Low-E Exterior Storm Windows

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Scope

A common and long standing window retrofit approach is the addition of storm windows to the exterior of the existing window frames. The most common design is a triple track window that combines a screen with operable upper and lower sashes. Traditionally, storms have been single glazed with clear glass, but more recently, hard coat low-E glass has become available. Low-E storm windows cost about the same as standard storm windows, but are about 50% more energy efficient than traditional uncoated storm windows (Cort 2013).

As summarized within the Ensuring Success tab, before beginning this work, inspect the interior and exterior of the building, including each window, to identify impacts and potential risks with completing the work. Diagnose water and air infiltration pathways, and choose strategies most appropriate to address each leak. Add gaskets and seals at common air infiltration locations to improve the overall air tightness of the window assembly.

Key points to consider when selecting Exterior Storm Windows are as follows:

1. Interior appearance of the window is maintained; however, the exterior appearance will change. The addition of exterior storms is typically acceptable for most historic preservation projects.
2. The measure is reversible. This is an important consideration for historic preservation.
3. This work should be done in conjunction with the rehabilitation work set out in the measure guide on Window Rehabilitation.
4. This work will improve the energy performance of the assembly by reducing air infiltration as well as thermal conductance through the assembly. Hard coat low-E storm window glazing can provide additional thermal benefits.
5. This work will reduce the potential for interior condensation problems on the window system, though it adds some risk of interstitial condensation between the original window and the exterior storm (generally an aesthetic/operational concern, as opposed to a durability concern).
6. Cost is low to moderate depending on the system chosen.

See the Compliance Tab for related codes and standards requirements, and criteria to meet national programs such as DOE’s Zero Energy Ready Home program, ENERGY STAR Certified Homes, and Indoor airPLUS.
Figure 1 - Exterior storm window example
Description

Before beginning this work, the window should be assessed as outlined within the Ensuring Success tab.

The addition of exterior storm windows to existing windows is a common, commercially available off-the-shelf technology, and is for the most part straightforward. This work should be completed in conjunction with the window rehabilitation work outlined in a separate guide. The existing window sill must be in good condition, as it will continue to be exposed to the elements (though exposure will be significantly reduced).

The exterior storm window is fastened to the outer window casing, or in some cases directly to the window trim. The storms should be sealed with an exterior grade paintable sealant at the jambs and heads, but left unsealed at the sill. Most storm windows have an adjustable bottom leg to account for variations in the sill height. This leg should not be caulked, to allow for drainage at the bottom. Some systems even provide small weep holes or notches in the bottom leg to promote drainage. Systems with enhanced drainage are recommended.

Figure 1 - Exterior aluminum storm windows, showing weep channel

In order to minimize the potential for interstitial condensation, the original window must be made as air tight as possible (Wilson, 1960). Slight ventilation of the exterior storm is typically provided by the weep holes provided at the sill. If the interior window is made sufficiently air tight, then the slight ventilation of the weep holes of the storm should provide adequate air change to prevent condensation. If condensation does form, slightly increasing the gap to allow for additional ventilation of the space is recommended.

Figure 2 - Condensation potential for exterior storm retrofits

Inner window must be made as air tight as possible

Thermal gradient created by the air space between the interior window and the exterior storm will result in warmer surfaces of the original wood window, but colder surfaces on interior side of the exterior storm. Uncontrolled air leakage into this space increases the risk of condensation on the interior side of the exterior storm.

Slight increase in ventilation at the sill may remedy the problem; however it will also diminish the overall thermal performance of the measure.
Ensuring Success

**Identifying Risks**
Prior to any retrofit work being conducted, it is important that the following conditions of the building systems be reviewed:

- Lead and other hazardous materials
- Site conditions and project staging
- Identification of water infiltration concerns
- Identification of deteriorated or damaged materials
- Identification of user comfort concerns

**Contractor/Homeowner Safety**
- US EPA: Lead in Paing, Dust and Soil: Renovation, Repair Painting
- OSHA: Fall Protection (if window work is to be done at height, from the exterior)

**Lead and Other Hazardous Materials**
Old wood windows and trim are a common location of lead paint in homes. Any work being completed on the window systems should follow all appropriate state and federal laws regarding handling of hazardous materials.

**Site conditions and Project Staging**
The home and site should be reviewed to identify impacts and potential risks with completing the work.

If the work is to be done for the exterior, scaffolding, lifts, ladders, or other means to access work areas may be needed. Work done at height may require fall protection be used. Proximity to adjacent property or vegetation may limit access or create unsafe work areas. Exterior staged work may also damage existing landscaping or vegetation.
If the work is intended to be completed from the interior, consideration should be given to disruption of the occupant and clearances for moving equipment and materials into and out of the space. With any interior work there is always a chance of damage to interior finishes. Appropriate planning and protection is required.

