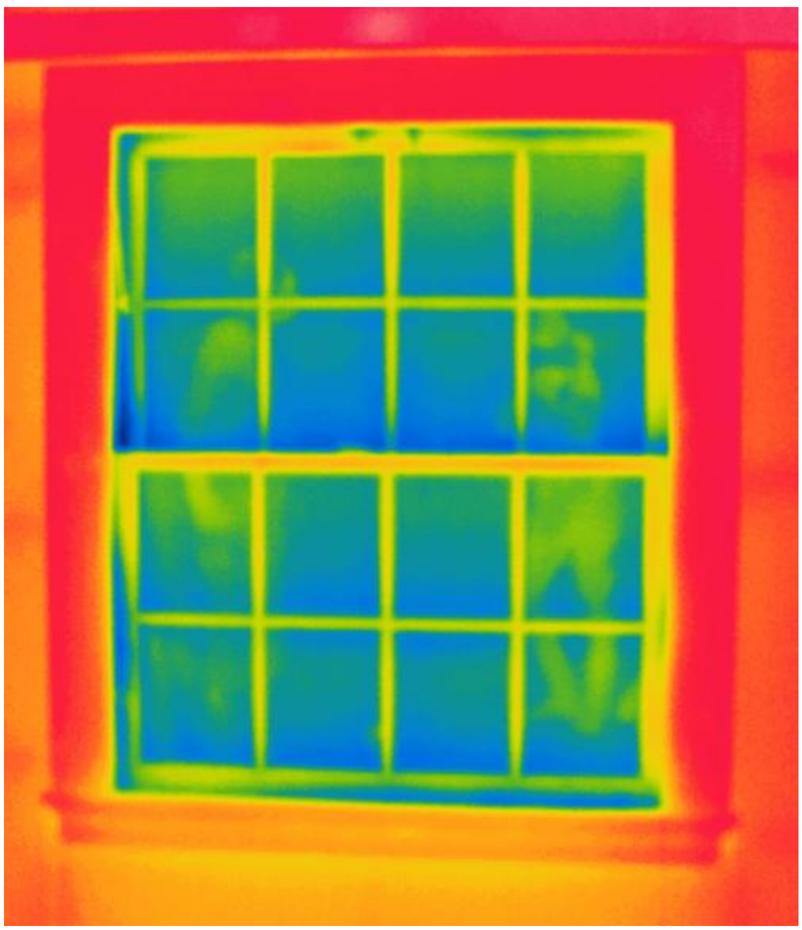
Straub Hall
University of Oregon

Report #1
Envelope Renovation Study



September 2012

Straub Hall
University of Oregon

Report #1
Envelope Renovation Study

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1.0 Summary Recommendations

Recommendations for Straub Hall include:

- Install slips
- Install insulation
- Install vapor barrier on the inside of the wall assembly
- Carefully weatherseal the windows and frames
- Provide daylighting controls for the perimeter spaces and extend the daylight zone by relighting
- Seal counterweight cavity
- Replace retrofitted sashes into their original frames

Of the improvements tested, the overall U-value of the wall and window of the test sample was reduced a maximum of 61%, from 0.44 to 0.17 BTU/hr-sf-°F. Energy savings over code from daylighting controls is estimated to be 67,300 to 101,000 kWh annually.

The slips will provide better daylighting savings. There is little difference in conduction performance between the slips and insulated glazing units although the insulated unit may perform slightly better (the results may be confounded by increased infiltration after the slips were installed). Photocontrols should be provided to harvest daylight for the spaces along the exterior walls. There is also the potential for relighting the corridors for further savings.

Insulation should be added to the exterior walls. Also, based on the wall monitoring results, a vapor barrier should be provided either on the inside finished surface of the wall or between the insulation and gyp board.

The windows should be weather-stripped. If the existing sashes are to be used, it is recommended that retrofitted sashes be reinstalled into their original frames. Additionally, the counterweight cavity should be sealed as well as filled with insulation.

2.0 Introduction

The University of Oregon is planning a renovation of Straub Hall and has retained Rowell Brokaw Architects for design consultation. Straub Hall comprises of 83,000SF of predominately offices and classrooms. This report evaluates and makes recommendations on improvements of the fenestration, wall, and daylighting renovations.

ESBL was tasked to complete 5 objectives: determine where the exterior wall experiences the most thermal loss; determine the thermal improvement of window treatments; determine the impact of adding insulation to the walls; determine if condensation could occur within or on the wall assembly; and determine the potential energy savings from daylighting. The scope of this report focuses on the findings and recommendations from these objectives.

ESBL conducted a series of co-heating, blower door, and wall monitoring tests to analyze the thermal and infiltration performance of the windows and the adjacent wall. The tests were conducted on a typical window and wall located in Room 337 (see Figure 1). Additionally, daylighting analysis and associated EUI estimates were determined using on-site measurements and hand calculations. The test window options were not evaluated in terms of solar radiation.

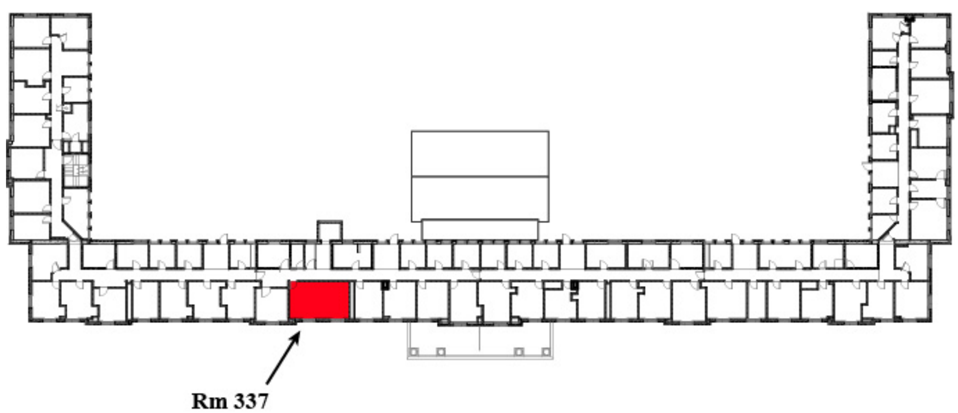


Figure 1, Third Floor Plan Showing Location of Test Room

ESBL was asked to evaluate the following window and wall improvements:

- Test 1A: Existing conditions, base case
- Test 1B: Weatherstripping added to existing window
- Test 2A: Wall insulation added
- Test 2B: External storm slip added to window (sashes from neighboring window)
- Test 2C: Existing window glazing changed to double-glazed (original sashes used)

3.0 Coheating Testing

3.1 Methodology

Using a guarded hot box, coheating testing establishes the thermal performance of the window/wall assemblies. Coheating testing was conducted using a sealed, conditioned meter chamber (see Figure 2). The function of the meter chamber is to inhibit airflow between the meter chamber and the room in which the meter chamber is located (the guard chamber).

The temperature of the meter chamber and the guard chamber (Room 337) were monitored and controlled to stay at the same temperature to ensure that the test window/wall caused the only heat flow into and out of the meter chamber. Heat loss through the test window/wall was calculated as a function of the energy used to maintain the meter chamber temperature with space heaters. Since the meter chamber was kept at a constant temperature with guard chamber, insulation between the two was not required.

The construction of the box was plywood sheets, 2x4's, and weatherstripping.

