12

WINDOWS AND EXTERIOR DOORS

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The word "window" is thought to have originated in an Old English expression that means "wind eye" or "wind hole." The earliest windows in buildings were open holes through which smoke could escape and fresh air could enter. Control devices of various kinds were soon added to the holes: Hanging skins, mats, or fabric were used to regulate airflow. Shutters were added to provide shading and to keep out burglars. Translucent membranes of oiled paper or cloth and, eventually, glass were developed to admit light while preventing the entry of air, water, and snow. When a translucent membrane was eventually mounted in a moving sash, light and air could be controlled independently of one another. With the addition of woven insect screens, windows permitted air movement while keeping out mosquitoes and flies. Further improvements followed one upon another as the centuries passed. A typical window today is an intricate, sophisticated mechanism with many layers of controls: curtains, shade or blind, sash, glazings, insulating airspace, low-emissivity coatings, insect screen, weatherstripping, and perhaps a storm sash or shutters.

Windows and doors are very special components of walls. Windows allow for simultaneous control of the passage of light, air, and visual images through walls. Doors permit people, goods, and, in some cases, vehicles to pass through walls. Windows and doors, in addition to these important functions, play a large role in establishing the character and personality of a building, much as our eyes, nose, and mouth play a large role in our personal appearance. At the same time, windows and doors are the most complex, expensive, and potentially troublesome parts of a wall. The experienced designer exercises great care and wisdom in selecting them and detailing their installation to achieve satisfactory results.

The size, proportion, and location of windows can have a significant impact not only on the character of a house, but also on its energy performance. Even the most energy-efficient window allows 4 to 10 times as much heat to pass through as does a reasonably well insulated wall, so the amount of window area in an exterior wall should be judiciously monitored by the designer. In fact, building codes set prescriptive limits for the percentage of the gross area of exterior wall that can be made of glass. The International Residential Code, for example, specifies a maximum of 15 percent *glazed* (glass) *area* for normally insulated houses. Windows can also contribute to heating a house when oriented to take advantage of passive solar heat gain. Codes typically boost the maximum allowable gross area of glass in exterior walls when 50 percent or more of the glass is located in a south-facing wall. Cooling energy savings can also be realized by locating operable windows in positions to take advantage of natural cross ventilation.

WINDOWS

The basic components of a window (Figure 12.1) are the *sash*, which holds the glass; the *jamb*, which is the frame around the sash that fits into the rough opening in the wall; and the *casing*, which surrounds the jamb and covers the gap between the window and the framing, both inside and out. At the base of the window, the sash rests on an exterior *sill*, which slopes away from the building to carry away rainwater. When two sashes are adjacent, the structural piece between them, whether horizontal or vertical, is called a *mullion*. Divisions within a sash are made with slender pieces called *muntins*.

A *prime window* is a window that is permanently installed in a building. A *storm window* is a removable auxiliary unit that is added seasonally to a prime window to improve its thermal performance. A *combination window*, which is an alternative to a storm window, is an auxiliary unit that incorporates both glass and insect screening; a portion of the glass is mounted in a sash that can be opened in summer to allow ventilation through the screening. A combination window is normally left in place year-round. Some windows are designed and manufactured specifically as *replacement windows* that install easily in the openings left by deteriorated windows that have been removed from older buildings.

Types of Windows

Figure 12.2 illustrates in diagrammatic form the window types most commonly used in residential buildings. Fixed windows are the least expensive and the least likely to leak air or water because they have no operable

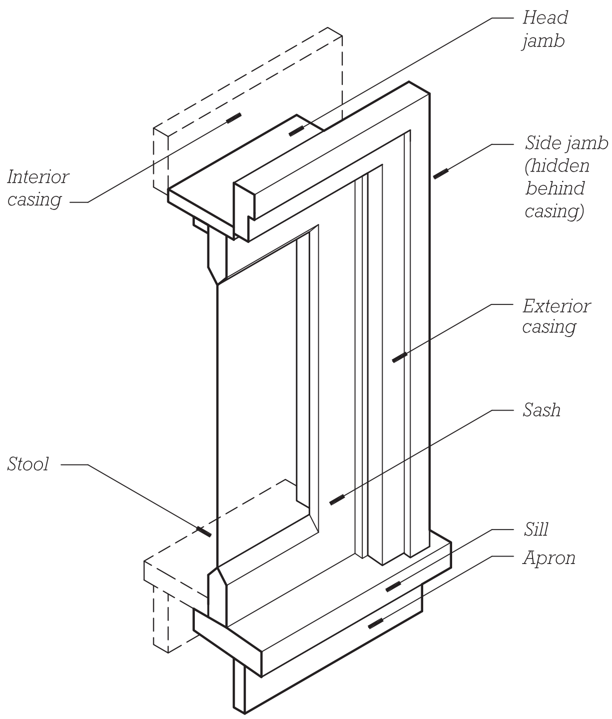


Figure 12.1
Window nomenclature follows a tradition that has developed over hundreds of years. The jamb and sill are known collectively as the frame. The head jamb is usually referred to simply as "the head."

components. *Single-hung* and *double-hung windows* have one or two moving sashes that slide up and down in tracks in the frame of the window (Figure 12.3). In older windows, the sashes were held in position by cords and counterweights, but today's double-hung windows usually rely on a system of springs to counterbalance the weight of the sashes. A *sliding window* is essentially a single-hung window on its side and shares with single-hung and double-hung windows the advantage that tracks in the frame hold the sash securely along two opposite sides. This inherently stable construction allows single-hung, double-hung, and sliding windows to be designed in an almost unlimited range of sizes and proportions. It also allows the sashes to be more lightly built than

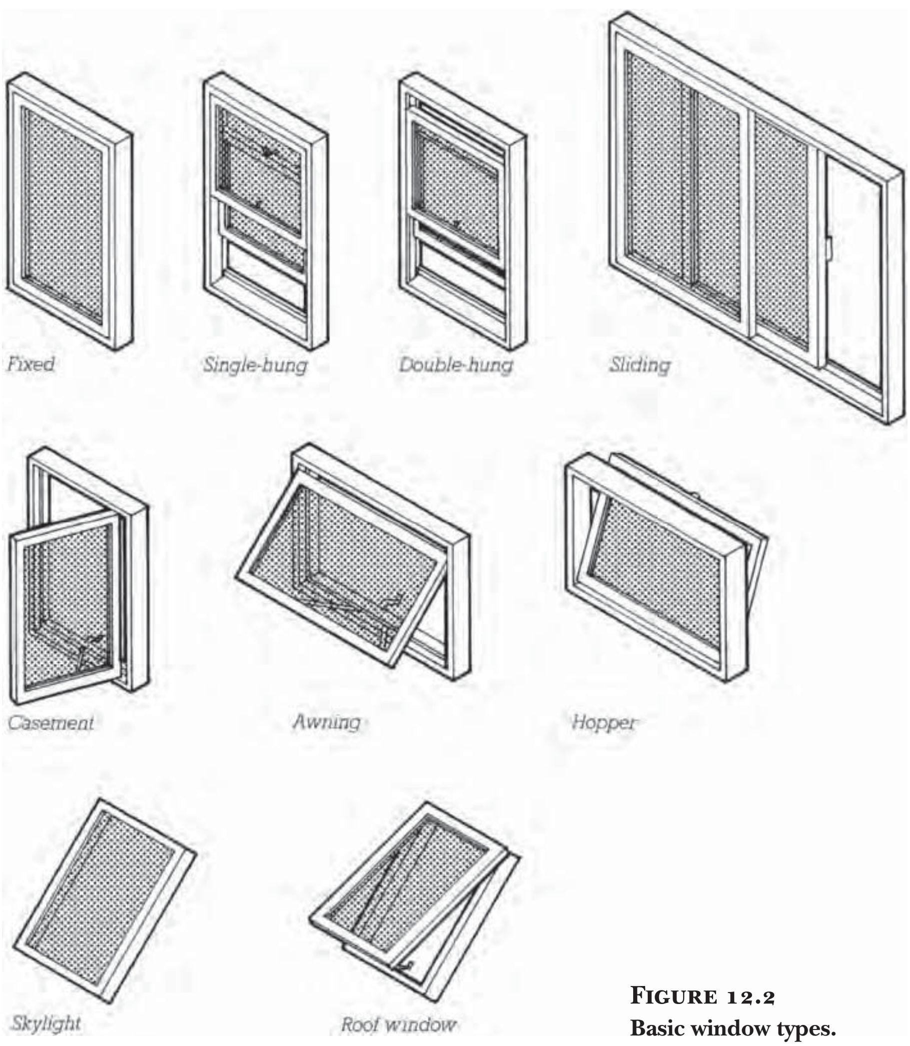


Figure 12.2
Basic window types.

