



# Home Window Design

WASHINGTON STATE ENERGY OFFICE

Washington Energy Extension Service

Wise Use of Resources Through Education

## Storm Windows

Most people are familiar with at least one type of storm window although many good options are widely available. The storm window that best serves your needs will largely depend on a consideration of intended use, appearance, and cost.

Storm windows not only save money on heating bills, but also make rooms more comfortable and can reduce condensation problems. This pamphlet discusses how storm windows work, their benefits, and what to look for in selecting storm windows for your home.

### How Storm Windows Work

Windows lose heat in basically two ways: "conduction" and "infiltration." Conduction is the transfer of heat directly through the glass and framing materials, just like through other building materials. Infiltration refers to air leakage around a window's edges. These forms of heat loss are shown schematically in Figure 1. Many older windows, particularly sliding ones, such as double hung, leak excessively. (If they wobble or rattle you can be sure they do).

By reducing both types of heat loss, storm windows result in warmer interior surfaces and fewer drafts. Maintaining a tight seal against your existing window using proper caulking and weatherstripping techniques is critical. It is necessary for stopping leaks as well as creating an undisturbed or "dead" air space between the primary and storm windows. As shown in Figure 2 (page 3), it is mostly this air space, and not more glass, that provides the additional window "R-value." (For a discussion of R-value, see page 2.) Storm windows can be applied to double pane or "insulated" glass units for still higher R-values (Figure 2C).

Two questions often asked are:

- Is it better to install storm windows on the inside or outside?
- Do plastic storm windows work as well as glass?

To answer these questions, refer once more to Figure 2B. We see that as long as there is an effective dead air space, it makes no difference (when considering heat loss) which side the storm window goes on, or whether it is made of glass or plastic. The overall R-value depends far less on window placement and glazing material than it does on the number of glazings used and air tightness. On the other hand, there may be important reasons for choosing a certain style of storm window as described on page 2.

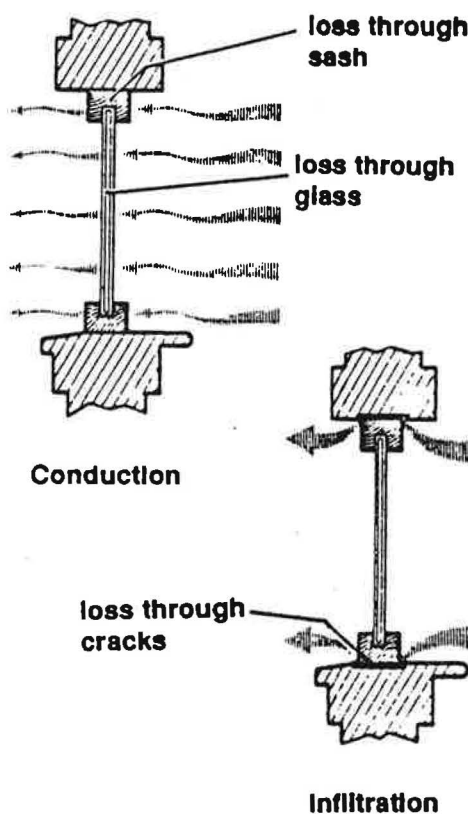


Figure 1. Two Kinds of Window Heat Loss

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## Inside Versus Outside

- **Convenience:** Most storm windows need to be removed periodically for cleaning or summer ventilation. In some cases, an inside storm window may be more convenient, especially on second or third floors.
- **Appearance:** Some inside storm windows may interfere with interior decorating plans such as Venetian blinds, Roman or roller shades, and curtains.
- **Protection:** Plastic storm windows, particularly rigid sheet types, offer protection against existing window breakage. Install them on the side where impact is most likely to occur.
- **Condensation:** To minimize the possibility of moisture condensing between panes, the window with the most air tight seal should be on the inside.

## Glass Versus Plastic

- **Glass:** Glass is an excellent glazing material because it provides clear visibility, low distortion, and long life, but it is heavy and fragile.
- **Rigid Plastic Sheets:** Some plastics offer optical qualities similar to glass. All offer high impact resistance and are typically easier to cut and handle. Drawbacks include possible shorter life, and limited resistance to scratching and strong cleaners.
- **Flexible Plastic Film:** Films are inexpensive and simple to work with but in many cases result in light diffusion and distortion. Life and impact

### Understanding "R" and "U" Values

- Two terms are in common use to express the insulating value of various window systems: "R-value" and "U-value."
- An R-value refers to the thermal resistance of a material where higher values mean more resistance to heat flow, and a better insulator.
- A U-value is just the opposite and refers to the thermal transmittance of a material where higher values mean more heat transmittance (less resistance to heat flow) and a poorer insulator. The terms are interchangeable by the formulas  $R=1/U$  and  $U=1/R$ .
- Although not normally expressed, conventional units are R (hr - ft<sup>2</sup> - F°/Btu) and U (Btu/hr - ft<sup>2</sup> - F°).

resistance are also low. More detailed information on glazing materials is given in Table 1 (page 4).

