

windows, doors + storefronts

OPTIMIZING SAFETY, DURABILITY, AND CLIENT SATISFACTION



COURTESY NABCO ENTRANCES

The use of monumental automatic sliding doors is being tested with projects like the new flagship Apple Store in San Francisco's Union Square, where Foster + Partners has detailed 23-foot-wide and 44-foot-tall glass doors. The new 24,819-sf glass-and-steel cube will take over for the current flagship on Stockton Street, which has served 13 million customers since it opened in 2005. The new store, which is scheduled to open in 2016, will be about two stories shorter but about 45% bigger than the store it replaces.

LEARNING OBJECTIVES

After reading this article, you should be able to:

- + **DISCUSS** current certifications, codes, and standards that affect fenestration system design with respect to energy performance, safety and security, and ease of use.
- + **LIST** the benefits and drawbacks of specific window, door, and glass envelope products, including tilt-and-turn windows, automatic sliding doors, and storefront systems.
- + **DESCRIBE** durability and resiliency problems, as well as occupant experience concerns related to optimal detailing of fenestration systems.
- + **COMPARE** products such as unitized storefront and tilt-turn windows to other more commonly used fenestration approaches.

BY C.C. SULLIVAN, CONTRIBUTING EDITOR

Does anyone on your Building Team have a master's degree in fenestration?

Consider this credential worth obtaining, say a growing number of experts in door, window, and storefront applications. The American Architectural Manufacturers Association (www.aamanet.org) created the FenestrationMasters program as a professional certification and education benchmark that covers technical and performance standards, product and material matters, test methods, and code requirements.

AAMA already had a Fenestration Associate for entry-level certification, the new master-level advanced certificate requires a prerequisite of either six years' fenestration product-related experience, or a four-year degree in engineering, architecture, or applied sciences plus four years of industry experience, says Tom Minnon, CFM, LEED AP, CDT, Eastern Region Sales Manager for Tubelite, who recently received his FenestrationMaster designation. "I've been involved in commercial fenestration most of my career, but it was challenging to learn some of the courses that involved PVC, fiberglass windows, residential installation standards, and anchorage," he says.

In nonresidential construction, Building Teams are finding that product and system selection is becoming increasingly complicated, due to three demands from building occupants:

1. Greater security concerns and desire for improved safety
2. The need for fenestration that is easier to use, especially with mounting use of operable windows
3. Doors and windows that improve client or user satisfaction, especially in highly competitive markets

All this has led to growth in new products—automatic doors, tilt-and-turn windows, and a new generation of robust storefront systems. But first, let's consider important regulatory, code, and standards factors related to windows, doors, and storefronts.

WHAT USERS WANT IN WINDOWS, DOORS, STOREFRONTS, AND ENTRY SYSTEMS

Durability and resiliency are two factors that are intimately tied to safety in windows, doors, and storefronts. In terms of user satisfaction, energy conservation and thermal efficiency are still the primary focus of fenestration design today. In a survey by *Building Design+Construction*, about three-quarters of respondents named efficiency as the top functional feature of windows, doors, and entry systems.

New techniques for assessing energy performance can give Building Teams a leg up on the design process. The National Fenestration Rating Council's (www.nfrc.org) new product certification program for commercial applications reduces the review of fenestration product energy performance to three key components and creates a library of those components that project designers and contractors can use to make selections. The NFRA process, called the Component Modeling Approach (CMA) Product Certification Program, lets you assess whole-product energy efficiency for custom systems designs with varied shapes, frame materials and depths, and glass materials.

The NFRC database includes only approved products and clearly lists the solar heat-gain coefficient (SHGC), visible transmittance (VT), and U-factor (also given as U-value, the overall heat-transfer capacity of the building component) for each. "Anytime you can avoid starting from scratch, it's a major advantage," says Todd Reynolds, with manufacturer's representative ASC, who used the CMA to detail a 44,100-sf curtain wall for the Utah Valley

Convention Center, in Provo. "CMA was integral in streamlining the selection, certification, and code compliance processes for the fenestration on this project," he says. "It's the kind of tool you can rely on to get things done easier than ever before."

