2 EXISTING WINDOW & DOOR OVERVIEW

Windows and doors are openings in the building envelope that often have multiple and contradictory performance requirements. Windows and doors serve not only as barriers but as a mediator, providing access but preventing entry of the elements, allowing views and ventilation but also protection from the weather. Door and window selection is a balancing of desired objectives including performance, function, appearance, and cost.

Window and door performance, particularly in terms of energy conservation, has progressed significantly in the last two decades as new, better performing materials have been introduced. Issues regarding materials, manufacture, finishes, and performance of doors and windows are similar, and the discussion of such issues within this guide is usually applicable to both.

2.1 EVALUATION OF EXISTING CONDITIONS, OPTIONS, AND SELECTION

The focus of this guide is to restore windows and doors and improve performance by means of new and innovative products. The repair of existing windows and doors, in combination with improvements such as adding a storm or screen unit and insulating the perimeter of the opening, often proves to be the most cost effective solution. The rehabilitation of a door may simply require the adjustment of a loose hinge or strike plate and the replacement of worn weatherstripping. However, the cost of skilled labor and the conveniences provided by new technologies may justify the use of an entirely new unit or some combination of repair and new components.

New window technology has resulted in dramatic savings and increased comfort for the homeowner with the use of new or reformulated frame materials and glazing products while requiring significantly less maintenance. However, a recent study conducted by the State of Vermont concluded the energy savings realized between a renovated window with a storm unit and a replacement unit, without the benefit of high-performance glass products (such as low-e or spectrally selective) were very similar. Infiltration rates (the exchange of air) between the renovated and replacement units were also comparable. The benefits of replacement will not necessarily be energy savings, but the opportunity to provide a more comfortable, durable window or door with ease of operation and the elimination of a lead paint hazard.

Initially an evaluation should be made as to the extent of repair or replacement required. There are essentially three progressive options in addition to repair and storm units, which are discussed separately: a replacement window sash or door; a secondary pre-assembled unit; and complete unit replacement. The first two partial replacement methods provide many of the benefits of a new window or door without disturbing the existing frame, trim, or the surrounding surfaces but do not address infiltration (leaks) at the perimeter, often a major source of energy loss and discomfort. A replacement window sash or door requires the existing frame to be in good condition and relatively square. If either of these con-

ditions does not exist a new sash or door will not operate properly. A secondary frame is suitable for openings that are not square, but these reduce the opening size, and the existing frame opening must be in good condition. Complete replacement provides the opportunity to improve the perimeter insulation as well as to inspect the existing construction for damage. Partial and total replacement units are available in custom sizes. Replacement units are also available in incremental stock sizes, which reduces lead time but often may require infill trim to enclose the existing opening.

The selection of a window should consider the appearance, building type, climate, durability, orientation, expected use, and all applicable codes. A single window type may not be applicable to the entire house. Manufacturers have begun to label their windows as orientation and climate specific to achieve optimal performance. Windows that face east or north or sources of noise (such as traffic) generally should have higher insulative values. Windows in either coastal areas or high altitudes must resist higher wind loads, differential pressures, and corrosive elements. A multi-story building such as a townhouse or apartment building will require low maintenance, ease of cleaning, and resistance to higher wind pressures. Historic buildings will require a matching appearance with existing materials and profiles.

Codes may require replacement window units to have minimum energy performance, safety and egress requirements, and the ability to withstand natural hazards such as wind. Building codes require safety glass, either tempered or laminated, to be installed where there is a potential for human impact. A replacement window must also comply with egress requirements in the size of the clear opening and the sill height above the floor for sleeping rooms in a home of three stories or less. Utilities, insurance companies, and financial institutions may also provide incentives to homeowners to choose units with better performance or safety in the form of premium savings or reduced rate mortgages. In addition to these factors, door selection should also consider fire resistance requirements as prescribed by the building code.

