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The Hilton North Scottsdale at Cavasson, designed by BRP Architects, was planned to emphasize the surrounding desert landscape. The project uses a mix of operable glass wall systems, each chosen to support a specific use case. In the lobby, a large-scale, single-track sliding door creates a direct connection between the arrival area and the outdoor space.

PHOTO COURTESY NANAWALL

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Henry Agorua

Henry is enrolled in the Electrician and Network Cabling Technology program at Herzing College and leads innovation initiatives through RenMobi Inc. Passionate about electrical systems, renewable energy, and smart infrastructure, he has worked on renewable energy, HVAC, and thermal storage projects.

### 2026 Certification Scholarships

#### Lauren Amaro



Lauren Amaro

A graduate of Texas Tech University, Lauren is an architectural designer at O'Connell Robertson. She is building expertise in construction documentation and technical coordination while pursuing architectural licensure. She has focused on strengthening her understanding of project delivery and serving as a trusted technical resource.

#### Oscar Chmiel



Oscar Chmiel

Oscar is a construction management student at Farmingdale State College with interests in project management, preconstruction, and infrastructure. He is focused on developing a comprehensive understanding of the construction process, from design and documentation through execution.

#### Annette Kiefer



Annette Kiefer

With a lifelong connection to the construction industry, Annette supports IMEG's engineers and project teams through specification review, contract preparation, and project coordination. She aims to deepen her understanding of the facility lifecycle, strengthen her contributions to project delivery, mentor others, and share knowledge.

#### Holly Sandberg



Holly Sandberg

Holly is an architect and structural engineer in training, with a master's degree in Space Architecture from the University of Houston. They have worked in the AEC industry for five years, designing municipal projects, and are passionate about bridging the gap between structural engineers and architects.



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# Security Glazing in Education

## Forced-entry Testing Used in School Building Assemblies

**School safety is increasingly shaping the design and specification of educational facilities. Over the past two decades, requirements have expanded beyond accidental injury prevention and basic security to address deliberate threats that often begin at glazed openings.** As school districts and universities reassess campus risk, glazing remains both a defining architectural feature and a potential vulnerability. The transparency supporting daylighting and passive supervision can also create opportunities for forced entry when assemblies are not engineered for it.

This shift extends beyond kindergarten to Grade 12 facilities. Universities face similar exposure across housing, administrative buildings, libraries, and other high-traffic spaces. Incidents may include after-hours break-ins, vandalism, or targeted violence, and in many cases, the initial breach occurs at a window or door assembly. As a result, glazing performance now plays a larger role in security planning.

Glass continues to provide architectural value, bringing daylight into interior spaces and maintaining visual openness. However, under deliberate impact, conventional glazing fractures

**By Derek Hubert**

PHOTOS COURTESY ISOCLIMA SPECIALTY GLASS



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Forced-entry testing evaluates how the full glazing assembly responds under repeated impact, including the glass, interlayer, frame, and anchorage. For schools and universities, tested security glazing can help delay intrusion by limiting the size of an opening created during an attack sequence.



This security glazing is shown during impact testing, where repeated strikes are used to evaluate forced-entry performance. For schools and universities, tested laminated systems can support security upgrades when intrusion delay, visibility, and assembly-level performance are design criteria.

quickly and can allow immediate access once breached. For design teams and specifiers, the focus has shifted beyond glass type to the complete assembly's performance under forced-entry conditions.

Security glazing is intended to delay intrusion long enough for lockdown procedures to activate and for first responders to respond. In incidents that unfold rapidly, glazing performance is often measured in seconds.

## Limits of life-safety glazing

Most glazing installed in educational facilities complies with the impact safety requirements of ANSI Z97.1, *Safety Glazing Materials Used in Buildings*, and 16 CFR 1201, *Safety Standard for Architectural Glazing Materials*, of the Consumer Product Safety Commission (CPSC). These standards were developed to reduce the risk of injury from accidental human contact. Tempered glass fractures into small, relatively blunt fragments, while laminated glass retains shards on its interlayer. Both perform well in environments where the goal is to limit injury when glass breaks unintentionally.

These standards, however, do not evaluate performance under deliberate, repeated impact. A lite that meets ANSI Z97.1 may still fail quickly when struck with a blunt object. Life-safety laminates are engineered to retain fragments and limit fallout, but they are not designed to withstand the stretching and displacement that occur during a forced-entry attempt. Under sustained impact, the interlayer can stretch, allowing the fractured laminate to bow inward. If the frame does not provide adequate retention, the assembly can be pushed out even when the interlayer remains intact.

Life-safety glazing protects occupants from broken glass. Security glazing is intended to delay intrusion. The two serve different functions, and compliance with impact safety standards alone does not provide forced-entry resistance.

## Assembly behavior under forced-entry conditions

Forced-entry resistance depends on how the entire assembly performs under stress. The glass, interlayer, frame, anchorage, and surrounding construction respond together, and failure typically develops through gradual displacement rather than a single break.

When laminated glazing is struck repeatedly, cracks form at the point of impact and spread



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outward with each blow. As damage accumulates, the glass plies lose their ability to carry load, and the interlayer becomes the primary barrier. Its ability to remain bonded to the fractured glass and resist tearing determines whether the assembly continues to function. If the interlayer stretches beyond its capacity, the fractured laminate can bow inward, creating an opening large enough to reach the lock or manipulate the door.

Frame retention often becomes the deciding factor. Shallow glazing pockets, loosened beads, or frame deflection under repeated impact can allow the fractured laminate to shift or be pushed through the opening, even if the interlayer remains intact. Anchorage is equally important. Fasteners must resist pull-out and leverage at the frame during an attack, and the surrounding substrate must remain stable under repeated loading. If the wall or framing system yields, the entire assembly can displace even if the glazing's remaining strength holds.

Evaluating forced-entry resistance at the assembly level provides a more realistic measure of performance than material-only testing. A strong laminate installed in a flexible frame may fail, and a reinforced frame cannot compensate for inadequate glass construction. Security performance depends on the system as a whole.

## Failure modes in doors, sidelights, and ground-level windows

Forced-entry events often begin at accessible openings, including door vision panels, sidelights near locks or latching mechanisms, and ground-level windows. These locations provide direct access to door hardware or locking components or allow an intruder to step through once the glazing is displaced.

Door vision panels are often the weakest part of a door assembly. Repeated impact can cause the door skin to flex around the vision opening, altering the glazing pocket. As the pocket distorts, the compression that restrains the laminate is reduced, allowing fractured plies to shift. If the lite kit lacks rigidity, one edge of the pocket may open slightly, allowing the interlayer to move toward the direction of impact. As deformation progresses, adhesion and tear resistance become the primary factors preventing the laminate from folding inward.



Ground-level doors, sidelights, and windows are often among the first areas reviewed during school security assessments. In educational facilities, security glazing can help improve forced-entry resistance where openings provide access to door hardware, locks, or occupied spaces.

Sidelights next to door locks present similar risks. A breach in this area allows direct access to the lock. The frame must maintain retention under repeated impact, and anchorage must resist pull-out and leverage during an attack.

Ground-level windows are also frequent targets. Many school entrances and first-floor facades use aluminum storefront or curtain wall framing, which may not include reinforcement for sustained impact. Vertical and horizontal framing members in storefront and curtain wall systems, also known as mullions, can bend or deform under concentrated impact, reducing retention and allowing the fractured laminate to displace. Curtain wall assemblies are engineered for environmental loads, not forced entry, and their anchors may not withstand repeated impact. Security measures should be incorporated into the system design rather than added later.

Recognizing these patterns helps specifiers determine where higher-performance glazing is appropriate. Door vision panels, sidelights, and ground-level windows are often the first areas to evaluate, particularly where rapid access could place occupants at risk.

## Forced-entry and multi-threat testing

Security glazing is evaluated through several established test methods, each addressing a different threat condition. These tests measure how the complete assembly performs under defined loading sequences.

- Forced-entry testing (ASTM F1233, *Standard Test Method for Security Glazing Materials and*



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Campus security planning often begins at the building perimeter, where glazing must support supervision, daylight, and access control. In schools, exterior windows and entrance areas should be evaluated as part of the complete assembly, including glass, framing, and anchorage.

## KEY CONSIDERATIONS FOR SPECIFYING SECURITY GLAZING

### Specifier checklist

- Confirm whether the threat profile requires forced-entry resistance, ballistic resistance, or both.
- Require assembly-level testing rather than material-only testing.
- Verify that frames, beads, and anchorage are designed to retain fractured laminates under cyclic loading.
- Prioritize door vision panels, sidelights, and ground-level glazing when planning upgrades.
- Ensure retrofit measures are clearly identified as interim or limited-performance solutions.
- Align specifications with applicable state or federal school safety funding requirements.
- Review third-party test reports to verify performance claims.

### Performance insights

- Forced-entry resistance depends on interlayer behavior, frame retention, and anchorage integrity.
- Ballistic resistance alone does not ensure post-impact forced-entry resistance.
- Films and surface-applied shields can delay intrusion, but do not replace tested laminated systems.
- Vestibule glazing must balance visibility with multi-threat security performance.

*Systems*, UL 972, *Standard for Safety for Burglary Resisting Glazing Materials*)—these standards use repeated impacts with specified tools to simulate intrusion attempts. The goal is to limit the size of any opening created during the test sequence. Performance depends on how the glazing, frame, and anchorage respond together under escalating attack.

- Ballistic testing (UL 752, *Standard for Bullet-Resisting Equipment*, NIJ 0108.01, *Ballistic Resistant Protective Materials*)—ballistic standards classify glazing by its ability to stop bullets from specific firearms and ammunition types. Ratings are based on caliber, shot placement, and number of rounds. However, ballistic resistance alone does not ensure forced-entry resistance. A panel that stops a projectile but dislodges from the frame may not perform adequately in the field.
- Blast testing (ASTM F1642, *Standard Test Method for Glazing and Glazing Systems Subject to Airblast Loadings)*—blast testing evaluates how glazing assemblies respond to explosive pressure waves. The primary concern is glass fragmentation and debris hazards. Laminated constructions and reinforced framing are used to reduce the risk of hazardous fallout into occupied spaces.

Some laboratories use more aggressive protocols that go beyond minimum industry standards, employing escalating tool attacks to estimate real intrusion conditions better. These evaluations reinforce the importance of assessing assembly-level performance rather than relying on material-only testing.

Each method isolates a specific threat, but real-world performance depends on how the entire system responds under load.

### Material categories and system performance

Security glazing is not a single product, but a category of assemblies designed to resist defined threats. Common options include:

- Laminated security glass—constructed by bonding multiple layers of glass with interlayers that remain adhered under impact. When struck, the glass may fracture, but the interlayer holds fragments in place and continues to act as a barrier. Some systems are specifically engineered and tested for forced-entry resistance.