**Identification of Water Infiltration Concerns**

Windows, above all other enclosure systems, are a common location of water infiltration issues. It is important to understand the various pathways for potential water infiltration, and identify current water leakage problems. While the details presented in this document are all intended to improve the moisture performance of the window assemblies, it is not intended to address all possibilities, and is not a replacement for inspection and evaluation of the performance of an individual window. Existing problems should be identified, and the strategy chosen that will be most appropriate to address the concern. Window systems water leaks can be grouped into four general categories (Figure 1 below):

1. Between the window frame and rough opening
2. Through the joints in the window frame
3. Between the window frame and the operable sashes
4. Through the joints between the glass and the sash frames

![Figure 1 - Common window water infiltration pathways](image)

Prior to any work being done, interior and exterior inspection and monitoring of the conditions of the building should be completed. Water staining, peeling paint or wall paper, and staining on trim or floor assemblies below window systems are indications of water infiltration and/or condensation. Leakage between the sashes and the frame and between the glass and the sash is usually marked by water staining on the interior window frame itself. Condensation on the window frames can also lead to staining of the interior finishes. It is important to monitor the questionable area to prevent a false diagnosis of the water management problem being experienced.

Leakage between the window and rough opening or through the joints in the window itself are typically contained within the wall assembly and may go unnoticed, or could manifest as staining and peeling paint below the window or damaged flooring.

Other problems such as water infiltration at the window head may be indications of failed or missing head flashing. However, other problems not associated with the window system may in fact be the cause of the water infiltration. Care must be taken to properly diagnose the infiltration pathway.

If it is a known recurring problem, then the infiltration problem must be addressed prior to or in conjunction with the window retrofit work.

If no obvious signs of water infiltration problems exist and the window elements and connection wall components are in good condition, no additional work may be needed. However, as stated above, water infiltration problems are often concealed within wall cavities with no outward signs. This becomes more of a concern if the window retrofit work is being done in conjunction with the addition of cavity fill insulation. With the addition of insulation to the wall cavities, water infiltration problems that previously may have had sufficient drying ability, may now lead to prolonged moisture accumulation. Prolonged moisture accumulation can lead to material deterioration. If there is suspected leakage, then further investigation, including but not limited to thermal scans, moisture content measurements, and cutting of investigation holes below window assemblies to look for signs of moisture problems would be recommended.

Unless the problem is obvious, it may be prudent to contact someone with experience with diagnosing water infiltration problems prior to proceeding.
Identification of Deteriorated or Damaged Materials
If damage to existing elements is noted, the materials should be removed and replaced as part of the retrofit. Certain elements will be more critical to the proper implementation of the chosen strategy.

Figure 2 - Failed window sill with replacement window installed

The window sill is arguably the most important element of the window assembly, as water will drain downward by gravity either into the wall (e.g., hole through sill) or directly onto the wall (failure of the sill extension). For all proposed measures in this document excluding complete window replacement, the condition of the sill is critical to the performance of the measure. Cracked or rotting sills need to be replaced prior to any work being done.

The window frame including the exterior casings is the next most critical element. If the casing is deteriorating, its replacement may be warranted. This should not be confused with the exterior trim, which is often installed as a decorative element on top of the casing.

Deteriorating trim may not affect the water management performance of the window however; it may be an indication of other problems and generally creates an aesthetic problem.

Figure 3 - Failed window sill with replacement window installed

Depending on the measure being examined, the condition of the window sashes may or may not be a concern to the performance of the measure taken. For window rehabilitation, sash retrofit, or interior storm retrofit, the condition of the sashes is critical to the performance of the window. For exterior storms, the sashes are more protected from the elements, and the condition is less important from a water management perspective, yet still critical from an energy and condensation resistance perspective. For sash replacement, window insert, or full window replacement, the condition of the sash is irrelevant, as they will be removed. For this reason, windows with severely deteriorated sashes may be better candidates for the latter retrofit measures.

Identification of User Comfort Concerns
As part of the initial review, associated comfort concerns relating to the window systems should be evaluated. Window air leakage is a significant source of occupant comfort problems. Unlike other common enclosure leakage pathways, window air
leakage is commonly very direct, resulting in distinct drafts.

Radiation effects from cool glass surfaces are another common comfort problem. This is more difficult to identify, as the tendency is to assume that the discomfort felt when near a window is from air leakage or drafts. This results in some misdiagnosis of the dominant function. A general recommendation is to increase the interior surface temperature of the window system to reduce the radiant heat transfer from the occupant to the window. This is commonly done by adding additional panes of glass (or films) to create an insulating air (or other gas) space between the layers.
Climate

No climate specific information applies.
Training

Right and Wrong Images
None Available
Compliance

The Compliance tab contains both program and code information. Code language is excerpted and summarized below. For exact code language, refer to the applicable code, which may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

2009, 2012, 2015, and 2018 IECC

Section R101.4.3. (Section R501.1.1 in 2015 and 2018 IECC) Additions, alterations, renovations or repairs. Additions, alterations, renovations or repairs to existing buildings, building systems, or portions of buildings or systems must meet the requirements of the code as they relate to new construction. Unaltered portions do not need to comply.