Figure 12.3
Double-hung window from the early 20th century. There are two operable sashes, each of which is counterbalanced with weights for ease of operation. The upper sash overlaps the lower sash to keep out the weather. Adding a storm sash to the exterior can weatherize historic sashes such as these. *(Photo by Rob Thallon)*

those in *projected windows,* a category that includes principally *casement windows* and *awning windows.* All projected windows have sashes that rotate outward from their frames and therefore must have enough structural stiffness to resist wind loads while also supporting their own weight at only two corners.

With the exception of the rare triple-hung window, no window with sashes that slide can be opened to more than half of its total area. By contrast, projected windows can be opened to their full area. Casement windows are helpful in catching passing breezes and inducing ventilation through the building; they are generally narrow (30 inches, or 762 mm, maximum) in width but can be joined to one another and to sashes of fixed glass to fill wider openings (Figure 12.4). Awning windows can be broad but are not usually very tall. Awning windows have the advantages of protecting an open window from water during a rainstorm and of lending themselves to a building-block approach to the design of window walls (Figure 12.5). *Tilt/turn windows* have elaborate but concealed hardware that allows each window to be operated either as an in-swinging casement or as a hopper. Windows in roofs are specially constructed and flashed for watertightness and may be either fixed (*skylights*) or openable (*roof windows*).

Projected windows are usually provided with synthetic rubber (elastomeric) *weatherstripping* that seals by compression around all the edges of the sash when it is closed. Single-hung, double-hung, and sliding windows generally must rely on brush-type weatherstripping because it does not exert as much friction as elastomeric materials against a sliding sash. Brush-type materials do not seal as tightly as compression weatherstripping, and they are also subject to more wear than elastomeric weatherstripping over the life of the window. As a result, projected windows are generally somewhat more resistant to air leakage than windows that slide in their frames.

Figure 12.4
Windows can be "ganged" at the factory or at the site. Ganging of windows consists of fastening standard windows together into a single unit. It is most efficient to gang at the factory, but if the assembly is very large, collections of sashes ganged at the factory must be further joined at the site. *(Photo by Rob Thallon)*

Figure 12.5
Awning and fixed windows in coordinated sizes offer the architect the possibility of creating patterned walls of glass. *(Courtesy of Marvin Windows and Doors)*

Insect screens may be mounted only on the interior side of the sash in casement and awning windows. To open the window with the screen in place, most manufacturers use a crank mechanism. Screens are mounted on the outside in other window types.

Glass tends to attract and hold dust and dirt on both inside and outside surfaces and must be washed at intervals if it is to remain transparent and attractive. Inside surfaces are usually easy for window washers to reach. Outside surfaces are often hard to reach, requiring ladders or scaffolding. Accordingly, most operable windows are designed to allow people to wash the outside surface of glass while standing inside the building. Casement and awning windows are usually hinged in such a way that there is sufficient space between the hinged edge of the sash and the frame when the window is open to allow access to the outer surface of glass for ease of cleaning. Double-hung and sliding windows are often designed to allow each sash to be rotated out of its track for cleaning (Figure 12.6).

Window Construction

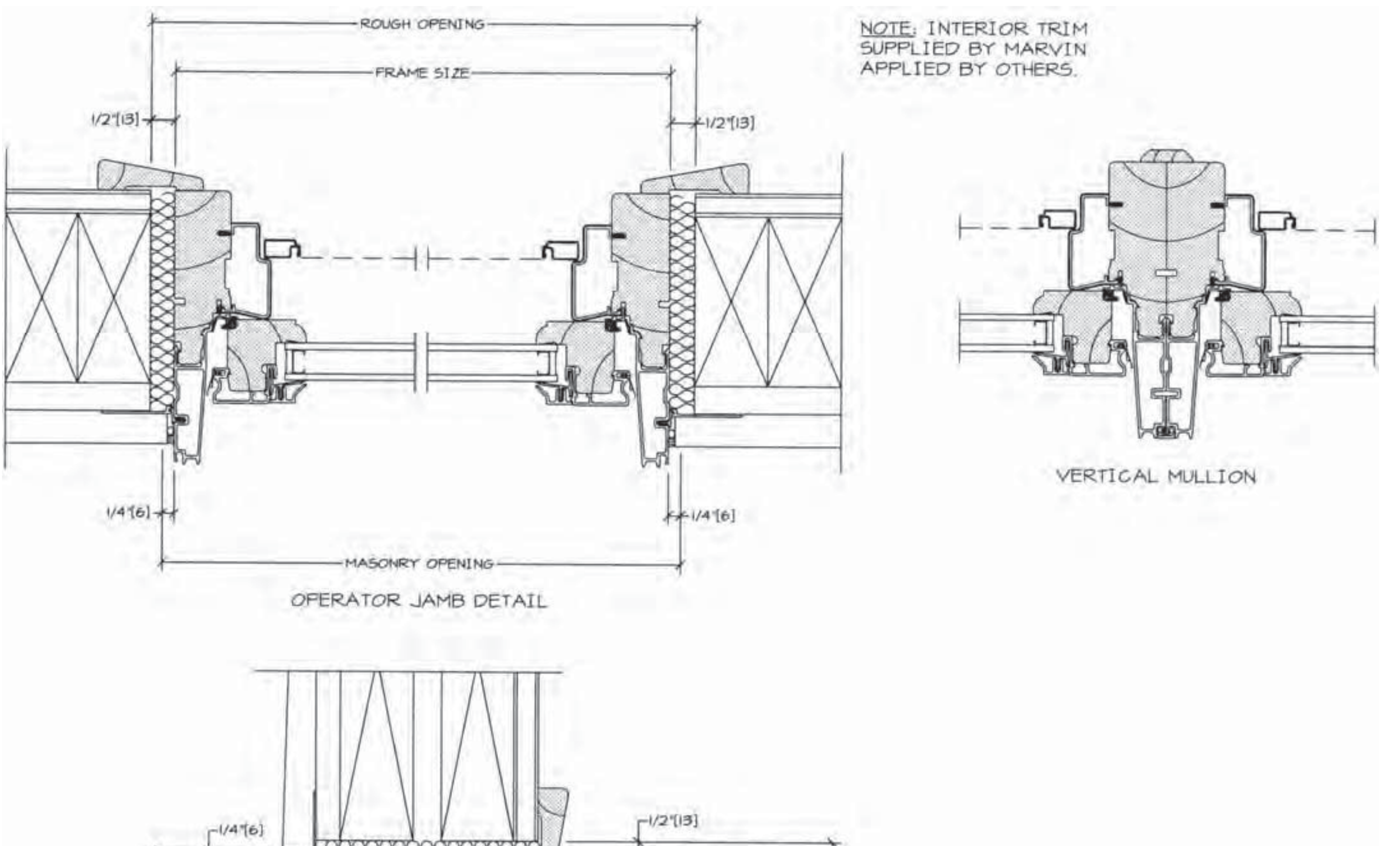
Windows were formerly made on the construction site by highly skilled carpenters, but nearly all are produced now in factories (Figure 12.7). Factory-produced windows cost less and, more important, are of better quality. Windows need to be made to a very high standard of precision if they are to operate easily and maintain a high degree of weathertightness over a period of many years.

