Economy windows offer little savings on the coast

In the U.S. market, there are literally thousands of window lines to choose from. Chris Mathis of MCSquared, a building-science consulting firm that focuses on windows, doors, and skylights, underscores this fact by explaining that it doesn't take much to get into the window-manufacturing business and capture local markets with cut-rate pricing. "These are the companies," Mathis cautions, "that may not be around when the glass fails."

Selecting Windows for Coastal Homes

by Clayton DeKorne

WARRANTY FIRST

To pick a window that will last, start with the warranty, Mathis advises. Look for a non-prorated, transferable warranty good for 20 years on the glass and at least 10 years on non-glass parts. These solid warranties are available from most of the bigger window companies, but Mathis says it's surprising how many companies do not offer such a warranty at all, or do not offer it on all their window lines. This reflects a serious compromise in the quality of a large percentage of the windows sold. Nearly 30% of the replacement windows installed today will replace windows that are only seven years old, reports Mathis. "That's a sad commentary on the quality of many windows out there."

Common failures. The most common window failure is the breakdown of the seal on an insulated glass unit. If the seal blows, the window will fog up between the panes, and a lost seal causes a drastic reduction in window R-value. Even if the seal fails gradually, air and moisture slowly entering the windowpane tends to oxidize the low-E coating, turning it into a high-E coating that

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All windows, regardless of where they are sold, should carry a good warranty and meet basic structural and thermal performance measures. On the coast, however, high wind loading makes it imperative that windows further meet enhanced structural measures, and the frequent occurrence of wind-driven rain demands giving a second look to test results for water leakage.

absorbs heat rather than reflects it away. This oxidation will look exactly like the salt spray that sticks to the glass, except that it can't be washed off. It looks like a permanent blur between the windowpanes.

While a 20-year glass warranty will adequately cover this most common window failure, a warranty on non-glass parts also becomes especially significant on the coast. Constant humidity, blowing rain, and salt attack will quickly degrade cheap finishes and hardware, and hinder sash movement.

Mathis, a former director of the National Fenestration Rating Council (NFRC) who now serves on the ASHRAE and ASTM code committees as well as on the International Energy Conservation Code Committee of the ICC, urges that choosing a manufacturer that will be around in 10 years to replace deteriorated parts may be the most important window selection criterion of all.

Warranty language. "If a window says 'lifetime warranty,' it makes me nervous," says Mathis. "'Lifetime' is usually written in big, bold letters, but you have to read the fine print to find out what this really means." Many warranties seem to cover a lot up front, but that impression quickly changes when all the details are spelled out.

Language to look for:

- **"Non-prorated"** warranties will cover the entire purchase price of the window for the term of the warranty. Unlike roofing materials, a well-made window shouldn't gradually degrade with exposure, so there is little justification for a prorated warranty.
- **"Fully transferable"** warranties are a sign that the window maker means business. For a homeowner selling a home, it can be a value-added feature that a builder or remodeler can make available when recommending a window.

A 20-year warranty on the glass and a 10-year warranty on non-glass components should be the baseline for any window

- **"Non-glass"** components, particularly hardware, should carry a minimum 10-year warranty. A good window with bad hardware is a bad window, Mathis insists. If a lock breaks or the crank handle strips out, it will reflect poorly on the remodeler who installed the window. Think about the window manufacturer's capacity to stock replacement parts well into the future.
- **Labor and installation.** Unless a certified representative of the manufacturer installed the unit, few warranties will cover the cost of installation. Some may, but for the most part, this will fall to whoever installed the window. This is yet another reason for builders and remodelers to stick with trustworthy brands.
- **Exclusions.** This is key in coastal climates. Some warranties specifically exclude coverage for damage from environmental factors, such as high humidity or salt spray. The exclusion may apply to the glass as well as to the hardware and finishes.
- **Finishes.** Coverage on finishes is rare, but some warranties do cover exterior coatings and finishes on cladding. However, painting or refinishing the exterior to match the home may null this coverage. This is particularly true on aluminum-clad and vinyl units.

