U.S. Department of Energy

A Comparison of Products for Reducing Heat Loss through Windows

INTRODUCTION

Windows are visually prominent and functionally important elements of buildings. They provide light and view; alter heating, cooling, and ventilation requirements; and affect the thermal comfort, visual comfort, safety, and general well-being of building occupants.

The heat loss from windows under the worst climatic conditions (a cold winter's night) has often caused windows to be considered villains in a building's energy performance. Architects and engineers generally understand, however, that by supplying solar heat in winter and natural lighting year round, windows may actually reduce overall energy consumption in a building.

In order to minimize the energy costs associated with windows, it is generally desirable to minimize winter thermal losses. In recent years there has been a major shift in patterns of prime window sales, with double glazed units now accounting for more than 60% of annual sales nationwide, and triple glazing capturing more than 20% of the market in the northernmost states. In addition to multiple glazing and storm windows there is a wide variety of window insulating options available to a building designer for new construction and to an owner and/or occupant for existing buildings. The use of conventional drapes, shades, and blinds to reduce heat loss is well known.

The array of available insulating options has been enlarged by the appearance of numerous new window insulating products. Some of these are static (fixed) devices; others are designed to be deployed over the window on a daily or seasonal basis. Many of the new products are variations of traditional roller shades, shutters, or storm windows. Two new classes of products have appeared: roll-up insulating shutters (which have been used extensively in Europe and now are being marketed in the U.S.) and low-emissivity plastic films (which reduce the heat loss rate by reducing radiative heat transfer) that are now marketed by several solar control film manufacturers. Intended for solar control, they have low shading coefficients and thus reflect a substantial fraction of the incident solar radiation. However, they break ground for more transparent low-emissivity coatings ("heat mirrors") that should be available in the next 1-3 years.

Window insulating devices have certain common characteristics and a common set of *potential* flaws. An insulating layer (air gap, rigid board, flexible batt, multilayer films, granular materials, etc.) reduces heat loss associated with conductive, convective, and radiative flows and with mass transfer. The insulating layer may be located in three positions relative to the existing glazing: internally, externally, or between glass. Many of the simpler devices, such as interior and exterior storm windows, can be installed permanently (or changed seasonally). Other types of insulating devices require active window management on a daily basis. When not in use, the insulating material slides, rolls, collapses, folds, or is otherwise removed from the window. Control and deployment of the devices may be initiated by automatic or manual means.

In addition to providing winter insulation, these devices may provide sun control, reduce infiltration, and fulfill requirements for privacy, security, thermal comfort, and aesthetics. This section focuses on approaches for reducing undesired winter heat losses.

Several important issues concerning potential performance flaws arise in any discussion of window insulating products. These are briefly identified below and should be considered when evaluating the products listed at the end of this section.

Condensation: Insulating devices placed on the interior of an existing prime window will reduce glass temperatures and increase the likelihood of condensation. The magnitude of this effect will depend in part on the degree of air leakage around the insulating device and the prime window. Severe condensation problems may be evidence of excess humidity in the building.

Infiltration/Air Leakage: Infiltration through poorly fitting windows is a major energy loss factor in many buildings. Tight-fitting window thermal barriers will substantially reduce this loss. Significant air leakage around the edge of the insulating device may negate its nominal insulating value. Since many of these devices have extensive moving surfaces, seals and air leakage at the edges will be critical design problems.

Overheating: Many insulating devices may be left in place or used year round. If the device seals effectively to the window, overheating may occur when the sun strikes the window while the device is in place. This is particularly true if the device is opaque or semi transparent. Unless provision is made to vent the accumulated heat, the insulating device, window, and all adjacent components must be designed to withstand the resultant high temperatures without failure or degradation.

Fire Safety: Many window insulating devices incorporate substantial quantities of plastic foams, plastic films, and synthetic fibers. If used improperly, these may constitute a smoke and fire hazard. Material properties, total flammable mass, and extent of coverage are all important factors in assessing fire safety.