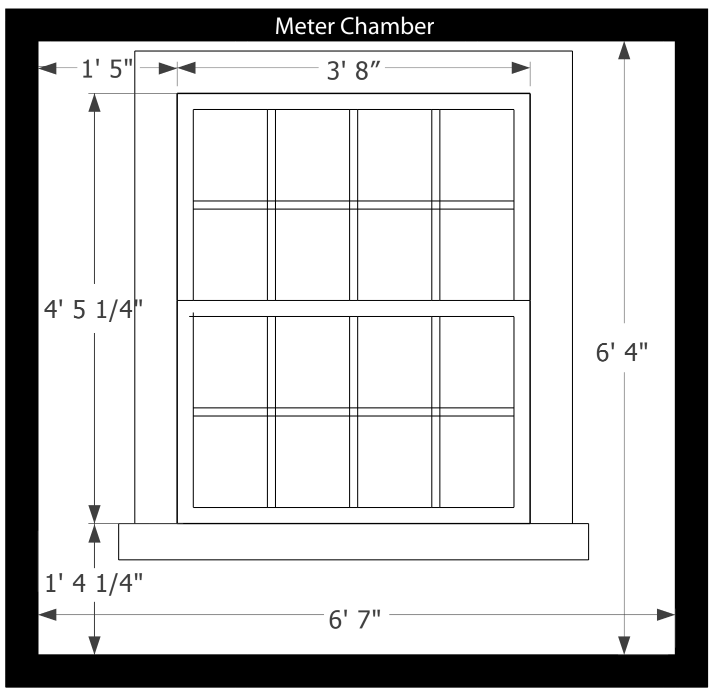


Figure 2, Meter Chamber Section (Chamber Depth = 2' 9½")

3.2 Results

The following chart (Figure 3) shows the change in performance for each of the window and wall improvements tested. It is specific to the window and wall area tested and does not represent the whole building. As seen in the chart, the overall U-value of the test window/wall assembly reduced 61%, from 0.44 to 0.17 BTU/hr-sf-°F, from the base case to the final configuration. The U-value reduction from baseline for each improvement is as follows: 18% for weather stripping, 15% for insulation, 26% for slips, and 28% for double pane. In other words, if only insulation would be added, the window/wall assembly would have a 15% reduction in U-value. Note that the double pane and the storm slip are alternates and only one of the two would be included; therefore, both are compared to Test 2A.

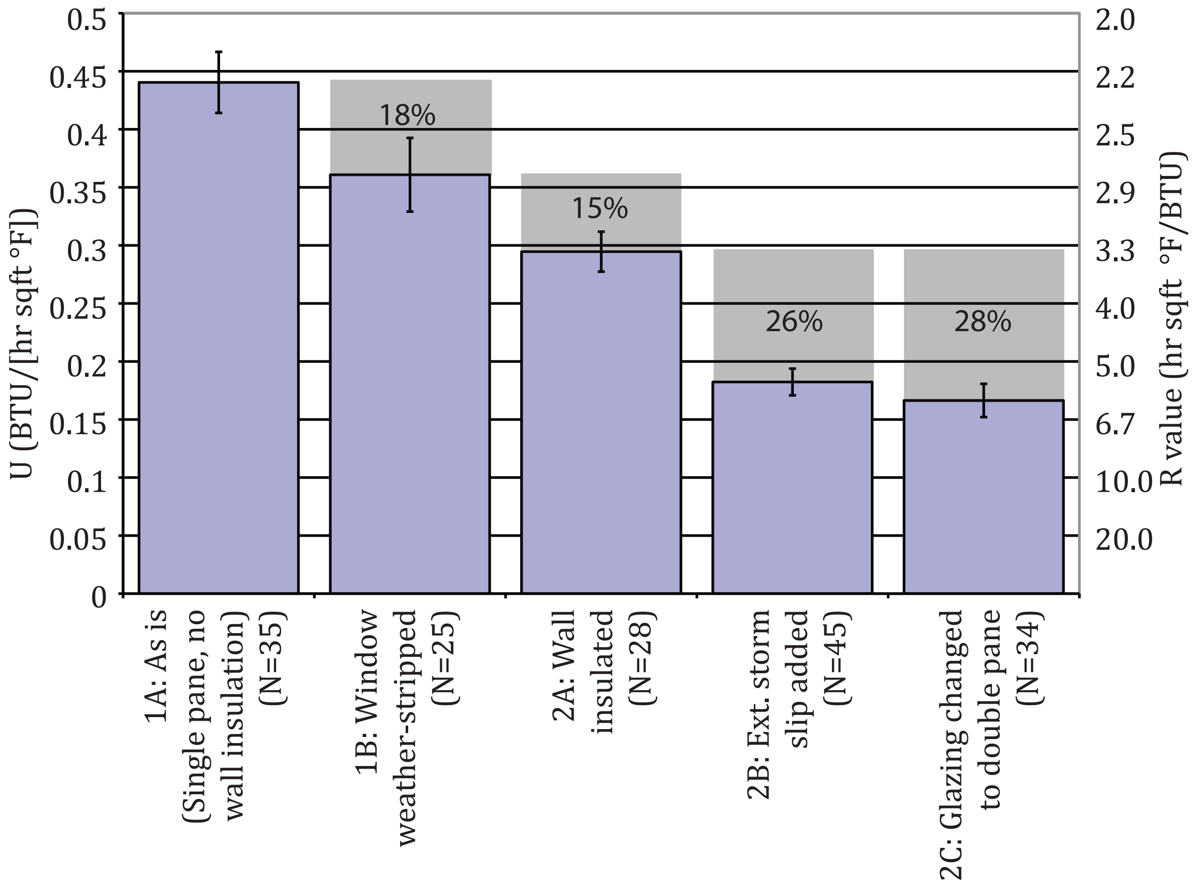


Figure 3, Straub Coheating Summary

4.0 Blowerdoor Testing

4.1 Methodology

Blower door testing was conducted for each test to determine infiltration rates (see Figure 4) and infrared (IR) images were collected to visualize air cracks.

Figure 4, Blower Door Testing in Meter Chamber

4.2 Results

The following chart (Figure 5) shows the results of the blowerdoor tests. These values are airflow rates at 50 Pa and do not represent rates at usual wind pressures. Note that in Test 2B leakage increased for an unknown reason. Using sashes from another window may potentially have been the cause for this increase; note that the sash used for the slip test were taken from a neighboring window and may not have had a good fit in the test window. It is recommended that retrofitted sash units be replaced into their original frames.