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- Glass-clad polycarbonate—a hybrid assembly combining exterior glass with interior polycarbonate layers. The glass surface provides scratch resistance and weather durability, while the polycarbonate absorbs impact energy. These systems are often specified where both ballistic and forced-entry resistance are required.
- Polycarbonate panels—solid, high-strength plastic sheets that resist shattering and absorb high-energy impact. Polycarbonate alone is not bullet-resistant unless incorporated into a tested ballistic assembly. It is lighter than glass but more susceptible to scratching and long-term discoloration without UV protection.
- Window security films—polyester-based films are applied to existing glazing to improve fragment retention. Films do not prevent breakage but can delay intrusion and reduce fallout. Some systems include mechanical anchoring to improve retention. Film is often used for budget-conscious retrofits, but it is not a substitute for tested security glazing systems.

Selecting the appropriate glazing system depends on the defined threat. Laminated assemblies are commonly specified for forced-entry resistance in educational facilities, while ballistic-rated systems may be required where firearm threats are identified. Glass-clad polycarbonate assemblies provide combined impact and ballistic resistance in higher-risk areas. Retrofit measures can improve delay performance, but should not be assumed to be equivalent to fully tested systems.

Regardless of material selection, performance needs to be evaluated at the assembly level to confirm how the system responds under load.

## Design integration in educational facilities

Designing with security glazing balances protection, visibility, and function. Educational facilities need to provide secure environments without compromising the learning atmosphere. Security glazing allows teams to improve intrusion resistance while preserving transparency.

Secure entry vestibules are a common component of school security strategies. These spaces create controlled transition points between public and private areas. Visitors are screened before gaining access to classrooms or administrative offices. Vestibules typically use a sequence of doors where the first set closes and locks before the second set opens. Glazing in these areas must maintain visibility while resisting forced entry. Laminated glass tested to forced-entry standards is commonly specified. In districts with elevated threat concerns, ballistic-rated assemblies may also be required.



Fractured laminated glazing can remain in place after impact, but forced-entry performance depends on the complete assembly. Glass, interlayer, frame, and anchorage must work together to resist displacement and delay access through the opening.

Within the building, classroom door vision panels and interior sidelights require similar attention. These openings can provide access to locks or latching mechanisms during an emergency. Laminated security glass is often specified to delay intrusion while maintaining sightlines for supervision. Some assemblies meet both forced-entry and ballistic standards, providing additional protection without compromising transparency. Glazing in instructional spaces should also support operational needs, including visual monitoring and lockdown procedures.

Ground-level glazing remains a primary concern. Entryways, classrooms, administrative offices, libraries, cafeterias, and nurse stations on the first floor are frequently reviewed during



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School safety requirements have expanded beyond accidental injury prevention to include deliberate threats that may begin at glazed openings. For specifiers, that shift puts greater emphasis on how windows, doors, and full assemblies perform under forced-entry conditions.

security assessments. Laminated glass with tested interlayers can increase delay time, but performance depends on proper anchorage into structural components to resist displacement.

Retrofit conditions present additional constraints. Many existing buildings were not designed with forced-entry resistance in mind. Polycarbonate shields, surface-mounted framing, and window films may improve performance without full replacement. These measures are often interim solutions. Where feasible, upgrades should include fully tested glazing systems designed to meet defined threat criteria.

### Cost, funding, and performance expectations

Security glazing typically carries a higher initial cost than standard glazing, but the value lies in the time it provides during an emergency. Even a short delay can allow staff to initiate lockdown procedures and contact emergency services. More durable systems can also reduce vandalism, damage, and long-term repair costs.

State and federal programs may help offset upgrade costs. Many jurisdictions offer grants for school safety improvements, and projects aligned with recognized standards are more likely to qualify for funding.

Value engineering requires careful review. Reducing interlayer thickness, substituting weaker framing components, or eliminating anchorage details can undermine system performance. Substitutions should be evaluated against the intended threat level, and supporting test data should be reviewed before approval.

Security glazing should be incorporated into the overall safety strategy rather than treated as an add-on. When properly specified and integrated, it can delay intrusion during an emergency while maintaining visibility.

## additional information

### AUTHOR



**Derek Hubert** is the architectural development manager for Isoclima Specialty Glass LLC and a previous account manager for CHILDGARD, a laminated security glazing system developed for U.S. K-12 educational environments. With more than a decade of experience in architectural consulting, specification development, and B2B sales, Hubert works with architects, designers, and industry partners to support the specification and integration of security glazing systems. He provides design assistance, manages product specifications, and collaborates with project teams throughout the design and construction process.

### KEY TAKEAWAYS

Security glazing plays a vital role in school safety planning, as forced-entry threats often target vision panels, sidelights, and ground-level windows. True protection depends on how the complete assembly—glass, interlayer, frame, and anchorage—performs under attack. Testing to forced-entry standards ensures glazing not only delays intrusion but also supports visibility and daily function in educational environments.

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Division 08
Educational facility safety
Forced-entry resistance
Glazing assembly performance
Laminated glass
Security glazing



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Octavio Diaz is the Sales Director for ALPOLIC Americas, a division of Mitsubishi Chemical America and a global leader in metal composite material manufacturing headquartered in Chesapeake, Virginia. In this role, he leads the company's sales strategy and business development initiatives across the Americas, directing a team of Regional Sales Managers and Product Representatives to drive growth, strengthen customer relationships, and expand market opportunities. Octavio works closely with architects, fabricators, contractors, and owners to deliver innovative cladding solutions that meet the evolving needs of the architectural and construction industries. With more than two decades of industry experience, he has successfully led strategic sales initiatives and managed programs for some of the world's most recognized brands, helping position ALPOLIC as a trusted partner in the built environment.

**Q: What does an architect need to show in their drawings so that a timber framer can accurately price the project?**
**A:** The most important thing an architect can provide the timber expert is Basis of Design (BOD) details. That will help them outline what should be included in the architect's drawings so that they get a tight, accurate budget and can advance the project. Timber framers don't need the architect to figure out how the timber connects, they just need to be pointed in the right direction. When sourcing and specifying, it's also important to understand the availability of materials and procurement and cost implications. Without properly vetting materials, an architect could inadvertently specify a product that takes 50% longer to produce and costs 25% more when other products are available faster, for a lower price, and still meet performance criteria. With these details in place, the timber framer can ask key questions and head off potential pitfalls before the next phase of drawings can advance.

**Q: What should be addressed up front in terms of sustainability?**
**A:** Outline specific sustainability goals for the project up front. Timber offers low embodied carbon, is a readily renewable resource, and a foundation for biophilic design. Specifying responsibly sourced wood ensures the material comes from responsible growers and harvesters. However, there are some procurement considerations when working with sustainable materials. Solid sawn timber that meets certain sustainability standards may be difficult to obtain in large volumes without extended lead times and higher costs. However, glulam and CLT are often readily available with recognized sustainability certifications.

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# Modern Masonry Meets Energy Codes

## Advanced Insulation Approaches for *IECC* Compliance

By Peter Chambers

PHOTO © BOHDAN STOCEK/UNSPLASH

**As energy codes become more rigorous, traditional masonry construction faces new challenges in meeting thermal performance requirements.** New methods are needed to meet thermal requirements without compromising structural integrity or project economics.

Advanced continuous insulation (c.i.) strategies, high-performance cavity innovations, and thermal bridge mitigation through low-conductivity anchoring systems enable masonry assemblies to meet *International Energy Conservation Code* (*IECC*) 2021 and ASHRAE 90.1-2019 requirements, while maintaining the durability and aesthetic benefits specifiers value in masonry construction.

### The three paths to compliance

*IECC* 2021 establishes stringent thermal performance requirements[1] for opaque wall assemblies based on climate zones. Designers should verify which code edition, whether 2018 or 2021, is locally enforced, as requirements can differ. Nonetheless, the trend is toward higher R-values and c.i. in all climate zones. These performance targets, often more than 80 percent of the annual baseline energy cost, need careful attention to assembly design and material selection.

The regulations recognize that different projects require different compliance strategies. The codes



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Building codes establish minimum anchor spacing based on wall height and exposure conditions.

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establish three distinct pathways that allow specifiers to choose the approach best suited to their project's complexity, design constraints, and performance goals. Understanding these options enables informed decisions early in the design process when changes remain cost-effective.

*Path 1: The prescriptive method*

The prescriptive method establishes minimum R-values for individual building components based on the climate zone. For masonry mass walls, this approach specifies either minimum c.i. values or cavity insulation values that must be met or exceeded.

This path offers straightforward compliance verification through plan review and field inspection. Code officials can quickly confirm specified materials meet minimum requirements without complex calculations. However, the prescriptive method provides limited flexibility for design optimization or trade-offs between building systems. Every component must meet its individual requirement regardless of how other assemblies perform.

*Path 2: The component performance method*

The component performance approach allows trade-offs between building envelope components, provided the overall assembly performance matches or exceeds prescriptive requirements. This method calculates a building's total UA (overall heat transfer coefficient) and compares it against the UA that would result from prescriptive compliance. If the proposed design's UA equals or falls below the baseline, the project demonstrates compliance.

COMcheck software streamlines this analysis by automating calculations and providing immediate feedback on proposed assemblies. A specifier might propose masonry walls slightly below the prescriptive R-values if they are offset by enhanced window performance, reduced air infiltration, or superior roof insulation. This flexibility enables designers to optimize for specific project conditions, architectural requirements, or budget constraints while maintaining code-compliant energy performance.

*Path 3: The total building performance method*

The total building performance path evaluates annual energy consumption for the entire building using approved energy modeling software. This approach compares a proposed design against a baseline building that meets prescriptive requirements. If the proposed design consumes the same amount of energy or less energy than the baseline, it demonstrates compliance regardless of how individual components perform.

This method offers maximum design flexibility, particularly valuable for complex projects incorporating renewable energy systems, advanced mechanical equipment, or innovative envelope strategies. Energy modeling can show that even a masonry wall with a lower R-value may comply when the design compensates with high-efficiency HVAC, optimized glazing placement, or the thermal mass effect of masonry. However, this path requires specialized expertise,



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The prescriptive method for modern masonry establishes minimum R-values for individual building components based on the climate zone. For masonry mass walls, this approach specifies either c.i. values or cavity insulation values that must be met or exceeded.

PHOTO © JASON LEUNG/UNSPLASH



Increasingly strict energy codes are challenging traditional masonry construction methods to meet thermal performance requirements without compromising structural integrity or project economics.

PHOTO © SOLOMEN/ UNSPLASH

detailed building information, and significantly more analysis time than prescriptive or component performance methods.

## Evaluating the pros and cons of each path

Selecting the appropriate compliance path depends on project complexity, design priorities, and available resources. Each approach offers distinct advantages and limitations that influence both the design process and construction outcomes.

For most masonry projects, the component performance path offers an optimal balance between design flexibility and analysis complexity. Projects incorporating advanced masonry strategies, such as high-performance cavity insulation or thermally broken anchoring systems, can particularly benefit from this approach. These innovations can offset requirements elsewhere in the envelope. High-performance systems with thicker insulation and specialty ties do raise initial costs, but energy modeling often shows a reasonable payback within a few years.