One last question relating to performance is the size of the enclosed air space. Greatest R-values result when the air space is between 1/2" and 3-1/2" wide. Below 1/2", conductive heat losses are excessive, so that at 1/4" air space, the overall R-value is reduced to just less than 1.7 (compared to 1.9). Above 3-1/2", convective heat losses begin to outweigh the conductive gains. Convective losses result from cold exterior glass and relatively warm interior glass causing circular currents and more rapid heat loss. In most cases, though, there should be little difficulty in achieving adequate air spaces. Remember that the R-value of any storm window system is reduced by air leakage, so be sure they are carefully installed.

## Benefits

Perhaps the most significant benefit of storm windows is savings on your heating bill, but other benefits should not be overlooked, for example, increased comfort. The range of benefits is summarized below.

## Energy Savings

A typical residential heating bill in Washington (2.5 household members) is about \$500 per year. This figure varies widely with utility prices, climate, household size, and conservation measures taken, but will serve for illustration purposes. The portion of this heat lost through windows by conduction and infiltration likewise varies, depending on the number and style of windows, and general level of air tightness and insulation in the home, but typically ranges from 25 - 50 percent. Storm windows will save about half this amount or \$62 - \$125 per year. If your heating bill is more than \$500, savings could be greater. On the other hand, if your bill is less than \$500, savings could be lower.

The payback in energy savings for investments in storm windows is often long except for the most inexpensive, do-it-yourself types. For example, at \$100 per year savings, a commercial installation costing \$1,500 has a 15 year simple payback (\$1,500/\$100 per year). However, vinyl film storm windows costing \$200 for materials you assemble and install, will have only a two year simple payback (\$200/\$100 per year).

## Increased Comfort

The improved comfort of storm windows, though hard to quantify, may be the benefit most appreciated by household occupants. Single pane glass can cause significant drafts even without actual air leakage due to convection currents formed by warm air cooling and

sinking at the cold window surface. By adding an air space serving as invisible but effective insulation, storm windows increase interior glass temperatures thus reducing drafts.

### Reduced Condensation

Condensation can be a serious problem during the winter when houses are not well ventilated and outside temperatures are low. Often the first place where condensation forms is on cold window surfaces, both glass and metal frames. By warming these surface temperatures, storm windows significantly reduce the chance of condensation forming and causing further mold, mildew, or wood decay problems.

### Reduced Maintenance

Besides reducing the possibility of interior moisture problems, exterior storm windows can help protect wood frames from exposure to weather thus reducing maintenance requirements. Painting and puttying will be needed less often. Plastic storm windows can also protect glass windows from breakage.

### Reduced Noise

Dead air spaces not only insulate against heat but also sound. A reduction in outside noise and a quieter home result from using storm windows.

### Storm Window Selection

The storm window that's right for you depends a great deal on how it will be used. Carefully evaluate present window conditions and uses. Is ventilation important? How about durability? Or, is a more temporary solution sought for a particularly drafty window? Do you desire a professional installation or would you rather build your own? The options are many. You may decide that various types of storm windows be used in different areas of the home. If your budget is limited, initial attention should be given to windows that are largest, leakiest and in the most frequently occupied rooms.

The relative merits of inside and outside placement, and various glazing materials have been discussed above. What's left to consider are the three concerns mentioned on page 1 - intended use, appearance, and cost. For simplicity, commercially installed and home-built storm windows will be discussed separately. No matter what type of storm window you select, be sure the existing window is in sound condition to support the addition, particularly with permanent installations. Furthermore, if the existing windows have significantly deteriorated, it may be worth replacing them with new insulated glass units.