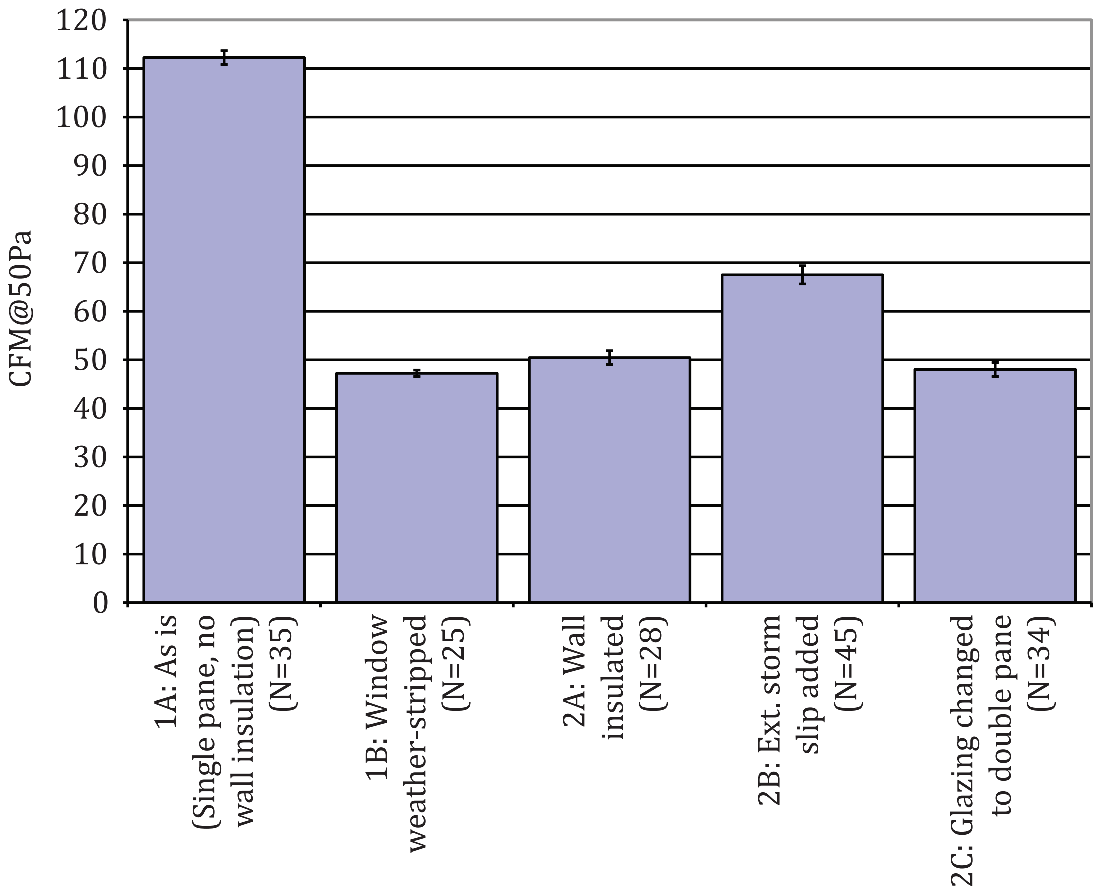


Figure 5, Straub Blower Door Summary

Infrared imaging was used to establish the infiltration locations around the window as well as thermal bridges in the wall assembly. The following IR images were taken during each of the tests to visualize the changes. The testing starts with the existing window and wall assemblies (1A) followed by the improvements: add weather-stripping, add wall insulation, add slips to glazing, and replace slips with double glazing.

Each column contains a visible light image and corresponding infrared images. Color represents surface temperature, with red being warmer and blue colder. There is a scale on the right edge of each image. The middle images in each column have been processed so that the temperature scales are the same for all photos, while in the lower images the scales are set to enhance the infiltration in each photo. Note that the camera is calibrated for the wall and painted wood surfaces—temperatures of the glass are not necessarily accurate.

These images were taken while depressurizing the room. Therefore, sources of infiltration can be seen where incoming cold air cools surfaces.

Straub Hall Infiltration Tests: Whole Window and Wall

Digital

TEST 1A

Existing window before treatment

TEST 1B

Window has been weather-stripped

TEST 2A

Wall insulation added

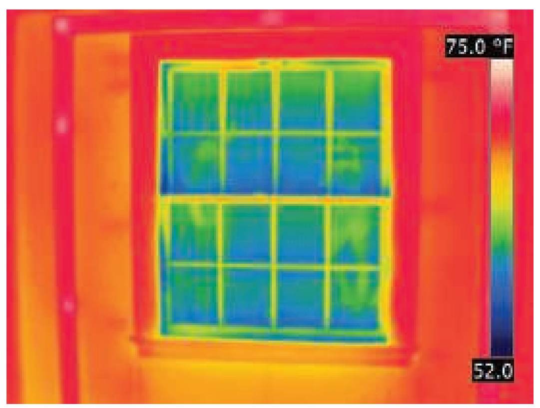
TEST 2B

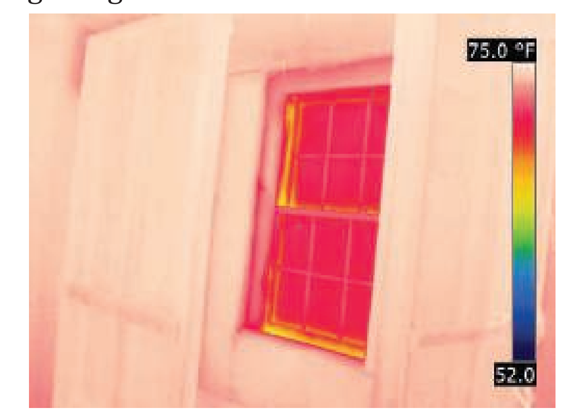
Sash & glazing replaced for units with slip installed

TEST 2C

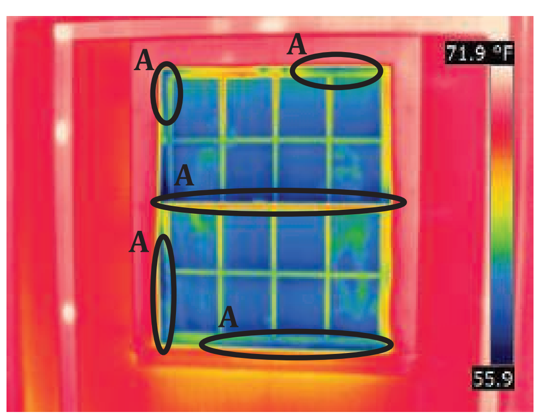
Original sash reinstalled with double glazing replacing original single glazing

Fixed Temperature Scale [52-75F]

