The Key to Unlocking Door Performance

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While significant time and effort are often put into specifying and reviewing the design and performance of window products on projects, the weatherproofing performance of doors is often overlooked. When designing and installing doors, it can be challenging to balance competing requirements for weatherproofing performance, operability, Americans with Disabilities Act (ADA) compliance, cost, and interior floor finishes. This article surveys various types of doors, how and where they are installed on buildings, and the weatherproofing performance anticipated for each door type and condition. We also discuss flashing and installation challenges related to specific door types and architectural applications.

DOOR RATINGS AND WEATHERPROOFING PERFORMANCE

When selecting a door product, it is important to understand what type of product is suitable for the project conditions and what weatherproofing performance is acceptable to the owner and architect. There is a variety of door types, and each type has specific weatherproofing performance expectations. Some doors have been tested in accordance with industry standards (generally AAMA/WDMA/CSA 101/I.S.2/A440[1]) and have a performance class and grade associated with them; the designer can determine the air- and water-penetration-resistance ratings based on the published performance class and grade. Other door products may not be tested or rated for air- and water-penetration resistance. Typically, when a door product is not rated for water-penetration resistance, it is because features that are inherent to the product design (such as low-profile thresholds or limited gasketing) mean that the product cannot meet water-penetration-resistance testing requirements.

In this article, we discuss four primary door types: storefront, hollow metal, terrace, and sliding doors. In general, a door's weatherproofing performance is improved by having continuous gasketing around the door perimeter, good compression of the operable door leaf against the fixed frame, reliable perimeter flashing, and continuity at the sill-to-jamb conditions. Some door products can achieve those characteristics more easily than others.

In general, because terrace and sliding doors tend to have high sill profiles or thresholds, they can be rated for air- and water-penetration resistance. Terrace doors also allow for continuous gasketing and multipoint locking around the door perimeter, which improve weatherproofing performance.

Storefront and hollow metal doors have low sill profiles or thresholds and are therefore rarely rated for air- and water-penetration resistance. Achieving gasket continuity around the door perimeter of these types of doors can be challenging, and panic hardware (hardware designed for fast egress) is sometimes installed with these door types. Storefront and hollow metal doors are also often used in spaces where a lower-cost door product may be desired (for example, mechanical penthouses, loading dock spaces, stairwells).

GENERAL PROJECT CONSIDERATIONS

To determine what types of doors are the best fits for specific locations within a project, the specifier should consider the project-specific conditions, including occupant use, types of space, code requirements, locations of doors, and interior or exterior conditions. Factors to consider include the following:

- **Placement of the door product:** When a door product is located above occupied space, the risk of damage from leakage to areas below is greater than when a door is located above an unfinished space such as a parking garage. Consider using a rated product at locations where doors are above occupied space.
- **Swing orientation of door:** In general, outswing doors provide better water-penetration resistance than inswing doors because of the location of the gaskets relative to the direction

of water flow. The swing direction of a door may be determined by the egress requirements of a space.

