General Services Administration
Public Buildings Service

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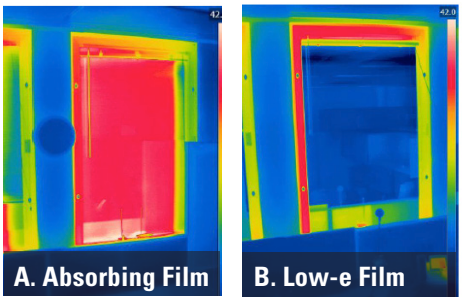
LOW-EMISSIVITY WINDOW FILM

Low-E Film Amplifies Efficiency by Combining Solar Control & Thermal Insulation

Conventional applied solar control window film reduces solar heat gain and decreases the use of cooling energy, but in cold weather it fails to take full advantage of the sun's warmth, offsetting summer energy savings with increased winter energy use. A new kind of applied window film combines the solar control functions of standard film with the insulating power of a low-emissivity (low-e) coating, which, until now, has been available only as part of a factory-produced unit. Adding insulation, which improves efficiency in all seasons, compensates for diminished solar heat gain in the colder months. Researchers from Lawrence Berkeley National Laboratory (LBNL) assessed the new film at two GSA locations: the Hansen Federal Building in Ogden, Utah, and the Cabell Federal Building in Dallas, Texas. A total of seven climates and four base windows were also studied in computer simulations. Compared to clear, single-pane glass windows, a version of the film with a visual transmittance of 35% averaged 29% HVAC savings in perimeter building zones. Savings were found across climate zones, including cold and moderate ones. When the film is applied to clear, single-pane glass, payback between two and six years is projected. At the test-bed sites, most occupants reported improved thermal comfort and reduced glare near windows.

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

INTRODUCTION



Low-e Film Reflects Room Temperatures

A. High room-side glass surface temperatures (104°F; 40°C) were recorded on the windows with conventional absorbing films under direct sunlight.

B. While the temperature of the glass with low-e film is as high or higher than the temperature of the glass with absorbing film, in summer the low-e film surface has a much cooler apparent radiant temperature because it is absorbing the heat and not reradiating it back into the room. In the winter, the apparent radiant temperature of the glass with low-e film will be higher than glass with standard films because the low-e film reflects the heat back into the room.

" Unlike replacing single-pane windows with double glazing, installation of the low-e film is not disruptive, and it can be done in stages and during off-hours. We are planning to retrofit the other floors of our building."

—Aaron Rock
Building Manager
Hansen Federal Building
Ogden, UT
Rocky Mountain Region
General Services Administration

What Is This Technology?

LOW-E FILM CONTROLS LIGHT AND THERMAL TRANSMISSION

Low-e film reflects considerably more thermal radiation than traditional applied solar control films and is therefore a better insulator. With its low-emittance surface facing the room, low-e film also helps lower solar heat gain during the cooling season, as a greater fraction of the energy absorbed by the window is prevented from entering the building. The low-e film is made by depositing thin metallic and proprietary coatings on a flexible adhesive film substrate. The hybrid product absorbs and reflects both visible and short-wave infrared portions of sunlight and reflects long-wave infrared radiation, thus reducing both types of heat transmission. Typical low-e processes do not produce a coating that is durable enough for room-side glazing or the transport and installation requirements of an applied film. This new low-e film manufacturing process has solved these challenges, expanding the use of low-e surfaces beyond the much more expensive factory-sealed double pane window. The film is applied to the interior surface of existing windows and is available in three visual transmission (VT) grades, allowing for a range of solar control and appearance options: VT35 allows only 35% of sunlight in the visual part of the spectrum through, whereas VT50 and VT70 transmit 50% and 70% respectively.

PERFORMANCE SPECIFICATIONS
Center of Glass

Typical Applied Absorbing Film	
SHGC	**0.659**
Tvis	**0.517**
Room-side emittance	**0.840**
VT35	
SHGC	**0.261**
Tvis	**0.335**
Room-side emittance	**0.048**
VT50	
SHGC	**0.368**
Tvis	**0.489**
Room-side emittance	**0.075**

What We Did

COMPARED LOW-E TO CLEAR SINGLE-PANE GLASS AND TRADITIONAL SOLAR CONTROL FILM

VT35 low-e film was installed at two GSA sites—the Hansen Federal Building in Ogden, Utah, and the Cabell Federal Building in Dallas, Texas. During measurement and verification (M&V) at both sites, LBNL researchers compared the performance of single-pane windows covered with the low-e film to both clear single-pane windows and single-pane windows equipped with traditional solar control film. Temperature and solar radiation data were recorded for six months at the Ogden site and for one year at the Dallas site. With the data sets collected, researchers used COMFEN software to model annual energy savings for buildings in Chicago, Washington DC, Miami, Minneapolis, and Phoenix. Comfort and satisfaction surveys were issued before and after installation of the low-e film.

