General Services Administration
Public Buildings Service

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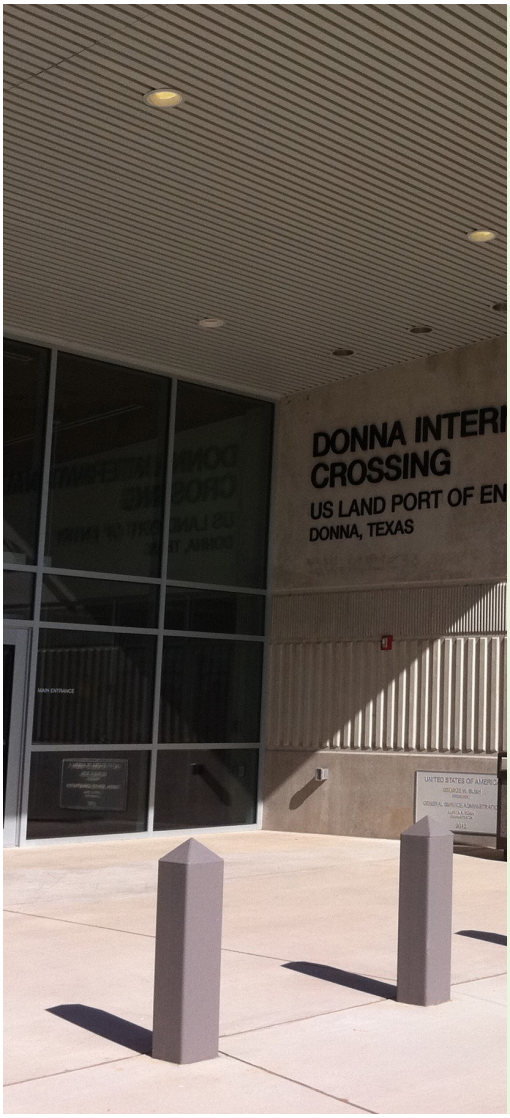
EC WINDOWS FOR LAND PORTS OF ENTRY



Electrochromic Windows Reduce Glare While Preserving Line of Sight

At Land Ports of Entry (LPOE), military installations and other facilities where occupants monitor outdoor activities, visibility through windows is critical. Most facilities use surveillance cameras to monitor their surroundings, but officers stress the unique importance of direct "line of sight," an uninterrupted visual path between the observer and the observed. In sunny conditions, direct visual contact can be severely compromised by window glare. But conventional solutions to control glare, like tinted films and window coverings, can obstruct views and inhibit visual security. Electrochromic (EC) windows preserve line of sight and beneficial daylight while controlling glare. With this technology, windows tint from clear to dark and back again, either automatically or in response to a manual override. To assess EC's glare-modulating performance, GSA's GPG program commissioned Lawrence Berkeley National Laboratory (LBNL) to conduct a pilot study at the Donna LPOE at the Texas border with Mexico. Researchers found a significant reduction in glare with EC windows, along with high user satisfaction. EC windows are also known to reduce building energy consumption, which is the focus of other completed and ongoing GPG studies.[1]

The GPG program enables GSA to make sound investment decisions in next generation building technologies based on their real world performance.

INTRODUCTION


A. Command Center Interior


B. Vehicle Booth Exterior

C. Switch

EC Windows at Donna LPOE

EC windows were installed using custom-built operable frames to facilitate cleaning and maintenance.

A. EC installed on the interior of command center windows.

B. EC installed on the exterior of vehicle inspection booth windows.

C. Manual wall switches associated with window control zones override automatic settings. Manual overrides were programmed to last for two hours.

" The benefits offered by this technology are priceless. Great technology, very professional."

—Occupant Survey Response
U.S. Customs and Border Protection,
Donna, TX

PERFORMANCE SPECIFICATIONS

ORIGINAL WINDOWS	
Tvis	.35
EC WINDOWS	
Tvis - Clear	.60
Tvis - Light Tint	.20
Tvis - Medium Tint	.06
Tvis - Full Tint	.01
ORIGINAL + EC	
Tvis - Clear	.21
Tvis - Full Tint	.0035

What Is This Technology?