Operational Reliability: Although many movable insulating devices can be automated and motorized, cost constraints make it unlikely that single windows will be automated in a cost-effective manner. Thus, if potential savings are to be fully realized, movable insulating devices must be closed and opened conscientiously. The degree of user responsibility is critical because a fixed permanent solution with low thermal resistance will perform better than a device with higher thermal resistance which is deployed only occasionally. One solution is to couple the deployment of the thermal insulating device with an action that will be routinely taken to achieve thermal comfort or privacy. For example, if the roll-up shade that is pulled to provide privacy has good insulating qualities, the thermal benefits will accrue on a regular basis. Effective energy conservation will be promoted and accelerated by coupling new thermal control functions to existing habits and lifestyles wherever possible.

Thermal Comfort: Like any other window with good insulating properties, if air leakage is reduced and interior surface temperatures rise, thermal comfort will be increased, particularly in the vicinity of the window. An equivalent level of thermal comfort can be achieved at lower air temperatures when drafts are eliminated and the mean radiant temperature of the room surfaces is raised. Occupant acceptance of lower air temperatures results in additional energy savings.

Durability-Maintainability: The real economic and energy-saving value of any insulating device is directly related to its lifetime and the ease with which it can be maintained in proper working condition during that time. Window insulating products normally operate in a relatively severe environment (temperature cycling, UV exposure, moisture, etc.), which may accelerate degradation of many materials. Operable devices must be carefully designed to facilitate repair when failures occur.

GENERAL

The table on pages 4, 5, 6, and 7 identify insulating products and systems that will be useful in reducing winter heat loss through windows. A wide variety of products is now available, and new products continuously are being developed and marketed; so this listing is, of necessity, incomplete. It should therefore be considered as illustrative of the types of products available and their relative performance attributes. Wherever possible, the manufacturer of the product is identified and should be contacted for further information regarding distributors, availability, pricing, and specific applications.

THERMAL PERFORMANCE DEFINITIONS

Several terms are frequently used to describe the various thermal performance characteristics of windows. These are defined below as commonly used. Metric equivalents are also given.

U Value: the total heat transfer rate across the installed product, given in Btu/hr-ft²-°F, under winter design conditions (T inside = 68°F, T outside = 0°F, still air — inside, 15 mph wind — outside). The separate U values are given for each device applied to both single and double glazing where appropriate.

Heat Flux: the rate of heat flow per unit area. May be used to denote a flux striking a surface or heat flow through a surface.

Device Conductance, C: the heat transfer rate across the insulating device only, given in Btu/hr-ft²-°F. Conductance does not include the effect of air layers or air spaces external to the device itself. A device such as a plastic or glass storm window thus has a very high conductance, offering little resistance to the flow of heat.

Thermal Resistance, R: a measure of the ability of a product or material to resist the flow of heat, given in hr-ft²-°F/Btu. R_{total} = 1/U for the whole window system, or R = 1/C for the device itself.

Shading Coefficient, S.C.: a measure of a product's ability to exclude the heat gain associated with solar radiation. S.C. is a dimensionless number between 0 and 1.0 which gives the fraction of solar gain compared to that admitted by clear single glazing under the same conditions.

Metric Conversions

Heat-Transfer Rate
(U value: Conductance)
1 Btu/hr-ft²-°F = 5.6745 W/m²-°C
1 W/m²-°C = 0.1762 Btu/hr-ft²-°F

Thermal Resistance
1 hr-ft²-°F/Btu = 0.1762 m²-°C/W
1 m²-°C/W = 5.6745 hr-ft²-°F/Btu

Heat Flux
1 Btu/hr-ft² = 3.1526 W/m²
1 W/m² = 0.3172 Btu/hr-ft²

PERFORMANCE DATA

The numerical performance data in the table have been assembled from calculations and test data reported in manufacturers' literature, calculations based upon standard ASHRAE methods (primarily chapter 26, *Handbook of Fundamentals*), and data collected from other sources. Owing to the variety of sources, **these values should be used with caution,** even for comparative analysis. Existing window conditions, installation details, air leakage characteristics, and product variations will add further uncertainty to calculations of installed product performance.