ASC helped design architect Populous (populous.com) and architect of record MHTN (www.mhtn.com) introduce extensive fenestration into the facility—an important factor in visitor and occupant satisfaction. "We really wanted to take advantage of Provo's beautiful mountain surroundings while at the same time making it a versatile and utilitarian gathering space," says Populous Project Manager Todd Parker. The team used the NFRC's CMA Product Certification Program to assess whole-product energy efficiency for custom systems designs with varied shapes, frame materials and depths, and glass materials.

CMA is organized into three primary components: glazing, frame, and spacer. It combines optical/spectral data from the International Glazing Database for the glass in question, thermal performance data of frame cross-sections from manufacturers, and spacer components, based on spacer geometry and materials. The CMA program manages the data with reference to the specific glazing,

frame, and spacer components to determine an overall rating for a chosen commercial fenestration system.

CMA's software tool, CMAST, is built on so-called "performance libraries" of the three component types. By accessing the libraries, you can evaluate U-value, SHGC, and VT for your chosen design, ensuring these factors meet the performance criteria and comply with all building codes. Once complete, you can print out a CMA Label Certificate.

Other techniques for achieving the aims of the new CMA method include the standard AAMA 507-12 – Standard Practice for Determining the Thermal Performance Characteristics of Fenestration Systems Installed in Commercial Buildings. This is an effective way to determine the thermal performance of building-specific commercial fenestration systems including windows, curtain walls, window walls, sloped glazing, storefronts, and doors.

A growing number of jurisdictions require the use of CMA. California's Title 24 nonresidential building energy code requires the use of CMA, default rating values, or simple equations to demonstrate compliance with its fenestration energy requirements, says NFRC CEO Jim Benney. CMA uses NFRC 100 and



New electromechanical ED 100/250 swing door operators installed at 1101 Vermont Avenue, NW, in Washington, D.C., are equipped with a proprietary wind-load control. In automatic mode, the system recognizes and compensates wind loads with a force of up to 150 N (maximum admissible force). The motor supports the spring during closing cycles. The wind-load control actively changes the driving parameters in opening and closing direction in order to tailor the door's driving behavior to prevailing weather conditions.



COURTESY DAL GLASS INC.; DALGLASS.CA

TD Bank in Mississauga, Ont., provides an example of the use of high-performance building-integrated photovoltaic (BIPV) installations, with awnings over the sidewalk and entryway. The project was hailed by Toronto's *Globe and Mail* newspaper as "solar power's new wave."

200 procedures (required by both ASHRAE 90.1 and the International Energy Conservation Code). It can be used for LEED projects, too.

TOUGH SAFETY AND SECURITY STANDARDS

Building Teams are gravitating toward improved glass products as part of a trend called "invisible security," a term was used by Margaret Rhodes in an article (<http://wrd.cm/1xzL4sx>) in *Wired.com* on the new replacement facility for Sandy Hook Elementary School, Newtown, Conn., the site of a 2012 gun attack. "Once visitors reach the school grounds, they pass through still more strategic, yet invisible, security measures," Rhodes wrote. The new Sandy Hook will have impact-resistant windows.

Another invisible technique is a souped-up glazing product developed by School Guard Glass. It is designed to protect occupants of a school for at least four minutes, which can be crucial in saving lives in the event of an attack. The glass is relatively thin and lightweight but holds together with heavy-duty lamination between two panels of safety glass. The product is about a quarter-inch thick; a glass door would cost about \$2,000. Standard bulletproof glass can be up to three inches thick and cost 20 times that, according to an article in the *New York Times*.

Building Teams and project suppliers reference ASTM C1172 – 14, Standard Specification for Laminated Architectural Flat Glass for most security glazing products "consisting of two or more lites of glass bonded with an interlayer material." The glass panels can be applied for safety and security, detention, hurricane and cyclic-wind resistance, and blast or bullet resistance. ANSI has a related test standard, Z97.1 – Safety Glazing Materials Used in Buildings. The National Institute of Justice provides performance guidance in its Standard NIJ0108.1 Ballistic Resistant Protective Materials.

