Room Side Low-E Experiments

Process, Findings and Impact

October 2018

PAYETTE

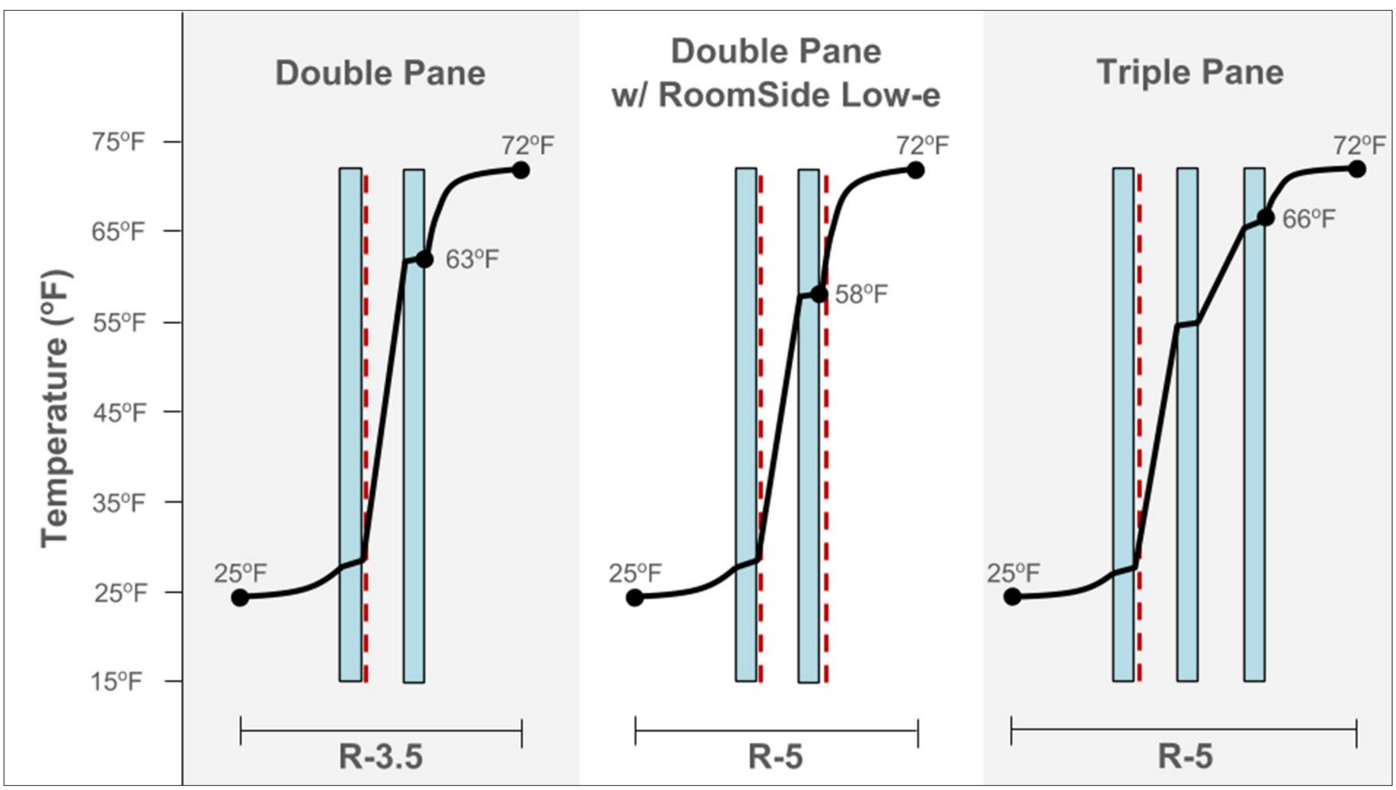
ROOM SIDE LOW-E EXPERIMENT

Those who follow the most recent trends in high performance insulated glass are likely aware of a recent manufacturing innovation that has enabled the application of durable, low-emissivity (low-e) coatings on the interior side of windows.

While such coatings have historically only been applied in between panes of glass in order to protect them, this new innovation has opened up a plethora of potential opportunities and research questions with major consequences for architectural practice.

Perhaps most notably, double-pane insulated glazing units (IGUs) with room side coatings have the potential to exhibit comparable thermal performance and U-values to some types of triple pane units but at a fraction of the cost. This means that they could easily become the default basis of design for many projects as practices seek solutions that lower building energy use without raising up-front cost. However, the impact that these new coatings might have on occupant wintertime thermal comfort has been difficult to assess.