Mathis contends that if the warranty passes muster, you are probably dealing with a manufacturer willing to protect its reputation. Behind that reputation will be reliable performance specifications. So, in addition to the warranty, you want to look for an NFRC label that outlines the window's energy performance and an AAMA label that provides third-party assurances of basic structural performance and establishes a norm for air leakage and water penetration.

BASELINE ENERGY SPECS

Much ado is made over low-E coatings — the invisible thin metallic coatings that block radiant heat flow — as well as other energy features, such as gas fills and low conductivity edge spacers. However, builders rarely have the option to choose these à la carte. One useful tool is to compare the performance values for various window configurations available using the Efficient Windows Collaborative's online Window Selection Tool (www.efficientwindows.org). But to make sense of this, you need to understand the baseline measurements of window performance.

Every window worth its salt comes with a label from the NFRC that provides a simple standard for window energy performance (**Figure 1**). Four numbers on this label describe the impact of the entire window unit, not just the glass, on the heating and cooling load of the building. However, only two these — the U-factor and the solar heat gain coefficient (SHGC) — bear close scrutiny.

U-factor is a measure of heat flow (and the inverse of R-value). The lower the U-factor, the less heat will move through the entire window. Mark LaLiberte of Building Knowledge Training Services, a national training and education consultancy that works with many of the nation's top home builders, recommends a U-factor of 0.35 or less, regardless of the climate in which you build. LaLiberte, a team adviser for the Department of Energy's Building America program, acknowledges that this recommendation is more conservative than the Energy Star program, which allows U-factors up to 0.65 in hot climates where radiant solar heat gain is of much greater concern than conductive heat flow (The Energy Star program divides the country into four climate regions and sets prescriptive and performance values for maximum U-value and SHGC. These values can be found at

FIGURE 1. An NFRC label rates the basic energy performance of a window using two critical numbers: the U-factor, which measures heat flow, and the solar heat gain coefficient (SHGC), which measures the percentage of radiant heat energy that will pass through the window. For optimal performance in all climates, both numbers should be below 0.35.


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FIGURE 2. Just a couple years ago, windows featuring impact-resistant glass were available in only a limited range of sizes. Now manufacturers competing in the coastal market offer a range of windows with a wide range of design pressures, making compliance with the International Residential Code wind requirements much easier.

www.energystar.gov, then navigating to the Windows, Doors and Skylights energy-efficiency guidelines.)

Solar heat gain coefficient (SHGC) measures the amount of solar heat gain that passes through a window. An SHGC of 0.35 means that 35% of the radiant heat striking the window will pass through the glass, while 65% will be reflected back outdoors. The lower the SHGC, the lower the cooling load on a home will be. Janet McIlvaine, a research analyst at the Florida Solar Energy Center, urges that a "low solar heat gain" window of SHGC 0.35 is best for hot climates. In cooler climates, designers sometimes spec windows with a higher SGHC, wishing to capitalize on solar heat gains. The most common strategy is to design the home with a 2-foot overhang (the widest overhang usually allowed in high-wind regions) to shade the windows from the high summer sun, and select a window with a SHGC above 0.50 to capture solar gains in winter when the sun is low. But LaLiberte, Mathis, and McIlvaine all caution that this strategy should be employed only when the orientation and shading of windows can assure that the windows won't "see" the hot summer sun. Anywhere air conditioning is used during the summer, a low-SHGC window is a safer bet.

Visible-light transmittance (VT) refers to the amount of daylight passing through the entire window area. The heavier the frame and the more divided lights a window has, the lower the VT will be. This number is far more important in commercial buildings, which often use heavily tinted or mirrored glazing that can reduce daylighting possibilities and increase electric lighting costs. For residential windows, McIlvaine advises that the VT rating should be higher than the window's SHGC. That is, there should be more light than heat coming through the glass. But otherwise, it's not a number worth sweating over.

