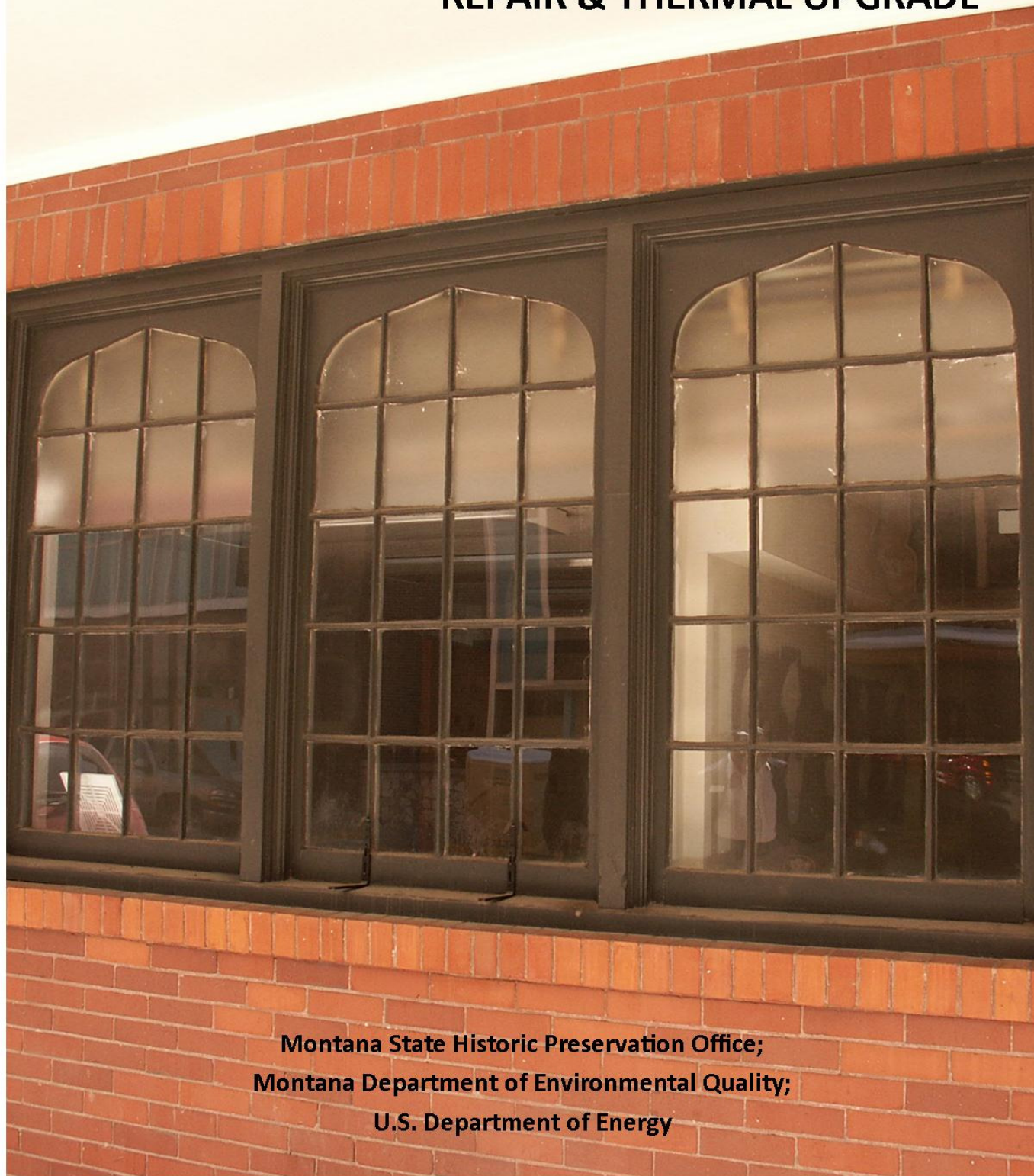


HISTORIC WINDOWS

REPAIR & THERMAL UPGRADE



**Montana State Historic Preservation Office;
Montana Department of Environmental Quality;
U.S. Department of Energy**

HISTORIC WINDOWS REPAIR & THERMAL UPGRADE

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ACKNOWLEDGEMENTS

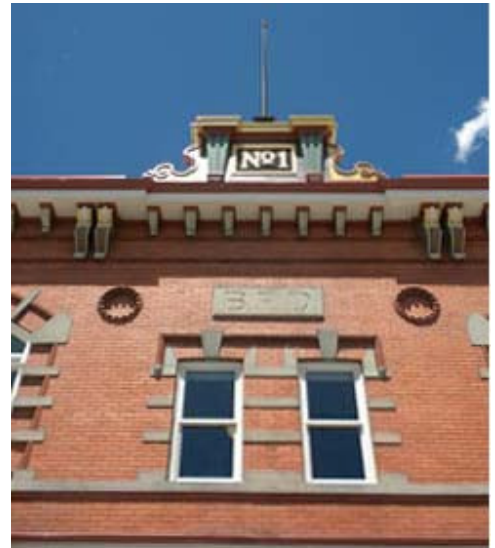
This handbook is a collaboration among state and Federal agencies, and the private sector. A&E Architects provided technical assistance, case studies, and appendices. The Montana State Historic Preservation Office edited the document and was helpful in the development of the final handbook. The Montana Department of Environmental Quality (DEQ) provided funding for this handbook through a grant from the U.S. Department of Energy and the American Recovery and Reinvestment Act of 2009 (AARA).

WHY REPAIR AND MAINTAIN HISTORIC WINDOWS?

Historic windows are important character-defining architectural features. They reflect a building's style and character, and are a tangible link to the craftsmen who built them. These reasons alone grant the treatment of windows extra consideration. However, beyond cultural and aesthetic reasoning, there are pragmatic reasons for repairing and maintaining historic windows.

While manufacturers and installers laud the benefits of replacements, the historic window is mostly without a spokesperson. No industry profits from windows that are already paid for. This handbook speaks for the historic windows and their latent qualities. It is also a how-to manual for effective repair and maintenance, and retention of a building's historic character.

There is no denying the problematic nature of unmaintained and unimproved windows. But the salvageable among these have renewable qualities the replacements do not. Historic windows are infinitely maintainable with components and remedies for upkeep available at any hardware store. Conversely the term *maintenance free* applied to replacement windows also means *not maintainable*.



Replacement windows, typically made of extruded vinyl plastic, wood, or metal-clad wood operate with proprietary parts. Repair becomes less of an option as manufacturers modify or discontinue proprietary components. The functional beauty of historic windows is in their simplicity and easily repaired or replaceable, standard components.