Section R101.4.3 (Section R503.1.1 Building envelope in 2015 and 2018 IECC) Exceptions are included for storm windows installed over existing fenestration and glass-only replacements in an existing sash and frame.


Section N1101.3. (Section N1107.1.1 in 2015 and 2018 IRC). Additions, alterations, renovations or repairs. Additions, alterations, renovations or repairs to existing buildings, building systems, or portions of buildings or systems must meet the requirements of the code as they relate to new construction. Unaltered portions do not need to comply.

Section N1101.3. (Section N1109.1.1 Building envelope in 2015 and 2018 IRC) Exceptions are included for storm windows installed over existing fenestration and glass-only replacements in an existing sash and frame.
Case Studies
None Available

References and Resources*

1. **2009 IECC - International Energy Conservation Code**
   - **Author(s):** International Code Council
   - **Organization(s):** ICC
   - **Publication Date:** January, 2009
   - Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems and service water heating systems in homes and commercial businesses.

2. **2009 IRC - International Residential Code for One and Two Family Dwellings**
   - **Author(s):** International Code Council
   - **Organization(s):** ICC
   - **Publication Date:** January, 2009
   - Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

   - **Author(s):** International Code Council
   - **Organization(s):** ICC
   - **Publication Date:** January, 2012
   - Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems and service water heating systems in homes and commercial businesses.

4. **2012 IRC - International Residential Code for One and Two Family Dwellings**
   - **Author(s):** International Code Council
   - **Organization(s):** ICC
   - **Publication Date:** January, 2012
   - Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

5. **2015 IECC - International Energy Conservation Code**
   - **Author(s):** International Code Council
   - **Organization(s):** ICC
   - **Publication Date:** January, 2015
   - Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems and service water heating systems in homes and commercial businesses.

6. **2015 IRC - International Residential Code for One and Two Family Dwellings**
   - **Author(s):** International Code Council
   - **Organization(s):** ICC
   - **Publication Date:** May, 2014
   - Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

7.
2018 IECC - International Energy Conservation Code
Author(s): International Code Council
Organization(s): ICC
Publication Date: November, 2017
Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems, and service water heating systems in homes and commercial businesses.

8. 2018 IRC - International Residential Code for One and Two Family Dwellings
Author(s): International Code Council
Organization(s): ICC
Publication Date: August, 2017
Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

9. Condensation Between Panes of Double Windows
Author(s): Wilson
Organization(s): National Research Council Canada
Publication Date: May, 1960
Document about condensation between the panes, on the inside surface of the outer glass of double pane windows.

10. Database of Low-e Storm Window Energy Performance across U.S. Climate Zones
Author(s): Cort, Culp
Organization(s): Pacific Northwest National Laboratory
Publication Date: September, 2014
Research study evaluating energy savings and cost effectiveness of installing low-emissivity (low-e) storm windows over existing windows in residential homes in all climate zones.

11. EIA Residential Energy Consumption Survey 2009
Author(s): EIA
Organization(s): EIA
Publication Date: January, 2009
Federal statistics about national energy consumption in residential homes.

12. Low-E Storm Windows & Panels: A New Tool for Utility and Weatherization Programs
(1MB)
Author(s): Cort
Organization(s): Pacific Northwest National Laboratory
Publication Date: September, 2013
Brochure describing use of low-e storm windows as effective ways weatherization programs can increase the efficiency of windows without significant costs.

13. Measure Guideline: Wood Window Repair, Rehabilitation and Replacement
Author(s): Baker
Organization(s): Building Science Corporation
Publication Date: December, 2012
Document providing information and guidance about rehabilitating, retrofitting, and replacing wood window assemblies in residential construction.

14. New Life for Old Double Hung Windows
Author(s): Davis
Organization(s): Fine Homebuilding Magazine
An article about double-hung windows.

15. NFRC 100A-2010 Procedure for Determining Fenestration Attachment Product U-factors
Author(s): National Fenestration Rating Council
Organization(s): National Fenestration Rating Council
Publication Date: January, 2010
Standard providing a procedure for determining fenestration attachment product U-factors.

Author(s): National Fenestration Rating Council
Organization(s): National Fenestration Rating Council
Publication Date: January, 2010
Standard for determining fenestration attachment product SHGC and visible transmittance.

17.
Window Condensation in Historic Buildings that Have Been Adapted for New Uses

Author(s): Brown
Organization(s): National Research Council Canada
Publication Date: January, 1997

Research study describing an evaluation of selected windows undertaken by IRC researchers at Ottawa’s Laurier House (now being used as a museum) to determine their effectiveness in controlling condensation.

*Publication dates are shown for formal documents. Dates are not shown for non-dated media. Access dates for referenced, non-dated media, such as web sites, are shown in the measure guide text.

Contributors to this Guide
The following authors and organizations contributed to the content in this Guide.

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