Air leakage (AL) ratings are expressed as an equivalent cubic feet of air passing through a square foot of window area. The lower the AL, the less air will leak through the window assembly. However, this rating is optional, and rarely included on residential windows, even though more energy is usually lost from air infiltration and exfiltration than by conduction or radiation. The justification put forward by some manufacturers for not including this rating is that air leakage between the rough opening and the window unit has the potential to carry away far more than heat than would leak through the unit. The bottom line: Be sure to properly seal the window rough opening with spray foam.

IMPACT-RESISTANT WINDOWS

By now, impact-resistant windows using laminated glass are nothing new to coastal builders and remodelers. Many of the technical difficulties we reported last year ("Speccing Windows in High-Wind Zones," Winter 2005; available online at www.coastalcontractor.net) have been worked out, and manufacturers are offering a wider selection of sizes of windows in a much broader range of design pressures (**Figure 2**).

Impact resistance is tested by firing a 2x4 missile at the window and evaluating how well it then holds up to pressure cycling — a test that is intended to simulate the forces of wind-borne debris striking the window during a hurricane (**Figure 3,** page 5). An impact-resistant window typically shatters during an impact test but maintains its integrity if the interlayer and glass shards hold together. While keeping the home and its occupants out of danger, the window will leak significantly.

Opening protection. Installing impact-resistant windows is just one way to meet the structural requirements for wind-blown debris, but it is the most convenient method and, for vacation homes, at least, it may be the most practical (**Figure 4,** page 5). If windows without laminated glass are used, a house must be shuttered during a tropical storm.

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FIGURE 3. An impact-resistant window can shatter and still pass the large missile test if the window remains largely intact through the 9,000 pressure cycles. The glass fragments tend to adhere to the plastic interlayer, which is considered intact if the size of any rips that develop during the test total less than 1/16 inch wide by 5 inches long.

FIGURE 4. Many windows would be very difficult to reach to install shutters, making impact-resistant windows the only practical choice for a range of residential buildings.

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However, though more convenient, impact-resistant windows do not necessarily offer the best protection. According to the Institute for Business and Home Safety (IBHS), steel storm panels that meet the Dade County standards for opening protection offer the highest level of protection possible. These products will prevent the windows behind them from breaking and keep water out better than impact-resistant windows or movable shutter systems. Plywood can be used for shutters, but according to the IBHS, to get near the protection offered by Dade County–approved storm panels requires 3/4-inch plywood, which makes for heavy shutters that are difficult to install. (IBHS recommends plywood over OSB, as it takes 30% thicker OSB to equal the impact resistance of plywood. See "Evaluating OSB for Coastal Roofs," Winter 2005; available at www.coastalcontractor.net.) Lighter 3/8-inch-thick plywood shutters offer only about half as much resistance to penetration as 3/4-inch plywood and provide few assurances that the building shell will not be breached during a major storm. Clear polycarbonate shutters offer nearly the same impact resistance as storm panels and are relatively light. Roll-down shutters, the most convenient option, often require putting up storm bars to offer adequate impact resistance.

The convenience offered by impact-resistant laminated glass may also mean the difference between adequate protection for the structure and its occupants or none at all. Post-hurricane damage assessments always turn up evidence of homes that were damaged because owners were unable to make arrangements to install shutters before a major storm struck. "Shutters," argues Dave Olsen, a code expert with Florida-based window maker PGT Industries, "demand that the homeowner is home, and able, to install them."

Cost. The most frequently cited shortcoming of impact-resistant glass is the cost. The added cost per unit varies with window size, shape, and design pressure (DP). Large windows, circle tops, and high-DP units add proportionally more to the price tag. Price quotes in the Florida and Virginia markets for double-hung units by several different manufacturers revealed costs for impact-resistant windows $150 to $350 higher than comparable units with conventional insulated glazing (for an added cost of about $13 to $30 per square foot of window area, with aluminum and vinyl windows at the lower end of the price range and clad wood at the upper end). This increase works out to $4,160 to $9,600 for 320 square feet of window area (or 20% window-to-floor area in a 1,600-square-foot home). In many southeastern markets, such an upcharge, which does not include markup or any added labor, might be a significant increase to the cost of a house, but in most housing markets along the mid-Atlantic and New England coast, it would likely be a relatively small proportion of the total house price.

