WHY SHOULDN'T I REPLACE MY WINDOWS?

People constantly say they need new windows because they fear lead paint, want better soundproofing, energy efficiency and easy cleaning. Then the answer is to restore original windows, not replace them.

Restoration costs less and the windows will be lead free, soundproof, energy efficient and easily cleaned. I've trained many small contractors and homeowners how to perform this task efficiently and cost effectively. For those who insist they want tilt-ins for easier cleaning, this system gives them an easy cleaning solution as well.

All of this and a new combination wood storm/screen or interior storm cost less than a wood tilt-in with vinyl jamb liners and no storm. This system keeps the sash weights, cuts nothing off the window sash and removes all old paint and glazing. My friend John Seekircher always says, "The reason they call them replacement windows is that you have to replace them over and over again,"

EPA & HUD lead paint regulations are out of control. The facts however fly in the face of this anti-preservation intrusion into our lives. Lead poisoning in children has been depicted by HUD and the EPA as an epidemic. The facts do not support this notion. Children today have less lead poisoning than ever before in history and it has little to do with lead paint regulations. Taking lead out of gasoline and better factory emissions are responsible for much of this.

In essence we should be teaching the uneducated, educated, poor and well-off families to clean their houses. Common sense education is all that's needed with lead paint. Lead paint is only a hazard if it's unstable. Removing lead paint from window jambs and sashes is a safe, quick and easy process if the homeowner or contractor knows how to do it. We must start immediately training small contractors & homeowners how to do this. Right now the contractors that are getting lead certified are gouging homeowner's pocketbooks because they can.

The reason homeowner's think they need to replace their windows is that the window industry spends tens of millions of dollars a year to convince them to buy their inferior products. It will take a consumer about 40+ years to get any payback from replacement windows with insulated glass and considering the following statements in the window industries trade periodical, Glass Magazine, the industry makes the case for restoration.

July 2001 Glass Magazine, By Editor, Charles Cumpstom, "The consumer's perception of glass is significantly different from the industry's. While some in the industry think a 15-year life is adequate, it is the rare homeowner who envisions replacing all his windows in 15 years."

Another article in 1995 in Glass Magazine by Ted Hart states, "Remember our industry, with rare exception, has chosen to hide the fact that insulating glass does have a life expectancy. It is a crime that with full knowledge and total capability to build a superior unit, most of the industry chooses to manufacture an inferior single-seal unit." **NOTE:** Single seal units are still the norm with an average seal life of 2 to 6 years.

Bob Yapp - Preservation Resources, Inc
COPYRIGHT 2007- PRESERVATION RESOURCES, INC

RESTORE WEATHERIZE & MAINTAIN WINDOWS

*****

DON'T REPLACE THEM

- New wood windows are made with new growth lumber that is not as strong or rot resistant as the old growth lumber in windows made before the 1950s.
- Insulated glass seals tend to fail in 2 to 6 years allowing condensation between the panes.
- Most insulated glass panels cannot be replaced once they fail. The entire window must be replaced.
- Primary window sashes were never intended to take a direct hit from the weather. In early years they had shutters then storms to protect them.
- Air infiltration is the biggest energy issue with windows. Vinyl windows, by their nature, have weep holes in their bottom rail to let the moisture seep out which allows massive air infiltration.
- PVC or vinyl is the most toxic consumer substance manufactured today. It can't be recycled, off gasses toxic fumes and has excessive contraction and expansion issues. It fades, cracks and has a maximum lifespan of 16 to 18 years.
- Metal clad windows are designed to allow water to seep behind the cladding. This causes early rot of the often finger jointed, new growth lumber underneath.
- The vinyl jamb liners that are needed for tilt-in windows have cheap spring balances and cheesy foam backing that have a lifespan of about 6 to 10 years.
- Double hung windows were invented in the 1400s as an air conditioning system. Lower the top sash and raise the lower sash. This lets the hot air and humidity out the top and brings the breezes in through the bottom. Most replacement units don't have a full screen to allow for this process.
- Aluminum, self-storing storm windows are not even a good windbreak. Metal conducts heat and cold while wood insulated against heat and cold.
- Sash weight pockets are only a problem if a house has not been caulked and painted properly.
- Quarter inch thick, laminated glass has better UV protection than all the low-e coatings. It also approaches the same thermal capabilities as insulated glass, is more soundproof, is safer and cost less than insulated glass. If retrofitting glass into an old sash is something you feel must be done, install laminated glass.
- Original window sash is a part of the footprint of your old house or building. Replacements often have different dimensions and sometimes the window contractor wants to reduce the size of your openings. This has a negative effect on the overall texture and look of the original footprint of your building.
- If you don't want to lift a finger to maintain or rehab your home then hire a contractor to restore your windows. Your restored windows will cost less, have a better payback, be easily cleaned, have a nice track system, and stop air infiltration, which means greater energy efficiency.
- Restored wood windows have another 100-year economic life before total restoration is needed again. Replacement windows can never be restored effectively.

Bob Yapp – Preservation Resources, Inc.
COPYRIGHT 2007- PRESERVATION RESOURCES, INC

The Repair of Historic Wooden Windows

John H. Myers

A NOTE TO OUR USERS: The web versions of the **Preservation Briefs** differ somewhat from the printed versions. Many illustrations are new, captions are simplified, illustrations are typically in color rather than black and white, and some complex charts have been omitted.

The windows on many historic buildings are an important aspect of the architectural character of those buildings. Their design, craftsmanship, or other qualities may make them worthy of preservation. This is self-evident for ornamental windows, but it can be equally true for warehouses or factories where the windows may be the most dominant visual element of an otherwise plain building. Evaluating the significance of these windows and planning for their repair or replacement can be a complex process involving both objective and subjective considerations. *The Secretary of the Interior's Standards for Rehabilitation* and the accompanying guidelines, call for respecting the significance of original materials and features, repairing and retaining them wherever possible, and when necessary, replacing them in kind. This Brief is based on the issues of significance and repair which are implicit in the standards, but the primary emphasis is on the technical issues of planning for the repair of windows including evaluation of their physical condition, techniques of repair, and design considerations when replacement is necessary.

Much of the technical section presents repair techniques as an instructional guide for the do-it-yourselfer. The information will be useful, however, for the architect, contractor, or developer on large-scale projects. It presents a methodology for approaching the evaluation and repair of existing windows, and considerations for replacement, from which the professional can develop alternatives and specify appropriate materials and procedures.

Architectural or Historical Significance

Evaluating the architectural or historical significance of windows is the first step in planning for window treatments, and a general understanding of the function and history of windows is vital to making a proper evaluation. As a part of this evaluation, one must consider four basic window functions: admitting light to the interior spaces, providing fresh air and ventilation to the interior, providing a visual link to the outside world, and enhancing the appearance of a building. No single factor can be disregarded when planning window treatments; for example, attempting to conserve energy by closing up or reducing the size of window openings may result in the use of *more* energy by increasing electric lighting loads and decreasing passive solar heat gains.

Windows are frequently important visual focal points, especially on simple facades such as this mill building. Replacement of the multi-pane windows with larger panes could dramatically alter the appearance of the building. Photo: NPS files.

Historically, the first windows in early American houses were casement windows; that is, they were hinged at the side and opened outward. In the beginning of the eighteenth century single- and double-hung windows were introduced. Subsequently many styles of these vertical sliding sash windows have come to be associated with specific building periods or architectural styles, and this is an important consideration in determining the significance of windows, especially on a local or regional basis. Site-specific, regionally oriented architectural comparisons should be made to determine the significance of windows in question. Although such comparisons may focus on specific window types and their details, the ultimate determination of significance should be made within the context of the whole building, wherein the windows are one architectural element.

After all of the factors have been evaluated, **windows should be considered significant to a building if they: 1)** are original, **2)** reflect the original design intent for the building, **3)** reflect period or regional styles or building practices, **4)** reflect changes to the building resulting from major periods or events, or **5)** are examples of exceptional craftsmanship or design. Once this evaluation of significance has been completed, it is possible to proceed with planning appropriate treatments, beginning with an investigation of the physical condition of the windows.

Physical Evaluation

The key to successful planning for window treatments is a careful evaluation of existing physical conditions on a unit-by-unit basis. A graphic or photographic system may be devised to record existing conditions and illustrate the scope of any necessary repairs. Another effective tool is a window schedule which lists all of the parts of each window unit. Spaces by each part allow notes on existing conditions and repair instructions. When such a schedule is completed, it indicates the precise tasks to be performed in the repair of each unit and becomes a part of the specifications. In any evaluation, one should note at a minimum:

- **1)** window location
- **2)** condition of the paint
- **3)** condition of the frame and sill
- **4)** condition of the sash (rails, stiles and muntins)
- **5)** glazing problems
- **6)** hardware, and
- **7)** the overall condition of the window (excellent, fair, poor, and so forth)

Many factors such as poor design, moisture, vandalism, insect attack, and lack of maintenance can contribute to window deterioration, but moisture is the primary contributing factor in wooden window decay. All window units should be inspected to see if water is entering around the edges of the frame and, if so, the joints or seams should be caulked to eliminate this danger. The glazing putty should be checked for cracked, loose, or missing sections which allow water to saturate the wood, especially at the joints. The back putty on the interior side of the pane should also be inspected, because it creates a seal which prevents condensation from running down into the joinery. The sill should be examined to insure that it slopes downward away from the building and allows water to drain off. In addition, it may be advisable to cut a dripline along the underside of the sill. This almost invisible treatment will insure proper water runoff, particularly if the bottom of the sill is flat. Any conditions, including poor original design, which permit water to come in contact with the wood or to puddle on the sill must be corrected as they contribute to deterioration of the window.

One clue to the location of areas of excessive moisture is the condition of the paint; therefore, each window should be examined for areas of paint failure. Since excessive moisture is detrimental to the paint bond, areas of paint blistering, cracking, flaking, and peeling usually identify points of water penetration, moisture saturation, and potential deterioration. Failure of the paint should not, however, be mistakenly interpreted as a sign that the wood is in poor condition and hence, irreparable. Wood is frequently in sound physical condition beneath unsightly paint. After noting areas of paint failure, the next step is to inspect the condition of the wood, particularly at the points identified during the paint examination.

Deterioration of poorly maintained windows usually begins on horizontal surfaces and at joints, where water can collect and saturate the wood. Photo: NPS files.

Each window should be examined for operational soundness beginning with the lower portions of the frame and sash. Exterior rainwater and interior condensation can flow downward along the window, entering and collecting at points where the flow is blocked. The sill, joints between the sill and jamb, corners of the bottom rails and muntin joints are typical points where water collects and deterioration begins. The operation of the window (continuous opening and closing over the years and seasonal temperature changes) weakens the joints, causing movement and slight separation. This process makes the joints more vulnerable to water which is readily absorbed into the endgrain of the wood. If severe deterioration exists in these areas, it will usually be apparent on visual inspection, but other less severely deteriorated areas of the wood may be tested by two traditional methods using a small ice pick.

An ice pick or an awl may be used to test wood for soundness. The technique is simply to jab the pick into a wetted wood surface at an angle and pry up a small section of the wood. Sound wood will separate in long fibrous splinters, but decayed wood will lift up in short irregular pieces due to the breakdown of fiber strength.

Another method of testing for soundness consists of pushing a sharp object into the wood, perpendicular to the surface. If deterioration has begun from the hidden side of a member and the core is badly decayed, the visible surface may appear to be sound wood. Pressure on the probe can force it through an apparently sound skin to penetrate deeply into decayed wood. This technique is especially useful for checking sills where visual access to the underside is restricted.

Following the inspection and analysis of the results, the scope of the necessary repairs will be evident and a plan for the rehabilitation can be formulated. Generally the actions necessary to return a window to "like new" condition will fall into three broad categories: ***1) routine maintenance procedures***, ***2) structural stabilization***, and ***3) parts replacement***. These categories will be discussed in the following sections and will be referred to respectively as **Repair Class I**, **Repair Class II**, and **Repair Class III.** Each successive repair class represents an increasing level of difficulty, expense, and work time. Note that most of the points mentioned in Repair Class I are routine maintenance items and should be provided in a regular maintenance program for any building. The neglect of these routine items can contribute to many common window problems.

Before undertaking any of the repairs mentioned in the following sections all sources of moisture penetration should be identified and eliminated, and all existing decay fungi destroyed in order to arrest the deterioration process. Many commercially available fungicides and wood preservatives are toxic, so it is extremely important to follow the manufacturer's recommendations for application, and store all chemical materials away from children and animals. After fungicidal and preservative treatment the windows may be stabilized, retained, and restored with every expectation for a long service life.

Repair Class I: Routine Maintenance

Repairs to wooden windows are usually labor intensive and relatively uncomplicated. On small scale projects this allows the do-it-yourselfer to save money by repairing all or part of the windows. On larger projects it presents the opportunity for time and money which might otherwise be spent on the removal and replacement of existing windows, to be spent on repairs, subsequently saving all or part of the material cost of new window units. Regardless of the actual costs, or who performs the work, the evaluation process described earlier will provide the knowledge from which to specify an appropriate work program, establish the work element priorities, and identify the level of skill needed by the labor force.

This historic double-hung window has many layers of paint, some cracked and missing putty, slight separation at the joints, broken sash cords, and one cracked pane. Photo: NPS files.

After removing paint from the seam between the interior stop and the jamb, the stop can be pried out and gradually worked loose using a pair of putty knives as shown. Photo: NPS files.

The routine maintenance required to upgrade a window to "like new" condition normally includes the following steps: 1) some degree of interior and exterior paint removal, 2) removal and repair of sash (including reglazing where necessary), 3) repairs to the frame, 4) weatherstripping and reinstallation of the sash, and 5) repainting. These operations are illustrated for a typical double-hung wooden window, but they may be adapted to other window types and styles as applicable.

Historic windows have usually acquired many layers of paint over time. Removal of excess layers or peeling and flaking paint will facilitate operation of the window and restore the clarity of the original detailing. Some degree of paint removal is also necessary as a first step in the proper surface preparation for subsequent refinishing (if paint color analysis is desired, it should be conducted prior to the onset of the paint removal). There are several safe and effective techniques for removing paint from wood, depending on the amount of paint to be removed.

Paint removal should begin on the interior frames, being careful to remove the paint from the interior stop and the parting bead, particularly along the seam where these stops meet the jamb. This can be accomplished by running a utility knife along the length of the seam, breaking the paint bond. It will then be much easier to remove the stop, the parting bead and the sash. The interior stop may be initially loosened from the sash side to avoid visible scarring of the wood and then gradually pried loose using a pair of putty knives, working up and down the stop in small increments. With the stop removed, the lower or interior sash may be withdrawn. The sash

Sash can be removed and repaired in a convenient work area. Paint is being removed from this sash with a hot air gun. Photo: NPS files.

cords should be detached from the sides of the sash and their ends may be pinned with a nail or tied in a knot to prevent them from falling into the weight pocket.

Removal of the upper sash on double-hung units is similar but the parting bead which holds it in place is set into a groove in the center of the stile and is thinner and more delicate than the interior stop. After removing any paint along the seam, the parting bead should be carefully pried out and worked free in the same manner as the interior stop. The upper sash can be removed in the same manner as the lower one and both sash taken to a convenient work area (in order to remove the sash the interior stop and parting bead need only be removed from one side of the window). Window openings can be covered with polyethylene sheets or plywood sheathing while the sash are out for repair.

The sash can be stripped of paint using appropriate techniques, but if any heat treatment is used, the glass should be removed or protected from the sudden temperature change which can cause breakage. An overlay of aluminum foil on gypsum board or asbestos can protect the glass from such rapid temperature change. It is important to protect the glass because it may be historic and often adds character to the window. Deteriorated putty should be removed manually, taking care not to damage the wood along the rabbet. If the glass is to be removed, the glazing points which hold the glass in place can be extracted and the panes numbered and removed for cleaning and reuse in the same openings. With the glass panes out, the remaining putty can be removed and the sash can be sanded, patched, and primed with a preservative primer. Hardened putty in the rabbets may be softened by heating with a soldering iron at the point of removal. Putty remaining on the glass may be softened by soaking the panes in linseed oil, and then removed with less risk of breaking the glass. Before reinstalling the glass, a bead of glazing compound or linseed oil putty should be laid around the rabbet to cushion and seal the glass. Glazing compound should only be used on wood which has been brushed with linseed oil and primed with an oil based primer or paint. The pane is then pressed into place and the glazing points are pushed into the wood around the perimeter of the pane.

The final glazing compound or putty is applied and beveled to complete the seal. The sash can be refinished as desired on the inside and painted on the outside as soon as a "skin" has formed on the putty, usually in 2 or 3 days. Exterior paint should cover the beveled glazing compound or putty and lap over onto the glass slightly to complete a weather-tight seal. After the proper curing times have elapsed for paint and putty, the sash will be ready for reinstallation.

While the sash are out of the frame, the condition of the wood in the jamb and sill can be evaluated. Repair and refinishing of the frame may proceed concurrently with repairs to the sash, taking advantage of the curing times for the paints and putty used on the sash. One of the most common work items is the replacement of the sash cords with new rope cords or with chains. The weight pocket is frequently accessible through a door on the face of the frame near the sill, but if no door exists, the trim on the interior face may be removed for access. Sash weights may be increased for easier window operation by elderly or handicapped persons. Additional repairs to the frame and sash may include consolidation or replacement of deteriorated wood. Techniques for these repairs are discussed in the following sections.

Following the relatively simple repairs, the window is weathertight, like new in appearance, and serviceable for many years to come.Photo: NPS files.

The operations just discussed summarize the efforts necessary to restore a window with minor deterioration to "like new" condition. The techniques can be applied by an unskilled person with minimal training and experience. To demonstrate the practicality of this approach, and photograph it, a Technical Preservation Services staff member repaired a wooden double-hung, two over two window which had been in service over ninety years. The wood was structurally sound but the window had one broken pane, many layers of paint, broken sash cords and inadequate, worn-out weatherstripping. The staff member found that the frame could be stripped of paint and the sash removed quite easily. Paint, putty and glass removal required about one hour for each sash, and the reglazing of both sash was accomplished in about one hour. Weatherstripping of the sash and frame, replacement of the sash cords and reinstallation of the sash, parting bead, and stop required an hour and a half. These times refer only to individual operations; the entire process took several days due to the drying and curing times for putty, primer, and paint, however, work on other window units could have been in progress during these lag times.