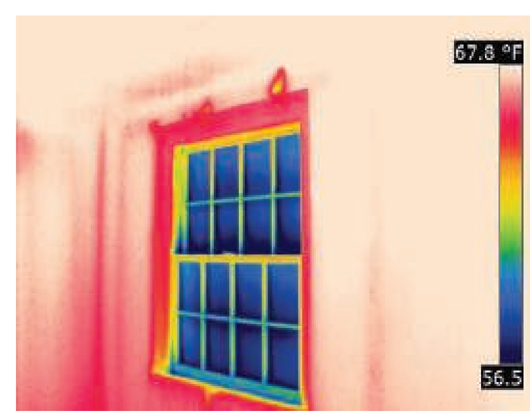




Varying Temperature Scale



A: Air leakage



Window frame still conductive

Straub Hall Infiltration Tests: Upper Sash

Digital

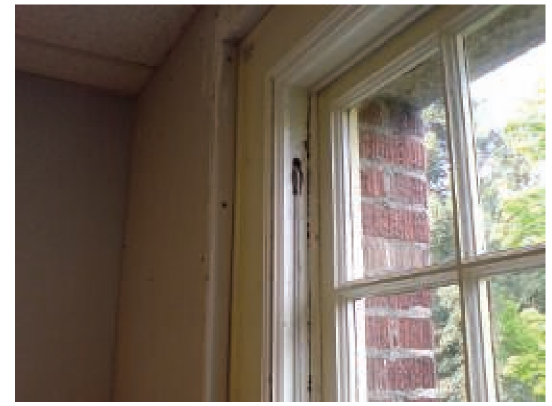
TEST 1A

Existing window before treatment

TEST 1B

Window has been weather-stripped

TEST 2A



Wall insulation added

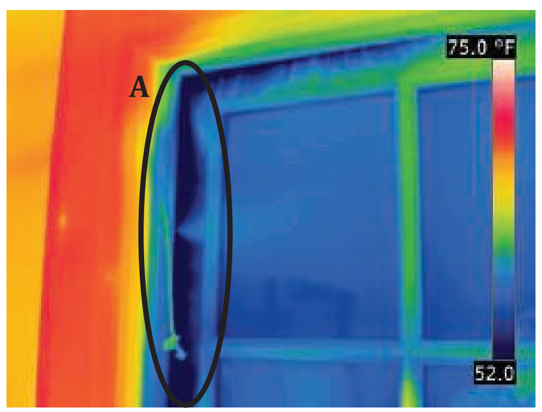
TEST 2B

Sash & glazing replaced for units with slip installed

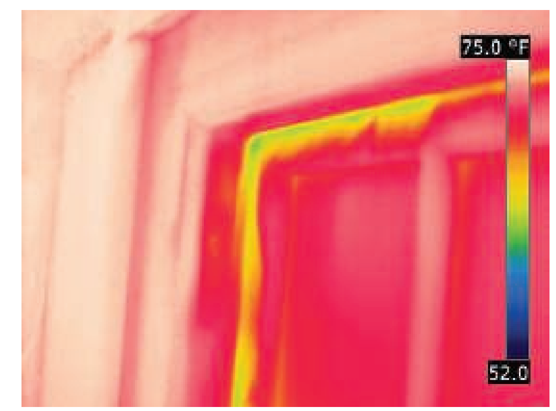
TEST 2C

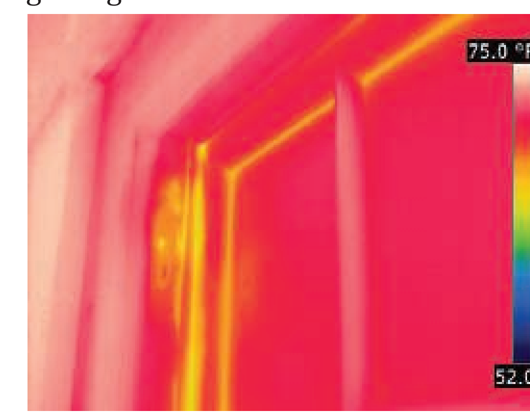
Original sash reinstalled with double glazing replacing original single glazing

Fixed Temperature Scale [52-75F]

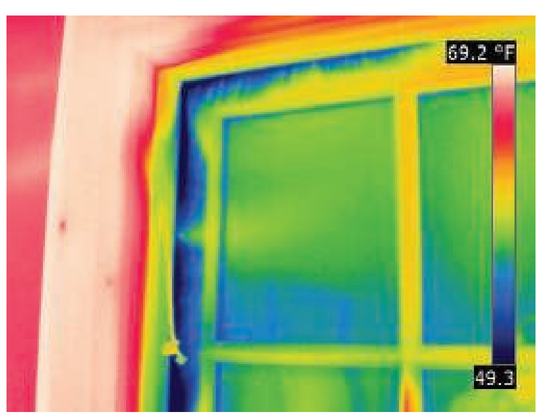


A: Infiltration noticed between sash and side jamb

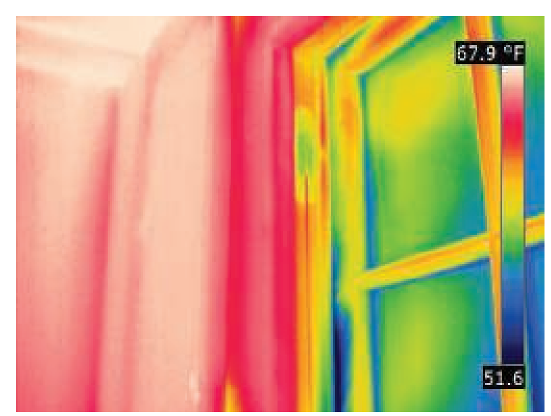


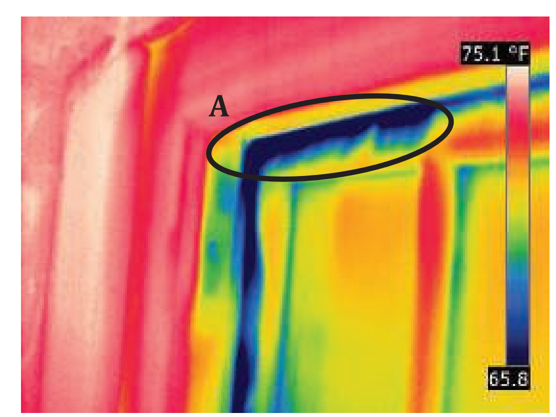


Varying Temperature Scale

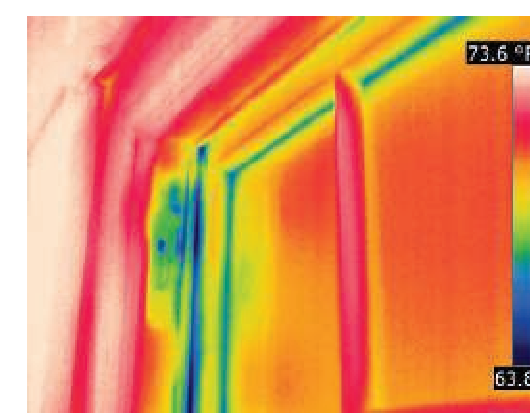


A: Need to seal counterweight pulley opening





A: Exchanging sashes increased air leakage around window



Straub Hall Infiltration Tests: Lower Sash

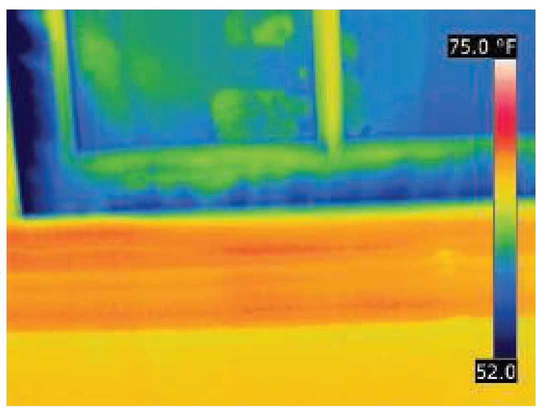
Digital

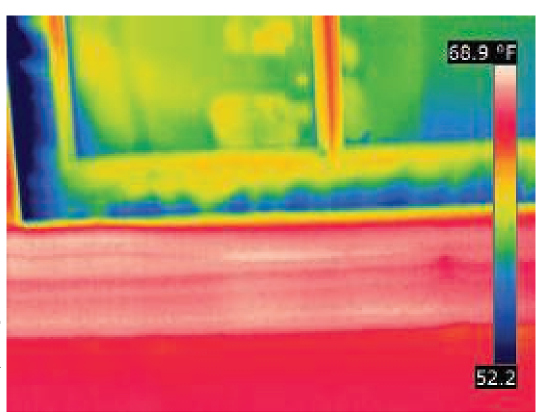
Fixed Temperature Scale [52-75F]