Replacement of otherwise repairable historic windows enrolls a building and its owners in a cycle of replacement every few decades. Depending on the product and its exposure to the elements, the lifespan of the double pane, insulating glass units (IGU) in new windows can range from 8 to 20 years.¹ Once the IGU fails, the glass fogs, and its thermal performance is diminished. Even when a replacement unit lasts longer than a few decades, money spent on replacement windows is unlikely recouped in energy savings within that window's service life.

Payback period for replacement windows

The Montana State Building Energy Program (MSBEP) calculates energy savings that capital projects bring to a building. A specialist from that program referenced a project at Montana State University demonstrating the excessive payback period for wholesale window replacement.² The replacement of Hamilton Hall's original 1910 wood, double-hung windows was part of an overall building rehab. The historic windows had no weather stripping or storm units, and their condition was poor with failing putty and lead-based paint, and extensive wood rot. The State decided to replace these units for a high-performance, metal-clad wood option. The work cost \$365,957 and came with a 165-year payback period. The MSBEP specialist describes this as more of a maintenance driven project than an energy savings project.

Long payback periods are partly due to the cost of quality units resembling their historic counterparts. The Montana Building Energy Program typically recommends insulation, air sealing, and HVAC upgrades. A typical payback period for a new heating system is 20 years.³

¹ InternNACHI's Standard Estimated Life Expectancy Chart for Homes. <http://www.nachi.org/life-expectancy.htm>; 2013.

² Interview with Ken Phillips, PE; Senior Energy Engineer, Montana State Building Energy Program; February 2012.

³ Ibid.

Cost Comparisons - Window Repair and Upgrade vs. Replacement Windows

Examples in this section show that retention, repair, and thermal upgrades to historic windows can be more economical than window replacement. The economics of window repair depends on each window's condition prior to repair. It also depends on whether or not the existing paint contains lead, and whether lead paint abatement is necessary. Though the repairs described below are costly, work items like lead paint abatement and weather stripping might be necessary only once in a window's lifetime. Epoxy putty repairs or full glazing putty replacement might only occur every 20 to 30 years. These *repair* costs should not be confused with smaller cyclical *maintenance* costs such as glazing putty and paint touch-up every two to five years. Continual maintenance significantly extends the time between repair intervals.



Havre Main Post Office Museum

The post office has large wood double-hung windows. Prior to repairs the sashes were loose within the frame enabling air leaks around the sash perimeter. The putty was cracked and the paint was peeling at the bottom sash and sills. The architect determined that the existing windows could be easily repaired and reused. Lead based paint on the windows of this public building necessitated temporary removal for abatement, repairs, repainting and weather stripping. The windows were installed with swing-out storm windows.

Repair and upgrade existing windows	\$ 900
New storm window	\$1,000
Total per window	\$1,900 per unit

Replacement with energy efficient window \$2,200 per unit

Old Faithful Inn, Yellowstone National Park

The Inn has a variety of wood hinged and fixed windows. The sashes were loose within the frame enabling air leaks around the sash perimeter. The putty was cracked and the lead based paint was peeling at the bottom sash and sills. These units vary with diamond-shaped lites, square lites, and circular windows. Therefore, repair costs varied depending on each unit's complexity. The architect determined that the existing windows could be easily repaired and reused. Lead paint abatement necessitated temporary removal for abatement, repairs, and repainting. Because the inn is closed during the winter months, and not heated, the National Park Service was not concerned about adding weather stripping or storm windows.

Repair of existing windows \$680 to \$1,250 per unit

Replacement in-kind \$850 to \$2,000 per unit



Union Pacific Oregon Shortline Dining Lodge, West Yellowstone

The lodge has very large steel sash windows with two operable sections. These windows had not been maintained so the lead based paint was peeling, and in many cases missing. The metal had rusted and showed deflection in some areas from shifts in the building. Lead based paint abatement necessitated their removal to a controlled environment for cleaning, straightening, re-glazing with insulating glass, and painting. The building's framing at windows openings also required repairs prior to reinstalling the windows.

Repair and upgrade of existing windows \$9,000 per unit

Replacement in-kind \$14,200 per unit

PRACTICAL CONSIDERATIONS FOR WORK

Determining if repairs can be done in-situ or in a shop will affect the cost of the work. Addressing paint failure, localized rot, or broken glazing can typically be done in-situ. A shop setting is better suited for more extensive repairs such as abatement or the reconstruction of components. The season in which work is done, and the location and size of windows may also influence the decision to perform repairs in-situ or in a shop.

Epoxy Putty Repairs of Historic Wood Windows

In-kind replacement of rotten wood window components (muntins, rails, and stiles) with new wood necessitates removal of the sash to join new components with old. Window joinery is technical and requires special tools. In some cases repairs with epoxy putty or consolidants are an alternative to replacing rotten window components in-kind. Where rot has not led to structural failure, epoxy materials make in-situ repairs an option. Various publications about the application of epoxy-based consolidants and putties are available online. The National Park Service's Preservation Brief Number 9, provides step-by-step instruction on the consolidating and puttying process.

Storm Windows

Storm windows do two things for a window assembly: they protect the primary window unit and heighten the thermal performance of the window. Snug-fitting storm windows cut down on drafts significantly and create airspace between themselves and the primary sash. This "dead" air is an insulator and separates the glazing on the primary sash from outdoor temperatures. Ideally, the historic storm windows on a building can be rehabilitated. Storm windows are easy to remove for repairs. However, if their condition failed it might be cost effective to replace the units in-kind. Several national window manufacturers offer wood storm windows.

Exterior-mounted, wood storm windows are traditional for wood sash windows, but steel sash units did not typically have storm windows. Some of these units have protruding hinges that preclude exterior storm units. Exterior storm windows on steel units that did not have them historically changes the window's appearance. In these cases it is appropriate to add an interior-mounted storm window. Several national window manufacturers offer low-profile, easily removable interior storm units. Local glass shops can usually construct a simple glazing panel framed in a low-profile aluminum extrusion.

Insulating Glass

Insulating glass units (IGU) commonly referred to as double-pane glass, can be retrofitted into certain historic wood or steel sash window units to increase the assembly's thermal performance. Coupling this type of retrofit with traditional wood storm windows increases the window's thermal performance and long-term durability. This approach is more practical and effective when applied to sashes with a glazing pocket large enough to accommodate the thicker IGU. Wood windows require shop work to adapt their glazing pockets. Retrofitting wood windows with IGU's is more practical with single or two-lite sash units with wide muntins. Retrofitting multi-lite wood units is technically difficult and not always cost effective. It is also potentially bad for the sash since muntin bars with an already slender profile become less structurally sound when its glazing pocket is routed to accept the thicker, heavier IGUs. Introducing IGU's into wood windows also increases the weight of a sash and requires modifications to the sash counter weights so they remain effective.