The traditional material for window frames and sashes is wood, although aluminum, plastics, and combinations of these three materials have also come into widespread use. Wood is a fairly good thermal insulator and, if free of knots, is easily worked into sash. However, in service, wood shrinks and swells with changing moisture content and requires repainting every few years. When dampened by weather, leakage, or condensate, *wood windows* are subject to decay. Knot-free wood is becoming increasingly rare and expensive, for which reason wood products made of short lengths finger jointed together, oriented wood strands, or veneers are now used more frequently in window construction than solid lumber. These substitute materials, while functionally very satisfactory, are not attractive to the eye, so they are usually covered (clad) with wood veneer on the inside and an exterior cladding of plastic or aluminum (Figures 12.8 and 12.9). *Clad windows* currently account for about three-quarters of the market for wood windows.

Vinyl windows, which are capturing a continuously increasing proportion of the residential window

Figure 12.6
For ease of washing the exterior surfaces of the glass, the sashes of this plastic window can be unlocked from the frame and tilted inward. *(Courtesy of Vinyl Building Products, Inc.)*

Figure 12.7
Most new windows and doors in North America are made in very large factories such as this. Assembly-line production and economy of scale result in high-quality products at prices with which it is difficult for small companies to compete. *(Photo courtesy of Andersen Windows, Inc.)*



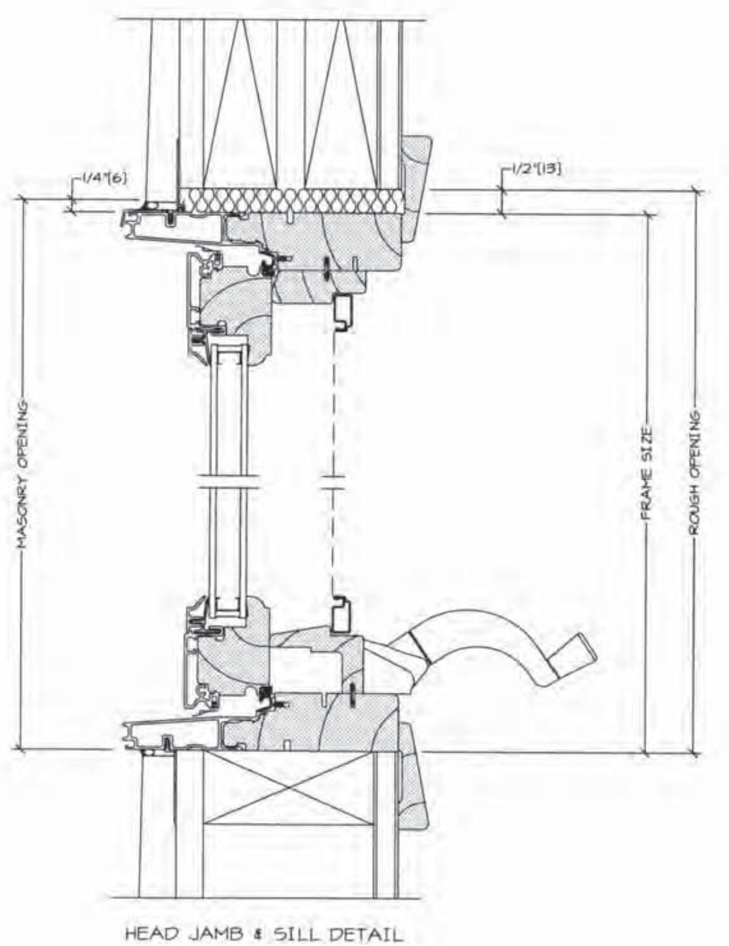


FIGURE 12.8
Manufacturer's catalog details for an aluminum-clad, wood-framed casement window with double glazing and an interior insect screen. *(Courtesy of Marvin Windows and Doors)*

FIGURE 12.9
Cutaway sample of an aluminum-clad, wood-framed window. *(Courtesy of Marvin Windows and Doors)*

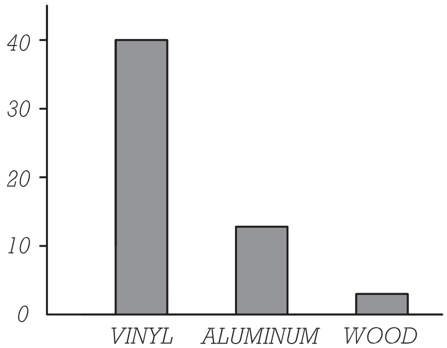


FIGURE 12.10
A comparison of the coefficients of thermal expansion for vinyl, aluminum, and wood. Vinyl expands about 10 times as much as wood, so allowances for differential movement must be made when joining these two materials in a building. Units in the graph are in./in./°F × 10^{-6}.

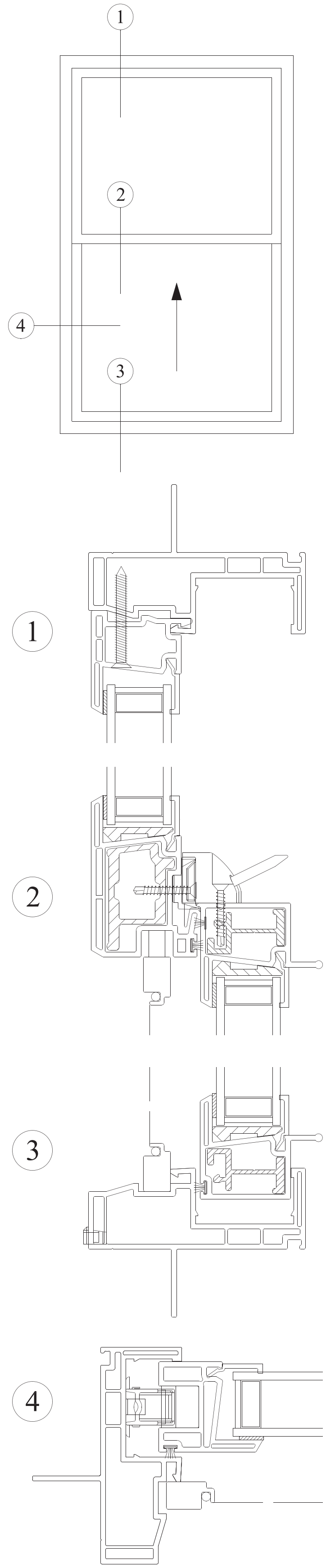


FIGURE 12.11
Details of a vinyl single-hung residential window. The small inset drawing at the top of the illustration shows an elevation view of the window with numbers that are keyed to the detailed sections below. *(© Milgard Manufacturing, Inc.)*

market, never need painting and are fairly good thermal insulators. The most common material for vinyl window frames is polyvinyl chloride (PVC) that is formulated with a high proportion of inert filler material to minimize thermal expansion and contraction. Even so, the coefficient of thermal expansion for vinyl is considerably greater than that of other materials used in window manufacture (Figure 12.10). For this reason, only light (non-heat-absorptive) colors are available, and manufacturers specify that installers allow tolerances between the window frame and the building frame to allow for expansion and contraction. Some typical PVC window details are shown in Figures 12.11 and 12.12.

Glass-fiber-reinforced plastic (GFRP) windows are new to the window market. GFRP frame sections are produced by a process of pultrusion: Continuous lengths of glass fiber are pulled through a bath of plastic resin, usually polyester, and then through a shaped, heated die in which the resin hardens. The resulting sash pieces are strong, stiff, and relatively low in thermal expansion. Like vinyl, they are fairly good thermal insulators.

