



**HISTORIC
NEW ENGLAND**

Defining the past. Shaping the future.

**Property Care White Papers
Weatherization Case Study
Interior Storm Windows**

Case Study - Interior Storm Windows

Lyman House Weatherization Project: Interior Storm Windows

A Component of Energy Retrofit project supported by Massachusetts Department of Energy Resources

Work completed June 2011-February 2012

Pre-Work

Statement of Condition

Interior storm windows did not exist prior to this project. The implementation of interior storm windows was a component of a Department of Energy Resources energy retrofit project.

Treatment Plan (scope of work)

Install in a minimally invasive manner interior storm windows to the basement, first and second floor openings where no exterior storm windows currently existed.

Philosophical Approach

Historic New England's philosophy steers away from implementing architectural components that didn't exist at the time of the acquisition of the property or are not readily visible in historic images of the period of interpretation.

Over the past 30 years the basic institutional philosophy when installing non-historic elements such as storm windows or, more commonly, UV protection in the museum buildings was to install these elements in the interior as opposed to the exterior. This approach stems from the concept that guests rarely notice an interior sheet of UV or storm window but on the exterior of the building these additions are very noticeable ó specifically in the aesthetic quality of how light is reflected off of the individual panes of the historic window compared to light reflecting off of a single storm pane. Historic New England's interpretative group confirmed this approach was still in keeping with our interpretive goals at the site.

The Massachusetts Historical Commission holds a preservation restriction on the property. As that restriction governs exterior changes to the building, the implementation of the interior storm windows was not reviewed. The implementation of exterior storm windows where they did not currently exist was not allowed.

In order to accommodate the interior storm windows, the round head brass wood screws that secured the window stops had to be exchanged for flat head brass wood screws to provide a flush mounting surface. All round head brass screws have been retained if future direction calls for the removal of the interior storm windows.

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Work

Work Performed

Interior storm window options were researched and evaluated along four key measures:

- Effectiveness of blocking air infiltration at the window opening
- Infringement on historic fabric
- Reversibility
- Cost

Historic New England's experience with interior storm windows has been limited over the years. Some properties have had such storm windows installed. These products have typically been single panes of glass in an aluminum or vinyl frame. The unit is then secured to the window opening through a magnetic strip or brackets screwed to the window frame.

Effectiveness of blocking air infiltration has never been measured and documented. Further, it appeared that the sealing of the opening has been compromised such that warm interior air has penetrated and condensed on the interior surface of the primary sash. This condensation has then resulted in water damage and deterioration of the interior surfaces. A similar effect has been seen where the organization has hung or secured UV rated Plexiglas® panels to the windows. Typically, this installation was done to help protect interior finishes from UV degradation and not as an energy efficiency technique. However, the same type of condensation damage has become increasingly prevalent. It was important for this project that the interior storm window selected provide a sufficient seal so as to avoid the condensation issue.

Three products were evaluated: Innerglass Storm Windows; Allied Storm Windows; ClimateSeal Storm Windows

Brand	Frame	Glass	Attachment	Color
Innerglass	Vinyl	Low E	Compression into opening + U channel at head	3 standard options
Allied	Aluminum	Various options (annealed, laminated, tempered, low E, tinted, polycarbonate, acrylic)	Aluminum tracks with magnetic tape strip installed into opening	Custom match
Climate Seal	Vinyl	Acrylic	Aluminum tracks with magnetic tape strip installed into opening	Custom match

The Innerglass and Climate Seal products were comparable on price when comparing the standard offering. However, the Innerglass product uses Low E glass as its standard offering whereas Climate Seal's standard offering is acrylic with a 10 year guarantee for

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yellowing. UV Plexiglas® would be an upgrade to the standard acrylic offering, but Low E glass was not an option. Allied Storm Windows were available in Low E glass and the frames would be custom color matched. However, the price per opening was approximately 50% greater than the Innerglass offering. All three products claimed to provide a tight seal and thus guard against any condensation issues. All three have significant install bases and happy customers. Innerglass was the chosen provider for the Lyman project due to the minimal impact on existing fabric and its price point.

