

# CHAPMAN HALL

## PRELIMINARY WINDOW ASSESSMENT



University of Oregon  
Campus Planning  
Campus Planning, Design and Construction

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Additional information on the history of Chapman Hall is available in the “Chapman Hall Historic Assessment” and the UO “Campus Heritage Landscape Plan: 4.0 Survey of Buildings,” which can be found on the CPDC website: <http://cpdc.uoregon.edu/>.

Historic images are courtesy the UO archives. Building drawings are available from UO Facilities Services.

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# **CHAPMAN HALL**

## **PRELIMINARY WINDOW ASSESSMENT**

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## INTRODUCTION

Windows are some of the most significant character-defining features of any building. From window opening, to frame, to sash, to glazing, their construction and materials play a major role in the design of the building's facade and overall composition. A building's window and facade design can indicate the aesthetic style, building materials, and building technologies of their time and place. Inappropriate or unsympathetic window upgrades and treatments can drastically alter the appearance of a building. With that said, concerns over energy conservation, continued maintenance, and other considerations have lead to growing needs of window treatments and alterations for our historic buildings.

This assessment identifies and documents the general condition of the typical window types found in Chapman Hall and provides a variety of treatment recommendations for their continued use. This initial assessment is intended to be used as a preliminary resource for the treatment of Chapman Hall's original historic windows when planning any alterations or additions.

It is important to note that this preliminary assessment is not intended to serve as a complete assessment of every window in Chapman Hall. An in-depth window survey is required in order to fully understand the existing condition of Chapman Hall's individual steel windows.

This assessment consists of a visual appraisal of a sampling of typical windows types found on each facade of Chapman Hall. A broad range of conditions were evaluated including interior paint, exterior paint, glazing compound, window parts, interior stool, exterior sill, hardware, and operability. The overall window condition was ranked using the following scale:

EXCELLENT = no/minimal repairs and routine maintenance required

GOOD = Some repair of parts required

FAIR = Invasive repair of parts required

POOR = Invasive repair/replacement required

## ASSESSMENT SUMMARY

The biggest cause of building degradation and failure is moisture (Preservation Brief 13). This is especially true for wet climates like the Pacific Northwest. In conjunction with moisture, another major enemy to buildings is UV exposure. This is why facade orientation and surrounding landscape features can greatly effect the degradation of a building.

Overall, while being no exception to these factors, the windows of Chapman Hall sampled for this survey are in GOOD-EXCELLENT condition. No windows were in POOR condition. The most common problems found through this initial survey were the peeling paint, light rust, and cracked and chipping glazing compound. Additional problems found include missing or replaced hardware, difficulty or inability in operating the windows, air gaps, and medium rust.

These problems and others can be categorized by facade and orientation. Please note that this is an initial general assessment of Chapman Hall's steel windows. Before beginning any work, the following summary of conditions for each facade should be further verified with an in depth condition assessment of each window.



*Typical exterior condition of northern windows.*



*Vegetative growth on northern window sill and typical paint bubbling on interior of northern windows.*



*Typical interior condition of eastern windows.*

### **NORTH FACADE:**

In general, the windows on the north facade are in GOOD-EXCELLENT condition. The north facade sees much less sun during the day and, as a result, less moisture evaporates. This has caused some minor vegetative growth on some of the exterior sills.

The steel window frames and sashes appear to be in good condition, although there appears to be some paint bubbling on the interior of some windows located in the offices. Also, there appears to be thick layers of paint on some of the windows. Further investigation should be performed to ensure that there is no corrosion hidden under the paint. Another condition found in some of the typical north windows is missing or replaced hardware.

In terms of alterations, one window on the first floor was converted into a second north entry. Also, the windows associated with the elevator shaft have been painted black and vents have been inserted. Vents were inserted into the windows of what is now Room 207A as well. Interior coverings were added on select windows on the first and second floors to provide visual privacy and reduce solar glare. (see Chapman Hall Historic Assessment for more detail)

### **EAST FACADE:**

There are only a few windows on the east facade. Overall, they appear to be in GOOD condition. The steel window frames and sashes appear to be in good condition, although there appears to be thick layers of paint and bubbling on the interior. Further investigation should be performed to ensure that there is no corrosion hidden under the paint. Also, there is dirt and grime on the exterior windows, especially those on the stairwell windows.

There have been no significant alterations to the windows on the east facade.



*Typical interior condition of southern windows.*



*Cracked paint, chipping glazing putty, and rust on southern window in Room 303.*



*Rust and animal nest on exterior steel lintels of Room 303 windows.*

### **SOUTH FACADE:**

The condition of the windows on the south facade are primarily in GOOD-EXCELLENT condition with the exception of those in Room 303, which are in FAIR-GOOD condition.

The windows in Room 303 that are in FAIR condition have been exposed to large amounts of sun, excessive moisture, improper maintenance/repairs, or various combinations of the three. Ultra Violet (UV) radiation from the southern sun can cause paint and glazing putty degradation. Cracked and chipping paint and glazing putty have allowed moisture to penetrate into the raw steel of the frames and develop into light-medium corrosion on the window interiors. Also, there is a visible amount of corrosion coming through the painted steel lintels. The extent of the rust cannot be determined at this time due to limited access. Considering that other south-facing windows are in better condition than those in Room 303, it appears that there is a greater moisture problem in Room 303. However, a more in-depth assessment should be performed to determine the cause and level of degradation. Finally, the exteriors of some windows have been affected by animal nests.

As mentioned above, the remaining windows on the south facade have the same amount of exposure but are in better condition. Also, the hardware of the south windows in Room 202 and 203 is missing or has been replaced. Throughout the building, some windows are harder to operate and there is what appears to be dirt and grime on the exterior of the frames.

Alterations made to south facade windows include the insertion of vents in Room 206 and an air conditioning window unit in Room 302. Also, one of the windows on the first floor has also been infilled and



*Typical exterior condition of west windows.*



*Typical interior condition of west windows.*

three windows on the basement floor were relocated to the first floor (see Chapman Hall Historic Assessment for more detail).

#### **WEST FACADE:**

Overall, the west-facing windows are in GOOD condition. Like the south facade, it receives a lot of exposure as evidenced by the interior cracked and chipped paint and glazing putty, although it is not as prominent as the south facade. Cracked and chipped paint have allowed moisture to find its way into the raw steel beneath and some light corrosion is present on the interior. Some of the steel lintels on the third floor show signs of rust as well. Further investigations should be conducted to verify the extent of the rust. Like the other three facades, the hardware of some of the west facing windows are missing or have been replaced.

There have been no major alterations to the windows on the west facade.

## SUMMARY OF RECOMMENDED TREATMENT STRATEGIES

Based on the overall GOOD-EXCELLENT condition of the windows, the following treatment strategies are recommended first (see page 16 for more information about treatment strategies):

**ROUTINE MAINTENANCE** (see page 18 for more details)

**REPAIR IN PLACE** (see page 18 for more details)

To address energy efficiency and thermal comfort concerns, a Weatherizing Strategies Matrix has been developed to help further assess the advantages and disadvantages of each treatment strategy. (see page 21). The following weatherization strategies are recommended for consideration after an in-depth window condition assessment is completed (see page 20 for more information about weatherization strategies):

**WEATHERSTRIPPING** (see page 22 for more details)

Weather stripping reduces air gaps where heated air can escape and can be combined with other weatherization strategies. It is recommended that it is applied to all operable windows in Chapman Hall and any fixed windows with air leaks.

**REPLACE ORIGINAL GLAZING WITH THERMAL GLAZING** (see page 24 for more details)

This strategy should be carefully considered upon a further in-depth window assessment and determination of potential energy savings and enhanced thermal comfort. The depth of the steel window sections and the load capacity of the steel frames should especially be considered when selecting and specifying the new thermal glazing. This strategy does not have to be applied to all windows - rather, it can be applied to specific rooms or groups of windows based on occupancy needs and the character defining features as described in the Chapman Hall Historic Assessment.

**STORM WINDOWS** (see page 25 for more details)

Options for storm windows include interior and exterior, fixed and operable. Interior storm windows are usually fixed but there are operable options. Exterior storm windows can be both fixed or operable. Exterior storm windows can negatively impact the appearance of the building facade by altering the appearance of the window composition. Fixed storm windows are most appropriate for fixed windows. If fixed storm windows are installed over operable windows, the storm windows will need to be removed seasonally.

This strategy should be carefully considered upon a further in-depth window assessment and determination of potential energy savings and enhanced thermal comfort. Also, it does not have to be applied to all windows - rather, it can be applied to specific rooms or groups of windows based on occupancy needs and the character defining features as described in the Chapman Hall Historic Assessment.

## BRIEF HISTORY OF STEEL-FRAMED WINDOWS

Metal windows were available as early as 1860 but did not become popular until after 1890. The technology of the rolled steel industry along with the scare of urban fires are the two primary factors that influenced the switch from wood windows to steel. Almost exclusively found in masonry or concrete buildings, steel windows boasted resistance to fire damage as well as extensive amounts of glass, increased ventilation, and thin profiles of extreme strength. This combination of features greatly affected and changed the appearance of industrial and commercial buildings of the early 20th century. The widespread use of rolled steel windows continued until after WWII when the use of non-corrosive aluminum windows became popular. Despite their decreased use, steel windows are still fabricated today.

## TYPICAL STEEL-FRAMED WINDOW TYPES

*Double-hung* industrial windows duplicated the look of traditional wooden windows. Metal double-hung windows were early examples of a building product adapted to meet stringent new fire code requirements for manufacturing and high-rise buildings in urban areas. Soon supplanted in industrial buildings by less expensive pivot windows, double-hung metal windows regained popularity in the 1940s for use in speculative suburban housing.



*Austral* windows were also a product of the 1920s. They combined the appearance of the double-hung window with the increased ventilation and ease of operation of the projected window. (When fully opened, they provided 70% ventilation as compared to 50% ventilation for double-hung windows.) Austral windows were often used in schools, libraries and other public buildings.



*Pivot* windows were an early type of industrial window that combined inexpensive first cost and low maintenance. Pivot windows became standard for warehouses and power plants where the lack of screens was not a problem. The window shown here is a horizontal pivot. Windows that turned about a vertical axis were also manufactured (often of iron). Such vertical pivots are rare today.



*Casement* windows adapted the English tradition of using wrought iron casements with leaded cames for residential use. Rolled steel casements (either single, as shown, or paired) were popular in the 1920s for cottage style residences and Gothic style campus architecture. More streamlined casements were popular in the 1930s for institutional and small industrial buildings.



*Projecting* windows, sometimes called awning or hopper windows, were perfected in the 1920s for industrial and institutional buildings. They were often used in "combination" windows, in which upper panels opened out and lower panels opened in. Since each movable panel projected to one side of the frame only, unlike pivot windows, for example, screens could be introduced.



*Continuous* windows were almost exclusively used for industrial buildings requiring high overhead lighting. Long runs of clerestory windows operated by mechanical tension rod gears were typical. Long banks of continuous windows were possible because the frames for such windows were often structural elements of the building.



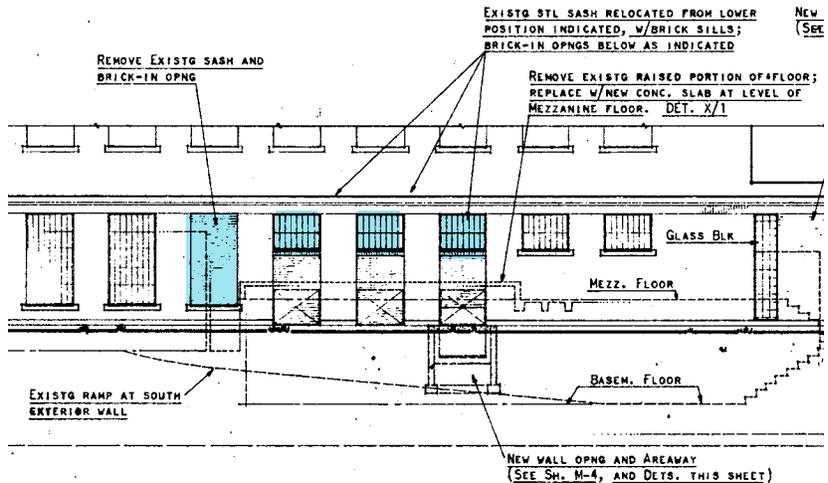
## BRIEF HISTORY OF CHAPMAN HALL

Chapman Hall, designed by Ellis Lawrence, was constructed in 1939 to house the Humanities departments and the Student Cooperative Store (university bookstore). Chapman Hall was named for Charles H. Chapman, president of the University from 1893-1896. The capitol project was funded by the Public Works Administration, a New Deal era program. Its siting was a part of the Lawrence plan for the central campus area anchored by the Memorial Quadrangle (1940).

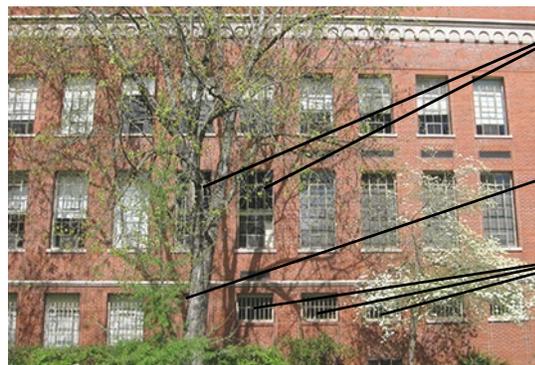
The first floor of Chapman Hall served as the students' Cooperative Bookstore from 1939-1966. Originally, the second floor housed the English department and the third floor housed facilities for the modern Home Economics department.

In 1966, the bookstore was relocated and interior partition walls were added to the basement and first floors to create a series of offices. Since the relocation of the bookstore, the upper floors of Chapman Hall have served as offices and classrooms for various departments. Presently, Chapman Hall houses offices, classrooms, and the undergraduate Honors College.

The first major alterations to the some of Chapman Hall's windows took place during the 1966 bookstore relocation. A window on the north facade was converted into a new entry and a window on the south facade was filled in. The second most significant window alterations were part of the 1990 ADA Remodel, when three windows associated with an elevator shaft on the north



1966 south elevation drawing showing infilled window and three relocated windows.

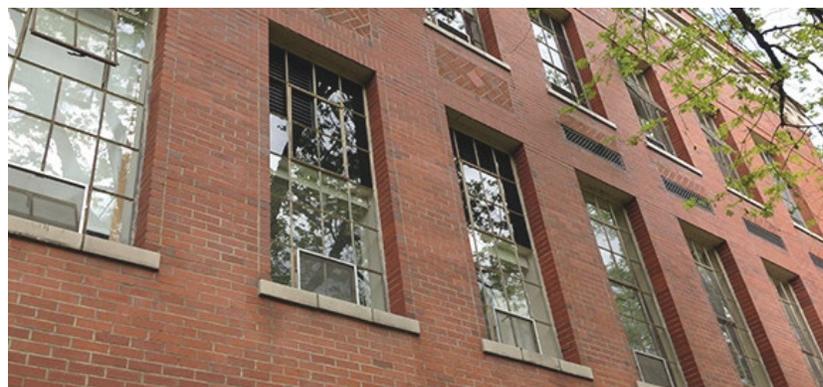


GLAZING ABOVE DROPPED CEILING DARKENED AND VENTS INSERTED DURING 2001 REMODEL

WINDOW INFILLED DURING 1966 REMODEL

THREE WINDOWS RELOCATED FROM BASEMENT TO FIRST FLOOR DURING 1966 REMODEL

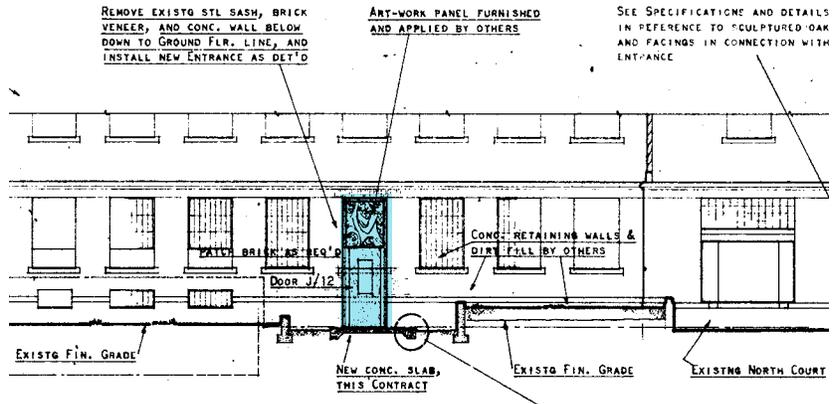
Existing south facade and its major window alterations.



Darkened glazing and vents on south facade of Room 206 as a part of the 2001 Room 207 remodel.

facade were painted a gloss black and vents were inserted. In 2001, Room 207 underwent a renovation. During this renovation, the ceiling of Room 206 was dropped. The glazing above the dropped ceiling was darkened (method used is unknown at this time) and vents were inserted. Also, glazing was darkened and vents were inserted into the window of room 207A on the north facade. In 2013, an air conditioning unit was installed in the third floor computer lab and window coverings were placed on select windows on the first and basement floors to provide visual privacy and reduce glare. Bug screens were also installed on select windows (unknown date).

A complete description of the alterations to Chapman Hall is provided in the *Chapman Hall Historic Assessment* and can be found in the Campus Planning website.



1966 north elevation drawing showing removal of old window and the new second north entry



WINDOW ALTERED TO INSTALL VENTILATION GRILL FOR NEW ELEVATOR DURING 1990 REMODEL  
 GLAZING DARKENED AND VENTS INSERTED DURING 2001 ROOM 207 REMODEL  
 GLAZING PAINTED A GLOSS BLACK AFTER INSTALLATION OF NEW ELEVATOR SHAFT DURING 1990 REMODEL  
 1966 SECONDARY NORTH ENTRY WITH 2010 ALTERATIONS

Existing north facade and its major window alterations.