Because steel sash units typically have a generous glazing pocket and are not counterbalanced, they are often candidates for retrofitting with IGUs. In this scenario urethane sealant, not traditional glazing putty holds the IGU in place. Something to consider is that the IGU's metal perimeter bar and perimeter seal will have to be specifically narrow so neither is visible. It is important to construct a mock-up to determine if the IGU components are visible.

Although thermally upgrading wood and steel sashes with IGUs is possible, the long-term performance of such systems is questionable. Adhesive failures between sealants and substrates are inevitable. When this happens moisture can be trapped in the glazing pocket where it leads to rot, rust, and failure of the IGU's perimeter seal. Failed perimeter seals lead to fogged IGUs and diminished thermal performance.

Weather Stripping

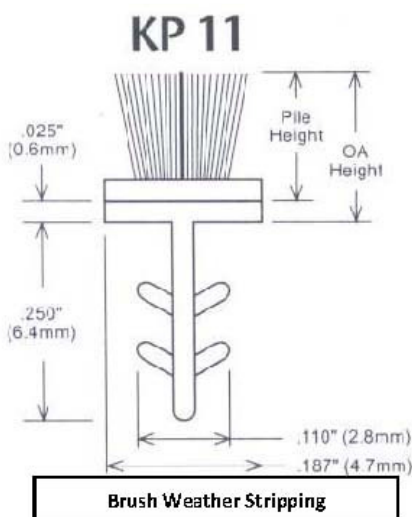
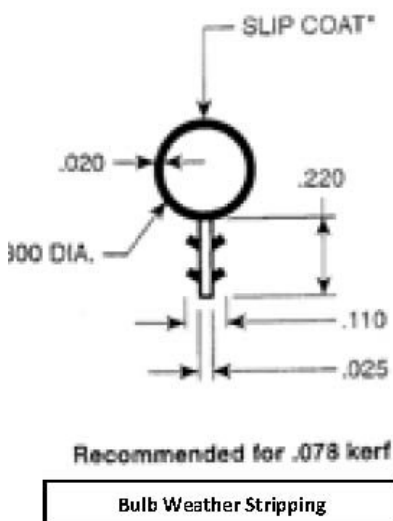
Weather stripping combined with storm windows is key to increasing thermal performance in a historic window assembly. Both wood and steel sash assemblies are candidates for weather stripping. It is desirable to introduce a concealed weather stripping system to maintain the clean look and function of a window. Installing concealed weather stripping on wood windows requires sash removal. Two effective weather stripping approaches include the brush-and-bulb system, and the metal, V-shaped system.

The brush-and-bulb system uses two weather strip profiles below; each has a barbed stem set in a newly cut .078 kerf at

the sash perimeter and meeting rail. A brush profile weather strip works best along the vertical edges of the sash stile, between sliding surfaces. The bulb profile works at compression points such as the meeting rail and sill. A continuously run bulb profile is effective for wood casement, hinged windows or hopper windows.

The metal v-shaped weather stripping is a resilient system installed with fewer tools, and more forgiving tolerances than the brush-and-bulb system. It can work on double-hung or casement windows.

Steel sash units typically have virtually no clearance for conventional weather stripping where operable sashes interface with the steel frame. It is also difficult to mechanically fasten weather stripping to steel. However, it is possible to improve the seal on these windows while maintaining an operable sash. The process involves temporarily applying bond-breaker tape to the window stop surface that would be in contact with the sash when the sash is closed. This is followed with a thin bead of urethane sealant on the edge of an opened sash that would contact the window stop. Closing the sash compresses the uncured sealant against the bond-breaker tape filling gaps between the sash and window stop. Once the sealant cures and the bond-breaker tape is removed, the sealant bead functions as a gasket for the operable sash.



CONDITION ASSESSMENT

For a property owner going about a major window rehab project, a condition assessment helps prioritize work, and establish likely expenses. For contract projects a condition assessment is the basis for the scope of work on which contractors will bid. Appendix A is a matrix form used to determine the extent of repairs for each window and its interior and exterior features. It is helpful to label each window with a number used in field notes, annotated photos or drawings, and window schedules.

A full inspection starts with a visual study of the paint, wood or metal components, glazing, hardware, sash weight system, and storm units. Beyond a superficial look, poking and prodding wood windows with a pocket knife determines how sound the wood is, and looking behind pieces of rotten or loose trim can expose otherwise concealed problems. Some problems such as condensation might only be evident under certain circumstances. Building occupants who work or live around the windows can provide additional information.

The conditions of window features and the assembly can be based on the following criteria for *good*, *fair*, *poor*, or *failed*:

Good: The feature is intact, structurally sound, and performing well; it needs no immediate maintenance or repair.

Fair: The feature is structurally sound and performing well, but shows early signs of wear that could lead to accelerated deterioration. The feature needs maintenance soon.

Poor: The feature shows advanced decay and requires immediate repairs to prevent it from reaching a failed state.

Failed: The feature is mostly non-functional and in need of substantial repair or reconstruction. Or the feature is completely missing and in need of in-kind replacement.

After looking at the various features of the window, an evaluation of the whole window is appropriate. The *good to failed* status of the different features should establish a qualitative averaging of the overall window unit condition.

A condition assessment can be distilled into annotated photos, drawings, and a window schedule. These documents can be the basis of a contractor's bid. It is also important to enable those bidding on work access to the windows prior to bid. A mutual understanding of the scope of work and project specifications results in more accurate bids and a better project. The specifications in the appendices are for reference and may need to be adapted to a particular situation.

CONCLUSION

Throughout most of architectural history, windows (unlike roof shingles, lime mortar, and paint) have been non-sacrificial building components. With maintenance they have always been able to resist the elements. It is only in the last 30 years that windows, particularly vinyl, have been made in a manner that makes them nearly as disposable as an asphalt roof shingle. Repair followed by cyclical maintenance of historic windows bucks the current trend.

The act of repairing and maintaining historic windows is eminently wise for many reasons. It is often environmentally and economically sensible. Because maintaining historic windows perpetuates the original design intent, retaining the historic windows is always the correct aesthetic approach. Intact historic windows differentiate a property from all that is unremarkable in today's built environment. Maintaining historic windows, like all preservation in a culture of disposability, is at once an aesthetic statement and heroically defiant act.