Resiliency in building projects is another growing concern, says the Insurance Institute for Business & Home Safety (<https://www.disastersafety.org/>). In hurricane-prone regions, the pressure rating of windows and their resistance to windborne debris are major factors in fenestration selection, according to IBHS. "Impact-rated windows are the only window systems designed and certified to protect buildings from both wind pressure and windborne debris without any additional exterior protection system such as shutters," says IBHS. They are "passive protection systems that are in

place 24/7" and don't have to be unrolled, nailed on, or activated when unexpected weather events arise.

Many jurisdictions are updating their building codes for better storm performance. A few are requiring that impact-rated products meet one or more specific testing standards:

- ASTM E 1886 and E 1996
- AAMA 506
- Florida Building Code TAS 201, 202, 203
- Miami-Dade Protocols PA 201, 202, 203

Leading-edge jurisdictions like Broward County, Fla., are mandating new building safety inspections for 40-year and older multifamily structures. Similar to the well-known program used in Miami-Dade County since the mid-1970s, the Broward program calls for structural and electrical safety inspections for buildings 40 years old or older and once every 10 years after that. The rule applies to everything larger than 3,500 sf but not to single-family, government, or school buildings. Broward County's recently developed 40-Year Condo Recertification Program is another source of work for Building Teams.

Later this year, in June, the Florida Building Code is scheduled to debut its Fifth Edition (2014), which updates the 2010 edition, says Jaime Gascon, PE, Supervisor, Product Control Section, Miami-Dade County Department of Regulatory and Economic Resources. In a recent AAMA meeting, Gascon said some changes were automatically adopted along with the 2012 International Building Code (IBC). These include an updated reference to the North American Fenestration Standard (NAFS)/AAMA/WDMA/CSA 101/I.S.2/A440 and adoption of the ultimate strength design method of ASCE/SEI 7-10 - Minimum Design Loads for Buildings and Other Structures.

Wind design requirements have been revised substantially to update and coordinate the standards and codes. "Wind load maps in ASCE 7 and the IBC are now based on ultimate design wind speeds," which produces "a strength-level wind load similar to seismic load effects," says John R. Henry, PE, Principal Staff Engineer with the International Code Council (www.iccsafe.org).

More extensive are the changes introduced based on state modifications, says Miami-Dade's Gascon, a member of the Structural Technical Advisory Committee to the Florida Building Commission. Among them: more-rigorous tests for large missile impacts for essential facilities, allowances for the interchange of approved door components in exterior entries, and reinstated window and door structural performance minimums for wind-related performance or any so-called High Velocity Hurricane Zone projects.

NEED TO PUT GREATER EMPHASIS ON TESTING FOR DURABILITY

The better the durability testing, the better the fenestration design and installation will be, say the experts. However, most test methods only look at immediate safety and performance requirements, according to AAMA, and offer "little in terms of long-term durability in a field environment." Today's building owners and financial backers prefer proof of the longevity of their investment—25 or more years of reliable performance, according to AAMA.

Existing test methods for fenestration durability include standards promulgated by UL, the International Electrotechnical Commission (IEC), and widely used accelerated stress testing (AST) methods called HALT (highly accelerated life test) and HASS (highly accelerated stress screen). Traditional vibration test methods and thermal testing provide some useful data, but for fenestration the specialized HALT/HASS equipment provides a more realistic range of stressors, combining random six-degree-of-freedom vibration and rapid thermal change rates, according to Qualmark, a testing lab that uses AST methods.

What about weathering? “Outdoor testing is a must, but it takes much too long to be of use as a decision maker,” says John H. Wohlgemuth, of the U.S. Department of Energy’s National Renewable Energy (www.nrel.gov). “We clearly cannot wait 25 years. We must develop and utilize accelerated tests to qualify these new products.”

