TECHNICAL PRESERVATION GUIDELINES

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UPGRADING HISTORIC BUILDING WINDOWS

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EXECUTIVE SUMMARY

Window upgrades often provide opportunities to restore a building's historic design integrity and workspace quality while reducing fuel consumption and improving occupant safety. There are two basic approaches for upgrading historic building windows for improved blast resistance and thermal performance: retaining and retrofitting the existing windows, or replacing them with new high performance windows designed to replicate the appearance of the original windows.

As with all work undertaken for compliance with current codes and standards, projects initiated to meet mandated energy reduction and security goals are subject to federal preservation standards and review procedures under Section 106 of the National Historic Preservation Act (NHPA). **Section 106 Compliance review is coordinated by the GSA Regional Historic Preservation Officer (RHPO), whose concurrence is required before designs are completed for submission to the SHPO or ACHP. Consult the RHPO early in design planning to ensure timely and successful 106 compliance.**

Standards and guidance for all federal historic building projects are provided in the Secretary of the Interior's Standards for Rehabilitation and guidelines for applying the standards published by the National Park Service, U.S. Department of the Interior (DOI Standards). In accordance with the DOI standards, preference must be given to reversible alternatives that can be removed or undone to reveal the original appearance of the windows.

Under the standards, options for retaining historic windows must be considered before pursuing replacement options. Retaining and retrofitting existing historic windows offers several advantages, from a preservation and environmental standpoint: original materials are preserved, waste is reduced and natural resources are reused. A variety of low cost/low intervention, to high tech/high performance retrofitting options meeting federal preservation standards are now available:

- weatherstripping and glazing film,
- blast curtains and shades,
- laminated glass interior storm windows, and
- replacement glazing.

Replacement of historic windows raises preservation and environmental issues requiring more extensive planning, analysis and mitigation to justify the substantial loss of historic materials. Studies exploring historic window replacement need to examine window conditions throughout the building and consider alternatives that preserve as many historic windows as possible. This might entail replacing only irreparably deteriorated windows or consolidating sound windows on principal facades or lower stories most visible to pedestrians.

FIGURE 1 Windows are character-defining features in every historic public building. Stone quoins, Ionic pilasters and carved pediments frame multi-light, arched windows defining this Georgian revival facade. (Carol M. Highsmith Photography, Inc./GSA)

To assist asset management and design teams in identifying issues to be addressed and appropriate alternatives, the guide includes a window project analysis matrix template and sample for assessing the range of factors that need to be considered in any potential window replacement scenario.

Section 106 project submissions must include an illustrated Preservation Report with captioned photographs of existing conditions and a narrative summarizing the preservation design issues and options, with a assessment justifying GSA's planned approach. GSA's Window Project Matrix for Historic Buildings must also be included to justify any project proposals involving removal of historic windows.

INTRODUCTION

Windows are character-defining features and an important part of every historic building's original design. From its inception, the federal government's public buildings construction program sought to create safe, high quality office buildings offering generous daylight and fresh air. Compared to many deep floor plate or substantially windowless buildings constructed after the commercial availability of fluorescent lighting, GSA's historic buildings constructed before WWII typically offer abundant windows and light courts admitting daylight to perimeter offices along doubled loaded corridors.

Awnings, shades, then blinds, provided light control on exterior windows. Transoms, glazed doors, and glazed partitions admitted light into corridors and other interior spaces. Skylights provided daylight for interior areas lacking access to perimeter windows. Often, historic daylighting features have been removed or obscured by suspended ceilings or other alterations. At other historic buildings, original windows have been inappropriately replaced with ill-matched or inferior replacement windows. Window upgrades and interior improvement projects may provide opportunities to restore the building's historic design integrity and workspace quality.

Standards and guidance for all federal projects involving historic buildings are provided in the Secretary of the Interior's Standards for Rehabilitation and guidelines for applying the standards published by the National Park Service, U.S. Department of the Interior (DOI Standards). The National Park Service has also published a variety of technical briefs addressing a range of window repair and improvement issues. All guidance publications are available free online at www.nps.gov/hps/tps/publications.htm.

In accordance with DOI Standards, GSA window projects must give first consideration to alternatives that repair and reuse the building's historic windows. Where historic windows no longer exist or are beyond repair, replacement windows must be designed and fabricated to replicate the original windows. Every GSA historic building window project begins with review of the Building Preservation Plan or Historic Structure Report to ensure that project design teams are well informed on the building's window history, conditions, and preservation goals prior to developing a design scope of work.