Varying Temperature Scale

TEST 1A

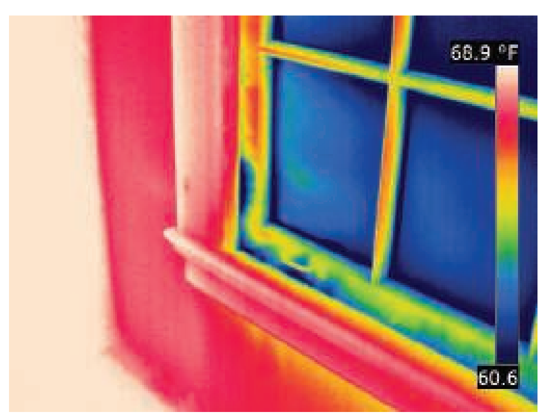
Existing window before treatment





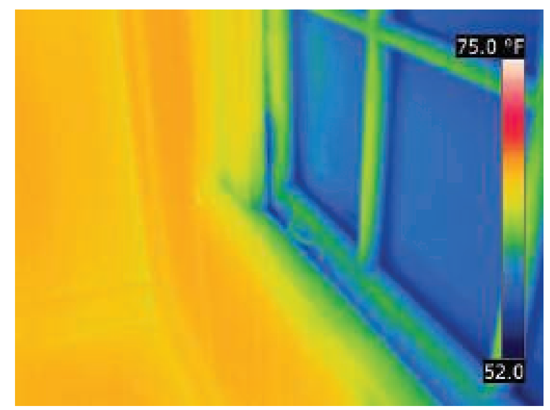
TEST 1B

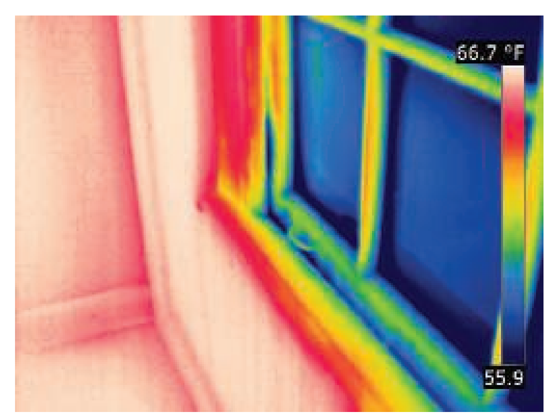
Window has been weather-stripped



TEST 2A

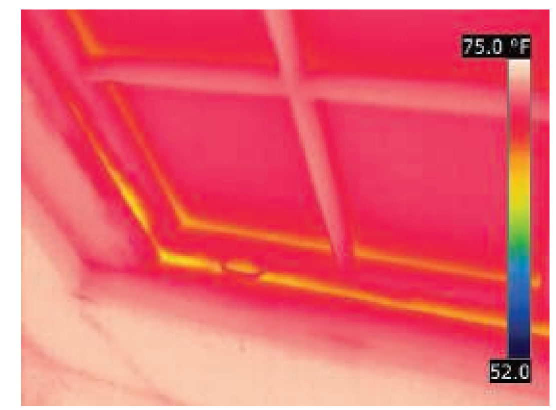
Wall insulation added

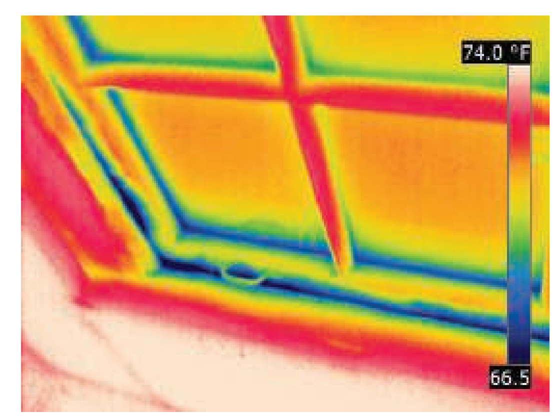




TEST 2B

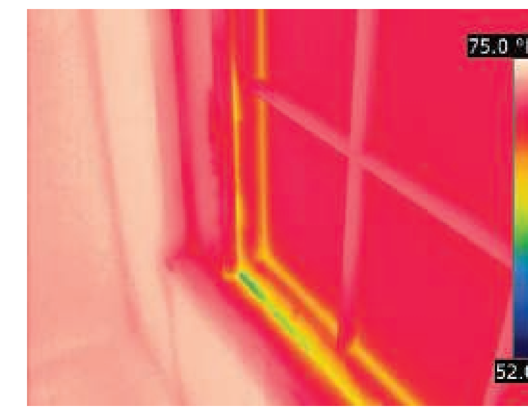
Sash & glazing replaced for units with slip installed

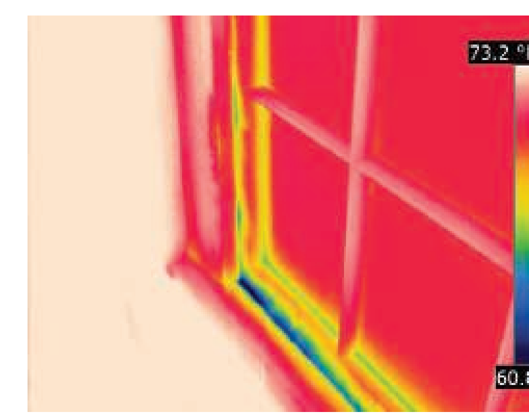




TEST 2C

Original sash reinstalled with double glazing replacing original single glazing





Straub Hall Infiltration Tests: Check Rail

Digital

TEST 1A

Existing window before treatment

TEST 1B

Window has been weather-stripped

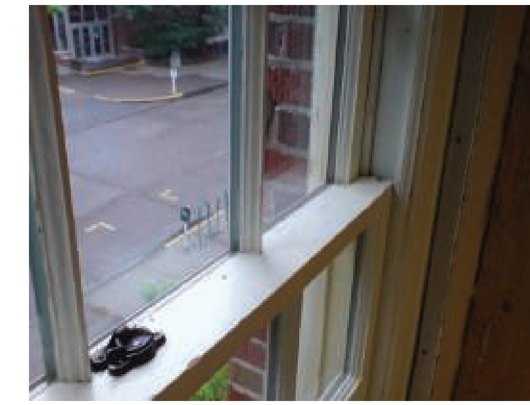
TEST 2A

Wall insulation added

TEST 2B

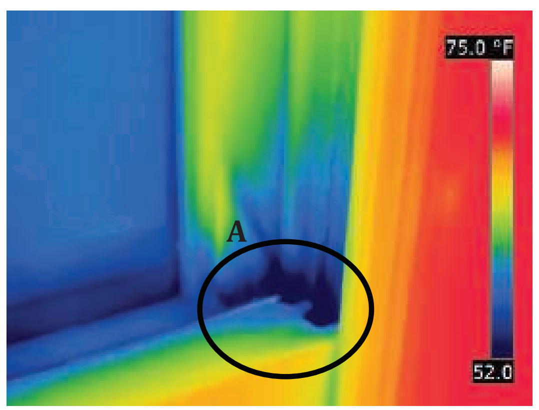
Sash & glazing replaced for units with slip installed