**TIMELINE OF WINDOW ALTERATIONS:**

<p>1939: Construction completed</p>	<p>1990 Universal Access remodel: alterations to windows in new elevator shaft</p>	<p>2013: Window A/C unit installed in third floor Computer Lab. Coverings installed over select windows on basement and first floors.</p>
<p>1966 Bookstore relocation: A new entry along north facade replaces an original window. On the south facade, a first floor window is infilled and basement windows are relocated to the first floor</p>	<p>2001 Room 207 remodel: Glazing darkened and vents inserted in the window in Room 207A. Glazing above dropped ceiling in Room 206 darkened and vents inserted.</p>	

# HISTORIC SIGNIFICANCE RANKING OF WINDOWS

The historic significance of Chapman Hall's windows have been identified and ranked as primary, secondary, tertiary, or non-contributing. These rankings are based on the level of significance (defined by their level of contribution to the overall facade composition and their use) and level of integrity (defined as the degree to which the key historic elements are evident today) of the window. The rankings are defined as follows:

**Primary:** Resources that have a high level of historic significance and excellent or good integrity

**Secondary:** Resources that have a reduced level of significance and good or excellent integrity. Also, resources that have a high level of historic significance but fair integrity

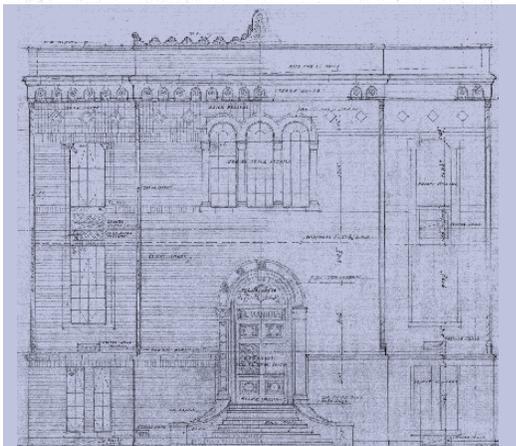
**Tertiary:** Resources that have a reduced (medium) level of historic significance but compromised (fair) integrity. Also, resources that have integrity but lack noteworthy significance at this time as an individual resource.

**Non-Contributing:** Resources that lack noteworthy significance or have severely compromised integrity. They do not contribute to the historic significance of a large grouping or district and are not eligible for listing in the National Register.

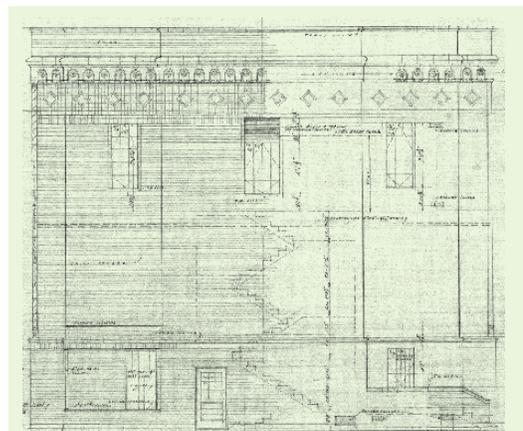
A detailed assessment of the history and significance of each full facade can be found in the Chapman Hall Historic Assessment. Please refer to Appendix A for a full description of the ranking methodology.

## Historic Significance Ranking of Windows

*Original facade drawing by Ellis Lawrence, 1938. Note that the original drawing does not reflect the existing conditions of the facade today.*



*West facade windows*



*East facade windows*

### Ranking Key:



Primary



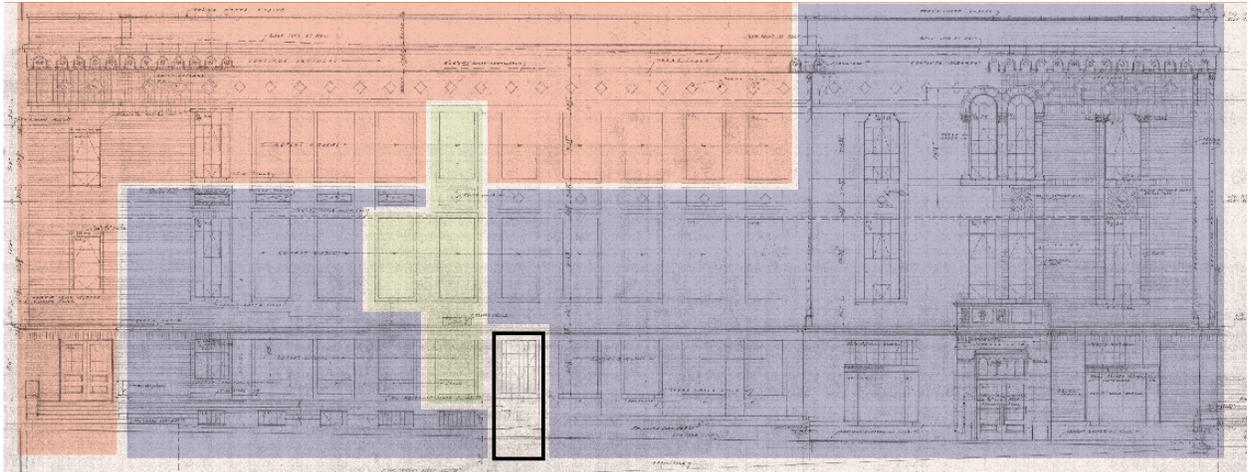
Secondary



Tertiary



Non-Contributing



North facade windows



South facade windows

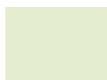
**Ranking Key:**



Primary



Secondary

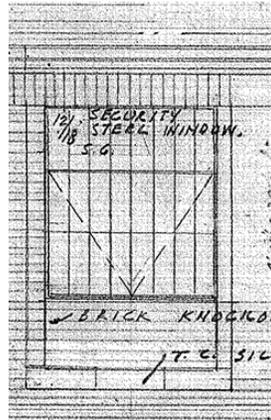


Tertiary



Non-Contributing

# TYPICAL STEEL-FRAME WINDOW TYPES OF CHAPMAN HALL



## BASEMENT AND FIRST FLOORS

The basement and ground floors were originally designed to be the Student Cooperative Bookstore. As a result, the typical windows found on these floors feature security bars. These windows are also combination windows, with some fixed panels and some operable. They are composed of windows 3 lights high by 4 lights wide or 4 lights high by 4 lights wide (see image below). In either window, a 2x4 light panel located one row below the top row of lights is operable and opens inward like a hopper window.

Typical basement and first floor windows, existing (left) and original drawings (right).

Incorporated into the window sash are the security bars. The construction of these bars match the original elevation drawings but not the

original detail drawings (see below). Rather than functioning as a separate element and being imbedded into the brick as they were drawn, they are a part of the window sash itself. The current bars appear to be original despite this discrepancy.

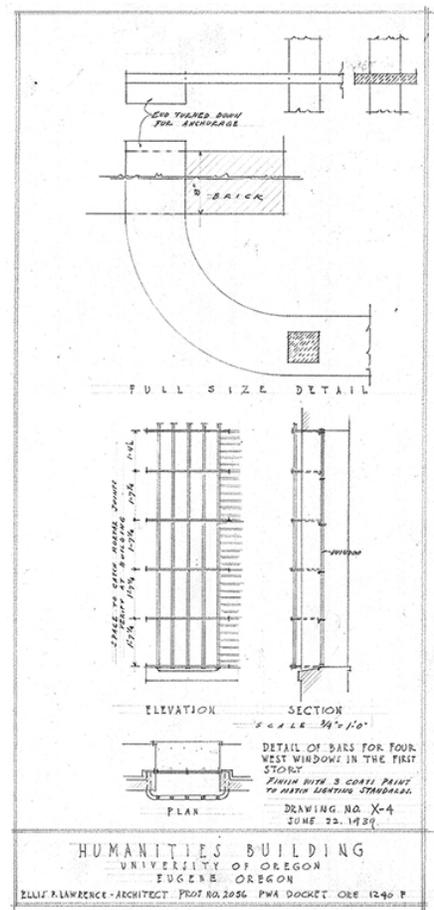
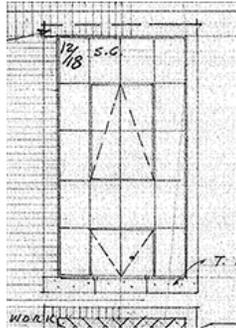


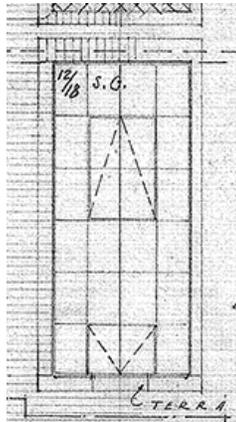
Photo of existing, but presumed original, security bars (left) and the original detail drawings for the security bars (right).



Typical third floor window, existing (left) and original drawings (right).

## SECOND AND THIRD FLOORS

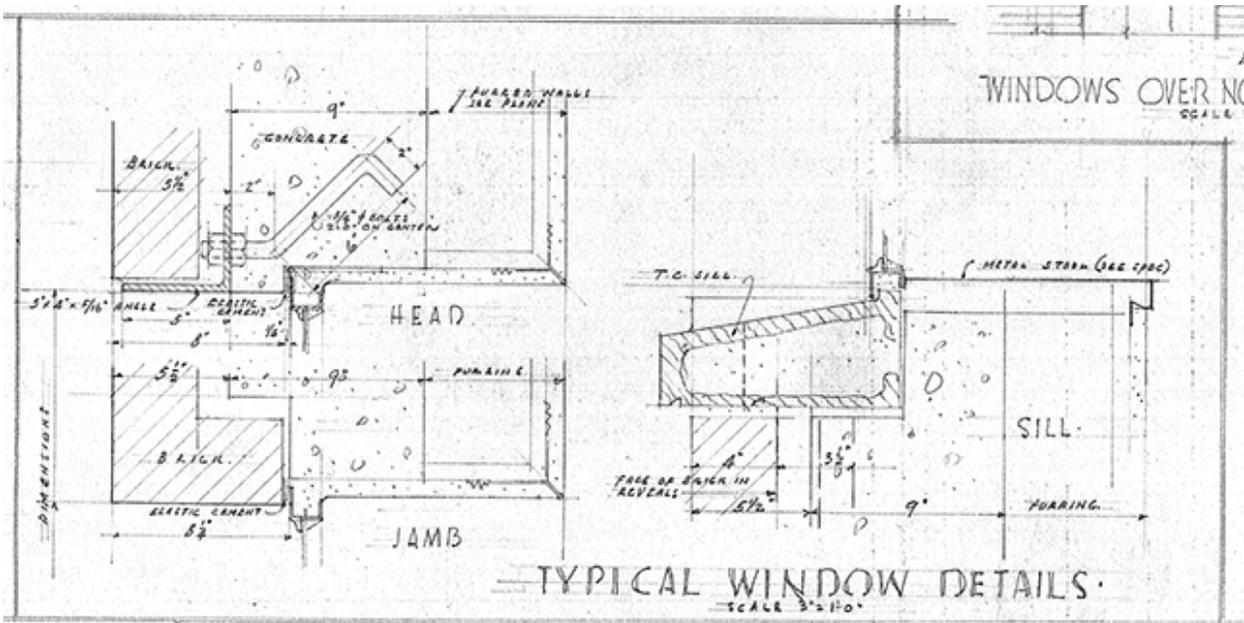
The typical steel-framed window type found on Chapman Hall is a combination window in that some panels are fixed while others are operable. The panels are placed in a vertical orientation and are composed in the frame 6 lights high by 4 lights wide on the second floor and 5 lights high by 4 lights wide on the third floor. In both the second and third floors, a panel of the two bottom center lights of each window open inward as hopper windows. Four upper center lights in a 2 by 2 composition open outward as awning windows.



Typical second floor window, existing (left) and original drawings (right).

According to the original drawings (see below), the header of a typical window is composed of a concrete lintel with imbedded bolts where a steel angle is attached. This steel angle is used to support the brick veneer over the window opening. The interior of the header is finished out with plaster.

The exterior of a typical sill is constructed from terracotta over concrete and slopes down to allow rain to drain away from the window. The interior is constructed from a concrete sill and finished with a metal stool.



Original window details.

## TYPICAL PROBLEMS FOUND IN STEEL FRAME WINDOWS



*Slight condensation found on interior of window in Chapman Hall. Notice corrosion appearing at joints of steel frame.*

### **THERMAL BRIDGING and CONDENSATION**

Both single-pane glazing and steel window frames without thermal breaks are poor insulators and can cause thermal bridging from the exterior to the interior. This means that when the air outside is cold, the interior surface of the window and window frame will also be cold. Not only does this result in greater heat loss, but it can also create condensation problems. When warmer, moist air of the interior touches the cold surfaces of the window, the water vapor in the air will cool, condense, and collect on the horizontal surfaces of the window.

If condensation is allowed to continuously come into contact with the raw metal of the frame, corrosion (rust) can occur, and if left to progress, can cause structural damage to the window. If the weather outside is at a freezing level, the poor insulation of the window and frame can cause the condensation in and around the window to freeze as well. The expansion of the freezing water also contributes to the degradation of the window.



*Corrosion found permeating through cracks in the paint and glazing compound on a window in Chapman Hall.*

### **CORROSION (RUST)**

The most common source of degradation in steel-frame windows is corrosion. Corrosion (oxidation) is caused by the exposure of raw steel (primarily composed of iron) to air and moisture. Exposure can be caused by excessive and long-term condensation, paint failure, glazing compound failure, building enclosure failures, and other causes that expose the steel to air and moisture.

The level of corrosion can be categorized as:

LIGHT = flaking, surface rust

MEDIUM = rust has penetrated the metal (manifests as a bubbling texture) but has not caused structural damage

HEAVY = rust has deeply penetrated the metal and has caused structural damage

A sharp tool can be used to determine the level of corrosion. Heavy corrosion is present if the metal can be penetrated by the tool and brittle strands can be dug out.

Because iron expands in volume when it oxidizes, if corrosion is left untreated, it can increase stress and damage the frame and parts of the adjoining assemblies.



*Paint failure found on a window in Chapman Hall.*

## **PAINT FAILURE**

Paint is used to protect the steel from exposure to air and moisture. When the paint is not regularly maintained, cracks and chipping can occur which may result in moisture penetration and subsequently corrosion.

Many layers of paint may also be present. It is important to remember that heavy layers of paint could hide any corrosion problems of the raw steel beneath. It could also negatively affect the operability of the window.

Historically, steel windows have been painted with lead paint. It is critical to be aware of the health hazards before removing existing paint.



*Condon Hall metal section deterioration (none found in Chapman Hall at this time).*

## **DETERIORATION OF METAL SECTIONS**

The deterioration of metal sections includes bowing, misaligned, and bent metal sections.

This deterioration is often caused by:

- expansion of the metal due to corrosion
- forceful operation
- impact to the window
- modifications due to unintended use of original window

Repair of the bowed, misaligned, and bent sections is possible through applied pressure and/or heat.



*Glazing compound failure found in Chapman Hall.*

## **GLASS AND GLAZING COMPOUND FAILURE**

The most common causes of breaking or cracking of glass include:

- impact
- bowing, misalignment, or bending of the frame which causes stress on the glass which may lead to breakage
- aggressive removal of old glazing compound or paint
- alterations to glass panes to allow for vents etc.

To prevent the individual panes of glass from falling out of the frame, it is necessary to maintain the glazing compound.

Glazing compound failure can cause glass failure and can allow moisture to penetrate to through the raw steel and induce the process of corrosion.



*Locking mechanisms on upper operable sections do not match the rest of the windows in Chapman Hall. It appears that they are missing handles.*

## **HARDWARE ABSENCE OR FAILURE**

The condition of the hardware is a critical factor in determining the level and ease of operability of steel windows. Maintaining the operability of windows allows for natural ventilation and reduces the demand on mechanical cooling systems.

It is common for hardware failure to result in removal or incompatible replacement.

When rehabilitating steel windows, it is important to assess the presence and condition of all window hardware. If hardware is absent or incompatible replacements are present, one should try to find or salvage original hardware from similar windows that may be too damaged to repair. If salvage is not possible, custom fabrication is an option for replication of original hardware.



*Corrosion of steel lintel in masonry surrounds on Chapman Hall.*

## **FAILURE OF MASONRY OR CONCRETE SURROUNDS**

Masonry or concrete surrounds not only provide structural support for the window but also, in routinely maintained conditions, move moisture away from the window.

Typically, steel windows are built directly into their masonry or concrete surrounds. Embedded in the mortar, the subframe is usually left in place if offsite repair is required. If replacement is required, the subframe can only be cut out through the use of a torch.

The condition of these surrounds is a major factor in determining if windows can be repaired in place.

# DETERMINING THE BEST TREATMENT STRATEGIES



When looking at treatment options for Chapman Hall’s steel frame windows, the project criteria below should be considered.

Typically, the assessment, repair, and continued maintenance of historic steel windows is always recommended before considering window replacement. If replacement is the only option, replacing with steel windows “in-kind” should be considered.

## PROJECT CRITERIA

<b>ENVIRONMENT</b>	<b>IMPROVE THERMAL COMFORT</b>	The <b>personal thermal satisfaction</b> within a certain space. “That condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation.” (ANSI/ASHRAE Standard 55-2013)
	<b>MAINTAIN OPERABILITY</b>	The <b>ease or efficiency with which a window or building can be used.</b> ( <a href="http://pdd-dart.rtkl.com/values/usability/">http://pdd-dart.rtkl.com/values/usability/</a> )
<b>SOCIAL</b>	<b>ARCHITECTURAL CHARACTER</b>	The <b>character defining features</b> of a historic building. That is, all visual aspects and physical features that comprise its appearance, including, but not limited to, the overall shape, its materials, craftsmanship, decorative details, interior spaces and features, and its site and environment. (Preservation Brief 17)
	<b>HISTORIC FABRIC</b>	The <b>original materials</b> of a historic building. That is, its integrity, or significant historic façade construction material or ornament, or fragments thereof. ( <a href="http://www.nyc.gov/html/lpc/html/faq/html/faqs/glossary.shtml#h">http://www.nyc.gov/html/lpc/html/faq/html/faqs/glossary.shtml#h</a> )
<b>ECONOMIC</b>	<b>LOWER INITIAL COSTS</b>	The <b>initial investment</b> associated with the construction, [renovation], or completion of a building or project. ( <a href="http://pdd-dart.rtkl.com/values/first-costs/">http://pdd-dart.rtkl.com/values/first-costs/</a> )
	<b>ENERGY COST SAVINGS</b>	The <b>savings achieved by reducing energy consumption.</b> Based on annual energy costs. (Preservation Green Lab, “Saving Windows, Saving Money: Evaluating the Energy Performance of Window Retrofit and Replacement,” National Trust for Historic Preservation, 2012, p. 32.)
	<b>LOWER MAINTENANCE COSTS</b>	The <b>ongoing costs</b> associated with maintaining a building or project after occupation. ( <a href="http://pdd-dart.rtkl.com/values/operating-costs/">http://pdd-dart.rtkl.com/values/operating-costs/</a> )

# REPAIR TREATMENT STRATEGIES

*"It is better to preserve than to restore, better to restore than to reconstruct."  
(A. N. Diron, Murtagh 2006, 4)*

Based on the Secretary of the Interior's Guidelines for Rehabilitation, the general order of approach for the treatment of historic windows are as follows:

1. **Identify** existing historic materials and features, assess their condition, and develop a plan
2. **Protect and Maintain** historic materials and features that are in EXCELLENT-GOOD condition and continue to maintain those that have been repaired or replaced.
3. **Repair** historic materials and features (in-kind where possible) that are in GOOD-FAIR condition
4. **Replace** deteriorated historic materials and features (in-kind where possible) that are in POOR condition or are no longer existing (if recommended)

The different condition definitions can be defined as follows:

EXCELLENT = no/minimal repairs and routine maintenance required

GOOD = Some repair of parts required

FAIR = Invasive repair of parts required

POOR = Invasive repair / replacement required

## 1. IDENTIFY

*"Total replacement need not be necessary.... A careful evaluation of the windows can lead to their retention and repair at a lower cost than complete replacement." (Young, 211)*

The first step in any treatment strategy is a careful inspection of each window and its condition to identify which windows can be preserved, which need repairs, and which need to be replaced.