Product characteristics checked off in the matrix are suggestive but not definitive judgments. Footnotes are provided where possible to indicate the source of the data.

a: reduces S.C. of prime window by 0.1-0.15
b: nominal value, ½" air space, uncoated glass, no sash, frame
c: U value
d: based upon reported emissivity of 0.2-0.3
e: single layer deployed
f: assumes air-tight fit to window
g: assumes 1" beadboard
h: device consists of insulation and glazing
i: assumes tight-fitting shade
j: single shade U = 0.85, double shade U = 0.68, double shade, metallized U = 0.60
k: lower range for exterior application
m: all three layers deployed

U.S. Department of Energy

A Comparison Matrix of Window Thermal Barriers

PRODUCT TYPE	DESCRIPTION	TRADE NAME	MANUFACTURER	FUNCTIONS: SUN CONTROL	FUNCTIONS: THERMAL INSULATION	FUNCTIONS: INFILTRATION BARRIER	FUNCTIONS: SECURITY/PRIVACY	MANAGEMENT & CONTROL: STATIC	MANAGEMENT & CONTROL: MOVABLE	MANAGEMENT & CONTROL: MANUAL	MANAGEMENT & CONTROL: AUTOMATIC	APPLICATIONS: WINDOW (VERT)	APPLICATIONS: SKYLIGHT (HORIZ)	APPLICATIONS: PRIME/REPLACEMENT	APPLICATIONS: ADD-ON/RETROFIT	INSTALLATION BY: HOME OWNER	INSTALLATION BY: CONTRACTOR	THERMAL PERFORMANCE Btu/Hr-ft²-°F WINTER VALUE: DEVICE CONDUCTANCE	THERMAL PERFORMANCE Btu/Hr-ft²-°F WINTER VALUE: U VALUE: DEVICE + SINGLE GLASS	THERMAL PERFORMANCE Btu/Hr-ft²-°F WINTER VALUE: U VALUE: DEVICE + DOUBLE GLASS	SHADING COEFFICIENT
INTERIOR SYSTEMS																					
Interior storm window	Acrylic glazing with a plastic frame	Thermatrol® storm window	Perkasie Industries Corp. 50 East Spruce St. Perkasie, PA 18944 (215) 257-6581		•	•			S	•		•			•	•		NA	.50 A	.32 A	a
Interior storm window	Vinyl film in an aluminum frame	Vinyl Therm	Insulated Pane Industries 136 Vesta St. Reno, NV 89502 (702) 323-2477		•	•			S	•		•			•	•		NA	.50 A	.32 A	a
Interior storm window	Glass in an aluminum frame	Kent Air Control Panel	Kent Air Control, Inc. 19 Belmont St. South Easton, MA 02375 (617) 238-1453		•	•			S	•		•			•	•		NA	.50 A	.32 A	a
Interior storm window	Acrylic glazing	Energlaze Systems	Dayton Corp 11 Beacon St Boston, MA 02108 (617) 523-5632		•	•			S	•		•			•	•		NA	.50 A	.32 A	a