This is primarily because the physics of how low-e coatings increase IGU insulation means that the interior surface temperature of such IGUs will be much colder than a window assembly without the coating. By contrast, the interior temperature of an IGU with an additional pane of glass and air gap would be warmer as illustrated below in the temperature profiles of three IGUs with cold outdoor temperatures of 25F and warm indoor temperatures of 72F.



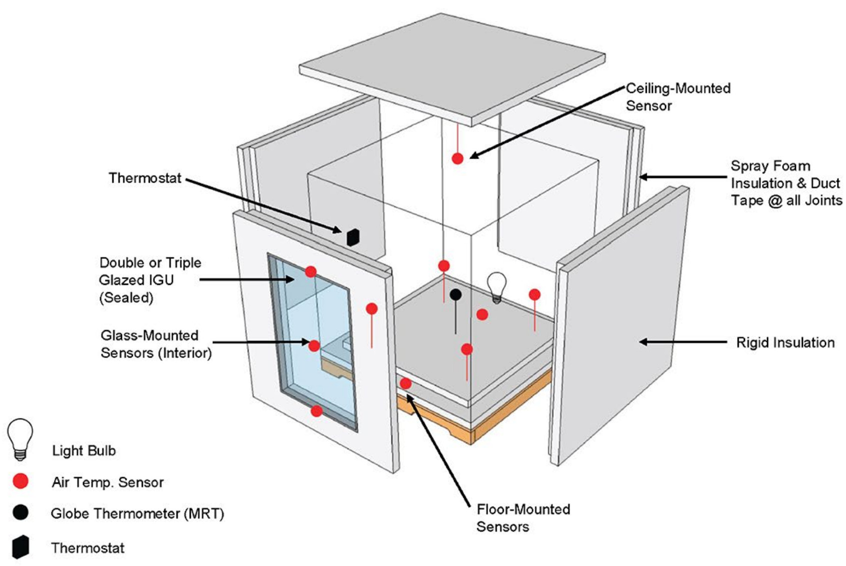
To make the matter more complex, the thermal reflectiveness of the room-side low-E coating means that, even though room side low-e coatings make interior surfaces colder, occupants are less likely to experience radiant heat loss from cold window assemblies. This means that full-body cold sensations experienced next to room side low-e windows are likely uncommon. However, cold window surface temperatures still have the potential to produce intensely cold downdrafts off the window, which could cause localized thermal discomfort for occupants at ankle-level.

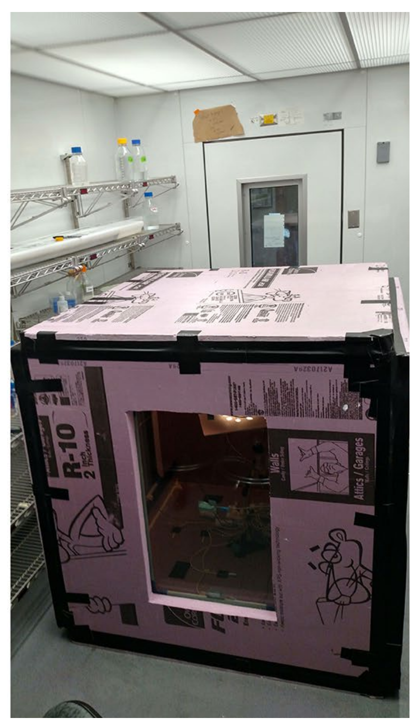
In order to understand these phenomena and assess their relative intensity, our practice performed a series physical experiments on three IGUs that Vircon donated to us:

- Traditional double-pane with a single low-e between glass panes
- Double pane with two low-e coatings (one of which is room side)
- Traditional triple pane with a single low-e between the outer glass panes

The IGUs were placed on one side of an insulated box with walls of R-20. The entire experimental setup was placed in a cold room kept at 40oF while an incandescent light bulb with a fixed wattage inside the box heated the box interior. On average, the bulb heated the box interior to 86oF, though the exact box temperature was allowed to vary with the overall insulation of the IGU. For each of the IGUs, the setup was left for 48 hours until steady state conditions were reached. The average temperature in the center of the box was used to deduce a relative insulation value for each of the IGUs. A globe thermometer in the center of the box was used to assess the mean radiant temperature that an occupant might experience. Lastly, several temperature sensors were located on the surface of the glass and along the floor of the box behind the IGUs in order to understand the downdraft conditions produced by each unit.