Elements to evaluate include, but are not limited to:

- sash, frame, and subframe
- presence and degree of corrosion
- deterioration of steel sections
- glass and glazing compounds
- presence and condition of hardware
- condition of the building surrounds



*Photo courtesy of NPS.*

Following this inspection, a rehabilitation plan should be developed. Typically, windows in EXCELLENT-FAIR condition should be Protected and Maintained. Those in GOOD condition should be Repaired in Place, while those in FAIR condition should be Repaired In-Place where possible or Repaired in Shop. Those in POOR condition should be Repaired if possible. If this isn't feasible, it is recommended that they be replaced in-kind.

The ultimate goal of this treatment method and the resulting rehabilitation plan is the retention and preservation of the historic fabric of the windows.

## POTENTIAL ADVANTAGES

- helps to maintain Operability, Architectural Character, and Historic Fabric by identifying and creating a rehabilitation plan for the continued future use of the windows
- Initial Cost is cheaper than full window replacement

## POTENTIAL DISADVANTAGES

- does not solve heat loss through the thermally unbroken steel or uninsulated glass or any air infiltration issues, so it will not dramatically improve Thermal Comfort or Energy Cost Savings



Photo courtesy of NPS.

## 2. PROTECT AND MAINTAIN

*“Maintaining historic steel windows for continued use is always recommended.”  
(Preservation Brief 13)*

If it is determined that the windows are in EXCELLENT - GOOD condition, the following **routine** maintenance is recommended:

- remove light rust, flaking and excessive paint
- prime exposed steel with a rust-inhibiting primer
- replace cracked or broken glass & glazing compound
- replace missing screws or fasteners
- clean & lubricate hinges
- repaint all steel sections with two coats of finish paint compatible with the primer
- caulk masonry surrounds with elastomeric caulk

This routine maintenance should also be performed on the windows in FAIR-POOR condition once they have been treated.

## POTENTIAL ADVANTAGES

- helps to maintain and improve Operability
- retains Architectural Character, and Historic Fabric by maintaining the existing historic windows rather than replacing them
- Initial Cost is cheaper than full window replacement
- helps improve Thermal Comfort and Energy Cost Savings by reducing some of the air infiltration

## POTENTIAL DISADVANTAGES

- does not solve heat loss through the thermally unbroken steel or uninsulated glass or any air infiltration issues, so it will not dramatically improve Thermal Comfort or Energy Cost Savings

### 3a. REPAIR: IN PLACE

If corrosion is extensive or the steel window sections are misaligned, routine maintenance will not suffice. Repairing in-place is recommended if the level of degradation allows. The following conditions can be repaired on-site:

- medium to heavy corrosion that has not caused structural damage to metal sections

- realignment of metal sections if distortion is not too great
- patching of small holes & uneven areas
- cosmetic repairs and routine maintenance

When extreme degradation is present, in-place repair may not be possible & may need to be removed for repair in a workshop off-site.

#### POTENTIAL ADVANTAGES

- helps to maintain and improve Operability
- retains Architectural Character, and Historic Fabric by maintaining the existing historic windows rather than replacing them
- lower Initial Cost than full window replacement

#### POTENTIAL DISADVANTAGES

- does not solve heat loss through the thermally unbroken steel or uninsulated glass or any air infiltration issues, so it will not dramatically improve Thermal Comfort or Energy Cost Savings
- higher risk of damage to historic building, especially if welding occurs on site



*Photo courtesy of NPS.*



*Photo courtesy of NPS.*

### 3b. REPAIR: IN WORKSHOP

When degradation of windows is extreme, in-place repair may not be possible. The following conditions require workshop repair:

- heavy to extreme corrosion to frame & sash that requires extensive rust removal & cleaning
- straightening of bent sections
- welding or splicing in of new metal sections

Typically, off-site repairs are reserved only for highly significant windows that cannot be replaced as the repairs are major and often cost-prohibitive. The procedures required for this level of repair should be performed only by skilled workmen.

#### POTENTIAL ADVANTAGES

- helps to maintain and improve Operability
- retains Architectural Character, and Historic Fabric by maintaining the existing historic windows rather than replacing them

#### POTENTIAL DISADVANTAGES

- does not solve heat loss through the thermally unbroken steel or uninsulated glass or any air infiltration issues, so it will not dramatically improve Thermal Comfort or Energy Cost Savings
- higher Initial Cost than Repair In Place. May be cost prohibitive than full window replacement

## 4. WINDOW REPLACEMENT

*“Replacement should be considered only as a last resort.” (Preservation Brief 13)*

While replacement should be considered last, it may be justified based on the extent of deterioration and availability of replacement steel sections. If repair is impossible and replacement required, consider the following when choosing compatible replacements:

- material
- configuration
- color
- operability
- number and size of panes
- profile and proportion of metal sections
- reflective quality of original glass

Replacement windows made of other materials should be carefully considered as they cannot replicate the thin profiles of the original rolled steel sections.

### POTENTIAL ADVANTAGES

- improves Thermal Comfort and Energy Cost Savings if new windows feature thermal breaks in the steel sections and are glazed with thermal glass

### POTENTIAL DISADVANTAGES

- higher Initial Costs
- loss of Historic Fabric
- can negatively affect Architectural Character if the new windows do not reflect the composition and design of the original windows.

## WEATHERIZING TREATMENT STRATEGIES

While historic steel windows are generally not energy efficient, there are weatherization methods that can help retain the historic fabric while improving their energy efficiency.

### WEATHERIZING STRATEGIES MATRIX

The weatherizing strategies discussed in this section have been ranked based on the operation, situation (condition, occupancy, and window type), and the seven project criteria found on page 16. The matrix on the following page has been created to help further assess the advantages and disadvantages of each treatment strategy based on the mentioned criteria.

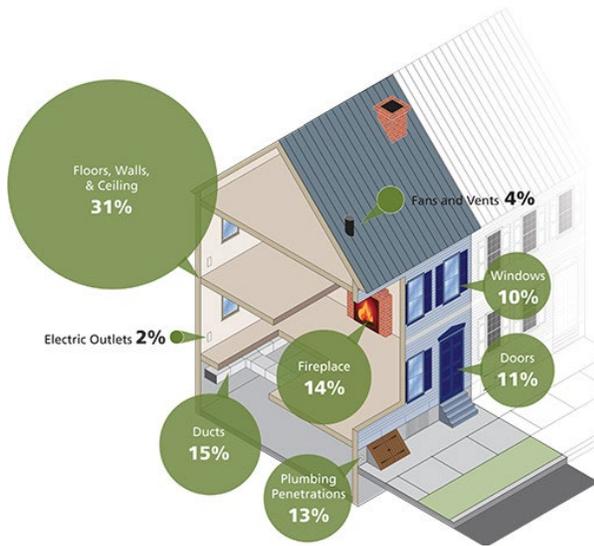


*Fig. 10 b. Close-up view of the new replacement steel windows which matched the multi-lighted originals exactly. Photo: Charles*

*Photo courtesy of NPS.*



# WEATHERIZING TREATMENT STRATEGIES



Major sources of air leaks. Image courtesy of NPS. Data source: U.S. Department of Energy.

## 1. TACKLE OTHER ENERGY EFFICIENCY MEASURES FIRST

If improving energy efficiency is a primary goal for future Chapman Hall alterations, typically greater efficiency can be achieved and at lower cost through other measures than through window upgrades alone. These measures include but are not limited to:

- whole building air sealing
- improved insulation
- upgraded HVAC system

### POTENTIAL ADVANTAGES

- enhances Thermal Comfort by reducing heat loss through more major heat loss sources (floors, walls, and ceilings especially)
- lower Initial Cost than window replacement
- increases Energy Cost Savings than window replacement alone

- retains Historic Fabric and Architectural Character of the windows by addressing greater sources of heat loss first

### POTENTIAL DISADVANTAGES

- may not address potential maintenance and repair needs of the windows themselves - i.e. continued condensation problems, paint or glazing putty failure, failure of masonry surrounds, etc.
- may not resolve Thermal Comfort alone if windows are drafty

## 2. WEATHERSTRIPPING

Weatherstripping is one of the most important first steps in reducing air infiltration around historic windows. There are four types of weatherstripping appropriate for metal windows:

- spring-metal
- vinyl or EPDM strips
- compressible foam tapes
- sealant beads

Spring-metal options are recommended for steel windows in good condition. The use of more than one type of weatherstripping may be necessary. The success of weatherstripping is dependent on the use of the thinnest material to fill the space where air is leaking in. Too

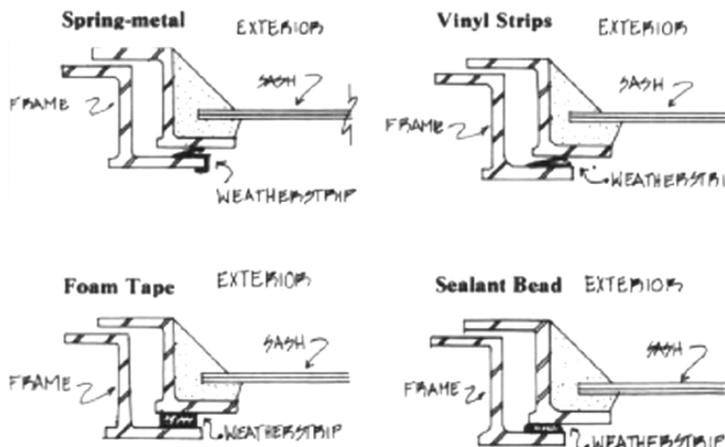


Fig. 8 APPROPRIATE TYPES OF WEATHERSTRIPPING FOR METAL WINDOWS. Weatherstripping is an important part of upgrading the thermal efficiency of historic steel windows. The chart above shows the jamb section of the window with the weatherstripping in place. Drawings: Sharon C. Park, AIA.

Drawing courtesy of NPS.

thick and it can bow or misalign the steel sections of the window sash and frame.

#### POTENTIAL ADVANTAGES

- improves Thermal Comfort by reducing drafts and heat loss through air infiltration
- lowers Initial Cost than additional glazing or window replacement
- retains the Historic Fabric and maintains the Architectural Character
- reduces entry points for insects and moisture

#### POTENTIAL DISADVANTAGES

- while drafts are reduced, heat still transfers through metal frames and glazing
- frequency of Maintenance depends on material, friction, weather, temperature changes, and normal wear and tear. Metal weatherstripping is the most long lasting.

### 3. INTERIOR SURFACE FILM

Interior surface films are a self-adhesive polyester film that are applied to the interior of the window usually to reduce solar heat gains or to improve security measures. There are a variety of different types of film including:

- Dyed/tinted films (NOT recommended for UO campus buildings)
- Reflective or metalized films (NOT recommended for UO campus buildings)
- Low-e films
- Security films

Although durable, films may scratch or bubble over time and need to be removed/replaced. Most films have a 5 to 10 year warranty, but can last longer with good care.

#### POTENTIAL ADVANTAGES

- improves Thermal Comfort and Energy Efficiency by reducing heat gain in the summer and potentially reducing radiant heat loss in the winter
- retains the Historic Fabric
- reduces UV transmission which reduces fading

#### POTENTIAL DISADVANTAGES

- does not retain Architectural Character of windows as it can alter the tint, color, and reflectivity of the window from the exterior
- may have a higher Maintenance Cost than other options as it may scratch or bubble over time and need to be removed/replaced
- reduces visible light transmission, however Low-E film can have greater light transmission than other films



*Application of interior surface film. Photo courtesy of Vision Glass Film Products.*

## 4. ADDITIONAL GLAZING

If weatherstripping alone does not sufficiently improve window thermal efficiency, an additional layer of glazing may be necessary. Before choosing this method of weatherization, a careful analysis of the options should be completed. The most common methods of additional glazing include:

- a glazing slip, which is a new layer of transparent glass or plastic installed onto to the window
- a separate, independent storm window

The energy savings associated with each method is approximately the same.

### 4a. ADDITIONAL GLAZING - glazing slips

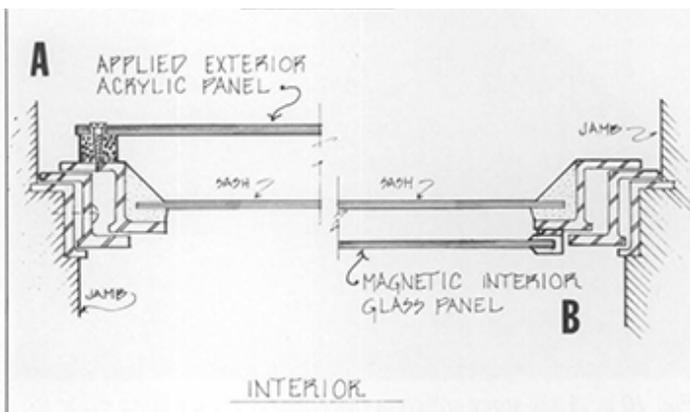


Fig. 9 Two examples of adding a second layer of glazing in order to improve the thermal performance of historic steel windows. Scheme A (showing jamb detail) is of a 1/4" acrylic panel with a closed cell foam gasket attached with self-tapping stainless steel screws directly to the exterior of the outwardly opening sash. Scheme B (showing jamb detail) is of a glass panel in a magnetized frame affixed directly to the interior of the historic steel sash. The choice of using glass or acrylic mounted on the inside or outside will depend on the ability of the window to tolerate additional weight, the location and size of the window, the cost, and the long-term maintenance outlook. Drawing: Sharon C. Park, AIA.

Plan section drawing of an additional glazing layer options added to a steel framed window. Image courtesy of NPS.

One method of additional glazing is a glazing slip. A glazing slip is a permanent second layer of glazing attached directly onto the window sash, either from the exterior or the interior. This glazing is usually made from glass or plastic. The choice depends on the ability of the window to support the weight, visibility needs, and continued maintenance needs. If a single sheet of glazing is applied over the sash of an operable window, the window will become inoperable. To retain operability, separate panels should be affixed to the sash. This could prove to be problematic with the typical windows of Chapman Hall because the operable sections of the windows are located in the center of the window's length, rather than spanning across the whole window. Consideration and care must be given to allow for condensation to escape between the window layers.

### POTENTIAL ADVANTAGES

- improves Thermal Comfort by reducing heat loss through the glass and steel frame by creating an insulating air space between the exterior and the interior layers
- retains Historic Fabric
- retains Architectural Character of the exterior if additional glazing is applied to the interior
- lower Initial Cost when compared to the other options for additional glazing
- greater Energy Cost Savings by reducing heat loss through the glass and steel frame by creating an insulating air space between the exterior and the interior layers

### POTENTIAL DISADVANTAGES

- Operability could be lost if the new glazing cannot be affixed to separate panels
- some Architectural Character is lost if new glazing layer is applied to the exterior of the windows
- increases Maintenance Costs if condensation, moisture, or grime build up between layers

#### **4b. ADDITIONAL GLAZING - exterior storm windows**

Exterior storm windows can also be used to improve a window's energy efficiency. Storm windows differ from glazing slips in that they are units independent of the window sash. Storm windows should be compatible with the original sash configuration. Consideration and care must be given to allow for moisture to escape from between the window layers. Storm windows can either be fixed or operable. If a fixed storm window is used over an operable window, to retain operability, the storm window should be removed seasonally. As a result, this option is NOT recommended for UO campus buildings.



*Operable exterior storm windows. Photo courtesy of NPS.*

#### **POTENTIAL ADVANTAGES**

- improves Thermal Comfort by reducing heat loss through the glass and steel frame by creating an insulating air space between the exterior and the interior layers
- comparable Energy Cost Savings to an entire window replacement with energy efficient windows
- lower Initial Costs, which can be significantly less than entire window replacement
- preserves Historic Fabric by protecting the original historic windows from the elements and extending the life of the historic windows
- they can come in Low-E coatings to reduce heat gain from solar exposure and UV radiation damage to the windows and the interior
- reduces noise infiltration

#### **POTENTIAL DISADVANTAGES**

- prevents or interferes with the Operability of Chapman Halls windows
- may alter the Architectural Character of the building
- some Low-E coatings may also alter the exterior appearance of the building and conflict with the original Architectural Character

#### **4c. ADDITIONAL GLAZING - interior storm windows**

Like exterior storm windows, interior storm windows can also be applied to a window to improve its energy efficiency. Some operable interior versions are available but most interior storm windows are inoperable and must be removed/installed seasonally for the original windows to remain operable. Consideration and care must be given to allow for excessive moisture to escape from between the window layers. If a fixed storm window is used over an

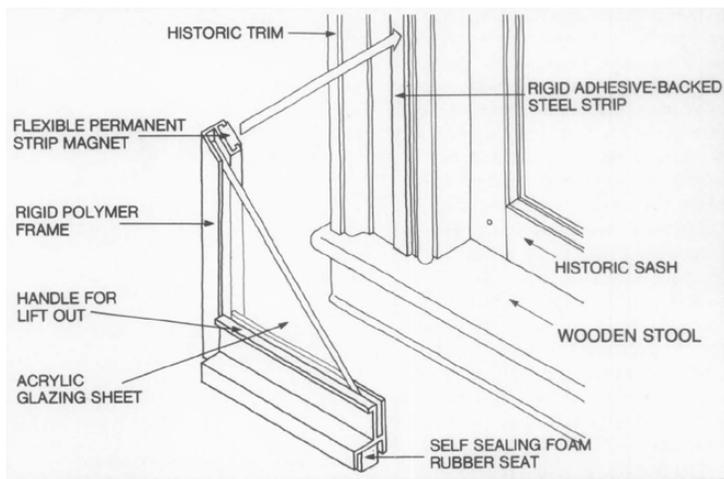


Figure 1. The interior storm window system chosen consisted of a clear acrylic glazing sheet set into a polymer frame that adhered to the existing window trim through use of a magnetic seal. Drawing: Christina Henry.