A total of 79 interior storm windows were purchased and installed.

The typical installation involves the securing of a U channel at the top of the window opening. This U-channel is secured with two #8 wood screws. The storm window is then inserted into the opening by compressing its sides and sliding the unit into the U-channel. The storm window unit has a silicone gasket at the top and bottom and a fiber gasket along the side spring loaded compression jambs. Once the unit is installed in the opening, two rivet pins are inserted about 1/3 of the way up the unit to provide final security. These pins require the drilling of two 3/32ø holes.



*Left:
Installation of
U-channel at
top of window
casing*



*Above: Rivet pin installed to
help secure side of storm
window*

In order to accommodate the interior storm windows, the round head brass wood screws that secured the window stops had to be exchanged for flat head brass wood screws to provide a flush mounting surface. All round head brass screws have been retained if future direction calls for the removal of the interior storm windows.

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The standard interior storm window is a single unit of low E glass. Fourteen of the window openings were treated with a UV Plexiglas[®] unit due to either size of opening or curved feature of opening. These openings were the ballroom (W1-15, W1-16, W1-17, W1-18, W1-19, W1-20), the Bow Parlor (W1-22, W1-23), the Ballroom Chamber (W2-18, W2-25), the Oval Chamber (W2-28, W2-29, W2-30) and the Palladian window (W2-31a, b, c).

The installation for the Bow Parlor and Oval Chamber required that the units curve to accommodate the opening. This can only be accomplished with the use of UV Plexiglas[®]. For these curved openings, the U-channel at the top was molded to follow the curve of the opening. These openings also require the use of a third pin, located at the bottom sash stop. This pin serves to hold the curve at the bottom of the unit. Note that each of the 5 openings was found to have a different radius. This is likely attributed to the hand construction of this room as part of the 1793 construction period.



Left: curved U-channel to fit curve of opening

Above: additional rivet pin at bottom to hold curve of storm window



Above: Curved opening in Bow Parlor

Interior storm windows have the advantage of being minimally visible from the exterior, but they also prevent the routine opening/closing of the window. From a Functions perspective, it was desirable to retain some level of functionality for some windows. This desire was based on past experience with the air conditioning system and the general use of the ballroom where the windows are often left open during an event to take advantage of prevailing breezes.

Sixteen windows were provided with a screen option ó Ballroom (W1-15, W1-16, W1-17, W1-18, W1-19, W1-20), Dining Room (W1-06, W1-09), East Parlor (W1-10, W1-

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13), Brideø Room (W2-07, W2-10), Groomø Room (W2-13, W2-16) and Ballroom Chamber (W2-18, W2-25).

In the case of the Dining Room, East Parlor, Brideø Room and Groomø Room, a decision was made by the PPIP sub-committee formed to oversee all 2011/2012 work at the Lyman Estate that allowed for a screen option in the side facing bay windows of these rooms. Functions desired this option as previous experience with the air condition system suggested that having an open window option was a good øjust in caseö practice. The new HVAC system has thus far eliminated the need for implementing the screen option, although all components are on site (stored in the attic) should this need evolve. In order to accommodate a screen opening for the lower sash an intermediate rail at the level of the meeting rail had to be installed. In the case of the Ballroom and Ballroom Chamber, this rail holds an upper and lower storm window during the winter. It also provides a mounting location for the U-channel for the lower storm window. During the spring/summer/fall, the two storm units can be removed for storage and the screen unit installed in the bottom location. In order to open the window, the screen must be removed, the lower sash lifted, and the screen reinstalled.

For the other windows with a screen option, the intermediate rail must be installed when the decision to go with a screen is required. Thus, more advanced planning is required in this situation as a full size storm window is a standard installation for these openings.

These intermediate rails have been installed so as to minimize impact on the window stops. The rail location was aligned with two sash stop screw locations. A brass threaded insert replaced each of the existing screws. The intermediate rail was then screwed into these inserts with the use of pocket screws. The use of a threaded insert will allow the intermediate rail to be removed and reinstalled repeatedly without gradually stripping out and deteriorating the sash stop.