WEB RESOURCES

National Park Service Preservation Briefs <http://www.nps.gov/tps/how-to-preserve/briefs.htm>

The Repair of Historic Wooden Windows <http://www.nps.gov/hps/tps/briefs/brief09.htm>

The Repair and Thermal Upgrading of Historic Steel Windows <http://www.nps.gov/hps/tps/briefs/brief13.htm>

Window repair tutorials <http://www.thisoldhouse.com> <http://www.oldhouseonline.com>

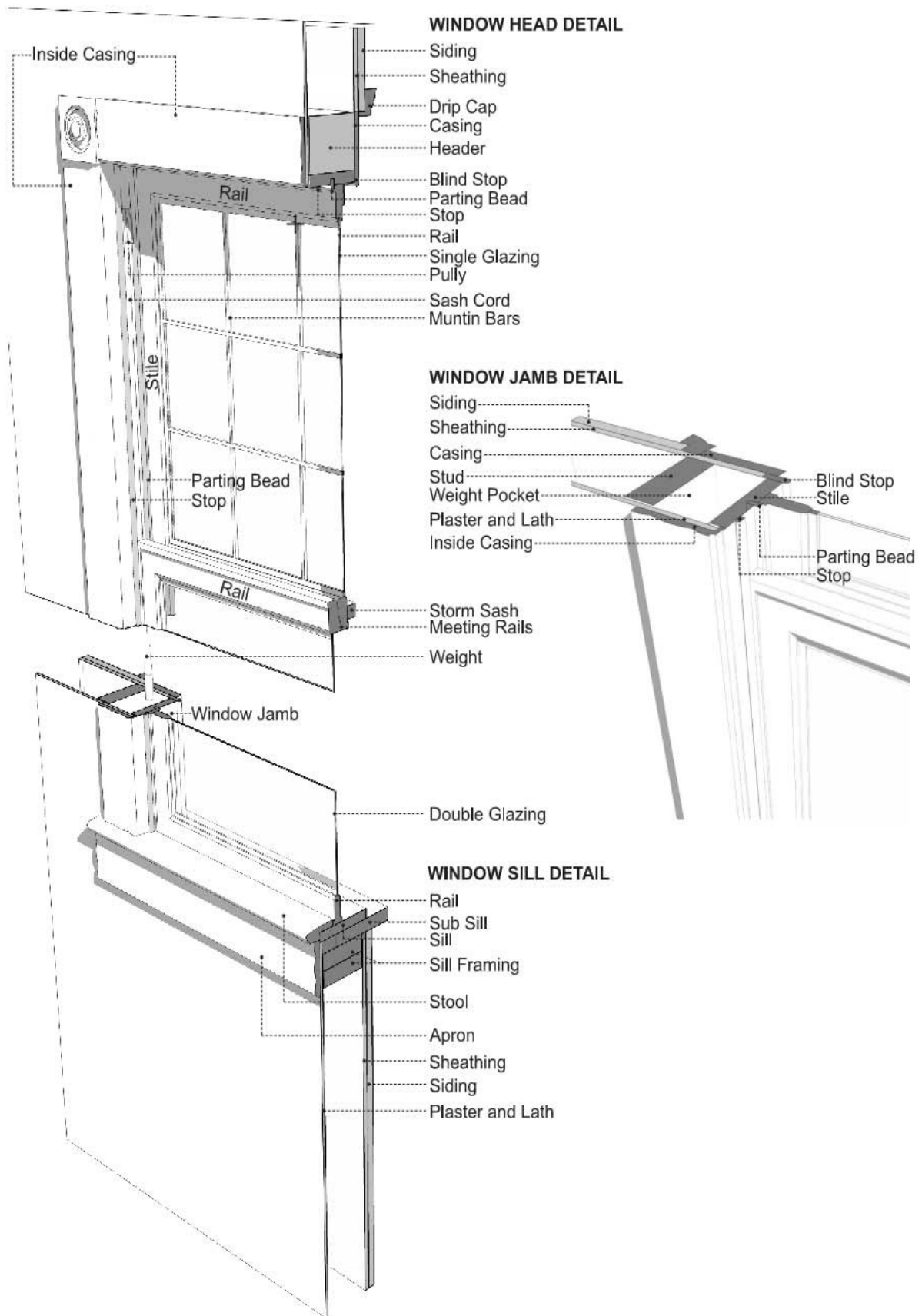
Appropriate Methods of Reducing Lead-Paint Hazards in Housing <http://www.nps.gov/hps/tps/briefs/brief37.htm>

Exterior Paint Problems on Historic Wood Work <http://www.nps.gov/history/hps/tps/briefs/brief10.htm>

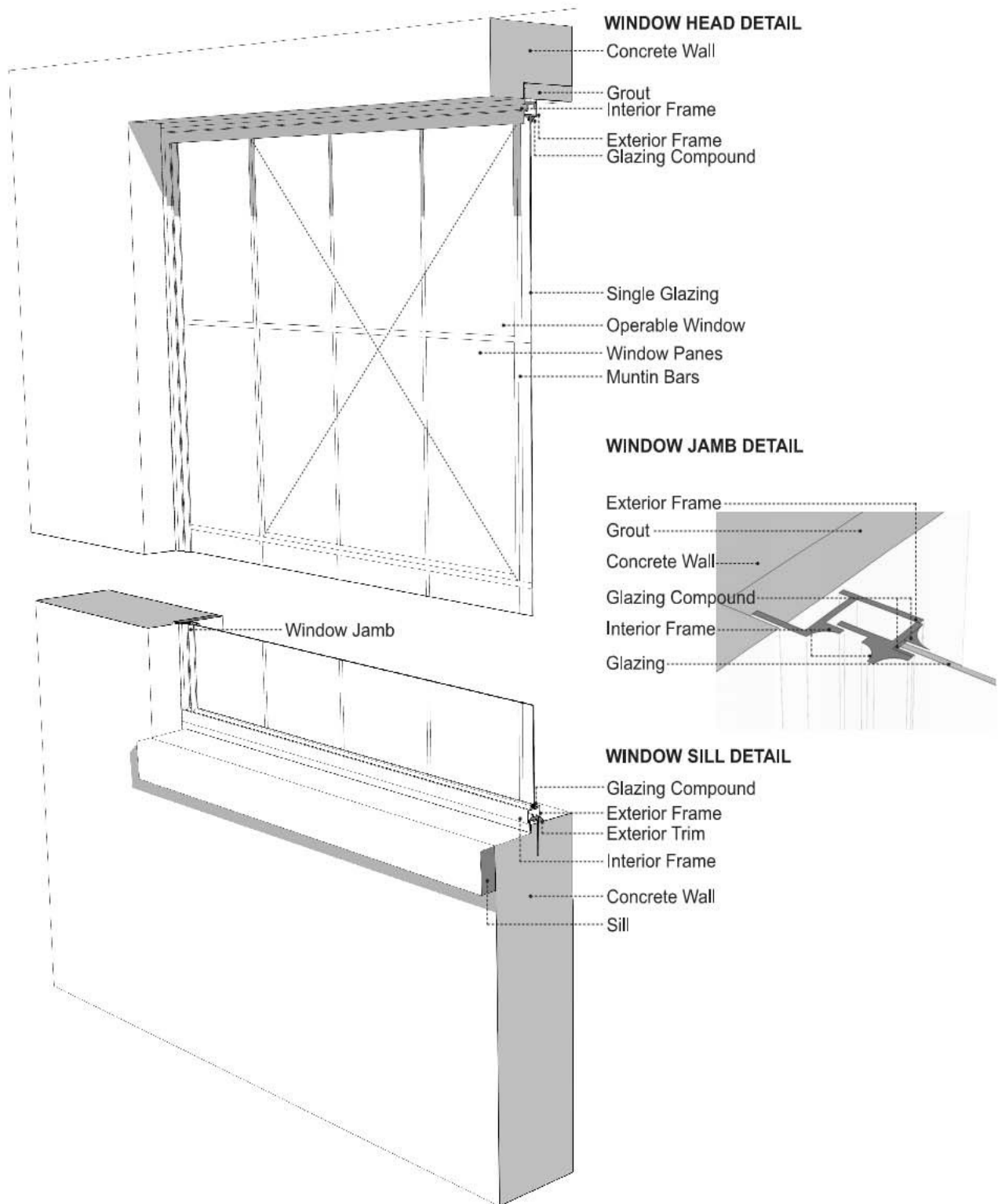
Improving Energy Efficiency in Historic Buildings <http://www.nps.gov/history/hps/tps/briefs/brief03.htm>