- **ADA requirements:** Typically, doors must be ADA compliant if they are part of an accessible entrance or used as a means of egress. Whether a door must be ADA compliant depends on the door's use, its location, and other code requirements. If the door must be ADA compliant, this will limit the options for sill-threshold gasketing and flashing heights. The door will likely need to include a low-profile threshold, which will limit its water-penetration-resistance performance. The *International Building Code*[2] and the *National Building Code of Canada*[3] limit threshold heights at doors used for egress to a maximum of ½ in. (13 mm) for doors other than sliding doors, and thresholds are required to be beveled and not exceed a 50% slope.
- **Egress requirements:** Depending on occupancy load and type of room use, panic hardware may be required for doors designated for egress so occupants can travel in the direction of egress without the use of a key or special effort. If panic hardware is required, it is challenging to provide multipoint locking around doors or use additional sill flashings or weatherproofing because these features can impede egress. Panic hardware can be added to hollow metal or storefront doors. Therefore, these doors often are used when egress is needed.
- **Tolerance for leakage:** For more-industrial spaces inboard of door areas (such as loading docks or mechanical spaces), the owner may not be concerned about minor, infrequent water leakage into the space. Walk-off mats or slot drains may be included inboard of doors to create a space where water can penetrate past the doors but be managed so it does not cause problems.
- **Interior flooring:** If flooring products inboard of the door are moisture sensitive, the designer should consider a robust door product that can resist moisture penetration.
- **Weather exposure:** Consider surrounding structures and the environment and how they will affect the door's exposure to weather. Overhangs, canopies, and shelves are helpful design elements to limit the amount of precipitation that will be directed toward the door. Design wind pressures can significantly affect the door design. If a door is located in an area that may see high wind speeds (such as exposed roof areas, oceanfront locations, and hurricane-prone areas), the door will be more exposed to the elements. High design wind speeds may require doors with additional reinforcement or structural subsills, and those features increase threshold heights and may require supplemental anchorage (that is, more penetrations). Robust door products should be considered at exposed locations and in areas with greater design wind speeds.
- **Exterior walking surface:** The relationship between the exterior walking surface and the door should be considered; to promote drainage away from the door, it is helpful to add an elevation change or slope to the exterior surface. Compared with surfaces that include spacing for drainage (such as pavers or wood decking), solid surfaces that do not drain allow for more water to pool at a door area.

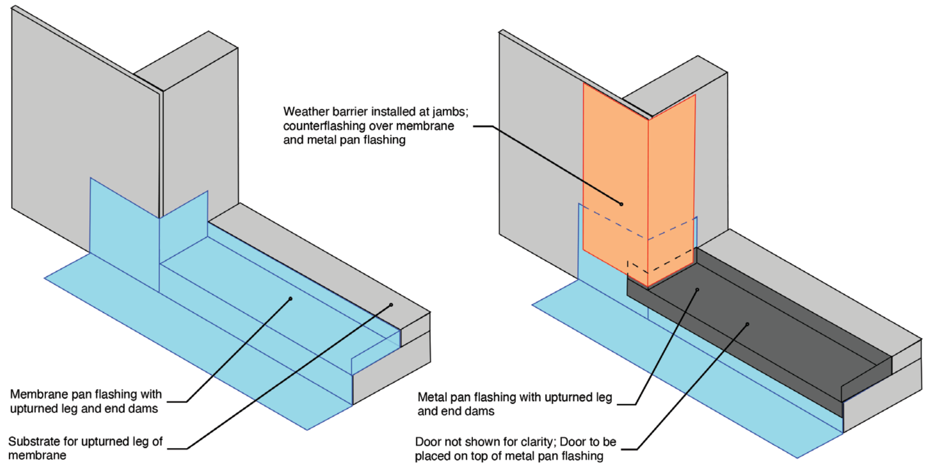

Figure 1. Example isometric showing membrane and metal pan flashing installed under a doorframe.

Project-specific conditions will vary, but in general, this guidance will assist the designer in selecting the appropriate type of door. By considering these items, the designer can also assess whether additional modifications should be made to the selected door to improve its weatherproofing performance.

GENERAL FLASHING CONSIDERATIONS

While the door product itself is important, designers should also consider the perimeter flashing and weatherproofing around the door. When designing window openings, it is good practice to include sill-pan flashing—which is formed from membrane or metal flashing with a watertight, upturned leg and end dams—to collect and drain water that bypasses the window to the exterior. A similar strategy can be used at the sills of doors, where a membrane or metal pan flashing is included underneath the door threshold (**Fig. 1**). Sill-pan flashings are fairly easy to include under terrace or sliding door products, where the pan flashing can be depressed beneath the doorframe at the sill and has some room for an upturned leg. It may be more challenging to include sill-pan flashings at locations where there is a low-profile threshold or where there is no exterior step to terminate the pan flashing. Installation of pan flashing must be coordinated with the adjacent slab conditions. It is helpful to review both manufacturers' installation instructions for specific product requirements and applicable industry standards. For example, ASTM E2112[4] provides guidance on flashing and weatherproofing considerations for doors.