Interior storm window	Double layer polyester film with plastic frame	Sol-R-Frame™	Thermotech Corp Box 478 Water St. N. Bennington VT 05257 (802) 442-2780		•	•			S	•		•			•	•		.94 ES	.37 ES	.27 ES	a
Interior storm window	Plastic glazing with plastic frame	In-Sider storm window	Plaskolite, Inc P.O. Box 1497 Columbus, OH 43216 (800) 848-9124		•	•			S	•		•			•	•		NA	.50 A	.32 A	a
Interior storm window	Plastic film with aluminum frame	Flexigard storm window	3M Company Special Enterprises Dept. Bldg. 223-2, 3M Center St. Paul, MN 55101 (612) 733-0306		•	•			S	•		•			•	•		NA	.50 A	.32 A	a
Interior storm window	Single or double 5 mil polycarbonate films on an aluminum frame	Sunwise® Insulating Window	Pemco Corp. 1902 Tigertail Blvd Dania, FL 33004 (305) 945-8855		•	•			S	•		•			•	•		NA	.41 EM	.34 M,h	a
Interior storm window	Double polystyrene sheet in a plastic frame. Available as a kit in four sizes	Durethene® Double Pane Storm Window Kit	ARCO Durethene 7001 West 60th St. Chicago, IL 60638 (312) 586-3300		•	•			S	•		•			•	•		.84 A	.33 A	.24 A	a
Interior storm window	Double-wall plastic glazing in an extruded plastic frame	Insul-Qwik® Winter Window	Oser Industries, Inc. 1918 Dixie Highway P.O. Box 2025 Hollywood, FL 33022 (305) 923-3050		•	•			S	•		•			•	•		1.32 EM	.38 EM	.27 EM	a
Interior storm window	Glass glazing in a PVC frame	E-Z Storm™	E-Z Storm Systems, Inc. 235 W. Colorado Ave. Colorado Springs, CO 80903 (303) 634-2476		•	•			S	•		•			•	•		NA	.50 A	.32 A	a
Interior storm window	4 mil vinyl glazing held in an extruded vinyl frame with a locking channel	Storm Window Kit	W. J. Dennis and Co 1111 Davis Rd Elgin, IL 60120 (312) 697-4800		•	•			S	•		•			•	•		NA	.60 A	.36 A	a
Interior storm window	Mahogany frame with glass glazing. Contains a dessicant strip.	Thermo-Plus Storm Window	Newton Waltham Glass Co 104 Pine St Waltham, MA 02154 (617) 894-5350		•	•			S	•		•			•	•		NA	.50 A	.32 A	a
Insulating window film	Sun control film with low emissivity surface	Various	Various	•	•			•				•	•		•	•	•	NA	.83–.76 EM,d	.44–.42 EM,d	.25–.22 M
Drapery (conventional)	Wide variety of fabrics	Various	Various	•	•		PR		D	•		•			•	•	•	NA	.83 A	.43 A	VAR A
Drapery, quilted	Polyester filled cotton	Window-Blanket™	WindowBlanket Co., Inc Route 1 - Box 83 Lenoir City, TN 37771 (615) 986-2115	•	•		PR		D	•		•			•	•		.50 M	.34 EM	.25 EM	-