## Continuous insulation strategies for code compliance

Continuous insulation (c.i.) is the most reliable approach for achieving *IECC* compliance in masonry assemblies. Installed across the entire wall surface without penetrations from structural members, c.i. eliminates thermal bridges that compromise cavity-only insulation performance. For instance, cavity insulation provides only about 45 percent of its rated R-value[2] in steel-framed walls without c.i.

### *Exterior continuous insulation*

Exterior c.i. provides superior thermal performance by positioning the insulation layer outside the structural masonry wythe. This placement keeps the structural elements at moderate temperatures, reducing thermal stress and improving long-term durability. Rigid foam boards, such as extruded polystyrene, polyisocyanurate (polyiso), or mineral wool, offer appropriate R-values. Architects must also ensure that exterior insulation assemblies in commercial walls meet fire performance codes, such as NFPA 285, *Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Wall Assemblies Containing Combustible Components,* for foam plastic insulation.

Installation typically involves mechanically fastening foam boards to the backup wythe, then supporting the exterior masonry veneer with adjustable anchors that penetrate through the insulation layer. The thickness of exterior c.i. can be adjusted to meet climate-specific requirements without altering the cavity dimension. This approach offers significant advantages for moisture management:

- Condensation control—exterior insulation maintains the backup wall above the dew point during cold weather, substantially reducing condensation risk.
- Thermal stress reduction—keeping structural elements at moderate temperatures improves long-term durability.
- Simplified flashing details—through-wall flashing and drainage-plane integration are easier than with interior c.i. alternatives.

### *Interior continuous insulation options*

Interior c.i. involves applying rigid foam or spray foam to the interior surface of the masonry backup wall. This strategy works well in



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renovation projects where historic preservation requirements or site constraints limit exterior modifications. Closed-cell spray polyurethane foam provides both insulation value and air sealing in a single application. Advanced modeling tools now help specifiers predict condensation and thermal bridging, ensuring designs avoid moisture issues, which is valuable for interior insulation.

The primary challenges with interior c.i. are managing moisture and preventing condensation on cold masonry surfaces. In heating-dominated climates, interior insulation can trap moisture within the masonry if vapor control strategies are insufficient. Specifiers must carefully evaluate vapor permeance and ensure adequate drainage between wythes (*e.g.* through weep holes and flashing).

Rigid foam boards combined with resilient metal furring channels offer another interior approach. This assembly creates space for mechanical and electrical distribution. The air gap between the foam and interior finish provides additional thermal resistance if properly detailed to prevent air circulation.

### Hybrid insulation approaches

Combining c.i. with high-performance cavity insulation delivers optimal thermal performance for masonry assemblies in severe climate zones. A 101.6-mm (4-in.) cavity filled with semi-rigid mineral wool (R-16) plus 50.8 mm (2 in.) of exterior polyiso (R-13) yields a total of R-29. This value exceeds *IECC* mass wall requirements for Climate Zones 7 and 8 while also meeting the R-13 and R-15 c.i. requirement for steel-framed walls in Zone 8, all while maintaining reasonable wall thickness.

The hybrid insulation strategy also addresses thermal bridging through structural connections. Low-conductivity anchors and thermally broken shelf angles become essential components in these high-performance assemblies. In addition to c.i., enhancements within the cavity can also boost performance, as described next.

### Advanced cavity wall innovations

The space between masonry wythes offers an opportunity to enhance thermal performance when detailed correctly. Traditional cavity wall construction creates a drainage plane that manages moisture effectively while accommodating insulation materials. Modern innovations in cavity insulation materials and installation techniques enable assemblies to achieve code compliance without c.i. in moderate climate zones.

### High-performance cavity insulation materials

Semi-rigid mineral wool batts designed specifically for masonry cavities offer superior performance compared to traditional fiberglass:

- High thermal resistance—R-values up to R-4.3 per inch in cavity applications.
- Dimensional stability—material will not slump over time in vertical installations, ensuring consistent performance throughout the building life cycle.
- Moisture resistance—resists moisture absorption while maintaining vapor permeability for cavity drainage.
- Durability—maintains integrity under freeze-thaw cycling and temperature extremes.

Installation requires careful attention to ensure complete cavity filling without compression or gaps. Friction-fit mineral wool batts sized 6.4 mm (0.25 in.) wider than the cavity dimension compress slightly during installation, maintaining contact with both wythes. Cutting batts to fit around anchors and ensuring tight joints at horizontal reinforcing can prevent thermal bypass that could compromise overall assembly performance.

Hydrophobic treatment on mineral wool products prevents water absorption and supports vapor permeability. This characteristic allows the cavity to serve as a drainage plane even with insulation in place. Water that penetrates the exterior wythe drains down the back face without accumulating in the insulation material.





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### Specifying faced or unfaced insulation in the cavity

Moisture management in masonry cavities influences the selection of insulation facing. Unfaced mineral wool generally performs better in cavity applications because it allows vapor to move freely in both directions. This permeability helps the assembly dry when moisture enters from either side. Faced insulation with vapor retarders can trap moisture against the backup wythe, potentially leading to condensation issues.

However, certain climates benefit from strategic vapor control. In mixed-humid climates where both heating and cooling seasons impose significant loads, faced installation allows for moisture control in exterior walls.[3] Still, positioning requires careful analysis of vapor-drive direction throughout the year.

Air barriers integrated with cavity insulation can improve thermal performance when detailed correctly. Manual air-sealing techniques can tighten a building envelope by about six to 17 percent,[4] reducing leakage compared to assemblies without explicit sealing measures. The air barrier should be continuous, sealed at penetrations, and integrated with window and door rough opening details.

### Optimizing cavity width for maximum thermal resistance

Cavity width directly impacts achievable R-value and construction feasibility. However, wider cavities introduce structural considerations for anchoring systems. As cavity width increases, anchor length and flexural demands also increase. The distance between wythes affects load transfer mechanics and requires careful evaluation. Adjustable anchors with extended length ranges accommodate wider cavities while maintaining structural adequacy.

Construction tolerances also factor into decisions about cavity width. A nominally 101.6-mm (4-in.) cavity may vary from 88.9 mm to 114.3 mm (3.5 in. to 4.5 in) across a wall surface due to normal masonry dimensional variation. Specifying insulation that accommodates this tolerance range without compression or gaps ensures there is consistent thermal performance.

### Thermal bridge mitigation through advanced anchoring

Metal anchors and shelf angles connecting masonry wythes create thermal bridges that significantly compromise assembly R-value. Standard steel anchors provide high tensile

| Compliance Path | Advantages | Limitations | Best For |
|---|---|---|---|
| **Prescriptive Method** | • Simple verification process<br>• Clear requirements<br>• Fast plan review<br>• Minimal analysis required | • No design flexibility<br>• Component compliance required<br>• Cannot leverage trade-offs<br>• May require oversizing | • Straightforward projects<br>• Standard construction<br>• Limited design team resources<br>• Fast-track schedules |
| **Component Performance Method** | • Allows trade-offs between envelope components<br>• Faster than energy modeling<br>• Accommodates budget constraints<br>• COMcheck software simplifies analysis | • Limited to envelope trade-offs<br>• Cannot credit mechanical systems<br>• Requires basic energy calculations<br>• Less flexibility than a total building approach | • Projects with envelope design constraints<br>• Cost optimization needs<br>• Architectural feature integration<br>• Moderate complexity buildings |
| **Total Building Performance Method** | • Maximum design flexibility<br>• Credits all energy-saving measures<br>• Enables innovative strategies<br>• Demonstrates thermal mass benefits | • Requires detailed energy modeling<br>• Needs specialized expertise<br>• Time-intensive analysis<br>• Complex review process | • Complex buildings<br>• High-performance designs<br>• Projects with renewable energy<br>• Innovative envelope strategies<br>• Situations when thermal mass provides a significant benefit |



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strength but conduct heat readily, creating cold spots on interior surfaces and degrading overall thermal performance. Advanced anchoring systems using low-conductivity materials and thermally broken designs address these concerns without decreasing structural integrity.

## Low-conductivity tie materials

Composite anchors manufactured from fiberglass-reinforced polymers or basalt fiber composites offer tensile strengths comparable to steel and offer dramatically reduced thermal conductivity. Research shows that thermal bridging through ties can reduce a wall's R-value by about 15 percent (with low-conductivity ties) to about 42 percent (with conventional steel ties),[5] highlighting the significant impact of proper anchor specification. This variation directly translates into improved comfort and reduced energy consumption.

Composite anchors meet structural requirements when specified correctly for the application. Testing protocols verify tensile capacity, shear resistance, and durability under freeze-thaw cycling. Specifiers should confirm that the selected composite anchors are accompanied by appropriate code evaluation reports demonstrating compliance with building code requirements. Installation procedures for composite anchors differ slightly from steel alternatives and require attention to several key factors:

- Embedment depth—manufacturers specify minimum depths that may differ from steel anchor requirements.
- Hole diameter tolerances—tighter tolerances prevent anchor rotation and ensure proper load transfer.
- Fastener torque specifications—over-tightening can damage composite materials, while under-tightening compromises connection integrity.
- Mock-up panels—preinstallation testing ensures field personnel understand proper techniques before full-scale installation.

## Thermally broken shelf angle design

Shelf angles supporting masonry veneer at floor lines represent major thermal bridges in multi-story construction. A continuous steel angle spanning the building perimeter creates a direct conductive path between the interior and exterior environments. Thermal imaging frequently reveals these connections as cold bands on interior walls, often with associated condensation or mold growth.



As *IECC* 2024 takes effect across jurisdictions, the trajectory toward more rigorous thermal performance standards is continuing.

PHOTO © WOLFGANG WEISER

Thermally broken shelf angle systems interrupt this heat flow path with low-conductivity pads or structural thermal breaks. These components insert between the shelf angle and supporting structure, reducing conductive heat transfer while maintaining load-bearing capacity. Proprietary systems using rigid mineral wool or reinforced polymer pads may achieve significant improvements in thermal resistance compared to traditional direct-bearing details.

Structural analysis becomes critical when specifying thermally broken shelf angles. The thermal break material must withstand bearing stress from the masonry veneer dead load, as well as any vertical loads from wind or seismic effects. The load-deflection characteristics of the thermal break influence long-term performance and should be evaluated during the design process.

## Adjustable anchoring systems

Adjustable anchors accommodate construction tolerances, thermal expansion, and the structural connection between wythes. These two-piece systems feature a base unit embedded in the backup wall and a pintle that adjusts both vertically and horizontally to engage the exterior wythe. This adjustability reduces installation complexity and accommodates wider insulation layers without custom anchor fabrication.

Modern adjustable anchor designs incorporate thermal break elements within the connector assembly. By separating the metal components



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with polymer insulators or reducing the cross-sectional area of the conductive path, these systems minimize thermal bridging and preserve structural performance. Some manufacturers offer adjustable anchors in composite materials, combining thermal efficiency with installation flexibility. Using at least 101.6 mm (4 in.) thick exterior insulation calls for longer, adjustable anchors and alignment to maintain structural ties. Teams should coordinate cladding attachments and flashed openings to accommodate the insulation layer.