EC WINDOWS TINT DYNAMICALLY IN RESPONSE TO GLARE AND USER PREFERENCES

In an EC window system, a thin, multilayer electrochemical reactive coating changes window tint in response to small amounts of direct current. A control system manages these changes either automatically, using photosensor readings and values for daily changes in the sun's arc, or manually, in response to wall switches with which occupants can override automatic settings. The controller can also respond to input from a building automation system (BAS), a control option that was not implemented in this study. Manually reset windows revert to automatic control after a specified period—two hours at Donna LPOE. Windows can be grouped in control zones so that they change tint in unison. The number of tints and their gradations, along with other characteristics of the glass, are set during manufacturing. In the Donna LPOE pilot study, the EC panes had four tint levels, with visible transmittance (Tvis) values of approximately 60% (clear), 20% (light tint), 6% (medium tint), and 1% (full tint).

What We Did

ASSESSED GLARE CONTROL AT A HOT, SUNNY BORDER CROSSING

The west-, south-, and east-facing windows in the Donna LPOE processing and command center and vehicle inspection booths provided an excellent test bed for EC's glare-control performance. Working with an EC window manufacturer in 2013-14, GSA retrofitted hinged custom-built frames holding EC glass over the original windows, which themselves were tinted. Custom installation was necessary in order not to void the warranty for existing bullet- and blast-resistant building components. Researchers conducted surveys of station officers before and after the EC installation. They also measured visual comfort using high dynamic range (HDR) imaging and analytical tools that converted time-lapsed luminance data to subjective ratings of glare as perceived by the human eye. They collected results for nighttime visibility as well. Data from the control system was used to monitor tint states and to capture how frequently occupants used the manual switches.

FINDINGS

DRAMATIC GLARE REDUCTION AND SATISFIED USERS Eight months after the installation, more than 90% of survey respondents said the EC windows improved visual comfort and met their need to monitor outdoor activity. Measurements confirmed that the EC windows kept glare below the threshold where it becomes perceptible, a Daylight Glare Probability (DGP) of 0.35 and above. Blinds were no longer needed.

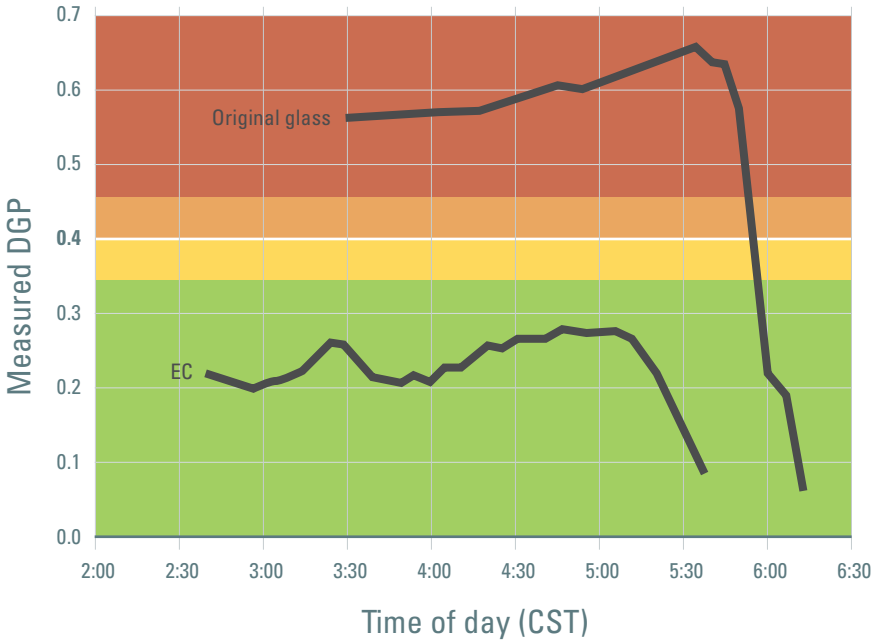
NIGHTTIME VISIBILITY MAY BE REDUCED Window coatings, including EC coatings, increase reflections on the interior surface of windows at night, making it harder to see outside. When the area outside is darker than the rooms inside, window reflections become more pronounced. At Donna LPOE, HDR camera measurements showed that the EC windows did reduce nighttime visibility when compared with the original windows. However, study participants did not report this as an issue. This may be explained by the fact that Donna LPOE officers routinely kept the indoor lights off at night, while the outdoor environment was brightly lit.