Most alternatives that retain the historic windows will be determined as having No Adverse Effect on the qualities that qualify the historic building for the National Register of Historic Places.

Projects involving removal and replacement of historic windows are determined as having an Adverse Effect on the qualities that qualify the building for the Register. Consultation to resolve Adverse Effects under 106 is more lengthy and involved than No Adverse Effect consultation and usually concludes in a Memorandum of Agreement signed by the SHPO and GSA's Regional Administrator or Assistant Regional Administrator and concurred upon by GSA's Federal Preservation Officer, Regional Historic Preservation Officer, and Counsel.

Any changes that will permanently alter or remove historic features or materials require a compelling justification supported by a systematic and building-specific analysis that takes into consideration preservation goals as well as window performance goals.

FIGURE 2 As part of every window assessment survey, the presence of rare, costly or difficult to replicate materials, such the wavy historic cylinder glass reproduced for these mid-19th-century windows, must be identified as features requiring a window retrofit approach rather than replacement. (GSA)

Section 106 project submissions must include an illustrated Preservation Report with captioned photographs of existing conditions, summarizing design issues and options, with a narrative assessment justifying GSA's planned approach. A preservation report template and scope of work is available at www.gsa.gov/historicpreservation>Project Management Tools>Section 106 Compliance Template. Include a completed GSA Section 106 Compliance Report-Short Form with each design submission to document the preservation design issues and solutions for RHPO clearance. In addition, a Window Analysis Matrix must also be included to justify any project proposals involving removal of historic windows.

Evaluation criteria for comparing window upgrade options must consider:

- preservation of historic materials,
- preservation of historic design and appearance,
- long-term performance, maintained as directed,
- maintenance requirements/convenience,
- life-cycle cost,
- energy performance, and
- security (blast resistance) requirements, if applicable.

Retrofitting, rather than replacing, windows to meet new energy conservation or security standards can bring about substantial project savings while preserving historic character and reducing demolition waste. New United States Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) certification for rehabilitation takes into consideration reuse of existing materials and reduction of waste to promote projects that examine the environmental benefits from a broad standpoint concerned with construction resources and operational benefits.

When upgrading original windows in historic structures, Section 106 compliance requires design teams to explore options that maintain historic materials while meeting energy and security goals. A demonstrated effort must be made to keep historic frames and sashes in place with modifications such weather-stripping installation, adding glazing films, installing reinforced laminated glass, interior storm windows, or blast containment curtains.

Most historic buildings constructed prior to 1960 used operable windows to meet fresh air requirements for occupied workspace. Historic and replica operable windows reflect the original design intent for the building and provide sustainable passive ventilation, as advocated by the USGBC. Even if temporarily secured to meet blast protection or other requirements, operable windows should be retained as such to ensure that this capability is preserved.

Improving thermal performance – low cost measures

Installing weather-stripping and sealing gaps between walls, window frames, and sash to reduce infiltration is one of the most cost-effective ways to achieve substantial energy savings for a small investment. Weather-stripping typically uses a thin, bendable strip of metal such copper to fill the gap between the door or window sash and frame to exclude cold or unconditioned air. Interior shades and blinds complement infiltration- reducing measures by controlling heat gain. Some products include sensor-driven operating mechanisms that respond to changing daylight conditions. These alternatives are regarded as maintenance repair, from a regulatory standpoint, and require no Section 106 review—a benefit for projects with a limited project delivery schedule.

FIGURE 3 Exterior view of 19th century windows repaired and retrofitted with weather-stripping to reduce air infiltration. Properly maintained, some old growth wood sash windows have demonstrated life cycles exceeding 200 years. (Carol M. Highsmith Photography, Inc./GSA)

Adding interior storm panels of polycarbonate, acrylic, or synthetic clear glazing to existing window systems is among the most discrete alternatives for addressing both security and energy conservation needs. See “Reversible blast retrofitting measures,” for details.

Reversible blast retrofitting measures

A variety of preservation-acceptable options now exist for upgrading historic windows in a manner that does no permanent harm to historic materials. Detailed and installed properly, these alternatives will result in a Section 106 determination of No Adverse Impact, eliminating the need for further SHPO consultation to develop a Memorandum of Agreement.

Reversible alternatives for securing sash and frames against the risks of glass fragmentation and sash detachment include

- Structural blast curtains;
- Blast shades;
- Laminated glass interior storm windows;
- Interior window film; and
- Replacement glazing.