Proper specification requires attention to anchor density, load capacity, and thermal performance. Building codes establish minimum anchor spacing based on wall height and exposure conditions. Denser anchor spacing improves structural capacity but increases thermal bridging, creating a balance point that requires analysis for each specific project condition.

## Future outlook of code-compliant masonry design

As *IECC* 2024 takes effect across jurisdictions, the trajectory toward more rigorous thermal performance standards continues. *IECC* 2030 may drive masonry insulation requirements toward net-zero energy standards, potentially mandating continuous exterior insulation for most climate zones to eliminate thermal bridging effectively.

Upcoming code cycles (*IECC* 2024 and beyond) present both challenges and opportunities for masonry construction. Material manufacturers continue developing lower-conductivity anchoring systems and higher-performance insulation products specifically engineered for masonry applications. Digital tools enabling thermal bridging analysis and moisture modeling have also become essential components of the design process. Specifiers who invest in understanding advanced masonry thermal performance strategies can prepare for increasingly demanding standards.

## Notes

[1] See *International Energy Conservation Code* (*IECC*), Chapter 4: Commercial Energy Efficiency, 2021. Available at: codes.iccsafe.org/content/IECC2021V3.0/chapter-4-ce-commercial-energy-efficiency

[2] Refer to Polyisocyanurate Insulation Manufacturers Association (PIMA), "R-value and Installation: Understanding the Link." Available at: polyiso.org/page/InstallationHowItImpactsR-Value

[3] Read more at Specialty Products & Insulation, "Best Applications for Faced vs. Unfaced Insulation," 2023. Available at: spi-co.com/roller/SPIBlog/entry/best-applications-for-faced-vs

[4] See U.S. General Services Administration, "Automated Building Envelope Sealing." Available at: gsa.gov/governmentwide-initiatives/federal-highperformance-buildings/highperformance-building-clearinghouse/emerging-technology-evaluations/building-envelope/automated-building-envelope-sealing

[5] Refer to University of Alberta, "Evaluating the Thermal Impacts of Different Masonry Wall Tie Designs Using FEM." Available at: ualberta.scholaris.ca/items/b46d1967-7bea-4f43-907a-fcae33dce923

## additional information

### AUTHOR



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### KEY TAKEAWAYS

Increasingly strict energy codes, such as the *International Energy Conservation Code* (*IECC*) 2021/2024 and ASHRAE 90.1, are pushing traditional masonry construction to adopt advanced continuous insulation (c.i.) and low-conductivity anchoring systems. To maintain structural integrity and aesthetic value without compromising project economics, specifiers must navigate multiple compliance pathways and prioritize thermal bridge mitigation to eliminate energy loss through cavity walls.

### MASTERFORMAT NO.

04 20 00–Unit Masonry
07 21 00–Thermal Insulation

### UNIFORMAT NO.

B2010–Exterior Walls

### KEYWORDS

Division 04, 07
Continuous insulation (c.i.)
Cavity wall assemblies
*IECC* compliance
Modern masonry
Thermal bridging



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# Specifying Glass Wall Systems

## A Guide to Effective Selection and Implementation

**In hospitality design, the most captivating environments often feel effortless.** Boundaries blur, daylight penetrates deep into interiors, and transitions between inside and outside become nearly invisible. These spaces are often described as seamless, but that seamless quality is seldom simple.

Operable glass wall systems are essential for creating this effect. They allow large openings, frame views, and meet the increasing demand for flexible indoor-outdoor spaces. At first glance, many of these systems seem similar, with large glass panes, minimal sightlines, and seamless transitions. However, their actual performance can vary greatly.

The ability of a system to truly "disappear" depends on more than its visual profile. It requires panels that can be fully cleared from the opening, thresholds that integrate without disrupting circulation, and a system that

**By Liz Snyder**
PHOTOS COURTESY NANAWALL



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Large openings allow ballrooms to expand into adjacent outdoor areas, supporting varying occupancy levels and event types.

performs reliably as part of the building envelope when closed. These demands are amplified in hospitality environments, where glass wall systems are operated frequently and must support both experience and revenue.

For specifiers, the challenge is not only selecting a minimal system but also determining which options can deliver that simplicity in design and remain durable over time.

## What it means for a system to disappear

Minimal sightlines and expansive openings often initiate design discussions, but they do not determine performance. The true test of a system is how well it performs under various conditions.

When open, a system meant to disappear should do so entirely. Panels should not remain within the main opening or block traffic flow. Furniture layout, service staff, and occupant movement all depend on clear, unobstructed spaces.

When closed, the same system must serve as a continuous transparent barrier. Proper alignment, sealing, and structural integrity become crucial, especially in climates with large temperature changes or exposure to wind and rain.

These dual roles create competing demands. Glass wall systems must be robust yet refined, capable of supporting large panel sizes while meeting precise project specifications. Thresholds must be flush for accessibility and code compliance, while effectively managing water. Hardware must support repeated use without losing performance.

As a result, the systems that appear minimal often require the most advanced engineering. The disappearance is visual, but the performance is highly tangible.

## Lumen at Beacon Park: Architecture as extension of landscape

At Lumen in Detroit, the architectural goal was to design a structure that feels like part of Beacon Park rather than a barrier to it. Created by architect Ted Touloukian, the building's sweeping canopy and open perimeter encourage movement, framing the park as an integral part of the dining experience.

Realizing this vision required more than just large openings. It required the ability to remove the enclosure completely.

The project features large operable glass wall systems, with openings reaching approximately 26.2 m (86 ft). These openings are not only wide but also have complex shapes. Tall panels must navigate corners, align across long spans, and stack and store in compact locations that do not interfere with circulation or views.

This set of requirements rules out many traditional system approaches. Folding systems, though effective for specific uses, need panel stacking at the edge of the opening. Multi-track



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The key task for specifiers is to understand how these differences affect real-world performance.

sliding systems support large spans, but since panels stack within the opening plane, they restrict the full clearance of the space and result in less desirable thresholds.

To meet the design intent, the system needed to allow panels to move independently along a single track and be stored completely outside of the primary opening. It also had to accommodate directional changes, enabling panels to turn corners and circumvent structural elements without breaking continuity.

This level of performance can be achieved with a single-track sliding system specifically designed for large-scale applications. In this project, that solution was delivered through a movable glass wall system, allowing the facade to open completely while maintaining a clean, unobstructed condition.

When open, the building dissolves into the park. The canopy appears to float, and the boundary between interior and exterior effectively disappears. When closed, the system performs as a complete enclosure, with interlocking panels and continuous seals that support environmental separation.

Equally important is the threshold design. A water-rated, low-profile saddle sill creates a smooth transition that supports accessibility while maintaining the visual continuity of the floor plane. This often overlooked detail is crucial for achieving usability, compliance with the *Americans with Disabilities Act* (*ADA*), and the desired architectural effect.




Operable glass wall systems are often grouped, yet their capabilities differ in ways that directly affect design outcomes.

The success of Lumen lies not only in its visual impact but also in how precisely the selected system aligns with architectural ambition. The result is a space that feels open, not because it appears minimal, but because it functions that way.

## System selection matters: Sliding, folding, and application fit

The Lumen project highlights a key consideration for specifiers. Operable glass wall systems are often grouped, yet their capabilities differ in ways that directly affect design outcomes.

Sliding systems, particularly single-track configurations, are uniquely suited to applications requiring complete spatial transformation. Since panels can be stored outside the opening, these systems allow for full clearance without obstruction.



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Glass wall systems must ensure reliability under higher wind loads.



A large-scale, single-track sliding door creates a direct connection between the arrival area and the outdoor space.

Folding systems offer a unique set of benefits. They allow quick opening over large spans and can be effective when some panel stacking is acceptable in the design. Often, they provide a practical way to balance openness with spatial limitations.

Multi-track sliding systems enable panels to move in parallel, facilitating large openings while maintaining a simpler track geometry. However, as panels remain within the opening plane, they inherently restrict the extent to which the opening can be cleared at any given moment.

Each system type has a specific purpose. The key task for specifiers is to understand how these differences affect real-world performance. In hospitality settings, where circulation, seating arrangements, and guest experience are closely connected to spatial layout, these distinctions become especially important.

## Hilton North Scottsdale: Aligning systems with the program

While Lumen demonstrates how a single system type can enable a bold architectural statement, Hilton North Scottsdale at Cavasson highlights a broader product specification strategy. Designed by BRP Architects, the project incorporates multiple operable glass wall systems throughout the property, each chosen to support a specific use case.

The architectural goal was to emphasize the surrounding desert landscape while creating a highly flexible and adaptable hospitality environment. Achieving this involved using a mix of system types rather than relying on a single solution.

In the lobby, a large-scale, single-track sliding door creates a direct connection between the arrival area and the outdoor space. The focus is on clarity and movement, with panels that are easily moved out of the way and stored when not in use, ensuring a seamless transition.

Dining areas introduce a different set of requirements. Spaces must adapt throughout the day, shifting between open-air dining and more controlled interior environments. Systems that allow for partial or full operation provide the flexibility needed to support these ever-changing conditions.

At the bar, an operable window system creates a direct connection between the interior service area and the exterior seating. This condition prioritizes efficiency and interaction, demonstrating how smaller-scale operable systems can play a critical role in overall design.

Event spaces further expand the range of applications. Large openings allow ballrooms to expand into adjacent outdoor areas, supporting varying occupancy levels and event types. At the same time, interior sound-rated folding glass wall systems provide acoustic separation when needed, enabling spaces to function independently without sacrificing daylight or visual openness.

On the rooftop, the focus shifts to performance under exposure. Glass wall systems must ensure reliability under higher wind loads while maintaining unobstructed views of the surrounding landscape for an authentic experience.

Together, these 11 system applications demonstrate that successful hospitality design



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often depends on selecting the right system for each condition. The seamless experience guests perceive is the result of multiple systems working in coordination, each addressing a specific architectural and operational requirement.

### Performance, code, and the reality of daily use

While visual integration drives initial design decisions, long-term performance determines whether those decisions succeed.

In hospitality environments, operable systems are frequently used. Panels are opened and closed throughout the day, often by staff rather than specialized operators. This places significant demands on hardware, track systems, and overall system durability. Smooth operation is not simply a convenience; it is essential to ensure that spaces are used as intended.

Building envelope performance remains equally critical. When closed, operable systems must limit air infiltration and water penetration while supporting thermal comfort. As glazing areas increase, the impact of these factors becomes more pronounced, making proper third-party accredited testing and detailing essential.

Code compliance introduces additional complexity. Egress requirements may necessitate integrated swing doors within larger systems, along with compatible panic hardware, higher kickplates, and door closers. Accessibility considerations influence threshold design, requiring flush or low-profile transitions that support continuous circulation.

Security must also be addressed, particularly in ground-level applications. Systems should also provide forced entry resistance without compromising the architectural goal of minimizing sightlines.