At the building's exterior perimeter, seals between the doorframe and the adjacent weathertight plane (typically a weather-resistive barrier) are typically used to create a weathertight seal around the door. It is important to consider the location of the plane of the door within the depth of the opening and whether a seal between the doorframe and the adjacent weathertight plane can be achieved. Sometimes, this seal may be challenging to achieve when using a storefront or hollow metal door where the doorframe is flush with, and sealed to, the cladding. If these door products seal only to the cladding and water can bypass the cladding, that can lead to leakage into

Figure 2. Metal flashing (red arrow) installed continuously around a hollow metal door's perimeter and covered with weather barrier.

the interior. Sometimes, additional modifications may be necessary to improve sealant geometry and create a positive connection between the weather-resistive barrier and the doorframe. Pocket filler inserts or caulk stops are accessories that may be added to the doorframe to provide a substrate for sealant and improve sealant joint geometry. Brake metal or other material may be used to box out the hollow metal frame portion of the door to provide a smooth and continuous substrate for membrane flashing and sealant termination (**Fig. 2**). At drainable wall assemblies, through-wall flashings should be included above door heads to help direct water away from the door.

STOREFRONT DOORS

Storefront doors are typically made of aluminum and glass housed within storefront assemblies (**Fig. 3**). They often are set adjacent to horizontal and vertical aluminum framing members. These types of doors commonly are used at first-floor entryways and for access to terrace areas. They are typically not rated for air- and water-penetration resistance. Storefront doors are often selected for low-pro-

Figure 3. Storefront door installed within a storefront assembly.

Figure 4. Discontinuity at the low-profile threshold of storefront assembly. The adjacent storefront subsill and frame do not extend under the doorframe area.

Figure 5. Metal feeler gage extended between the doorframe and operable storefront door to show that gaskets are not compressed.

file thresholds and in situations where ADA compliance or panic hardware is needed.

Water that bypasses the exterior seals of storefront glazing systems can drain down through vertical mullions and onto a subsill below. Managing this water becomes a challenge at the sill of a storefront door because the door sill flashing and the storefront subsill do not extend under the vertical mullions adjacent to the door, creating a discontinuity at the storefront jamb-to-sill corners, where leakage can occur (**Fig. 4**). Storefront glazing systems rely on gaskets at the interface between the operable door leaf and the fixed frame at the jamb and head, but these gaskets typically stop at the sill of the door. We have observed that these gaskets can sometimes be uncompressed, for a variety

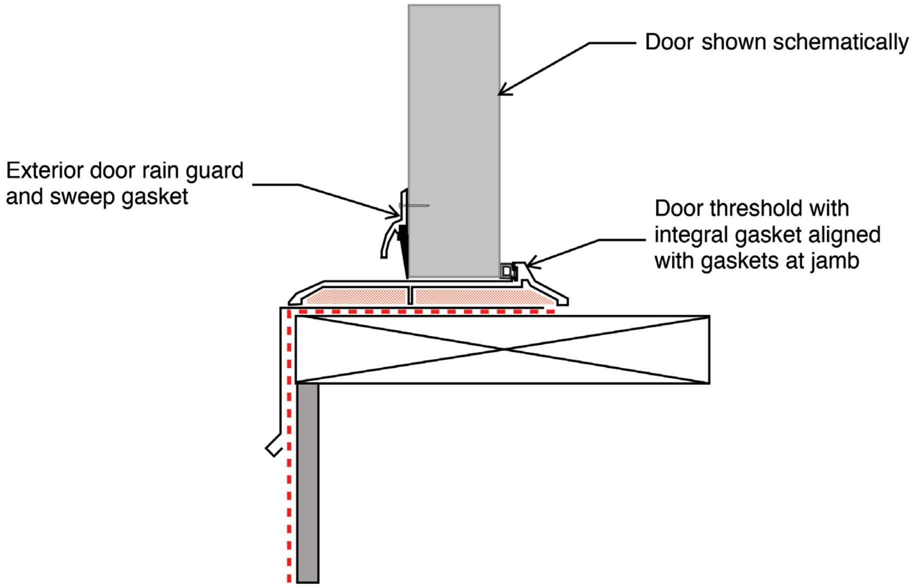

Figure 6. Supplemental gasketing at the threshold and door rain guard to improve weatherproofing performance at door sill.

of reasons. For example, single-locking mechanisms, alignment or location of hinges, and alignment between the strike plate and the lock may all affect compression (**Fig. 5**). The door relies on a metal threshold, which is fastened through the membrane flashing and set in sealant, to provide protection at the sill.