*Interior storm window detail that is fastened magnetically.  
Drawing courtesy of NPS.*

appearance, thus preserving Architectural Character

- can come in Low-E coatings to reduce heat gains from solar exposure and UV radiation damage to the interior

#### POTENTIAL DISADVANTAGES

- fixed interior windows installed over operable windows require greater Maintenance needs as they have to be removed/installed seasonally if windows are to remain operable in the warmer months. Fixed storm windows over operable windows is NOT recommended for use on UO campus buildings
- some Low-E coatings may also alter the exterior appearance of the building and conflict with the original Architectural Character
- not as effective as preserving the Historic Fabric as an exterior storm window since it does not protect the historic window from the exterior elements

### 5. GLAZING REPLACEMENT

A second method of additional glazing is replacement with thermal glass. This could come in the form of insulated glass, laminated glass, E-coated glass, and other thermal performance options. Consideration should be made for the weight capacities of the original frame and the depth of the muntin bar sections. Thermal glass can differ in thickness and weight from the original glazing of the Chapman Hall steel windows.

#### POTENTIAL ADVANTAGES

- improves Thermal Comfort by reducing heat loss through uninsulated glazing
- retained Architectural Character if the original glazing is not of special interest (stained, figured, etc.). At this time, it is assumed that the original glass of Chapman Hall is not of special interest
- greater Energy Cost Savings by reducing heat loss through uninsulated glazing, but heat loss still occurs through thermal bridging from the steel window sash
- retains Operability

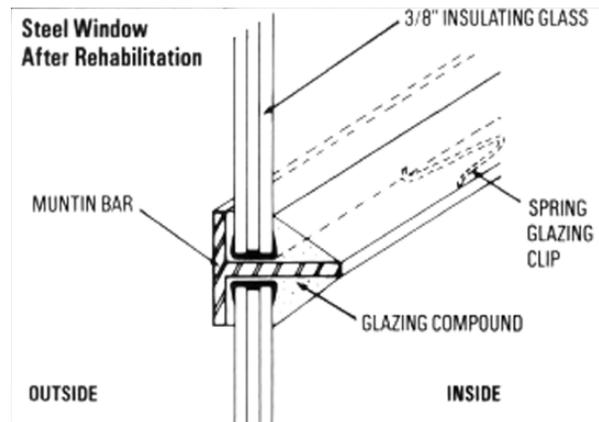
operable window, to retain operability, the storm window should be removed seasonally. As a result, this option is NOT recommended for UO campus buildings.

#### POTENTIAL ADVANTAGES

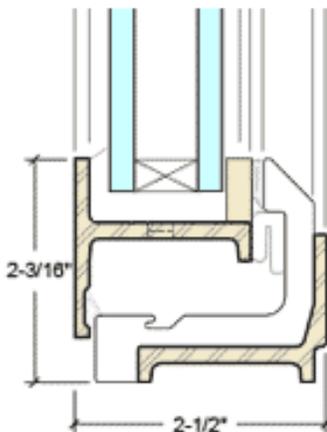
- improves Thermal Comfort by reducing heat loss through the glass and steel frame by creating an insulating air space between the exterior and the interior layers
- comparable in Energy Cost Savings to an entire window replacement with energy efficient windows
- Initial Cost significantly less than window replacement
- interior storm windows have less of an impact on the exterior

## POTENTIAL DISADVANTAGES

- usually greater Initial Cost than the Additional Glazing options, but less expensive than window replacement
- the depth of the muntin bars may not allow for the thickness of the thermal glass required for the windows to meet certain energy efficiency standards
- the original metal sashes may not be able to accommodate the weight of thicker thermal glass.
- using glass with a different color, reflective property, or texture can alter the exterior appearance of the building and thus affect Architectural Character
- thermal bridging through the steel frames is not addressed



*Section of a steel window with original plate glass replaced by insulated glass. Drawing by Martha L. Werenfels and courtesy of NPS.*



*Section drawing of a thermal break detail in a steel window frame. Drawing courtesy of Hope's Windows.*

## 6. WINDOW REPLACEMENT WITH THERMALLY BROKEN STEEL WINDOWS

If a historic steel frame window must be replaced, an additional solution for energy efficiency is the replacement of the historic metal frames with thermally broken frames. Traditionally, steel window frame sections were rolled as one solid piece. A thermally broken steel frame can be achieved by fabricating the interior and exterior sections of the window sash separately and then assembling them with a gasket or other thermally resistant material between the sections. This acts as a thermal break. To reiterate, the strategies mentioned earlier in this document should be considered first before considering window replacement.

### POTENTIAL ADVANTAGES

- improves Thermal Comfort and Energy
- Cost Savings by reducing heat loss through the metal sash
- lowers continued maintenance cost due to reduced potential condensation problems from thermal bridging of uninsulated glass and solid steel window sections

## POTENTIAL DISADVANTAGES

- loss of Historic Fabric by replacing the original windows
- potential loss of Architectural Character through incompatible window sash configuration and composition
- greatest Initial Cost

## RESOURCES

### RESTORATION/REPAIR

Window Restoration & Repair:  
www.windowrestorationandrepair.com  
3377 Cerritos Avenue  
Los Alamitos, CA 90720  
562.493.1590  
WebInfo@WindowRnR.com

Re-View:  
www.re-view.biz  
1235 Saline St. N  
Kansas City, MO 64116  
816.741.2876

Turner Restoration:  
www.turnerrestoration.com  
James (Jim) Turner  
P.O. Box 02775  
Detroit, MI 48202  
313.574.9073  
turnerrestoration@sbcglobal.net

Restoric LLC:  
no website  
Neal Vogel  
8 S Michigan Avenue, 38th Floor  
Chicago, IL 60603  
312.854.7456  
restoricllc@earthlink.net  
\*will not bid against Seekircher

Seekircher Steel Window Repair Corp.  
www.seekirchersteelwindow.com  
John Seekircher  
423 Central Avenue  
Peekskill, NY 10566  
914.734.8009  
seekirchersteelwindow@gmail.com

Viridian Window Restoration LLC  
www.viridianwindow.com  
P.O. Box 12230  
Portland, OR 97212  
503.922.2202  
info@viridianwindow.com

MCM Construction Inc.  
www.mcmbuild.com  
5621 Willow Lane  
Lake Oswego, OR 97035  
503.699.9600  
info@mcmbuild.com

### REPLACE WITH STEEL

Hope's Windows, Inc.:  
www.hopeswindows.com  
84 Hopkins Avenue, P.O. Box 580  
Jamestown, NY 14702-0580  
716.665.5124

Torrance Steel Window Co.:  
www.torrancesteelwindow.com  
1819 Abalone Avenue  
Torrance, CA 90501  
310.328.9181 / 866.776.7563  
info@torrancesteelwindow.com

Steel Windows & Doors USA:  
www.steelwindowsanddoors.com  
690 Surf Avenue  
Stratford, CT 06615  
203.579.5157  
info@steelwindowsanddoors.com

The Steel Window Institute  
www.steelwindows.com  
1300 Sumner Avenue  
Cleveland, OH 44115-2851  
216.241.7333  
swi@steelwindows.com

### REPLACE WITH ALUMINUM

St. Cloud Window:  
www.stcloudwindow.com  
390 Industrial Blvd.  
Sauk Rapids, MN 56379  
320.251.9311  
info@stcloudwindow.com

## BIBLIOGRAPHY

- ANSI/ASHRAE. ANSI/ASHRAE Standard 55-2013: Thermal Environmental Conditions for Human Occupancy. Atlanta: ASHRAE, 2013.
- Ellis Lawrence, Chapman Hall: Original Drawings, 1938, University of Oregon.
- Fisher, Charles E. Preservation Tech Notes: Windows Number Two - Installing Insulating Glass in Existing Steel Windows. National Park Service, 1984. Accessed April 21, 2014. <http://www.nps.gov/tps/how-to-preserve/tech-notes/Tech-Notes-Windows02.pdf>.
- International Energy Agency. "Energy Efficiency." Accessed June 2, 2014. <http://www.iea.org/topics/energyefficiency/>.
- Nelson, Lee H. Preservation Brief 17: Architectural Character--Identifying the Visual Aspects of Historic Buildings as an Aid to Preserving their Character. National Park Service, 1982. Accessed June 2, 2014. <http://www.nps.gov/tps/how-to-preserve/briefs/17-architectural-character.htm>.
- NYC Landmarks Preservation Commission. "Glossary." Accessed June 2, 2014. <http://www.nyc.gov/html/lpc/html/faqs/glossary.shtml#h>.
- Park, Sharon C. Preservation Brief 13: The Repair and Thermal Upgrading of Historic Steel Windows. National Park Service, 1984. Accessed April 21, 2014. <http://www.nps.gov/tps/how-to-preserve/briefs/13-steel-windows.htm>.
- Powers, Robert M. Preservation Tech Notes: Windows Number Seventeen -Repair and Retrofitting Industrial Steel Windows. National Park Service, 1989. Accessed April 21, 2014. <http://www.nps.gov/tps/how-to-preserve/tech-notes/Tech-Notes-Windows17.pdf>.
- RTKL. "The Dart." Accessed June 2, 2014. <http://pdd-dart.rtkl.com/>.
- United States Environmental Protection Agency. "Glossary of Terms." Accessed June 2, 2014. <http://www.epa.gov/iaq/glossary.html#I>.
- Young, Robert A. *Historic Preservation Technology*. Hoboken: J. Wiley & Sons, 2008.

# APPENDIX A - HISTORIC RANKING METHODOLOGY

excerpt from pp. 44-46 of the *Campus Heritage Landscape Plan: 1.0 Landscape Preservation Guidelines and Description of Historic Resources*

## Significance:

*“the meaning or value ascribed to a structure, landscape, object, or site based on the National Register criteria for evaluation...”*

## Integrity:

*“the authenticity of a property’s historic identity, evinced by the survival of physical characteristics that existed during the property’s historic or prehistoric period...”*

Source: National Park Service, Guidelines for the Treatment of Cultural Landscapes, p. 5

Integrity criteria evaluated for each of the twenty-one landscape areas surveyed:

- Location/Setting** – Are important elements still in their original location and configuration?
- Design** – How has the general structure of the landscape changed since its period of significance?
- Materials** – Are original materials/vegetation that were used to structure and shape the landscape still present?
- Workmanship** – Does the landscape retain characteristic workmanship from the period of significance?
- Feeling** – Does the landscape evoke the period of significance?
- Association** – Is it possible to associate elements of the landscape with significant people or events?

## SIGNIFICANCE

The actual evaluation of significance was based upon the process developed for listing in the National Register of Historic Places, in which a resource must demonstrate significance based upon one or more of the following criteria:

- A. Association with significant events that have made a significant contribution to the broad patterns of campus or community history.
- B. Association with significant persons.
- C. Distinctive architecturally because it
  - embodies distinctive characteristics of a type, period, or method of construction;
  - represents the work of a master;
  - possesses high artistic value; or
  - represents a significant and distinguishable entity whose components may lack individual distinction.

(Note: Criterion D, which addresses archeological significance, was not applicable to any campus resources.)

Four levels of significance were designated and used to rank each historic resource. The levels and their criteria were:

- **high significance** – considerable contribution to the history of the campus and its growth.
- **medium significance** – noteworthy contribution the history of the campus and its growth.
- **low significance** – discernible contribution to the history of the campus and its growth.
- **very low significance/no significance** – no discernible importance to the history of the campus and its growth.

There is always room for debate about a resource’s level of significance, as this determination is not a strictly objective exercise. Though the rationale for determining a specific level might never be entirely irrefutable, it should be defensible. It also needs to be recognized that a resource’s significance might change as important connections to the campus character are eventually realized or discovered.

## INTEGRITY

Integrity is the degree to which the key elements that comprise a resource’s significance are still evident today.

Evaluation of integrity is based upon the National Register process—defining the essential physical features that represent it’s significance and determining whether they are still present and intact enough to convey their significance. For example, if a building is deemed significant because of its exterior detailing and materials (criterion C), one would evaluate whether those items have remained relatively

unaltered. If this is the case, the resource has excellent integrity.

Criteria were developed and used in the survey process to help determine each landscape area’s level of integrity (described at left).

Integrity is ascertained based on the specific era (or eras) of significance for that particular landscape area. Four levels of integrity were established and applied to each landscape area:

- excellent integrity – retains a very high percentage of original fabric, and the original design intent is apparent.
- good integrity – retains a significant percentage of original fabric, with a discernible design intent.
- fair integrity – original fabric is present, but diminished.
- poor integrity – contains little historic fabric, and the original design intent is difficult to discern.

### RANKING LEVELS

Historic rankings were determined by evaluating two factors: the resource’s historic significance and its integrity. Using a matrix (below), a historic ranking for each resource was determined based on one of four ranking levels: primary, secondary, tertiary, and non-contributing.

<input checked="" type="checkbox"/> <b>Primary Ranking</b>	Resources that have a high level of historic significance and excellent or good integrity (likely to be eligible for listing in the National Register).			
<input type="checkbox"/> <b>Secondary Ranking</b>	Resources that have a reduced level of significance and good or excellent integrity. Also, resources that have a high level of historic significance but fair integrity (possibly eligible for listing in the National Register).			
<input type="checkbox"/> <b>Tertiary Ranking</b>	Resources that have a reduced (medium) level of historic significance but compromised (fair) integrity. Also, resources that have integrity but lack noteworthy significance at this time as an individual resource. These resources could contribute to the historic significance of a large grouping or district, though they are likely not eligible for listing individually in the National Register.			
<input type="checkbox"/> <b>Non-Contributing Ranking</b>	Resources that lack noteworthy significance or have severely compromised integrity. They do not contribute to the historic significance of a large grouping or district and are not eligible for listing in the National Register.			
	high historic significance	medium historic significance	low historic significance	very low or no historic sig.
excellent integrity	primary ranking	secondary ranking	tertiary ranking	non-contributing
good integrity	primary ranking	secondary ranking	tertiary ranking	non-contributing
fair integrity	secondary ranking	tertiary ranking	tertiary ranking	non-contributing
poor integrity	non-contributing	non-contributing	non-contributing	non-contributing
Matrix used to determine the historic ranking levels for the landscape areas and buildings under study.				

# APPENDIX B - PRESERVATION BRIEF 13: THE REPAIR AND THERMAL UPGRADING OF HISTORIC STEEL WINDOWS

## 13 PRESERVATION BRIEFS

### The Repair and Thermal Upgrading of Historic Steel Windows

Sharon C. Park, AIA



U.S. Department of the Interior  
National Park Service  
Cultural Resources  
Heritage Preservation Services



The Secretary of the Interior's "Standards for Rehabilitation" require that where historic windows are individually significant features, or where they contribute to the character of significant facades, their distinguishing visual qualities must not be destroyed. Further, the rehabilitation guidelines recommend against changing the historic appearance of windows through the use of inappropriate designs, materials, finishes, or colors which radically change the sash, depth of reveal, and muntin configuration; the reflectivity and color of the glazing; or the appearance of the frame.

Windows are among the most vulnerable features of historic buildings undergoing rehabilitation. This is especially the case with rolled steel windows, which are often mistakenly not deemed worthy of preservation in the conversion of old buildings to new uses. The ease with which they can be replaced and the mistaken assumption that they cannot be made energy efficient except at great expense are factors that typically lead to the decision to remove them. In many cases, however, repair and retrofit of the historic windows are more economical than wholesale replacement, and all too often, replacement units are unlike the originals in design and appearance. If the windows are important in establishing the historic character of the building (see fig. 1), insensitively designed replacement windows may diminish—or destroy—the building's historic character.

This *Brief* identifies various types of historic steel windows that dominated the metal window market from 1890-1950. It then gives criteria for evaluating deterioration and for determining appropriate treatment, ranging from routine maintenance and weatherization to extensive repairs, so that replacement may be avoided where possible.<sup>1</sup> This information applies to do-it-yourself jobs and to large rehabilitations where the volume of work warrants the removal of all window units for complete overhaul by professional contractors.

This *Brief* is not intended to promote the repair of ferrous metal windows in every case, but rather to insure that preservation is always the first consideration in a rehabilitation project. Some windows are not important elements in defining a building's historic character; others are highly significant, but so deteriorated that repair is infeasible. In such cases, the *Brief* offers guidance in evaluating appropriate replacement windows.



*Fig. 1 Often highly distinctive in design and craftsmanship, rolled steel windows play an important role in defining the architectural character of many later nineteenth and early twentieth century buildings. Art Deco, Art Moderne, the International Style, and Post World War II Modernism depended on the slim profiles and streamlined appearance of metal windows for much of their impact. Photo: William G. Johnson.*

<sup>1</sup>The technical information given in this brief is intended for most ferrous (or magnetic) metals, particularly rolled steel. While stainless steel is a ferrous metal, the cleaning and repair techniques outlined here must not be used on it as the finish will be damaged. For information on cleaning stainless steel and non-ferrous metals, such as bronze, Monel, or aluminum, refer to *Metals in America's Historic Buildings* (see bibliography).

## HISTORICAL DEVELOPMENT

Although metal windows were available as early as 1860 from catalogues published by architectural supply firms, they did not become popular until after 1890. Two factors combined to account for the shift from wooden to metal windows about that time. Technology borrowed from the rolling industry permitted the mass production of rolled steel windows. This technology made metal windows cost competitive with conventional wooden windows. In addition, a series of devastating urban fires in Boston, Baltimore, Philadelphia, and San Francisco led to the enactment of strict fire codes for industrial and multi-story commercial and office buildings.