FIGURE 12.12
Cutaway sample of a plastic double-hung window with double glazing and an external half-screen. *(Courtesy of Vinyl Building Products, Inc.)*

In earlier times, because of the difficulty of manufacturing large pieces of glass, sashes were necessarily divided into small *lights* by muntins (Figure 12.13). A typical double-hung window had its upper sash and lower sash each divided into six small lights and was referred to as a "six over six." Muntin arrangements changed with changing architectural styles and improvements with glass manufacture. Today's windows, glazed with large, virtually flawless lights of float glass, need no muntins at all, but many building owners and designers prefer the look of traditional *true-divided-light windows*. This desire for divided lights is greatly complicated by the necessity of using double glazing. Some manufacturers offer the option of individual small lights of double glazing held in deep muntins. This is relatively expensive and tends to look heavy because the muntins must be wide to cover the edges of the double glazing. The least expensive option uses grids of imitation muntin bars, made of wood or plastic, that are clipped into each sash against the interior surface of the glass. These are designed to remove easily for washing the glass. Other alternatives are imitation muntin grids between the sheets of glass, which are not very convincing replicas of the real thing, and grids, either removable or permanently bonded to the glass, on both the outside and the inside faces of the window. Another option is to use a prime window with authentic divided lights of single glazing and to increase its thermal performance with a storm sash. Of all the options, this looks the best from the inside, but reflections in the storm sash largely obscure the muntins from the outside.

FIGURE 12.13
A pair of 6/1 double-hung windows. The muntins in the divided upper sash can be made in a variety of ways that are only apparent upon close scrutiny. These two windows were "ganged" at the factory into a single unit with a vertical mullion at the center. *(Courtesy of Marvin Windows and Doors)*

Glazing

The term *glazing* refers to glass incorporated into a building or set within a window sash. A number of glazing options are available for residential windows (Figure 12.14). *Single glazing* is acceptable only in the mildest climates because of its low resistance to heat flow and the likelihood that moisture will condense on its interior surface in cool weather. Sealed *double glazing* or single glazing with storm windows is the minimum acceptable glazing under most building codes. More than 90 percent of all residential windows sold today in North America have two or more layers of glazing. Double glazing with a *low-emissivity (low-e) coating* on one glass surface performs at least as well as triple glazing. The most usual form of *triple glazing* today consists of two outer sheets of glass with a thin, virtually weightless, highly transparent plastic film stretched in the middle of the airspace. Removable glazing panels and storm windows must be removed periodically and cleaned, which is a nuisance that can be avoided by using sealed double glazing.

Figure 12.15 shows the thermal properties of various glazing options. These values apply only to the center area of each light of glass. The edges of the light transmit heat much more rapidly because of the solid strips of material used to space the sheets of glass and hold them together. For this reason, whole-window values for heat transmission that take into account heat transmission through the edge spacers, sash, and frame are the only accurate way of comparing the thermal efficiencies of different windows.

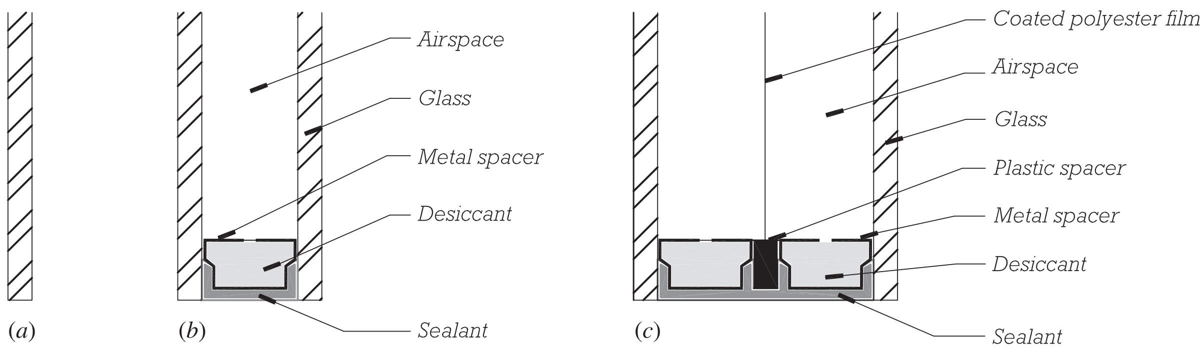


FIGURE 12.14
Comparison of single, double, and triple glazing: (*a*) Single residential glazing is usually double strength, about ⅛ inch (3 mm) thick. (*b*) Double glazing consists of two sheets of glass with an airspace between them. A metal spacer at the edge of the glass contains desiccant that absorbs moisture contained in the air between the two sheets of glass. The entire unit is sealed at the edges. If this seal fails, moisture can enter and saturate the desiccant, causing the unit to fog. (*c*) Triple glazing is similar to double glazing but with an extra airspace created by either a transparent polyester film or another layer of glass between the outer layers of glass. Single, double, or triple glazing can be coated to transmit only selected parts of the light spectrum, and the cavity can be filled with argon or other inert gases to increase thermal performance.

Thermal Insulating Values, Center of Glass

	U		R	
	U.S.	S.I.	U.S.	S.I.
Single glass	1.11	6.29	0.90	0.16
Double glass or single glass plus storm window	0.50	2.84	2.00	0.35
Double glass with argon fill	0.46	2.61	2.17	0.38
Double glass with low-e coating on one surface	0.34	1.93	2.94	0.52
Double glass with argon fill and low-e coating on one surface	0.28	1.59	3.57	0.62
Triple glass	0.34	1.93	2.94	0.52
Double glass, polyester film in middle of airspace, argon fill, low-e coating on two interior surfaces	0.17	0.96	5.88	1.03

FIGURE 12.15
Center-of-glass thermal insulating values for various types of glazing.

Higher whole-window thermal efficiency is achieved by using thermally efficient frames and less conductive spacers around the perimeter of lights of multiple glazing.

In warm climates, the dominant thermal problem in windows is likely to be excessive admission of solar heat to the interior of the building through windows on the east, west, and south sides of the building. Tinted glass can reduce the transmission of solar heat somewhat and make the building easier to cool. More effective, however, are low-e coatings that are designed specifically to reflect the wavelengths of sunlight that contain the most heat, while admitting useful amounts of light to the building and providing good viewing conditions to the outdoors.

Safety Considerations in Windows

To prevent accidental breakage and injuries, building codes require that window lights that are near enough to the floor or doors must be made of breakage-resistant material. *Tempered glass* is most often used for this purpose, but *laminated glass* and plastic glazing sheets are also permitted. Building codes also require that at least one window in each bedroom must open to an aperture large enough to permit occupants of the bedroom to escape through it and firefighters to enter through it. Called an *egress window*, the typical requirement is that the clear opening must be at least 5.7 square feet (0.53 m^2), the clear width must be at least 20 inches (510 mm), the clear height must be at least 24 inches (610 mm), and the sill may be no higher than 44 inches (1.12 m) above the floor.

Window Testing and Standards

The designer's task in selecting windows is facilitated by testing programs that allow objective comparisons of the thermal and structural performances of windows of different types and different manufacturers. Performance-based standards for wood and clad windows are published by the Window and Door Manufacturers Association (WDMA), for aluminum and plastic windows by the American Architectural Manufacturers Association (AAMA), and for PVC windows by ASTM International. Each of these standards establishes performance grades of windows. Within each grade, a design wind pressure, water resistance, structural performance, air infiltration, and operating force are specified. The WDMA ratings for wood windows, for example, establish six grades corresponding to satisfactory performance in wind pressures of 15, 20, 25, 30, 35, and 40 pounds per square foot (718 to 1914 Pa). The designer may select a grade of window to correspond to the severity of exposure to weather of the building site and the level of performance that the building owner is willing to pay for. For an inexpensive residence in a sheltered location, a Grade 15 window, the lowest classification, is likely to suffice. For an expensive custom house at the coast, a Grade 35 or 40 window is likely to be a better match for the more demanding environmental conditions in which it must perform.