Although not generally required of single-family homes, accessibility for the disabled may often be readily provided for doors and windows. Various accessibility regulations govern the design and construction of residential, typically multi-family, buildings. There are several prescriptive requirements, but *Accessible and Usable Buildings and Facilities* (ANSI A117.1) is the most prevalent. Where local codes differ from the national specification the more stringent requirements should be utilized. There are numerous products available for rehab to make homes accessible (see Further Reading for sources).

2.2 WINDOW AND DOOR TYPES

Window types may generally be categorized as either fixed, sliding, pivot, or hinged, with the distinction among the many varieties described by their typical application (Fig. 1). A hinged window is either a casement, awning, or hopper according to its operation. An individual window unit may have combined properties such as a single hung window that has a fixed and sliding sash, or a projecting window with a fixed and hinged sash.

Door types may be hinged, sliding, pivot, or some variation thereof (Fig. 2). A hinged door may be described as either a passage, accordion, side hinge folding, or bi-fold. An example of a pivot door, often confused with hinged units, in a residential application is a kitchen door that swings in both directions and does not require the use of a latch. Sliding doors are either by-passing, surface sliding, or pocket sliding.

Doors are also categorized by their method of construction, such as panel, batten, or flush. Traditional wood panel doors are made of horizontal rails and vertical stiles that frame one or more panels. Batten doors are usually constructed of solid lumber in a series of planks that are secured with a board attached diagonally on the surface. Flush doors have interior structural cores covered with a thin surface material. This interior structure may be composed of either rails and stiles with hollow cavities or a solid monolithic material such as rigid insulation, particle board, or engineered (jointed) wood members. The exterior surface may be a variety of materials, including metal, plastic laminate, wood (veneer, hardboard, plywood), and fiberglass. The expressive form of a wood panel door can be simulated by flush