TEST 2C

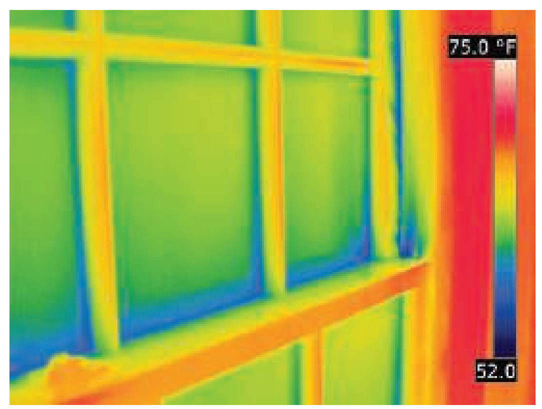


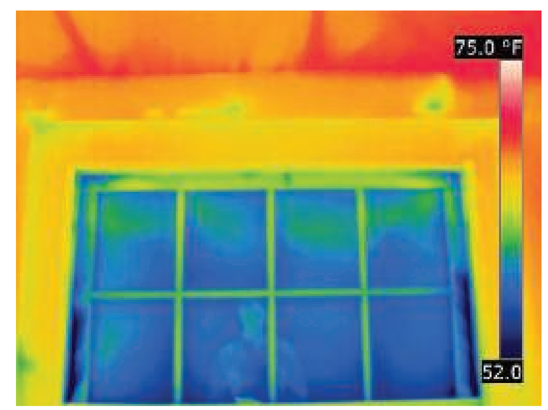
Original sash reinstalled with double glazing replacing original single glazing

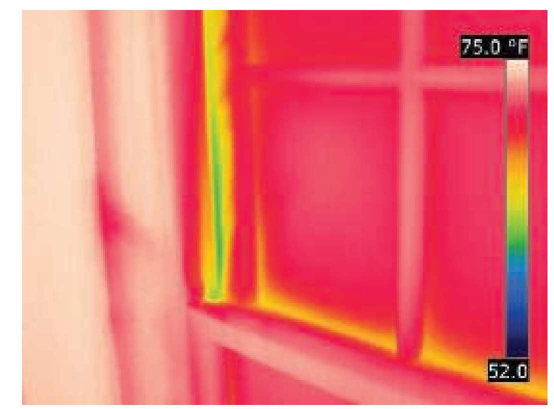
Fixed Temperature Scale [52-75F]



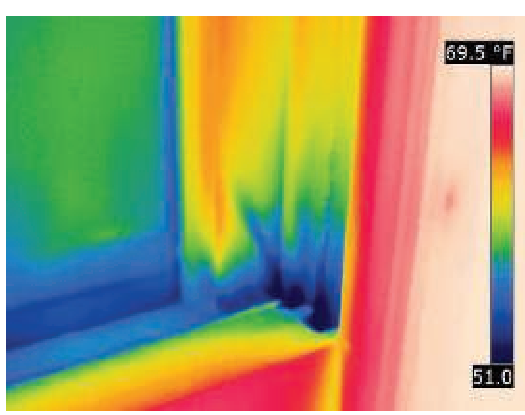
A: Noticeable infiltration in between check rails especially near the jamb

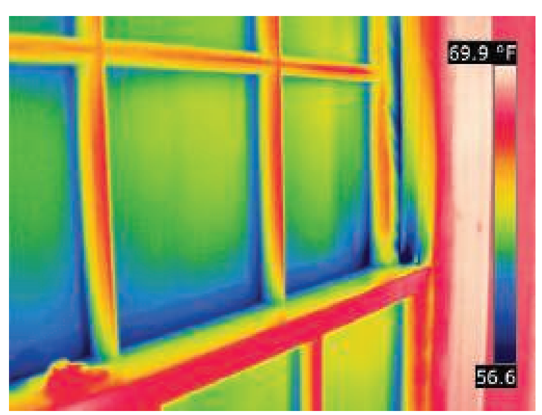


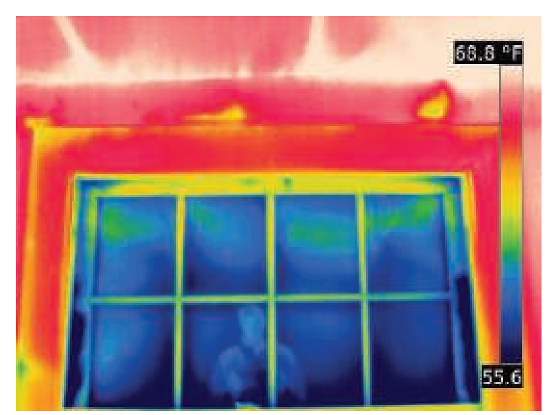


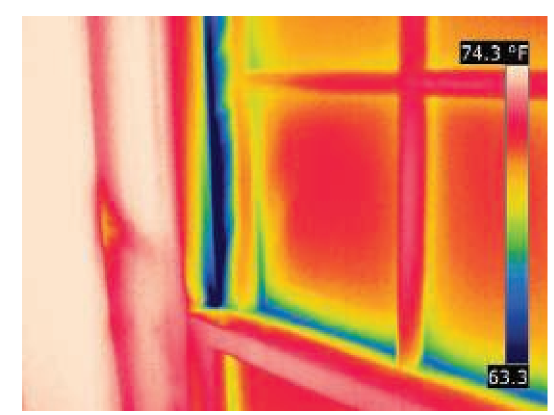


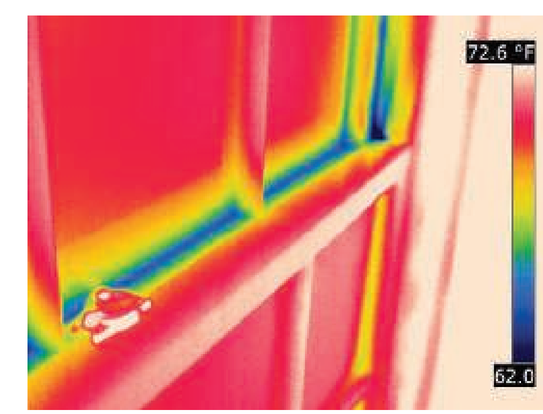
Varying Temperature Scale











5.0 Wall Monitoring

5.1 Methodology

Wall monitoring was conducting using HOBO dataloggers with thermistors embedded within the exterior wall (see Figure 6). Data was collected throughout the test period.