M&V FINDINGS

29% AVERAGE PERIMETER ENERGY SAVINGS Across the seven climate zones modeled, VT 35 low-e film averaged 29% annual HVAC savings in a 15-foot-deep perimeter zone, when compared to single-pane clear-glass windows. Whole building HVAC savings is estimated to be at least 1/3 of the perimeter savings.

SHORTER PAYBACK THAN OTHER SOLAR CONTROL FILMS Payback of between 2 and 6 years is projected, assuming the film is applied to clear, single-pane glass, and installation costs $7.75 ft^2 ($4.25/ft^2 film; $3.50/ft^2 labor). Removing existing solar control film will add $1.50-$2.00/ft^2 to labor costs.

INSTALLATION IMPACT ON BUILDING OCCUPANTS IS MINIMAL Film is installed on the room side of existing windows and can be accomplished in stages and after hours.

IMPROVED THERMAL COMFORT AND GLARE REDUCTION Most occupants surveyed recommended adoption of the low-e film. Respondents noted reductions of glare and of window-related temperature fluctuations. Occupant satisfaction was at times influenced by the before-retrofit conditions. Some occupants who were accustomed to clear glass objected to the color of the film and to the perceived loss of natural daylight associated with its installation.

WIDESPREAD GSA DEPLOYMENT POTENTIAL Low-e film's thermal insulating properties make it less sensitive to summer/winter solar heat gain trade offs and therefore appropriate for deployment in a wider range of climates than other solar control films. The biggest efficiency gain, largest improvement in comfort, and fastest payback will be in buildings with either single glazing or existing applied film that is low performing or nearing the end of its (~15 year) service life.

Modeled Perimeter Energy Savings for Range of Climates

Whole building energy savings is estimated to be at least 1/3 of perimeter savings

Location		Single Clear Glazing to VT35 Film			Single Bronze Glazing to VT35 Film		
CLIMATE ZONE	CITY	HEATING kBtu/ft2/yr	COOLING kBtu/ft2/yr	TOTAL %	HEATING kBtu/ft2/yr	COOLING kBtu/ft2/yr	TOTAL %
1A	Miami, FL	0.01	12.16	33%	0.03	8.08	25%
2A	Dallas, TX	0.47	10.94	33%	1.52	7.12	26%
2B	Phoenix, AZ	0.20	15.24	38%	0.45	10.40	30%
4A	Washington, D.C.	0.51	6.40	26%	3.24	3.74	23%
5A	Chicago, IL	1.97	5.66	24%	5.79	3.23	22%
5B	Ogden, UT	1.45	7.13	30%	4.97	4.12	27%
6A	Minneapolis, MN	2.97	5.45	22%	7.51	3.06	21%
AVERAGE PERIMETER SAVINGS		**1.08**	**9.00**	**29%**	**3.36**	**5.68**	**25%**

CONCLUSIONS

These Findings are based on the report, "Low-e Applied Film Window Retrofit for Insulation and Solar Control," which is available from the GPG program website, www.gsa.gov/gpg

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

Technology for test-bed measurement and verification provided by Eastman Chemical Company.

What We Concluded

RECOMMENDED ACROSS ALL CLIMATE ZONES

The low-e film consistently achieved the best incremental performance of any of the applied films considered and is recommended for deployment in a wide range of climates and window configurations. It nearly doubled the thermal insulation performance of a single-pane window, approximating the performance of double-glazing. Also, in addition to being an excellent retrofit for single-pane windows, low-e window film can boost the performance of lower-performing double glazings, which do not already have low-e coating between the panes.

Installation and Operations Guidelines

Site Analysis Before deploying low-e film, conduct a site-specific examination. In some cases, where daylight harvesting is as valuable as solar heat gain control, VT50 low-e film may be more appropriate than VT35. Note also that the energy savings measured in this study apply only to a 15-foot perimeter zone. The percentage of a building's total area that falls in the perimeter will vary depending on its shape and size. Whole building HVAC savings is estimated to be at least 1/3 of the perimeter savings. Buildings with high perimeter-to-interior ratios will see greater energy savings.

Test Application If appearance is a concern, consider different visible transmissions and conduct a trial application.

Installation Installation is comparable to other applied films and requires certified installers to preserve the warranty. Low-e film can be applied to both fixed and operable windows and will not interfere with the operation of window shades or blinds.

Cleaning Care To avoid scratching, film should be cleaned with diluted dish detergent and soft cloth only. Film should not be cleaned with squeegees or ammonia-based products. Do not attach suction cups or additional adhesives to window film.

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.