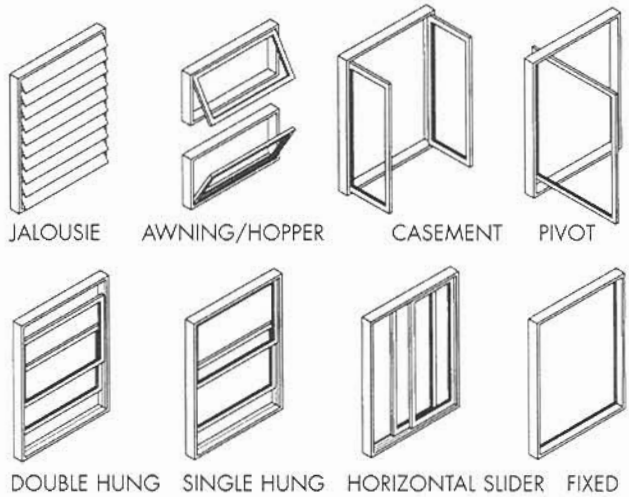


FIGURE 1 WINDOW TYPES

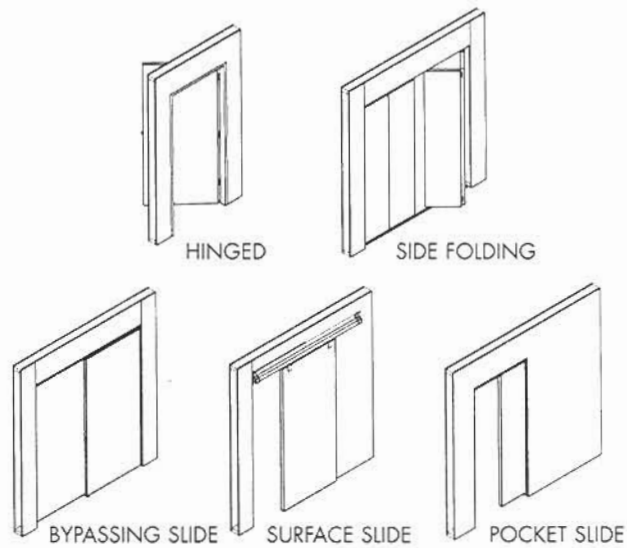


FIGURE 2 DOOR TYPES

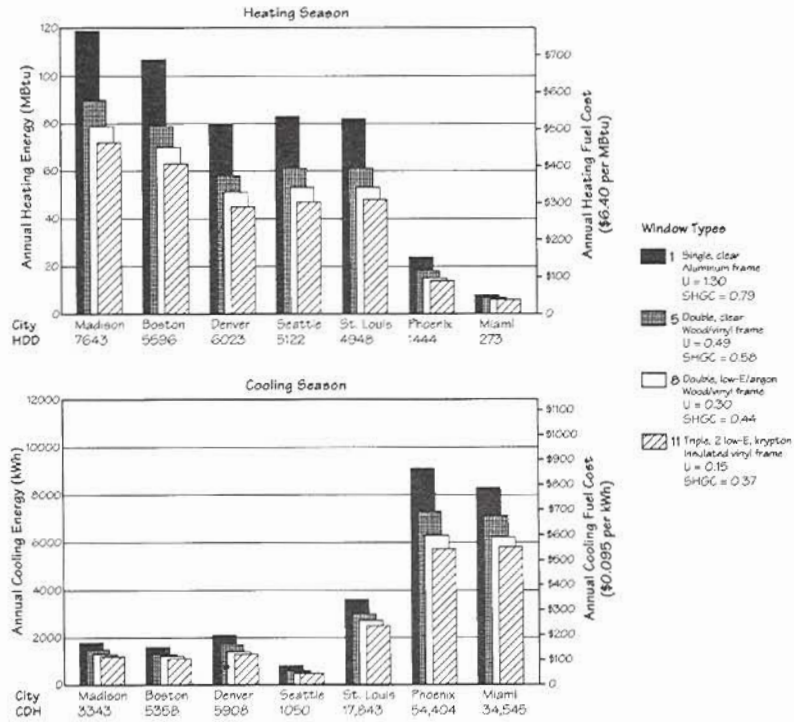
doors with either formed (negative relief) panels or the addition of built up (positive relief) materials to achieve similar profiles, textures, and the appearance of wood, often with the ability to be stained.

Door installation previously required the precision skills of a cabinet maker; the door constructed and hung on site had to be installed absolutely square and plumb in order to operate properly with repeated use. Today, the door and frame are usually pre-assembled by either the factory, distributor, or lumber yard. Such pre-hung doors, which may also be pre-drilled for hardware, have greatly simplified door installation. Pre-hung doors are also available with two-piece (split) or knock down frames, with attached trim and adjustable thresholds, for rapid installation in an out-of-square opening. A pre-hung insert door, similar to a secondary window frame, may be inserted within the frame of an existing door. However, the opening will be smaller, which may not be desirable or code compliant.

Hinged windows and doors, in comparison with sliding units, generally provide a tighter air seal and have less air and water leakage rates because of locking mechanisms, compression gaskets, and stronger frames. They also permit a full opening for egress and ventilation. However, the swing of hinged windows and doors may be an obstruction. Alternatively, bi-fold or accordion style doors provide access

with a minimum of space consumed. Sliding doors consume minimum space but allow only half the width of the opening for clearance. Sliding units typically use a brush type weather-seal subject to wear and tear and a shorter service life. Pocket doors permit the full width of an opening to be used, but may prove inconvenient to operate and are best suited for locations where they are infrequently operated. Ultimately, the performance of a particular unit is determined by the quality of design, construction, and materials—all of which are often difficult to evaluate by visual inspection alone.

Advances in window and door materials over time have balanced the unique qualities of materials for optimum performance. Wood, the oldest window frame material, requires more maintenance than others but is undergoing a transformation with reformulation as a composite and is being used with the protective cladding of aluminum, vinyl, and fiberglass. Wood windows and doors have remained popular because this material is easy to modify in the field for the installation of hardware, or for future adjustment. Steel doors can be coated with vinyl films to give them the appearance of wood grains and to accept stain. Aluminum, often selected for its strength and ease of manufacture and maintenance, is a poor choice in colder climates because of its conductive qualities, which transmit cold outdoor temperatures through the frame (Fig. 3). Window manufacturers responded to this deficit by combining aluminum with less conductive materials such as plastic to provide a "thermal break." Vinyl windows have enjoyed larger market acceptance in recent years for both new and rehab applications.