Because storefront doors are not rated for water-penetration resistance and leakage may occur, these doors should only be used in situations where some amount of water leakage is acceptable, such as situations where doors are not located above interior space, where weather exposure is limited (such as where overhangs are present or where there is limited risk of high winds), or where leakage can be mitigated. Ways to manage leakage include

- vestibules added inboard of doors to provide a space for water to leak past the door, or
- walk-off mats or slot drains inboard of storefront entrances.

With some designs, it may be appropriate to consider modifying a threshold to include a gasket at the threshold that aligns with gaskets at the jamb and head. Some manufacturers produce ADA-compliant thresholds that include gaskets, and there are after-market gaskets, sweeps, and rain-drip guards that can be added to thresholds and doors to improve weatherproofing performance (**Fig. 6**). While membrane flashing can sometimes extend under the sill of the threshold of a storefront door, it can be challenging to include a pan flashing underneath the door. If there is a curb beneath a storefront door, the designer could consider providing a depressed step beneath the door area to allow water leakage to drain to the exterior, but this would require an alternative support of the door.

HOLLOW METAL DOORS

Typically, hollow metal doors are fabricated from sheet steel and have a hollow core with a rolled steel frame (**Fig. 7**). Usually, they include a metal frame at the head and jamb but are open at the sill so a threshold can be installed.

The hollow-frame geometry may vary, but it usually includes a U-shaped frame with a rabbet to create a stop for the door. These types of doors often are used for utility spaces such as mechanical penthouses, loading docks, and other similar areas. They are generally selected for fire rating and security features; and are not rated for air- and water-penetration resistance.

Weatherproofing provisions for hollow metal doors are limited. These systems typically rely on gun-grade sealant installed between the hollow metal doorframe and the adjacent systems at the jamb and head. Thresholds are typically set in a bed of sealant at the sill. Gasketing can be installed at the perimeter of the door, between the operable leaf and the doorframe (jamb and head). Because these doors lack weatherproofing provisions, some amount of water leakage should be anticipated, particularly at the sill-to-jamb interface (**Fig. 8**).

It is best practice to wrap the door's rough opening in membrane flashing and seal or clamp the membrane to the doorframe, but this work is difficult due to the shape of the doorframe. The relatively narrow (typically about ½ in. [13 mm]) return flanges on the hollow side of the frame are not wide enough to receive membrane flashing. To provide a more durable interface condition, we often recommend sealing membrane flashing to the inboard face of the frame or adding supplemental metal shapes to the frame to receive the flashing. It can be difficult to include pan flashings beneath hollow metal doorframes because of the low-profile thresholds that are used. Typically, the pan flashing is installed after the doorframe, making it difficult to create a continuous seal between the flashing and the frame.

Continuous gasketing should be included at

Figure 7. Hollow metal doorframe.

Figure 8. Water leakage at a hollow metal door's jamb-to-sill corner.

Figure 9. Door sill-to-jamb intersection of a terrace-style door installed at a Juliet balcony.

the perimeter of hollow metal doorframes to improve weatherproofing performance. One of the weatherproofing challenges with hollow metal doors occurs at the sill-to-jamb interface. While gasketing can be added at the jamb and head, that gasketing often does not continue at the sill area, leaving the sill corners vulnerable. Similar to thresholds for storefront door systems, thresholds for hollow metal door systems can be upgraded to include gasketing that aligns with the jamb gaskets. However, if hollow metal doors are used in high-traffic areas where equipment may be loaded over the door threshold, these gaskets can become damaged or may deteriorate.

Hollow metal doors typically include single-locking mechanisms, which sometimes do not fully compress the gaskets around these doors. Because of the risk of water infiltration, hollow metal doors should only be used in situations where some amount of leakage is acceptable, where doors are not located above interior space, where weather exposure is limited (such as where overhangs are present or where there is limited risk of high winds), or where leakage can be mitigated.

