General Services Administration
Public Buildings Service

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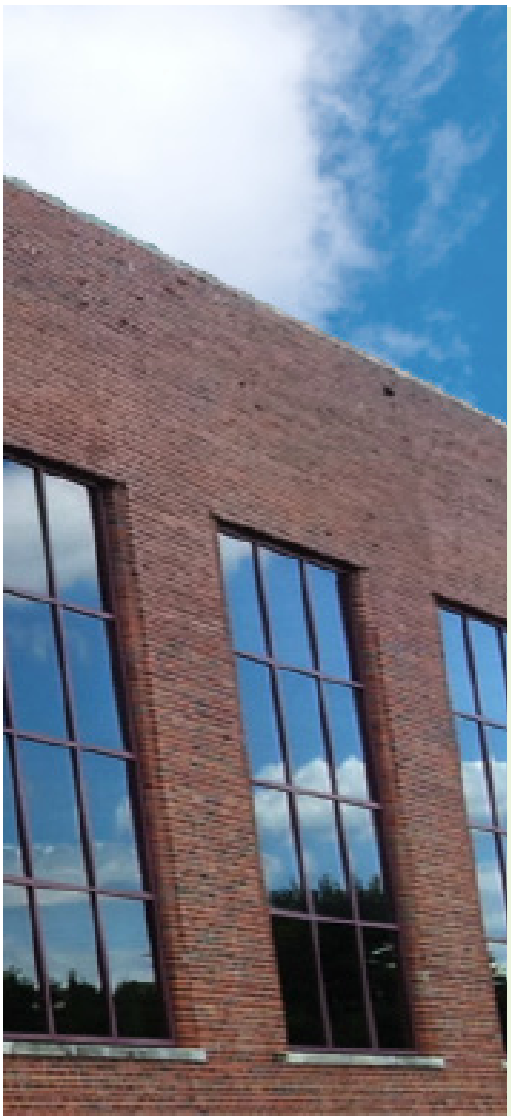
SOLAR-CONTROL FILMS

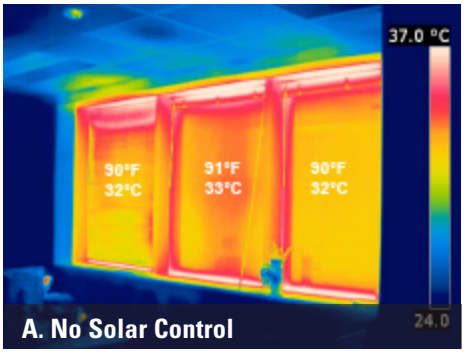


Applied Solar-Control Films Recommended for Single-Pane Clear Windows

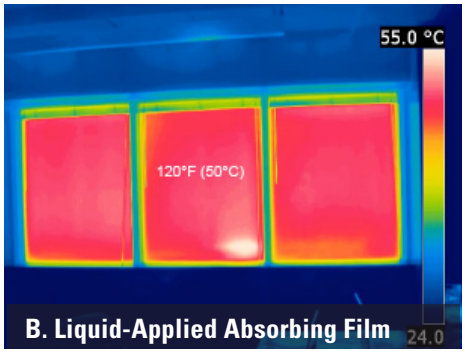
Heat gain through windows accounts for 28 percent of cooling energy demand in US commercial buildings.[1] Applied solar-control films can reduce a portion of that demand by reflecting or absorbing solar energy before it reaches interior spaces. In 2012, GSA's GPG program commissioned Lawrence Berkeley National Laboratories (LBNL) to assess the performance of a liquid-applied, spectrally-selective absorbing film installed at the Goodfellow Federal Center in St. Louis, Missouri. Spectrally-selective films treat solar energy in the infrared spectrum only and have very little impact on the visible appearance of glass. When applied to the interior of the double-pane windows in St. Louis, the liquid-applied absorbing film saved 8 percent of cooling energy, though this savings was offset by an increase in heating energy use during winter months. Given the geographical diversity of the GSA real estate portfolio, LBNL expanded their assessment by modeling the energy performance of both absorbing and reflective spectrally-selective films in a range of warmer climates, where winters are milder than those in St. Louis. Reflective films outperformed absorbing films, reducing HVAC energy use by 29 percent when modeled using single-pane clear windows in warmer climates. Still, absorbing treatments maintain a unique utility for historic buildings, where exterior wood trim might be compromised by the reflection of infrared solar radiation.

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

INTRODUCTION



A. No Solar Control



B. Liquid-Applied Absorbing Film

Absorbing Film Traps Heat In Glass, Reducing Transmission

A. Double-pane bronze windows with no solar-control film register an interior glass temperature of 91°F when the exterior temperature is 84°F.