Preservation and Repair of Historic Stained and Leaded Glass <http://www.nps.gov/history/hps/tps/briefs/brief33.htm>

WOOD WINDOW DETAILS



STEEL SASH WINDOW DETAILS



GLOSSARY OF WINDOW TERMS

Boxed Frames: Hollow built-up frames to receive the weights for vertically sliding sashes.

Feather: Divider used to separate weights and prevent them from fouling one another.

Frame: The outside surround of the window unit, can be solid, boxed, or cased.

Glazing Pocket: Rabbeted slot in a window rail, stile, or muntin in which glass is seated and secured with putty.

Glaziers Points: Metal diamond or triangle shaped fasteners that hold glass in the glazing pocket against the putty bed and components of a sash frame; glazing points are covered by the putty application.

Head: Horizontal member at top of frame.

Jamb: Vertical side pieces of frame.

Light or pane: A section of glass surrounded by wood, lead or some other metal.

Mullion: Vertical division in a window frame.

Muntin: A small member which divides the glass or openings of a sash.

Parting Bead: A wood component at the jamb and head of double-hung windows that separate upper and lower sash.

Pocket: The hole in the pulley stile of a sash and frame window for placing and maintaining weights in the box.

Putty: Typically made of whiting and linseed oil, and used in sealing glass in sash.

Rail: Horizontal member of the sash frame – top, bottom, meeting.

Sash: A single light frame to a window, containing one or more lights of glass. May be hinged, pivoted, sliding or fixed.

Sill: Horizontal member making up the base of the frame unit, onto which the bottom sash seats.

Stile: The outer vertical members of the sash or window frame.

Stool: A flat molding fitted over the window sill between jambs and contacting the bottom rail of the lower sash.

Stop: Molding sealing the inside and outside of the upper and lower sash from weather penetration.

Sub-sill: Larger scale horizontal member beneath the sill, usually separate from the frame - wood or stone.

WINDOW TYPES

Bottom Hinged/Tilt-In: Hinges are positioned on the sash's bottom rail; these typically tilt to the building's interior.

Casement: Operable sashes pivoting on hinges affixed to the unit's vertical edge.

Double-Hung: Both sashes slid up and down, and are held in position by counter weights or pins.

Fixed: An inoperable unit intended only for light filtration purposes.

Horizontal Sliding, Yorkshire Light: Sash slides horizontally on a rail or in a track.

Jalousie: Window made up of adjustable glass louvers

Pivoted, Hospital, Hopper: Sash swings on a pivot and socket configuration, either vertically or horizontally.

Sash and Frame, Boxed: Windows with vertically sliding sashes and boxed frame that are counterbalanced.

Sliding/Fixed: Solid frame with the upper sash in a fixed position. No parting bead.

Top Hinged/Awning: Hinges are positioned on the sash's top rail; these typically tilt to the building's exterior.

TOOL SUPPLIERS

Carpentry, Cabinetmaking Hand, and Power Tools

Garrett Wade Co., Inc. 161 Avenue of the Americas New York, NY 10013 Telephone: (800) 221-2942;
(212) 807-1155
www.garrettwade.com

Woodcraft 210 Wood County Industrial Park
P.O. Box 1686 Parkersburg, WV 26102-1686 (800) 225-1153
www.woodcraft.com

Lee Valley Tools Ltd.
P.O. Box 6295, Station J Ottawa, Ontario, K2A 1T4 (613) 596-0350
www.leevalley.com

McMaster-Carr Supply Company
P.O. Box 440 New Brunswick, NJ 08903-0440 (201) 329-3200; (201) 329-6666
www.mcmaster.com

Glaziers Tools

Red Devil, Inc. 2400 Vauxhall Road Union, NJ 07083-1933 (800) 4 A Devil
www.reddevil.com

Embee Corporation 552 West State Street
P.O. Box 788 Springfield, OH 45501 (513) 323-3795
www.embee.com

Fletcher-Terry Company 65 Spring Lane Farmington, CN 06032-3139 (800) 843-3826
www.fletcherviscom.com

Hyde Tools 54 Eastford Road Southbridge, MA 01550 (508) 764-4344
www.hydetools.com

PRODUCT SUPPLIERS

Abatron, Inc. Wood Putty and Consolidant 5501 95th Ave. Kenosha, WI 53144 (262) 653-2000
www.abatron.com

Architectural Resource Center (weather stripping)
PO Box 217 557 Old Turnpike Road Northwood, NH 03261 (800) 370-8808
www.aresource.com

A&A Millwork Wood Storm Windows 3320 E. 41st Street Minneapolis, MN 55406
http://www.aamillwork.com/w_scr_win.htm

Allied Exterior Storm Windows 11111 Canal Road Cincinnati, OH 45241 (800) 445-5411
info@alliedwindow.com

Marvin Storm Windows John Bartram PO Box 1776 Billings, MT 59103 (406) 896-1756
jwbj45@msn.com

TRADES PEOPLE

Contact the SHPO for current contractors: 1410 8th Avenue Helena, MT 59620 (406) 444-7715
www.mhs.mt.gov.shpo

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APPENDIX A

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 Maintenance Cycle (1-3)	Initial Cost of Rehabilitation (1-3)	Cyclical Maintenance Cost (1-3)	Total Score
Option 1 Repair Existing Sash and Add Glazing Film/ Weatherstripping											
Option 2 Repair Sash and Add Storm											
Option 3 Repair Existing											
Option 4 Repair Existing Sash and Replace existing Glazing											
Option 5 New Wood Frame and Sash											
Option 6 Combination 1 & 5: Repair Reusable Windows and Replace All Others with Replica Sash											

* See key on next page

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*; Has a similar overall appearance, but has been modified to accommodate insulated glass and conform to *The Secretary of Interior's Standards*;
- 2 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 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 Maintenance Cycle: The anticipated life before requiring rehabilitation with cyclical maintenance.