A COMPARISON MATRIX OF WINDOW THERMAL BARRIERS

KEY:

D	Daily	NA	Not Applicable	M	Manufacturer's Data
S	Seasonal	VAR	Varies widely depending on specific material and designs	EM	Estimated from manufacturer's data
SEC	Security			ES	Estimated from other sources
PR	Privacy				
-	Not Available	A	Based upon ASHRAE calculation procedures		

PRODUCT TYPE	DESCRIPTION	TRADE NAME	MANUFACTURER	FUNCTIONS: SUN CONTROL	FUNCTIONS: THERMAL INSULATION	FUNCTIONS: INFILTRATION BARRIER	FUNCTIONS: SECURITY/PRIVACY	MANAGEMENT & CONTROL: STATIC	MANAGEMENT & CONTROL: MOVABLE	MANAGEMENT & CONTROL: MANUAL	MANAGEMENT & CONTROL: AUTOMATIC	APPLICATIONS: WINDOW (VERT)	APPLICATIONS: SKYLIGHT (HORIZ)	APPLICATIONS: PRIME/REPLACEMENT	APPLICATIONS: ADD-ON/RETROFIT	INSTALLATION BY: HOME OWNER	INSTALLATION BY: CONTRACTOR	THERMAL PERFORMANCE Btu/Hr-ft²-°F WINTER VALUE: DEVICE CONDUCTANCE	THERMAL PERFORMANCE Btu/Hr-ft²-°F WINTER VALUE: U VALUE: DEVICE + SINGLE GLASS	THERMAL PERFORMANCE Btu/Hr-ft²-°F WINTER VALUE: U VALUE: DEVICE + DOUBLE GLASS	SHADING COEFFICIENT
INTERIOR SYSTEMS (continued)																					
Drapery liner	Metallized plastic film	*Wind-N-Sun Shield NRG Shield	*Wind-N-Sun Shield Inc 131 Tomahawk P.O. Box 2504 Indian Harbor Beach, FL 32937 (305) 777-3558 *NRG Shields Inc Main & River Rd Tullytown, PA 19007 (215) 943-8850	•	•		PR		•	D		•			•	•	•	-	-	-	-
Drapery, double layer	Two layer drapery system	Thermo-fold™ Drapery System	Thomas W. Raftery, Inc 1055 Broad St P.O. Box 3221 Hartford, CT 06103 (203) 278-9870	•	•		PR		•	D		•			•	•		NA	.34 EM	.25 EM	.33 VAR
Insulation panel	Rigid foam insulation panels held in place by magnetic cleats	Nightwall	Zomeworks Corp P.O. Box 712 Albuquerque, NM 87103 (505) 242-5354	•	•		PR		•	D		•			•	•		.29 M,g	.27 EM	.21 EM	-
Insulation panel	Single or double panel of extruded polypropylene	In-Sol Slider	Energy Industries Solar Shutter Division 2010 N. Redwood Drive Route 1 Independence, MO 64050 (816) 257-1919	•	•		PR		•	S		•	•		•	•	•	1.85 A	.41 A	.28 A	-