In designing for protection against fragmented glass, consideration must also be given to protecting occupants from detached sash pulled into the building by negative pressure following a blast event. This requires anchoring film, blast curtains, reinforced sash, and other movable components to the building structure, usually using flexible anchoring devices designed to absorb the temporary impact of the blast.

Blast curtains, shades and blinds

Blast curtains, shades and blinds generally serve as standalone blast protection, but may be used in conjunction with window film and weather-stripping for improved thermal performance and UV reduction. Blast curtains are structurally secured at the top and bottom of the window and billow inward to contain glass fragments in a blast event. Lighter weave blast shades are designed to contain fragments in a similar manner but “puddle” on the floor in front of the window and have the general advantage of excluding less daylight than heavier blast curtains do. Blast blind systems use glazing film to control glass fragmentation and UV, along with aluminum blinds hung on anchored steel cables to retain sash units and provide daylight control.

Additional information on blast curtain and shade products is provided in GSA's Technical Preservation Guideline on perimeter security and the McGraw Hill publication Building Security: Handbook for Architectural Planning and Design (Nadel, 2004), Chapter 9, Historic Preservation Guidance for Security Design .

FIGURE 4. Used in conjunction with glazing film, blast blinds retain historic windows while providing improved thermal efficiency and blast protection. Supporting cables are anchored at the top and bottom of the window frame, so blinds can be opened and closed, not raised or lowered.

Storm Windows

Among the most discrete high-performance alternatives for addressing both security and energy conservation goals are storm panels of safety glass, acrylic, or synthetic clear glazing that can be added to existing window systems. Polycarbonate panels may be also appropriate as a low-cost retrofit solution for windows containing period glazing.
Blast resistant laminated glass storm windows offer the energy saving advantage of reducing heat loss and gain. The demountable units are structurally anchored to the frame, relying on a flexible connection and cable between sash and sub frame to absorb, rather than resist impact, much as a tree bends with the wind, then returns to its normal position. Large, fixed glass expanses common in modern-era buildings and multi-leaf doors not actively used can be secured using steel cables anchored into the building structure. Patented systems address a variety of facade configurations and are visible at close range, but are not noticeable from exterior grade level view.

Some storm window products have size constraints that may require designing multiple storm windows with carefully aligned muntins for windows exceeding a given size threshold. The ability of the existing window frame to support added storm sash containing laminated glass must also be confirmed. Some frames will require structural reinforcement. Sash access for cleaning and maintenance must also be considered.

FIGURE 4 Used in conjunction with glazing film, blast blinds retain historic windows while providing improved thermal efficiency and blast protection. Supporting cables are anchored at the top and bottom of the window frame, so blinds can be opened and closed, not raised or lowered. (GSA)

FIGURE 5 Blast shade detail showing fabric anchored to the window frame to contain glass fragments and sash units. Shades can be designed to conform to the contours of arched windows and other unusual openings. (GSA)

FIGURE 6 Interior views of blast-resistant storm windows. They are designed to contain flying debris, preserve the historic character of building exteriors and interiors, admit daylight, offer energy savings and, with operable product options, allow fresh air inside the building. (Oldcastle-Aral, Inc.)

FIGURE 7 Detail views of demountable blast-resistant, thermal storm windows with built-in blinds to control daylight. (Chad Randal, National Park Service)

Blast and Low-E Film

For some buildings, applying shatter-resistant Low-E film to window glazing is the least costly and least intrusive option for reducing heat gain from sunlight and reducing risk of injury from flying glass as a result of high wind or a blast condition. However, only film systems designed to be mechanically attached to the window frame offer protection against entire sash units becoming airborne, at potentially fatal velocity. These systems require robust frames, capable of reinforcing the sash connection to the frame and, if necessary, upgrading the window frame anchorage to the masonry walls.

Caution should be used in applying any material directly to antique glass, as the performance over time has not been well tested. Film may not properly adhere to irregular glass surfaces and differential thermal movement between film and glass could cause stress cracking.

Replacement Glazing

Replacing glass with a shatter-resistant laminated glass or specialty dual glazing may necessitate changing the profile and width of the window's muntins, the strips of wood or metal separating and holding panes of glass in a window. Before selecting this option, the impact of any change should be evaluated. Often delicately detailed, divided-light window sashes are important building components. Wider muntins to hold new, heavier glazing may not be appropriate.

Larger, simpler sash may accept replacement glazing and improve thermal performance without substantially changing the window profiles and detailing. Fanlights and sidelights to exterior historic doors can be similarly retrofitted for improved blast resistance and thermal performance, but as these features are at eye level, the integration of films, new glazing, or panels should be carefully detailed. Overhead skylights and interior lay lights or decorated stained glass should also be reinforced with some measure of protective film or secured glazing to protect persons below.