- 1 Estimated lifespan of 50+ years;
- 2 Estimated lifespan of 25 years;
- 3 Estimated lifespan of less than 25 years.

Initial Cost of Rehabilitation: (insert project specific cost range - high, medium, low)

- 1 Below \$_____;
- 2 Between \$_____ and \$_____;
- 3 Over \$_____.

Cyclical Maintenance Costs: (insert project specific cyclical maintenance 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.

APPENDIX B*

SECTION 086100 - WOOD WINDOW RESTORATION

PART 1 – GENERAL

1.1 SUMMARY

- A. The Work of this Section outlines the restoration of the existing wood windows, including screen and exterior trim replacement Work to match in-kind to existing historic details.
- B. Wood windows have historically been coated with lead based paint (LBP). The testing, removal and proper disposal of such paint shall be the responsibility of a certified Lead Paint Contractor. Work involving the disruption of interior and exterior finishes shall take necessary precautions following a lead abatement spec and complying with EPA ruling 40 CFR Part 745, 'lead; renovation, repair, and painting program; lead hazard information pamphlet; notice for availability; final rule' implemented April 22, 2010.
- C. All damaged glazing on all elevations shall be replaced with new glass to match in-kind historic conditions.

1.2 SUBMITTALS

- A. Submit the following items for owner's written approval:

- 1. Samples:

- a. Four (4) 12" x 12" square samples of each type of glass and glazing materials;
- b. Replacement materials for weatherstripping replacement;
- c. Testing results as requested.
- d. Replacement hardware and accessories

- 2. Glazing compound:

- a. Manufacturer's product literature;
- b. Compatibility certificate.

- 3. Caulking:

- a. Manufacturer's product literature;
- b. Color samples for Owner's color selection.

- 4. Paint Samples:

- a. Manufacturer's product literature for both primer and finish paint;
- b. Four (4) 6" X 6" square color samples of each finish paint. Color to match existing colors.

- 5. Chemical Cleaner:

- a. Manufacturer's product literature;
- b. Testing result from field test:

- 1. Conduct testing in accordance with manufacturer's recommendations.

- 6. Weather Stripping:

- a. Manufacturer's product literature;
- b. Weather stripping samples to verify compatibility with existing window operation and detail.

- 7. Shop Drawings:

*This specification may need to be amended to suit unique circumstances.

- a. At a minimum, provide drawings including elevations, sections, and details necessary to describe all damage to existing windows and frames and to describe methods of repair.
- b. Plans and details of abatement protection.

8. Restoration Plan:

- a. Develop a plan of restoration encompassing all stages of work.
- b. Include at a minimum:
 - 1. Written description of all damage and methods and techniques of repair.
 - 2. Environmental factors affecting the work, and techniques and methods proposed to ensure construction within appropriate environmental conditions.
 - 3. Methods of protection for surrounding construction and exterior vegetated areas and soils.

9. Mockup:

- a. Completed restoration of one (1) window to demonstrate aesthetic effects and set quality standards for material and execution. Review completed mock-up for approval by Owner. Correct all conditions noted during review process. Re-check until approved, at no additional cost to Owner.
- b. Do not begin remaining restoration work until mock-up is approved.

1.3 QUALITY ASSURANCE

- A. The Work of this Section shall be conducted by a firm with not less than three (3) years of successful experience in wood window restoration work similar to the historic restoration work indicated.

1.4 DEFINITION

- A. In-Kind: Replacement material to match original material in detail and design in every way.

1.5 PROJECT CONDITIONS

- A. Install all finish work plumb, level, true, and straight, with no distortions. Anchor finish work securely to supports and substrates, using concealed fasteners and blind nailing where possible. There are conditions that will not be made level or true due to settlement in the historic building.

- 1. Work of this Section shall be performed on a window-to-window basis.
 - 2. Use fine finishing nails for exposed nailing, except as indicated, countersunk and filled flush with finish surface.

- B. Salvage all undamaged glass.

- C. Remove and replace rotten, damaged and/or deteriorating wood.

- D. Chemically remove lead base paint finishes. Apply primer and final finish only after testing chemically treated wood surfaces for alkalinity and moisture content compatible to paint manufacturer's written limitation(s). Submit a written copy of the test results to Owner's Representative.

1.6 PRE-INSTALLATION CONFERENCE

- A. Conduct a Pre-Installation Conference at the Project site.

PART 2 – PRODUCTS

2.1 WOODS

A. The following may be used for screens and exterior trim – Contractor's option:

1. Soft maple
2. Alder

2.2 GLASS

- A. Provide replacement glass to broken or damaged glazing. Match with existing glass to be replaced.
- B. Reference the Drawings for windows to receive new glazing. At a minimum, replace all damaged and/or broken glass with new to match existing.

2.3 GLAZING COMPOUND

A. "Pure" Linseed Oil Putty, manufactured by Dap.

2.4 SCREENS

- A. Charcoal colored aluminum in custom wood frame to match in-kind to existing.
- B. Use mortise and tenon for end-to-end joints to screen frames. Match existing conditions.

2.5 FASTENERS AND ANCHORAGES

- A. Provide nail, screws and other anchoring devices of type, size, material, and finish suitable for intended use and required to provide secure attachment, concealed where possible. Hot-dip galvanize fasteners for work exposed to exterior and high humidities to comply with ASTM A 153.

2.6 STANDING AND RUNNING TRIM

- A. Install with minimum number of joints possible, using full-length pieces from maximum length of lumber available. Cope at returns, miter at corners to produce tight fitting joints.

2.7 MISCELLANEOUS MATERIALS

- A. Glass cleaners, primers, sealers, filling compounds, hardware, glazing points and weather stripping.
1. Provide all additional materials as necessary for work. Field coordinate extent of work with all conditions indicated.

PART 3 – EXECUTION

3.1 REMOVAL

A. Removal of Window Sash:

1. Remove Stop.

- a. Salvage to re-use.
- b. Strip paint using chemical stripper.
- c. Sand and repair.
- d. Test alkalinity and moisture content of chemical treated wood.
- e. Prime (oil base primer, brush on).
- f. Paint (oil base, two coats, brush on).

B. Remove sashes from jamb. Contractor shall be aware that existing cords and pulleys shall be reused. Do not allow weight to be lost in wall.

C. Remove all hardware.

1. Salvage to re-use.
2. Clean to remove paint drips, spills and dirt.
3. Replace damaged or missing hardware with new hardware to match in-kind to existing.
 - a. Field verify extent of hardware replacement at each window location indicated.