Sliding window insulation panel	Window with a sliding interior insulation panel which is stored in a pocket in the wall	Sunflake™ Window System	Sunflake Window Co 625 Goddard Ave P.O. Box 676 Ignacio, CO 81137 (303) 563-4597	•	•	•	PR SEC		•	D		•		•			•	NA	.08 EM,h	NA	-
Sliding window insulation panel	Panels of foam sandwiched in sheet steel mounted on interior tracks. Panels interlock to cover large window.	Sunflake™ Bypass System	Sunflake Window Co 625 Goddard Ave. P.O. Box 676 Ignacio, CO 81137 (303) 563-4597	•	•	•	PR SEC		•	D		•			•		•	.09 A	.08 A	.07 A	NA
Sliding window insulation panel	Window unit with sliding insulating shutter stored in stud cavity	Aardvark & Sun Thermal Window Shutter System	Aardvark & Sun Solar, Inc 167 Webbers Path West Yarmouth, MA 02673 (617) 394-6391	•	•	•	PR SEC		•	D		•		•			•	NA	NA	.12 A	-
Interior folding shutter	¾ inch polystyrene core sandwiched with ⅛ inch plywood	Therma-Shutter™	Wallrich, Inc 2601 E. Missouri Ave El Paso, TX 79903 (915) 566-9426	•	•	•	PR SEC		•	D		•			•	•	•	.25 A	.17 A	.14 A	-
Interior folding shutter	Folding wood shutter with foam core	Insul Shutter	Insul Shutter, Inc Box 338 Silt, CO 81652 (303) 876-2743	•	•	•	PR SEC		•	D		•			•	•	•	.20 EM	.15 EM,i	.13 EM,i	-
Interior folding shutter	Folding wood shutter with foam core. Pre-hung in mounting box	Wovoak™ Shutter	FTR 5725 Arapahoe Boulder, CO 80302 (303) 449-7893	•	•	•	PR SEC		•	D		•			•	•	•	.14 M	11 EM	10 EM	-
Interior shutter	Foam slat roll-up shutter with low emissivity exterior surface	Sol-R-Fold Shutter	Solar Power West 709 Spruce St Aspen, CO 81611 (303) 925-4698	•	•	•	PR		•	D		•			•	•	•	.12 A	10 A	09 A	-
Skylight shutter	Aluminum skin over insulating core	Skylid	Zomeworks Corp P.O. Box 712 Albuquerque, NM 87103 (505) 242-5354	•	•		PR SEC		•		D		•		•	•	•	.33 M	.26 EM	20 EM	-
Insulating window	Polystyrene beads in a double glazed window	Beadwall	Zomeworks Corp P.O. Box 712 Albuquerque, NM 87103 (505) 242-5354	•	•		PR		•	D	B	•		•		•	•	13 M	NA	11 EM,h	-