TERRACE DOORS

A terrace door includes a fixed frame—typically around the entire perimeter (sill, jamb, and head)—with an operable leaf that seals to the fixed frame (**Fig. 9**). The sill of a terrace door is often raised and permits some amount of drainage within the system. There is usually full gasketing around the door perimeter between the fixed frame and the operable leaf and multipoint locking mechanisms around the door perimeter, which allow gaskets to compress. These doors usually are rated for air- and water-penetration resistance. Terrace doors can be challenging to make ADA compliant because they have raised thresholds. However, to achieve ADA compliance, the threshold may be depressed into the slab so the sill is flush. In some terrace doors, the integral sills can be replaced with low-profile thresholds that achieve ADA compliance, but that design can complicate the weatherproofing continuity and water-penetration-resistance ratings.

Because terrace doors generally perform better than alternative door types with respect to air and water infiltration, it is advisable

Figure 10. Sliding door's doorframe at the sill.

to use them at locations above interior space (for example, at balconies, terraces, or upper floors) or at any other location where leakage is not acceptable. Sill pan flashings should be included at the sill of terrace doors, and there should be a means of drainage for water that may bypass the door seals or doorframe. It is also helpful to include drainage provisions within the doorframe (such as glazing pocket weep holes) to enhance system reliability.

SLIDING DOORS

Sliding door systems typically include a fixed frame around the sill, jamb, and head as a unit, with a sliding door placed within the doorframe (**Fig. 10**). Similar to terrace doors, sliding doors typically have a raised sill frame, and the doors are often rated for air and water infiltration. Sliding door systems rely on gasketing between the sliding door and the adjacent fixed-frame perimeter to create a watertight seal. These doors typically are not ADA compliant because they have raised sill frames; however, as noted previously, some doors can be depressed to create a lower profile at the sill.

Similar to terrace doors, sliding doors should be used where weatherproofing performance is needed and leakage is not acceptable. Sometimes, leakage may be observed at the intermediate vertical mullion where sliding door systems typically rely on brush gaskets between the fixed frame and the door. The door system should incorporate drainage into the sill frame to catch this leakage and drain it to the exterior. Sill pan flashings should be installed at the sill of sliding doors to permit drainage of incidental leakage. Sliding doors typically are anchored through the sill (and therefore penetrate through the sill flashing). Designers should consider alternative anchorage at the inboard side of the doorframe (via continuous or clip angle) to avoid anchor penetrations through the sill flashing.

TAKEAWAYS

The following factors related to weatherproofing performance must be carefully evaluated when selecting door products for projects:

- Door use, space use, weatherproofing, interior and exterior conditions, and tolerance for leakage.
- Code requirements (such as ADA compliance or use of panic hardware) that may limit the weatherproofing performance of door products.
- What modifications can be made to door assemblies to improve door performance, such as improved sill flashing, improved gasketing, or modified thresholds.
- The risk and consequences of leakage, particularly in high-risk areas above occupied space such as terraces, balconies, and penthouse areas. Choosing door systems with a good water-penetration-resistance rating (such as terrace doors) is preferable at locations where leakage is not acceptable or may affect areas below the door.

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SPECIAL INTEREST

ASHRAE Says Its HQ Is Now Net-Zero Energy

The global headquarters of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) in Peachtree Corners, Georgia, has reached net-zero energy (NZE) status. The milestone for the headquarters of ASHRAE—which develops resources and standards for building systems, energy efficiency, indoor air quality, and sustainability—is the culmination of a $20 million project that started in January 2020.

The final project component needed to achieve NZE was installation of a large photovoltaic (PV) system. The 332 kW project, completed through Creative Solar USA, combines three subarrays:

- A 187 kW ballasted rooftop
- A 65 kW ground mount on a south-facing hill adjacent to the building (allowing narrower spacing between rows and thus greater energy density)
- An 81 kW ground mount situated in an unused section of the parking lot

ASHRAE said such PV systems provide a quarter century of performance. Cesar Prieto, business development director, Creative Solar USA, added that the reduced maintenance requirements associated with the new system means "the levelized cost of energy ends up being around four times lower than the retail rate from the utility."

Source: ASHRAE.