With regard to energy efficiency, the National Fenestration Rating Council (NFRC) sponsors a program of testing and labeling that is based on the performance of the whole window, not just the glass. At the present time, the standard label that is affixed to each window shows values for the thermal insulating value (U-value), solar heat gain coefficient, and visible light transmittance (Figure 12.16). Air leakage and condensation resistance categories have recently been added as optional ratings that manufacturers may choose to include.

Installing Windows

Some catalog pages for windows are reproduced in Figures 12.8 and 12.12 to give an idea of the information on window configurations that is available to the designer. The most important dimensions given in catalogs are those of the *rough opening*. The rough opening height and width are the dimensions of the hole that must be left in a framed wall for the window's installation. They are slightly larger than the corresponding outside dimensions of the window unit itself to allow the installer to locate and level the unit accurately. The *frame size* is the size of the unit itself and is used by the designer to calculate the overall size of ganged windows made of individual window units joined together.

Information from the manufacturer's catalog is used by the designer to assemble a *window schedule* for utilization by the contractor (Figure 12.17). The window schedule lists each window shown on the plan and describes its operation, the size of rough opening it requires, its position on the wall (head height), its jamb depth, and any other information pertinent to its complete installation. The contractor uses the window schedule in conjunction with the construction drawings to get bids for windows, to order them, and to frame the window openings.

Most factory-made windows are extremely easy to install, often requiring only a few minutes per window. Figure 12.18 shows a typical

National Fenestration Rating Council Incorporated

CERTIFIED

AAA Window Company

Manufacturer stipulates that these ratings were determined in accordance with applicable NFRC procedures.

Energy Rating Factors	Ratings Residential	Ratings Nonresidential	Product Description
U-Factor Determined in Accordance with NFRC 100	0.40	0.38	Model 1000 Casement Low-e = 0.2 0.5" gap Argon Filled
Solar Heat Gain Coefficient Determined in Accordance with NFRC 200	0.65	0.66	
Visible Light Transmittance Determined in Accordance with NFRC 300 & 301	0.71	0.71	

NFRC ratings are determined for a fixed set of environmental conditions and specific product sizes and may not be appropriate for directly determining seasonal energy performance. For additional information contact:

Figure 12.16
A typical certification label that is affixed to a window unit so that buyers may compare energy efficiencies. *(Courtesy of National Fenestration Rating Council, Inc.)*

Sheldon Village Window Schedule for a Three-Bedroom Townhouse

Location Key	Type	No. Ea.	Rough Opening	Jamb Depth	Header Height	Header Size	Notes: All Screened
1	XO	1	4-0X4-0	6⅝	6-10½"	See plan	
2	XO	1	4-0X4-0	6⅝	6-10½"	See plan	
3	SH-F-SH	3	7-6X4-0	6⅝	6-10½"	See plan	(3) 2–6 windows
4	SH	1	2-6X4-0	6⅝	6-10½"	See plan	
5	XO	1	4-0X4-0	6⅝	6-10½"	See plan	
6	SH	1	2-6X4-0	6⅝	6-10½"	See plan	Tempered
7	XO	1	4-0X3-0	6⅝	6-10½"	See plan	
8	SH	1	3-0X5-0	6⅝	6-10½"	See plan	Egress
9	XO	1	2-0X4-0	6⅝	6-10½"	See plan	
10	SH	1	3-0X5-0	6⅝	6-10½"	See plan	Egress
11	AWNING	1	2-0X2-0	6⅝	4-10½"	See plan	
12	SH	1	3-0X5-0	6⅝	6-10½"	See plan	Egress
13	SKYLT	1	1-8X2-10				

Figure 12.17
A window schedule from a set of construction documents. Each window has a reference number that is keyed to a plan drawing. Window manufacturers use this schedule to create a bid for the general contractor, and framers use it to coordinate installation of the windows.

(*a*)

(*b*)

(*c*)

(*d*)

Figure 12.18
Installing a wood casement window unit in an existing building. (Installation in new construction is identical, except that the siding is installed after the window.) (*a*) The window unit, with its factory-applied exterior wood casing flange, is placed in the opening and centered. (*b*) A single finish nail is driven through a lower corner of the casing and into the wall framing. (*c*) The unit is plumbed, leveled, squared, and shimmed before inserting nails around the remainder of the unit. (*d*) Sealant is applied between the siding and the exterior casing of the unit to reduce water leakage. The installation is now complete except for the installation of interior casings, which is shown in Chapter 20. Installation procedures for other types of wood windows are similar. *(Courtesy of Marvin Windows, Warroad, Minnesota)*

procedure for installing a wood window, nailed through the casing into the framing. Windows that are framed or clad in aluminum or vinyl are usually provided with a continuous flange called a *nailing fin* around the perimeter of the window unit (Figure 12.19). When the unit is pushed into the rough opening from the outside, the flange bears against the sheathing along all four edges. After the unit has been located and leveled and squared in the opening, it is attached to the frame by means of nails driven through the flanges. The siding or trim later conceals the flanges (Figure 12.20). The edges around windows and doors must be carefully flashed for resistance to leakage of water and air (Figures 12.21 and 12.22). Caulking behind casings or flanges seals the window unit to the flashing or weather barrier.

Figure 12.19
Most windows are attached to the building by means of a nailing fin. The fin is nailed to the sheathing to hold the window in the plane of the wall, and caulking between the fin and the weather barrier seals against moisture and air infiltration. *(Photo by Rob Thallon)*

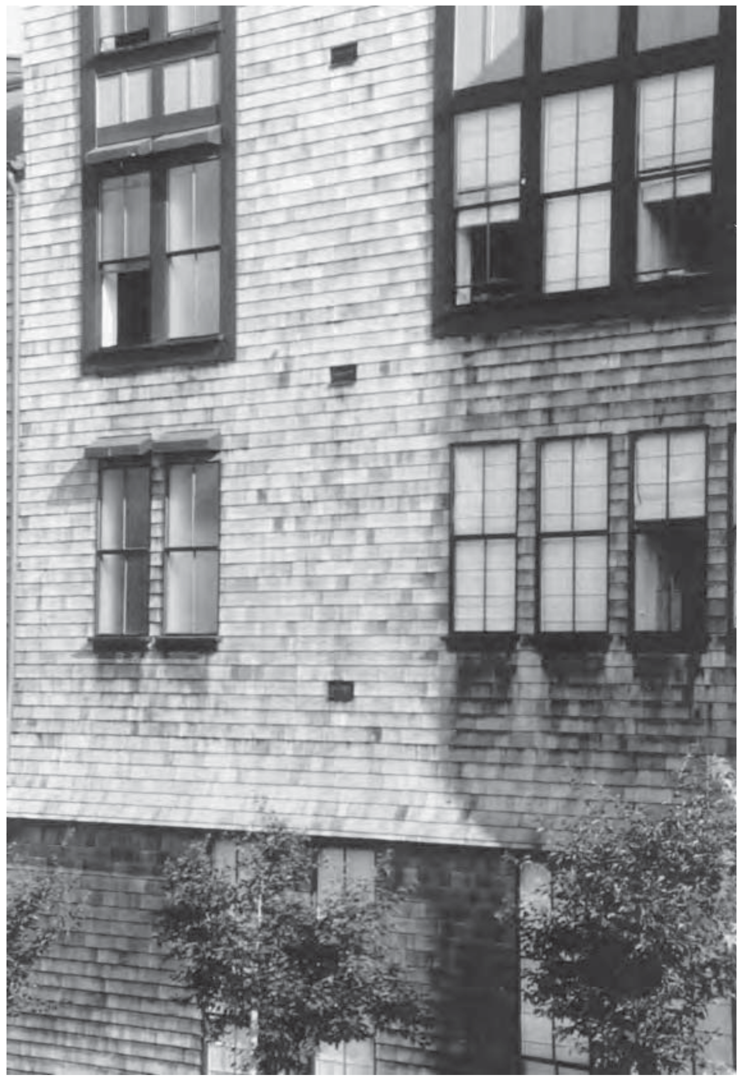


Figure 12.20
The windows at the top of the photo have a wide casing, whereas those at the bottom of the photo do not, reflecting the intention of the architect to differentiate the two otherwise identical sets of windows. *(Photo by Rob Thallon)*