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INTERIOR SYSTEMS (continued)																					
Roll-down shade (conventional)	Made from a variety of translucent or opaque fabrics & plastics	—	Various	•	•		PR		•	D		•	•		•	•		NA	.85 ES	.43 ES	.25–.70 ES
Roll-down shade	Shade with metallized films	Various	Various	•	•		PR		•	D		•			•	•		NA	.52 ES,i	.33 ES,i	.16–.51 ES
Roll-down shade (side tracks)	Interior roller shade with side tracks	*NRG Shade	*NRG Shields, Inc Main & River Rd Tullytown, PA 19007 (215) 943-8850	•	•	•	PR		•	D		•			•	•		NA	.51 ES	.33 ES	.28–.51 ES
		*N-R-G Shade	*Sun Control Products, Inc 431 4th Ave., S.E Rochester, MN 55901 (507) 282-2776																		
Interior roller shades (tape seals)	Interior roller shade with tape sealing to reduce air leakage	Minute Man™ adjustable storm windows	Minute Man Anchors, Inc 305 W Walker St E. Flat Rock, NC 28726 (704) 692-0256		•	•			•	D,S		•			•	•		NA	.50 A	.32 A	a
Roll-down shade	Roll-down shade system	Printaroll	MRS 1800 New Highway Farmingdale, NY 11735 (212) 895-4788	•	•		PR		•	D	D	•			•		•	NA	.85 ES	.43 ES	
Roll-down shade	Single or double layer shade using metallized film or vinyl sunscreen	Electro Shade™ Mecho Shade*	Joel Berman Associates Inc 102 Prince St New York, NY 10012 (212) 226-2050	•	•	•	PR		•	D	D	•			•		•	NA	.60–.85 M,j	.36–.43 EM,j	.25–.69 M,j
Roll-down shade	Vinyl-coated fiberglass	Sol-R-Veil*	Sol-R-Veil, Inc 60 West 18th St New York, NY 10011 (212) 924-7200	•	•		PR		•	D	D	•			•		•	NA	.90 ES	.44 ES	.12–.47 M,k
Roll-down shade	Multiple shade system with frame	Insealsnaid™	Ark-tic Seal Systems, Inc P.O. Box 428 Butler, WI 53007 (414) 276-0711	•	•	•	PR		•	D	D	•			•	•	•	NA	.20 EM,m	.16 EM,m	.25 EM
Roll-down shade	Five layers of aluminized plastic with air spaces	Heatstopper™ Shade	Insulating Shade Co., Inc P.O. Box 282 Branford, CT 06405 (203) 481-2337	•	•	•	PR		•	D		•			•	•	•	.08 EM	.07 EM	.07 M	
Roll-down shade	Aluminized nylon	Curtain Wall	Thermal Technology Corp P.O. Box 130 Snowmass, CO 81654 (303) 963-3185	•	•		PR		•	D	D	•			•	•	•	11 M	10 EM	.09 EM	.20 ES
Roll-down shade	Five layer quilt	Window Quilt™	Appropriate Technology Corp 4700 Green St P.O. Box 975 Brattleboro, VT 05301 (802) 257-4501	•	•	•	PR		•	D		•			•	•	•	.31 EM	.24 M	.19 EM	
Pull-down shade	Quilted fabric shade used for large windows	Sun Quilt Thermal Gate	Sun Quilt Corp. Box 374 Newport, NH 03773 (603) 863-2243	•	•	•	PR		•	D		•			•	•	•	.17 EM	.15 EM	.13 EM	
Interior roll-down slat shade	Hollow PVC slats	Thermo-Shade	Solar Energy Components, Inc 212 Welsh Pool Rd Lionville, PA 19353 (215) 644-9017	•	•	•	PR SEC		•	D	D	•			•	•	•	·	40 ES	.30 ES	
Interior roll-down slat shade	Wood slat with low emissivity backing	Thermal Blind	Solar Power West 709 Spruce St Aspen, CO 81611 (303) 925-4698	•	•	•	PR		•	D		•			•	•	•	.50 M	.29 EM	.22 EM	
Venetian blind (conventional)	Plastic, metal or wooden slats	—	Various	•	•		PR		•	D		•	•		•	•	•	NA	.83 A	.43 A	.55–.64 A
Venetian blind	Slats black on one side, white on other	*Various	*Various Venetian blind manufacturers	•	•		PR		•	D		•			•	•	•	NA	.83 A	.43 A	
		*Solar Heating Venetian Blinds	*Solar Master, Inc 223 E Knight Ave Collingwood, NJ 08108 (609) 854-2960																		
EXTERIOR SYSTEMS																					
Storm windows (conventional)	Single glazing in metal wood or plastic frame	—	Various		•	•		•	•	S		•			•	•	•	NA	.50 A	.32 A	a
Exterior roll-down shutter	Hollow PVC or aluminum slats	Rolladen	American German Industries 14611 N Scottsdale Rd Scottsdale, AZ 85260 (602) 991-2345	•	•	•	PR SEC		•	D	D	•			•		•	2.66–7.69 EM	45–50 M	.29–.32 M	.04–.07 M
Exterior roll-down shutter	Hollow PVC slats	Roll-Awn	Abox Corp 629-3 Terminal Way Costa Mesa, CA 92627 (714) 645-0623	•	•	•	PR SEC		•	D	D	•			•		•	1.56 EM	40 M	.27 EM	04–.07 ES