FIGURE 8 Detail views of historic windows retrofitted with laminated glass containing film to resist glass fragmentation and reduce heat gain. (Kaaren Staveteig, National Park Service)

WINDOW REPLACEMENT

When original windows are no longer present, design for replacement windows is guided by existing original windows or documentation confirming the muntin pattern and detailing of the building's original windows. Where conditions potentially warrant replacement of historic windows, an analysis of cost and performance benefits weighed against preservation and sustainability goals must be undertaken to corroborate cost benefit assumptions. The analysis must clearly support replacement and must be included as part of the 106 consultation submission package for any project involving window replacement.

Original frames should be repaired and retained, replacing only window sash, whenever possible. In addition to meeting DOI standards giving preference to retaining historic materials, reuse has lifecyle, cost, performance, and sustainability benefits. Some historic materials, such as old growth wood, are no longer available and offer superior durability, compared to new materials.

Retaining original window sash and frames reduces material waste by eliminating a substantial volume of construction debris, reduces the risk of damage to adjacent materials such as brick or terra-cotta masonry and eliminates the time, cost, and tenant disturbance associated with removing and installing replacement window units. Industrial metal windows, in particular, are often grouted into the wall and side frames cannot be removed without removing adjoining historic wall material, increasing the risk of damage and additional repair expense. Such window replacements sometimes install new extruded metal side frames large enough to cover the original side frames, but this approach has the disadvantage of widening the profile of the frame and can conceal deterioration.

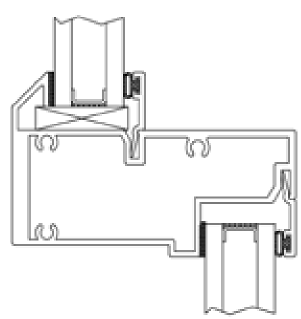

FIGURE 9 Section detail showing custom muntin simulating the meeting rails of a double hung window with upper and lower sash in two planes. (Raming Distribution, Inc.)

If blast protection requirements rule out replicating original double hung windows, single hung sash adaptations no longer need sacrifice accurately recreating the historic window appearance. The section detail in Figure 7 shows how a custom muntin can create the appearance of a double hung window with upper and lower sash in different planes.

FIGURE 10 Exterior view of blast windows fabricated with custom muntin placing upper and lower panes in separate planes to simulate the appearance of double hung windows. (Mariah McGunigle/GSA)

The slender profiles of some muntins cannot be replicated when blast or inulated glass windows are required. Energy and blast glazing composites are often thicker than single pane glazing, requiring larger muntins and stops to hold the thicker assembly in place. True-divided light (TDL) windows have, in the past, been generally preferred for replicating historic multi-paned windows, but simulated divided light (SDL) sash when properly crafted can produce a convincing effect. SDL use spacers between the panes of the insulated unit, aligned with three-dimensional muntin-grids on the interior and exterior glass surfaces. Keeping the surface grid permanently tight to the surface is critical for effective simulation and can be difficult on very large pieces of glass. SDL offer greater flexibility for matching historic muntin profiles, allowing even narrow muntins to be replicated with insulated units. When replicating any divided light window, specify that replacement windows must match the depth, width and profile of the original window muntins. The addition of insulated glass without the use of a deeper sash will, however, necessitate some compromise in the depth of profiles, and such compromises should generally be made at the interior face.

FIGURE 11 Exterior before (top two rows) and after (bottom two rows) views showing original windows and blast resistant replicas illustrates minor muntin-widening needed to secure the thicker laminated glass of the new blast window. (Mariah McGunigle/GSA)

Replacement ballistic-resistant windows weigh more than the carrying capacity of most existing window units. Many of these custom window units weigh over 1000 pounds and are not detailed to match historic configurations. Unless there is substantial interior reinforcement, installing these specialty windows without substantial structural reinforcement is sometimes not feasible.

Combination Approaches

When analysis strongly supports replacement of window sash or entire window units, consideration must also be given to the feasibility of a combination preservation and replacement approach that retains in place or relocates intact original windows to the building's primary facades or most visible locations (e.g. lower floor levels). As a Section 106 mitigation measure, some GSA projects have preserved sound original windows by consolidating them on the building's lower levels or replacing windows on secondary facades only.