As in the process of making rails for railroads, rolled steel windows were made by passing hot bars of steel through progressively smaller, shaped rollers until the appropriate angled configuration was achieved (see fig. 2). The rolled steel sections, generally 1/8" thick and 1" - 1 1/2" wide, were used for all the components of the windows: sash, frame, and subframe (see fig. 3). With the addition of wire glass, a fire-resistant window resulted. These rolled steel windows are almost exclusively found in masonry or concrete buildings.

A byproduct of the fire-resistant window was the strong metal frame that permitted the installation of larger windows and windows in series. The ability to have expansive amounts of glass and increased ventilation dramatically changed the designs of late 19th and early 20th century industrial and commercial buildings.

The newly available, reasonably priced steel windows soon became popular for more than just their fire-resistant qualities. They were standardized, extremely durable, and easily transported. These qualities led to the use of steel windows in every type of construction, from simple industrial and institutional buildings to luxury commercial and apartment buildings. Casement, double-hung, pivot, projecting, astral, and continuous windows differed in operating and ventilating capacities. Figure 4 outlines the kinds and properties of metal windows available then and now. In addition, the thin profiles of metal windows contributed to the streamlined appearance of the Art Deco, Art Moderne, and International Styles, among others.

The extensive use of rolled steel metal windows continued until after World War II when cheaper, non-corroding aluminum windows became increasingly popular. While aluminum windows dominate the market today, steel windows are still fabricated. Should replacement of original windows become necessary, replacement windows may be available from the manufacturers of some of the earliest steel windows. Before an informed decision can be made whether to repair or replace metal windows, however, the significance of the windows must be determined and their physical condition assessed.

Cover illustration: from *Hope's Metal Windows and Casements: 1818-1926*, currently Hope's Architectural Products, Inc. Used with permission.

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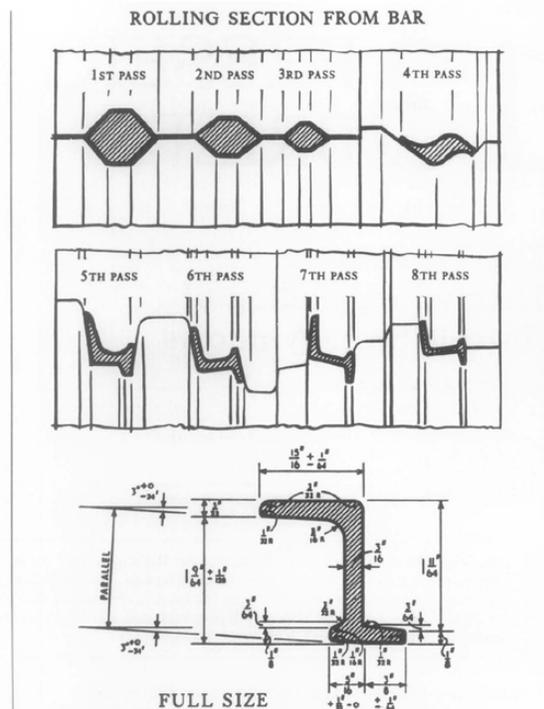


Fig. 2. The process of rolling a steel bar into an angled section is illustrated above. The shape and size of the rolled section will vary slightly depending on the overall strength needed for the window opening and the location of the section in the assembly: subframe, frame, or sash. The 1/8" thickness of the metal section is generally standard. Drawing: *A Metal Window Dictionary*. Used with permission.

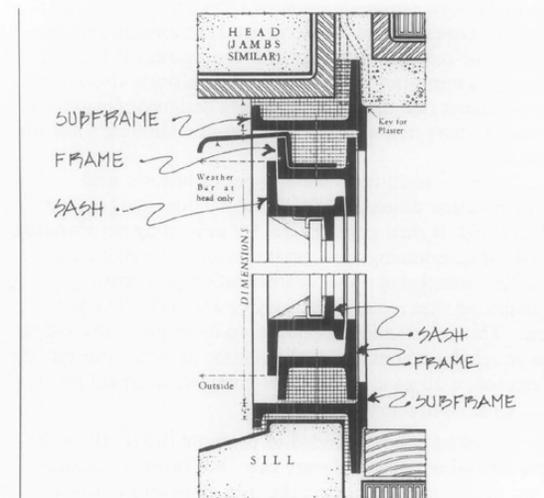


Fig. 3 A typical section through the top and bottom of a metal window shows the three component parts of the window assembly: subframe, frame, and sash. Drawings: Catalogue No. 15, January 1931; International Casement Co, Inc., presently Hope's Architectural Products, Inc., Jamestown, NY. Used with permission.

## EVALUATION

### Historic and Architectural Considerations

An assessment of the significance of the windows should begin with a consideration of their function in relation to the building's historic use and its historic character. Windows that help define the building's historic character should be preserved even if the building is being converted to a new use. For example, projecting steel windows used to introduce light and an effect of spaciousness to a warehouse or industrial plant can be retained in the conversion of such a building to offices or residences.

Other elements in assessing the relative importance of the historic windows include the design of the windows and their relationship to the scale, proportion, detailing and architectural style of the building. While it may be easy to determine the aesthetic value of highly ornamented windows, or to recognize the importance of streamlined windows as an element of a style, less elaborate windows can also provide strong visual interest by their small panes or projecting planes when open, particularly in simple, unadorned industrial buildings (see fig. 5).

One test of the importance of windows to a building is to ask if the overall appearance of the building would be changed noticeably if the windows were to be removed or radically altered. If so, the windows are important in defining the building's historic character, and should be repaired if their physical condition permits.

### Physical Evaluation

Steel window repair should begin with a careful evaluation of the physical condition of each unit. Either drawings or photographs, liberally annotated, may be used to record the location of each window, the type of operability, the condition of all three parts—sash, frame and sub-frame—and the repairs essential to its continued use.

Specifically, the evaluation should include: presence and degree of corrosion; condition of paint; deterioration of the metal sections, including bowing, misalignment of the sash, or bent sections; condition of the glass and glazing compound; presence and condition of all hardware, screws, bolts, and hinges; and condition of the masonry or concrete surrounds, including need for caulking or resetting of improperly sloped sills.

Corrosion, principally rusting in the case of steel windows, is the controlling factor in window repair; therefore, the evaluator should first test for its presence. Corrosion can be light, medium, or heavy, depending on how much the rust has penetrated the metal sections. If the rusting is merely a surface accumulation or flaking, then the corrosion is light. If the rusting has penetrated the metal (indicated by a bubbling texture), but has not caused any structural damage, then the corrosion is medium. If the rust has penetrated deep into the metal, the corrosion is heavy. Heavy corrosion generally results in some form of structural damage, through delamination,

to the metal section, which must then be patched or spliced. A sharp probe or tool, such as an ice pick, can be used to determine the extent of corrosion in the metal. If the probe can penetrate the surface of the metal and brittle strands can be dug out, then a high degree of corrosive deterioration is present.

In addition to corrosion, the condition of the paint, the presence of bowing or misalignment of metal sections, the amount of glass needing replacement, and the condition of the masonry or concrete surrounds must be assessed in the evaluation process. These are key factors in determining whether or not the windows can be repaired in place. The more complete the inventory of existing conditions, the easier it will be to determine whether repair is feasible or whether replacement is warranted.

### Rehabilitation Work Plan

Following inspection and analysis, a plan for the rehabilitation can be formulated. The actions necessary to return windows to an efficient and effective working condition will fall into one or more of the following categories: routine maintenance, repair, and weatherization. The routine maintenance and weatherization measures described here are generally within the range of do-it-yourselfers. Other repairs, both moderate and major, require a professional contractor. Major repairs normally require the removal of the window units to a workshop, but even in the case of moderate repairs, the number of windows involved might warrant the removal of all the deteriorated units to a workshop in order to realize a more economical repair price. Replacement of windows should be considered only as a last resort.

Since moisture is the primary cause of corrosion in steel windows, it is essential that excess moisture be eliminated and that the building be made as weathertight as possible before any other work is undertaken. Moisture can accumulate from cracks in the masonry, from spalling mortar, from leaking gutters, from air conditioning condensation runoff, and from poorly ventilated interior spaces.

Finally, before beginning any work, it is important to be aware of health and safety risks involved. Steel windows have historically been coated with lead paint. The removal of such paint by abrasive methods will produce toxic dust. Therefore, safety goggles, a toxic dust respirator, and protective clothing should be worn. Similar protective measures should be taken when acid compounds are used. Local codes may govern the methods of removing lead paints and proper disposal of toxic residue.

### ROUTINE MAINTENANCE

A preliminary step in the routine maintenance of steel windows is to remove surface dirt and grease in order to ascertain the degree of deterioration, if any. Such minor cleaning can be accomplished using a brush or vacuum followed by wiping with a cloth dampened with mineral spirits or denatured alcohol.

<p><i>Double-hung industrial windows</i> duplicated the look of traditional wooden windows. Metal double-hung windows were early examples of a building product adapted to meet stringent new fire code requirements for manufacturing and high-rise buildings in urban areas. Soon supplanted in industrial buildings by less expensive pivot windows, double-hung metal windows regained popularity in the 1940s for use in speculative suburban housing.</p>	<p><i>Austral windows</i> were also a product of the 1920s. They combined the appearance of the double-hung window with the increased ventilation and ease of operation of the projected window. (When fully opened, they provided 70% ventilation as compared to 50% ventilation for double-hung windows.) Austral windows were often used in schools, libraries and other public buildings.</p>
<p><i>Pivot windows</i> were an early type of industrial window that combined inexpensive first cost and low maintenance. Pivot windows became standard for warehouses and power plants where the lack of screens was not a problem. The window shown here is a horizontal pivot. Windows that turned about a vertical axis were also manufactured (often of iron). Such vertical pivots are rare today.</p>	<p><i>Casement windows</i> adapted the English tradition of using wrought iron casements with leaded cames for residential use. Rolled steel casements (either single, as shown, or paired) were popular in the 1920s for cottage style residences and Gothic style campus architecture. More streamlined casements were popular in the 1930s for institutional and small industrial buildings.</p>
<p><i>Projecting windows</i>, sometimes called awning or hopper windows, were perfected in the 1920s for industrial and institutional buildings. They were often used in "combination" windows, in which upper panels opened out and lower panels opened in. Since each movable panel projected to one side of the frame only, unlike pivot windows, for example, screens could be introduced.</p>	<p><i>Continuous windows</i> were almost exclusively used for industrial buildings requiring high overhead lighting. Long runs of clerestory windows operated by mechanical tension rod gears were typical. Long banks of continuous windows were possible because the frames for such windows were often structural elements of the building.</p>

Fig. 4 Typical rolled steel windows available from 1890 to the present. The various operating and ventilating capacities in combination with the aesthetics of the window style were important considerations in the selection of one window type over another. Drawings: Sharon C. Park, AIA.

If it is determined that the windows are in basically sound condition, the following steps can be taken: 1) removal of light rust, flaking and excessive paint; 2) priming of exposed metal with a rust-inhibiting primer; 3) replacement of cracked or broken glass and glazing compound; 4) replacement of missing screws or fasteners; 5) cleaning and lubrication of hinges; 6) repainting of all steel sections with two coats of finish paint compatible with the primer; and 7) caulking the masonry surrounds with a high quality elastomeric caulk.

Recommended methods for removing light rust include manual and mechanical abrasion or the application of chemicals. Burning off rust with an oxy-acetylene or propane torch, or an inert gas welding gun, should never be attempted because the heat can distort the metal. In addition, such intense heat (often as high as 3800° F) vaporizes the lead in old paint, resulting in highly toxic fumes. Furthermore, such heat will likely result in broken glass. Rust can best be removed using a wire brush, an aluminum oxide sandpaper, or a variety of power tools



Fig. 5 Windows often provide a strong visual element to relatively simple or unadorned industrial or commercial buildings. This design element should be taken into consideration when evaluating the significance of the windows. Photo: Michael Auer.

adapted for abrasive cleaning such as an electric drill with a wire brush or a rotary whip attachment. Adjacent sills and window jambs may need protective shielding.

Rust can also be removed from ferrous metals by using a number of commercially prepared anti-corrosive acid compounds. Effective on light and medium corrosion, these compounds can be purchased either as liquids or gels. Several bases are available, including phosphoric acid, ammonium citrate, oxalic acid and hydrochloric acid. Hydrochloric acid is generally not recommended; it can leave chloride deposits, which cause future corrosion. Phosphoric acid-based compounds do not leave such deposits, and are therefore safer for steel windows. However, any chemical residue should be wiped off with damp cloths, then dried immediately. Industrial blow-dryers work well for thorough drying. The use of running water to remove chemical residue is never recommended because the water may spread the chemicals to adjacent surfaces, and drying of these surfaces may be more difficult. Acid cleaning compounds will stain masonry; therefore plastic sheets should be taped to the edge of the metal sections to protect the masonry surrounds. The same measure should be followed to protect the glazing from etching because of acid contact.

Measures that remove rust will ordinarily remove flaking paint as well. Remaining loose or flaking paint can be removed with a chemical paint remover or with a pneumatic needle scaler or gun, which comes with a series of chisel blades and has proven effective in removing flaking paint from metal windows. Well-bonded paint may serve to protect the metal further from corrosion, and need not be removed unless paint build-up prevents the window from closing tightly. The edges should be feathered by sanding to give a good surface for repainting.

Next, any *bare* metal should be wiped with a cleaning solvent such as denatured alcohol, and dried immediately in preparation for the application of an anti-corrosive primer. Since corrosion can recur very soon after metal has been exposed to the air, the metal should be primed immediately after cleaning. Spot priming may be required periodically as other repairs are undertaken. Anti-corrosive primers generally consist of oil-alkyd based paints rich in zinc or zinc chromate.<sup>2</sup> Red lead is no longer available because of its toxicity. All metal primers, however, are toxic to some degree and should be handled carefully. Two coats of primer are recommended. Manufacturer's recommendations should be followed concerning application of primers.

## REPAIR

### Repair in Place

The maintenance procedures described above will be insufficient when corrosion is extensive, or when metal window sections are misaligned. Medium to heavy corrosion that has not done any structural damage to the metal sections can be removed either by using the chemical cleaning

process described under "Routine Maintenance" or by sandblasting. Since sandblasting can damage the masonry surrounds and crack or cloud the glass, metal or plywood shields should be used to protect these materials. The sandblasting pressure should be low, 80-100 pounds per square inch, and the grit size should be in the range of #10-#45. Glass peening beads (glass pellets) have also been successfully used in cleaning steel sections. While sandblasting equipment comes with various nozzle sizes, pencil-point blasters are most useful because they give the operator more effective control over the direction of the spray. The small aperture of the pencil-point blaster is also useful in removing dried putty from the metal sections that hold the glass. As with any cleaning technique, once the bare metal is exposed to air, it should be primed as soon as possible. This includes the inside rabbeted section of sash where glazing putty has been removed. To reduce the dust, some local codes allow only wet blasting. In this case, the metal must be dried immediately, generally with a blow-drier (a step that the owner should consider when calculating the time and expense involved). Either form of sandblasting metal covered with lead paints produces toxic dust. Proper precautionary measures should be taken against toxic dust and silica particles.

Bent or bowed metal sections may be the result of damage to the window through an impact or corrosive expansion. If the distortion is not too great, it is possible to realign the metal sections without removing the window to a metal fabricator's shop. The glazing is generally removed and pressure is applied to the bent or bowed section. In the case of a muntin, a protective 2 x 4 wooden bracing can be placed behind the bent portion and a wire cable with a winch can apply progressively more pressure over several days until the section is realigned. The 2 x 4 bracing is necessary to distribute the pressure evenly over the damaged section. Sometimes a section, such as the bottom of the frame, will bow out as a result of pressure exerted by corrosion and it is often necessary to cut the metal section to relieve this pressure prior to pressing the section back into shape and making a welded repair.

Once the metal sections have been cleaned of all corrosion and straightened, small holes and uneven areas resulting from rusting should be filled with a patching material and sanded smooth to eliminate pockets where water can accumulate. A patching material of steel fibers and an epoxy binder may be the easiest to apply. This steel-based epoxy is available for industrial steel repair; it can also be found in auto body patching compounds or in plumber's epoxy. As with any product, it is important to follow the manufacturer's instructions for proper use and best results. The traditional patching technique—melting steel welding rods to fill holes in the metal sections—may be difficult to apply in some situations; moreover, the window glass must be removed during the repair process, or it will crack from the expansion of the heated metal sections. After these repairs, glass replacement, hinge lubrication, painting, and other cosmetic repairs can be undertaken as necessary.

<sup>2</sup>Refer to Table IV. Types of Paint Used for Painting Metal in *Metals in America's Historic Buildings*, p. 139. (See bibliography).

To complete the checklist for routine maintenance, cracked glass, deteriorated glazing compound, missing screws, and broken fasteners will have to be replaced; hinges cleaned and lubricated; the metal windows painted, and the masonry surrounds caulked. If the glazing must be replaced, all clips, glazing beads, and other fasteners that hold the glass to the sash should be retained, if possible, although replacements for these parts are still being fabricated. When bedding glass, use only glazing compound formulated for metal windows. To clean the hinges (generally brass or bronze), a cleaning solvent and fine bronze wool should be used. The hinges should then be lubricated with a non-greasy lubricant specially formulated for metals and with an anti-corrosive agent. These lubricants are available in a spray form and should be used periodically on frequently opened windows.

Final painting of the windows with a paint compatible with the anti-corrosive primer should proceed on a dry day. (Paint and primer from the same manufacturer should be used.) Two coats of finish paint are recommended if the sections have been cleaned to bare metal. The paint should overlap the glass slightly to insure weathertightness at that connection. Once the paint dries thoroughly, a flexible exterior caulk can be applied to eliminate air and moisture infiltration where the window and the surrounding masonry meet.

Caulking is generally undertaken after the windows have received at least one coat of finish paint. The perimeter of the masonry surround should be caulked with a flexible elastomeric compound that will adhere well to both metal and masonry. The caulking used should be a type intended for exterior application, have a high tolerance for material movement, be resistant to ultraviolet light, and have a minimum durability of 10 years. Three effective compounds (taking price and other factors into consideration) are polyurethane, vinyl acrylic, and butyl rubber. In selecting a caulking material for a window retrofit, it is important to remember that the caulking compound may be covering other materials in a substrate. In this case, some compounds, such as silicone, may not adhere well. Almost all modern caulking compounds can be painted after curing completely. Many come in a range of colors, which eliminates the need to paint. If colored caulking is used, the windows should have been given two coats of finish paint prior to caulking.