Repair Class II: Stabilization

The preceding description of a window repair job focused on a unit which was operationally sound. Many windows will show some additional degree of physical deterioration, especially in the vulnerable areas mentioned earlier, but even badly damaged windows can be repaired using simple processes. Partially decayed wood can be waterproofed, patched, built-up, or consolidated and then painted to achieve a sound condition, good appearance, and greatly extended life. Three techniques for repairing partially decayed or weathered wood are discussed in this section, and all three can be accomplished using products available at most hardware stores.

One established technique for repairing wood which is split, checked or shows signs of rot, is to: **1)** dry the wood, **2)** treat decayed areas with a fungicide, **3)** waterproof with two or three applications of boiled linseed oil (applications every 24 hours), **4)** fill cracks and holes with putty, and **5)** after a "skin" forms on the putty, paint the surface. Care should be taken with the use of fungicide which is toxic. Follow the manufacturers' directions and use only on areas which will be painted. When using any technique of building up or patching a flat surface, the finished surface should be sloped slightly to carry water away from the window and not allow it to puddle. Caulking of the joints between the sill and the jamb will help reduce further water penetration.

This illustrates a two-part expoxy patching compound used to fill the surface of a weathered sill and rebuild the missing edge. When the epoxy cures, it can be sanded smooth and painted to achieve a durable and waterproof repair. Photo: NPS files.

When sills or other members exhibit surface weathering they may also be built-up using wood putties or homemade mixtures such as sawdust and resorcinol glue, or whiting and varnish. These mixtures can be built up in successive layers, then sanded, primed, and painted. The same caution about proper slope for flat surfaces applies to this technique.

Wood may also be strengthened and stabilized by consolidation, using semirigid epoxies which saturate the porous decayed wood and then harden. The surface of the consolidated wood can then be filled with a semirigid epoxy patching compound, sanded and painted. Epoxy patching compounds can be used to build up missing sections or decayed ends of members. Profiles can be duplicated using hand molds, which are created by pressing a ball of patching compound over a sound section of the profile which has been rubbed with butcher's wax. This can be a very efficient technique where there are many typical repairs to be done. The process has been widely used and proven in marine applications; and proprietary products are available at hardware and marine supply stores. Although epoxy materials may be comparatively expensive, they hold the promise of being among the most durable and long lasting materials available for wood repair. More information on epoxies can be found in the publication "Epoxies for Wood Repairs in Historic Buildings," cited in the bibliography.

Any of the three techniques discussed can stabilize and restore the appearance of the window unit. There are times, however, when the degree of deterioration is so advanced that stabilization is impractical, and the only way to retain some of the original fabric is to replace damaged parts.

Repair Class III: Splices and Parts Replacement

When parts of the frame or sash are so badly deteriorated that they cannot be stabilized there are methods which permit the retention of some of the existing or original fabric. These methods involve replacing the deteriorated parts with new matching pieces, or splicing new wood into existing members. The techniques require more skill and are more expensive than any of the previously discussed alternatives. It is necessary to remove the sash and/or the affected parts of the frame and have a carpenter or woodworking mill reproduce the damaged or missing parts. Most millwork firms can duplicate parts, such as muntins, bottom rails, or sills, which can then be incorporated into the existing window, but it may be necessary to shop around because there are several factors controlling the practicality of this approach. Some woodworking mills do not like to repair old sash because nails or other foreign objects in the sash can damage expensive knives (which cost far more than their profits on small repair jobs); others do not have cutting knives to duplicate muntin profiles. Some firms prefer to concentrate on larger jobs with more profit potential, and some may not have a craftsman who can duplicate the parts. A little searching should locate a firm which will do the job, and at a reasonable price. If such a firm does not exist locally, there are firms which undertake this kind of repair and ship nationwide. It is possible, however, for the advanced do-it-yourselfer or craftsman with a table saw to duplicate moulding profiles using techniques discussed by Gordie Whittington in "Simplified Methods for Reproducing Wood Mouldings," *Bulletin* of the Association for Preservation Technology, Vol. III, No. 4, 1971, or illustrated more recently in *The Old House*, Time-Life Books, Alexandria, Virginia, 1979.

The repairs discussed in this section involve window frames which may be in very deteriorated condition, possibly requiring removal; therefore, caution is in order. The actual construction of wooden window frames and sash is not complicated. Pegged mortise and tenon units can be disassembled easily, if the units are out of the building. The installation or connection of some frames to the surrounding structure, especially masonry walls, can complicate the work immeasurably, and may even require dismantling of the wall. It may be useful, therefore, to take the following approach to frame repair: **1)** conduct regular maintenance of sound frames to achieve the longest life possible, **2)** make necessary repairs in place, wherever possible, using stabilization and splicing techniques, and **3)** if removal is necessary, thoroughly investigate the structural detailing and seek appropriate professional consultation.

Another alternative may be considered if parts replacement is required, and that is sash replacement. If extensive replacement of parts is necessary and the job becomes prohibitively expensive it may be more practical to purchase new sash which can be installed into the existing frames. Such sash are available as exact custom reproductions, reasonable facsimiles (custom windows with similar profiles), and contemporary wooden sash which are similar in appearance. There are companies which still manufacture high quality wooden sash which would duplicate most historic sash. A few calls to local building suppliers may provide a source of appropriate replacement sash, but if not, check with local historical associations, the state historic preservation office, or preservation related magazines and supply catalogs for information.

If a rehabilitation project has a large number of windows such as a commercial building or an industrial complex, there may be less of a problem arriving at a solution. Once the evaluation of the windows is completed and the scope of the work is known, there may be a potential economy of scale. Woodworking mills may be interested in the work from a large project; new sash in volume may be considerably less expensive per unit; crews can be assembled and trained on site to perform all of the window repairs; and a few extensive repairs can be absorbed (without undue burden) into the total budget for a large number of sound windows. While it may be expensive for the average historic home owner to pay seventy dollars or more for a mill to grind a custom knife to duplicate four or five bad muntins, that cost becomes negligible on large commercial projects which may have several hundred windows.

Most windows should not require the extensive repairs discussed in this section. The ones which do are usually in buildings which have been abandoned for long periods or have totally lacked maintenance for years. It is necessary to thoroughly investigate the alternatives for windows which do require extensive repairs to arrive at a solution which retains historic significance and is also economically feasible. Even for projects requiring repairs identified in this section, if the percentage of parts replacement per window is low, or the number of windows requiring repair is small, repair can still be a cost effective solution.

Weatherization

A window which is repaired should be made as energy efficient as possible by the use of appropriate weatherstripping to reduce air infiltration. A wide variety of products are available to assist in this task. Felt may be fastened to the top, bottom, and meeting rails, but may have the disadvantage of absorbing and holding moisture, particularly at the bottom rail. Rolled vinyl strips may also be tacked into place in appropriate locations to reduce infiltration. Metal strips or new plastic spring strips may be used on the rails and, if space permits, in the channels between the sash and jamb. Weatherstripping is a historic treatment, but old weatherstripping (felt) is not likely to perform very satisfactorily. Appropriate contemporary weatherstripping should be considered an integral part of the repair process for windows. The use of sash locks installed on the meeting rail will insure that the sash are kept tightly closed so that the weatherstripping will function more effectively to reduce infiltration. Although such locks will not always be historically accurate, they will usually be viewed as an acceptable contemporary modification in the interest of improved thermal performance.

Many styles of storm windows are available to improve the thermal performance of existing windows. The use of exterior storm windows should be investigated whenever feasible because they are thermally efficient, cost-effective, reversible, and allow the retention of original windows (see "Preservation Briefs: 3"). Storm window frames may be made of wood, aluminum, vinyl, or plastic; however, the use of unfinished aluminum storms should be avoided. The visual impact of storms may be minimized by selecting colors which match existing trim color. Arched top storms are available for windows with special shapes. Although interior storm windows appear to offer an attractive option for achieving double glazing with minimal visual impact, the potential for damaging condensation problems must be addressed. Moisture which becomes trapped between the layers of glazing can condense on the colder, outer prime window, potentially leading to deterioration. The correct approach to using interior storms is to create a seal on the interior storm while allowing some ventilation around the prime window. In actual practice, the creation of such a durable, airtight seal is difficult.

Window Replacement

Although the retention of original or existing windows is always desirable and this Brief is intended to encourage that goal, there is a point when the condition of a window may clearly indicate replacement. The decision process for selecting replacement windows should not begin with a survey of contemporary window products which are available as replacements, but should begin with a look at the windows which are being replaced. Attempt to understand the contribution of the window(s) to the appearance of the facade including: **1)** the pattern of the openings and their size; **2)** proportions of the frame and sash; **3)** configuration of window panes; **4)** muntin profiles; **5)** type of wood; **6)** paint color; **7)** characteristics of the glass; and **8)** associated details such as arched tops, hoods, or other decorative elements. Develop an understanding of how the window reflects the period, style, or regional characteristics of the building, or represents technological development.

Armed with an awareness of the significance of the existing window, begin to search for a replacement which retains as much of the character of the historic window as possible. There are many sources of suitable new windows. Continue looking until an acceptable replacement can be found. Check building supply firms, local woodworking mills, carpenters, preservation oriented magazines, or catalogs or suppliers of old building materials, for product information. Local historical associations and state historic preservation offices may be good sources of information on products which have been used successfully in preservation projects.

Consider energy efficiency as one of the factors for replacements, but do not let it dominate the issue. Energy conservation is no excuse for the wholesale destruction of historic windows which can be made thermally efficient by historically and aesthetically acceptable means. In fact, a historic wooden window with a high quality storm window added should thermally outperform a new double-glazed metal window which does not have thermal breaks (insulation between the inner and outer frames intended to break the path of heat flow). This occurs because the wood has far better insulating value than the metal, and in addition many historic windows have high ratios of wood to glass, thus reducing the area of highest heat transfer. One measure of heat transfer is the U-value, the number of Btu's per hour transferred through a square foot of material. When comparing thermal performance, the lower the U-value the better the performance. According to ASHRAE 1977 Fundamentals, the U-values for single glazed wooden windows range from 0.88 to 0.99. The addition of a storm window should reduce these figures to a range of 0.44 to 0.49. A non-thermal break, double-glazed metal window has a U-value of about 0.6.

Conclusion

Technical Preservation Services recommends the retention and repair of original windows whenever possible. We believe that the repair and weatherization of existing wooden windows is more practical than most people realize, and that many windows are unfortunately replaced because of a lack of awareness of techniques for evaluation, repair, and weatherization. Wooden windows which are repaired and properly maintained will have greatly extended service lives while contributing to the historic character of the building. Thus, an important element of a building's significance will have been preserved for the future.

Additional Reading

ASHRAE Handbook 1977 Fundamentals. New York: American Society of Heating, Refrigerating and Air-conditioning Engineers, 1978 (chapter 26).

Ferro, Maximillian. *Preservation: Present Pathway to Fall River's Future.* Fall River, Massachusetts: City of Fall River, 1979 (chapter 7).

"Fixing Double-hung Windows." *Old House Journal* (no. 12, 1979): 135.

Morrison, Hugh. *Early American Architecture*. New York: Oxford University Press, 1952.

Phillips, Morgan, and Selwyn, Judith. *Epoxies for Wood Repairs in Historic Buildings.* Washington, DC: Technical Preservation Services, U.S. Department of the Interior (Government Printing Office, Stock No. 024016000951), 1978.

Rehab Right. Oakland, California: City of Oakland Planning Department, 1978 (pp. 7883).

"Sealing Leaky Windows." *Old House Journal* (no. 1, 1973): 5.

Smith, Baird M. "Preservation Briefs: 3 Conserving Energy in Historic Buildings." Washington, DC: Technical Preservation Services, U.S. Department of the Interior, 1978.

Weeks, Kay D. and David W. Look, "Preservation Briefs: 10 Exterior Paint Problems on Historic Woodwork." Washington, DC: Technical Preservation Services, U.S. Department of the Interior, 1982.

Washington, D.C. 1981

Home page logo: Historic six-over-six windows--preserved. Photo: NPS files.

This publication has been prepared pursuant to the National Historic Preservation Act of 1966, as amended, which directs the Secretary of the Interior to develop and make available information concerning historic properties. Technical Preservation Services (TPS), Heritage Preservation Services Division, National Park Service prepares standards, guidelines, and other educational materials on responsible historic preservation treatments for a broad public.

Specifications for the Rehabilitation & Weatherization of Historic Windows

Sample

By
Preservation Resources, Inc.
July 31, 2012

#100) Work Specifications

NOTE: All sash and stop work, including paint, glass and putty removal as well as repair & painting, is to take place off-site at your facility.

A) Double Hung Sash Openings

1) Sash & Stop Removal

Carefully remove all interior sash stop, parting stop, all old metal weather stripping in jambs & all window sashes, including transoms, from each opening and mark for location in a way can survive paint removal. Remove and discard any metal, ribbed flange attached to the bottom or top of the jamb and discard. Discard parting stop but keep all interior finish stop. If any interior stop is broken or missing on a unit, new interior stop, to match, shall be made & installed. Replace parting stop with pine to match size of original.

Leave all functioning sash pulleys in place. Remove non-functioning sash pulleys for repair or replacement with new or salvaged pulleys that match the originals.

Provide and install 1/2" OSB neatly installed over the entire openings from the inside. Attach with galvanized screws that can be easily removed for daily jamb work and then re-installed at the end of every work day.

2) Jamb Paint & Caulking Removal

Remove all paint, caulking & non-original obstructions from the entire jamb including brick moldings. Interior casings, stools and aprons will be removed, in advance, by others.

All on site paint removal from jambs, exterior brick moldings must be done with infrared heating devises or with SoyGel made by Framnar (no methylene chloride based liquid strippers are allowed) or wet scraping with carbide scrapers or any combination of these three methods. Heat guns are discouraged but may be used if they do not exceed 640 degrees. DO NOT dry scrape paint, ever.

Certified HEPA vacuums must be used constantly to avoid lead dust. Dispose of all paint debris according to regulations. **Follow all local, state and federal regulations for safe management of paint dust and debris.**

3) Jamb & Brick Molding Repairs

Where there is separation from the jamb of the brick molding and blind stop, re-attached to jamb. One method is to remove all the debris from the weight pocket and all gaps between the wood surfaces. The using pipe or bar clamps, pull the wood elements together and re-nail with galvanized nails set 1/8" below the surface of the wood.

Assure that the bottom and top rails of the jamb are secured to the stiles of the jamb snuggly.

If any brick molding or blind stop is not repairable, replace with new, non-treated pine that matches the old. No treated wood is allowed because it will not hold paint for an extended period of time.

Minor rot or wood deterioration should be repaired with non-treated pine Dutchman splices or exterior grade architectural epoxies. All architectural epoxy to be manufactured by ABATRON. Two part LiquidWood must be applied to the area of repair first and then two part WoodEpox putty can be installed within one hour of LiquidWood application. All wood must be free of paint, caulk and graying from UV damage before epoxy application

In about half of the double hung jambs, blind stop and brick moldings there is considerable deterioration of the summer wood grain between the winter wood grain. This has created a wash board effect. This can be treated with two part LiquidWood and then two part WoodEpox as described above.

Open sash weight pocket access panels in lower side of jambs. Determine if all the weights are there. If weights are missing, obtain new or salvaged sash weights to match size and weight. Clean out weight pockets, remove old chain or cords and repair access panels as needed.

Shape and sand all Dutchman and epoxy repairs smooth and flush with surrounding surfaces to 100 grit. Sand the entire jamb and brick mold system to 100 grit.

4) Jamb Priming & Painting

Brush prime entire jamb and brick molding with an exterior grade, premium alkyd oil based primer with a solid content, by weight, of not less than 56%.

After primer has cured, fill all nail holes and small voids with a boiled linseed oil based glazing putty. Do not use soy bean based putties like DAP 33. Caulk brick molding to the masonry and blind stop using appropriate caulking.

Brush apply two top coats of exterior grade premium semi-gloss, acrylic latex paint with a solid content by weight not less than 56%. This can be determined by going to the paint manufacturers website and looking at either their MSDS PDF or Data Sheet PDF.

The brick molding and jamb parts that can be seen from the exterior when the sashes are closed will be one color and the jamb that can be seen from the interior another color. Color and paint brand to be approved by Construction Manager.

5) Window Sash Paint Removal

Again, all sash work is to be done off-site at your facility.

Remove all hardware for cleaning and later re-installation. Any missing or broken sash locks are to be replaced to match originals. Safely store all hardware & screws. Clean the surface of the pulleys and sash lifts without removing patina. Do not buff unless you can establish that the original finish was polished. Boiling the hardware in plain water will remove dirt and paint while retaining the original factory finish.

Remove all paint & varnish to bare wood on all surfaces of all sashes and interior finish stops. This may be done with infrared heating devises; steam; SoyGel made by Framnar (no methylene chloride based liquid strippers are allowed); wet scraping with carbide scrapers; heat guns or any combination of these four methods. Heat guns are discouraged but may be used if they do not exceed 640 degrees.

Remove all remnants of glazing putty and carefully remove glass. Save as much original glass as possible for re-installation later.

6) Window Sash Repairs

Repair individual window sashes, as needed. If an original meeting rail is bowed more than 1/8" in its length, replace it with non-treated pine to match original.

Clamp and re-pin all rails, stiles and muntins. If a sash is disassembled, **DO NOT** glue-up the mortise and tenon joints when re-assembling. Pin each mortise and tenon joint by drilling a 3/32" pilot hole for two, 1-1/4" x 1/8" diameter stainless steel pins at opposing angles and driven into and through the solid portion of the tenon. Set the pins 1/4" below the surface. Pins are item #1NU20 through WW Grainger, available through http://www.grainger.com/Grainger/Dowel-Pin-1NU20?Pid=search.