Note: The annual energy performance figures shown here are for a typical 1540 sq ft house. U-factor and SHGC are for total window including frame. House and windows are described in Appendix A. MBtu=millions of Btu, kWh=kilowatt hours. HDD=heating degree days. CDH=cooling degree hours

FIGURE 3 COMPARISON OF SEASONAL HEATING AND COOLING COST FOR FOUR WINDOW TYPES

2.3 RATINGS AND STANDARDS

The selection of windows and doors based on energy performance criteria has been simplified with the establishment of uniform rating procedures established by the National Fenestration Rating Council (NFRC). The NFRC is a non-profit public/private organization, comprised of a diversified group which includes man-

ufacturers, utilities, code authorities, and others, and sanctioned by the Energy Policy Act of 1992.

Through the NFRC Certification Program, participating manufacturers obtain certification authorization for total product energy ratings such as the U-Value, solar heat gain coefficient, and visible transmittance. Door labels provide the U-Value only. It is anticipated that in late 1998 NFRC will also have certified ratings for both a heating rating and cooling rating. NFRC is presently working on future rating systems for air infiltration, condensation resistance, and long-term energy performance. The values are determined by licensed independent laboratories accredited by the NFRC correlating the results of computer simulations and actual physical testing for two different prescribed sizes. The performance data for both sizes, which vary by type, are designated as "AA" - Residential and "BB" - Non-Residential and are identified on the label.

The ratings for each individual product can be found on the product itself in the from of an NFRC Temporary Label (Fig. 4), and also with a permanent marking somewhere on the unit. The energy performance ratings of manufacturers participating in the NFRC Certification Program can also be found in the NFRC Certified Products Directory, which is published annually.

Presently seven states—California, Idaho, Massachusetts, Minnesota, Oregon, Washington, and Wisconsin—and some local jurisdictions require NFRC ratings for new windows (including those used in rehab) as well as the 1995 Model Energy Code.

FIGURE 4 NFRC TEMPORARY LABEL

Windows or doors should also be selected by their respective performance class designation, which is their ability to resist wind pressure, water, and air infiltration, and resistance to forced entry. The Window and Door Manufacturers Association (WDMA) and the American Architectural Manufacturer's Association (AAMA) have recently developed a new voluntary standard for aluminum, vinyl, and wood windows and glass doors (AAMA/NWWDA 101/I.S.2-97). The new standard combines the two national window performance standards ANSI/AAMA 101.93 and NWWDA I.S. 2.93 and will be applicable to new materials such as composites and plastics.

This standard uses a design pressure designation in lieu of the former structural test pressure value such as grade 20, 40, and 60. Minimum criteria have been established for five performance classes, the lowest of which is "Residential." A new designation code identifies the product type, performance class, performance grade, and maximum size unit tested. Additional voluntary standards, such as acousti-

cal performance, thermal resistance and condensation resistance may also be evaluated by this standard. This new standard, commonly employed in the selection of commercial window and door units, allows for the selection of products for specific applications.

2.4 INSTALLATION

The selection of a suitable window or door does not ensure performance; a unit is only as good as its installation. Improper or inadequate anchorage of the unit will defeat the wind and weather resistance of the best performing window or door. Installation of a replacement window or door may require modification of an existing opening for squareness, caulking, fastening securely to structural members, and insulation of gaps with a product prescribed by the manufacturer.

A common problem encountered is rough openings not large enough to allow for expansion of unit and structural movement, in particular the space required to accommodate header deflection. Out-of-square installation will also impair the proper functioning of the unit and result in a poor weather seal. A window or door that is not functioning properly or has deteriorated may be an indication of damage elsewhere. Windows or doors that are difficult to operate may be swollen due to the effects of moisture that has leaked from a remote area such as the roof and has traveled through the wall cavity only to be discovered at the opening. Often such leaks are present for some time and rot may extend throughout the wall framing. Replacement of water damaged windows offers an opportunity to explore the cause and to examine framing members, which may be structurally compromised.