Reliability concerns for building-integrated photovoltaic (BIPV) fenestration, for example, include not only delamination and fracture and moisture ingress but also such effects as connector reliability, failure of inverters and bypass diodes, and corrosion or improper insulation leading to a loss of grounding.

These problems may be resolved by developing a multi-track test program that incorporates traditional testing with new global composite testing cycles, says Atlas Material Testing Technology’s Scott Zimmerman. Atlas has developed a BIPV product testing program designed to validate a minimum 25-year service life by means of a four-track solution: weather testing of materials and components, laboratory functional testing, outdoor weathering, and long-term durability.

A 25-year service warranty would help the BIPV market reach its targeted \$35 billion global revenues target for 2019, a big leap from the \$2 billion earned in 2012, according to research firm NanoMarkets.

STOREFRONT INSTALLATIONS LEAD FENESTRATION-SECTOR GROWTH

The use of window walls and storefront has been accelerating in recent years. According to AAMA, storefronts lead the category for new construction and total nonresidential buildings, with growth exceeding that for commercial windows or curtain wall. As for punched openings, factory-fabricated windows lead for renovation usage, says AAMA. Projected/awning configurations remain the most common architecturally rated, shop-fabricated window product, especially for education and healthcare projects. “Thermally broken aluminum frames continue to grow in popularity across all nonresidential window product types following the trend of increasing energy-efficiency standards,” says AAMA.

Demand for commercial entry doors began increasing at an accelerated pace last year, and sustained growth is expected to continue through 2016, says AAMA. Steel entry doors represent the largest share of both residential and commercial applications, followed by



COURTESY WEINSTEIN A/U ARCHITECTS

The 69,000-sf Fire Station #10, in Seattle, designed by Weinstein A/U Architects with Ross Drulis Cusenbery Architecture; construction was overseen by Hoffman Construction. The low-key structure is long on security and safety features—durable and highly resistant to wind, seismic shock, and heavy use—but appears open and brightly illuminated. Its flexible spaces are accessible through secure storefront glass doors and six rapid-opening swing doors painted bright red to match the fire trucks; the contrasting frame color, in deep black anodized aluminum, adds dignity to the civic structure.

aluminum for nonresidential construction projects.

What’s behind the growth in storefront and entrance systems? Classic storefront systems earned their name from traditional stick-built retail settings, where they were used to present large display windows above wood or metal bulkheads. The classic retail storefront was complemented with awnings, integral matching doors (often with a transom sash), signage, lighting, and merchandise displays.

These days, storefronts may be used for institutional and commercial settings where nothing is for sale. A number of the best new systems are not stick-built but rather unitized, says Joe Schiavone, with manufacturer C.R. Laurence. He notes that unitized systems have always been associated with high-rise curtain wall and multi-story building applications

Unitized storefront systems work about the same as traditional storefront assemblies, says Schiavone, whether installed in punched openings, in bands across a single floor, or in a floor-to-floor or multi-level application. Used with matching slab covers, the unitized assemblies may be mistaken for curtain wall. Water management can be built into the frame’s sill flashing and weeped near the base.

These are usually low-cost, single-story bands of framed glass that don’t require supplemental structure within the frames. They also offer the benefit of short lead time and fabrication by a single supplier; for stick-built products, even a relatively small subcontractor can do the work. Most storefront systems built up on site use dry gasket methods, speeding both initial installation and downstream repairs or replacement.

Storefronts do face limitations. While they are ideal for big ground-floor openings and the interiors of shopping malls and other large volumes, in exterior applications they should not be stacked or applied to upper floors due to their design loads and ultimate wind pressures. Storefront systems can work well for upper floors in cases where water management and structural needs have been relaxed.

TILT-TURN WINDOWS from Europe

Learn how European manufacturers like Solar Innovations, Gaulhofer, Intus, Henselstone, TiltCo, Bieber USA, Bravo Windows & Doors, and Menck are importing tilt-turn windows to the U.S. Tilt-turns are similar to casement windows but open inwardly and don't have a crank. Go to www.BDCnetwork.com/Fenestration for more about tilt-turns.