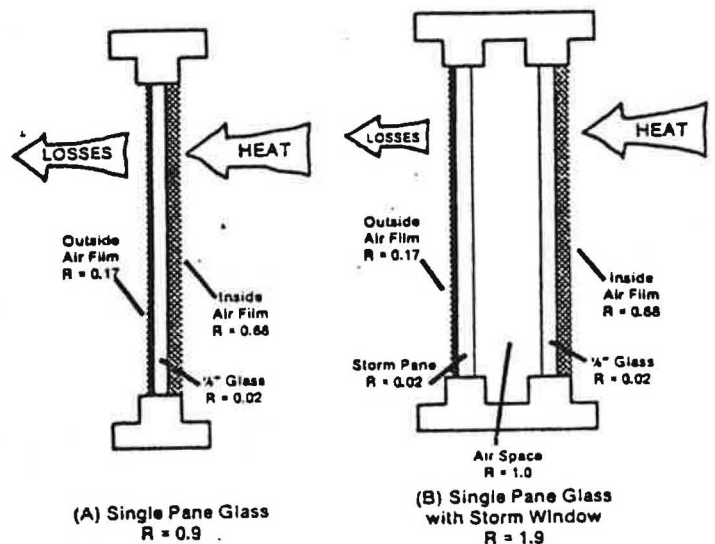
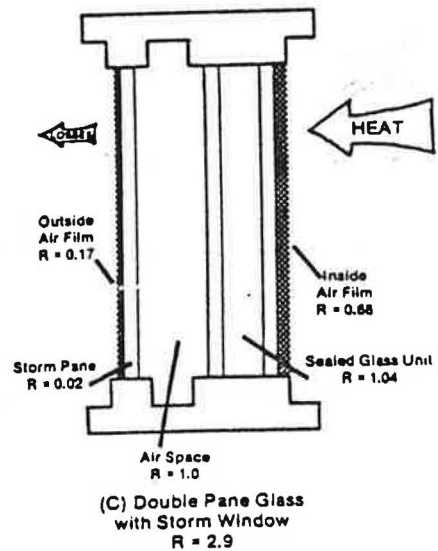


Figure 2. Typical Window R-Values

Note: The R-values of air spaces, including inside and outside air films, vary according to spacing, inside and outside temperatures, and air velocities. Overall window R-values further depend on framing materials and geometry.



## Glazing Materials

Glazing Material	Common <sup>(1)</sup> Names	Visible Light (VL) Transmittance	Ultraviolet (UV) Transmittance	Optical Characteristics	Ultraviolet <sup>(2)</sup> Resistance	Abrasion <sup>(3)</sup> Resistance	Impact Resistance	Flammability	Cleaning	Cutting <sup>(4)</sup>	Other <sup>(5)</sup> Thicknesses	Cost
Float Glass (1/8")	—	90%	79%	clear, low distortion	high	high	low	no	strong cleaners okay	glass cutter	3/32 - 1/2"	moderate
Tempered Glass (1/8")	—	90%	79%	clear, low distortion	high	high	moderate	no	strong cleaners okay	cannot be cut	1/8 - 1/2"	moderate
Acrylic (1/8")	Plexiglas Acrylite	92%	similar to glass, varies <sup>(6)</sup>	clear, low distortion	moderate (unless treated)	low (unless coated)	high	yes	no strong cleaners, mild soap, special cleaners	scored/broken, fine toothed saw, drillable	30 mils - 1/2"	moderate
Polycarbonate (1/8")	Lexan Tuffak	85%	significantly lower than glass	clear, low distortion	moderate (unless treated)	low (unless coated)	very high	self extinguishing	no strong cleaners, mild soap, special cleaners	scored/broken, fine toothed saw drillable, nailable	30 mils - 1/2"	high
Polyethylene (4 mils)	'poly film' Visqueen	85%	—	some light diffusion, significant distortion	low (unless treated)	low	moderate	slow burning	no strong cleaners mild soap	scissors, knife	2 - 10 mils	very low
Polyester (5 mils)	Mylar	80-90%	—	clear, some distortion	low (unless treated)	low	moderate	yes	no strong cleaners, mild soap	scissors, knife	1 - 20 mils	low
Polyvinyl Chloride (PVC) (8 mils)	'vinyl'	90-94%	—	clear, some distortion	low (unless treated)	low	moderate	self extinguishing	no strong cleaners, mild soap	scissors knife	4 - 20 mils	low
Polyolefin (75 mils)	'heat shrink film' 'stretch film'	95%	98%	clear, some distortion	—	low	low	slow burning	no strong cleaners, mild soap	scissors, knife	1 mil	very low