These considerations reinforce a key point. Systems that are designed to disappear visually must still perform in highly visible ways over the life of the building.

### Beyond aesthetics: Specifying for long-term success

The allure of transparent glass wall systems lies in their ability to enhance architectural design without attracting undue attention. In hospitality settings, this effect elevates both experience and functionality, establishing environments that are open, adaptable, and connected to their surroundings.

For specifiers, achieving this outcome requires a comprehensive assessment of system capabilities. The differences between sliding, folding, and other operable configurations are not merely technical distinctions. They directly impact how a space performs, how it is used, and how it evolves.

Projects such as Lumen and Hilton North Scottsdale show that successful results depend on aligning system choices with design goals at every stage. When this coordination is achieved, the outcome is not only a seamless visual experience but also a system selection that ensures the long-term performance of spaces.

In this context, the most effective operable glass wall systems do not simply disappear. Instead, they seamlessly integrate into the building's functional operations.

## additional information


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**KEY TAKEAWAYS**

Operable glass wall systems are essential for creating flexible, seamless indoor-outdoor spaces in hospitality design. However, achieving this "effortless" effect requires specifiers to look past minimal sightlines and evaluate critical structural demands—such as frequency of operation, threshold transitions, and real-world envelope performance against wind and water penetration when closed—to ensure long-term durability and protect venue revenue.

**MASTERFORMAT NO.**

08 32 13–Sliding Aluminum-Framed Glass Doors
08 43 33–Folding Glass Storefronts

**UNIFORMAT NO.**

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# Selecting Finishes for Aluminum Fenestration

## Accelerated Weathering Data Guide Window and Door Longevity

By Rich Rinka

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**Driven by growing scrutiny of embodied carbon in building materials and the importance of specifying materials that support the longevity and durability of windows and doors, vetting the long-term performance of finishes for architectural aluminum is critical.**

As building owners increasingly demand longer service lives while lowering operational and replacement costs, the expectations of aluminum finishes are rising. This shift has elevated the role of scientific testing and data-backed performance metrics in finish selection, making accelerated weathering not just a best practice but an essential part of modern window and door design.

A key strategy for achieving this is the performance requirements, including weathering protocols, established by AAMA 2603/2604/2605, *Voluntary Specification, Performance Requirements and Test Procedures for High Performance Organic Coatings on Aluminum Extrusions and Panels (with Coil Coating Appendix)*. Finishes on aluminum



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AAMA 2603, *Voluntary Specification, Performance Requirements and Test Procedures for Pigmented Organic Coatings on Aluminum Extrusions and Panels (with Coil Coating Appendix),* requires coatings to undergo one year of outdoor testing in South Florida—a region known for its intense sunlight, heat, and humidity.

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windows and doors are exposed to environmental factors such as UV radiation, moisture, temperature fluctuations, and pollutants. Accelerated testing attempts to replicate these variables to predict how coatings will perform over years of real-world exposure. This key performance data is then used to estimate the long-term appearance and performance of finished aluminum panels and extrusions. In many cases, these controlled simulations can reveal degradation patterns long before they become apparent. This gives manufacturers and specifiers a powerful tool to improve formulations, set warranty expectations, and prevent premature failures without the need for lengthy outdoor exposure.

For example, these AAMA finish-related standards can help architects and specifiers evaluate corrosion resistance, color and gloss retention, impact resistance, and weathering. Each of these attributes contributes to finish durability in different ways, creating a holistic picture of how the coating system will age.

There are many questions to consider when evaluating the performance of a coating on an aluminum substrate. How do finishes on windows and doors degrade over time? To what extent will the color fade? At what point might chipping begin to occur? When will the material become more vulnerable to peeling, marks, and scratches? These are all especially important for high-visibility windows and doors—where appearance is closely linked to perceived building quality.



Outdoor weathering can be a lengthy process.



Driven by growing scrutiny of embodied carbon in building materials and the importance of specifying materials to support longevity and durability in facades, vetting the long-term performance of finishes for architectural aluminum is critical.

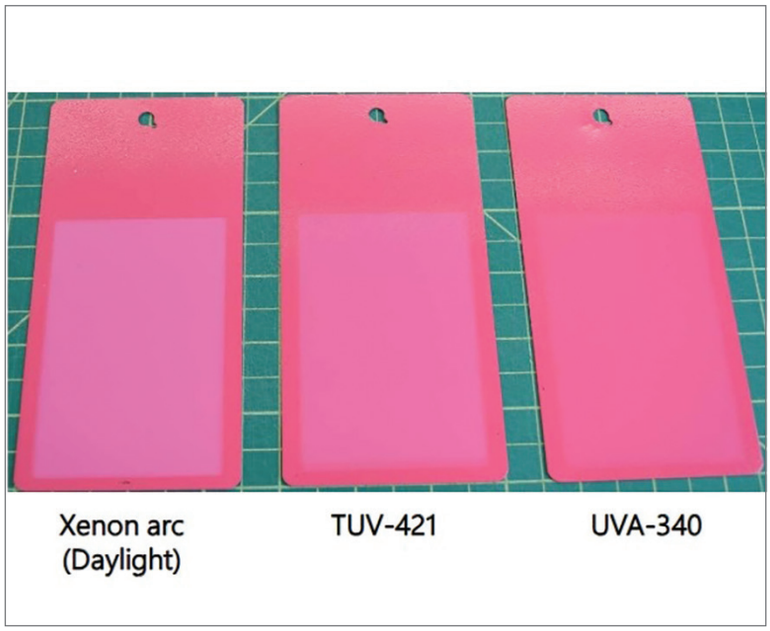
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Not only does testing help predict how aluminum windows and doors will stand up to environmental exposure and conditions over time, but the standards also serve as a basis for comparison, enabling specifiers to evaluate finish options, meet building code requirements, reduce liability, and establish long-term maintenance protocols to support long-term performance.

Since AAMA standards have been widely recognized and referenced across North America for decades, they also create a shared technical language between manufacturers, design teams, contractors, and building owners. This common



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As building owners increasingly demand longer service lives and lower operational and replacement costs, the expectations placed on aluminum finishes continue to rise.

framework reduces ambiguity during specification, streamlines submittal reviews, and helps avoid disputes during bidding or construction.

To provide a better understanding of how accelerated weathering works for architectural aluminum finishes, which key performance factors are tested, and how to best clean and maintain these surfaces, this article organizes information and insights from key AAMA standards.

## Understanding accelerated weathering and its role in finishing

Accelerated weathering is a process designed to simulate the long-term effects of environmental exposure on building materials—especially finishes—within a condensed timeframe. Unlike structural testing, which focuses on load-bearing or impact resistance, accelerated weathering is unique to finishing and is essential for predicting how coatings and colors will perform over years of service.

Since windows and doors often incorporate multiple finishes, accelerated weathering data also helps specifiers develop compatible assemblies, ensuring that adjacent materials age at similar rates and maintain a cohesive appearance.

Architects and specifiers rely on these tests to make informed decisions about which finishes will best support the longevity and durability of their projects. The Fenestration and Glazing Industry Alliance (FGIA) provides a suite of standards and documents clarifying the unique attributes of various materials and finishes, helping professionals understand how color and finishes perform over time.

## Performance attributes: What specifiers need to know

When specifying finishes for architectural aluminum windows and doors, performance attributes are paramount. The following key factors are evaluated when demonstrating compliance with the AAMA finishes standards:

- Corrosion resistance—ensures the finish protects the aluminum substrate from moisture, pollutants, and chemical attack.
- Color and gloss retention—measures the ability of the finish to maintain its appearance and vibrancy over time.
- Impact resistance—assesses the finish's ability to withstand physical damage.
- Weathering—evaluates the finish's durability against sunlight, temperature fluctuations, and moisture.
- Dry film hardness—measures the coating's resistance to scratching, marring, or other surface damage.
- Film adhesion—tests how well the coating bonds to the aluminum substrate, which is critical for long-term durability.



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- Chemical resistance—evaluates the finish's ability to withstand exposure to cleaning agents, pollutants, and other chemicals without degrading.

These attributes are not only critical for aesthetics but also for the long-term structural integrity and maintenance planning of commercial buildings. Inadequate performance in any of these areas can shorten the effective service life of windows and doors—sometimes dramatically—leading to costly remediation or full replacement. This makes early-stage specification decisions particularly consequential.

## AAMA standards: The backbone of finish specification

When specifying finishes for architectural aluminum, the AAMA 2603, 2604, and 2605 standards serve as the industry's guiding framework. Each standard represents a different performance tier, tailored to different building environments and project requirements. Specifiers must understand all testing needed to meet the requirements of each of these standards and identify the correct performance needs for an application.

As the entry point for pigmented coatings, AAMA 2603, *Voluntary Specification, Performance Requirements and Test Procedures for Pigmented Organic Coatings on Aluminum Extrusions and Panels (with Coil Coating Appendix)*, is typically used for interior applications or exterior settings with minimal exposure. The standard requires coatings to undergo one year of outdoor testing in South Florida, a region known for its intense sunlight, heat, and humidity. After this exposure, the finish must show no signs of checking, crazing, or adhesion loss, and only slight chalking or fading is permitted. For example, coatings should be visibly free from flow lines, streaks, blisters, or other surface imperfections in the dry-film state on exposed surfaces when observed at 3 m (10 ft) from the metal surface and inspected at an angle of 90 degrees to the surface. Evaluation is primarily visual, ensuring that basic coatings meet the minimum expectations for appearance and integrity.

For projects requiring greater resilience, AAMA 2604, *Voluntary Specification, Performance Requirements and Test Procedures for High*



Accelerated weathering tests are indispensable for architects and specifiers seeking to ensure longevity, durability, and aesthetic integrity of aluminum finishes used in commercial buildings.

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By understanding AAMA technical standards, professionals can make informed decisions, objectively compare products, and support sustainable, high-performance building envelopes.




The process of accelerated weathering provides the data and assurance needed to specify finishes that, with proper application, cleaning, and handling, should stand the test of time, even in the most demanding environments.



As the industry continues to prioritize resilience, sustainability, and whole-building performance, accelerated weathering data will play an increasingly important role in guiding specification and design decisions.



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Dream Nashville features aluminum-framed entrance and window systems with painted finishes that meet AAMA 2605, *Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels (with Coil Coating Appendix).*

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Some key factors AAMA finish-related standards can help architects and specifiers evaluate are corrosion resistance, color and gloss retention, impact resistance, and weathering.

*Performance Organic Coatings on Aluminum Extrusions and Panels (with Coil Coating Appendix),* is the next step. Coatings must withstand five years of simulated South Florida weathering, followed by more rigorous and quantitative testing. The standard sets clear thresholds for color, gloss, and film thickness. Color change must not exceed 5 ΔE units; gloss retention must remain above 30 percent; and film loss must stay below 10 percent. This ensures that finishes specified for exterior architectural applications will maintain their visual appeal and protective qualities over time.