Minor rot or wood deterioration should be repaired with non-treated pine Dutchman splices or exterior grade architectural epoxies. All architectural epoxy to be manufactured by ABATRON. Two part LiquidWood must be applied to the area of repair first and then two part WoodEpox putty can be installed within one hour of LiquidWood application. All wood must be free of paint, caulk and graying from UV damage before epoxy application

Shape and sand all Dutchman and epoxy repairs smooth and flush with surrounding surfaces to 100 grit. Lightly sand the entire sash to 100 grit on the exterior and 120 grit on the interior.

Provide new, pine parting stops to match originals. Dimensions should match original except the thickness. This dimension should be 1/16" less than the original thickness to account for pre-priming and painting and so that when screwed into place, they can be removed for later repairs and maintenance. Pre-drill four, evenly spaced, counter sunk hole into the parting stop to accept four #8 x 1-1/4" flat head, slotted brass screw.

Using all stripped interior stop as well as any new made to match and drill four 1/2" holes, evenly spaced, to accept a brass, unlacquered "*stop bead adjuster*" available through Kilian's Hardware, http://kilian.stores.yahoo.net/stopbeadad.html

7) Sash Weather Stripping

A zinc flange/ribbed track and bulb rubber weather stripping system is to be installed on all double hung window sashes.

Use “Double Hung Wood Window, Return Flange Equipment” on page 34 of the Dorbin Metal Strip Companies catalogue (see attachments). Order Item #7-C in zinc for the four side tracks. Do not order the nails to install the track, you will be screwing the track in place for easier removal for maintenance. These can be ordered cut to exact length or cut to length in the shop. Call Dorbin at 708-656-1333 for a catalogue.

Cut 5/32” wide x 7/16” deep slots in the sides of all double hung sashes that is offset correctly to match the flange/rib. These slots are for the flange/ribbed tracks. This creates a smooth track and stops air infiltration on the sides of the double hung sashes. Cut the track 1" longer than the height of each sash when fully closed.

Drill four 5/32" holes in the lower tracks, between the corrugations and evenly spaced. For the upper tracks, cutout to the rib for the pulleys and drill a 5/32" hole between the corrugations at the top; just above the pulley cutout; just below the pulley cutout; one centered between the bottom of the pulley cutout and the bottom of the track; one at the bottom of the track. These will be installed with a zinc #4 x 1/2" flat head, phillips screws.

Cut a 3/32” wide x ½” deep slot, centered, into upper sash meeting rail as well as the bottom edge of the lower sash bottom rail and the top edge of the upper sash top rail. Dorbin sells rolls of t-flanged, rubber tubing for weather stripping #199S "*Santoprene*". This product is inserted into these slots with a stiff 2" putty knife with the sharp corners rounded off to avoid cutting into the rubber when inserted. Add a small amount of pure silicon caulking into these slots before inserting the rubber.

8) Priming Sash & Stops

Brush prime all bare wood sash surfaces except the side stile edges. All priming, including the glazing bed, interior stop and parting stop to be done with an exterior grade, premium alkyd oil based primer with a solid content, by weight, of not less than 56%.

After primer has cured, fill all pin holes and small voids with a boiled linseed oil based glazing putty. Do not use soy bean based putties like DAP 33. alkyd oil based primer.

After primer has cured install the t-slot rubber tubing into the slot in the upper sash meeting rail, bottom edge of the lower sash rail and top edge of the upper sash rail.

9) Setting & Glazing Glass

All new glass is to match original in thickness, texture and weight. Match the textured glass in all of the first floor sashes.

Install all original & new glass into bed of caulking. Use a paintable, acrylic-latex with silicon caulking & secure with adequate glazing points. Install new glazing putty so that the putty, at glass, is just behind the sight plane of the interior molded edge of sash. This allows top coats of paint to come on the glass 1/16" without seeing the paint or putty from the interior side of the sashes.

The glazing putty to be used must be boiled linseed oil based. No soy based putties are allowed. Do not use DAP 33. Professional grade, boiled linseed oil based putties skin over enough to paint in 24 to 48 hours while soy based putties take as long as 28 days to skin over.

Alkyd oil prime glazing putty after the putty skins over.

10) Painting Sashes and Stops

Brush apply two topcoats of exterior grade premium semi-gloss, acrylic latex paint with a solid content by weight not less than 56% to all surfaces and stops except the side stile edges. Solid content can be determined by going to the paint manufacturers website and looking at either their MSDS PDF or Data Sheet PDF.

The exterior sash color may be different than the interior color. Color and paint brand to be approved by Construction Manager.

11) Install Restored Double Hung & Transom Sash

Install missing sash pulleys with slotted screw.

Install new sash chain to match original in link shape and finish. New chain to be rated for a minimum of 60 lbs. Hang weights on the sash chain.

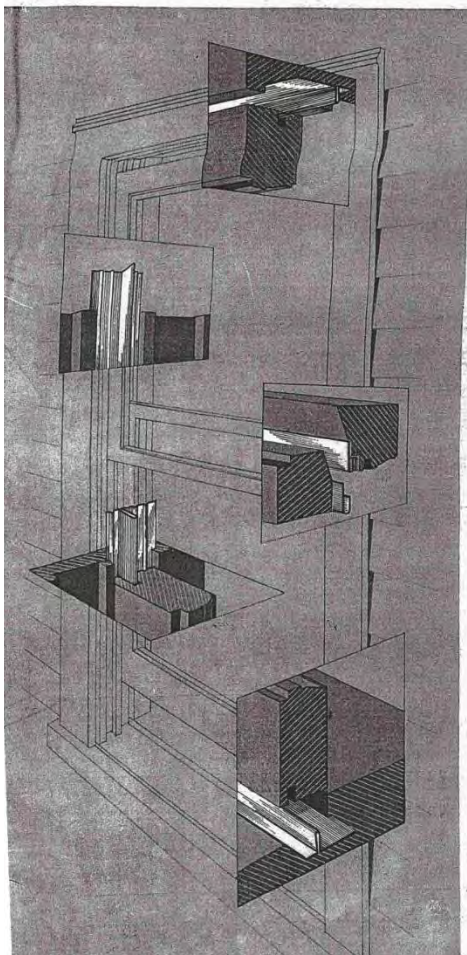
Install upper sashes with the Dorbin track system. Screw the track in place as described in **7)**. Side parting stops are pre-painted and attached with 4 brass screws that are counter sunk instead of nailed. The top parting stop has 3 brass screws.

Install refinished or newly finished interior sash stop with stop bead adjusters. This allows easier access for repair and interior cleaning of the exterior glass from inside the building.

Test the top and bottom sash for smooth, one finger operation. Adjust track and weather stripping if needed to provide smooth operation.

Install transom sashes with a small bead of acrylic latex with silicon caulking at the exterior stop on all four edges. Install interior transom stop with finish nails.

MASTER INTERLOCKING EQUIPMENT "A"

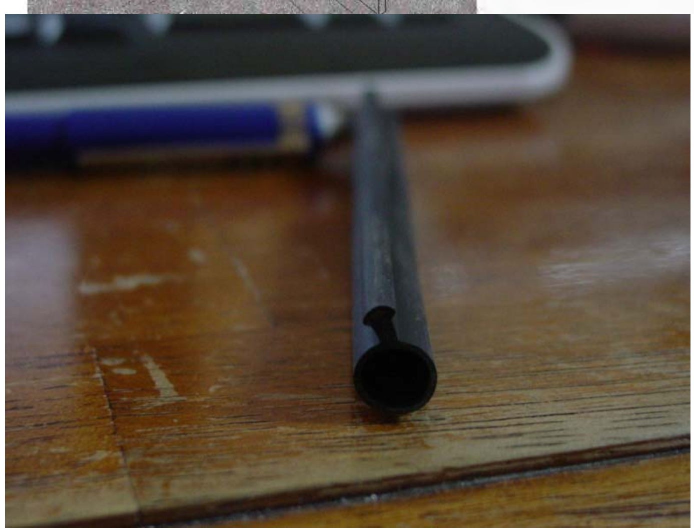


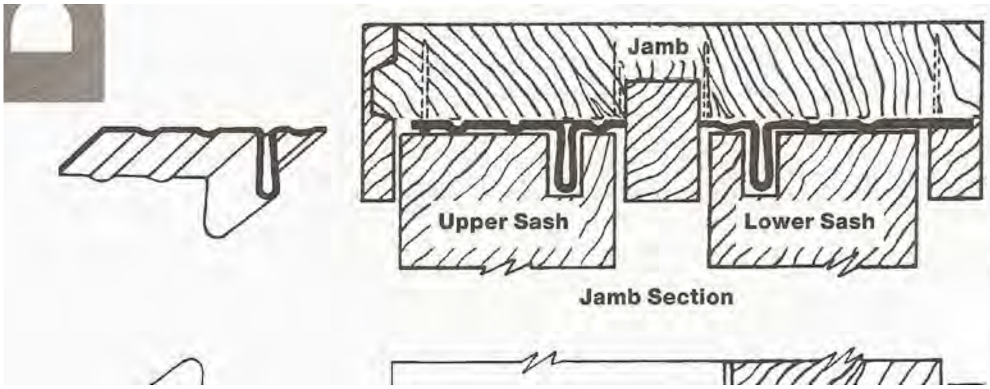
FOR DOUBLE-HUNG WOOD SASH

For residential work where the equipment is subject to only moderate use, Equipment "A" is ordinarily specified. Here, of course, the lower cost is also a factor of *importance.*

Strips are wide enough to cover full width of head, sill and pulley stiles. Height of rib strip is full 7/16", assuring positive contact regardless of sash shrinkage.

Sash grooves are 5/32" wide and 1/2" deep, allowing a clearance of 1/32". Where smaller clearance is wanted, the groove can be 9/64" wide. Experience has shown that these clearances permit maximum efficiency, yet are sufficient to allow the sash to operate smoothly even though the wood may warp. Lower side strips are usually kerfed 1/8" into the parting stop, but this is not ordinarily done on the upper sash. Meeting rail installation is optional and can also be installed as shown on page 17.





M42 (.018) double
flat

Zinc

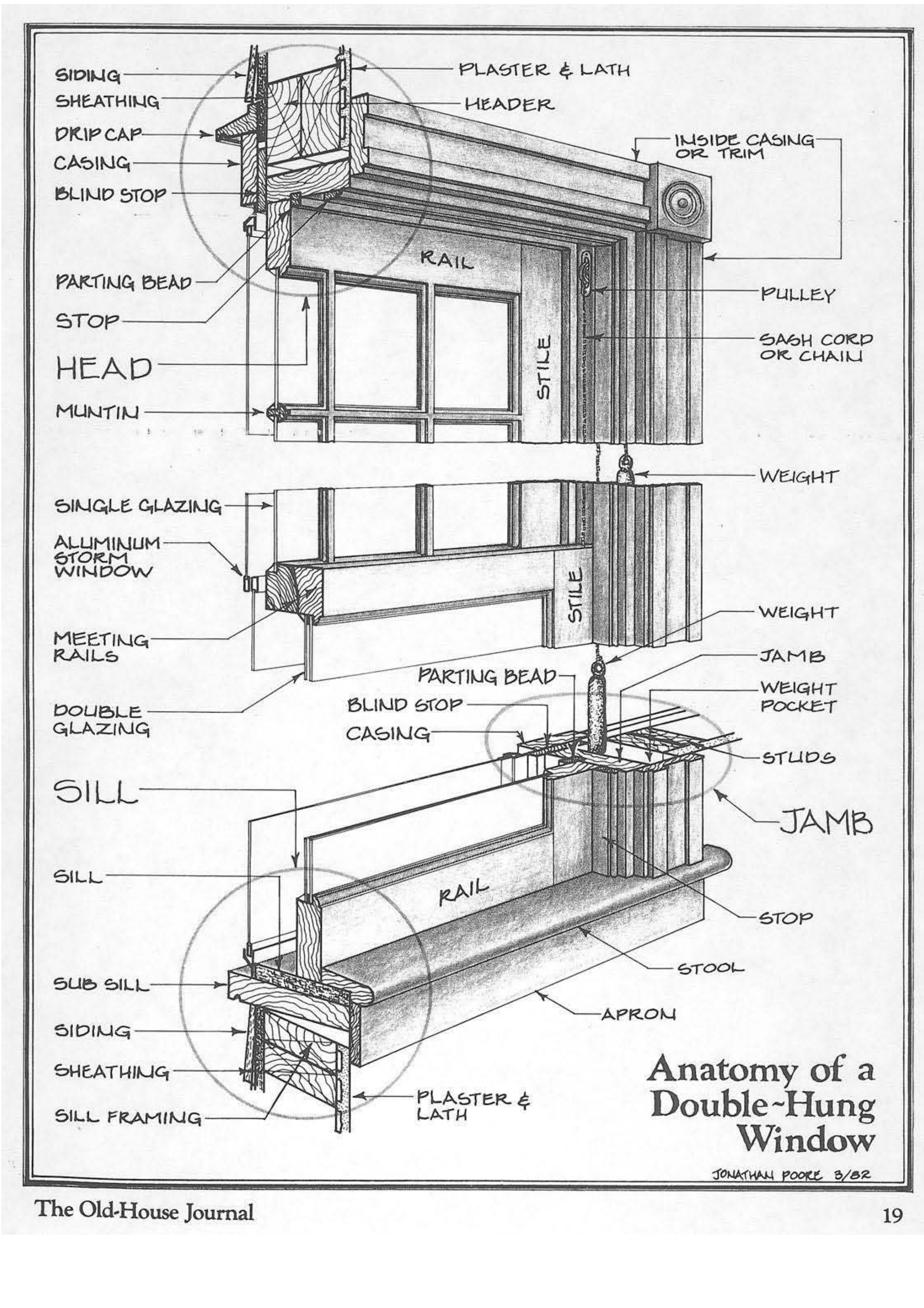
Upper & Lower
Sides—Corrugated
$1/8$" rib x $7/16$" high
$3/8$" flange (.018)

4C $1\,3/8$" wide
7C $1\,3/4$" wide
9C 2" wide
10C $2\,1/4$" wide
11C $2\,1/2$" wide

How to Install a Ribbed Metal Track System with Rubber Seals

Copyright 2013, Preservation Resources, Inc.

Here is a drawing that clearly shows the anatomy of a historic double hung window. As you follow the directions below, refer to this drawing to understand the parts being described.

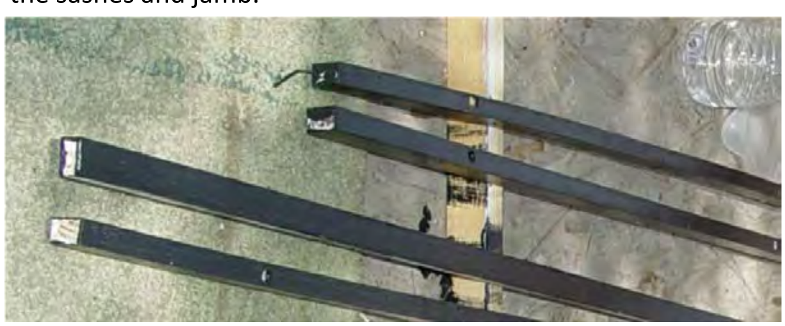


1. Check the sashes while still in place and completely shut for side to side play in the jamb opening. This can vary between 1/8" and 3/8" on well maintained windows. Check play in sashes from top to bottom. In order for the meeting rails to meet properly in the middle there needs to be no more than 1/4" and no less than 1/8' play, top to bottom, when both sashes are closed. If the side-to-side play exceeds 3/8" and the top to bottom play exceeds 1/4" the jamb may have come apart and you should repair this first or hire a carpenter to make the repairs.
2. Carefully remove the interior sash stops, parting beads and both window sashes from the opening and mark them for location with an ink pen on the unpainted sides of each sash.

Mark the unpainted sides of the sash side stiles

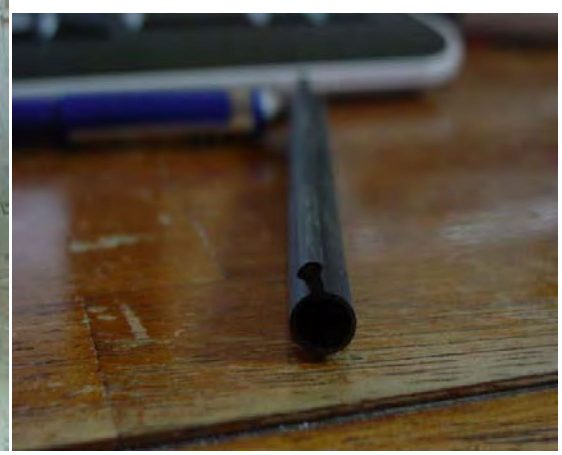
   Discard parting bead but keep all of the interior finish stop. If any interior stop is broken or missing on a unit, new interior stop, to match, shall be made & installed.

3. Make or buy at the lumberyard, new pine parting bead to match the dimensions of the original. Pre-prime/paint and countersink for a #6 screw of choice. The idea being that the parting stop is not nailed back in, as traditionally done, but screwed in so it can be easily removed for future maintenance of the sashes and jamb.



New stock parting stop, primed, drilled and painted

4. Leave all functioning sash pulleys in place. Remove non-functioning sash pulleys for repair or replacement with new or salvaged pulleys that match the originals.
5. Using a 5/32" slotting bit in a router, rout a groove on both sides of each sash 7/16" deep. The rib on the metal flange is 3/8" deep. The lower sash grooves are closer to the interior face of the lower sash and the slots on the upper sash are closer to the exterior face of the sash.



Rubber installed in bottom of lower sash *"Santoprene" T-ribbed, rubber gasket*

6. Rout a narrow 3/32" slot in the check/meeting rail of the upper sash dead center. Also the bottom edge of the lower sashes bottom rail and the top edge of the upper sashes top rail. This is for your choice of rubber tube weather stripping. Be sure the rubber has a T-flange or barbed flange to friction fit in this narrow slot.