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PR	Privacy				
-	Not Available	A	Based upon ASHRAE calculation procedures		

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EXTERIOR SYSTEMS (continued)																					
Exterior roll-down shutter	Hollow PVC slats	Rolsekur	The Rolsekur Corp. Fowler's Mill Rd Tamworth, NH 03886 (603) 323-8834	•	•	•	PR SEC		•	D	D	•			•		•	2.86 ES	.45 ES	.29 ES	.04-.07 ES
Exterior roll-down shutter	Hollow PVC slats	Everstrait Rolling Shutter	Pease Co. Ever-Strait Division 7100 Dixie Highway Fairfield, OH 45023	•	•	•	PR SEC		•	D	D	•			•		•	1.75 EM	41-.57 M	.28 EM	.04-.07 ES
Exterior roll-down shutter	Wood or hollow plastic slats	Serrande Shutter	Serrande of Italy P.O. Box 1034 W. Sacramento, CA 95691 (916) 371-6960	•	•	•	PR SEC		•	D	D	•			•		•	2.86 ES	.45 ES	.29 ES	.04-.07 M
Exterior roll-down shutter	Hollow plastic slats	Sunega Thermal Shutter Blind	Sunega Associates P.O. Box 6 Springfield, NJ 07081 (201) 376-8457	•	•	•	PR SEC		•	D	D	•			•		•	2.86 ES	.45 ES	.29 ES	.04-.07 ES
Exterior roll-down shutter	Hollow PVC or aluminum foam-filled slats	Rollocks™ Window Shutter	Rollocks Corp. of America 9421 Winnetka Ave. Chatsworth, CA 91311 (213) 885-1100	•	•	•	PR SEC		•	D		•			•		•	1.56 EM	.40 EM	.27 EM	.04-.07 ES
Exterior roll-down shutter	Wooden slats	Soleil™ Wood Roll Shutters	Soleil, Division ELR, Inc. 2810 N.W. South River Dr Miami, FL 33125 (305) 635-2372	•	•	•	PR SEC		•	D	D	•			•		•	2.22 A	.42 A	.28 A	.04-.07 ES
Exterior roll-down reeling-blind shutter	Enameled aluminum louvres; pantograph mechanism	Guardian Shutter Blind	Nichols-Homeshield, Inc. 1000 Harvester West Chicago, IL 60185 (312) 231-5600	•	•	•	PR SEC		•	D	D	•	•		•		•	7.69 ES	.50 ES	.32 ES	.13-.27 M
Exterior sliding or hinged shutter	Steel or aluminum panels	Willard Shutters	Willard Shutter Co. 4420 N.W. 35th Court Miami, FL 33142 (305) 633-0162	•	•		PR SEC		•	D		•			•	•	•	NA	-	-	-
Exterior bi-fold shutter	Bi-fold wood shutter with foam core. Stows under soffit when not in use	Tymura Shutter	Tymura Solardesigns R.R. 15 Hillidale Rd. Thunder Bay, Ontario Canada P7B 5N1 (807) 767-8254	•	•		PR SEC		•	D		•			•		•	.12 A	.10 A	.09 A	-
Exterior shutter	Large bi-fold shutter with foam core. Use over glass doors	Thermafold shutter	Shutters Incorporated 110 East 5th St. Hastings, MN 55033 (612) 437-2566	•	•		PR SEC		•	D		•			•		•	.15 A	.12 A	.10 A	-
GLAZING SYSTEMS																					
Conventional multiple glazing	Window incorporating two or more glazing layers with air space between	Various	Various	•	•	•		•				•	•	•			•	.50 double .32 triple A,b,c			VAR
Low conductance insulating glass assembly	Sealed insulating glass with low emissivity coating and low conductivity gas fill	Thermoplus	Flachglas AG Auf de Reihe P.O. Box 669 D-4650 Gelsenkirchen West Germany	•	•			•				•		•			•	.28-.32 M,c	NA	NA	.17-.55 M
Translucent sandwich panel	Two sheets of fiberglass bonded to an aluminum frame	Kalwall*	Kalwall Corp. 1111 Candia Road P.O. Box 237 Manchester, NH 03105 (603) 627-3861	•	•		PR	•				•	•	•			•	06-.40 M,c	NA	NA	.84-.04 M
Translucent sandwich panel	Fiberglass panel with a foam core	Lascolite	Lasco Industries 3255 E. Miraloma Ave Anaheim, CA 92806 (714) 993-1220	•	•		PR	•				•	•	•			•	.53 M,c	NA	NA	VAR
Double wall plastic glazing	Fiberglass reinforced acrylic sheet with a honeycomb core	Cemcel Insulated Panel	Cemcel Corporation 49 Industrial Way Greenbrae, CA 94904 (415) 924-4554	•	•		PR	•				•	•	•			•	.24-.40 M,c	NA	NA	.27-.85
Double wall plastic glazing	Extruded double wall glazing panel	*Alkcobar	*Alkco Manufacturing Co 734 N. Pastoria Ave Sunnyvale, CA 95086 (408) 733-3344																		
		*Exolite	*CYRO Industries West Main St Bound Brook, NJ 08805 (201) 356-2000	•	•		PR	•				•	•	•		•	•	.58-.62	NA	NA	.25-.88 VAR
		Tuftak-Twinwal	*Rohm & Haas Independence Mall West Philadelphia, PA 19105 (215) 592-3000																		
Retrofit insulating glass system	Glass with aluminum frame, dessicant and seal	Energy Seal Thermal Add-A-Pane System	Energy Seal Thermal Add-A-Pane 1 N. Wacker Dr Chicago, IL 60606 (312) 263-3132		•			•				•			•		•	NA	49 A	.31 A	a