### Repair in Workshop

Damage to windows may be so severe that the window sash and sometimes the frame must be removed for cleaning and extensive rust removal, straightening of bent sections, welding or splicing in of new sections, and reglazing. These major and expensive repairs are reserved for highly significant windows that cannot be replaced; the procedures involved should be carried out only by skilled workmen. (see fig. 6a—6f.)

As part of the orderly removal of windows, each window should be numbered and the parts labelled. The operable metal sash should be dismantled by removing the hinges; the fixed sash and, if necessary, the frame can then be unbolted or unscrewed. (The subframe is usually left in place. Built into the masonry surrounds, it can only be cut out with a torch.) Hardware and hinges should be labelled and stored together.

The two major choices for removing flaking paint and corrosion from severely deteriorated windows are dipping in a chemical bath or sandblasting. Both treatments require removal of the glass. If the windows are to be dipped, a phosphoric acid solution is preferred, as mentioned earlier. While the dip tank method is good for fairly evenly distributed rust, deep set rust may remain after dipping. For that reason, sandblasting is more effective for heavy and uneven corrosion. Both methods leave the metal sections clean of residual paint. As already noted, after cleaning has exposed the metal to the air, it should be primed immediately after drying with an anti-corrosive primer to prevent rust from recurring.

Sections that are seriously bent or bowed must be straightened with heat and applied pressure in a workshop. Structurally weakened sections must be cut out, generally with an oxy-acetylene torch, and replaced with sections welded in place and the welds ground smooth. Finding replacement metal sections, however, may be difficult. While most rolling mills are producing modern sections suitable for total replacement, it may be difficult to find an exact profile match for a splicing repair. The best source of rolled metal sections is from salvaged windows, preferably from the same building. If no salvaged windows are available, two options remain. Either an ornamental metal fabricator can weld flat plates into a built-up section, or a steel plant can mill bar steel into the desired profile.

While the sash and frame are removed for repair, the subframe and masonry surrounds should be inspected. This is also the time to reset sills or to remove corrosion from the subframe, taking care to protect the masonry surrounds from damage.

Missing or broken hardware and hinges should be replaced on all windows that will be operable. Salvaged windows, again, are the best source of replacement parts. If matching parts cannot be found, it may be possible to adapt ready-made items. Such a substitution may require filling existing holes with steel epoxy or with plug welds and tapping in new screw holes. However, if the hardware is a highly significant element of the historic window, it may be worth having reproductions made.

Following are illustrations of the repair and thermal upgrading of the rolled steel windows in a National Historic Landmark (fig. 6). Many of the techniques described above were used during this extensive rehabilitation. The complete range of repair techniques is then summarized in the chart titled *Steps for Cleaning and Repairing Historic Steel Windows* (see fig. 7).

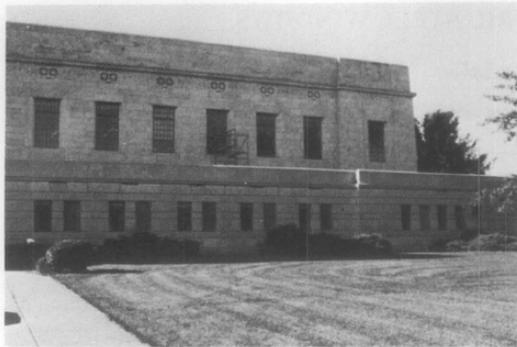


Fig. 6 a. View of the flanking wing of the State Capitol where the rolled steel casement windows are being removed for repair.

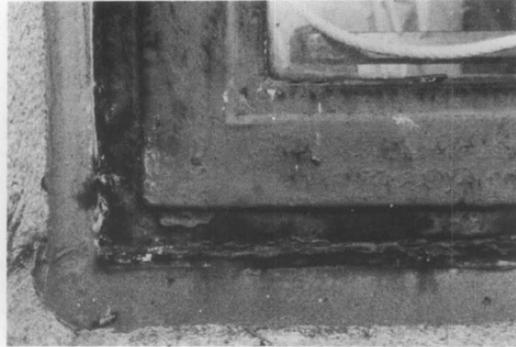


Fig. 6 b. View from the exterior showing the deteriorated condition of the lower corner of a window prior to repair. While the sash was in relatively good condition, the frame behind was rusted to the point of inhibiting operation.

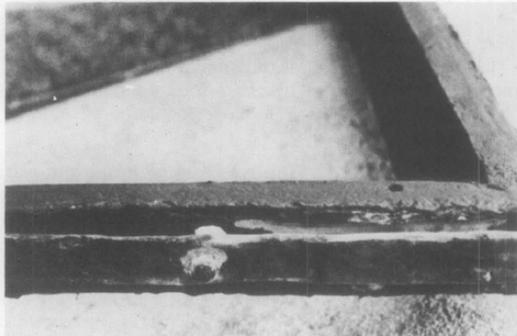


Fig. 6 c. View of the rusted frame which was unscrewed from the subframe and removed from the window opening and taken to a workshop for sandblasting. In some cases, severely deteriorated sections of the frame were replaced with new sections of milled bar steel.



Fig. 6 d. View looking down towards the sill. The subframes appeared very rusted, but were in good condition once debris was vacuumed and surface rust was removed, in place, with chemical compounds. Where necessary, epoxy and steel filler was used to patch depressions in order to make the subframe serviceable again.

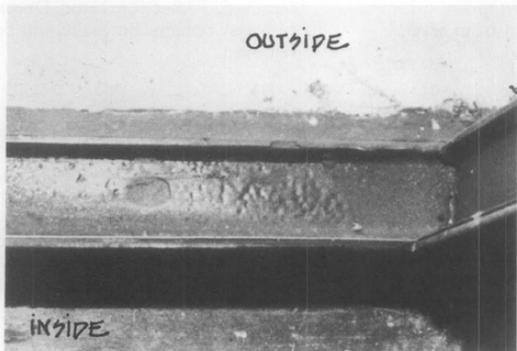


Fig. 6 e. View looking down towards the sill. The cleaned frame was reset in the window opening. The frame was screwed to the refurbished subframe at the jamb and the head only. The screw holes at the sill, which had been the cause of much of the earlier rusting, were infilled. Vinyl weatherstripping was added to the frame.

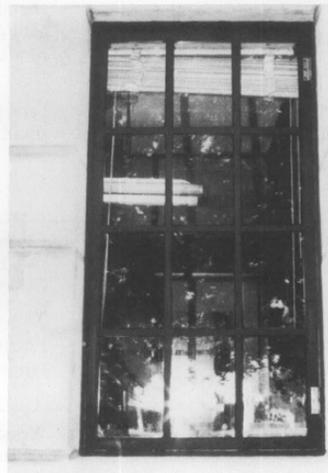


Fig. 6 f. View from the outside of the completely refurbished window. In addition to the steel repair and the installation of vinyl weatherstripping, the exterior was caulked with polyurethane and the single glass was replaced with individual lights of thermal glass. The repaired and upgraded windows have comparable energy efficiency ratings to new replacement units while retaining the historic steel sash, frames and subframes.

Fig. 6. The repair and thermal upgrading of the historic steel windows at the State Capitol, Lincoln, Nebraska. This early twentieth century building, designed by Bertram Goodhue, is a National Historic Landmark. Photos: All photos in this series were provided by the State Building Division.

## STEPS FOR CLEANING AND REPAIRING HISTORIC STEEL WINDOWS

Work Item	Recommended Techniques	Tools, Products and Procedures	Notes
	*(Must be done in a workshop)		
1. Removing dirt and grease from metal	General maintenance and chemical cleaning	Vacuum and bristle brushes to remove dust and dirt; solvents (denatured alcohol, mineral spirits), and clean cloths to remove grease.	Solvents can cause eye and skin irritation. Operator should wear protective gear and work in ventilated area. Solvents should not contact masonry. Do not flush with water.
2. Removing Rust/Corrosion			
Light	Manual and mechanical abrasion	Wire brushes, steel wool, rotary attachments to electric drill, sanding blocks and disks.	Handsanding will probably be necessary for corners. Safety goggles and masks should be worn.
	Chemical cleaning	Anti-corrosive jellies and liquids (phosphoric acid preferred); clean damp cloths.	Protect glass and metal with plastic sheets attached with tape. Do not flush with water. Work in ventilated area.
Medium	Sandblasting/abrasive cleaning	Low pressure (80-100 psi) and small grit (#10-#45); glass peening beads. Pencil blaster gives good control.	Removes both paint and rust. Codes should be checked for environmental compliance. Prime exposed metal promptly. Shield glass and masonry. Operator should wear safety gear.
Heavy	*Chemical dip tank	Metal sections dipped into chemical tank (phosphoric acid preferred) from several hours to 24 hours.	Glass and hardware should be removed. Protect operator. Deepset rust may remain, but paint will be removed.
	*Sandblasting/abrasive cleaning	Low pressure (80-100 psi) and small grit (#10-#45).	Excellent for heavy rust. Remove or protect glass. Prime exposed metal promptly. Check codes for environmental compliance. Operator should wear safety gear.
3. Removing flaking paint.	Chemical method	Chemical paint strippers suitable for ferrous metals. Clean cloths.	Protect glass and masonry. Do not flush with water. Have good ventilation and protection for operator.
	Mechanical abrasion	Pneumatic needle gun chisels, sanding disks.	Protect operator; have good ventilation. Well-bonded paint need not be removed if window closes properly.
4. Aligning bent, bowed metal sections	Applied pressure	Wooden frame as a brace for cables and winch mechanism.	Remove glass in affected area. Realignment may take several days.
	*Heat and pressure	Remove to a workshop. Apply heat and pressure to bend back.	Care should be taken that heat does not deform slender sections.

Work Item	Recommended Techniques	Tools, Products and Procedures	Notes
5. Patching depressions	*(Must be done in a workshop) Epoxy and steel filler	Epoxy fillers with high content of steel fibers; plumber's epoxy or autobody patching compound.	Epoxy patches generally are easy to apply, and can be sanded smooth. Patches should be primed.
	Welded patches	Weld in patches using steel rods and oxy-acetylene torch or arc welder.	Prime welded sections after grinding connections smooth.
6. Splicing in new metal sections	*Cut out decayed sections and weld in new or salvaged sections	Torch to cut out bad sections back to 45° joint. Weld in new pieces and grind smooth.	Prime welded sections after grinding connection smooth.
7. Priming metal sections	Brush or spray application	At least one coat of anti-corrosive primer on bare metal. Zinc-rich primers are generally recommended.	Metal should be primed as soon as it is exposed. If cleaned metal will be repaired another day, spot prime to protect exposed metal.
8. Replacing missing screws and bolts	Routine maintenance	Pliers to pull out or shear off rusted heads. Replace screws and bolts with similar ones, readily available.	If new holes have to be tapped into the metal sections, the rusted holes should be cleaned, filled and primed prior to redrilling.
9. Cleaning, lubricating or replacing hinges and other hardware	Routine maintenance, solvent cleaning	Most hinges and closure hardware are bronze. Use solvents (mineral spirits), bronze wool and clean cloths. Spray with non-greasy lubricant containing anti-corrosive agent.	Replacement hinges and fasteners may not match the original exactly. If new holes are necessary, old ones should be filled.
10. Replacing glass and glazing compound	Standard method for application	Pliers and chisels to remove old glass, scrape putty out of glazing rabbet, save all clips and beads for reuse. Use only glazing compound formulated for metal windows.	Heavy gloves and other protective gear needed for the operator. All parts saved should be cleaned prior to reinstallation.
11. Caulking masonry surrounds	Standard method for application	Good quality (10 year or better) elastomeric caulking compound suitable for metal.	The gap between the metal frame and the masonry opening should be caulked; keep weepholes in metal for condensation run-off clear of caulk.
12. Repainting metal windows	Spray or brush	At least 2 coats of paint compatible with the anti-corrosive primer. Paint should lap the glass about 1/8" to form a seal over the glazing compound.	The final coats of paint and the primer should be from the same manufacturer to ensure compatibility. If spraying is used, the glass and masonry should be protected.

Fig. 7. STEPS FOR CLEANING AND REPAIRING HISTORIC STEEL WINDOWS. Compiled by Sharon C. Park, AIA.

## WEATHERIZATION

Historic metal windows are generally not energy efficient; this has often led to their wholesale replacement. Metal windows can, however, be made more energy efficient in several ways, varying in complexity and cost. Caulking around the masonry openings and adding weatherstripping, for example, can be do-it-yourself projects and are important first steps in reducing air infiltration around the windows. They usually have a rapid payback period. Other treatments include applying fixed layers of glazing over the historic windows, adding operable storm windows, or installing thermal glass in place of the existing glass. In combination with caulking and weatherstripping, these treatments can produce energy ratings rivaling those achieved by new units.<sup>3</sup>

### Weatherstripping

The first step in any weatherization program, caulking, has been discussed above under "Routine Maintenance." The second step is the installation of weatherstripping where the operable portion of the sash, often called the ventilator, and the fixed frame come together to reduce perimeter air infiltration (see fig. 8). Four types of weatherstripping appropriate for metal windows are spring-metal, vinyl strips, compressible foam tapes, and sealant beads. The spring-metal, with an integral friction fit mounting clip, is recommended for steel windows in good condition. The clip eliminates the need for an applied glue; the thinness of the material insures a tight closure. The weatherstripping is clipped to the inside channel of the rolled metal section of the fixed frame. To insure against galvanic corrosion between the weatherstripping (often bronze or brass), and the steel window, the window must be painted prior to the installation of the weatherstripping. This weatherstripping is usually applied to the entire perimeter of the window opening, but in some cases, such as casement windows, it may be best to avoid weatherstripping the hinge side. The natural wedging action of the weatherstripping on the three sides of the window often creates an adequate seal.

Vinyl weatherstripping can also be applied to metal windows. Folded into a "V" configuration, the material forms a barrier against the wind. Vinyl weatherstripping is usually glued to the frame, although some brands have an adhesive backing. As the vinyl material and the applied glue are relatively thick, this form of weatherstripping may not be appropriate for all situations.

Compressible foam tape weatherstripping is often best for large windows where there is a slight bending or distortion of the sash. In some very tall windows having closure hardware at the sash mid-point, the thin sections

<sup>3</sup>One measure of energy efficiency is the U-value (the number of BTUs per hour transferred through a square foot of material). The lower the U-value, the better the performance. According to *ASHRAE HANDBOOK-1977 Fundamentals*, the U-value of historic rolled steel sash with single glazing is 1.3. Adding storm windows to the existing units or reglazing with 5/8" insulating glass produces a U-value of .69. These methods of weatherizing historic steel windows compare favorably with rolled steel replacement alternatives: with factory installed 1" insulating glass (.67 U-value); with added thermal-break construction and factory finish coatings (.62 U-value).

of the metal window will bow away from the frame near the top. If the gap is not more than 1/4", foam weatherstripping can normally fill the space. If the gap exceeds this, the window may need to be realigned to close more tightly. The foam weatherstripping comes either with an adhesive or plain back; the latter variety requires application with glue. Compressible foam requires more frequent replacement than either spring-metal or vinyl weatherstripping.

A fourth type of successful weatherstripping involves the use of a caulking or sealant bead and a polyethylene bond breaker tape. After the window frame has been thoroughly cleaned with solvent, permitted to dry, and primed, a neat bead of low modulus (firm setting) caulk, such as silicone, is applied. A bond breaker tape is then applied to the operable sash covering the metal section where contact will occur. The window is then closed until the sealant has set (2-7 days, depending on temperature and humidity). When the window is opened, the bead will have taken the shape of the air infiltration gap and the bond breaker tape can be removed. This weatherstripping method appears to be successful for all types of metal windows with varying degrees of air infiltration.

Since the several types of weatherstripping are appropriate for different circumstances, it may be necessary to use more than one type on any given building. Successful weatherstripping depends upon using the thinnest material adequate to fill the space through which air enters. Weatherstripping that is too thick can spring the hinges, thereby resulting in more gaps.

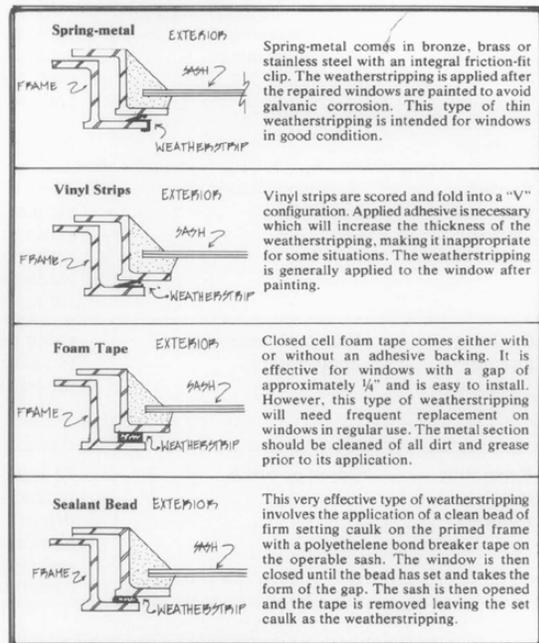


Fig. 8 APPROPRIATE TYPES OF WEATHERSTRIPPING FOR METAL WINDOWS. Weatherstripping is an important part of upgrading the thermal efficiency of historic steel windows. The chart above shows the jamb section of the window with the weatherstripping in place. Drawings: Sharon C. Park, AIA.

## Thermal Glazing

The third weatherization treatment is to install an additional layer of glazing to improve the thermal efficiency of the existing window. The decision to pursue this treatment should proceed from careful analysis. Each of the most common techniques for adding a layer of glazing will effect approximately the same energy savings (approximately double the original insulating value of the windows); therefore, cost and aesthetic considerations usually determine the choice of method. Methods of adding a layer of glazing to improve thermal efficiency include adding a new layer of transparent material to the window; adding a separate storm window; and replacing the single layer of glass in the window with thermal glass.