Window manufactures cite a study commissioned by the North American Laminated Glass Information Center, which concludes that the cost for laminated glass is less than the installed cost of roll-down shutters — the most convenient but also most expensive shutter option available. The "Hurricane Shutter Guide" published by the South Florida *Sun-Sentinel* confirms this conclusion, estimating the installed cost of roll-down shutters to be $26 to $40 per square foot, or $8,320 to $12,800 for the equivalent window coverage used to compare window costs as noted above (320 square feet). The installed cost for the equivalent size and number of steel storm panels ranges from $1,280 to $2,240 — considerably less than the upcharge for laminated glass but considerably less convenient as well.

Added value. The benefits to using laminated glass go far beyond convenience in meeting the destructive force of a tropical cyclone. The clear advantages that should help justify the higher costs for impact-resistant windows include:

- **Security.** It's as difficult for a burglar to shatter a laminated windowpane as it is for a wind-blown roof tile to smash through it. Therefore, this option is especially attractive for vacation homes that are unoccupied for much of the year. Few beach communities allow homes to remain shuttered for more than a few hours before and after a storm (and few homeowners would be wise to do so, as it is an invitation to burglars, who will know nobody's home). Laminated glass also provides a measure of safety protection: Children are unlikely to fall through a laminated window or get hurt by a broken pane.
- **Sound dampening.** Glass is inherently brittle and readily transmits sound vibrations. Adding a flexible interlayer has the same effect as putting a finger on a drumhead: It deadens the vibration. An ordinary double-pane insulated glass window has a sound transfer coefficient (STC) of 28. When made with laminated glass, the window's STC jumps to 35 — about the same as an insulated 2x4 wall with 5/8-inch drywall on both sides.
- **UV protection.** The plastic interlayer blocks ultraviolet light, which might otherwise cause carpets and home fabrics to fade and vinyl flooring to yellow.

PGT's Olsen says that laminated glass has become a standard feature on a majority of windows sold in Europe, not for protecting homes from hurricanes but for the increased security, safety, and sound resistance afforded by these units. And he points to the fact that prices have fallen as manufacturers have become more familiar with the thicker glazing and have filled out their window lines.

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FIGURE 5. The Pressure Test: In the laboratory, wind pressures applied to a window in a high-wind event are simulated by applying a static pressure across a random window specimen for a prescribed amount of time and measuring the maximum uniform load deflection.

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FIGURE 6. On this AAMA label, F-HC40-96x72 is the critical designation for this window. F is the product type (Fixed); HC is the performance class (Heavy Commercial); 40 is the performance grade (40 psf design pressure); and 96x72 is the maximum size tested (width x height).

DESIGN PRESSURE

Impact resistance and design pressure are two distinct structural requirements for windows used in hurricane zones: One resists failure from wind-blown debris, and the other resists failure caused by sustained wind pressure.

Wind pressures are simulated in the laboratory by applying a static pressure across a window specimen for a prescribed amount of time and measuring the maximum uniform load deflection (**Figure 5**, page 6). During this test, pressure is applied in both directions, simulating sustained positive and negative wind loads. Design pressure will vary with area, so the window dimensions are critical to choosing the correct design pressure.

Window Classes	Design Pressure	Structural Test Pressure	Water Resistance Test Pressure
Residential	15	22.5	2.86
Light Commercial	25	37.5	3.75
Commercial	30	45	4.5
Heavy Commercial	40	60	6
Architectural	40	60	8

FIGURE 7. The water resistance value required for the AAMA/NWWDA 101/I.S.2 standard is 15% of the design pressure for all window class, except Architectural class, which requires a water penetration resistance at 20% of design pressure. While required by code for any window, this standard is not intended to evaluate the performance of windows in hurricane zones. All windows that meet these basic performance criteria will leak in any major tropical storm.

To comply with the International Residential Code, all windows in high-wind zones must meet the “Components and Cladding” requirements, found in prescriptive tables listing minimum design pressures for windows in different positions on the house exterior. For example, windows placed near corners, where the wind pressures are highest, must have a higher design pressure. (For a detailed discussion of these window performance requirements, see again “Speccing Windows in High-Wind Zones,” Winter 2005; available online at www.coastalcontractor.net.)

