products is the use of materials and finishes that are low in toxicity and volatile organic compounds, or VOCs. Various certification programs qualify interior doors and window materials or finishes for IEQ credits in LEED, ASHRAE, and the Collaborative for High Performance Schools. These include Greenguard and Greenguard Gold, with perhaps the strictest certification criteria, as well as the SCS's "Indoor Advantage Gold" standards for paints, coatings, adhesives, sealants, insulation, and other components of interior and exterior openings.

Increasingly, environmental performance factors related to IEQ, recycled content, and life cycle factors, are being consolidated and

warranted within a single document called an environmental product declaration, or EPD. EPDs are used as a part of life cycle assessment by means of standardized protocols that dictate both content and presentation. The role of an EPD is to quantify the environmental impact of the product or system. It should include details related to:

- Impacts related to extracting and producing raw materials.
- Embodied energy from manufacturing and installed energy efficiency.
- Material content.
- Chemicals and additives.
- Emissions.
- Waste generated.

According to ASSA ABLOY's Vitale, LEED v4 EPDs will become a major factor in the future, as will "materials ingredient reporting" through health product declarations, or HPDs, which is being promoted by the Health Product Declaration Collaborative (www.hpdcollaborative.org). The Building Hardware Manufacturers Association recently announced plans to release "product category rules," or PCRs, for builders hardware. Product category rules must be determined for any material or assembly that is seeking an EPD. After the initial phase of development within BHMA, the association plans to put out a draft for public review before the PCRs are finalized later this year.

BHMA's objective is to specify testing methods for EPDs. "The Product Category Rules highlight BHMA's focus on environmental sustainability and creating uniform standards for comparison of environmental impact," says Executive Director Ralph Vasami. The first PCRs in development have focused on automatic doors and gates, revolving doors, locks, and fittings.

With these standardized, industry-wide practices coming into the mainstream, Building Teams will find even more useful solutions for window and door applications from manufacturers and suppliers who are responding to new third-party requirements.

COURTESY SAFTI FIRST

In Orlando, fire-rated glass was employed for a Department of Veterans Affair Medical Center. Fire-resistive glazing and assemblies are increasingly used to benefit occupants in various settings, including healthcare.

> EDITOR'S NOTE

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