EC TECHNOLOGY STILL EXPENSIVE The cost of EC windows that are not bullet- and blast-resistant is estimated to be $45/ft^2. New bullet- and blast-resistant EC windows are likely to be more expensive, and custom-built operable frames holding EC windows, such as those used at Donna LPOE, are more expensive still. Only two companies currently manufacture EC windows in the U.S., and as the market matures, prices are expected to decline.

DEPLOY WHERE WINDOW GLARE IS INCOMPATIBLE WITH OUTDOOR VISIBILITY EC windows are suitable for Land Ports of Entry and other facilities where window glare compromises mission-critical outdoor visibility.*

Daylight Glare Probability in Vehicle Inspection Booths Facing West

Booth with EC windows has much lower glare throughout a sunny afternoon



DGP	Qualitative Interpretation
> 0.45	Intolerable glare
0.40 to 0.45	Disturbing glare
0.35 to 0.40	Perceptible glare
< 0.35	Imperceptible glare

DGP is a metric for visual comfort, with values from 0 to 1, representing the probability that a person would experience disturbing glare in a particular situation.

CONCLUSIONS

These Findings are based on the report, "Electrochromic Window Demonstration at the Donna Land Port of Entry," which is available from the GPG program website, www.gsa.gov/gpg

For more information, contact GSA's GPG program gpg@gsa.gov

What We Concluded

ELECTROCHROMIC WINDOWS RELIABLY CONTROLLED DAYTIME GLARE AND WERE WELL RECEIVED BY OCCUPANTS

One-hundred percent of survey respondents said they would choose EC windows over conventional windows. Based on LBNL's findings, EC windows should be considered for Land Ports of Entry and other facilities where it is important to maintain unobstructed visual contact with exterior surroundings under glary, sunny conditions. When extrapolating from this study, it is important to note that results may vary if a bullet- and blast-resistant EC insulated glass unit (IGU) replaces the original glass. In such cases, the window will have a higher visible transmittance than the window assembly at Donna LPOE and glare control may be less effective. Results may also vary for structures that do not have deep overhangs like those at Donna LPOE. Care should be taken when applying these results to facilities with stringent nighttime visibility requirements and inadequate exterior illumination. Like other window coatings, EC windows can increase interior-facing reflectance and thereby reduce nighttime visibility.

Barriers to Adoption

EC Window Retrofitting Requires Careful Planning For Land Ports of Entry and other secure facilities, maintaining bullet-, blast-, and wind-load resistance in building components is critical. For this reason, the use of EC windows needs to be carefully considered, as any change in structure or materials risks voiding manufacturer warranties. Retrofitting EC windows on top of existing bullet- and blast-resistant windows also needs to be carefully planned. Dirt, heat, and/or moisture can accumulate between the EC windows and the original IGUs, compromising performance. At Donna LPOE, EC IGUs were installed in operable window frames to guard against such problems.

Prohibitively Expensive for Some Applications At a minimum of $45/ft^2$ for EC windows and more for EC glass that is bullet- and blast-resistant, this technology might be too expensive for some applications. Alternatives provide some glare control at a lower cost but have notable operational limitations. For instance, permanently applied screens or tinted films cannot be adjusted to a wide variety of glare and light levels. Operable screens or tinted films could overcome some of these problems but would require frequent adjustments by occupants who wish to maintain optimal viewing conditions. An automated film/shade solution would have the potential to perform as well as ECs in controlling glare and would cost considerably less, approximately $5/ft^2$,[2] but the movement of automated film/shades could prove distracting.

Reference to any specific commercial product, process or service does not constitute or imply its endorsement, recommendation or favoring by the United States Government or any agency thereof.

Footnotes

[1]A Pilot Demonstration of Electrochromic and Thermochromic Windows in the Denver Federal Center, Building 41, Denver, Colorado. Eleanor S. Lee (LBNL), March 2014, p.51 (http://www.gsa.gov/portal/content/193339)

[2]Lee, Eleanor S., Luis L. Fernandes, Brian Coffey, Andrew McNeil, Robert D. Clear, Thomas L. Webster, Fred S. Bauman, Darryl J. Dickerhoff, David Heinzerling, and Tyler Hoyt. 2013. A Post-Occupancy Monitored Evaluation of the Dimmable Lighting, Automated Shading, and Underfloor Air Distribution System in The New York Times Building. Berkeley, CA: Lawrence Berkeley National Laboratory.

*Subject to evaluation and approval by GSA-IT and Security.

Technology for test-bed measurement and verification provided by SageGlass.