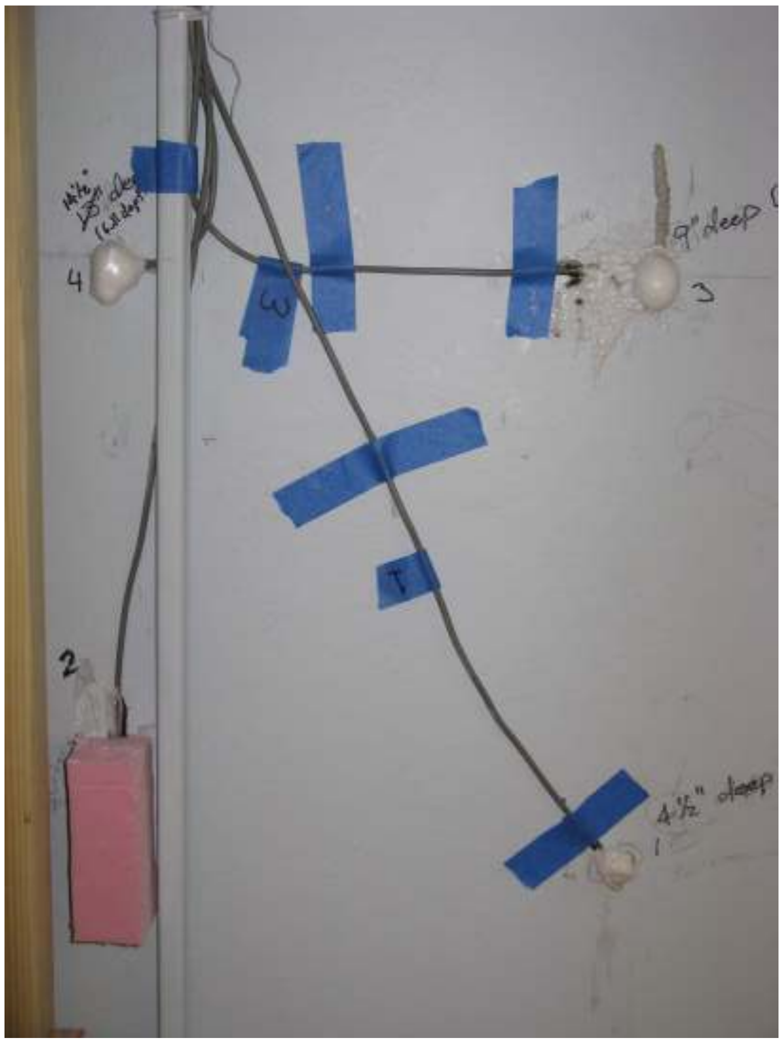


Figure 6, Embedded Wall Monitoring Sensors

5.2 Results

The following charts (Figures 7 & 8) show the temperature profiles calculated for non-insulated and insulated wall sections based on the wall monitoring results. Dew-point temperatures are represented with points to indicate where in the assembly the dew point occurs for various room temperatures and relative humidities.

In the non-insulated wall, under operating conditions the dew point will likely occur between the outer surface of the concrete and the outer surface of the brick.

In the insulated wall the dew point occurs in the brick veneer with lower temperature/humidity conditions and between the finished wall and plaster in higher temperature/humidity conditions. With the dew point occurring inside the inner surface of the concrete under operational conditions, a vapor barrier should be added to avoid moisture build-up. The vapor barrier should be located between the interior atmosphere and the rigid insulation.

As the room air temperature goes down, the surface temperature of the concrete will go down and the RH in the room will go up, both of which combine to increase the likelihood of condensation. Likewise, as the room air temperature goes up, the surface temperature goes up and the RH goes down, reducing the chance of condensation.

The minimum temperature of the inner surface of the concrete wall was established over a one-year period by extrapolating and applying the measured temperatures to TMY3 climate data for Eugene.