The least expensive of these options is to install a clear material (usually rigid sheets of acrylic or glass) over the original window. The choice between acrylic and glass is generally based on cost, ability of the window to support the material, and long-term maintenance outlook. If the material is placed over the entire window and secured to the frame, the sash will be inoperable. If the continued use of the window is important (for ventilation or for fire exits), separate panels should be affixed to the sash without obstructing operability (see fig. 9). Glass or acrylic panels set in frames can be attached using magnetized gaskets, interlocking material strips, screws or adhesives. Acrylic panels can be screwed directly to the metal windows, but the holes in the acrylic panels should allow for the expansion and contraction of this material. A compressible gasket between the prime sash and the storm panel can be very effective in establishing a thermal cavity between glazing layers. To avoid condensation, 1/8" cuts in a top corner and diagonally opposite bottom corner of the gasket will provide a vapor bleed, through which moisture can evaporate. (Such cuts, however, reduce thermal performance slightly.) If condensation does occur, however, the panels should be easily removable in order to wipe away moisture before it causes corrosion.

The second method of adding a layer of glazing is to have independent storm windows fabricated. (Pivot and austral windows, however, which project on either side of the window frame when open, cannot easily be fitted with storm windows and remain operational.) The storm window should be compatible with the original sash configuration. For example, in paired casement windows, either specially fabricated storm casement windows or sliding units in which the vertical meeting rail of the slider reflects the configuration of the original window should be installed. The decision to place storm windows on the inside or outside of the window depends on whether the historic window opens in or out, and on the visual impact the addition of storm windows will have on the building. Exterior storm windows, however, can serve another purpose besides saving energy: they add a layer of protection against air pollutants and vandals, although they will partially obscure the prime window. For highly ornamental windows this protection can determine the choice of exterior rather than interior storm windows.

The third method of installing an added layer of glazing is to replace the original single glazing with thermal glass. Except in rare instances in which the original glass is of special interest (as with stained or figured glass), the glass can be replaced if the hinges can tolerate the weight of the additional glass. The rolled metal sections for steel windows are generally from 1" - 1 1/2" thick. Sash of this thickness can normally tolerate thermal glass, which ranges from 3/8" - 5/8". (Metal glazing beads, readily available, are used to reinforce the muntins, which hold the glass.) This treatment leaves the window fully operational while preserving the historic appearance. It is, however, the most expensive of the treatments discussed here. (See fig. 6f).

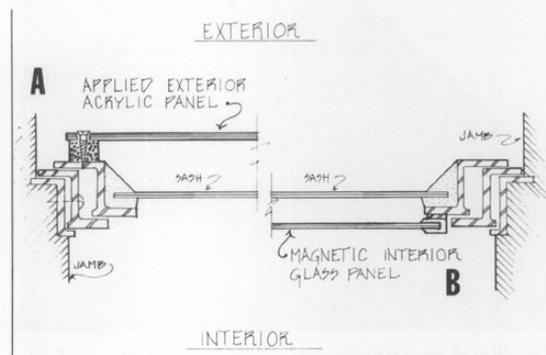


Fig. 9 Two examples of adding a second layer of glazing in order to improve the thermal performance of historic steel windows. Scheme A (showing jamb detail) is of a 1/4" acrylic panel with a closed cell foam gasket attached with self-tapping stainless steel screws directly to the exterior of the outwardly opening sash. Scheme B (showing jamb detail) is of a glass panel in a magnetized frame affixed directly to the interior of the historic steel sash. The choice of using glass or acrylic mounted on the inside or outside will depend on the ability of the window to tolerate additional weight, the location and size of the window, the cost, and the long-term maintenance outlook. Drawing: Sharon C. Park, AIA.

## WINDOW REPLACEMENT

Repair of historic windows is always preferred within a rehabilitation project. Replacement should be considered only as a last resort. However, when the extent of deterioration or the unavailability of replacement sections renders repair impossible, replacement of the entire window may be justified. In the case of significant windows, replacement in kind is essential in order to maintain the historic character of the building. However, for less significant windows, replacement with compatible new windows may be acceptable. In selecting compatible replacement windows, the material, configuration, color, operability, number and size of panes, profile and proportion of metal sections, and reflective quality of the original glass should be duplicated as closely as possible.

A number of metal window manufacturing companies produce rolled steel windows. While stock modern window designs do not share the multi-pane configuration of

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historic windows, most of these manufacturers can reproduce the historic configuration if requested, and the cost is not excessive for large orders (see figs. 10a and 10b). Some manufacturers still carry the standard pre-World War II multi-light windows using the traditional 12" x 18" or 14" x 20" glass sizes in industrial, commercial, security, and residential configurations. In addition, many of the modern steel windows have integral weatherstripping, thermal break construction, durable vinyl coatings, insulating glass, and other desirable features.

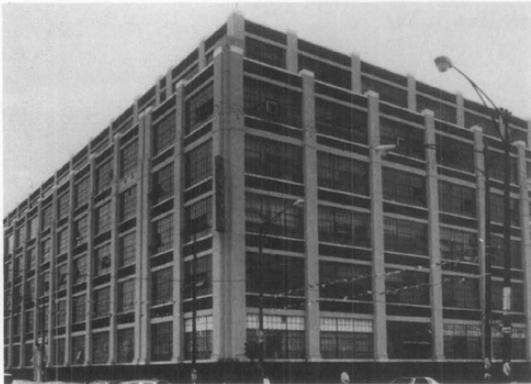


Fig. 10 a. A six-story concrete manufacturing building prior to the replacement of the steel pivot windows. Photo: Charles Parrott.



Fig. 10 b. Close-up view of the new replacement steel windows which matched the multi-lighted originals exactly. Photo: Charles Parrott.

Windows manufactured from other materials generally cannot match the thin profiles of the rolled steel sections. Aluminum, for example, is three times weaker than steel and must be extruded into a box-like configuration that does not reflect the thin historic profiles of most steel windows. Wooden and vinyl replacement windows generally are not fabricated in the industrial style, nor can they reproduce the thin profiles of the rolled steel sections, and consequently are generally not acceptable replacements.

For product information on replacement windows, the owner, architect, or contractor should consult manufacturers' catalogues, building trade journals, or the Steel Window Institute, 1230 Keith Building, Cleveland, Ohio 44115.

## SUMMARY

The National Park Service recommends the retention of significant historic metal windows whenever possible. Such windows, which can be a character-defining feature of a historic building, are too often replaced with inappropriate units that impair rather than complement the overall historic appearance. The repair and thermal upgrading of historic steel windows is more practicable than most people realize. Repaired and properly maintained metal windows have greatly extended service lives. They can be made energy efficient while maintaining their contribution to the historic character of the building.

## BIBLIOGRAPHY

- ASHRAE Handbook - 1977 Fundamentals*. New York: American Society of Heating, Refrigerating and Airconditioning Engineers, 1978.
- Crittall, W. F. *A Metal Window Dictionary*. London: Curwen Press, 1926. Reprinted by B.T. Batsford, Ltd., 1953.
- Gayle, Margot; David W. Look, AIA; John G. Waite. *Metals in America's Historic Buildings: Uses and Preservation Treatments*. Technical Preservation Services, U.S. Department of the Interior. Washington, D.C.: U.S. Government Printing Office, 1980.
- Gillet, William. "Steel Windows." *Windows and Glass in the Exterior of Buildings*. National Academy of Sciences Publication 478. Washington, D.C.: 1957, 75-78.
- Sarton, R. H. "Selecting and Specifying an Appropriate Type of Steel Window." *Metalcraft*. Vol 6, No. 1 (January, 1931): 43-48, 64-65.
- Sweet's Architectural Catalogue*. 13th Edition, New York, Sweets Catalogue Service, Inc., 1918.

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This publication has been prepared pursuant to the Economic Recovery Tax Act of 1981, which directs the Secretary of the Interior to certify rehabilitations of historic buildings that are consistent with their historic character; the guidance provided in this brief will assist property owners in complying with the requirements of this law.

*Preservation Briefs: 13* has been developed under the technical editorship of Lee H. Nelson, AIA, Chief, Preservation Assistance Division, National Park Service, U.S. Department of the Interior, Washington, D.C. 20240. Comments on the usefulness of this information are welcomed and can be sent to Mr. Nelson at the above address.

# APPENDIX C - TECH NOTES WINDOWS NO. 17: REPAIR AND RETROFITTING INDUSTRIAL STEEL WINDOWS



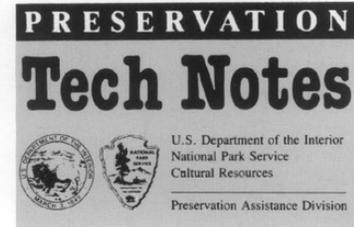
**LIPPINCOTT PRESS BUILDING**  
Philadelphia, Pennsylvania

Located along Philadelphia's Schuylkill River, the Lippincott Press Building is a prominent early twentieth-century industrial structure contributing to the Schuylkill National Register Historic District. Designed by Mahlon H. Dickinson and constructed in 1915, it is a six story, 118,000 square foot structure of reinforced concrete with brick infill. The tripartite industrial steel windows, each with a central pivoting sash, were the dominant architectural feature of the building.

Constructed for the A.H. and F.H. Lippincott Company, the building served as a printing plant until the 1940's, at which time the U.S. Navy converted the building into offices. In

the 1960s the University of Pennsylvania leased portions of the structure for offices and laboratory space.

In 1985 the Lippincott Building was purchased by Historic Landmarks for Living, a Philadelphia-based development firm that specialized in the rehabilitation of historic properties. Their proposal was to convert the building into 105 apartments. The treatment of the windows needed to meet current residential and energy code requirements. In addition, the rehabilitation had to comply with the Secretary of the Interior's Standards for Rehabilitation in order to qualify for the historic preservation tax credits.



## WINDOWS NUMBER 17

### Repair and Retrofitting Industrial Steel Windows

**Robert M. Powers**  
Mid-Atlantic Regional Office  
National Park Service

*Historic steel windows should be repaired rather than replaced whenever possible.*

**Problem**

Since the Lippincott Building was used for a long time as a storage facility, the windows had not been painted, oiled, reglazed, or caulked, nor had missing or damaged parts been replaced in well over twenty years (see figure 1). Naturally, many of the windows exhibited problems typically found on inadequately maintained steel windows, including corrosion, bent and bowed metal sections, non-operable ventilators, missing or non-functional hardware and broken glazing. Furthermore, some of the original windows had been removed and replaced with double-hung aluminum windows, and other window openings had been infilled with glass and concrete block, metal louvered air vents, ductwork and other mechanical equipment (see cover photo).

**Solution**

To ascertain the feasibility of repairing the existing steel windows, the project architects conducted a preliminary window condition survey. With this preliminary survey, each window opening was assigned a number and a physical inspection was undertaken window-by-window (see figure 2). The results of the inspection were recorded on a survey sheet that typically listed six window openings per page and included the following information:

1. The type of window present and the overall condition of the unit, evaluated on a scale of one to five, five being the poorest condition.
2. Whether the window in its current condition met the Pennsylvania State Energy Code requirements for heat loss, air infiltration, and other energy/comfort criteria.

3. Whether the window met the City of Philadelphia Code, Section 809.4, which requires that operable windows with sill heights no greater than 44" above finished floor level be provided for all habitable apartment spaces below the fourth floor level.

4. Comments on the type and location of deterioration or structural problem found on the window.

From this preliminary condition survey conducted in June, 1986, the following results were obtained. Of the building's 415 windows contained within 193 window openings:

- 6% of the historic windows on all elevations were missing. These windows had been removed and replaced over the years with incompatible windows, or had been enclosed with concrete block and/or mechanical equipment.
- 58% of the historic windows were in poor or nonrepairable condition. The windows designated as being in poor condition contained some heavily corroded sections, primarily in the jamb and sill areas. However, it was considered possible to bring these windows back to a weather-tight, structurally sound state. The nonrepairable windows were those with substantial warping or heavy corrosion on over fifty-percent of the steel members or were irreparably damaged by duct/mechanical equipment.
- 36% of the historic windows were in fair condition. These units had minor sill deterioration and slight warping and were clearly repairable.

Anticipating that full replacement of the historic windows was necessary,



Figure 1. Typical multi-light steel window with ventilator as seen from the interior. This window exhibits typical pre-rehab conditions including sill corrosion, missing hardware and a poorly operating ventilator. Photo: Clio Group.

the project architects prepared detailed drawings of the fifteen existing window types as well as the proposed replacement window options (see figure 3). The new replacement window options considered were:

1. An industrial steel sash with double-glazing manufactured by A and S Steel Company—exterior bars would have a cavetto rather than a bullnose shape.
2. A "Landmark Series" steel window, also with double-glazing, manufactured by Hope's Architectural Products, Inc.—exterior bars would be flat.

WINDOW DESIGNATION	WINDOW TYPE	WINDOW CONDITION					ENERGY COMPLIANCE			CODE COMPLIANCE			REMARKS	RECOMMENDATIONS	WINDOW DESIGNATION	
		1.	2.	3.	4.	5.	PASS	FAIL	NOT APPL.	PASS	FAIL	NOT APPL.				
116a														MISSING 9 PANE		116a
116														1200		116
216														LOUVER IN 6 PANE		216
316														LOUVER IN 6 PANE		316
416																416
516														OP. BRACK. LAMPS DEM.		516
616														WINDOW REPAIR RUST DET. AT SILL		616

Figure 2. Window survey form. Prepared by H2L2 Architects.

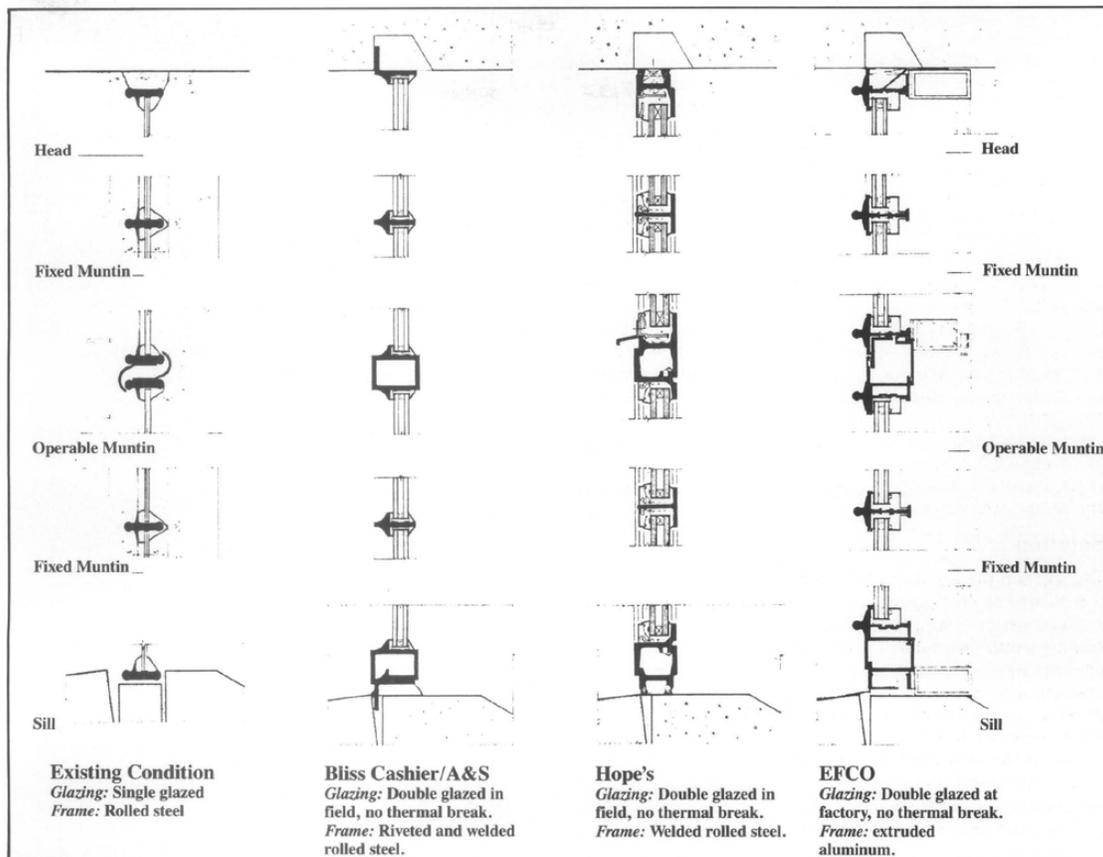


Figure 3. Comparative window sections showing the existing steel window on the left and the three thermally glazed replacement proposals on the right. Drawing: H2L2 Architects.

3. An EFCO, non-thermally broken aluminum sash with double-glazing—exterior pieces would be extruded with a bullnose shape.

In addition to the comparative drawings, mock-ups of the windows manufactured by Hope's and EFCO were installed on the third floor of the south elevation to evaluate how closely the replacements matched the historic windows.

As seen in the comparative drawings and as evident from the mock-ups, the new double-glazed windows did not match the proportions, dimensions, thin profiles and sight lines of the historic steel windows due to the increased dimensions of the new window members. Thus, although the new proposed windows promised increased energy performance, the installation of these non-matching windows would

not have been in keeping with the building's historic character.

Recognizing the visual problems with the proposed replacement windows, the project team decided to examine further the feasibility of repairing and retrofitting the existing windows. Since the preliminary window survey indicated that 58% of the historic windows were in either poor or nonrepairable condition, a second and more detailed analysis of these windows was undertaken by the architectural firm and historical consultants. Particular emphasis was placed on distinguishing between windows categorized as poor-but-repairable and those considered nonrepairable.

From this more detailed analysis it was concluded that in 85–90% of the windows originally categorized as poor or unrepairable condition, heavy

corrosion was confined to the jamb and sill areas and that these units were in fact repairable. Of all the windows within the building, only 10–15% of the existing historic windows were in a non-repairable condition according to the second, more in-depth survey, and 6% were missing, leaving 80–85% of all the windows in arguably repairable condition.

The project team decided to rehabilitate the majority of the existing windows after taking into account the following factors: the majority of the existing windows were repairable; the proposed replacement windows installed as mock-ups did not adequately match the existing windows; and the entire rehabilitation project was on a fast-track work schedule that could not allow for delays in the manufacturing and delivery of a new design for custom-made windows.

The rehabilitation included replacing the deteriorated steel sections, particularly in the sill areas, and replacing the missing and nonrepairable windows with new single-glazed steel windows similar in profile and configuration to the existing windows. As part of the repair process, the existing ventilator windows would be modified from center pivoting sash to projecting sash (to meet Philadelphia code for emergency egress), and both the repaired and new steel windows would receive interior storm windows to bring the windows into compliance with the Pennsylvania State Energy Code requirements for heat loss, air infiltration, and other energy/comfort criteria.

