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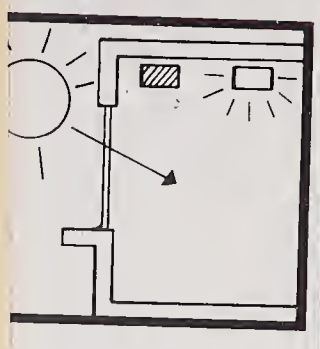

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National Engineering Laboratory

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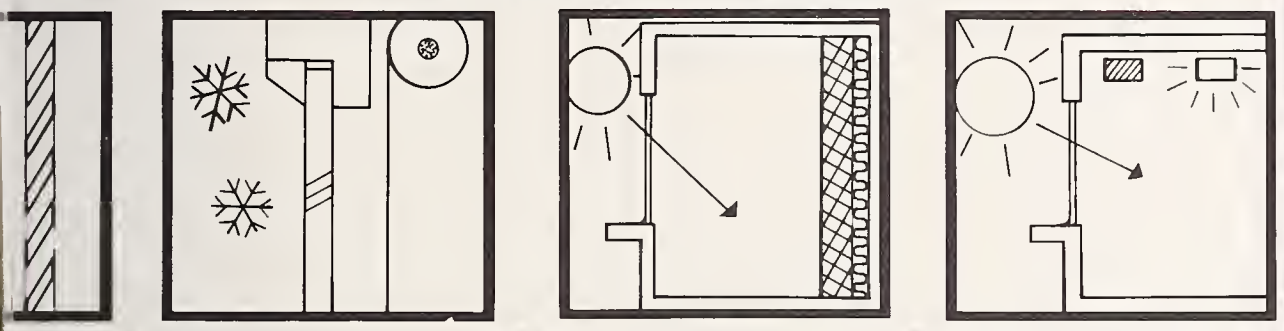
EXAMPLES

A. Air Tightness

B. Water Tightness

ITERIOR DESIGN ELEMENTS



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	14. Interior Coverings	15. Integrated Lighting	16. Interior Mass	EXAMPLES
rtical /eave	Roll shades, inside storm sash, heavy drapery, shutters	Fixture circuiting, task lighting, light-sensing automatic controls	Masonry, concrete, stone, water	
	Solid weather-stripped shutters improve air-tightness			A. Air Tightness
			Water container seams critical. Also see "M" below	B. Water Tightness

DESIGN FOR BETTER WINDOW PERFORMANCE

U.S. DEPARTMENT OF COMMERCE
Philip M. Klutznick, Secretary
Luther H. Hodges, Jr., Deputy Secretary
Jordan J. Baruch, Assistant Secretary for Productivity, Technology and Innovation

NATIONAL BUREAU OF STANDARDS
Ernest Ambler, Director

Center for Building Technology
National Engineering Laboratory
National Bureau of Standards
Washington, D.C. 20234

EXAMPLES	EXTERIOR DESIGN ELEMENTS			
	 **1. Landscaping** Shade trees and windbreaks consisting of hedges, tree lines, fences	 **2. Shades** Sun screens, louvers, awnings, architectural projections	 **3. Coverings** Roll blinds, shutters, storm sash	 **4. Sun Orientation** South-facing windows
A. Air Tightness	Reduced potential for water or air leakage to extent that windbreak shields the window, reducing wind and water velocity	Reduced potential for water or air leakage to the extent the device shields the window. Provide positive drainage for trapped water Lack of drainage and freezing can increase air and water leakage		May or may not coincide with optimum orientation for summer prevailing breezes vs. winter wind. Correct conflicting orientation requirements by using other design elements such as wind scoops or planting
B. Water Tightness				
C. Natural Ventilation	A windbreak may alter summer wind direction and increase or decrease local velocity	May impede natural ventilation. Even insect screen reduces air flow by 50%		
D. Insulation	Windbreaks and shades will reduce rate of erosion of insulating layer of air at surface of glass to extent window is shielded from wind		Dead air space between covering and window insulates. More airtight coverings better	Sol-air temperature useful concept. See ASHRAE Handbook of Fundamentals. Locate spaces to receive winter sun during time of occupancy
E. Solar Admittance	Trees and tall hedges can reduce insulation	Ventilate space between window and shade at top and bottom. Remove or adjust to admit winter sun	Reduced solar gain according to shading coefficient Adjust to admit winter sun	
F. Daylighting	Landscaping elements may block daylight if in overgrown condition	If overdone, shading can necessitate expensive electric lighting. Ideally, device should reflect light to ceiling for maximum depth of daylight penetration into room		Intensive solar exposure for winter heating may cause glare. Provide control using design elements
G. Visual Separation	Opportunity to provide privacy as desired	Some types as seen from outside are opaque during day but transparent at night		
H. Acoustical Isolation	Principal benefit is psychological. Provides minimal actual sound isolation	Decreases as distance of noise increases. Overhangs can reflect noise to the window	Can be effective if airtight and materials not same thickness or density	
I. Safety	Could alter circulation patterns to keep people away from windows	Projections within 7 ft. of grade may be hazardous to pedestrians	Can reduce frequency or severity of breakage-related accidents	
J. Access/ Egress	Must be located so as not to block emergency access or egress	Must be easily removable from inside for emergency exiting through windows used for egress. Must not reduce area or dimension below minimum required		
K. Ease Of Operation	Accumulated organic debris may reduce ease of operation	Interior operation of exterior devices desirable to meet changing exterior conditions or interior requirements		
L. Forced Entry Resistance	May provide cover for intruders or act as partial barrier	May deter intruders depending on ease of removal or noise from breakage. Locked shutters or roll blinds very effective		
M. Durability/ Maintenance	Require pruning, feeding, watering (plants), painting (fences)	Must withstand wind, rain, ice, and intense solar radiation. May require seasonal removal. Some are self storing—e.g., roller awnings. Detail installation to avoid staining adjacent materials		Avoid use of materials whose appearance is diminished by fading