The opening types and orientations of most storefront are typically restricted to a few basic design options, and the building's rough openings may need to be modified to receive stock structural anchorage assemblies. Mullions and accessories may be only stock types or generally have few, if any, custom options.

Storefronts help make urban areas engaging, walkable, and commerce-friendly. More traditional notions in storefront can be considered even when the building's design expression is decidedly contemporary. When used on the lower floors, storefronts benefit from awnings, which define the base and embellish the commercial street, a city plaza, or a terrace in a campus setting. Most jurisdictions require that storefront awnings be attached to and supported solely by the building. Originally used as a shade and sheltering device, awnings provide protection from the sun and rain, as well as protecting interior finishes and contents from ultraviolet degradation. They can also hide a security gate that retracts into a gatebox. Where these functional purposes are not central to the building design or use, a more modern expression without awnings may be warranted.

Less is more when it comes to storefront expression, says the New York City Department of Small Business Services. "The simpler your design, the better," the department reported in a recent guide, warning that visual clutter makes it difficult for passersby to take notice of individual businesses. One well-placed sign is often the most attention grabbing, says the guide. "When executed well, the storefront can serve as an invitation to the shopper, increasing business for individual merchants and improving the overall shopping experience," says Department Commissioner Robert W. Walsh.

KEYS TO SPECIFYING ENTRIES AND DOORS

As the first point of physical interaction with a building, entryways play a symbolic as well as functional role that is reflected in door

selection and detailing. Building codes, public right-of-way factors, and infrastructure considerations such as stormwater and site will affect the orientation, opening action, and security options available. About three-quarters of Building Team professionals surveyed by *BD+C* prioritized energy and thermal efficiency as the most critical functional feature of entry and door systems selected. "Durability or reliability" ranked a close second, followed by weather protection and aesthetics.

Site design, driveways, and line of sight are key factors that influence entry design. For the Hollywood Casino in Columbus Ohio, the Building Team of Marnell Architecture, m+a architects, The Edge Group (planning and landscape architects), and E.P. Ferris and Associates (CE) developed a classic Western-style porte-cochère with Art Deco-inspired forms that glow brightly at night to draw in gamers and thrill-seekers.

The 300,000-sf casino is constructed on the site of an abandoned auto parts factory. The poker room alone fits 30 tables. Hollywood Columbus had to plan for a wide and capacious entryway with enough automatic sliding glass doors to accommodate wheelchairs, scooters, and peak-time foot traffic. At peak hours, vehicles may idle for several minutes under the porte-cochère while loading and unloading passengers, so the fast action of the doors along with positive-pressure air handling near the entry help reduce the movement of exhaust and pollutants into the reception area.

Penn National Gaming, the developer of the \$400 million project, encouraged the designers to "capture the golden age of Hollywood but incorporate high-tech elements," says SVP Eric Schippers. Flanking the main entrance are self-supporting, vertically oriented translucent channel-glass assemblies within extruded metal frames that form colorful piers. Between the two piers is a large digital billboard. Three more glass piers fan out beyond each exterior entrance, descending in height from about 40 feet down to 28 feet. The design concept is echoed inside the casino, with columns clad in metallic gold channel glass. For exterior use, low-iron channel glass was custom tempered and coated in a translucent metallic gold, a motif that is repeated at the parking garage.

> EDITOR'S NOTE

Additional reading is required for this course.

*To earn **1.0 AIA CES HSW learning units**, study the complete article carefully and take the 10-question exam posted at*

www.BDCnetwork.com/Fenestration.



PETER CLAUSEN, MASTER MEDIA

Industriens Hus, headquarters of the Confederation of Danish Industries. The 2013 building is set atop the original concrete columns and foundations. A new atrium is topped by an angular expanse of triple-glazed, rhomboid BIPV and screen-printed glass skylights and space frames. Danish design firm Transform and BIPV supplier/installer altPower specified double-insulated safety glass BIPVs with coatings in irregular shapes. "There's not a single right angle," says altPower President/CEO Anthony Pereira. The street-facing façades form a curtain wall with 3,331 segments of glass and miles of LED panels with more than 80,000 diodes.