FIGURE 12 Thoughtful analysis to balance GSA preservation, cost, and performance goals supported historic window retention with replacement of non-historic windows at this 1930 courthouse. Blast-resistant, thermal storm windows were installed where original windows remained on courtrooms and the upper and lower levels of the light court. Roman arched windows in the light court were determined to meet blast protection requirements and did not require storm windows. Non-historic windows on the exterior facades were replaced with new blast resistant windows carefully replicating the building's original windows. (Carol M. Highsmith Photography, Inc./GSA)

CONCLUSION

GSA asset managers, tenants and project teams all share a responsibility for stewardship of the nation's historic properties, wise use of federal funds and conservation of finite resources. Thoughtful and well-documented analysis promotes sound, consistent decisions and positive project outcomes that reflect well on GSA. Documenting and disseminating successful approaches also helps to raise the standard for future GSA projects. Toward that end, the Center for Historic Buildings encourages readers to share images and information documenting their own project successes for the benefit of future updates to this guide.

For additional guidance and building specific information, contact your RHPO (see www.gsa.gov/historicpreservation for a current list).

WINDOW PROJECT MATRIX FOR HISTORIC BUILDINGS

Window Repair / Replacement Option	Retains Historic Material (1-3)*	Matches Historic Appearance (1-3)	Thermal Performance (1-3)	Meets Security Requirements (1-3)	Ease of Maintenance (1-3)	Maintains Operability (1-3)	Installation Risk - Damage to Interior / Exterior Finishes (1-3)	Expected Lifespan with Maintenance (1-3)	Initial Cost (1-3)	Life-cycle Cost (1-3)	Total Score
Option 1 Repair Existing Sash + Add Glazing Film / Weatherstripping											
Option 2 Repair Sash + Add Interior Storm											
Option 3 Repair Existing + Add Interior Blast Curtains / Drapes											
Option 4 Repair Existing Sash + Replace Existing Glazing with IGU											
Option 5 New Wood Frame and Sash with IGU											
Option 6 New Aluminum Frame and Sash with IGU											
Option 7 Combination 1 & 5: Repair Reusable Windows + Replace All Others with Replica Sash											

*See key on reverse

Window Matrix Ranking Key

Retains Historic Material: Extent to which original window components (sash & frame) are preserved.
1 preserves original sash and frames
2 preserves frames only;
3 preserves no original window components.

Matches Historic Appearance: How closely the exterior appearance of a window option conforms to the original window.
1 matches the appearance of the existing window close and conforms to The Secretary of Interior's Standards;
2 has a similar overall appearance, but has been modified to accommodate insulated glass and conform to The Secretary of Interior's Standards;
3 has a different appearance due to manufacturer or material limitations and will not meet The Secretary of Interior's Standards.

Thermal Performance: A qualitative comparison based on the relative thermal values of the respective window options.
1 maximizes the thermal improvement of the glazing and sash;
2 offers a moderate improvement in thermal performance of the glazing;
3 offers no improvement in thermal performance.

Meets Security Requirements: A qualitative comparison based on the extent to which GSA glass fragmentation protection requirements are met.
1 protects occupants from glass fragments and unit detachment;
2 protects occupants from glass fragmentation only;
3 offers no blast protection.

Ease of Maintenance: A qualitative comparison based on the relative maintenance required for the respective window options.
1 requires little or no routine maintenance;
2 requires occasional light maintenance;
3 requires routine regular repairs and maintenance.

Maintains Operability: Extent to which each option maintains window operability.
1 maintains window operability by occupants;
2 maintains window operability by facilities staff only;
3 maintains no window operability.

Risk of Damage to Interior Finishes: If an option requires replacement of the window frame, the surrounding finishes are damaged to install the new window. Any option that involves only the sash will cause little or no damage to surrounding finishes.
1 does not require removal and replacement of surrounding finishes;
2 requires some removal or alteration of surrounding finishes;
3 requires significant removal and replacement of surrounding finishes.

Expected Life Span: The anticipated life before requiring replacement.
1 estimated lifespan of 25+ years;
2 estimated lifespan of 15-25 years;
3 estimated lifespan of 15 years.

Initial Cost: (insert project specific cost range -high, medium, low)
1 below $________________;
2 between $__________________ and $_________________;
3 over $__________________.

Life-Cycle Cost: (insert project specific lifecycle cost range -high, medium, low)
1 cost less than $___________________;
2 cost between $________________and $__________________;
3 cost over $_____________________

Sustainability goals are addressed in the following factors: Retains Historic Material, Thermal Performance, Maintains Operability, and Expected Life Span.