The design pressures used to meet the code’s “Components and Cladding” requirements should not be confused with the pressure ratings that are central to the joint specification from the American Architectural Manufacturers Association (AAMA) and the National Wood Window and Door Association (NWWDA). Known as AAMA/NWWDA 101/I.S.2 (or shorthand as AAMA 101), this standard defines the baseline performance characteristics required for every window, regardless of the market. The primary specification is a “structural test pressure” rating, which is established using a test procedure developed by ASTM that evaluates the window after applying a pressure 50% higher than the design pressure. If no permanent deformation occurs to the window, it passes the test and is awarded a small gold label affixed to an inside surface of the frame (**Figure 6**). However, the minimum design pressure rating listed in AAMA 101 may be lower than what is required for “Components and Cladding.” For example, the AAMA 101 baseline for residential-class windows starts at a minimum design pressure of 15 psf. While this pressure is equivalent to the pressure sustained by a 75-mph wind — the defining wind speed for a Category 1 hurricane — it would not pass muster in any coastal wind zone.

Currently, the AAMA 101 draws a distinction between several classes of windows, with residential (R) at the low end of the design pressure range, and heavy commercial (HC) and an unspecified "architectural" (AW) class at the upper end. Dean Lewis, manager of product certification for the AAMA, has suggested that these distinctions may become obsolete as more and more residential windows are being made to meet higher design pressures.

WATER PENETRATION

In addition to the structural performance ratings, AAMA 101 also establishes minimum air infiltration and water penetration values (**Figure 7**, page 7). The water penetration values are found using an ASTM test procedure that applies a negative pressure equal to 15% or 20% (depending on the window's performance class) of the design pressure to the inside of the test assembly, and then hoses the window exterior with a rack of water jets that is equivalent to a rainfall of 8 inches per hour (**Figure 8**). At best, a window meeting the AAMA 101 spec will leak in a 35-mph wind, which virtually guarantees it will leak in a hurricane.

The assessment of Joe Lstiburek of Building Science Corporation is even worse: In developing a report commissioned by the Florida Home Builders Association to evaluate the high incidence of water damage to homes during the 2004 hurricane season, Building Science Corp. found that most windows leak when no pressure is applied. For that report, Building Science Corp. tested 50 windows. "We had 100% failure," notes Lstiburek. "Okay, it was 'only 50 windows,' you might say. 'There are thousands of windows available.' But when every one of them leaked, we felt pretty safe drawing the general conclusion that windows leak."

The AAMA acknowledges the problem and issued the statement: "The lesson learned in 2004 is that water penetration from heavy wind-driven rains occurred in more cases than acceptable, leading to interior water-related damage that could have been prevented." And an AAMA Southeast Region Hurricane Standard Development Task Group is currently gathering data on real-world indoor/outdoor pressure differentials due to hurricane-force winds to find ways to better simulate actual wind gusting and effects of turbulent wind flow.

But despite his report, Lstiburek feels that the results should be kept in perspective. For starters, he contends, it's significant that the windows won't blow out, and the occupants can remain safe inside during a major wind event. In addition, the water leakage for windows is not just a shortcoming for the windows. "There are no standards for the walls, which will leak much more than the windows," said Lstiburek. "The point is, let's accept that walls and windows leak. But let's design them to first drain to the exterior, and second to dry out if they do get wet. That's the best way to avert widespread water damage." If the main criterion is reducing water leakage, Lstiburek recommends sealing the roof vents where the most water is likely to come into a home, and cause the most damage, during a hurricane. ~

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FIGURE 8. The Water Test: To meet AAMA minimum water penetration rating, a sample window is subjected to a negative pressure equal to 15% or 20% of the design pressure across the inside of the test assembly. The window exterior is then hosed down with a rack of water jets that is equivalent to a rainfall of 8 inches per hour. If any leakage occurs on the interior, the window does not pass.