A window or door without proper structural support will not operate properly and will be subject to infiltration around the perimeter. Insulating between the unit and the rough opening is critical to ultimate performance. Batt insulation or injectable non-expansive foam are the two most popular means of filling this gap. Care must be exercised during installation of batt insulation that it is not too loose (permitting air flow) or too tight (reducing the thermal resistance). Foam products must be installed so as not to apply pressure to the unit itself (which can distort the frame) or chemically interact with the frame material.

Installing new windows and doors also presents the opportunity to eliminate airborne lead and peeling paint from lead based paints, typically present in homes built before 1978. Moving sashes and doors grind the paint into dust, which is easily transported by air movement. Typically, a window requiring lead abatement will cost about the same as a new sash replacement unit. However, replacement of the entire unit will require removal of trim, which is another potential source of lead contamination. The removal of lead-based paint requires precautions that are beyond the scope of this guidebook (see Further Reading for more information on lead-based paints and mitigation methods).

The American Society for Testing and Materials (ASTM) is presently developing a window and door installation standard that will provide a consensus document for the installation of windows, doors, and skylights. This standard will likely serve as the comprehensive reference for both specification and instructional purposes.

2.5 COSTS AND BENEFITS

The repair and/or replacement of windows and doors can pay for itself through improved energy performance and can provide increased comfort. Reduced drafts and warmer surfaces will permit lower temperature settings. However, beware of the enthusiastic promises of manufacturers who may overstate the value of a product. All improvements may be evaluated on a payback basis of their potential savings relative to

cost. Potential savings may also include incentives provided by local government or utilities and special financing referred to as an Energy Efficient Mortgage (EEM) that enables the homeowner to finance the cost of the improvement at no additional net operational cost (mortgage plus utilities). The NFRC certified ratings for U-Factor and Solar Heat Gain Coefficient may be considered for use when using computer simulation programs to assess the potential economic benefit new windows and doors will have on the energy performance of a home. RESFEN, a computer program for the purpose of calculating the annual heating and cooling energy use and cost due to window selection, is available from the Lawrence Berkeley National Laboratory. Fax a request to Resfen Request at 510-486-4089 or e-mail your request to plross@lbl.gov. The Department of Energy (DOE) intends to provide an interactive version of this software program in the near future at the Efficient Windows Collaborative web site (www.efficientwindows.org).

FURTHER READING

Accessible Housing by Design: Universal Design Principles in Practice, Steven Winter Associates, New York: McGraw-Hill, 1997.

ASHRAE Handbook of Fundamentals, Atlanta, GA: American Society of Heating, Refrigerating and Air Conditioning Engineers, 1997.

"Choosing a Front Door," Rich Ziegner, *Fine Homebuilding*, No. 90.

"Choosing Replacement Windows," *Journal of Light Construction* (New England Edition), February 1993.

Choosing the Best Window for Hot Climates, R. McCluney, Florida Solar Energy Center, 1993.

"Creating Windows of Energy-Saving Opportunity," Andrew M. Shapiro and Brad James, *Home Energy*, September/October 1997.

Designing Low-Energy Buildings: Passive Solar Strategies and Energy-10 Software, Passive Solar Industries Council, Washington, DC, Passive Solar Industries Council, 1996.

"Energy-Efficient Window Retrofits: Install with Care," James O'Bannon and Andre Grieco, *Home Energy*, January/February 1997.

Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing, Washington, DC: U.S. Department of Housing and Urban Development, 1995.

"Historic Metal Windows: Their Architectural History," Elan Zingman-Leith, *Old-House Journal*, November 1986.

The Passive Solar Design and Construction Handbook, Steven Winter Associates, New York: John Wiley & Sons, 1998.