BOX DESIGN: TESTING EQUIPMENT



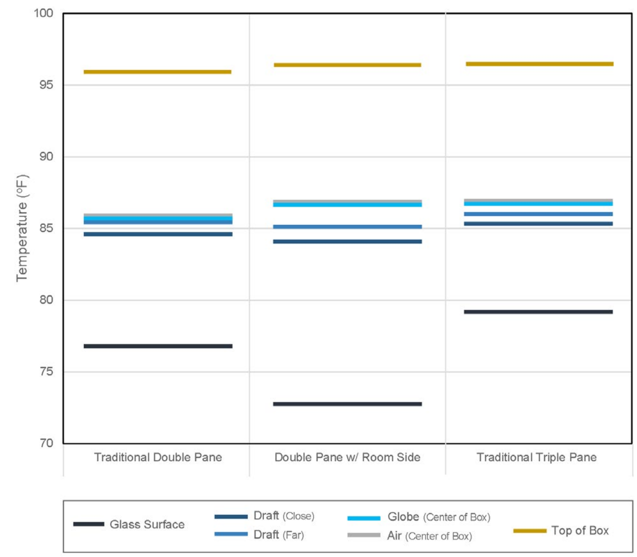


Results show a minimal difference in average box temperature between the triple pane and the double pane with room side low-e while the double pane without a room side coating was at a significantly lower temperature. This verified the hypothesis that that the use of the room side coating effectively increased the window insulation and, accordingly, the use of room side coatings should contribute to heating energy savings when applied on buildings. Furthermore, the interior low-e coating resulted in similar radiant effects on the globe thermometer as the triple pane, indicating that the presumed minimization of radiant heat loss from occupants to windows with the room side coating is also apparent.

However, the surface temperature of the glass with the interior low-e was 6.4oF colder than that of triple pane and 4oF colder than double pane without the interior low-e. Correlating these values with models of downdraft speeds, it is estimated that the downdraft produced by the double pane with interior low-e coating is 0.06 m/s faster than for triple pane without room side low-e, given typical window heights of 10'. This speed difference will be much greater for taller windows that allow greater distances for downdrafts to build momentum. Plugging this draft difference into recent ankle draft discomfort models from the ASHRAE-55 thermal comfort standard shows that this difference can contribute significantly towards not meeting the comfort standard. Specifically, a draft increase of 0.06 m/s increases ankle draft PPD by ~6% for a 10' window and, as noted previously, this difference will be larger for taller windows.

The results of this experiment have imbued us with a particularly nuanced perspective on room side coatings as they have entered the market. Notably, seeing the impact of room side low-e coatings on the average interior temperature of our test boxes has given us confidence that it is a suitable means of increasing window insulation and saving on heating energy. However, for many of our projects, the glazing U-value targets are not driven by energy-saving goals but rather by a desire to remove perimeter heating systems while maintaining occupant thermal comfort in winter.

TEMPERATURE PROFILES OF GLAZING UNITS



This is particularly so since our research into the [impact of glazing on winter comfort] has revealed that an upgrade from double to triple pane in Boston's climate is usually enough to keep occupants thermally comfortable without the need for perimeter heating.

This discovery revolutionized our attitude towards triple pane when it was combined with a realization that the up-front cost premium of upgrading to triple pane is usually 1/10th to 1/4th the up-front cost of the perimeter heating system, with all of its piping, boilers, and heating elements.

The findings of our test box experiment have been particularly enlightening with regards to this design situation. We can now say confidently that, for situations where our glazing U-value targets are not set by goals of removing perimeter heat (like in warm climates where perimeter heat is not at all necessary), using room side low-e coatings is highly recommended since it saves energy with minimal impact on up-front cost. However, in colder climates like Boston's, it is clear that the cold window surface temperatures and draft speeds we have measured off of room side low-e assemblies will almost always necessitate the application of perimeter heat. Accordingly, for cooler climates like Boston's, we are likely to benefit most by using triple pane assemblies without room side coatings since they can usually establish thermally comfortable conditions that enable the removal of expensive perimeter heating systems.

This discovery has had a noticeable impact on our design practice. These research findings have changed the way we design buildings. While the use of triple pane on Payette our projects has historically been ~3 projects per year, this number has more than tripled in the last couple of years, largely thanks to the findings of this study in conjunction with the previously mentioned "Glazing and Winter Comfort" research. Today, virtually all of our new construction in cold climates is using triple pane in order to forego the use of perimeter heating systems.

One could easily imagine an alternative present where thermal comfort conditions around room side low-e coatings were never questioned and the change we see in the chart above could have been towards double pane room side units instead of triple pane. For this reason, physical experiments like that which we present here remain a critical component of the informed feedback between design and building science at our practice.

HISTORY OF TRIPLE PANE AT PAYETTE