B. Under same conditions, double-pane bronze windows with the liquid-applied absorbing film register an interior glass temperature of 120°F.

"This is a glazing-dependent technology. When applied to single-pane windows, solar-control films, particularly the reflective variety, really do save energy."

—Charlie Curcija
Principal Investigator
Lawrence Berkeley National Laboratory

PERFORMANCE SPECIFICATIONS
Center of Glass

SINGLE-PANE CLEAR	
SHGC Base Window	**.82**
+ Absorbing*	**.54**
+ Reflective*	**.45**
Tvis Base Window	**.88**
+ Absorbing*	**.64**
+ Reflective*	**.67**
DOUBLE-PANE BRONZE	
SHGC Base Window	**.50**
+ Absorbing*	**.44**
+ Reflective*	**.36**
Tvis Base Window	**.47**
+ Absorbing*	**.34**
+ Reflective*	**.37**

*Spectrally-Selective

What Is This Technology?

SOLAR-CONTROL WINDOW RETROFIT TECHNOLOGY REDUCES SOLAR HEAT GAIN

Solar-control films reduce the transmission of solar heat energy by increasing the absorbing or reflecting properties of window glass. Spectrally-selective controls treat solar energy in the infrared spectrum only, so the finished appearance is essentially clear, unlike the mirrored or tinted appearance of non-selective films. The St. Louis study evaluated an absorbing, spectrally-selective film that is unique primarily because it is applied as a liquid; it cures in 30 minutes into an 8-micron-deep durable window film. Nanoparticles suspended in the film reduce solar heat gain (SHG) without noticeably diminishing the transmission of visible light (Tvis). The tested retrofit absorbing film is intended for installation on the inside of an existing window and guaranteed for a lifespan of 15 years. Other commercially available applied films have lifespans of between 6 and 15 years.

What We Did

COMPARED MEASURED PERFORMANCE AGAINST MODELED BASELINES ACROSS CLIMATES

The liquid-applied absorbing film was installed on 25 double-pane bronze windows in five different zones in the three-story, 135,500 ft^2 Goodfellow Federal Center in St. Louis, Missouri. Though the mixed climate in St. Louis was not ideal for maximizing cooling energy savings, it did allow LBNL researchers to test the ability of the film to achieve both heating and cooling savings. Over a period of eight months, researchers monitored the energy performance of treated and untreated windows in comparable control zones. Researchers also modeled annual energy consumption for a generic commercial-building perimeter zone, using a range of climates, base window configurations, and applied solar-control products, both absorbing and reflective.

FINDINGS

REFLECTIVE SOLAR-CONTROL FILMS OUTPERFORM ABSORBING In modeling, the liquid-applied absorbing film demonstrated greater efficiencies than other absorbing films. However, spectrally-selective reflective films outperformed all modeled configurations and climates, generating up to 29 percent HVAC energy savings in warmer climates with hot summers and mild winters.

REFLECTIVE FILM CURRENTLY MORE COST-EFFECTIVE THAN LIQUID-APPLIED ABSORBING FILM At the current pricing of $10/ft^2 for both the liquid-applied absorbing film and the spectrally-selective reflective film, the reflective film is more cost-effective. Payback may be more comparable in the future, with cost reductions of between 20 and 25 percent projected by the manufacturer of the liquid-applied film.

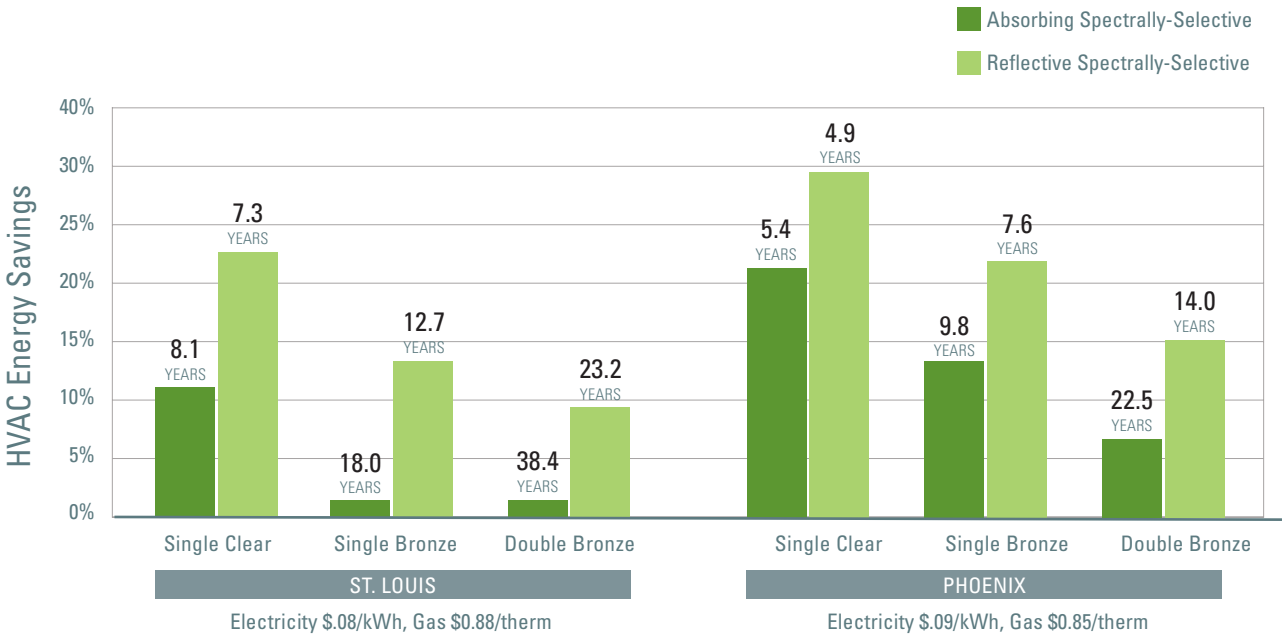
EASY INSTALLATION, NO MAINTENANCE Like other solar-control retrofits, the liquid-applied absorbing solar film can be applied quickly, with minimal disruption to building occupants and productivity.