5/32" slotting bit for track *3/32" slotting bit for rubber*

Rubber installed in upper sash meeting rail

7. Using tin snips, cut four metal ribbed/flange track pieces the height of each sash plus 3/8". Be sure to cut an angle on the bottom of the two lower sash tracks that match the angle of the bottom of the jamb.
8. Pre-drill holes between the corrugations of the metal track a diameter that is slightly smaller than the head of the #4 sheet metal screw that will attach the track to the side of the jamb for each sash. This oversized hole creates a counter sink in the thin metal and allows for adjustment

when installing the sashes. For the two lower sash tracks drill one hole 1/4" down from the top and 1" up from the bottom and then one dead center.

Track cut out for pulley

9. The two upper sash tracks will need to be cut out for the sash pulleys. Put the tracks in place and mark the track for the top and bottom of the pulleys. Using tin snips, cut the two marks all the way to the rib. Score several times against the rib between these two cuts with a sharp utility knife. Bend this cut metal several times back and forth until it breaks loose. Dress with a bastard file. Drill the upper tracks between the corrugations slightly smaller than the head of the #4 sheet metal screw that will attach the track to the side of the jamb for each sash. Drill one hole 1" from the top one 1/2" above the pulley, one 1/2" below the pulley, one dead center and one 1/4" from the bottom.

10. Attach sash ropes to the upper sash sides and slip the tracks into their slots over the sash cords. Ease the sash, with tracks, into the upper opening and screw the track to the jamb with #4 sheet metal screws. Adjust track as needed and test for ease of operation. Cut the ends of the rubber tube weather stripping on the upper sash meeting rail and top rail so they just touch the tracks on both sides.
11. Install new parting stop using a #6 screw.
12. Attach sash ropes to the lower sash sides and sash weight in the pocket. Slip the tracks into their slots over the sash cords. Ease the sash, with tracks, into the lower opening. Screw the track to the jamb with #4 sheet metal screws. Adjust track as needed and test for ease of operation. Cut the ends of the rubber tube weather stripping on the lower rail it just touches the tracks on both sides.
13. Test upper and lower sashes for ease of operation and install a sash lock that brings the meeting rails close enough together to compact the rubber tube weather stripping at the check/meeting rail.

Materials:

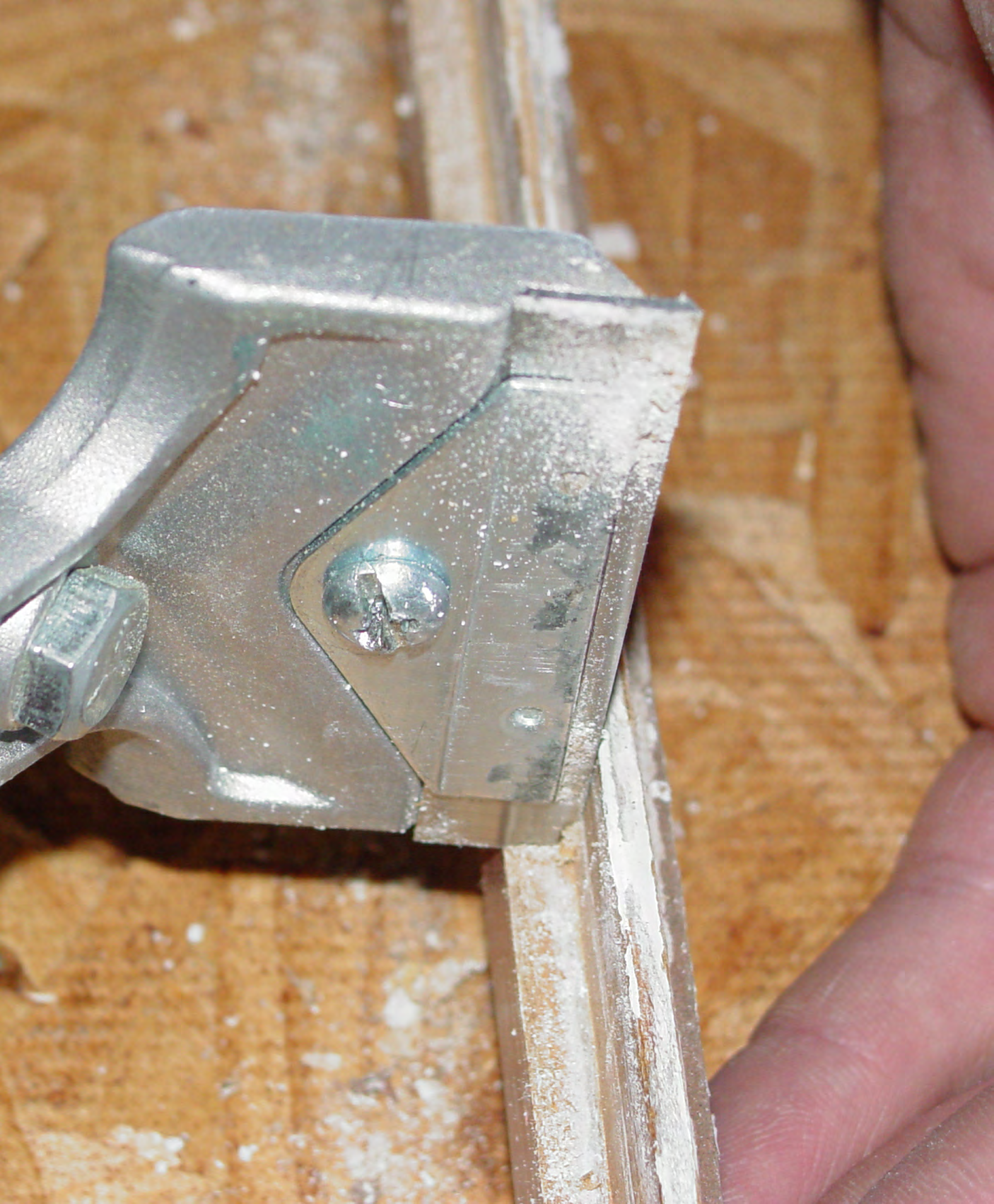
- Ribbed metal track material
- # 4 sheet metal screws for track
- #6 x 1-1/4" brass slotted screws for parting stop
- Rubber tube weather stripping with t-flange or barded flange
- Parting stop to match original

Quality of Results

A quality installation will be snug with a slight amount of play. The sashes should move up and down with one finger. The rubber tube weather stripping should just touch the tracks and the sash lock should pull the meeting rails snugly to the rubber tube weather stripping. No air infiltration can be detected.

Inadequate Work

Sashes have too much play; rubber does not touch metal tracks; window is hard to operate; sash lock does not bring meeting rails to the rubber; air infiltration is present because of sloppy work.




WARNING!
SIDE


BLUE

Dorbin Metal Strip Mfg. Co., Inc.

Thresholds

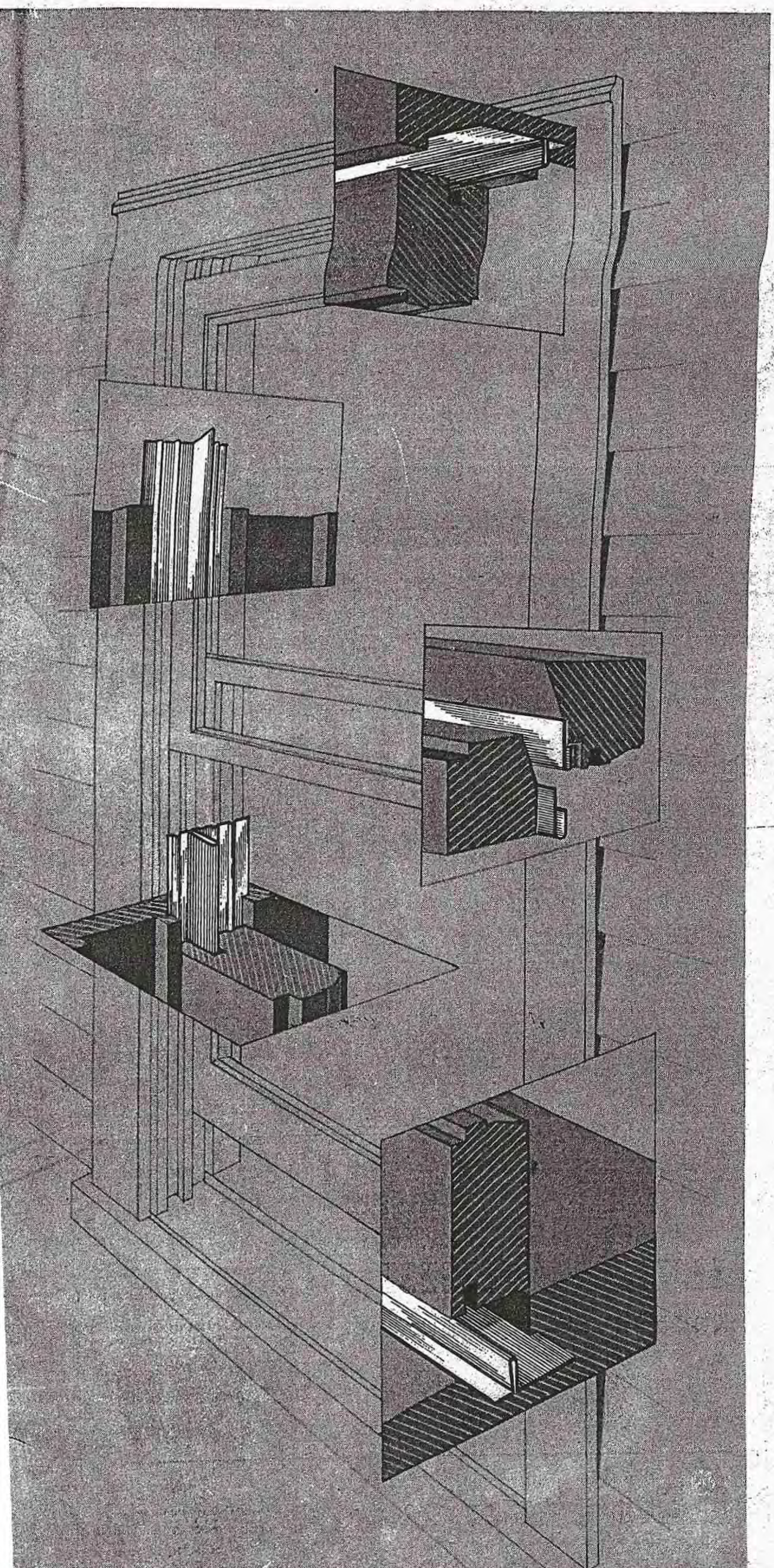
Weather Strips

Door Equipment

Window Equipment

Chicago Phone: **773-242-2333** Cicero Phone: **708-656-2333** Fax Number: **708-656-1333**

MASTER INTERLOCKING EQUIPMENT "A"



FOR DOUBLE-HUNG WOOD SASH —

For residential work where the equipment is subject to only moderate use, Equipment "A" is ordinarily specified. Here, of course, the lower cost is also a factor of *importance.*

Strips are wide enough to cover full width of head, sill and pulley stiles. Height of rib strip is full 7/16", assuring positive contact regardless of sash shrinkage.

Sash grooves are 5/32" wide and 1/2" deep, allowing a clearance of 1/32". Where smaller clearance is wanted, the groove can be 9/64" wide. Experience has shown that these clearances permit maximum efficiency, yet are sufficient to allow the sash to operate smoothly even though the wood may warp. Lower side strips are usually kerfed 1/8" into the parting stop, but this is not ordinarily done on the upper sash. Meeting rail installation is optional and can also be installed as shown on page 17.

Save 1/3 on Your Coal Bills!

With Storm Sash—HERE'S PROOF

Our Storm Sash and Doors SAVE YOU MONEY. The houses shown below are the same size and both located in the same town. Mr. A. W. [illegible], however, has storm sash and doors on all windows and doors. By this investment in storm sash and doors he is SAVING MORE THAN $30.00 ON HIS COAL BILL. [illegible] Mr. Hoop. The saving on one year's coal bill alone will pay for the storm sash. Compare the statements of these two owners. [illegible] at wholesale, factory-to-you prices. High grade. Full line of stock sizes. Satisfaction guaranteed.

"Storm windows will save 25 to 30 per cent on costs of fuel." The above statement taken from circular letter No. 227, issued in 1922 by the Department of Commerce, Bureau of Standards, Washington, D. C.

With Storm Sash $60.00 for Coal

Sears, Roebuck and Co.

[illegible]

Yours very truly,

ALBERT W. [illegible]

(Address furnished on request.)

Glazed Storm Sash

[illegible]

Insulating Feature

[illegible]

STILL AIR SPACE

No Storm Sash—$90.00 for Coal

Sears, Roebuck and Co.

[illegible]

Yours very truly,

HENRY HOOP

(Address furnished on request.)

Four-Light Storm Sash

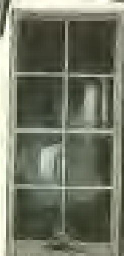
1⅛ inches thick. Carried in stock in the following sizes only. Prices do not include ventilators. Ventilators, 15 cents each, extra. In some cases a little trimming will avoid necessity of ordering special sizes. Size of sash allows for trimming. When ordering be sure to give width first. Shipped from our own factory in NEWARK, N. J. Not prepaid.

Size of Each Light of Glass	Outside Measurement of Sash				63P117285 Glazed Clear Glass	Ship. Wt. Lbs.
	Width		Height			
	Ft.	In.	Ft.	In.		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Two-Light Storm Sash

1⅛ inches thick. Carried in the following sizes only. Prices do not include ventilators. Ventilators 15c each extra. Sizes not printed are not carried in stock. Shipped from our own factory in NEWARK, N. J. Not prepaid.

Size of Each Light of Glass	Outside Measurement of Sash				63P[illegible] Glazed Clear Glass	Ship. Wt. Lbs.
	Width		Height			
	Ft.	In.	Ft.	In.		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]



Eight-Light Storm Sash

1⅛ inches thick. Carried in following sizes only. Prices do not include ventilators. Ventilators, 15c each, extra. Size of sash allows for trimming. When ordering be sure to give width first.

Shipped from our own factory in NEWARK, N. J. Not prepaid.

Size of Each Light of Glass	Outside Measurement of Sash				63P117290 Glazed Clear Glass	Ship. Wt. Lbs.
	Width		Height			
	Ft.	In.	Ft.	In.		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Twelve-Light Storm Sash

1⅛ inches thick. Carried in the following sizes only. Prices do not include ventilators. Ventilators 15c each, extra.

Size of Each Light of Glass	Outside Measurement of Sash				63P[illegible] Glazed Clear Glass	Ship. Wt. Lbs.
	Width		Height			
	Ft.	In.	Ft.	In.		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Shipped from our own factory in NEWARK, N. J. Not prepaid.

Let the Numbers Convince You: Do the Math

U-Value = A measure of air-to-air heat transmission (loss or gain) due to thermal conductance and the difference in indoor and outdoor temperatures

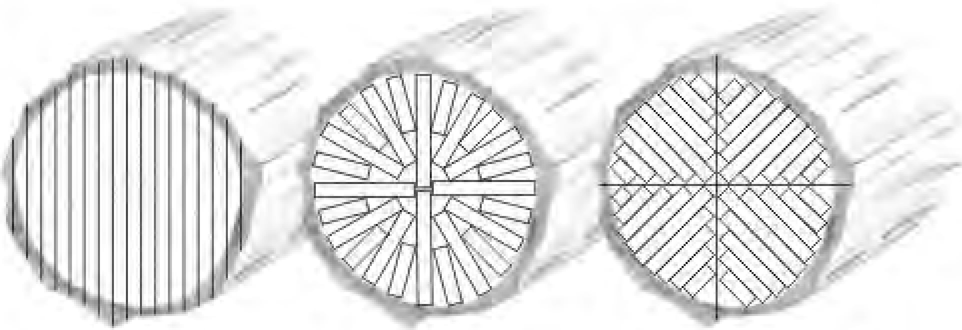
TUNE-UP STRATEGIES	**Storm window over single-pane original window**	**Double-pane thermal replacement of single-pane window**	**Low-e glass double-pane thermal replacement of single-pane window**	**Low-e glass double-pane thermal replacement of single-pane window with storm window**
ANNUAL ENERGY SAVINGS	**722,218 Btu**	**625,922 Btu**	**902,772 Btu**	**132,407 Btu**
ANNUAL SAVINGS PER WINDOW**	**$13.20**	**$11.07**	**$16.10**	**$2.29**
SIMPLE PAYBACK	$50/$13.20 = **4.5 Years**	$450/$11.07 = **40.5 Years**	$550/$16.10 = **34 Years**	$550/$2.29 = **240 Years**

JOHN VAN PELT

*Cost of 3' x 5' window, installed
**Assuming gas heat at $1.09/therm

U-Value = A measure of air-to-air heat transmission (loss or gain) due to thermal conductance and the difference in indoor and outdoor temperatures

Source: Keith Haberern P.E., R.A.
Collingswood Historic District Commission



Plainsawn **Riftsawn** **Quartersawn**

PRESERVATION RESOURCES, INC

Bob Yapp-573-629-2226 or yapperman@msn.com

WINDOW & STORM PAINTING SPECIFICATIONS

Work Description

A) Preparation

A-1) Remove all paint from sashes, jambs, sills and interior stools. Remove the paint with either liquid strippers or infrared heat and carbide hand scrapers. DO NOT DRY SCRAPE. Always mist the paint with water before carbide scraping. Do not excessively heat the wood or it will produce lead fumes over 600 degrees or scorch the wood. If using a standard heat gun, it is not necessary to heat the paint very long. After lightly heating the paint go to another sash or jamb. This allows the heated paint to cool down making removal of the water misted paint easier. Stage the paint removal, except jambs/sills/stools either off-site or outside the building, on the grounds. Before scraping, all areas on the ground must be tarped off and all windows must be closed. Dispose of all paint debris according to local regulations. Always wear a double filtered respirator rated for lead fumes as well as safety glasses.

B) Wood Repairs

B-1) Repair any rotted broken or cracked siding and trim with like material and/or architectural epoxies. All epoxy wood repairs to be made with both LiquidWood & WoodEpox by ABATRON 262-653-2000 or www.abatron.com.

C) Hand Washing

C-1) All bare wood should be hand washed with TSP and water. Use ¼ cup of TSP for every gallon of water and scrub the siding. This should then be rinsed with a hose without a spray nozzle.