Requiring the highest level of performance, AAMA 2605, *Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels (with Coil Coating Appendix),* is used for monumental buildings and severe climates where long-term durability is paramount. Following accelerated weather testing simulating 10 years in South Florida's challenging environment, the finish must still retain its color within 5 ΔE units, maintain at least half of its original gloss, and show minimal chalking and erosion. These demanding requirements are typically met by advanced fluoropolymer-based coatings, which offer exceptional resistance to UV degradation and environmental stressors.

## Surface preparation: The foundation of finish performance

Aluminum is the only substrate that requires special surface preparation. This is because its surface chemistry and physical properties differ significantly from those of other common architectural materials. Unlike steel or other metals, aluminum naturally forms a thin oxide layer that can affect how coatings adhere and perform over time. Since improper surface preparation leads to finish failure, *i.e.* poor adhesion, premature corrosion, or aesthetic defects, this step must not be overlooked.

The requirements for aluminum surface preparation are designed to ensure the substrate is optimally prepared as part of the entire coating system. This preparatory step, while invisible in the final product, is critical to longevity. Proper pretreatment ensures the coating chemically bonds to the aluminum surface, creating a unified system that resists moisture intrusion, corrosion, and adhesion loss. Even the most advanced coating



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technologies cannot compensate for inadequate preparation, which is why the standards emphasize it so strongly.

## Beyond pigmented coatings: Anodized and hybrid finishes

Another document providing important information and direction for architectural aluminum finishes is AAMA 611, *Specification for Anodized Architectural Aluminum*. The guideline provides specifications for anodized finishes, which provide a hard, durable surface that is integral to the material. Intended for exterior use, Class I anodize delivers excellent weatherability and strong resistance to UV degradation, chalking, and fading. It maintains color and gloss for many years and withstands harsh environments, such as coastal areas. Ten years of color retention with a maximum ΔE color change of 5 and high durability against erosion and corrosion are required for exterior building products where long-term durability and hardness are critical.

A related document, AAMA 612, *Voluntary Specification, Performance Requirements, and Test Procedures for Combined Coatings of Anodic Oxide and Transparent Organic Coatings on Architectural Aluminum,* covers finishes that combine a thin anodic layer with a transparent organic coating, often referred to as "white anodize." The organic layer improves resistance to staining and chemical attack but compromises the extreme hardness and wear properties of pure anodizing. Weathering performance is generally lower than that of AAMA 611 because the organic coating can degrade under UV exposure, leading to reduced colorfastness and durability over time. A maximum of 5 ΔE color change is tolerated after five years.

## Cleaning, maintenance, and handling: Protecting the finish

In practice, the long-term performance of an architectural finish depends not only on laboratory-tested coating durability, but also on how the finished components are handled and maintained. Improper cleaning agents, construction debris, and mishandling during shipping and installation can cause irreversible damage long before the building is occupied.

Proper care of aluminum surfaces is crucial for maintaining appearance and reducing the risk to finishes. Assisting with this, the AAMA 609 and 610, *Cleaning and Maintenance Guide for Architecturally Finished Aluminum*, provide guidance on cleaning and maintenance:

- Anodized aluminum—requires reasonable care before and during installation and periodic cleaning after. Harsh chemicals, rough conditions, or neglect can mar the surface finish, though service life is generally unaffected.
- Painted aluminum—dirt or soil may not pose a risk, but cleaning is desirable for appearance. In industrial environments, periodic cleaning may be necessary to prevent dulling or soiling.
- Protective films—used to minimize physical damage during fabrication and handling, selection and use of protective films must balance the risk of damage from outside sources versus the film itself. Films should be easily removed and not interfere with other operations. It is important to remember that





A medical office building in Texas showcases aluminum doors, entrance, and window systems finished in clear anodize, specified to meet AAMA 611, *Specification for Anodized Architectural Aluminum*.

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these protective films should be on for a limited time, and the manufacturers' instructions for both the film and the window and door products should be followed.

Care of aluminum surfaces is not a one-and-done task. Periodic cleaning and maintenance will help prevent long-term soil accumulation, which, under certain conditions, may accelerate the deterioration of the finish. Frequent cleaning can make subsequent cleaning easier. The finish supplier typically provides information on the recommended frequency of cleaning and materials to be used.

## Care and handling from producer to jobsite

AAMA CW-10, *Care and Handling of Architectural Aluminum from Shop to Site*, covers the proper care and handling of aluminum parts. If a coated part becomes damaged, it must be repaired or replaced, which can result in delays or additional costs. Consequently, proper handling protocols help minimize these risks.

The document begins with a visual inspection and provides a step-by-step guide for fabricators and contractors to carefully follow to ensure that windows and doors are not damaged. This includes care during fabrication, packaging, shipping, unloading, and on-site storage before and after building completion.

## The value of accelerated weathering for architectural aluminum

Accelerated weathering tests are indispensable for architects and specifiers to ensure the longevity, durability, and aesthetic integrity of finishes on aluminum windows and doors in commercial buildings. By understanding AAMA technical standards, professionals can make informed decisions, compare products objectively, and support sustainable, high-performance building envelopes.

The accelerated weathering process provides the data and assurance needed to specify finishes that, with proper application, cleaning, and handling, should stand the test of time, even in the most demanding environments.

As the industry continues to prioritize resilience, sustainability, and whole-building performance, accelerated weathering data will continue to guide design decisions. Whether the goal is to reduce carbon, extend replacement cycles, or ensure a high-quality building envelope for decades, these tests provide a level of predictability and assurance that cannot be replicated through field observation alone.

## Resources

All AAMA documents referenced are available at FGIAonline.org/store.

## additional information

### AUTHOR



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### KEY TAKEAWAYS

Vetting the long-term performance of aluminum finishes through accelerated weathering is essential for meeting rising demands for building longevity and durability. By using standardized AAMA protocols to simulate environmental stressors such as UV radiation and moisture, manufacturers and specifiers can predict degradation patterns, set accurate warranty expectations, and prevent premature failures without waiting years for real-world exposure.

### MASTERFORMAT NO.

05 05 13–Shop-Applied Coatings for Metal
08 41 13–Aluminum-Framed Entrances and Storefronts
08 51 13–Aluminum Windows

### UNIFORMAT NO.

B2010–Exterior Walls
B2020–Exterior Windows
B2050—Exterior Doors and Grilles

### KEYWORDS

Architectural aluminum finishes
Accelerated weathering
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Divisions 05, 08
Window and door durability



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# The Guide to Specifying Masking Sound

**People's perception of sound is strongly influenced by the ambient acoustic conditions or "background sound" within our listening space.** To dependably manage its overall level and spectral distribution within the built environment, one must employ a sound masking system.

This type of system consists of a series of loudspeakers installed in a grid-like pattern in an open ceiling or above the ceiling treatment, and electronics to control their output. When handled correctly, the sound achieved within the space not only minimizes the disruptive impact of noise and protects the privacy of conversation, but does so consistently and unobtrusively.

Despite being one of the three pillars of effective architectural acoustical design (the "C" in the ABC Rule, which stands for "cover"), masking sound remains the most poorly understood of these strategies. Given the lack of widely adopted

**By Niklas Moeller**

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Occupant-generated noise is the most significant source of workplace disruption and because of its complex nature, building professionals are not easily able to account for it during design unless they implement masking sound.

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A sound masking system consists of a series of loudspeakers, as well as electronics to control their output, but the final product is the sound itself and the acoustical benefits it provides. Delivery is only complete upon reporting conformity within specified tolerances, preferably using testing procedures that meet or exceed ASTM E1573-22.

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independent standards governing the sound masking industry, there are also unusually large differences between available technologies and implementation methods. Strong specification is needed to ensure consistent, verified masking performance, enabling reliance on the sound to improve occupant focus, privacy, and comfort, and potentially reduce construction costs.[1]

By far the most challenging sound masking specifications for suppliers to respond to are those the author calls "Frankenspecs." Just as the monster Victor Frankenstein constructs in Mary Shelley's novel, these specifications are brought to life by stitching together parts harvested from several different bodies—in this case, elements of various manufacturers' proprietary specs. Often, the result is a document so inconsistent in its requirements that no supplier can meet them.

One particular document immediately springs to mind. It began by calling for a centralized sound masking system. The products and manufacturer section were from the spec for a different centralized system. The ensuing description and performance requirements pertained to a particular brand of networked decentralized system. It concluded with a mixture of installation, testing, and reporting requirements from all three.

If the terms of this document had been upheld as they should have been—after all, a spec forms a legal part of construction documents—every bidder would have been rejected. Instead, it was ignored because it was confusing and unworkable.

In these situations, there is effectively no spec, and the client is left at the mercy of:

- The selected equipment's control capabilities, which vary widely between system architectures, layouts, and brand offerings.
- The supplier's expertise and commitment to consistently distributing sound throughout the facility so that it meets the required masking spectrum and level(s).
- The accuracy of the measurement equipment (if any) they use to accomplish that goal.



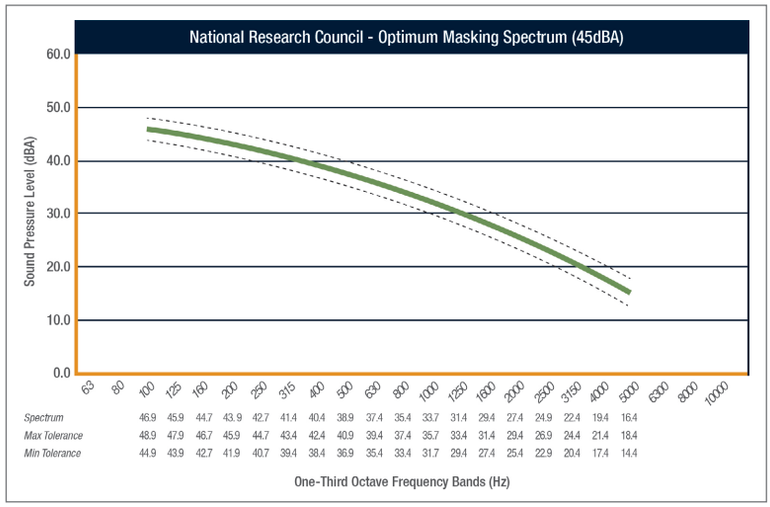
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Why do these three elements matter? Because the end product is the sound, not the equipment that delivers it. If the sound is to provide the desired acoustical effects, the supplier must measure it at ear height and use the equipment's frequency and volume controls to adjust it at defined spatial intervals. This is so that a conforming masking spectrum and level are consistently achieved throughout all treated areas—a process known as tuning. Masking sound delivery can only be considered complete upon reporting conformity within specified tolerances, preferably using testing procedures that meet or exceed the requirements of ASTM E1573-22, *Standard Test Method for Measurement and Reporting of Masking Sound Levels Using A-Weighted and One-Third-Octave-Band Sound Pressure Levels*.

In an industry that lacks independent performance standards, it is extremely valuable to at least be able to rely on ASTM E1573-22 for measurement and reporting because even minor deviations from optimal masking characteristics can affect the sound's acoustical impacts.