ABSORBING FILM INCREASES GLASS SURFACE TEMPERATURE Because of the highly absorbing nature of the film and the insulating properties of dual glazing, room-side surface temperatures of double-pane glass were found to be high, up to 140° F, which could negatively impact comfort in offices where occupants sit close to windows. In St. Louis, occupants noticed no difference in the look of the liquid-applied absorbing film when compared with the original bronze windows and reported no significant changes in thermal comfort or glare, though researchers observed that interior blinds were frequently closed.

USE WITH SINGLE-PANE CLEAR GLASS IN CLIMATES WITH HOT SUMMERS AND MILD WINTERS Target buildings with large window areas relative to floor, exposure to direct sun without exterior shading, and south, east or west orientations. Consider warranty, durability, aesthetics, and impacts of reflected radiation when selecting a film.

Modeled Energy Savings For Range of Base Windows and Climates

Payback for liquid-applied absorbing @ $8/ft^2 (80% of current cost) and reflective @ $10/ft^2



CONCLUSIONS

These Findings are based on the report, "Liquid-Applied Absorbing Window Film Retrofit ," 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

SOLAR-CONTROL RETROFIT IS A GOOD STRATEGY FOR SINGLE-PANE CLEAR WINDOWS

The promise of both heating and cooling energy savings was not realized with the liquid-applied absorbing film. Still, solar-control retrofit films can provide significant cooling savings. They are particularly effective in buildings with single-pane clear windows in warm climates with mild winters. Solar-control retrofit films were not found to be cost-effective for double-pane bronze windows in most climates. Modeling results, which are useful for comparing trends across different climates and building configurations, show that spectrally-selective reflective films outperform all other solar-control strategies. That said, absorbing treatments maintain a unique utility for historic buildings where reflected solar radiation might damage exterior wood trim.

Lessons Learned

Consider climate Limiting solar gain through windows, while it saves cooling energy during hot seasons, can increase heating consumption in winter by decreasing the amount of solar heat transferred to interior spaces. For this reason, a retrofit's site- and climate-specific annual energy performance must be considered. Building managers should use a climate specific, whole-building energy model to assess solar controls' annual energy impacts on heating, cooling, and daylighting.

Physical principals drive better reflective performance The most effective coatings and films reflect solar energy back to the exterior environment. If the film absorbs energy, some of the absorbed energy may ultimately reach the occupied space and result in a reduction of cooling energy savings. This is more likely to occur when absorbing film is applied on the interior face of a double-pane window.

Absorbing layer on interior surface of double-pane windows limits performance When absorbing solar-control treatments are installed on the interior face of a double-pane window, the double-pane insulating properties limit the dissipation of heat to the exterior environment, transmitting absorbed heat energy into the building instead. When installed on the exterior face of a double-pane window, however, researchers found that absorbing film can outperform reflective film by a slight margin. Though currently there are no liquid-applied absorbing products made for exterior application, there are exterior plastic substrate films on the market.

Footnotes

[1]Apte, J., Arasteh, D. (2006), Window-Related Energy Consumption in the US Residential and Commercial Building Stock. Berkeley, CA: Lawrence Berkeley National Laboratory report, LBNL-60146 http://gaia.lbl.gov/btech/papers/60146.pdf

Technology for test-bed measurement and verification provided by eTime Energy.