D) Moisture

D-1) Before any primer or paint is applied on the wood, you must test the wood to be sure the moisture content does not exceed 15%. The only way to determine this is with a moisture meter. All house painters should have one of these meters. Painting wood above 15% moisture can knock 5 to ten years off the life of the paint job. Power washing is an automatic prescription for paint failure and is not allowed. The high pressure drives moisture deep into the wood and it can take as long as six months to dry down to 15% moisture.

E) Priming

E-1) Prime all bare wood surfaces only with Benjamin Moore "Moorwhite" exterior alkyd oil primer. Latex primer does not bite into the wood and condition it properly for caulk and topcoats. This should be applied by brush, not spray. Cover all areas not to receive paint to assure no dripping or spilling on these surfaces.

F) Caulking

F-1) Use a paintable, acrylic/latex caulk with silicon. Imagine your house under Niagara Falls. Caulk all areas the cascading water can penetrate, but don't caulk where it can't.

G) Two Top Coats

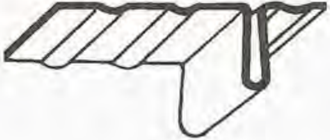
G-1) Brush-on two coats of Benjamin Moore, MoorGlo semi-gloss, acrylic latex as topcoats to all wood surfaces. Color determined by owner.

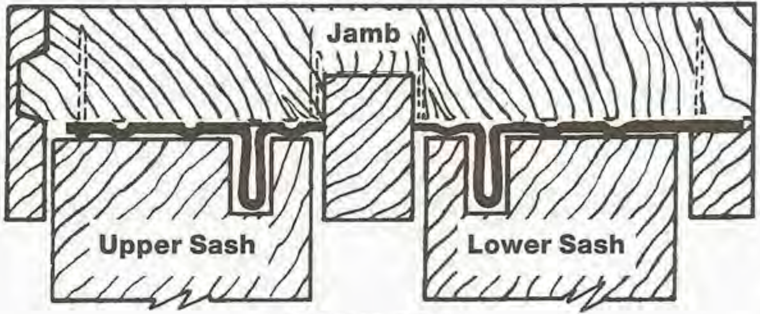
H) Paint Maintenance

H-1) A paint job must be maintained on a yearly basis. Look around the house to see if any paint is failing. Paint failure, on a properly painted house, can be caused by things such as exhaust fans not sealed properly, leaky gutters or roof problems. Correct the moisture problems first, then scrape, prime and paint the failed areas.

COPYRIGHT 2007- PRESERVATION RESOURCES, INC

M42 (.018) double
flat





Jamb Section

Zinc
Upper & Lower
Sides—Corrugated
$^1/_8$" rib x $^7/_{16}$" high
$^3/_8$" flange (.018)

4C $1^3/_8$" wide
7C $1^3/_4$" wide
9C 2" wide
10C $2^1/_4$" wide
11C $2^1/_2$" wide

THE RIGHT COMBINATION FOR SAVING MONEY.

Marvin's Combination Windows are handsome companions to our E-Z Tilt Double Hung, Magnum Double Hung and Glider windows.

Combinations let you quickly change your windows with the seasons. The self-storing screens and storm panels can be removed from the inside in seconds for easy cleaning.

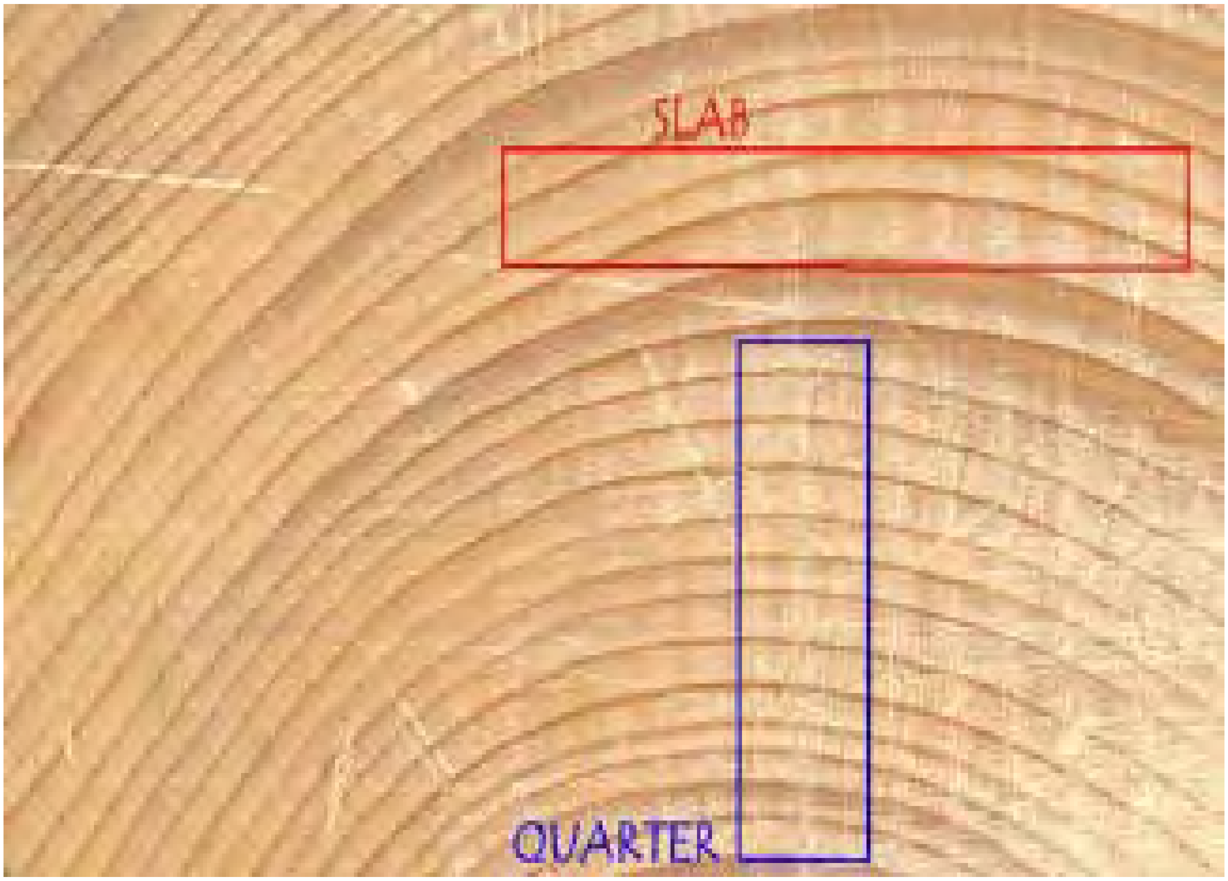
Strong wood frames offer sturdy durability. A weatherstripped wood crossbar provides strength and energy efficiency.

Marvin wood combinations are available primed or with Marvin's factory cured finish. Finish comes in four standard colors and 50 standard optional colors.

Extruded aluminum combinations are available for Clad Double Hungs and Clad Gliders.

For options, details, sizes and energy information, see page 81.

WOOD & ALUMINUM
COMBINATIONS.


SLAB
QUARTER

The Vinyl Lie

By Gary Kleier

Every day unsuspecting owners of historic homes, believing they are actually making an investment in their home, succumb to the vicious lies of an unscrupulous industry. Unfortunately, most will never know it. Most will never see the immediate undermining of their property value or the long term destruction of the structure of their house. And what is this vicious lie? Vinyl siding. Vinyl siding installed over wood siding. And the most vicious lie is that it will improve the property value of an historic house.

Debunking the lies

Lie number one: Vinyl siding will increase the value of your home.
As an architect involved in numerous historic restorations, I am frequently asked to evaluate an historic house prior to purchase. In virtually every case where vinyl siding has been used to cover original wood, the buyer wants to know the cost of having the vinyl removed and the original siding restored. In every case the same question comes up; "Why would they desecrate an historic house in this manner?"

Increasingly people across America are understanding the value of our historic properties. Like antiques, the closer it is to original the higher is its value. Frequently, the buyer not only sees vinyl siding as decreasing the value of the house, but wants the seller to pay for its removal. This removal and repair of the original wood siding is normally as expensive as the original installation of the vinyl siding.

Lie number two: Vinyl siding will make your house maintenance free.
There is no such product! Every material, every installation requires maintenance!
Vinyl siding installations require significant caulking, around windows, at corners, around doors, anywhere a "J" channel is used to terminate a run of siding. I have never seen a vinyl siding installation where caulking is installed in accordance with the manufacturer's instructions. Even the very best caulking, when improperly installed, will fail within a few years. And when it does, water will enter. Time to do some maintenance.

Vinyl siding is secured to the house by a nail or staple driven through a tab. This tab is designed not only to hold the siding to the house, but to allow it to move as it expands and contracts with temperature. If the fastener is too tight, the siding may buckle in the heat or break in the cold. This will usually result in the siding coming off the house in a windstorm. This rarely happens immediately. Usually it occurs a year or two after the installation, and after the warranty has expired. In addition, since the higher areas of the house are subjected to more wind, that is where the damage is most likely to occur. More maintenance, and maintenance the average homeowner cannot do.

Vinyl siding commercials will show you how the siding can withstand a blow from an object like a hammer. What they do not tell you is that the longer siding is on the house the more brittle it will become. Ten years later, that same piece of siding, exposed to the elements, may crack or even shatter under the same blow. A blow from a tree limb or from a ball and you have more maintenance.
In short, vinyl siding is not maintenance free.

Lie number three: You will never have to paint again.
Maybe we shouldn't call this a lie. The truth is, you never can paint again. Even the best vinyl siding will fade. The deeper the color, the faster it will happen and the more noticeable it will be. In 10 to 15 years vinyl siding will show a significant change in color.

Vinyl siding will also become dingy through an accumulation of dirt. Contrary to what the commercials would have you believe, we are talking about dirt that spraying with a garden hose will not remove. In ten to fifteen years many home owners are dissatisfied with the dingy look of their siding and want to do something to restore it. (Sounds like maintenance, doesn't it?)

Sorry folks, not a lot you can do. Scrubbing the siding with soap and water (not just spraying it) will help a little. While that is faster than painting, it is far less satisfactory. Painting, however, is totally out of the question. At this time there are no paint manufacturer's I am aware of that will guarantee their paint over vinyl siding. Within a few years the paint will begin to peal.

By the way, if you do decide to wash your vinyl siding, never use a high pressure sprayer. The high water pressure may force water around the siding and through bad caulk joints into your house. Further, the high pressure may loosen the siding, or even remove whole sections that are already loose.

Lie number four: Vinyl siding will save you money.

In spite of what the manufacturers would have you believe, the life expectancy of a high-quality vinyl siding installation is approximately 20 to 30 years. The life expectancy of a high-quality, professional paint job is approximately 10 to 15 years. Since the vinyl siding installation will cost approximately twice that of painting, there is virtually no savings.

Should you choose to remove the old vinyl siding at the end of its life, you now incur the cost of removal as well as the cost of the new installation. At this point painting has become far less expensive.
Now that we've discussed what they do tell you, let's talk about what they don't tell you, and hope you will never discover.

Destruction of details

When you look at an historic frame house, you will notice a significant amount of detail. This may include moldings and brackets at the eaves, details in the siding such as fish scales or beaded edges, headers over windows and doors, and shadow lines at window and door trim. Virtually all of this is covered up when vinyl siding and vinyl eaves are added to a house. In addition, eave details such as brackets and moldings are frequently removed to facilitate the installation of the vinyl material. In short the installation of vinyl siding and eaves significantly reduces the character of the house.

To the individuals seeking to purchase an historic home, the installation of vinyl siding and eaves has not improved the value of the house but rather has destroyed the character for which he/she is looking. Therefore, the value of the house has been significantly reduced.

Destruction of Walls.

In a typical historic house of wood frame construction a wall would normally be composed of the following: plaster on wood lath, the wood studs, exterior sheathing, and wood siding. While these materials may seem solid to us, water vapor easily moves through these materials and escapes from the house during the winter months.

During the installation of vinyl siding a layer of styrene insulation board is applied over the wood siding, and the vinyl siding is applied to that. This insulation board forms an effective barrier to the passage of water vapor, thereby trapping it within the wall. During the winter months this water vapor will condense to liquid water and began rotting the wood materials. Over a period of years the structural integrity of the exterior walls can be completely destroyed. Further, the presence of deteriorating wood has been shown to attract termites and other wood attacking insects.

In summary, it is my opinion based on my experience as an architect that vinyl siding is not maintenance free, and it is not less expensive than painting. It is also my opinion that vinyl siding destroys the aesthetic quality of an historic house, and decreases its value, and can, over time, destroy the structural integrity of the house.

Like many products, vinyl siding has a place. It works adequately in inexpensive new construction where proper precautions are taken to prevent water damage. However, when the industry tries to sell this product as a maintenance free improvement to older homes, they are doing the public a great disservice. And when it comes to historic homes, they are costing you money.

Gary Kleier is the resident Old Louisville Architectural Conservator. He lives on Floral Terrace and is one of those folks who was instrumental in the landscaping and beautification of that little jewel of a walking court between Sixth and Seventh Streets. Gary specializes in restoration architecture and architectural forensic services and has a wide range of talents which are described on his own web site at http://www.kleierassociates.com/. This is reprinted with his permission.

PRESERVATION RESOURCES, INC
Bob Yapp-217-474-6052
yapperman@msn.com
www.bobyapp.com
Updated 10-10-2011

A COST BREAKDOWN FOR WINDOW RESTORATION V.S. WINDOW REPLACEMENT

The following is a break down of the costs to **completely** restore & weather- strip two original wood sashes in a double-hung window opening, including a new wooden storm window. It is important to note that often, total paint removal, epoxy repair, all new glass, new interior stop-molding, etc. isn't needed.

Window sash and jambs that are **completely** restored have a life of another 100 years with painting every 12 to 20 years depending on conditions. With the wooden storm they also exceed the u-value of a comparable replacement as described in the next paragraphs.

Replacement with two new wooden sashes in an original 33" X 67" double hung jamb unit with four, true divided lights on the top and one light on the bottom will run $800 to $1,200 for single pane with no storm window. Double paned/insulated glass in the new wood sash would raise the cost to $1,000 to $1,400 per unit installed with no storm.

Commercial grade, double paned aluminum sashes with fake divided light muntins and spring balances in the same size opening will run $1,200 to $2,000 with no storm.

The restoration labor time estimates below are based on a worker who is highly experienced in this type of window restoration process. They are also listed as accumulated time, not consecutive time. In other words, if you apply primer and two topcoats, there is dry time in between when other work is performed.

(A) is a traditional wood storm with putty glazed, fixed glass. (B) is a traditionally constructed wood storm with removable glass and screen from inside the house or building.

NOTE: These numbers do not include overhead, profit or travel time etc..

(A)

Material & Labor to Restore & Weatherize a Double Hung Window Unit with a 33” X 67” Opening. The Top Sash is 4, True Divided Lights & the Bottom Sash is 1 Light. Includes 1 New Traditional Wood Storm Window

Materials (Actual cost with no markup)

What	Description	Cost
Storm Window	Factory primed traditional wood storm 33” x 67”	$200.00
Glazing Putty	Linseed oil based glazing compound	$1.03
Weather Stripping	Rigid metal with EPDM rubber tube for storm & #199S-"Santoprene" T-slot rubber tube for bottom rail of lower sash, meeting/check rail & top rail of upper sash	$20.50
Weather Stripping	Dorbin ribbed/slotted strip metal double hung track system four-1-3/8"x 34", #4C	$14.17
Glass	Double strength glass, 4 lights per upper sash & 1 light on lower @ $2.00 per square foot	$36.00
Storm Hardware	Traditional storm hangers and 2 hook & eyes	$4.50
Sandpaper	100 grit 5” sanding disc- 2 pieces	$.30
Epoxy	Architectural epoxy wood filler-liquid & putty	$4.50
Tack Cloths	For cleaning bare wood surface	$.29
Glazing Points	For setting glass	$.20
Caulk	1 tube, Acrylic Latex caulk with silicone for bedding glass	$1.00
Sash Cord	24'-1/4" cotton sash cord with nylon core	$2.50
Moldings	New interior finish stop & parting stop	$8.50
Primer	Alkyd oil based primer with linseed oil-sash only	$2.25
Paint	Acrylic latex semi-gloss, 2 top coats-sash & storm	$3.50
Total Material Costs with Traditional Wood Storm		**$299.24**

Labor @ $35 Per Hour ($25 p/h plus employment overhead)

Task	What	Time	Cost
Sash removal	Remove sash from jamb, take off all hardware	.50 hrs	$17.50
Paint & Glazing Removal	Infrared paint removal from jamb. Infra red paint removal from glazing from sash	2.00 hrs	$70.00
Repair Sash	Re-pin and repair with wood or epoxy	1 00 hrs	$35.00
Clean & Prime all	Tack-off, clean & oil prime	.75 hrs	$26.25
Glaze	Set glass in caulk with points & install linseed based glazing putty	.75 hrs	$26.25
Paint Sash, Storm & Jamb	Apply and cleanup two top coats	1.00 hrs	$35.00
Hardware	Buff or wire wheel & lacquer or spray paint.	.25 hrs	$8.75
Weather-Stripping	Cut sash slots & install weather-stripping-sash & storm	1.00 hrs	$35.00
Hang Storm & Sash	Re-hang two sashes & one storm with hardware	2.00 hrs	$70.00
Total Labor Costs with Traditional Storm		**9.25 hrs**	**$323.75**
Total Material Costs with Traditional Storm			**+$299.24**
Total Window Restoration Costs with Traditional Storm			**$622.99**

NOTE: This is absolute worst-case/total restoration & weatherizing scenario

(B)

Material & Labor to Restore & Weatherize a Double Hung Window Unit with a 33” X 67” Opening. The Top Sash is 4, True Divided Lights & the Bottom Sash is 1 Light. Includes 1 New Screen/Storm Combo Wooden Storm Window

Materials (Actual cost with no markup)