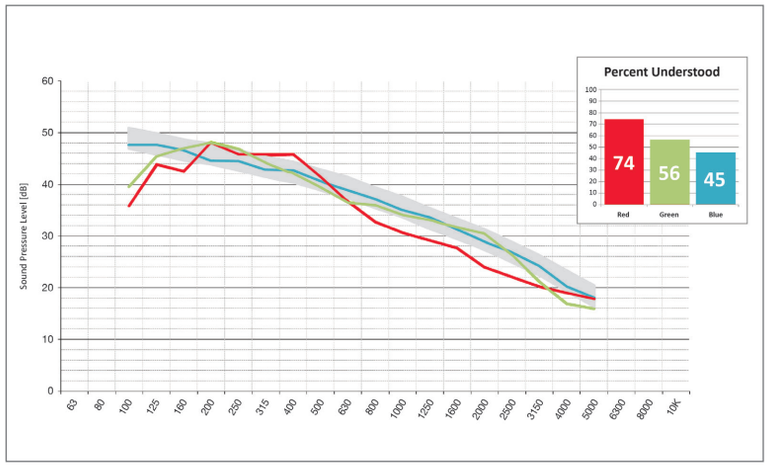
Using E1573-22 as the starting point also provides an objective basis for specifying performance in two key, interconnected categories:

- Control performance—determines the system's potential to be tuned to specification. E1573-22 requires control of one-third-octave frequency band and overall level testing in open-plan areas not exceeding 92 $m^2$ (1,000 sf), as well as in a percentage of individual closed rooms, based on overall system size and the number of rooms covered. Suppliers are free to design their system as appropriate to their product offerings, provided control zone size and frequency resolution do not exceed these limits. By aligning control performance with the E1573-22 measurement criteria, they will be able to adjust the sound to comply with the tolerances established by the spec for frequency and level when tested per this standard. Further, because the test area limits are maximums, suppliers are also permitted to implement smaller zones, which will provide even greater control over the sound across the space.
- Tested performance—objectively validates the sound meets specifications. Although occupants can gauge their personal comfort with the resulting sound, they cannot assess its compliance with the specifications simply by listening. By the same token, a supplier cannot claim that the tuning process is unnecessary or that it can use inadequate equipment for the task at hand. No matter how a system is designed, engineered, or installed, the sound cannot defy the laws of physics; it will always be affected by the physical attributes (*e.g.*, architecture, fit-out) of the space to which it is introduced. Fortunately,




The masking spectrum or 'curve' should be specified by an acoustician or supplied by an independent third party such as the National Research Council (NRC), shown here to 5,000 Hz. Outcomes are strongly related to the consistency with which the masking sound is delivered, but specs often fail to include targets and tolerances for overall and frequency levels.

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In an industry that lacks independent performance standards, it is extremely valuable to be able to rely on ASTM E1573-22 for measurement and reporting because even minor deviations from optimal masking characteristics can affect the sound's acoustical impacts. Here, a masking system is tuned with varying degrees of precision. The resulting sounds are at the same overall level (*i.e.* 47 dBA), but note the impact on comprehension (*i.e.* privacy) when the frequencies defined by the NRC masking spectrum are not met.



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ASTM E1573-22 requires one-third-octave frequency band and overall level testing in open-plan areas not exceeding 92 $m^2$ (1,000 sf) as well as a percentage of individual closed rooms based on overall system size and the number of rooms covered.

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ASTM E1573-22 also establishes the equipment (*i.e.* a Class 1 sound analyzer, shown above), method, and minimum test quantities for the measurement process—and, hence, verification of tuning.

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E1573-22 also establishes the equipment (a Class 1 sound analyzer), method, and minimum test quantities for the measurement process—and consequently the verification of tuning. Proof of masking sound delivery comes in the form of a detailed written report showing E1573-compliant results for each test area.

When preparing the spec using the above framework, it is key to avoid the following common pitfalls that can significantly affect masking outcomes.

## Ensure a template reflects current technologies and needs

Like most technologies, sound masking systems are constantly evolving as new research, standards, and technical understanding have demanded changes to continue improving client outcomes, and thus new documentation will be needed.

Using a template as a starting point can be useful, provided the user ensures it has kept pace with these developments and, if it has not, updates it accordingly. Unfortunately, templates reflecting 1970s masking capabilities are still in circulation, and products based on older architectures remain available. The most conspicuous of these is the centralized system, in which loudspeakers—sometimes as many as hundreds—are grouped into large control zones, providing very little ability to adjust the sound delivered to the facility. The technician cannot fine-tune the sound in the numerous areas where it is affected by the space.

It is also important to ensure the spec reflects the particular project at hand and does not include functional requirements (*e.g.* paging) from a past project that do not apply to the current one. Otherwise, it may not reflect the current client's needs, and they are also within their rights to ask the supplier for something that was not contemplated during project meetings or in quotes, but is in the spec.

## Reference appropriate, up-to-date standards

Ensure the spec references the most current versions of the relevant standards that apply to masking systems and to the evaluation of their performance.

Masking specifications sometimes state that the system must comply with ASTM E1374, *Standard Guide for Office Acoustics and Applicable ASTM Standards*, which is purely informational and does not contain any requirements. At most, it defines what a masking system is and identifies its basic components. The only way a masking system can "comply" with E1374 is simply by virtue of including those components, just as a "car" complies with the dictionary definition of "a motor vehicle on wheels."

Others reference standards that are many years—or even decades—out of date, such as ASTM E1041, *Standard Guide for Measurement of*



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*Masking Sound in Open Offices*, which was withdrawn more than 20 years ago. Because such old standards reflected older technologies and were too lax in their requirements, in 2018, ASTM issued an updated, much more rigorous standard for measuring masking sound in both open and closed spaces. This new standard was further revised in 2022, resulting in the aforementioned ASTM E1573-22.

This standard offers guidance and instruction on the measurement procedure to evaluate the performance of a commissioned masking system. Measurements are performed in every 92 $m^2$ (1,000 sf) of open space and a representative number of closed rooms to review the effectiveness of the tuning process against performance targets and tolerances, and to provide an indication of the spatial uniformity of the masking sound.

## Use defined, consistent terminology

To communicate effectively and ensure all parties understand one another, it is necessary to define key terms at the outset and use them consistently throughout the document.

Unfortunately, many sound masking specifications use terms inconsistently throughout the document; for example, using "zone" to refer to a masking control zone and to an area where masking is expected to be at a particular level. Another example is specifying requirements for a "zone" in one paragraph, but substituting the words "channel," "area," "loudspeaker group," or "device" in others. These kinds of inconsistencies require suppliers to interpret what is meant, creating misunderstandings and, in the worst case, loopholes.

## Set an effective performance bar

Outcomes are strongly related to the consistency with which masking sound is delivered, so it is key to set control requirements for the system, including the size of zones permitting one-third octave adjustment, as well as tested performance requirements for the masking sound, including the target spectrum (*e.g.* the National Research Council [NRC] Optimum Masking Spectrum or another specified by an independent third party, such as an acoustician), overall level(s), and acceptable tolerances for both.

Often, specifications fail to include performance targets for spectrum and level. In some cases, they simply call for "a sound masking system" to be installed or for the supplier to "tune to the spectrum as best as possible." This allows suppliers to proceed without targets to which they could be held accountable. In other words, the primary reason for purchasing the technology—the masking effect—is left to chance.



Proof of masking sound delivery comes in the form of a detailed report showing ASTM E1573-compliant results for each test area.

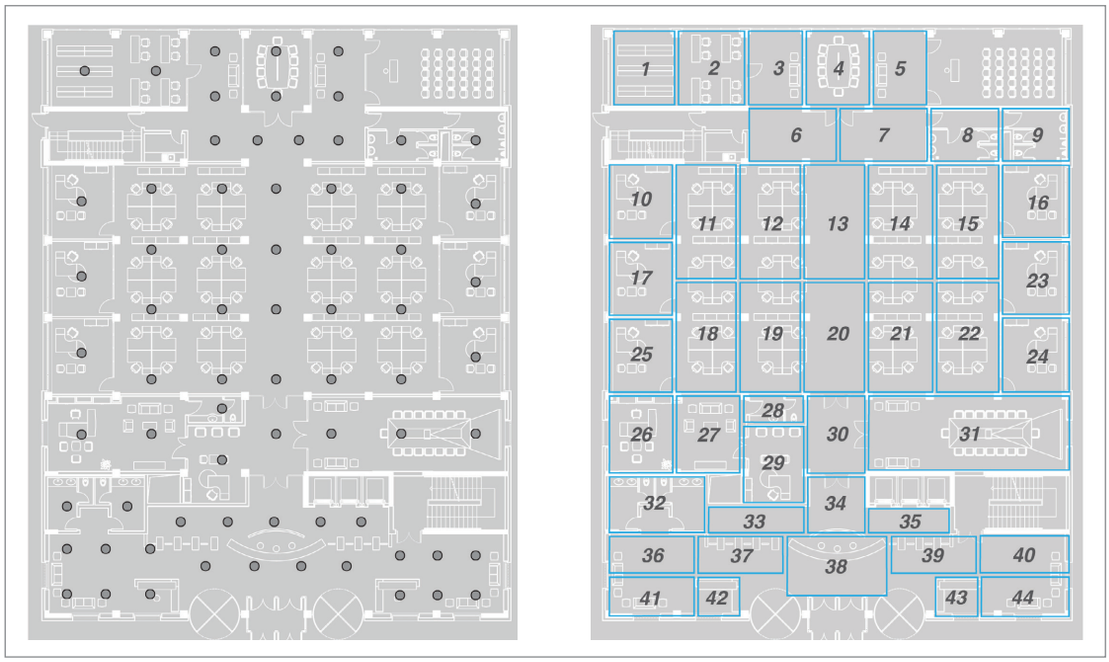
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Performance requirements should not be overly lenient; for example, specifying broad tolerances for level and frequency variation, a masking spectrum that covers too narrow a range, or control capabilities that are insufficient to meet stated targets and testing standards. In such cases, masking results can vary significantly—and in unpredictable locations across the client's space—compromising the consistency of occupants' speech privacy and noise control, and also potentially, their comfort. It may be difficult or even impossible for the supplier to address these problems after installation, particularly if the specified control criteria were inadequate. If comfort is negatively affected by the sound being too loud in certain areas and/or too hissy or rumbly, the client may have no choice but to turn the masking off.

In the last decade or so, great advancements have been made with regard to masking technology's ability to accurately and consistently achieve a comfortable and effective masking sound across treated spaces. For example, when designed with control zones aligned with ASTM E1573 test areas (or smaller) offering fine volume (0.5 dBA) and frequency (one-third-octave) control, a networked-decentralized system can



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Including drawings is good practice because it helps align competitive bids with respect to system coverage, loudspeaker locations (above left), installation approaches, and control zones (above right).

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provide consistency in the overall masking volume not exceeding ±0.5 dBA, as well as highly consistent masking spectra from 100 to 10,000 Hz.