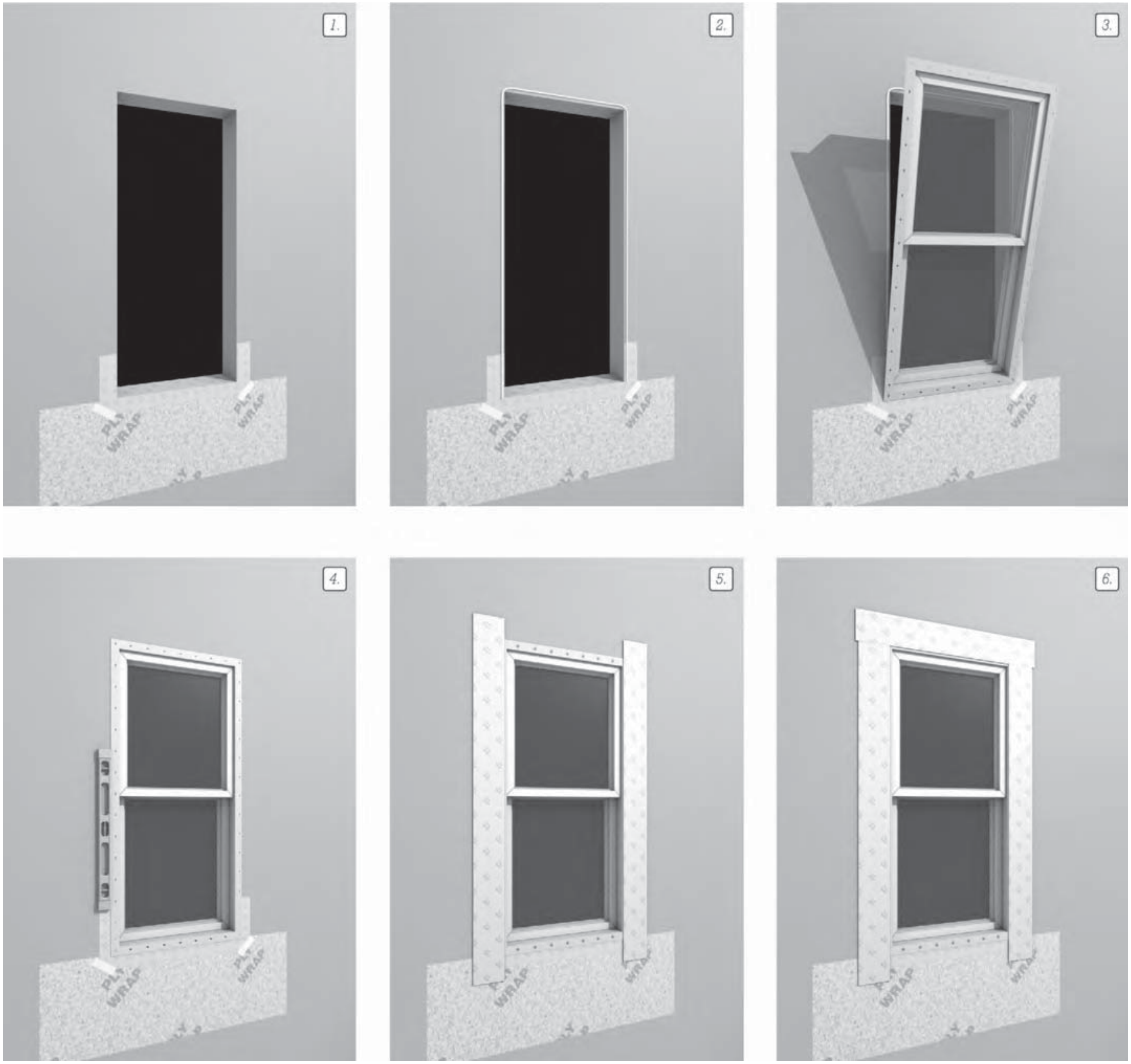


FIGURE 12.21
Installing a vinyl-clad wood window in a wall that has been covered with housewrap: 1. With a single strip of self-sticking, flexible, waterproof sheet material, a U-shaped flashing is formed along the sill and up onto the side jambs. 2. A bead of sealant is placed around the opening. 3. The window unit is pushed into the opening from the outside. Its exterior flange is bedded in the sealant. 4. One corner of the window unit is anchored with a nail through its flange and into the framing of the wall. With the aid of a level, a measuring tape, and thin wooden wedges, the unit is carefully squared as further nails are driven through the flanges. 5, 6. Strips of self-sticking waterproof sheet are adhered to the window flanges and housewrap over the side jambs and head for airtightness and watertightness.

Figure 12.22
The strip of weather barrier around this window is first stapled to the framing around the rough opening. Next, as the window is installed, its flange is bedded in a bead of sealant to seal it to the strip. When the complete weather barrier is applied later, it will be taped to the strip around the window, making the barrier continuous. Flashing will be added at the top of the window to divert rainwater.
(Photo by Edward Allen)

Exterior Doors

Exterior doors fall into two general categories, swinging (hinged) and sliding (Figure 12.23). Swinging doors are available in a wide range of styles and are often combined with *sidelights* or *transoms* to make an elegant entry (Figure 12.24). Simple swinging doors are also used in the most mundane of locations such as between the garage and the house. Sliding doors, however, are almost invariably glazed and are typically used as a connection between house and garden (Figure 12.25).

Residential hinged entrance doors almost always swing inward and are mounted at the interior edge of the jamb (Figure 12.26). This arrangement pulls the door back slightly from the weather and exposes the hinges only at the interior, making the door more secure and avoiding the need for nonremovable pin hinges. An in-swinging door also allows a storm door, swinging outward, to be mounted on the outside of the same frame for improved wintertime thermal performance. In summer, a screen door may be substituted for the storm door. A combination door, which has easily interchangeable screen and storm panels, is more convenient than separate screen and storm doors.

The hinged *French door* opens fully and can be used to regulate airflow through the room if both leaves are fitted with doorstops that can hold them securely in any open position. With its seven separate edges that must be carefully fitted and weatherstripped, the French door is prone to air leakage along these edges. The recently developed *terrace door,* with only one operating door, minimizes this problem but it can open to only half its area.

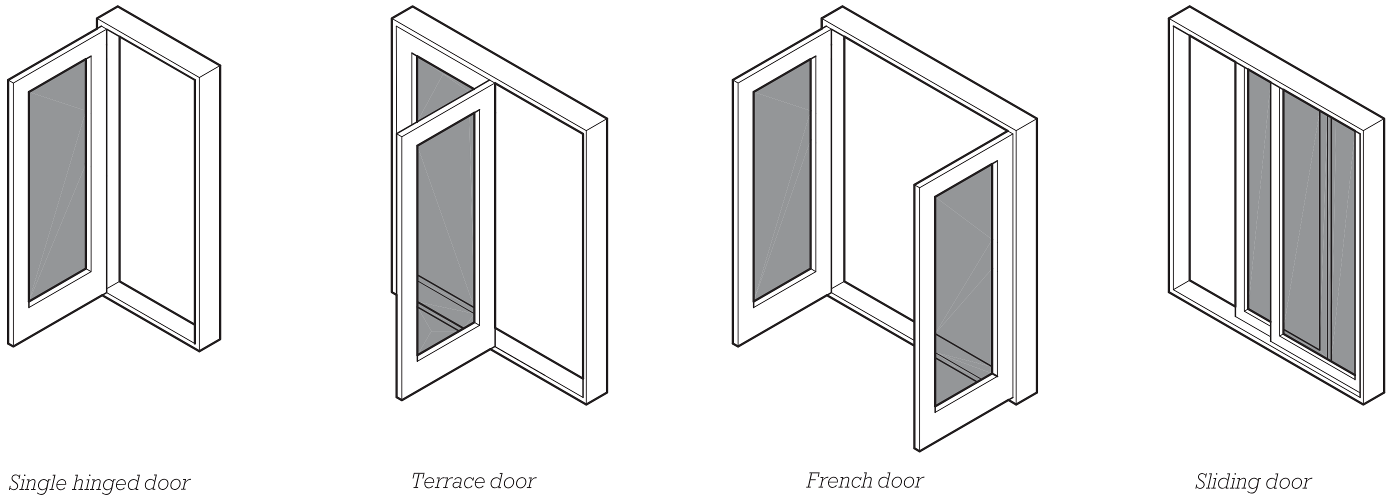


Figure 12.23
Basic exterior glass door operational types as seen from the inside of the house.