What	Description	Cost
Storm Window	Factory primed combination storm/ screen wood storm 33” x 67”	$250.00
Glazing Putty	Linseed oil based glazing compound	$1.03
Weather Stripping	Rigid metal with EPDM rubber tube for storm & #199S-"Santoprene" T-slot rubber tube for bottom rail of lower sash, meeting/check rail & top rail of upper sash	$20.50
Weather Stripping	Dorbin ribbed/slotted strip metal double hung track system four-1-3/8"x 34", #4C	$14.17
Glass	Double strength glass, 4 lights per upper sash & 1 light on lower @ $2.00 per square foot	$36.00
Storm Hardware	Traditional storm hangers and 2 hook & eyes	$4.50
Sandpaper	100 grit 5” sanding disc- 2 pieces	$.30
Epoxy	Architectural epoxy wood filler-liquid & putty	$4.50
Tack Cloths	For cleaning bare wood surface	$.29
Glazing Points	For setting glass	$.20
Caulk	1 tube, Acrylic Latex caulk with silicone for bedding glass	$1.00
Sash Cord	24'-1/4" cotton sash cord with nylon core	$2.50
Moldings	New interior finish stop & parting stop	$8.50
Primer	Alkyd oil based primer with linseed oil-sash only	$2.25
Paint	Acrylic latex semi-gloss, 2 top coats-sash & storm	$3.50
Total Material Costs with Screen/Storm Wooden Combo Storm Window		**$349.24**

Labor @ $35 Per Hour ($25 p/h plus employment overhead)

Task	**What**	**Time**	**Cost**
Sash removal	Remove sash from jamb, take off all hardware	.50 hrs	$17.50
Paint & Glazing Removal	Infrared paint removal from jamb. Infrared paint removal from glazing from sash	2.00 hrs	$70.00
Repair Sash	Re-pin and repair with wood or epoxy	1 00 hrs	$35.00
Clean & Prime all	Tack-off, clean & oil prime	.75 hrs	$26.25
Glaze	Set glass in caulk with points & install linseed based glazing putty	.75 hrs	$26.25
Paint Sash, Storm & Jamb	Apply and cleanup two top coats	1.00 hrs	$35.00
Hardware	Buff or wire wheel & lacquer or spray paint.	.25 hrs	$8.75
Weather-Stripping	Cut sash slots & install weather-stripping-sash & storm	1.00 hrs	$35.00
Hang Storm & Sash	Re-hang two sashes & one storm with hardware	2.00 hrs	$70.00
Total Labor Costs with Storm/Screen Wood Combo Storm Window		**9.25 hrs**	**$323.75**
Total Material Costs with Storm/Screen Wood Combo Storm Window			**+$349.24**
Total Window Restoration Costs with Storm/Screen Wood Combo Storm Window			**$672.99**

NOTE: This is absolute worst-case/total restoration & weatherizing scenario

Keeping Original Materials is Sustainable & Economic Rehab

1. The vast majority of heat loss in homes & buildings is through the attic/roof not windows.

2. Adding just three and one-half inches of fiberglass insulation in the attic has three times the R factor impact as replacing a single pane window with no storm window with the most energy efficient window.

3. Properly repaired historic windows have an R factor nearly indistinguishable from new, so-called “weatherized” windows.

4. Regardless of the manufacturers’ “lifetime warranties,” 30 percent of the windows being replaced each year are less than 10 years old.

5. One Indiana study showed that the payback period through energy savings by replacing historic wood windows is 400 years. While this is the high end, you can expect paybacks from 40 to 400 years. In the construction industry this is considered no payback.

6. Many old homes and buildings were built more than a hundred years ago, meaning their windows were built from hardwood timber from old growth forests.

Environmentalists go nuts about cutting down trees in old growth forests, but what’s the difference? Destroying those windows represents the destruction of the same scarce resource.

7. Finally, the diesel fuel to power the bulldozer consumed more fossil fuel than would be saved over the lifetime of the replacement windows.

The point is this: Sustainable development is about, but not only about, environmental sustainability.

• Repairing and rebuilding the historic windows would have meant the dollars were spent locally instead of at a distant manufacturing plant. That’s economic sustainability, also part of sustainable development.

• Maintaining the original fabric is maintaining the character of the historic neighborhood or institutional environment. That’s cultural sustainability, also part of sustainable development.

Note: This is a portion of a speech given by - *Donovan D. Ripkema a principal partner with Place Economics, a Washington, D.C.–based real estate consulting firm.*

BASIC TOOLS & SUPPLIES
FOR DOUBLE-HUNG, WOOD WINDOW RESTORATION

PRESERVATION RESOURCES, INC
Bob Yapp-217-474-6052 or yapperman@msn.com

TOOLS

Window Removal
* Window zipper
* Utility knife
* Utility knife blades
* Numbered die stamps (to mark for replacement in correct jamb)
* Screw drivers
* Small, flat ply bar
* Spray bottle for water
* Sharpie to mark sashes & parts

Restoration
* Speed Heater – infrared heating devise to remove lead paint safely
* Spray bottle - to mist wood before scraping
* Carbide scraper - for 2” blades
* Profile scrapers & pull/hook shave scrapers
* 1.5” stiff, bent putty knife for applying glazing putty
* Bastard file to sharpen profile, steel scraper blades
* Orbital Palm Sander, 5” with dust bags or a sanding block
* Wood chisels
* Sharpening stone & oil
* Large garbage can
* Hammer & nail set
* C-clamps, Quik-Grip Clamps- lots
* 3/4” Bar Clamps- lots
* 2 1/2”, quality, angled bristle, trim paint brushes. One set for oil & one for latex
* Exhaust fan for fumes
* Double filtered face mask with lead cartridges
* Compressor with blower
* Bench grinder with wire wheel and/or cotton buffing wheel to clean-up hardware
* Caulk guns
* Table saw with thin kerf blade or router with slot bit for slotting edges for Dorbin system
* Off-set, dovetail saw
* HEPA vacuum

SUPPLIES
* Carbide scraper blades. 2” - lots of them
* Profile steel scraper blades. Several different profiles (curved etc.)
* 80, 100 & 120 grit, orbital sticky disks with dust holes
* Abatron Liquid Wood & Wood Epox - two parts each
* Glazing compound & glazing points. (no DAP! Use compound with linseed oil)
* #6 hot dipped, galvanized casing/finish nails (used as new mortise & tenon pins)
* Slotted wood screws & cup washers for re-installing parting and interior stop
* Tack cloths
* Acrylic latex, siliconized caulking
* Boiled linseed oil
* Primer - alkyd oil based
* Paint thinner & glass cleaner
* Brush cleaner - the type that spins around.
* Acrylic latex paint or oil enamel - color to be determined
* Aerosol spray paint - matte black for pulleys etc
* Dorbin Metal Window Weather-Stripping System.
* Storm window weather-stripping - from Dorbin or hardware store.
* Boxes of cotton rags & paper towels

PRODUCT DATA SHEET

GLAZOL® ELASTIC GLAZING COMPOUND

DESCRIPTION

Superior to putty, Glazol may be used for glazing wood or metal sash, setting plumbing fixtures and filling cracks and nail holes. Glazol remains pliable, does not chip or crack and has year-round workability. Glazol forms a “cushion” against shock and vibration when used in replacing broken glass and is ideal for use as a knife-grade compound.

SURFACE PREP

Remove old putty and make sure surface is clean and dry. Air and surface temperature should be above 40°F. For best results, window frames should be primed with a good oil-base primer. For bedding glass, if desired, soften Glazol slightly with a small amount of mineral spirits. When installing glass into frame, secure with glaziers points or clips.

APPLICATION

Glazol is ready to use. Place Glazol in hands and roll to warm and soften. Apply with putty knife using flat side of blade against material, not the bottom edge. Press Glazol onto sash, filling height and width of L-shaped recess completely. Smooth to an angle that sheds rain. For best results, Glazol should be painted after it is applied. When used under latex paint, allow Glazol to cure for several days before painting. Before painting with oil-based paint, allow Glazol to dry overnight.

IMPORTANT

Glazol is not for use on insulated glass units with an organic seal, plastic window panes, or any window pane over 48” in any direction. To minimize skinning of unused material, cover with aluminum foil or plastic wrap before replacing lid.

CLEAN-UP

Before setting, excess material may be removed with mineral spirits. After setting, material must be cut or scraped away. Clean tools with UGL Fastrip Brush Cleaner or mineral spirits.

CAUTION

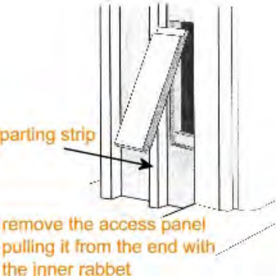
To avoid spontaneous combustion during temporary storage, soak soiled rags and wastes immediately after use in a water-filled closed metal container.
Do not take internally. Close container after each use.
KEEP OUT OF THE REACH OF CHILDREN

AVAILABILITY

UGL Glazol Elastic Glazing Compound is available in half-pint, pint, quart and gallon containers. Glazol is sold in hardware stores, home centers, paint stores and lumber-yards.

LR 2/99

United Gilsonite Laboratories:
Corporate Headquarters
1396 Jefferson Avenue
Dunmore, PA 18509
Tel: 1-800-272-3235
www.ugl.com


parting strip
remove the access panel
pulling it from the end with
the inner rabbet

pull the counter weight
and broken cord out
of the casing

An Analysis of the Thermal Performance of Repaired and Replacement Windows

ROBERT SCORE AND BRADFORD S. CARPENTER

Data and analysis of in-situ thermal monitoring reveal that the repair of aging steel windows offers the opportunity to retain historic building fabric and secure a level of energy performance that can match or exceed that of modern aluminum-framed replacement windows.

Fig. 1. Southwest elevation, Lafayette Building, Vermont Avenue and H Street NW, Washington, D.C. The building's neoclassical exterior has regularly placed, double-hung steel windows. All images by authors.

Introduction

As federal buildings that were constructed to support the expanding role of the U.S. government and the war effort during the late 1930s and 1940s reach the end of their useful lives, their caretakers are embarking on rehabilitation and modernization projects to meet modern and often greatly expanded performance standards. The original window systems often lack the construction detailing and other characteristics needed to provide a level of performance acceptable for modern office space, such as humidification and energy performance. Many of these window systems have suffered years of neglect and deferred maintenance and owe their longevity largely to the durability of original materials, the robustness of the original construction, and layers upon layers of paint.

A common and as-yet unresolved issue is the final fate of these windows. More often than not, building-renovation projects call for the replacement of original windows with modern replicas rather than the rehabilitation of the existing windows, often under the guise of improving energy performance or occupant safety (blast resistance), with little thought given to the embodied energy in the existing windows or the whole-life energy commitment of the new product. This consideration becomes even more crucial when considering the demands of achieving LEED ratings in a renovation project.

One structure currently being considered for such renovation is the Lafayette Building, a federal office building located in downtown Washington, D.C. (Fig. 1). Originally housing the Export-Import Bank of the United States and more recently the Department of Veteran Affairs, the Lafayette Building has had a long and storied history of federal use and is being proposed for a significant modernization project. Built in 1940 and designed by the Chicago architectural firm of Holabird and Root, it is a National Historic Landmark.

The building has nearly 1,200 windows along the primary facades and a single interior light court. The windows are constructed of steel shapes and were installed in a double-hung configuration (Fig. 2). The windows are approximately 54 inches wide and 72 inches high and have single glazing without intermediate muntins. Many of the windows exhibit paint flaking and some surface rusting, while others have more significant rusting, particularly at the base of the jambs (Fig. 3). The windows are currently operable and have counterweights in concealed weight pockets. This paper discusses a brief study comparing two options for treating the windows during the planned repair program.

Performance Requirements and Design Options

The Lafayette Building is scheduled to undergo a comprehensive renovation, including upgrades to the mechanical and electrical systems, reprogramming and renovation of interior spaces, and renovations to all exterior facades, including upgrading the windows for blast resistance in accordance with requirements of the General Services Administration (GSA), the building owner. In order to assist the building owner in selecting the most appropriate treatments for the windows, an overall design program for the windows was developed. It identified the performance requirements for the windows, including the following:

- provide blast resistance per GSA requirements.

Fig. 2. View of an unrepaired steel-framed window on the east elevation of the Lafayette Building. Note the loss of paint coatings and corrosion of the built-up steel frame.

- preserve the original window sash and frames where possible, including original materials, configuration, dimensions, sight lines, and profiles, as well as the clarity and reflectivity of the original glazing. Any replacement windows must match existing window configuration, dimensions, sight-lines and profiles, as well as the clarity and reflectivity of the original glazing.
- improve energy performance and reduce air infiltration and water penetration at the windows.
- provide windows that are easily maintainable.
- provide a cost-efficient treatment.

These performance requirements were used to develop design options, evaluate the technical options, and then help select the most appropriate treatment. Based on the existing conditions and the design requirements, the following two options were identified:

Option 1. Repair the existing steel windows and provide a supplemental interior storm window that meets the blast requirements and also improves the thermal performance of the existing window. The window frame would not be removed from the window opening during repair. The sash would be removed, repaired, and reinstalled; all steel would be prepared to SSPC-SP3, the standard specification for power-tool cleaning of steel surfaces by the Society for Protective Coatings (SSPC), and given two coats of acrylic enamel paint. The exterior light of glass, a single pane of clear float glass, would be retained where possible. Blast resistance requires that the original sash be fixed shut. A blast-resistant aluminum-framed storm window would be installed on the interior face of the window, approximately 3 inches from the face of the glass in the lower operable sash. The storm window would include a single laminate sheet of glazing that includes low-E glass with a high solar heat-gain coefficient (SHGC) to provide improved passive solar heat gain.

Option 2. Replace the existing windows with new blast-resistant, thermally broken, aluminum-framed windows with 1-inch insulating glazing. The new windows would closely match the existing configuration, dimensions, profiles, and sight lines of the original windows. Original windows would be removed from the opening; interior finishes would be removed from the perimeter of the window; and modifications made to the perimeter substrate and trim to allow installation of mounting clips to secure the replacement windows to the masonry back-up. Interior finishes would then be repaired to conceal the anchorages. The replacement-window insulated-glass unit would include low-E glass that has a high SHGC glazing, which would minimize passive solar heat gain. The operable sash would be fixed shut to meet blast requirements. More historically accurate steel replacement windows were not considered for this option as they were cost prohibitive compared to restoring the existing windows as described in Option 1 and offered little thermal-performance improvement over the existing windows.

Window Mock-ups

To assist in evaluating the two options, in-situ mock-ups of both options were installed in the building, allowing for a review of aesthetic impacts, constructability, and cost, as well as testing and monitoring of the thermal performance.[1] These mock-ups were constructed using the same materials and treatments proposed for the actual construction in order to provide accurate results for comparison (Figs. 4 through 7). Mock-ups were installed in the east elevation of the building at the eleventh-floor level based upon input from the owner and design team. The location on the east elevation of the eleventh floor, a height roughly equal with the rooftops of surrounding building, allowed a relatively unobstructed solar exposure and conditions that vary between the diffuse solar radiation of north exposures and the intense solar radiation of south and west exposures.

Performance Monitoring

The monitoring study was undertaken in 2006 by Harboe Architects and Simpson Gumpertz & Heger, Inc. (SGH). The purpose of the study was to document and evaluate the performance of a repaired window and a proposed replacement window under similar exposures and to provide direction and feedback to the design team for incorporation into the rehabilitation program. The monitoring system allowed for the recording of surface and air temperatures, as well as relative humidity for multiple locations.

The two mock-up windows were monitored between March and July 2006. Though the duration was limited to just over three months by program and tenant constraints, sufficient data was gathered to compare the performance of the mock-ups over a significant range of exterior conditions. This recorded performance allowed for the extrapolation of performance outside of the range of measured interior and

Fig. 3. View of a steel window sill on the east elevation of the eleventh floor. Note the significant corrosion of the steel frame at the sill-to-jamb corner.

Fig. 4. Sill of the replacement window.

Fig. 5. Sill of the repaired window.

exterior conditions. Though relatively limited in scope and duration, this study provided valuable real-world performance information, which was used to help guide the design team in the evaluation of potential treatment options. Additional analysis using computer simulation and other analytical tools could be used to further develop performance characteristics, such as evaluating other exposures and other glazing options.

Setup and procedure. Surface temperatures, ambient conditions, and the heat gain and loss experienced through each window were measured in order to fully evaluate and compare the thermal performance of the two mock-ups. A sealed chamber was installed on the interior face of each specimen window. The chambers were insulated, and the interior surface of each chamber (facing the window) was covered with a reflective white coating to minimize unwanted solar heat gain within the chamber. An air inlet was installed at the top of the chamber, and an outlet with an electric fan was installed at the bottom to ventilate the chamber with a known quantity of air. The air inlet and outlet temperatures were measured using thermistors and recorded on a data logger. The change in temperature between the inlet and outlet was used to calculate the heat gain or loss through the window, as described below.

Both window mock-ups were instrumented with surface-temperature sensors (thermocouples) at critical frame and glass locations where maximum and minimum surface temperatures are expected to occur, such as at the center of the glass, the horizontal meeting rail, and perimeter frame locations. Relative-humidity and air-temperature sensors were also installed within the air cavity between the storm glazing and the exterior window to evaluate condensation potential within the storm cavity (Figs. 8 and 9). Ambient conditions were recorded on the building's exterior and interior, including the pressure differential between the interior and exterior conditions, using relative-humidity and temperature sensors and a digital pressure gauge. Data points for accessible locations were recorded on a laptop computer, while inaccessible data points (temperature and relative humidity within the storm of the rehabilitation window) were recorded on stand-alone data loggers.

Heat-flow calculations. Following data collection, raw temperature and humidity data were used to calculate the heat loss or gain through each window. Window heat-flow calculations were made by comparing the temperature of the air entering the insulated chamber to the temperature of the air leaving. The humidity ratio was calculated using interior temperature and relative humidity, allowing calculation of the change in enthalpy of the air as it entered and exited the chambers.[2] Formulas for air properties are found in the *ASHRAE Handbook: Fundamentals* 2005.