## Set specific, consistent requirements

To avoid confusion, keep requirements clear and consistent throughout.

Vaguely worded requirements confuse the procurement process and are impossible to assess post-implementation. For example, while a spec calling for "equalization in thin strips" creates the impression of requirements, they are unclear and unenforceable. Rather than holding a supplier to account, this wastes time by requiring clarification or opens the door to underperforming bids.

Responding to a specification calling for a particular requirement in one place and a different or incompatible one elsewhere is also challenging. Examples include a document outlining two distinct testing methods, or one that calls for a masking spectrum covering 100 to 10,000 Hz to be delivered by a system that only provides control from 200 to 5,000 Hz. When a spec includes two or more contradictory requirements, no one can tell which one is the goal.

## Establish strong, thorough testing requirements

Include testing requirements that meet or exceed the current version of ASTM E1573, and require a detailed report of the results.

Setting performance requirements for the masking sound is meaningless if the sound is not properly tested post-implementation. Fortunately, E1573-22 provides a high-quality, industry-accepted measurement method. Unfortunately, many specs either omit this standard, include it and then contradict it, or specify other measurement methods that are insufficient to ensure the sound consistently provides masking across all treated areas. For example, it is common to see specs that permit testing using inaccurate (non-Class 1) sound analyzers, overly short measurement periods, or not enough measurement locations; that measure only overall levels; that use a frequency range that is too narrow; or that use full rather than one-third-octave bands. These lax requirements only serve to make life easier for the supplier. Without an objective assessment using E1573-22 as the basis for conformity and detailed reporting of results, there is no evidence that the client has received what they are paying for, which is masking sound.

## Remain consistent with referenced standards

Ensure all spec content is in keeping with the referenced standards.

At times, specs refer to a standard, but then include requirements that do not comply with it. For instance, indicating that the masking sound should be measured per ASTM E1573-22,



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but only in the single 2,000 Hz full-octave band, or using Class 2 sound analyzers or 4-second measurements, all of which contradict the standard.

### Avoid 'thou shalt not' statements

State what is required for the project, not what is not.

Specifications asserting something is not allowed raise concerns about objectivity and professionalism, because such statements are typically included to limit competition rather than serve the client; for example, statements such as "systems using above-ceiling active electronics are not permitted."

Similarly, some specifications purport to allow competitive bids but include proprietary details that technically preclude all but one product from being proposed. Worse still, these proprietary elements are often immaterial to masking performance. In these cases, one must either limit bids to a single product or scrap the spec to allow others to bid. At times, an attempt to justify the proprietary feature follows. An example is calling for loudspeakers that use a particular mounting mechanism and adding "to minimize installation time in ceiling tiles and enclosures." It is best to stick to the facts and save any editorializing for marketing materials.

### Include clear and complete drawings

Including drawings is a good practice because it helps align competitive bids on system coverage, loudspeaker locations, installation approaches, and control zones. However, if they are unclear or incomplete, they can pose an obstacle to suppliers. A drawing should show not only loudspeaker locations but also how they are grouped into control zones. Otherwise, vendors can propose systems with control zones that cannot meet the desired performance in all areas. Also, ensure loudspeakers are located and spaced in the manner required to achieve the stated expectations for masking sound coverage and consistency.

### Ensure pre-approved manufacturers or products can meet spec

Masking specs usually include a list of approved manufacturers. Still, because some manufacturers offer a variety of products—some of which may not meet the particular spec—they should list only specific conforming products.

Similarly, a spec that names a particular product as the basis of design should only outline requirements the product actually meets.



Although masking delivery can only be assessed after installation and tuning, the appointed team member can review each submission to ensure the vendor is offering a product that can meet the stated control performance, has the measurement equipment required by E1573-22, and will provide a detailed tuning report.

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### In summary

When preparing a specification for masking sound:

- Update a template to reflect modern technologies and project-specific requirements.
- Refer to the most current version of the relevant standards.
- Define key terms and use them consistently throughout the spec.
- Set control requirements, including zone sizes and adjustment capabilities.
- Set performance requirements, including the target masking spectrum, overall level(s), and acceptable tolerances for both.
- Include testing requirements that meet or exceed the current version of ASTM E1573 and require a detailed report of the results.
- Keep requirements clear and consistent throughout the document.
- Include clear and complete drawings.
- Only list conforming products.

Of course, issuing an effective specification is only the first step toward ensuring end users receive a masking system that works. A member of the project team needs to enforce the requirements. Although masking sound delivery



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If not properly specified and implemented, the client may endure many years of underperforming sound and its detrimental impact on employees' privacy, concentration, and overall comfort.

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cannot be assessed until after the equipment is installed and the sound is tuned, the team member can carefully review each vendor's submission to ensure the vendor:

- Is offering a product that can meet the stated control zone requirements, allowing the sound to be adequately tuned to meet final tested (*i.e.* measured) performance per ASTM E1573-22.
- Has the measurement equipment required by E1573-22 and budgeted sufficient time to perform the testing procedures and adjustments.
- Will provide proof of performance with a detailed written report showing E1573-compliant test results for each control zone. E1573-22 outlines the required details for this report, but it is also wise to request samples of prior project reports from each vendor to assess their quality. Alternatively, the sound can be independently verified by an acoustical engineer separately contracted by the client.

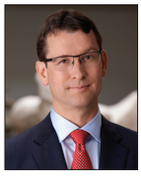
Because one can only verify masking compliance after the purchasing decision has been made and the equipment is installed, it is essential to specify control performance carefully from the outset and consider only systems that meet those requirements. If the sound is then tuned by a competent, properly equipped supplier, it should meet the performance specifications. However, if this solid foundation is not laid, it will be too late to remedy without substantial disruption to the project. If left unaddressed, the client may endure many years of underperforming sound and its detrimental impact on employees' privacy, concentration, and overall comfort.

## Notes

[1] For more information, read Viken Koukounian and Niklas Moeller's "Rethinking Acoustics: Understanding silence and quiet in the built environment" in the August 2020 issue of *The Construction Specifier*.

## additional information

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### KEY TAKEAWAYS

Sound masking specifications should define the desired acoustic outcome—not merely identify hardware. Clear requirements for control-zone size, frequency adjustment, masking spectrum, overall sound level, acceptable tolerances, testing procedures, and reporting give project teams a meaningful basis for evaluating products and verifying performance after installation. Specifications should also use current, applicable standards; consistent terminology; complete drawings; and a list of products that can meet the stated requirements. Avoiding outdated templates, contradictory requirements, proprietary restrictions disguised as performance criteria, and inadequate testing provisions reduces procurement confusion and helps protect speech privacy, concentration, and occupant comfort.

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# Map Cracking in Concrete? It May Be ASR

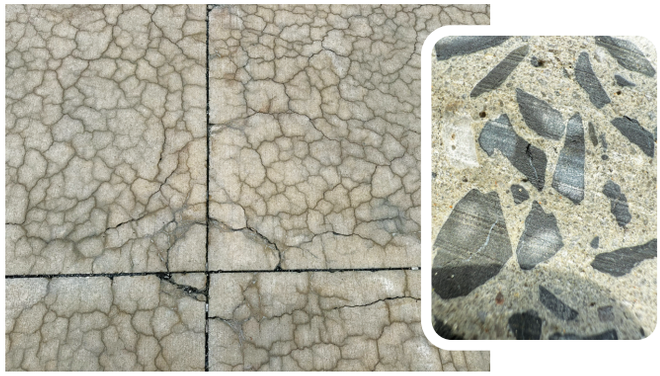
**Is your concrete exhibiting extensive interconnected map-pattern cracking?** Does the cracking contain staining or a gel-like substance? Your concrete may be experiencing alkali-silica reaction (ASR).

ASR is a deleterious chemical reaction that occurs within hardened concrete containing reactive aggregates. As its name suggests, ASR is a reaction between *alkali* hydroxides in cement and reactive *silica* in aggregates, producing an expansive hygroscopic (moisture-attracting) gel that causes internal pressure, cracking, and long-term deterioration of concrete. Cracking from ASR typically presents as a polygonal, map-like pattern, with dark-colored staining, and the cracks are sometimes filled with white gel. The three prerequisites for ASR are reactive silica-bearing aggregate, sufficient pore-solution alkalinity (developed during portland cement hydration), and a source of moisture for ASR gel swelling.

Mitigation strategies in new construction include using non-reactive aggregate; limiting the alkali content of concrete; using supplementary cementitious materials (SCMs), such as fly ash and slag, as a partial replacement for portland cement; and using lithium admixtures. AASHTO R80, *Standard Practice for Determining the Reactivity of Concrete Aggregates and Selecting Appropriate Measures for Preventing Deleterious Expansion in New Concrete Construction*, and ASTM C1778, *Standard Guide for Reducing the Risk of Deleterious Alkali-Aggregate Reaction in Concrete*, provide guidance for determination of ASR susceptibility and prescription of appropriate SCM dosages to mitigate ASR in concrete based on aggregate-reactivity class, concrete element size and exposure conditions, severity of consequence should ASR occur, and alkali content of the concrete.

So, what makes an aggregate reactive? Not all silica-bearing (siliceous) aggregates are reactive. The reactivity of a siliceous aggregate is related to its crystallinity (microstructural order). Quartz (silicon dioxide) has the most ordered microstructure (crystalline) of silica, making it a non-reactive aggregate. The most reactive aggregates, such as opal and glass, are amorphous (non-crystalline), followed by microcrystalline silica and crystalline forms with defects, residual strains, or internal microcracks. Certain rocks such as chert, flint, shale, sandstone, rhyolite, marl, and basalt contain reactive silica-bearing minerals, making them ASR-susceptible.

Aggregate reactivity varies by region. Several state departments of transportation (DOTs) have publicly available aggregate source databases with published ASR test data and reactivity ratings for use by engineers and those developing concrete mix designs.



Concrete deterioration of a loading dock pavement due to alkali-silica reaction (ASR). **Inset:** Concrete core upon extraction for petrographic examination to confirm ASR diagnosis. Concrete coarse aggregate is partially consumed and contains cracks partially filled with ASR gel.
PHOTOS COURTESY WISS, JANNEY, ELSTNER ASSOCIATES INC.

ASR susceptibility of aggregates is commonly determined with laboratory tests that measure sample expansion, including ASTM C1293, *Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction,* or ASTM C1260, *Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method).* If the one-year ASTM C1293 expansion exceeds 0.04 percent or the 14-day ASTM C1260 expansion exceeds 0.10 percent, the aggregate source is considered reactive, and ASR mitigation shall be implemented.

ASR is a progressive, irreversible mechanism of concrete deterioration. The only options for ASR-affected concrete are to limit moisture access or replacement. ASR prevention is a fraction of the cost of management or concrete replacement. It is important for specifiers to incorporate aggregate expansion limits into concrete specifications and to determine whether ASR mitigation is needed during the mix design review. ASR test data should be required with concrete mix design submittals. The inclusion of an ASR review should be treated as routine on projects involving concrete.



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