Above: screen insert installed in ballroom



Above: Added support rail for screen / lower storm in ballroom

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In order to establish the curve at the top of the Palladian window, a pattern was created. In the shop, a piece of curved wooden molding was fashioned to match the pattern. A piece of UV Plexiglas® was then cut to fit into this molding profile. The top section of the Palladian window has been screwed into the jambs to prevent the falling of this component. The bottom section is easily removable and installed in the same manner as the other interior storm windows.



Installation of Palladian storm window



Palladian storm window installed

Interior storm windows were also installed in the basement openings where windows were currently installed. Some openings had previously been blocked up over the years and had no windows. These openings were left blocked. As the basement windows were mounted flush with the basement walls, a wooden frame had to be built to hold the storm window. These frames were fabricated on site from poplar and painted grey to match the existing grey sash. The new storm window units were then secured to these frames. This installation process allows can be easily reversed by simply unscrewing the storm window frames.

During the HVAC installation, it was determined that two window openings (WB-16 and WB-23) were needed for the routing of exhaust and intake piping. These storm windows are labeled and stored with the associated sash on the 3rd floor of the mansion house.

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*Basement window installation
of storm window sash.*

Interior storm windows were also installed at the front entry for the fan light and the side lights. For this application, the storm window solution from Allied was used. This decision was based on the size of these openings, the desire for as thin of a profile as available, and the need for a tempered glass solution to meet code requirements. For this instance, aluminum L brackets were installed with a minimum of screw penetrations to the surrounding window frames. This aluminum L bracket is faced with a magnetic strip that interfaces with the magnetic strip on the edges of the storm window. While this magnet creates a positive seal, two screws per unit provide additional security as vibrations from the repeated door closing may loosen the seal. In this case, the default cream color of the Allied product provides a near match to the existing paint treatment.



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Issues

The key issue with the interior storm windows is that the color for the frames was not matched to the paint color of the interior. An alternative product could have been selected that would have been color matched, but the expense of that would have resulted in cuts in other energy efficient strategies. As most windows have (or will have) interior textile treatments this color difference is somewhat minimized.

It should also be noted that while the interior storm windows are invisible when viewed from the exterior, they do have a reflective component such that when viewed closely one can see the reflection of the muntins. One would have to be very sensitive to this detail to truly observe it, but it is there.



Interior storm windows installed



*Interior storm windows installed
Note muntin reflection in top sash*

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Energy Efficiency Metrics

After installation of the storm windows, various blower door tests were performed on rooms with the storm windows. These rooms are the East Parlor, Dining Room, and Brideø Room. Infiltration measurements found that there was an overall decrease in infiltration by 30% in each room tested. With the storm windows uninstalled, approximately 10% of the reduction could be attributed to the sash conservation and weatherization efforts.