This analysis method produces representative heat flows for comparison; however, the method has some error because it does not account for the dynamics of constantly changing boundary conditions. Also, the data comparisons produced anomalies when one window heat flow indicates a thermal loss or gain while the other window indicates the opposite. The heat-flow analysis compares only the loss at one window to the simultaneous loss at the other window and the gain at one window to the simultaneous gain at the other window, while ignoring the time periods when the windows indicated opposing flows, which is limited to less than 10 percent of the data where flux approaches equilibrium between gains and losses. Overall, the effect of these two minor simplifications on the overall comparative thermal analysis was considered negligible.

Results

The analytical review of the thermal performance of the two mock-up windows was a complex process with many obvious variables, as well as several that were not so obvious. The main variables considered were heat gains and losses due to conduction through the window frame and solar heat gain (radiation) through the glass, as these were the most significant mechanisms for heat transfer through the window assembly. The mock-up apparatus was designed to determine heat gain and loss, as noted above. However, it was not capable of isolating conductive heat loss or gain from solar heat gain without additional processing of the data. In order to isolate conductive losses from solar gain, the data indicating heat loss was isolated from the data indicating solar gain (i.e., daytime conditions with solar exposure) where possible. As most conductive heat-gain opportunities during the monitoring were during the warmer, sunny hours of the day, conductive heat gain was unable to be isolated from solar heat gain. Therefore,

Fig. 6. Head of the replacement window.

Fig. 7. Head of the repaired window. Note the similar sight lines but missing articulations and accessories of the replacement window when viewed in conjunction with the repaired window.

conductive performance is best measured during nighttime conditions during colder temperatures (i.e., night conditions with no solar exposure and large thermal gradient across the mock-up). Total heat gain and loss through the windows were then calculated (Table 1).

Solar heat gain. As expected for the east-facing windows, solar heat gain is the largest source of heat gain for the window system and spikes for both window mock-ups in the late morning when the windows are most exposed to sunlight. Heat gain tapers off in the afternoon as direct solar exposure decreases due to indirect diffuse solar exposure. There was a significant difference in peak heat gains between the two mock-up windows (Fig. 10).

Calculations show that the daily peak solar heat gain for the repaired window was approximately 35 to 40 percent greater than for the replacement window during the coldest week of monitoring. In addition, the net heat gain also included reductions in heat gain due to conductive heat loss through the window unit, which was greater for the replacement window, as noted below. As expected, when comparing the measured performance during warmer weather, the difference between the peak heat gains of the two windows was smaller (Fig. 11).

Calculations reveal that the peak solar heat gain for the repaired window was only 10 to 25 percent greater than that of the replacement window during the warmest week. A comparison with the solar gains during the coldest week illustrates the improved conductive heat gain and loss performance of the repaired window mock-up with respect to the replacement window mock-up. Heat loss was calculated to be 4.0 kW for the replacement window and 1.5 kW for the repaired window during the warmest week. When daytime solar heating conditions (net heat gain for both windows) were considered, a heat gain of 150.6 kW for the replacement window and 169.3 kW for the repaired window was calculated during the coldest week. The net heat gain/loss for the week (excluding conditions where one window is experiencing heat gain or loss and the other window is experiencing the opposite) for each window was found to be 146.6 kW gain for the replacement window and 167.7 kW gain for the repaired window. The repaired window experienced approximately 15 percent more heat gain during the warm week.

Conductive and radiation heat loss and gain. Conductive heat loss or gain occurs through the frame of the window and was the primary mode of energy loss through the window-frame assembly. Radiation heat loss or gain occurs through the glazing assembly and was the primary mode of energy loss through the window. Conductive and radiation heat losses and gains are driven by temperature differential across the window and are easiest to measure during cold winter months, when the temperature differential across the window is greatest. However, conductive and radiation heat gains can occur during summer months when exterior temperatures are greater than the conditioned interior temperature. Since hot-weather conductive and radiation heat gains occur during the hottest part of the day when solar gain is peaking, it was not possible to separate solar and conductive gains through the window, and the data therefore were not separated in the analysis.

The coldest exterior temperatures were observed during the first week of monitoring. Temperatures were not as cold as typical peak winter conditions.[3] However, they provided adequate opportunity to measure window performance during cold weather. Heat-loss data was isolated from the heat-gain data, and the differences in the daily peak heat loss for each of the windows were compared for this cold week (Fig. 12).

As expected, heat-loss peaks occurred in the very early morning hours, before solar heat gain begins. The repaired window experienced 15 to 35 percent less heat loss through the window than the replacement window during the coldest week. Heat loss was calculated to be 121 kW for the replacement window and was 89.5 kW for the repaired window during the week. Considering daytime solar heating conditions (net heat gain for both windows) only, a heat

Table 1. Heat Gain and Loss Totals for the Two Mock-up Windows over a Testing Period of Approximately 12 Weeks

Specimen	Net Heat Loss (kW)	Net Heat Gain (kW)
Replacement Window	-419.1	994.6
Repaired Window	-296.9	1264.8

gain of 33.1 kW for the replacement window and 62.1 kW for the repaired window was calculated for the coldest week, a significantly smaller heat flux than with conductive losses alone. The net heat gain or loss for the week for each window (excluding conditions where the mock-ups are experiencing opposing heat flows) was found to be 87.9 kW loss for the replacement window and 27.4 kW loss for the repaired window. The repaired window experienced nearly 70 percent less heat loss during the cold week. It is important to understand that as the exterior temperature drops, the heat loss (and difference in heat loss) for the windows will increase and that this difference in performance would be expected to become more pronounced during typical peak wintertime conditions. Thus, the conductive gains during hot weather are inversely proportional to the losses.

Fig. 8. Interior view of the repaired window prior to installation of the interior chamber. Note the thermal and relative-humidity sensors are indicated with dots. Some sensors are installed on the repaired window, and others are installed on the storm sash, resulting in more sensor locations than on the replacement window.

Fig. 9. View of the replacement-window mock-up prior to the installation of the interior chamber. The temperature sensors are indicated with dots.

Discussion

The purpose of this study was to compare differences in thermal performance of the two window mock-up specimens under identical operating conditions. After analyzing the monitoring data, several trends became apparent, and they may impact the selection of the window-treatment option for the repair and replacement program. To better understand the results of the testing and monitoring, it is essential to have a general understanding of window performance. The pertinent performance factors and observations are discussed below.

Solar heat-gain performance. The most significant component of heat gain is solar heat gain through the window glazing. Several factors affect the solar heat-gain performance of windows, including the geometry and configuration of the window unit (such as the amount of clear window opening), its placement and orientation, the type of glazing and coatings used, and the amount of interior and exterior shading. Optimizing these characteristics to improve thermal performance can significantly improve building operating costs and occupant comfort.

Window configuration. The configuration and geometry of a window affects its solar heat-gain performance. For example, a window with a wide frame and numerous small lights separated by mullions and muntins has less glazing area available to capture solar energy. By contrast, a window in the same rough opening with a thin frame and one large light will have a greater proportion of glass-to-frame area and will allow more sunlight into the building interior. Both mock-up windows had similar construction, with large unobstructed glazing areas and narrow metal perimeter frames. Therefore, the difference in performance due to frame configuration and design was small.

Window orientation. Placement and orientation of the window with respect to compass direction is the root factor affecting solar gains. West- and south-facing windows experience the most significant gains, but some gain is possible in all directions from diffuse sky radiation. The majority of the windows at the Lafayette Building are on the east, west, and north elevations, with very few windows facing due south. Both mock-up windows faced east, and therefore the recorded data represents only one of the four possible orientations existing on the building, a limitation of the study scope and budget.

During the winter the low elevation of the sun at midday causes it to shine through south-facing windows, in addition to east-facing windows in the morning and west-facing windows in the afternoon. The resulting solar gains can help reduce heating costs during the winter. In the summer, when the sun is much higher at midday, the angle of incidence of the solar radiation is much sharper. Consequently, more solar radiation reflects off of south-facing windows than is transmitted to the interior. Overheating in summer therefore tends to occur more frequently at unshaded west-facing windows and, to a lesser extent, at east windows than at windows that face directly south. The desired amount of summer and winter solar heat gain is determined by the design of the mechanical system for the building. If the primary load on the building is heating during winter, then optimizing solar heat gain during winter months should dictate window-performance requirements.

Glazing coatings. The number and type of glazing layers and coatings will also affect the thermal performance of the

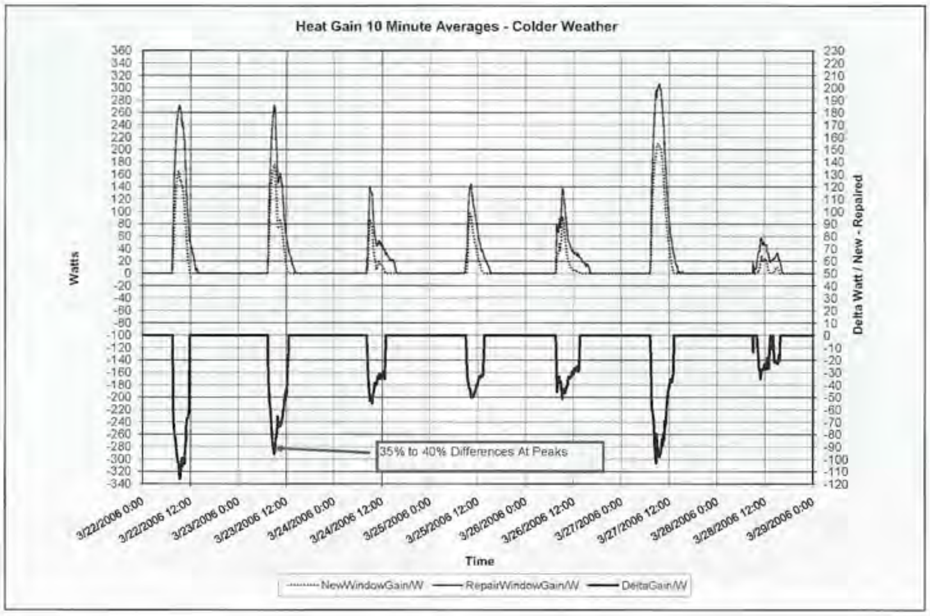


Fig. 10. Heat gain during the coldest week.

windows. For example, a double-glazed, insulated glass unit consisting of ordinary clear glass reduces solar gain by approximately 10 percent compared to a single-glazed window with the same glazing area. Since both mock-up windows included two layers of glazing, the glazing is not a differentiating factor. The addition of glazing coatings have a more significant impact. Low-emittance (low-E) coatings are microscopically thin metal or metallic-oxide layers or a film coating deposited on the surface of the glass (typically on a surface within the glazing cavity) to reduce the U-factor (the heat transfer through the glazing) by suppressing radiation heat flow.

The difference in solar heat gain between the repaired window and the replacement window is likely due to the location and type of glazing coating on the two window mock-ups, in addition to the configuration of the glass. The replacement window had a low-E coating with a relatively low solar heat-gain coefficient (SHGC) in the outer pane of glass. The low-E coating has a SHGC of 0.41, meaning that 41 percent of the solar heat gain is absorbed and transmitted through the glazing, while the rest is reflected back to the exterior. The repaired window has a low-E coating with a higher SHGC on the repaired window storm. This low-E coating has a SHGC of 0.83, meaning that 83 percent of the solar heat gain is absorbed and transmitted through the glazing. This difference in SHGC of the two glazing systems had a substantial effect on the solar heat gain measured in the two mock-ups. Adjusting the heat gains to offset the heating load during the winter or to minimize the cooling load in the summer can be achieved in either window treatment option, in part by the selection of the glazing coating.

If building-load calculations reveal that summer solar heat gain must be minimized, the solar heat-gain performance of the repaired window can be improved with some modification. The least invasive modification involves reducing the low-E coating on the storm window to reduce the solar heat gain. A second option for reducing solar gain through the repaired window would be to add a low-E coating on the inside surface of the exterior glass. The addition of a low-E coating would require replacement of the original glass with a pane of laminated low-E glass (the thermal stress placed upon the original float glass of the existing windows by adding a coating would likely result in glass fracture). Even though there is a diminished benefit to adding low-E coating to the interior storm window rather than to the exterior glass, this procedure does not require replacement of the exterior glass and avoids a change in appearance.

Changes in the position and type of low-E coating on the repaired window may also affect the condensation resistance of the glazing. Although not specifically discussed in this paper, it is important to note here that the most susceptible location for condensation is the interior face of the exterior glass in the repaired window. Adding a low-E coating with a lower SHGC to the interior storm would likely improve condensation resistance of the exterior glass, as would providing a new outer pane of glass with a low-E coating with a mid- to low SHGC.

Other factors. Covering the window openings with draperies and curtains or other shading devices will also reduce the amount of solar heat gain transmitted to the building interior. Keeping the window coverings open to admit as much solar gain as possible on sunny days during the winter will improve performance. This testing did not include interior window treatments, so their impact on thermal performance was not quantified; however, it seems likely that they would impact both mock-ups similarly.

Heat-loss performance. Several processes influence the rates of non-solar heat gain or loss through window components. These processes follow a basic law of thermodynamics: heat energy tends to move from warmer areas to colder areas. In Washington, D.C., the primary flow of heat is from interior spaces to the building exterior during fall, winter, and early spring. The differential temperature tends to be lower during summer months, when heat flow is from the hot exterior to the cooler, conditioned interior. The principal heat-transfer processes in windows are radiation, conduction, and convection. In addition, excessive air leakage can contribute to the overall heat loss.

During colder temperatures, heat is absorbed by the inside pane of a double-glazed window, moves to the cooler outside pane, and is released to the outdoors. Not only does this heat loss take place through the glazing by radiation; it also occurs across the spacer material of the insulating glass unit, which separates the two glazing layers at their edges (at the replacement window only); through the frame of the window by conduction; through the movement of air in the space between the two glazing layers by convection (more pronounced in the larger air space of the repaired window); and between the moveable or operable frame components by air leakage. Convective losses are typically negligible with respect to other losses and were not addressed in this study.

Radiative losses and gains. Typically, radiation losses through the window glass represent about two thirds of the total heat loss in a standard window. Because ordinary glass readily emits heat to colder surfaces (i.e., has a high emissivity), radiation losses can be reduced by lowering the emissivity of the glass by installing low-E films. Placement of the low-E coating in the pane of glass experiencing the greatest temperature differential will have the greatest effect on radiation loss through the window. Review of data from this study indicates the greatest temperature differential is across the outer pane of glass in the repaired window during cold weather. Therefore, placement of the low-E coating in the exterior glass will have the greatest impact on radiative loss.

Conductive losses and gains. Conduction losses in windows occur primarily through the edges and frames of the units and are often expressed in terms of U-value, the overall measurement of conductive heat transfer through the window. The thermal-conductance characteristics or resistance to heat transfer, i.e. R-value of the aluminum frame of the replacement window and the steel frame of the repaired window, also has an effect. Steel is less conductive than aluminum and has a higher R-value, thereby reducing the overall U-value of the window. Data from this study indicate that the temperature drop across the frame was different for the two windows. The thermal break installed in the aluminum-framed replacement window helps to reduce the heat loss across the frame; however, the interior storm window of the repaired window better isolated the steel window frame of the repaired window from the building interior (e.g., no

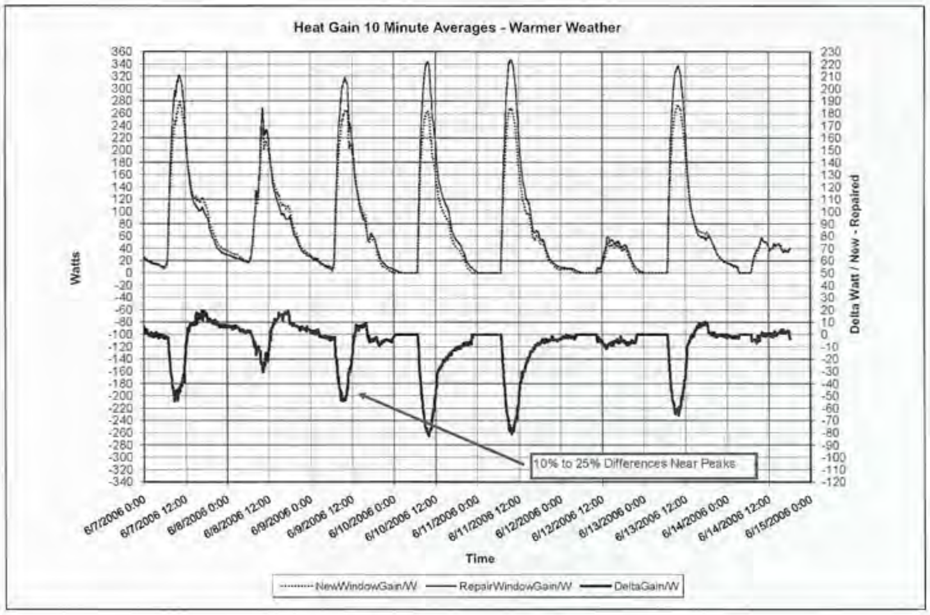


Fig. 11. Heat gain during the warmest week.

metal-to-metal contact at the sash meeting rail), thus reducing heat transfer.

Air leakage. Window air leakage is a significant contributor to energy costs during both heating and cooling seasons for most buildings. Air leakage also affects occupant comfort. Most of the air leakage through operable windows occurs between the window's sash and frame or at the meeting rails of a sliding sash, as on the replacement window. Bigger windows tend to leak less air per unit area than smaller ones. In poorly constructed fixed windows, air leakage also occurs between the insulated glass unit and the frame. Windows with the lowest leakage rates, regardless of type, tend to be fixed windows. Although the repaired window had a fixed sash, it originally was an operable window.

The condition of the perimeter construction also affects the air-infiltration resistance of the replacement window. Air leakage around the replacement window can be a significant problem if the windows are carelessly installed in the rough opening. Air infiltration at and through the perimeter (frame) of the window mock-ups was evident during air-infiltration testing, particularly around the replacement window. Air leakage is likely increased by construction activities to remove the original window and install the new replacement window. Air infiltration around the perimeter of the replacement window can be improved by installing spray foam in the cavity when the original window is removed. Foam will improve thermal performance of the window frame, as well as limit air infiltration. Similar improvements can be made at the repaired window by installing spray-foam insulation in weight pockets and the window perimeter.