Repairing Old and Historic Windows: A Manual for Architects and Homeowners, New York Landmarks Conservancy, New York: John Wiley & Sons, 1992.

Residential Windows, John Carmody, Stephen Selkowitz & Lisa Heschong, New York: W.W. Norton, 1996.

Residential Window and Door Installation Guide, Association of Window and Door Installers, 11300 U.S. Highway 1, Suite 400, North Palm Beach, FL 33408-3296.

"Shopping for Entry Doors," Clayton DeKorne, *Journal of Light Construction* (New England Edition), December 1991.

"Shopping for Replacement Windows," Marylee MacDonald, *Journal of Light Construction*, June 1989.

"Shopping for Wood Windows," Charles Wardell, *Journal of Light Construction*, June 1994.

"Taking a Look at Windows," Jefferson Kolle, *Fine Homebuilding*, No. 97.

Twentieth Century Building Materials: History and Conservation, Thomas C. Jester, New York: McGraw-Hill, 1995.

"Understanding Energy-Efficient Windows," Paul Fisette, *Fine Homebuilding*, February/March 1998.

"Windows: Looking through the Options," Alex Wilson, *Environmental Building News*, March/April 1996.

"Window Technology Update," Alex Wilson, *Journal of Light Construction* (New England Edition), December 1991.

"Worrisome Windows," Paul Engstrom and Jeanne Huber, *This Old House*, January/February 1997.

PRODUCT INFORMATION

Andersen Windows, 100 North 4th Avenue, Bayport, MN 55003-1096; 800-426-4261; www.andersen-corp.com (wood, vinyl clad, and composite wood windows and doors).

Caradco, P.O. Box 920, Rantoul, IL 61866; 217-893-4444 (wood, alum. clad, and vinyl windows and doors).

CertainTeed Corporation, P.O. Box 860, Valley Forge, PA 19482; 800-233-8990; www.certainteed.com (vinyl windows and doors).

Comfort Line Inc., 5500 Enterprise Boulevard, Toledo, OH 43612; 800-522-4999 (wood, composite wood, vinyl, and fiberglass windows and doors).

Hope's Architectural Products, 84 Hopkin's Avenue, Jamestown, NY; 716-665-5124;(metal (steel) framed windows).

Hurd Millwork, 520 South Whelan Avenue, Medford, WI 54451; 715-748-2011 (wood, alum. clad, and vinyl windows and doors).

Jeld-Wen Window Products (Pozzi, Wenco, Norco, Caradco), P.O. Box 1329, Klamath Falls, OR 97601-0268; 800-877-9482; www.doors-windows.com (wood, alum. clad, composite wood, vinyl, and fiberglass windows and doors).

Kolbe and Kolbe, 1323 S. Eleventh Avenue, Wausau, WI 54401-5998, 800-955-8177, www.kolbe-kolbe.com (wood and alum. clad windows and doors).

Marvin Windows, P.O. Box 100, Warroad, MN 56763; 800-346-5128; www.marvin.com (wood, alum. clad, composite wood, and fiberglass windows and doors).

Milgard Windows, 1010 54th Ave. E., Tacoma, WA 98424; 800-645-4273 (wood, vinyl, and fiberglass windows and doors).

Omniglass, 1205 Sherwin Road, Winnipeg, MB R3H 0V1; 204-987-8522 (composite wood and fiberglass windows).

Pella Corporation, 102 Main Street, Pella, IA 50219; 800-847-3552; www.pella.com (wood and alum. clad windows and doors).

Seekircher Steel Window Repair, 630 Saw Mill River Rd., Ardsley, NY 10502; 914-693-1920 (metal framed window repair).

Torrance Steel Window Co., Inc.,1819 Abalone Ave., Torrence , CA 90501; 310-328 -9181 (metal framed windows).

Weather Shield Manufacturing, Inc., P.O. Box 309, Medford, WI 54451; 800-222-2995; www.weather-shield.com (wood, alum. clad, vinyl clad, and vinyl windows and doors).