3.2 TYPICAL DOUBLE-HUNG WINDOW RESTORATION

A. Double-Hung Window Restoration:

1. Remove glazing from windows.
2. Save historic glass.
3. Strip paint using chemical stripper or heat gun.
4. Sand and repair sashes.
 - a. Fill gouges with epoxy.
 - b. Replace missing and broken pieces with wood "Dutchman" patches.
 - c. Stabilize weather checked frames.
 - d. Sand.
5. Test alkalinity and moisture content of chemical treated wood.

B. Prime sashes:

1. Oil-based paint, brush on.

C. Replace lites:

1. Replace broken glazing with new to match

E. Glaze lites:

1. Apply putty bed in glazing pocket
2. Lay glazing unit into glazing pocket in continuous putty bed
3. Insert 1 glazing point each 6 inches.
4. Apply putty over glazing points and edge of glazing continuously filling glazing pocket with a uniform bevel.

F. Paint sashes:

1. Two (2) coats oil-based paint, brush on.
 - a. Paint shall cover glazing compound to seal.

D. Replace lites:

1. Replace broken glass.

E. Glaze lites:

1. Two (2) glazing points per side on the large glass.
2. One (1) glazing point per side on the small glass.

F. Paint sashes:

1. Two (2) coats oil-based paint, brush on.
2. Paint shall cover glazing compound to seal.

3.3 ALL WINDOWS

A. Re-install existing and/or new hardware.

B. Re-install sashes.

1. Replace parting stop as necessary.

C. Re-install stop:

1. Fasten with set finish nails
2. Putty nail holes in stop.
3. Touch-up paint on stop.
4. Apply finish coat of paint.

D. Clean glass.

3.4 SCREENS

A. Construct new screen frames to match in-kind with existing screen frame.

1. Mortise and tenon joints
2. Routed inside edge.
3. Beaded screen molding.
4. Paint all wood with one (1) coat oil-base primer and two (2) coats finish paint.

B. Install new screen wire and screen molding.

1. Touch up paint wood finish.

C. Install screen hardware.

1. Salvage screen hardware removed from existing window screen, clean and install to new screen.
2. Install two (2) screen door hooks at bottom of large screens.
3. Install one (1) screen door hook at bottom of small screens.

3.5 EXTERIOR WINDOW MOLDING

A. Reproduce in-kind molding.

B. Remove existing top molding.

C. Remove old drip cap.

D. Replace rotted sill.

E. Repair damaged siding.

- F. Install new molding.
- G. Sand and prepare existing molding to remain.
- H. Stabilize exterior sill with epoxy.
- I. Paint:
 - 1. Prime all new wood with oil-base paint.
 - 2. Finish all wood with two (2) coats oil-base paint.
- J. Re-hang window screens.

3.6 INTERIOR PROTECTION

- A. The Contractor shall use care to protect and maintain interior surfaces and finishes. Provide necessary touch-up of interior finishes as required by the Owner's Representative.

3.7 CURE, PROTECTION AND CLEANING

- A. Cure glazing sealants and compounds in compliance with manufacturer's written instructions and recommendations, to obtain high early bond strength, internal cohesive strength and surface durability.
- B. Protect glass from chemical cleaning.
- C. Protect glass from breakage immediately upon installation by use of crossed streamers attached to framing and held away from glass. Do not apply markers to surfaces of glass.
- D. Remove and replace glass which is broken, chipped, cracked, abraded or damaged in other ways during construction period, including natural causes, accidents and vandalism.
- E. Maintain glass in a reasonably clean condition during construction so that it will not be damaged by corrosive action and will not contribute (by wash-off) to deterioration of glazing materials and other Work.
- F. Wash and polish glass on both faces, interior and exterior, not more than four (4) days prior to the date of Substantial Completion. Comply with glass manufacturer's recommendations for final cleaning.
- G. Touch-up paint and/or stain finish surfaces as required.
- H. Clean, dust, and leave adjacent Work area of the window in a clean and neat manner.

END OF SECTION 086100

APPENDIX C

SECTION 086210 - STEEL SASH WINDOW RESTORATION*

PART 1 – GENERAL

1.1 SUMMARY

- A. Work included under this section is the complete restoration of the existing steel windows and frames on the building. It includes removal and replacement of existing window glazing. All Work will match existing historic details.
- B. Steel windows have historically been coated with lead base paint (LBP). The testing, removal and proper disposal of such paint shall be the responsibility of a certified Lead Paint Contractor.
- C. All damaged or non-historic type glazing on all elevations shall be replaced with new glass to match historic conditions.

1.2 SUBMITTALS

- A. Submit the following samples for Owner's written approval:

- 1. Four (4) 12" x 12" square samples of each type of glass and glazing materials;
- 2. Replacement materials for weatherstripping replacement;
- 3. Testing results as requested.
- 4. Replacement hardware and accessories
- 5. Glazing compound:
 - a. Manufacturer's product literature;
 - b. Compatibility certificate.
- 6. Caulking:
 - a. Manufacturer's product literature;
 - b. Color samples for Owner's color selection.
- 7. Paint Samples:
 - a. Manufacturer's product literature for both primer and finish paint;
 - b. Four (4) 6" X 6" square color samples of each finish paint. Color to match existing colors.
- 8. Chemical Cleaner:
 - a. Manufacturer's product literature;
 - b. Testing result from field test;
 - c. Conduct testing in accordance with manufacturer's recommendations.
- 6. Weather Stripping:
 - a. Manufacturer's product literature;
 - b. Weather stripping samples to verify compatibility with existing window operation and detail.
- 7. Shop Drawings:
 - a. Provide elevation, section, and detail drawings describing damage to windows and to describe repair methods.
 - b. Plans and details of abatement protection.
- 8. Restoration Plan:
 - a. Develop a plan of restoration encompassing all stages of work.
 - b. Include at a minimum:

*This specification may need to be amended to suit unique circumstances.

1. Written description of all damage and methods and techniques of repair.
2. Environmental factors affecting work, and methods proposed to ensure construction within appropriate environmental conditions.
3. Proposed phasing and timing of the work including coordination with progress of adjacent restoration work.
4. Methods of protection for surrounding construction and exterior vegetated areas and soils.

9. Mockup:

- a. Completed restoration of one (1) window to demonstrate aesthetic effects and set quality standards for material and execution. Review completed mock-up for approval by Owner. Correct all conditions noted during review process. Re-check until approved, at no additional cost to Owner.
- b. Do not begin remaining restoration work until mock-up is approved.

1.3 QUALITY ASSURANCE

- A. The work of this section shall be conducted by a firm with not less than three (3) years of successful experience in window restoration work similar to the historic restoration work indicated.

1.4 DEFINITION

- A. In-Kind: Replacement material to match original in detail and design in every way; new material to match adjacent existing materials.