Conclusions

This analysis shows significant differences in thermal behavior between the repaired-window and the replacement-window mock-ups. The repaired window experienced more solar heat gain during morning and early afternoon hours than the replacement window. In turn, the replacement window experienced more heat loss through the glass and frame during evening and early morning hours. Because solar heat gain can be manipulated (e.g., through the use of low-E coatings) but heat loss through the frame cannot, the repaired window provides superior heat-loss performance and significantly greater potential for optimizing glazing and heat-gain performance (particularly for the different building exposures) than the replacement window. Solar heat gains for both windows tended to more than offset the heat loss through the frame and glazing, a conclusion that

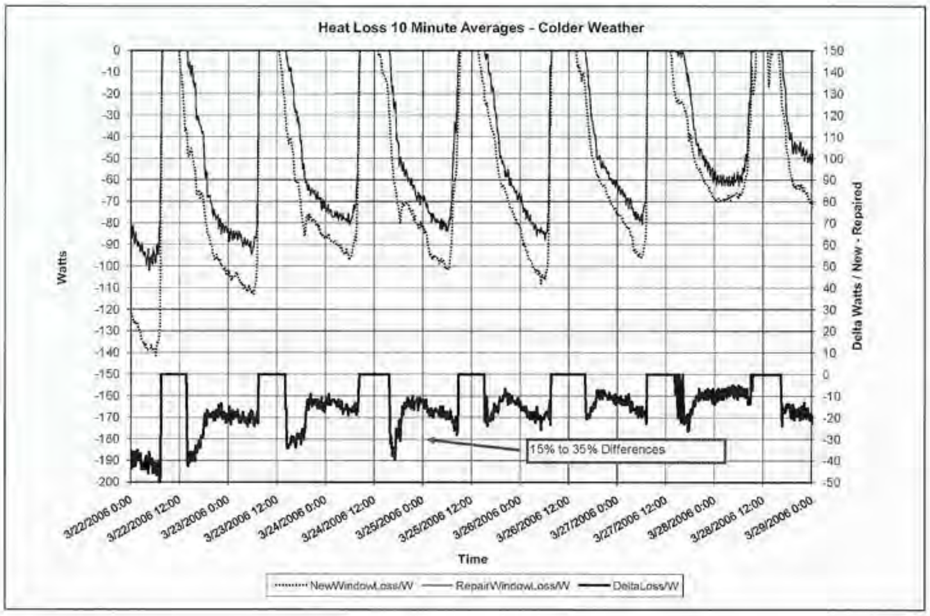


Fig. 12. Heat loss during the coldest week.

may not be applicable to north-facing windows and requires further analysis. As solar heat gains vary throughout the year, careful consideration of the comprehensive building heating and cooling loads and mechanical-system requirements are needed to optimize the gains and losses through the windows, maximizing gains when needed while minimizing losses throughout the day and the changing seasons. Additional assessment — including the evaluation of other exposures (e.g., north and south), glazing-coating options, and other factors — is required to fully develop the options and will likely impact overall design decisions. This analysis can be achieved with additional mock-ups, careful application of computer simulation, or a combination of both.

The overall result of this study does not diminish the fact that thermal performance is only a portion of the overall decision process. While the repaired window offers superior thermal performance, it will also conserve original building fabric and minimize material waste by maximizing efficient use of preexisting embodied energy. Careful evaluation of historical and architectural significance, as well as the physical condition of the windows, must also be considered, in addition to future maintenance and operation needs. For an in-depth discussion of these and other considerations, the reader should refer to the Secretary of the Interior's *Preservation Brief 13: The Repair and Thermal Upgrading of Historic Steel Windows,* by the U.S. Department of the Interior (available at http://www.nps.gov/history/hps/tps/briefs/brief13.htm). Any rehabilitation project considering similar window programs should include careful identification and evaluation of these often competing factors conducted in concert with technical analysis performed by competent professionals so that appropriate options can be evaluated and an optimal solution selected.

ROBERT SCORE is a project architect at Harboe Architects in Chicago, Illinois, and specializes in the restoration of commercial and cultural properties. He was previously on the Historic Resources Committee of the Chicago Chapter of the AIA and a director of APT and is currently helping to found the Western Great Lakes Chapter of APT.

BRADFORD S. CARPENTER is a staff engineer in the Washington, D.C., office of SGH. While at SGH, he has investigated, designed, and rehabilitated building envelopes on both historic and modern structures. He previously worked at Newport News Shipbuilding in Newport News, Virginia, and for the Architect of the Capitol in Washington, D.C. He can be reached at BSCarpenter@sgh.com.

Acknowledgements

The authors would like to acknowledge our colleagues at Harboe Architects and Simpson Gumpertz & Heger, Inc., as well as the effort of both DMJM and the U.S. General Services Administration in the execution of this project.

Notes

1. Both window mock-ups were instrumented with temperature sensors and relative-humidity and air-temperature sensors installed within the air cavity between the storm glazing and the repaired window. Surface-temperature sensors were self-adhesive E-type thermocouples that were connected to Veriteq thermocouple loggers. Each Veriteq logger monitored the temperature of four thermocouples. Thermocouples were installed at the following locations on the interior face of the repaired window frame and the replacement window frame: windowsill frame (center), horizontal meeting rail (center), left jamb (upper left), center of glass (lower light). Thermocouples were also installed on the cavity face of the storm window at the following locations: windowsill frame (center), frame of window head (center), left jamb (upper left), and center of glass (corresponding with lower light). Two Dickson D-200 data loggers were installed within the cavity space between the repaired window and the storm. The D-200 data loggers recorded air temperature and relative humidity at the lower left and upper right corners of the cavity between the storm and the repaired window. To record ambient conditions on the building exterior and interior, two Vaisala HMP44 probes and an Omega data-logging pressure box were installed. The pressure box measured the difference in interior and exterior ambient pressure.

The window mock-ups were constructed on site to allow review of numerous features, including but not limited to appearance, constructability, cost, and impact to building tenants, as well as performance. In addition to thermal-performance monitoring, testing included air-infiltration testing in accordance with American Society for Testing of Materials (ASTM) E783: Standard Test Method for Field Measurement of Air Leakage through Installed Exterior Windows and Doors, as well as water-penetration testing in accordance with ASTM E1105: Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Static Air Pressure Difference. Though not discussed in this paper, the repaired-window mock-up allowed roughly 50 percent less air-infiltration leakage than the replacement window, likely due to the operable sash of the repaired window being fixed and sealed shut with sealants and paint coatings, while the replacement window, though fixed shut, relied upon gasket seals. The repaired-window mock-up had comparable water-penetration resistance to the replacement window.

2. Since monitoring did not include barometric-pressure measurements, calculations include a constant barometric pressure of 101.325 kPa. This assumption carries through calculations for both windows and will cancel out as the

windows are compared. The humidity ratio in kg/kg is calculated using interior temperature and relative humidity. The entering- and leaving-air enthalpy is calculated in kJ/kg using the humidity ratio and respective air temperatures. The mass of the air flow is calculated using the specific volume of the discharge air in m^3/kg. The data-logger time interval is five minutes, and all kJ calculations are converted to watts by multiplying by 1,000 and dividing by 300 seconds. *American Society of Heating, Refrigerating and Air-Conditioning Engineers Handbook*, vol. 1, *Fundamentals* (Atlanta: ASHRAE, 2005).

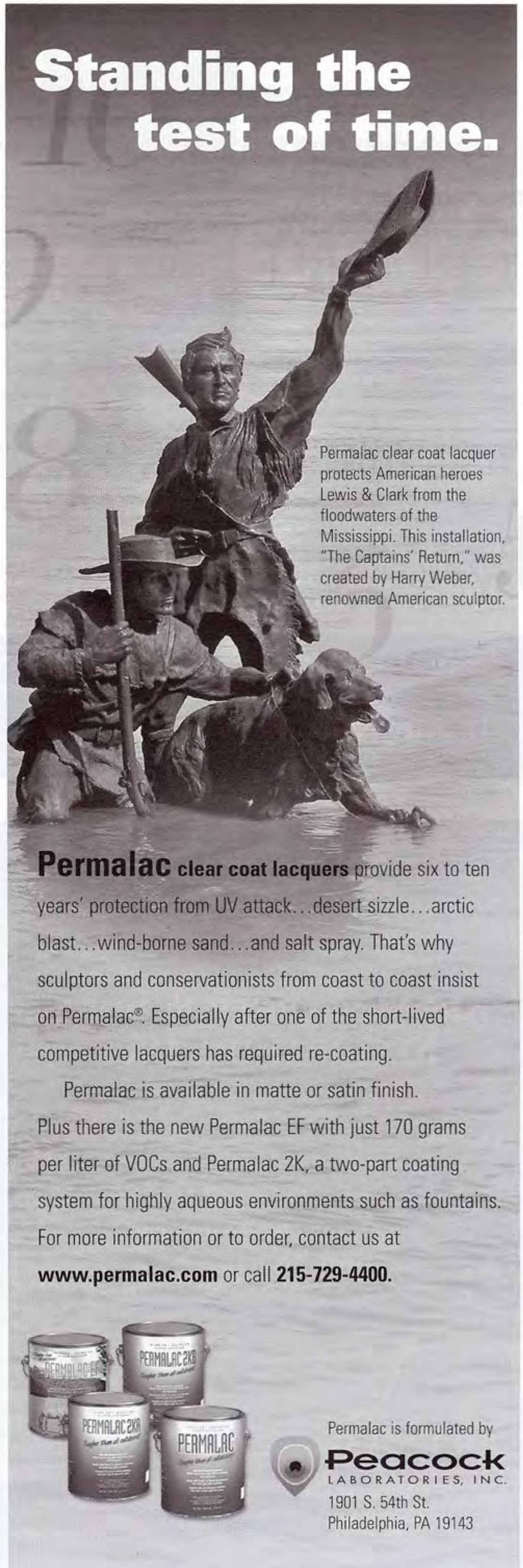
3. The coldest temperatures recorded were approximately 32°F (0°C), observed over a span of several hours throughout the first week of data recording. The average peak wintertime temperatures are typically found by using the exterior heating design temperature for Washington, D.C., which can be found in Table D-1 of the ASHRAE Standard 90.1-2004. The exterior heating design temperature of 15°F (-9.5°C) corresponds to the 99.6 percent annual cumulative frequency of occurrence, which means that actual exterior temperatures exceed this design temperature for all but 0.4 percent of the year, or about 1.4 days, during a typical year.

Bibliography

American Society of Heating, Refrigerating and Air-Conditioning Engineers. ASHRAE Standard 55-2004, *Thermal Environmental Conditions for Human Occupancy.* Atlanta: ASHRAE, 2004.

American Society of Heating, Refrigerating and Air-Conditioning Engineers. ASHRAE Standard 90.1-2004, *Energy Standard for Buildings Except Low-Rise Residential Buildings.* Atlanta: ASHRAE, 2004.

Park, Sharon C. *Preservation Brief No. 13: The Repair and Thermal Upgrading of Historic Steel Windows.* Washington, D.C.: National Park Service, 1984.



© 2010 *Door and Window Manufacturer* (DWM) Magazine. All rights reserved. No reproduction of any type without expressed written permission.

EYE ON ENERGY

Repair or Replace?

Weatherization Program Says Repair

BY ARLENE STEWART

I recently spent two weeks in a beta test for intermediate Department of Energy (DOE) weatherization training. The little program that could has been chugging along since it was granted savior-like status in the stimulus package. I had high hopes for the work when the increased funding was announced two years ago, but this was my first opportunity to really get involved. As a rater, I expected to slip right in since I've been evaluating and recommending energy efficiency improvements for years. I wonder how many others have experienced the culture shock I did.

What is Weatherization?

I knew that weatherization targeted low-income families, but that knowledge becomes infinitely more real when you start crawling around a qualifying house. While Merriam-Webster defines weatherization as "to make a house better protected against weather," in actuality, it is more remedial. First and foremost, it's about making the home safe, especially when combustion appliances are present. Second, it's about bringing the house back to a minimum state, like replacing weatherstripping, realigning doors and teaching occupants how to operate their homes. Next comes improving what is already installed, like wrapping the water heater with insulation. Then, if there is anything left of the typical $5,000 allotment per house, maybe you can get to actually upgrading features, like appliances, systems or windows.

Except you can't.

"We repair windows, we don't replace them," said my instructor. "The clients want you to, but you can't do that." We can replace heating systems and refrigerators, but not windows? Color me stunned. I knew windows were a tough improvement to justify on return-on-investment, but a blanket prohibition? What's with that?

> "We repair windows, we don't replace them," said my instructor. "The clients want you to, but you can't do that."

Apparently, years ago, in the early days of the program, windows were a favorite improvement—so much so that the basics were neglected. A low-income house would have state-of-the-art windows, but the wind would be blowing like mad through the holes in the walls.

Pushing for Replacement

Still, window replacement in weatherization is not without its advocates. Ian Shapiro and his team at Taitem Engineering in Ithaca, N.Y., have been searching for ways to show just how big an impact window replacement can have.

"My fear is that we are underestimating the energy loss, especially [with] single-pane," said Shapiro.

Funded by a grant from the New York State Energy Research and Development Authority (NYSERDA), Taitem has developed a way to derive U-factors in the field that the agency feels are relatively close to tested National Fenestration Rating Council (NFRC) ratings. In this way, NYSERDA is hoping to show just how important window replacements are. For example, the method could show how important it is to replace a single-pane window located over a radiator because the heat loss would be so much greater in close vicinity of a heat source.

I have mixed feelings about the prospect of this U-factor method hitting the streets. On one hand, I'm all for any help that the industry can get to justify window replacement. On the other hand, NFRC ratings (and ASHRAE defaults for unlabeled units) were created to level the playing field, deliberately ignoring site and user specific variables. I worry that Taitem's method will migrate out of weatherization, to be used by the uninformed or unscrupulous to discredit manufacturer claims on new construction or mainstream retrofits. The method has a 10 percent margin of error, which would be easy to exploit, though Taitem has applied for additional NYSERDA funding to further refine its accuracy.

Clearly though, the people doing these evaluations would appreciate a field U-factor method. A vast majority of the session attendees at 2011 RESNET Conference, where Shapiro premiered the method, wanted to use the method immediately. Nature abhors a vacuum, and window manufacturers need to continue the efforts they are making for cost-competitive window replacements, because we will continue to see non-fenestration folk trying to justify their purchases or not making purchases at all. ■

Arlene Zavocki Stewart is a nationally known energy and green building advocate. Ms. Stewart's opinions are solely her own and not necessarily those of this magazine.

WINDOW REFLECTIONS CAN MELT VINYL SIDING

Musings of an Energy Nerd

Contemplating residential energy use

WINDOW REFLECTIONS CAN MELT VINYL SIDING

Siding and window manufacturers are reluctant to discuss the problem

POSTED ON AUG 27 BY **MARTIN HOLLADAY, GBA ADVISOR**

In almost every corner of the U.S., reports are increasing of vinyl siding that has been melted by sunlight bouncing off nearby windows. This melted-siding pandemic makes vinyl manufacturers very nervous — so nervous that the topic is rarely discussed.

Most reported cases involve siding that melts, gets replaced, and then melts a second time. One possible reason for the apparent increase in cases of melted siding is the increasing use of high-performance glazing.

Image 1 of 3

Tell-tale warping. When vinyl siding is melted by sunlight reflecting off a window, the warped siding usually traces a diagonal path. This pattern follows the way the reflected sunlight moves across the wall as the sun travels across the sky. The photo shows melted siding on the home of Robb Kowalik, who lives in a suburb of Chicago.

Not our problem, says Pulte

Arlene Taraschi, a homeowner in Delanco, New Jersey, described her melted siding in a letter to a Q-and-A column in the *Philadelphia Inquirer*: “Two years ago, my husband and I purchased a new, Pulte-built home in South Jersey. After a few months we noticed the vinyl siding on one side of the house seemed to be dented in a diagonal pattern. The siding contractor replaced the siding on the entire side of the house. This was done last January, and by February the denting pattern began again. We were told at this time that it was because of the reflection of the sun’s rays from our neighbor’s house. Pulte has termed this melting of the siding ‘thermal distortion,’ and refuses to correct the problem.”

As Taraschi’s case makes clear, these cases aren’t just public relations nightmares — they’re legal nightmares. Arlene’s husband, Carl Taraschi, told me, “I’ve sued Pulte, the siding installer, and the siding manufacturer.”

Since 2007, when I first reported on cases of siding melted by window reflections, I’ve collected homeowner reports of the phenomenon from 16 states (Connecticut, Georgia, Florida, Illinois, Iowa, Maine, Massachusetts, Michigan, Minnesota, New Jersey, North Carolina, Ohio, Oregon, Pennsylvania, South Carolina, and Washington).

Wm A. Kilian HARDWARE CO.

Stop Bead Adjuster

A solid brass stop bead adjuster for mounting removable window stops. The slotted screw hole permits 1/8" of lateral adjustment.

Shown above in Solid Brass, Oil-Rubbed Bronze, Satin Nickel and Polished Nickel.

Measures 11/16" diameter. Screw is 1" long. Drill 1/2" hole in Stop Bead.

Stop Bead Adjuster Regular price: $1.60 Sale price: **$0.85, 100/$75.00, 250/$150.00**

Finish: Solid Brass, Lacquered Order Now

Stop Bead Adjuster in Custom Finish Solid brass finished to order. Choose desired finish from pop-up menu.

Stop Bead Adjuster Custom Regular price: $3.20 Sale price: **$1.70, 100/$150.00, 250/$300.00**

Finish: Oil-Rubbed Bronze on Solid Brass Order Now

Ives No. 6 Stop Bead Adjuster Plated Steel Available in 3 finishes. See popup menu below.

Ives 6F3,14,10B Regular price: $0.60 Sale price: **$0.59, 10/$5.40, 100/$45.00, 1000/$360.00, 10000/$3,000.00**

Finish: Brass Plated Steel

Order Now

---

http://kilian.stores.yahoo.net/stopbeadad.html