EXAMPLES	FRAME DESIGN ELEMENTS			
	 **5. Insulated Frames** Wood or metal with a thermal break	 **6. Opening Type** Casement, awning, double-hung, sliding, jalousie, pivoting and hopper	 **7. Weatherstrip** Pile, vinyl, foam, brass, or copper	 **8. Hardware** Latches, operating devices, locks, and hinges
A. Air Tightness	Are as important as insulating value. Performance varies greatly with quality of window and type of operation. Hinged windows tend to be more airtight than vert. or horiz. sliding units. Excellent to minimum performance: 0.1 to 0.5 cfm per crack foot at 26 mph wind. ASTM e283-73 test. Note: Specify mfgr's production average. Provide positive drainage and keep weeps clear. Hopper, awning or jalousie provide some rain protection when open. ASTM E-331 water penetration test used for evaluation		Since tightness degrades with use, ease of replacement essential. Pile type w/fin desirable for sliding units; use compression or spring type for hinged units	By cam action hardware can force tight closure of sash. Improper design can twist frame causing increased air and water infiltration
B. Water Tightness				
C. Natural Ventilation		Direction and axis of opening directs air flow. Openable free area critical		May limit how window opens thus affecting quantity and quality of ventilation
D. Insulation	Should be specified with multiple glazing in moderate and severe climates			
E. Solar Admittance	Excessive widths of sash and frame members reduce solar gain. Use net glazing areas for calculations			
F. Daylighting	Frame interior faces should be a light color to reduce contrast glare. Position window head near ceiling for maximum room depth of daylight penetration			
G. Visual Separation				
H. Acoustical Isolation	Airtightness critical to "sound tightness"			
I. Safety		Windows projecting in or out can be hazardous depending on location	Should not require excessive force to open or close window	Can limit opening dimensions to prevent children from falling out
J. Access/ Egress	Must not interfere with easy exiting	Typical exit window: 5.7 sq. ft. min. area, 21" min. dimension, 44" max. sill height	Should not inhibit the easy opening of windows used for emergency egress	Should facilitate rapid opening for emergency egress
K. Ease Of Operation	Must resist forces of operation and prevent binding of sash	Height affects ease of operation of different window types	See "I" above	Gear reduction or leverage can increase ease of operation
L. Forced Entry Resistance	Rigidity of frame and sash important to resist prying	No exposed removable hinges. Sash or glass should be removable from inside only	Soft weatherstripping can permit insertion of wire to unlock window	Function, quality placement, and anchorage critical to security
M. Durability/ Maintenance	Thermal break material must be UV stable or protected from sunlight	The more movable parts the greater the possible need for maintenance	Must be detailed to permit periodic replacement	Simple is beautiful and makes economic sense