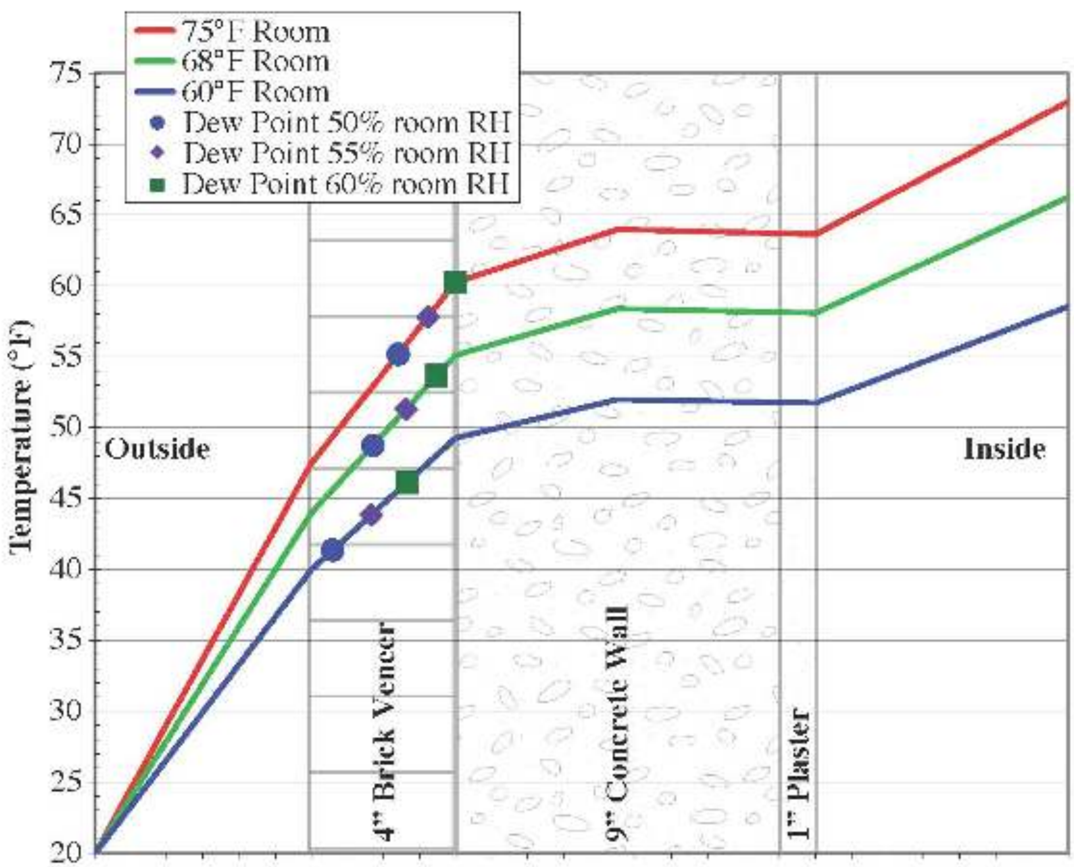


Figure 7, Non-insulated Wall Dew Point and Temperature Profiles

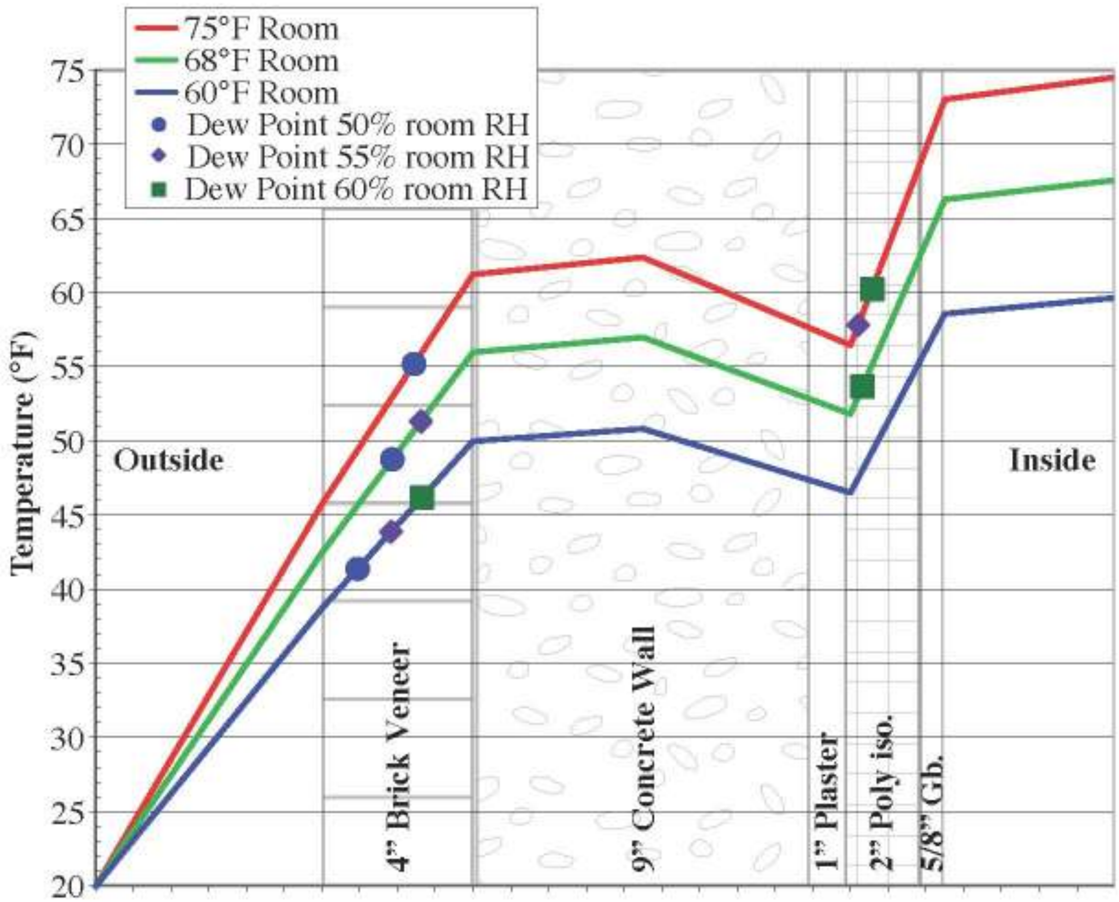


Figure 8, Insulated Wall Dew Point and Temperature Profiles

6.0 Daylighting Analysis

6.1 Methodology

The daylight factor was determined through applying isolux contours to rooms that closely approximate the majority of rooms in the building. These contours were generated using the Millet Daylighting Method. The "Millet Method" is based on simplified geometry and assumes no exterior reflections and an overcast sky. These rooms include a small meeting room with a double hung 36" x 60" window, and an administrative office with a double hung 48" x 60" window. Exterior obstruction corrections were then applied by using 12 solar pathfinder readings that are representative of different areas of the building, both horizontally and vertically. A total of 6 representative building groups were formed based on similar façade orientations and characteristics, while accounting for vertical differences.

6.2 Results

Daylight Factors were estimated to be between 2-3% in the middle of the space for a typical room (see Figure 9). For a December noon overcast day this will produce an interior illumination of 13-20 foot-candles, and at noon in April an interior illumination of 42-63 foot-candles. Also, with the high gradient between the window and the back wall, glare could be an issue. Glare control should be considered for the perimeter spaces. Corridors were not included in the analysis but isolux patterns indicate that relighting the hallway from the offices is feasible. More in-depth calculations would be needed to verify corridor daylighting potential.

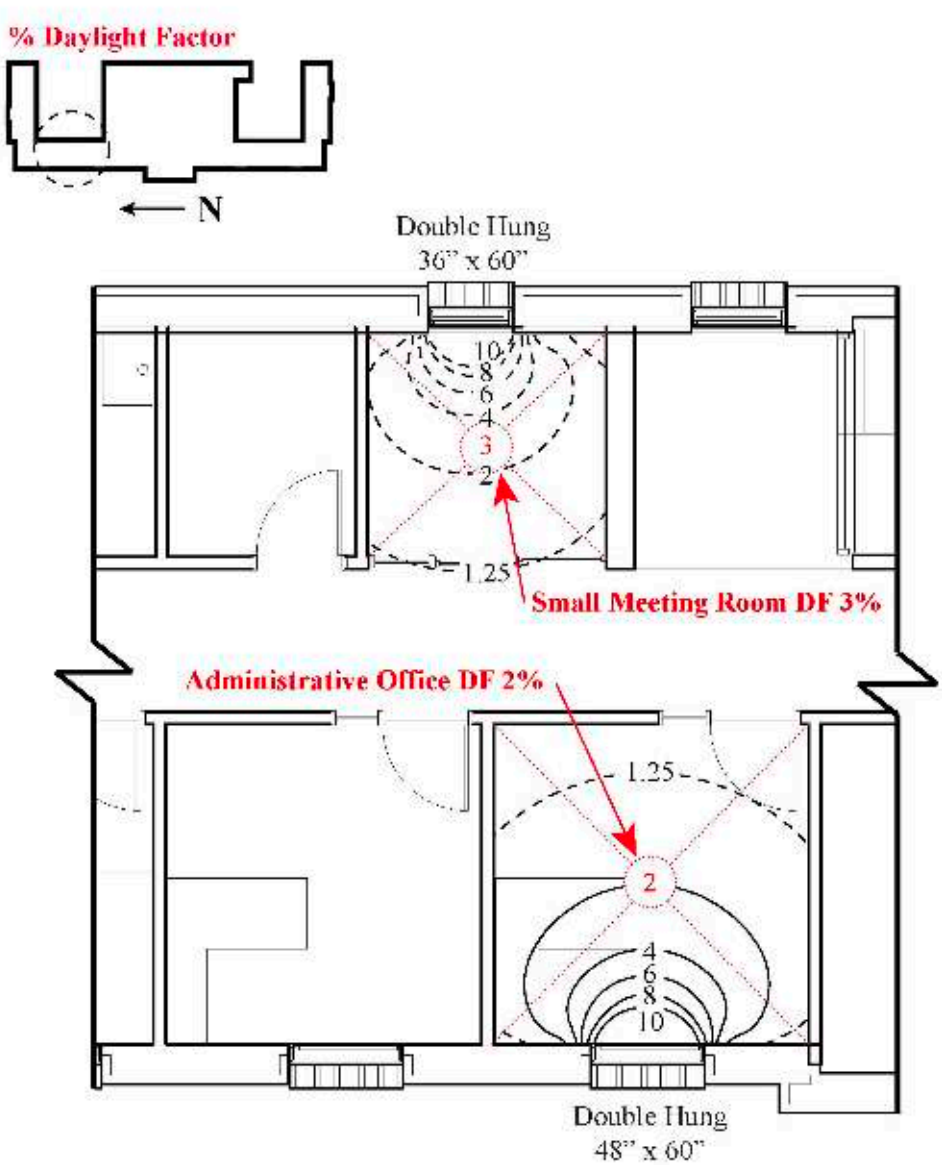


Figure 9, Daylighting Contours of Typical Spaces

Assuming office space is the primary program, the target light levels for the work plane will be 30 fc. Given this assumption, the lighting energy use intensity (EUI) totals under three control types were calculated based on lighting power density, daylight factors, and estimates of available daylight illumination by month and hour (see Figure 10). Savings is for perimeter spaces only and does not include circulation square footage. If circulation spaces are daylit with controls, annual savings would increase.

Daylighting Control Type	EUI, kWh/SF	Annual Savings, kWh/yr
Continuous Dimming and Off	1.3	101,000
On/Off	1.8	67,300
Code (2012 OEESC)	2.8	-

Figure 10, Daylighting Controls EUI and Annual Savings

Assumptions include:

- Minimum Optical Dimming Level: 0%
- Lighting Types: Continuous Dimming and Off, On/Off, and CODE.
- Lighting Power Density Category: Office Building
- Lighting Power Density: 0.7 w/ft^2
- Minimum Dimmed LPD: Determined as 25% of LPD
- Code Maximum: 0.97, as determined from 2012 Oregon Energy Efficiency Specialty Code Table 505.5.2(a)
- Electric Lighting Schedule: Office ASHRAE 90.1-2004

7.0 Contacts

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