1.5 JOB CONDITIONS

- A. Do not proceed with any portion of the Work outlined until unsatisfactory conditions have been corrected in a manner acceptable to the applicator.
- B. Notify Owner about anticipated problems and request direction.

PART 2 PRODUCTS

2.1 GLASS

- A. Salvage existing historic glass and return to Owner. Provide new glass to existing steel window frames to match in-kind.
- B. Provide new, restoration glass for broken or missing panes.
 - 1. For historic glass: match in-kind existing. Based on approval of samples matching existing historic glass condition, provide Hollander Glass "Restover" 3.5 mm machine drawn restoration glass or approved equal.

2.2 HARDWARE AND ACCESSORIES

- A. Identify missing or damaged hardware, including but not limited to, latches, hinges, hold opens, trims and accessory profiles. Salvage all hardware and accessories for repair, cleaning, and reinstallation at original location.
- B. Contractor shall repair all hardware in no-working condition. If hardware cannot be made to operate as original or hardware is missing, contractor shall provide replica hardware to match existing in-kind in every regard. For any hardware replicated provide attic stock (4 pieces of each).

2.3 CHEMICAL CLEANERS

- A. Dumont Chemicals, Inc., Peel Away 1 for removal of lead base paint.

2.4 GLAZING COMPOUND

- A. Use AllPro Corporation Glazing Compound for metal window frames, or an approved equal.
- B. DAP 1012 Glazing Compound or approved Equal.

2.5 WEATHERSTRIPPING

- A. Three (3) types of weather stripping shall be tested for use in this project:
 - 1. Bronze spring metal with integral friction fit mounting.
 - 2. Vinyl strip "V" shape with adhesive attachment.
 - 3. Sealant bead set with bond breaker tape to the operable sash.
- B. Apply weather stripping following final paint operation.
- C. Coordinate final selection and installation of weatherstripping using a test window in the field.

2.6 MISCELLANEOUS MATERIALS

- A. Primers, Sealers and Filling Compound and caulking. Provide materials needed to complete the Work specified.
 - 1. Paint products, both primer and paint finish, shall be by Sherwin Williams.

PART 3 - EXECUTION

3.1 RESTORATION SEQUENCE

A. Determination was made that recognizes that the existing windows are in sound condition. The restoration work of this project includes, but is not limited to, the following:

1. Remove existing glazing and glazing putty. Salvage for reinstallation or delivery to Owner.
2. Removal of surface rust, flaking and existing paint finish (interior and exterior).
3. Prepare existing steel window frames for new paint finish.
4. Prime and paint existing steel window frames with a rust-inhibiting primer.
5. Remove and replace damaged and deteriorating screws and fasteners; replace missing screws and fasteners.
6. Install new and existing glazing to window frames.
7. Install new glazing putty.
8. Finish paint steel window frames.
9. Clean and lubricate existing hinges and operating (movable) parts.
10. Caulk window to masonry surround with elastomeric caulk.
11. Clean glazing (interior and exterior).

3.2 INTERIOR FRAME AND TRIM

A. The Work of this Contract entails complete restoration of the existing steel window including the interior window frame, jamb, and sash finishes, unless noted otherwise.

B. The Contractor shall use care to protect and maintain interior surfaces and Owner due to the Work of this Contract.

3.3 PREPARATION

A. Remove all existing historic glass from steel window frame. Salvage undamaged glazing for reinstallation to Owner.

1. Mark glass and map to drawings in an approved method to be reused to ensure reinstallation in original location.

B. Remove existing window putty in its entirety.

C. Remove caulking from window frame and surrounding frame in its entirety.

3.4 STEEL FRAME PREPARATION

A. Remove existing paint finish to expose bare steel frame typically. Use a chemical paint remover as specified.

1. Protect adjacent historic surfaces from chemical cleaning operations, typically.
2. Chemical cleaners shall be used to remove rust and paint. Hydrochloric acid is not allowed.
3. Chemical cleaning shall be completed in strict accord with manufacturer's recommendations for the field conditions.

B. Rinse treated surfaces with running water to remove chemical residue.

C. Immediately dry treated surfaces with clean cotton disposable rags.

D. Wipe bare metal using cleaning solvent as recommended by the chemical cleaner.

E. Dry surfaces immediately.

F. Remove rust and staining with a wire brush and/or electric wire brush. Sand surfaces smooth with aluminum, oxide sandpaper. Hand sand edges as required.

G. Following cleaning: Patch small holes and uneven areas with a steel based epoxy recommended for metal repair and patching.

H. Sand edges smooth and even to adjacent frame surfaces.

I. Test surface to ensure requirements of primer and painting applications are in accordance with manufacturer's

requirements.

J. Prime exposed steel immediately following drying operations with anti-corrosive primer.

1. Anti-corrosive primer shall be oil-alkyd based containing zinc.
2. Apply in accordance with manufacturer's written instructions.
3. Handle primer as directed by manufacturer's written instructions.

K. Following primer drying and curing, provide one coat of finish paint.

1. Paint and primer shall be obtained from the same manufacturer.

L. Install new glazing to steel window frames.

1. Set using a glazing compound formulated for installation with metal windows.

M. Caulk window frames to adjacent wall finish surfaces. Use elastomeric compound compatible with field conditions:

1. Insure caulking is compatible with field conditions.
2. Use paintable caulk or colored caulk as selected by the Owner.
3. Caulking compound shall be UV resistive with a durability of ten (10) years in application conditions encountered.
4. Insure adjacent materials and finishes are in sound, durable condition.
5. Use a neoprene gasket for caulking backer as required due to field conditions.

N. Follow caulking with final paint finish:

1. Install no less than two (2) coats of final finish following installation of new glazing.
2. Install paint to overlap glass slightly to insure weather tight condition.

3.5 CURE, PROTECTION AND CLEANING

A. Cure glazing sealants and compounds in compliance with manufacturer's instructions and recommendations, to obtain high early bond strength, internal cohesive strength and surface durability.

B. Protect adjacent surfaces, both exterior and interior from the Work of this Contract.

C. Protect glass from breakage immediately upon installation by use of crossed streamers attached to framing and held away from glass. Do not apply markers to surfaces of glass.

D. Remove and replace glass which is broken, chipped, cracked, abraded or damaged in other ways during construction period, including natural causes, accidents and vandalism.

E. Maintain glass in a reasonably clean condition during construction so that it will not be damaged by corrosive action and will not contribute (by wash-off) to deterioration of glazing materials and other work.

F. Wash and polish glass on both faces, interior and exterior, not more than four (4) days prior to the date scheduled for inspection intended to establish date of substantial completion of the project. Comply with glass manufacturer's recommendations for final cleaning.

G. Touch-up paint finish surfaces as required, both exterior and interior.

H. Clean, dust, and leave adjacent work area of the window in a clean and neat manner.

END OF SECTION 086210