The Truth about Thermal Comfort

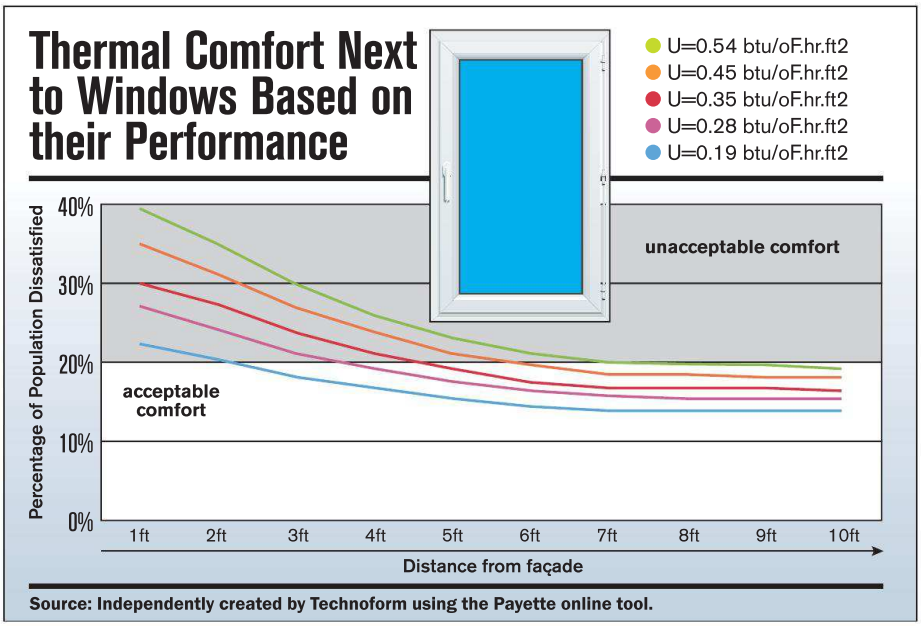
Why Windows Matter to Ensure Occupant Well-Being

by Mark Silverberg and Helen Sanders

According to the annual surveys conducted by the International Facilities Management Association (IFMA), the top two complaints of occupants in office buildings are always "it's too hot" or "it's too cold"[1]. Thermal discomfort can also have a significant impact on productivity—a fact that anyone who has tried to type with cold hands, or think clearly when too hot, knows all too well. Quantitatively, studies show that there is about a 1 percent drop in productivity for every 1°F deviation from the optimum temperature of 71-72°F (either higher or lower)[2]. Interestingly, when occupants are thermally uncomfortable, their dissatisfaction with other aspects of indoor environmental quality also increases[3].

Poor-performing fenestration can be a significant source of thermal discomfort, which can provide additional justification for those trying to reduce window area. If we can encourage the use of higher-performing fenestration that delivers both higher energy performance and thermal comfort, designers can use more glazed area without taking a thermal comfort penalty.

Also, while we know that it's hard to achieve a short-term monetary payback on energy savings for window retrofits, achieving a payback through improving occupant productivity by enhancing thermal comfort is more feasible. Since the cost of human capital in commercial buildings is nearly 100 times more than the cost of energy, a 1 percent improvement in productivity can be much more significant than, say, a 5 percent decrease in energy performance. By making the perimeter space adjacent to the façade more comfortable to occupy, usable space can be increased.



This graph shows the thermal discomfort of occupants due to downdrafts as a function of distance from a façade with four different window thermal performances when the exterior temperature is 0°F.

Assessing Thermal Comfort

Controlling and assessing thermal comfort isn't easy. Unfortunately, it's not just a matter of turning the thermostat to 71°F. Many other factors, including air speed, humidity, level of activity, clothing weight and the temperature of the surrounding surfaces (radiant temperature), contribute to thermal comfort. ASHRAE Standard 55 "Thermal Environment Conditions for Human Occupancy" specifies conditions for acceptable thermal environments in buildings and considers all these factors.

To add even more complexity, thermal comfort is so subjective that a satisfactory environment is judged by the percentage of the population that would be predicted to be uncomfortable. "Acceptable" comfort is said to be achieved when 80 percent of the population is comfortable. There's truth to the saying you can't please everyone all the time!

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1. Temperature wars: Savings vs Comfort, IFMA, 2009. http://www.ifma.org/docs/default-source/surveys/hvacsurvey2009.pdf?sfvrsn=2)
2. Seppanen et. al., Effect of Temperature on Task Performance in Office Environment, LBNL Report 60946, 2006. https://eetd.lbl.gov/sites/all/files/publications/lbnl-60946.pdf
3. Jamrozik et. al., A novel methodology to realistically monitor office occupant reactions and environmental conditions using a living lab, Building and Environment, Volume 130, 2008. https://www.sciencedirect.com/science/article/pii/S0360132317305929
4. https://www.payette.com/building-science/glazing-and-winter-comfort-tool/

The Impact of Windows

Windows can contribute significantly to thermal comfort in a building, especially for those who sit immediately adjacent to them. In addition to considering the discomfort due to differences in radiant temperature caused by adjacent cold or hot window surfaces, considerations related to the impact of solar heat gain through windows have been added to ASHRAE Standard 55 recently.

One key factor that's not yet included is the impact on comfort of convective currents set up near cold windows: The cold window surfaces cool adjacent air. This cooled air then falls downward and is replaced by warmer air, which is also then cooled by the window and falls, and so on. These currents (downdrafts) manifest themselves to occupants as cold drafts and are often mistaken for air infiltration.

Using high-performance windows can make a dramatic difference to thermal comfort. An online calculator has been developed by architectural firm Payette to assess the thermal comfort, including the downdraft phenomenon, specifically next to glazing[4]. The graph shows the thermal discomfort of occupants due to downdrafts as a function of distance from a façade with four different window thermal performances when the exterior temperature is 0°F. The model assumes the occupants are centered on windows that are 11 feet wide, have a sill height of 2.5 feet and are 7 feet tall. Using the limit of "20-percent dissatisfied" as the standard for comfort, occupants would have to move more than 7 feet away from the poorest-performing window to be comfortable, yet for the highest-performing window, occupants could be comfortable at only 2 feet away. That's 5 feet more of usable space around the perimeter of the building. That's huge!

Owners and occupants desire large expanses of windows for views and daylight. By promoting high-performance windows, these positive benefits can be delivered without compromising thermal comfort and productivity, while increasing space utilization. ■

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