Figure 12.24
A six-panel wood entrance door with flanking sidelights and a fanlight above. A number of elaborate traditional entrance designs such as this are available from stock for use in light frame buildings. *(Courtesy of Morgan Products, Ltd., Oshkosh, Wisconsin)*

Figure 12.25
Sliding glass patio doors are common in affordable housing and apartment buildings because a single unit provides both a door and a large area of glass. *(Photo by Rob Thallon)*

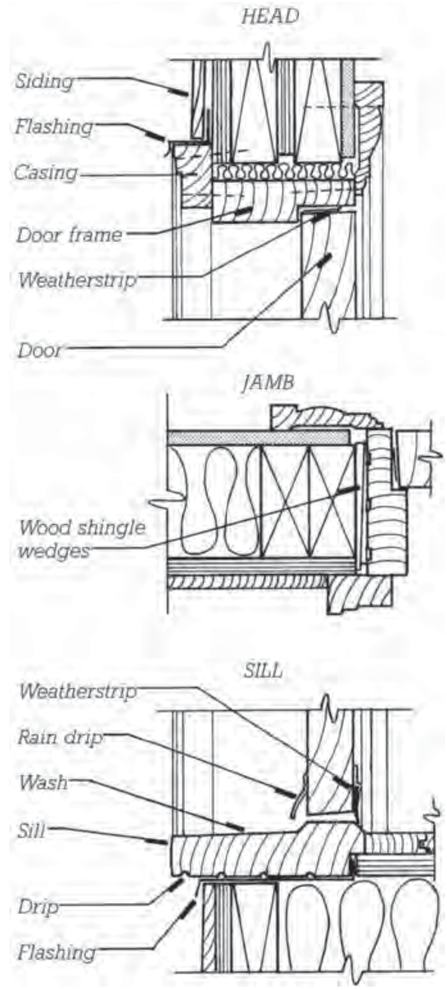
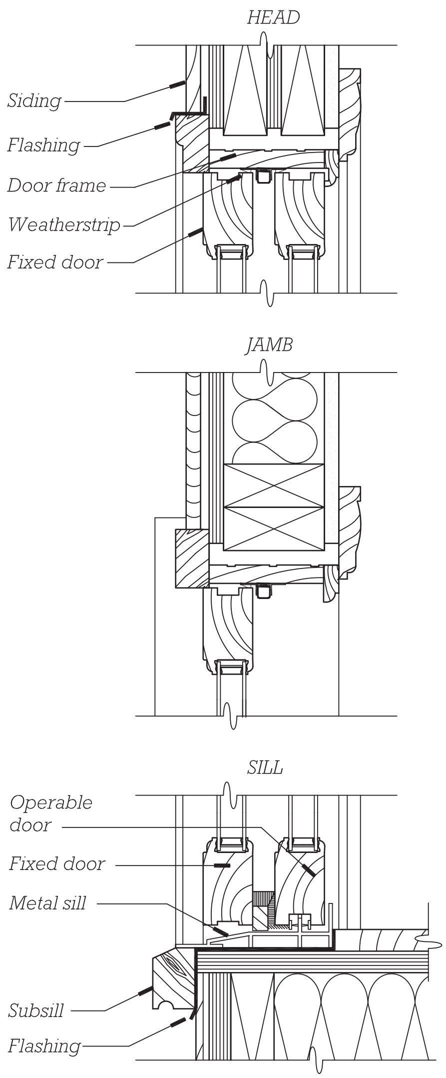


Figure 12.26
Details of an exterior wood door installation. The door opens toward the inside of the building to protect it from the weather, to keep the hinges on the inside for security, and to allow for a screen door on the outside.



Sliding *patio doors* are more like overgrown sliding windows than doors in their details and operation (Figure 12.27). These doors are used extensively in affordable housing schemes because they offer both a large glazed area and a door in a single inexpensive unit. The sliding patio door opens to only half of its area and is difficult to secure except from the inside with a site-made stick placed in the track to prevent door movement. An exterior-mounted sliding screen is available.

Weather resistance is an important factor in choosing exterior doors. Exterior doors must be well constructed and tightly weatherstripped if they are not to leak air and water (Figure 12.26). In most climates, doors should be protected with porches or eaves from the brunt of winter storms, and they should be weatherstripped to prevent occasional driving rain from entering the building. Weatherstripping also seals against air infiltration. A tight-fitting threshold at the base of the door completes the weather seal.

Figure 12.27
Details of a wood sliding patio door. A sliding screen door is typically mounted at the exterior of the fixed door panel.

Door Construction

At one time, nearly all doors were made of wood (Figure 12.28). In simple buildings, doors made of planks and Z-bracing were once common. In more finished buildings, *stile-and-rail doors* gave a more sophisticated appearance while avoiding the worst problems of moisture expansion and contraction to which plank doors are subjected. In recent decades, while stile-and-rail doors have continued to be used in higher-quality buildings, pressed sheet metal doors and molded GFRP doors, usually embossed to resemble wood stile-and-rail doors, have become a popular alternative. Their cores are filled with insulating plastic foam. Their thermal performance is superior to that of wood doors. They do not suffer from moisture expansion and contraction as wood doors do. The major disadvantage of metal and plastic exterior doors is that they do not have the satisfying appearance, feel, or sound of a wood door. *Flush wood doors,* constructed with a solid core of wood blocks or wood composite material, are also common exterior doors chiefly because they are easier to manufacture and therefore cost

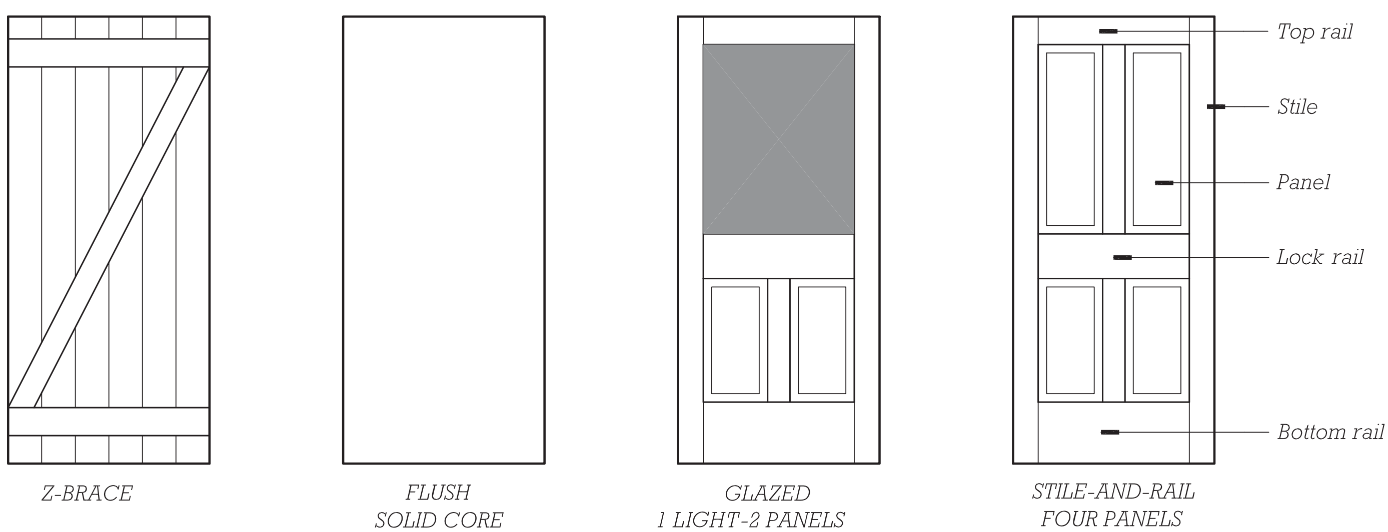


Figure 12.28
Types of exterior wood doors. Standard sizes range from 2½ to 3 feet (863 to 915 mm) wide by 6¾ feet (2.0 m) tall. Exterior doors are typically 1¾ inches (44 mm) thick. There are endless variations of the glazed and panel types.

less. *Fire doors* have a noncombustible mineral core and are rated according to the period of time for which they are able to resist fire as defined by Underwriters Laboratories Standard 108. In single- and double-family residential work, a 20-minute door between garage and living space is usually the only fire door required.