To accommodate the first floor lobby and parking garage, the decision was made to repair and reglaze with frosted glass the existing steel windows in the garage area, and to install new windows in the newly created lobby area where no windows previously existed. The garage windows retained their operable pivoting sash, since compliance with energy requirements was not applicable. To provide for adequate garage ventilation, glazing was omitted from a number of the ventilators (see figure 4).

#### Work Description

The new steel windows were ordered immediately so that their installation would be concurrent with the repair of the historic windows. All the other windows were to be repaired.

Working directly with the project's general contractor, a number of specialized subcontractors were chosen for the window work:

1. Two contractors for the repair and replacement work of the steel components;
2. A contractor who worked directly with a steel window company and supplied all the replacement window parts, including entire windows for those locations that required new windows and stock lengths of steel window sections for replacement pieces for deteriorated members;
3. A glazing contractor who removed all the old glazing and putty, cleaned the steel sections and glazed the windows; and
4. A painting contractor who caulked and painted the windows.

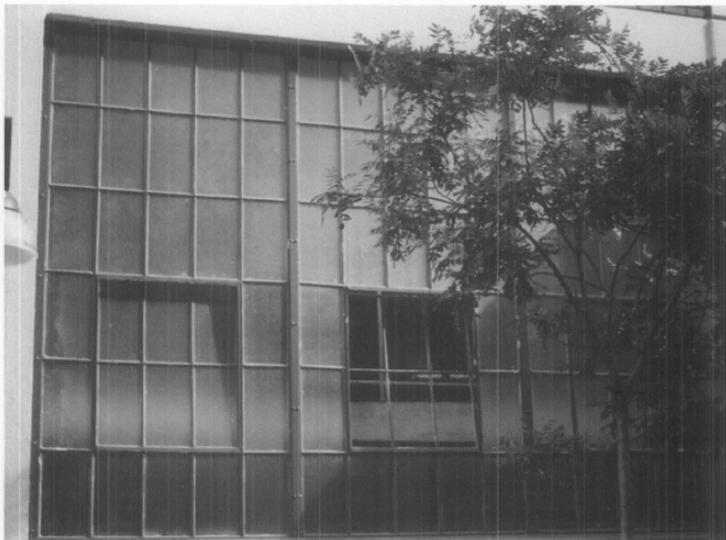


Figure 4. First floor, garage level showing the frosted glass and the center ventilator without glazing. Photo: Robert Powers.

The repair work on the historic steel windows began in November 1986, under the direction of the general contractor.

#### Glazing Removal

The first step in the repair process was the removal of all the wire glass and other types of more recent glazing. The glazing contractor with a team of eight to twelve men, usually in two-man crews, began breaking out the glass, commencing on the top floor and completing all of the elevations on one entire floor at a time. As much

of the glass as possible was removed at this time, but there was no attempt made to remove all of the putty.

#### Steel Repair and Ventilator Retrofitting

Immediately after the glazing contractor had removed the glazing from an entire floor, the contractors for the metal work began. Since this rehabilitation was on such a tight completion schedule, and given the labor-intensive nature of the repair work, two metal working contractors were utilized. Each contractor was responsible for



Figure 5. Sill corrosion typically found on 95% of the windows. Photo: Clio Group.

the repair/replacement of windows on three floors of the building. Although most of the seriously deteriorated windows were identified as part of the window surveys, the general rule for the contractors was that if, after close examination, more than 50% of the window unit exhibited severe deterioration, then the entire unit could be replaced. The remaining reusable members would be salvaged for use as replacement pieces on other windows.

Generally employing three crews of three to four men, each contractor began by cutting out all the severely corroded and/or heavily bent metal sections from each window. Severe corrosion occurred primarily in the sill areas where the original steel sill section was embedded in concrete—a condition existing in approximately 95% of the window sills to be repaired (see figure 5). The spalled concrete and the corroded metal sill sections were chopped out with a portable band saw. In addition to the corrosion in the sill areas, extensive deterioration typically extended up the window muntins approximately three to six inches. These members were cut at a 45 degree angle with a five-inch grinding wheel using a five-inch disk, usually at a point four to seven inches from the sill or where the steel was no longer corroded.

Concurrent with the cutting out of the window's corroded steel members, each of the existing pivot window ventilators on floors two through six were cut from their jambs, labeled and brought to an on-site work station. At the work station, the pivoting ventilators were modified to operate as projecting windows (see figure 6). This was accomplished by cutting off the bullnose outside face of the side and bottom rails on the sash and riveting a new water-shed steel angle at the same locations. To allow the ventilators to swing out, two 16", heavy duty, 6 bar, zinc chromate plated steel, TRUTH hinges were screwed to each ventilator (see figure 7). New right-hand, cast iron, bronze lacquered, locking handles were installed on the bottom rail by face-mounting and screwing to each ventilator.

In addition to the retrofitting of the ventilators, many of the window muntins and structural mullions needed to be straightened, patched and repaired (see figure 8). Members that were seriously bowed and could not be adequately straightened were cut off using grinding wheels and salvaged;

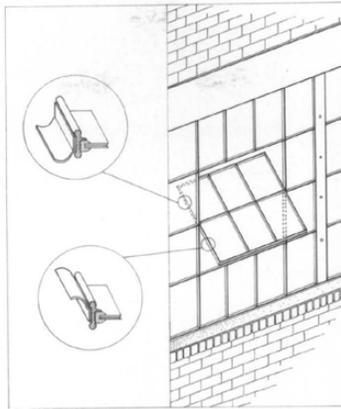


Figure 6. Pivot ventilators prior to retrofitting on the upper floors. Bullnose trim pieces to be modified as part of the retrofitting from pivot to projecting ventilators. Drawing: Martha Raymond.



Figure 7. Retrofitted projecting ventilator with the TRUTH hinges. Photo: Robert Powers.

replacement members were welded into place. Two relatively simple techniques were used to straighten the less seriously bent and bowed steel members. With mullions, a wooden brace (usually a two-by-four) was attached to the mullion; a wire cable was wrapped around the wooden brace and the mullion; and slowly the cable was pulled with a "come-along" winch hooked to the ceiling of the building. Since the mullions had typically bowed toward the exterior, the member was pulled in the direction opposite its bowing, towards the inside of the building. To straighten out bent and bowed muntins, the contractor applied constant pressure through the use of 14" bar-type clamps on the muntin. All indentations and gouges left in the steel members were filled with an auto-body patching compound containing steel fibers and an epoxy binder, sanded smooth and primed with a rust-inhibiting primer.

Once the muntins and mullions were set plumb, the final steps in the steel repair process began. In most of the sill areas, lengths of new steel sections were installed to replace the original corroded members. The new cavetto-shaped steel sections did not match exactly the bullnose profile of the historic windows (see figures 9 and 10). However, the original profile was no longer available and the new profile was close enough so that the overall proportions, profile, and shadow lines were compatible with the historic window appearance. The new steel sections at the sill and the lengths



Figure 8. Bowed and corroded window during construction. Photo: Clio Group.

extending up into the muntins were welded together, installed in the appropriate location and then clamped and welded to the remaining original window. All welds were ground smooth and primed immediately with a rust-inhibiting primer. The concrete sills were then patched. Concurrent with the splicing-in of the new members, the ventilator jambs were also retrofitted to accept the new projecting ventilator. Similar to the work on the ventilators, the bullnose trim piece on the upper portion of the exterior side rails was cut off and a new steel angle was installed on the interior of the side and bottom rails and the hinges were attached.

### Cleaning of the Steel, Glazing and Painting

After the metalworkers had cut out the deteriorated pieces, spliced in new steel sections, retrofitted the ventilators and ventilator jambs, and straightened out all the bent and bowed muntins and mullions, the glazing contractor began preparing the steel windows for the installation of new glass. A formidable task in reglazing the windows was the removal of the old glazing putty still left in the glazing rabbet. Two basic techniques were employed. Hammer-guns with chisel-ends were used extensively, although care had to be taken to prevent damage to the steel sections. Slower and less effective, acetylene torches were also used to remove the putty. The torches softened the putty to the point where it could be removed with a scraper.

After the putty was removed, remaining flaking and loose paint and light surface corrosion were removed by rotary wire brushes attached to electric drills or by hand-scraping and sanding. No attempt was made to remove sound paint from the steel windows since the paint did not interfere with the effective operation of the windows.

The windows were then backglazed and new double-strength glass was installed in the bed of compound. Fortunately most of the original clips that helped secure the glass in place remained in good condition and were reinstalled wherever possible. New glazing clips were used as needed. The same compound was used for the finish glazing.

The final step in the repair of the historic steel windows was painting. Operating from swing-staging, which

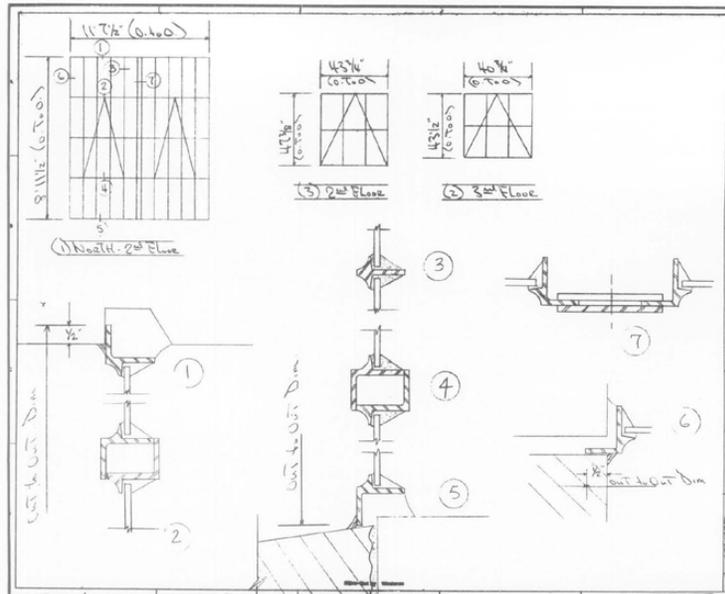


Figure 9. Sectional drawings of replacement window manufactured by A & S Window. Drawing: Winderco, Inc.

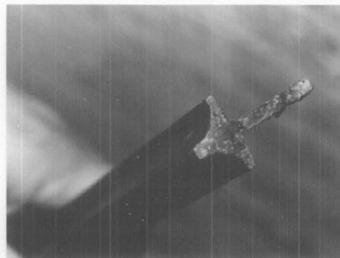


Figure 10. Replacement steel window section used primarily in the sill areas. Photo: Clio Group.

extended the width of an entire three-window opening, the painting contractor lightly sanded and primed with a rust-inhibiting primer all the surfaces that had not been previously primed. All of the windows were then given two coats of a dark green, alkyd-based paint. Prior to the final paint coat, all of the window perimeters were caulked with a vinyl acrylic caulking compound that was also given a coat of finish paint.

### Weatherization

An essential component of the rehabilitation project was the upgrading of the steel windows to meet current residential and energy code requirements. The repair and retrofitting of

the existing steel windows in and of itself was not sufficient in bringing the windows up to code. The development of an interior storm window system provided the additional thermal performance for code compliance. The solution involved an aluminum, triple-track, interior storm unit with flanking, fixed "sidelites" (see figure 11). A major consideration in the development of this storm system was the desire to minimize the outside visibility of the storm unit by aligning as closely as possible the meeting rails and other aluminum members with the steel window members (see figure 12). The exterior face of the storm windows was painted the same color as the steel windows so as to be as inobtrusive as possible (see figure 13). Although, the aluminum members do not match exactly the width of the opposite steel members, the storm windows were not readily visible from the exterior.

### Project Evaluation

Whether to repair or replace historic windows is a complex issue often facing building owners, contractors, architects and others involved in the rehabilitation field. In this case, the various options available to the development team—from full replacement with a new insulated window system to repairing the existing windows—

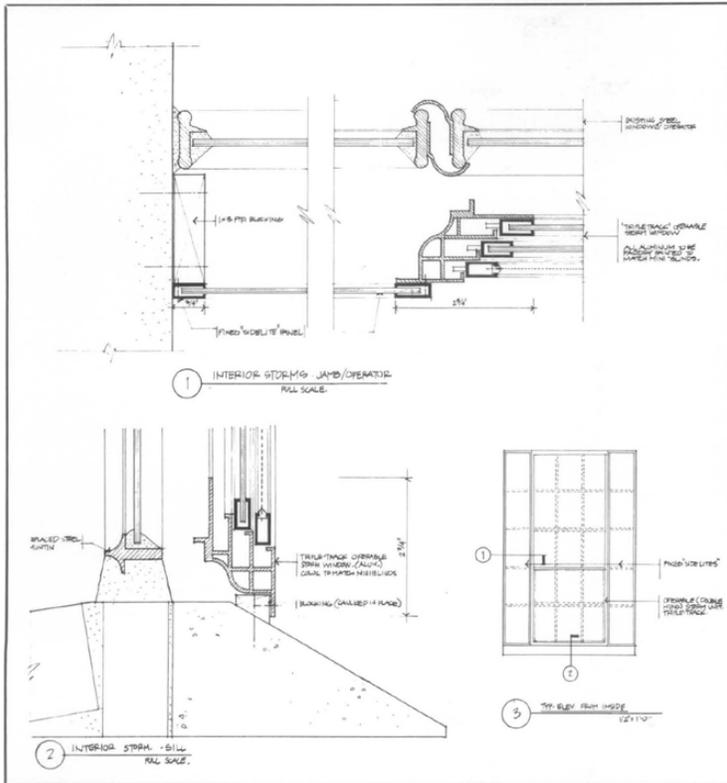


Figure 11. Interior storm window drawings, showing the alignment of the storm and steel window members. Drawings: H2L2 Architects.



Figure 12. Installed interior triple-track storm window with fixed sidelights. Photo: Clio Group.

were explored with the ultimate decision made to repair the significant historic steel windows. This decision was based on the assumption that repair of the windows was both a practical and cost-effective undertaking. The end product was a practical, cost-effective and ultimately successful solution to a difficult rehabilitation problem. The prominence of the thinly profiled, multi-light, industrial steel windows has been retained while current residential and energy code requirements as well as the Secretary of the Interior's Standards for Rehabilitation have been met.

There were, however, some aspects of this project that could be modified in future rehabilitations involving the repair of steel windows. First and foremost would be hiring skilled metal workers experienced to undertake the intricate steel work. Since most of the metal workers on the job had little or no experience in this type of work, considerable time was spent training



Figure 13. Lippincott Press Building (now Locust Point) after repair of the multi-light steel windows. Photo: Robert Powers.

and supervising the workers. For optimum paint performance and long-term maintenance, the repaired steel windows should have been sandblasted to fully remove the remaining paint and rust and to ensure a long-lasting bond between the steel and the new coats of paint. The additional cost would undoubtedly be justified by the more effective paint finish. Finally, although the storm window installed met the energy and overall visibility criteria established for the project, alternative schemes could have been developed that more closely reflected the operational and structural design of the historic steel window.

#### PROJECT DATA

##### Building:

Lippincott Press Building (Locust Point)  
25th and Locust Streets  
Philadelphia, Pennsylvania

##### Owner:

Lippincott Penn Historic Associates  
c/o Historic Landmarks for Living  
30 South Front Street  
Philadelphia, Pennsylvania

##### Project Dates:

November, 1986—April, 1987  
(Window work)

##### Architects:

H2L2 Architects/Planners  
714 Market Street  
Philadelphia, Pennsylvania

##### Historic Consultants:

Clio Group  
Lancaster Avenue  
Philadelphia, Pennsylvania

##### Contractors:

J.J. DeLuca, Inc. (General)  
Chester, Pennsylvania

##### Metal:

Colory Metal, Inc.  
Bensalem, Pennsylvania  
Ornamental Security and Maintenance  
Company  
Moorestown, New Jersey

##### Windows:

Winderco, Inc.  
Mt. Laurel, New Jersey  
A and S Windows  
Glendale, New York

##### Glazing:

H. Perilstein Glass Division  
Philadelphia, Pennsylvania

##### Painting:

Murphy Painting  
Trevose, Pennsylvania

##### Project Costs:

\$12,100,000 (Total project rehabilitation costs)  
\$708,800 (Total window rehabilitation costs)  
\$41,800 (Window repair work, material)  
\$351,000 (Window repair work, labor)  
\$116,000 (Window demolition, glass and glazing)  
\$130,000 (Storm windows)  
\$70,000 (Painting)  
Total of units rehabilitated:  
191 window openings  
408 windows  
8,964 total lights

This PRESERVATION TECH NOTE was prepared by the National Park Service. Charles E. Fisher, Preservation Assistance Division, National Park Service, serves as the Technical Coordinator for the PRESERVATION TECH NOTES. Information on the steel window repair work described here was supplied by Tim Noble of the Clio Group, Jeffrey L. Matthews AIA, of H2L2 Architects, Greg Mason of Colory Metal, Inc., Edward J. McCourt of Winderco, Inc., Neil Goldberg of H. Perilstein Glass Division and Sam Marabella and Terry Adams of J.J. DeLuca, Inc., the General Contractor for the project. Special thanks go to the following National Park Service staff who contributed to the production of this Tech Note: William Bolger, John Hnedak, Cynthia MacLeod and Martha Raymond of the Mid-Atlantic Regional Office. Cover photo: Clio Group, Inc.

This and many of the PRESERVATION TECH NOTES on windows are included in "The Window Handbook: Successful Strategies for Rehabilitating Windows in Historic Buildings."

For information write to the Historic Preservation Education Foundation, P.O. Box 27080, Central Station, Washington, D.C. 20038.

PRESERVATION TECH NOTES are designed to provide practical information on practices and innovative techniques for successfully maintaining and preserving cultural resources. All techniques and practices described herein conform to established National Park Service policies, procedures and standards. This Tech Note was prepared pursuant to the National Historic Preservation Amendments of 1980 which direct the Secretary of the Interior to develop and make available to government agencies and individuals information concerning professional methods and techniques for the preservation of historic properties.

Comments on the usefulness of this information are welcomed and should be addressed to PRESERVATION TECH NOTES, Preservation Assistance Division-424, National Park Service, P.O. Box 37127, Washington, D.C. 20013-7127.

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