EXAMPLES	GLAZING DESIGN ELEMENTS			
	 **9. Multi Glazing** Fused-edge or organically sealed insulating glass	 **10. Reflective Glazing** Reflective coated glass or films	 **11. Plastic Glazing** Polycarbonate (PC) or acrylic (AC) sheet	 **12. Glass Block** Hollow masonry units of glass
A. Air Tightness			Large thermal movement requires large edge clearance, deep containment, gaskets or flexible sealants	Seal at joint between adjacent construction and glass block important. Expansion can be great
B. Water Tightness	Drain sill channels well to prevent failure of organic edge seal of glass			
C. Natural Ventilation				Operable vents available same size as block module
D. Insulation	Single glass U-value: (winter) = 1.10 btu/ft²h°f Storm = 0.5 Double = 0.6 (½" space)	I.R. refl. = 0.7 Sol. refl. = 0.9	Polycarbonate or acrylic = 1.06	12" sq. face 1 cavity = 0.52 2 cavity = 0.44
E. Solar Admittance	⅛" glass: shading coeff. (sc) = 1.0, % sol transmission (sol) = 87 (⅛ + ⅛) clear: sc = 0.89 % sol = 69	Low example sc = 0.38 % sol = 17	sc = 0.98 AC = 0.98 PC % sol = 85 AC = 82 PC	High example sc = 0.65 % sol = 60
F. Daylighting	⅛" glass: % visible transmission (vis) = 90 % vis = 81	Low example % vis = 15	% vis = 92 AC = 88 PC	High example % vis = 75
G. Visual Separation		Tend to distort color rendition of view and correct sense of time	Scratches can detract from quality of view out	View out/in distorted or entirely obscured depending on type
H. Acoustical Isolation	⅛" single glass sound transmission loss (db) = 24 ½" cavity = 32 6" cavity = 40		¼" thick = 29 AC = 31 PC	Stand blk = 38 Solid blk = 45
I. Safety	Insulating glass eliminates hazard of installing/removing storm sash	May cause disorienting glare to pedestrians/drivers	Reduced probability of breakage-related accidents	
J. Access/ Egress	Greater hazard to enter/exit through broken-out window	Avoid creating reflections that could confuse emergency exiting	Pop out gasketing may be desirable for egress through fixed units	Essentially inpenetrable for emergency egress
K. Ease Of Operation	Increased weight makes operation more difficult due to inertia, friction	Requires no management by the occupant	Decreased weight makes operation easier	
L. Forced Entry Resistance	See "J" above	Impedes outside daytime surveillance	⅛" glass breaks when ¼ lb. steel ball dropped on a 12" sq. Sample at height of 24" AC = 72" to 1000" PC = 1000"	Stand blk. = 200" Solid = marred at 320"
M. Durability/ Maintenance	Durability of edge seal of insulating glazing critical	Scratch resistance important Caution in cleaning	Easily scratched. May increase frequency of replacement	Very durable but if damaged, replacement difficult

EXAMPLES	INTERIOR DESIGN ELEMENTS			
	 **13. Interior Shading** Venetian or vertical blinds, open-weave drapery	 **14. Interior Coverings** Roll shades, inside storm sash, heavy drapery, shutters	 **15. Integrated Lighting** Fixture circuiting, task lighting, light-sensing automatic controls	 **16. Interior Mass** Masonry, concrete, stone, water
A. Air Tightness	Negligible	Solid weatherstripped shutters improve airtightness		
B. Water Tightness				Water container seams critical Also see "M" below
C. Natural Ventilation	Concurrent shading and ventilation desirable	Closed mode may preclude natural ventilation		Mass cooled by night air can provide daytime cooling
D. Insulation	Minimal if free movement of room air between device and window	Depends on airtightness of covering and tightness of edge fit		Daytime heat loss reduced because mass absorbs heat, reducing overheating of space
E. Solar Admittance	Shading coeff ⅛" gl = 1.0 Ven. Blind = 0.6* Open weave curtains = 0.8* *Closed	Roll shade = 0.3* Tight weave curtains = 0.3* *Closed		Solar heat absorbed by mass permits greater glass area, w/o overheating
F. Daylighting	Experimental reflective Venetian blind. Contact: 1 Oak Ridge Lab 2 Lawrence Berkeley Lab	Can be effective for complete black-out	Daylight sensing control operation on/off or continuous dimming	Dark color for solar absorption reduces room daylighting
G. Visual Separation	See exterior shading and coverings			"Mass" walls can provide complete visual separation and passive solar heat
H. Acoustical Isolation	Negligible	Depends on airtightness as in "D" above	No lighting system hum with daylight	Mass provides the best acoustical isolation if no penetrations
I. Safety	May help prevent direct contact with glass in impact situations			Check allowable floor loading, caution in disposal of toxic additives
J. Access/ Egress	Should not hide windows, and thereby reduce the likelihood of their use for emergency egress, nor impede any quick-opening qualities			
K. Ease Of Operation	Due to easy accessibility interior coverings are more likely to be used		No occupant operation required with automatic controls	No operation required
L. Forced Entry Resistance	Can prevent burglar's surveillance of interior	Can discourage penetration if locked closed	Can be integrated with security system to turn on lights upon intrusion	
M. Durability/ Maintenance	The need for periodic cleaning makes ease of removal desirable		Daylight use increases lamp life if switching infrequent	Water may require antifreeze, rust inhibitor, or algaecide

NBS Special Publication SP 575 S. Robert Hastings and Porter Driscoll

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 Price $2.25
☆ U.S. GOVERNMENT PRINTING OFFICE : 1980 O—327-167

Issued May 1980