HOW TO CORRECTLY SPECIFY AUTOMATIC DOORS

According to the American Association of Automatic Door Manufacturers (www.aaadm.org), the top-ranking building types for automatic doors are hospitals, airports, hotels/motels, and shopping mall entrances.

ANSI and the BHMA maintain the key standards for automatic pedestrian doors, says AAADM's Christopher Johnson. The American National Standard for Power Operated Pedestrian Doors, ANSI/BHMA A156.10, provides details and installation guidance, such as minimum or maximum dimensions, recommended forces, and layouts for various components of "full-power" operated door systems. Low-energy operator systems can refer to the related standard, ANSI/BHMA A156.19, American National Standard for Power Assist and Low Energy Power Operated Doors.

Other standards critical for automatic door design review include prevailing fire codes and NFPA 101, the National Fire Protection Association's Life Safety Code; the Americans with Disabilities Act (ADA); all I-Codes and local jurisdictional building codes; and ANSI A117.1-2009, Accessible and Usable Buildings and Facilities. By following these regulations and codes, safety of use and emergency situations should be adequately handled, says Johnson.

AAADM administers a program to certify automatic door inspectors, says Johnson. "Automatic doors boast an exceptional performance record and are manufactured with sophisticated technologies, sensing systems, and built-in features for added customization. Performance

is enhanced when AAADM recommendations for proper installation and annual inspections, both performed by an AAADM-certified inspector, are followed."

The main door type used in commercial and institutional facilities is the automatic slider, which allows for two-way traffic. Automatic sliders protect occupants with a breakout or breakaway feature that allows occupants in emergency egress situations to push the sliding door outward, turning it into a swing operating door.

For normal operating circumstances, the choice of a biparting, telescoping, or single-action door will depend on anticipated traffic flow, opening time, entry configuration and slide room (the area in which the door moves). If there is not enough room for the retracting slider panel, an automatic folding door with accordion action may be used.

If circulation can be controlled, an automatic swinging door system may be used. At minimum two doors are used—one to swing inward, the other to swing outward. Think about grocery stores and movie theaters: A steady stream of users is expected; therefore, obvious signage to indicate the direction of travel is called for. Safety zones for swinging doors are covered in Section 8.1.2 of ANSI A156.10. "The requirements depend on what combination of sensors and control mats is used," says Johnson.

The use of monumental automatic sliding doors is being tested with projects like the new flagship Apple Store in San Francisco's Union Square, where Foster + Partners has detailed 23-foot-wide and 44-foot-tall glass doors.

part 2

TILT-TURN WINDOWS FROM EUROPE HIT USA

The recent focus on durability and weather resiliency has created an opening for European window technologies. Commercial versions of steel-framed windows and specific styles such as tilt-turn frames benefit from their global reputation for durability and adaptability. These fenestration products have deep, thermally broken frame profiles and can accommodate double-glazed, triple-glazed, and gas-filled glass panels.

Several suppliers—notably Solar Innovations, Gaulhofer, Intus, Henselstone, TiltCo, Bieber USA, Bravo Windows & Doors, and Menck—have been marketing commercial products to U.S. Building Teams with growing market share. Many are establishing U.S. shops that are eating into the import market, estimated at up to \$200 million a year.

"Tilt-and-turn windows are a predominantly European-style operable window," says Aurimas Sabulis, Managing Director of Intus Windows, which focuses on high-performance fenestration products. "Here in the States, we are typically more familiar with single- and double-hung windows, sliding windows, and casement windows," Sabulis says that, according to most operable window

tests, single-hung, double-hung, and sliding windows are the most likely to leak air. "Tilt-and-turn windows do a much better job at sealing, because their design is similar to the common casement window," says Sabulis.

Tilt-and-turn windows are similar to casement windows, but open inwardly and don't have crank handle hardware, says Sabulis. Common models have up to three handle positions: one for swinging inwardly (full ventilation), a partial inward tilt at the top or bottom, or both (outdoor air ventilation). In some cases, the window may have an open mode for cleaning purposes.