Installing Exterior Doors

The installation procedure for a door is essentially identical to that for a window (Figure 12.29). The designer selects the exterior doors and prepares a door schedule, showing the dimensions of the rough opening and other information. Prior to installation, the framing around the door is protected with a weather barrier, and caulk is applied around the perimeter of the opening to seal against air infiltration.

Exterior hinged doors are usually furnished *prehung*, meaning that they are already mounted on hinges in a surrounding frame, complete with weatherstripping and casing, ready to install by merely nailing the frame into the wall. When the unit is pushed into the rough opening from the outside, the sill rests on the subfloor and the casing bears against the sheathing along the other three edges. After the unit has been plumbed and squared in the opening, it is shimmed all around and attached to the building frame by means of nails driven through the casing and/or the jamb.

Doors are not typically delivered with a *lockset* or *deadbolt* installed but may be predrilled for this hardware (Figure 12.30). The locksets, deadbolts, and other hardware for all doors should be specified by the designer and included in the door schedule. The carpenter who installs the doors usually installs these items at the site. Screen doors and storm doors may be installed at this time or may be delayed in deference to the painter.

Sliding doors, although heavy, are even simpler to mount than hinged doors because they include fins around the perimeter through which nails are driven into the sheathing and studs to fasten the unit securely in place. These doors are generally furnished complete with hardware and screens.

Overhead garage doors operate differently and are installed differently from either hinged or sliding exterior doors, so they are typically installed by a specialized subcontractor.

FIGURE 12.29
The base of an exterior hinged door installation. A metal flashing to protect the framing has been installed below the extruded aluminum sill. The aluminum door sill in this example is covered with typical construction debris. *(Photo by Rob Thallon)*

Figure 12.30
Doors are typically prehung and predrilled for hardware by the distributor. Here, a worker is routing the door and its jamb for hinges. Holes for the door handle have already been drilled by the machine at the bottom edge of the door. *(Photo by Rob Thallon)*

Building Green with Windows and Doors

• The major raw materials for glass—sand, limestone, and sodium carbonate—are finite but abundant minerals. The high embodied energy of glass, 6750 to 7500 Btu/pound, can be reduced by 30 to 65 percent as new manufacturing technologies are introduced.

• The impact of windows (and glazed doors) on energy consumption can be very detrimental, very beneficial, or anything in between, depending on how intelligently they are used. If used in excessive quantities or oriented poorly with respect to the sun, they can contribute to summertime overheating from unwanted solar gain, excessive wintertime heat losses due to inherently low R-values, visual glare, wintertime discomfort caused by radiant heat loss from the body to cold glass surfaces, and excessive condensation of moisture that can destroy nearby components of the building. In appropriate quantities and properly oriented, they can bring solar heat into a building in winter and exclude it in summer, with attendant savings in heating and cooling energy. With good design, they can also bring daylight into a building without glare, reducing the use of electricity for lighting. These benefits accrue over the entire life of the building and the payoffs can be huge.

• The thermal properties of the glass in a window or door, the thermal conductivity of the frame, and the air leakage of the unit, especially the last, have very significant effects on the amount of energy that will be required to heat and cool the building.

• Doors can leak significant quantities of heat by conduction through the material of the door. Foam-core doors have better thermal performance than other types. The performance of any exterior residential door in a cold climate can be improved substantially by adding a storm door during the cold season of the year. An airlock vestibule can significantly reduce the amount of outdoor air that enters a building when the exterior door is open. All doors should be tightly weatherstripped to limit loss of conditioned air.

• With respect to the frame materials of windows and doors, the green considerations of wood are discussed in Chapter 4, PVC (vinyl) window frames are thermally efficient, and aluminum frames must be thermally broken for the sake of energy efficiency.

• Most windows and doors can be recycled during demolition, and a significant percentage are being recycled at the present time.

C.S.I./C.S.C.
MasterFormat Section Numbers for Finishing the Walls

07 62 00	Sheet Metal Flashing
07 65 00	Flexible Flashing
08 10 00	Doors and Frames
08 13 00	Metal Doors
08 14 00	Wood Doors
08 15 00	Plastic Doors
08 16 00	Composite Doors
08 32 00	Sliding Glass Doors
08 35 00	Folding Doors and Grilles
08 36 00	Panel Doors
08 50 00	WINDOWS
08 51 00	Metal Windows
08 52 00	Wood Windows
08 53 00	Plastic Windows
08 54 00	Composite Windows
08 60 00	ROOF WINDOWS AND SKYLIGHTS
08 60 00	Roof Windows
08 62 00	Unit Skylights
08 70 00	HARDWARE
08 70 00	Door Hardware
08 75 00	Window Hardware
08 80 00	GLAZING

Selected References

1. Selkowitz, Stephen; Arasteh, Dariush; Heschong, Lisa; and Carmody, John. *Residential Windows: A Guide to New Technologies and Energy Performance* (3rd ed.). New York: Norton, 2007. A comprehensive analysis of the window from a technical point of view with a nice introduction to window history.

2. The reader should acquire current catalogs from a number of manufacturers of residential windows. Most lumber retailers also distribute catalogs of windows and doors that can be an invaluable part of the designer's and builder's reference library.

Key Terms and Concepts

glazed area
sash
jamb
casing
sill
mullion
muntin
prime window
storm window
combination window
replacement window
single-hung window
double-hung window
sliding window
projected window
casement window
awning window
tilt/turn window
skylight
roof window
weatherstripping
insect screen
wood window
clad window
vinyl window
glass-fiber-reinforced plastic (GFRP) window
light
true-divided-light window
glazing
single glazing
double glazing
low-emissivity (low-e) coating
triple glazing
tempered glass
laminated glass
egress window
rough opening
frame size
window schedule
nailing fin
sidelight
transom
French door
terrace door
patio door
stile-and-rail door
flush wood door
fire door
prehung door
lockset
deadbolt

Review Questions

1. What steps are involved in the installation of a window into the rough opening of a wall? Remember to include steps that control air infiltration.

2. List the operational types of windows. Which types can open to their full area?

3. What was the historical reason for the true divided light? Why are true divided lights employed today? What are the alternatives to the true divided light, and what are the advantages of these alternatives?

4. Draw from memory a section through the edge of a double-glazed window light and label all of the components.

5. Why do hinged residential doors typically swing inward?

6. Draw a four-panel door and label the component parts.

Exercises

1. Draw the head, jamb, and sill sections of an existing installed residential window. Can you draw the hidden parts of the assembly based on the surface profile?

2. Find a historic double-hung or casement window and compare the sill section to the sill of a modern wood window. What are the most significant differences?

3. Visit a lumberyard or building materials supplier that has a good selection of windows and doors. Take notes on the differences among the various brands and summarize your findings in way that would help a potential buyer select windows and/or doors for a new residential project.