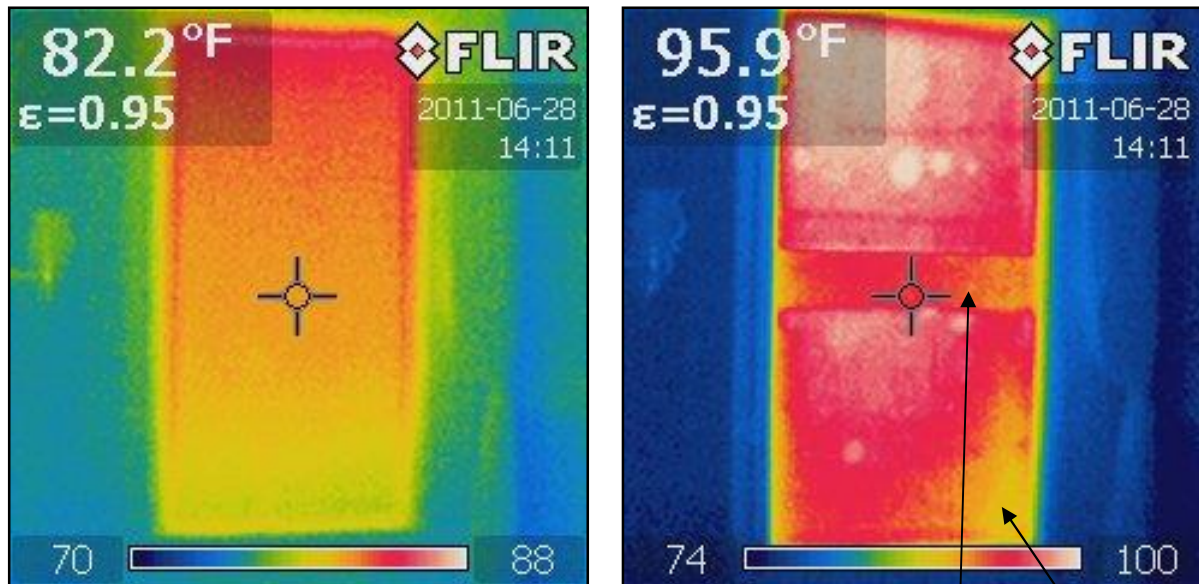
Relative affect on air infiltration of sash conservation/weatherization and implementation of interior storm windows.

- *Black represents net room "opening" before intervention*
- *Grey represents sash conservation / weatherization contribution (~10%)*
- *White represents net opening after interior storm window installation. (additional 20%)*

In addition to the impact on air infiltration, the low E glass is an important component for energy efficiency. Low E glass is glass that has been treated with a thin film coating that reflects heat, but allows visible light to pass through. The result is that in winter conditions, heat is reflected back into the room and in summer conditions, solar heat is reflected back to the exterior.

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The following images using infrared imaging demonstrate the impact of this feature.



*With interior storm
Exterior heat is largely
blocked from the interior*

*Without interior storm
Significant exterior heat is
allowed to pass through to
the interior space*

*Conditions:
Window 2-06
West facing window
Black ½" plywood blank insert
Exterior temp: 81
Partly sunny*

Installation Guidelines

The size and weight of the storm windows can lead to challenges in their installation. Following these steps will help lead to successful installation / removal.

- Set the storm window on the floor and compress the sides so that the storm window is set in the opening along the stops
- Keeping the storm window compressed in the opening formed by the window stops, slowly raise the window from the bottom corners
- Raise the window into the U-channel at the top of the opening
- Press in one lower corner and then the other lower corner
- Set the rivet pins in the existing holes
- To remove storm windows, simply reverse the process being careful to have full control of the window as you lower it down.

While most storm windows can be installed by one person, success with the 5 curved openings in the Bow Parlor and Oval Chamber comes with the aid of a second person to help keep the curve as the sash is slid up to the U-channel.

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Maintenance Requirements

The interior storm windows should require no significant maintenance. However, they should be routinely monitored to note the appearance of any condensation buildup that may suggest a leak in the seal. They should probably also be removed at least annually so that any dirt or bugs that have entered from the outside can be removed and cleaned. While the glass storm windows can be cleaned with a mild window cleaning product (vinegar / water mixture), the UV Plexiglas windows must be cleaned with an approved plastic cleaner. A supply of Brillianize plastic cleaner and static free cloths has been provided for routine cleaning of these windows.

Storm windows are only to be removed by Property Care staff. Property Care staff shall be responsible for the removal and reinstallation of the storm windows in the ballroom on a seasonal basis. The storm windows would be installed from approximately October 15 through April 15.

Cost

Work Performed	Company	Amount
Interior Storm Windows	Innerglass Storm Windows	\$ 28,313.66
Brass flat head screws for stops	Jamestown Distributors	\$ 212.82
Interior Storm Windows ó Front Door	Heritage Restoration	\$ 2,357.18
Total Interior Storm Windows		\$30,883.66
Average Cost per Window Opening		\$ 390.93