The openings can be relatively large. A continuous gasket around the opening seals at the sash for good weather protection. A significant portion of tilt-and-turn products have multiple locking mechanisms that draw the window shut for a relatively airtight and highly secure seal in this fixed mode.

Commercial tilt-turn windows are often combined with matching hopper- and fixed-style products as well as curtain wall and storefront systems with matching frames and mullions. Frame materials for these fenestration products include steel, solid wood, wood with

aluminum cladding, and uPVC with a steel core. A few decorative options are being used to achieve certain stylistic goals, such as raised base panels or grids made with interior muntins between the glass panels or with interior and exterior simulated divided lites (SDLs).

The growing influence of European brands has expanded the use of tilt-turn products in U.S. nonresidential projects. Commercial applications include restaurants, office buildings, and high-rise apartments, according to Solar Innovations. Tilt-turns could also play a role in high-rise condominium projects, since they can be opened inwardly for cleaning and do not require the services of professional cleaning crews.

Tilt-turn windows also provide additional advantages for other high-end facilities:

- **U-value and structural value:** A number of products balance performance criteria for energy transference with structural solidity.
- **Noise reduction and health promotion:** With their gaskets and tight locking modes, tilt-turn windows can meet rigorous sound-transmission class (STC) specifications. In many settings, noise is a negative factor for occupant health and performance, so windows with a high STC allow for more productivity-enhancing daylight while minimizing annoying background noise.
- **Security and comfort:** Some uPVC triple-pane windows can achieve a Grade 10 Forced Entry Resistance (per ASTM F588-07) while offering windows rated at good SHGC values ranging from 0.25 through 0.62. This means a safe opening that also helps boost energy efficiency.

According to Sabulis, some triple-pane windows feature three gaskets, helping to create an airtight and watertight seal. While an air infiltration rate of 0.03 cfm/sf is the minimum for today's windows, even better products are out there.

Recent projects using tilt-turns show how windows can be used to differentiate a property, even in the most lackluster markets. One example is a small, speculative office building in the Journal Center area of Albuquerque, N. M., by architect, builder, and developer Knight Seavey. It is the first spec office space that's not fully preleased to be preleased since early 2009, in a rental market with 25% vacancies. "It's going to be a more boutique project with high-quality space," Seavey told the *Albuquerque Journal*. "We're trying to deploy a new concept for office space" with the \$1.2 mil-



The 23-story Montage, an adaptive-reuse conversion of a casino into a multifamily community in Reno, Nev., used European-style uPVC tilt-turns for its new floor-to-ceiling windows. The Building Team: Antunovich Associates (architect), Matsen Ford Design Associates and Summit Engineering (engineers), and UPA Group (general contractor).

lion Conejos Common. Aimed at LEED Platinum certification, the building features triple-glazed tilt-turn windows along with high-performance enclosure systems and a 25kw solar array that also provides parking shelter.

At the other end of the scale, The Montage, in Reno, Nev., shows how uPVC tilt-turn windows can be employed for adaptive-reuse conversions of a casino into a multifamily community. The architects first planned to use commercial-grade aluminum-frame systems in the 23-story building's new floor-to-ceiling windows. After some investigation, they turned to uPVC tilt-turn windows and doors. The key benefits for the owner, ST Residential, included superior sound abatement properties, reduced heat loss and air infiltration, and the ability to build awning and hopper styles with natural ventilation.

Two long-term goals for many North American building owners and their Building Teams are 1) to significantly improve thermal performance to help counter the trend of decreasing window-to-wall ratios, and 2) to introduce cost-effective and resilient technical solutions for the building envelope. Tilt-turn windows can help achieve both of these goals.

Today's storefronts, tilt-turn windows, and automatic door systems will benefit from further development to achieve anticipated performance goals. The industry has already taken great strides toward this goal over the last few years. These three fenestration categories now contribute to even better performance with respect to safety and security, ease of use, and greater satisfaction for building occupants and users.