- 1) Common brand names are listed because many of these materials are better known by proprietary names than chemical or generic names. No endorsement of any product or brand is intended or implied, nor is there any implication that brand names not listed are in any way inferior to those listed.
- 2) UV Resistance refers to the ability of glazing to resist degradation caused by sunlight. UV degradation can cause discoloration, reduce light transmission and embrittlement. If a supplier doesn't know if a material is treated for UV resistance, assume it is not.
- 3) Abrasion Resistance refers to the ability of glazing to resist scratching. This is primarily of concern when washing the glazing. The lower the abrasion resistance, the more care required when washing the glazing. Many rigid plastics can be coated to improve abrasion resistance.
- 4) The coefficient of thermal expansion for rigid plastics (acrylic and polycarbonate) must be considered when cutting. Thermal expansion refers to the expansion of glazing as temperature increases (or contraction as temperature decreases). The coefficient of 0.00004 means that for every inch of glazing length and °F of change, the length will change 0.0004 inches. As an example, if installing a 60" long piece of acrylic at 60°F, and if expecting a maximum temperature of 110°F, the glazing would expand  $(0.00004)(60")(50°F) = 0.12$  inches. In this case, cut the glazing 1/8" shorter than the opening to allow for expansion.
- 5) Thicknesses are often given in both inches and mils. One mil is 1/1000 of an inch. As an example, 1/8 inch = 125 mils.
- 6) UV transmittance is significantly reduced through general purpose grade acrylic after about 2 years of outdoor exposure. Other grades offer a variety of optical qualities.

## Commercially Installed

In general, commercially installed storm windows look great and last a long time but cost much more than homebuilt varieties. They are usually chosen for reasons of operability, durability, or appearance. Costs range upwards from \$5 per square foot. Further information on three major types of commercially installed storm windows is given below.

- **Tracked Units:** These storm windows are installed permanently on the outside or inside and are most convenient since you can easily slide them open and closed as desired. Both vertical and horizontal designs are available. Screens can also be added. Their only drawback is possible air leakage due to the general difficulty of weatherstripping sliding surfaces.
- **Fixed Units:** Most storm windows are intended to be put up and taken down once a year, although they could be left in place permanently if the primary window cannot, or does not need to be opened. Typically an exterior glass or acrylic product, they attach by a variety of fasteners (screws, turn-buttons, hooks) and generally offer improved weatherstripping over tracked units due to compression type seals.
- **Magnetic Strip Units:** Interior acrylic storm windows using magnetic strips for attachment are gaining in popularity since they are more convenient than fixed units but more energy efficient and often less expensive than tracked units. They typically utilize a two-part vinyl frame. One part, the base strip, permanently attaches to the existing window frame. The other part, the cover strip, frames the edges of the glazing. They join by a continuous magnetic strip installed in either or, in some cases, both framing parts. An alternative but similar design employs a hook and loop (velcro) mounting system. Additional shopping tips for commercially installed storm windows are given in the shopping tips on this page.

## Homebuilt

Depending on the type selected and the time you put into them, homebuilt storm windows can blend well with existing windows or look quite unappealing. While rigid glazing is long lasting, those with plastic films may last only five years or less. All types are considerably less expensive than commercial installations (less than \$5 per square foot). While some homebuilt options are quite simple, others, like working with rigid plastic glazing, require careful assessment of one's abilities. Table 1 (page 4) provides

## *Shopping Tips* Commercially Installed Storm Windows

**Aluminum frames lose heat** much faster than wood or vinyl. If you do choose aluminum, be sure that it will not contact an existing metal frame. Closed cell foam, neoprene, or other gasket material should be used to prevent a direct path for heat loss through frames. An anodized frame (available in several colors) will resist corrosion better than a mill (flat) finish. Hardware must also be compatible with the frame to prevent corrosion.

**Signs of quality** include effective weatherstripping where the storm unit contacts the home and along any sliding surfaces, glazing that is tightly sealed in the frame, tight joints at corners, and structural reinforcements.

**Get at least three bids** from contractors for the type of windows you want. Deal only with reputable firms that are licensed, bonded, and guarantee their work. Inspect other work by the contractor and talk to previous customers before making your final decision.

data on common glazing materials. Further information is provided below.

- **Wood Framed:** Although wood is easy to work with, depending on the glazing material used, constructing wood framed storm windows can be quite simple or complex. Since working with glass requires special skills, most people prefer to use plastic glazing, either rigid sheets such as acrylic or flexible films such as polyethylene and vinyl. Rigid

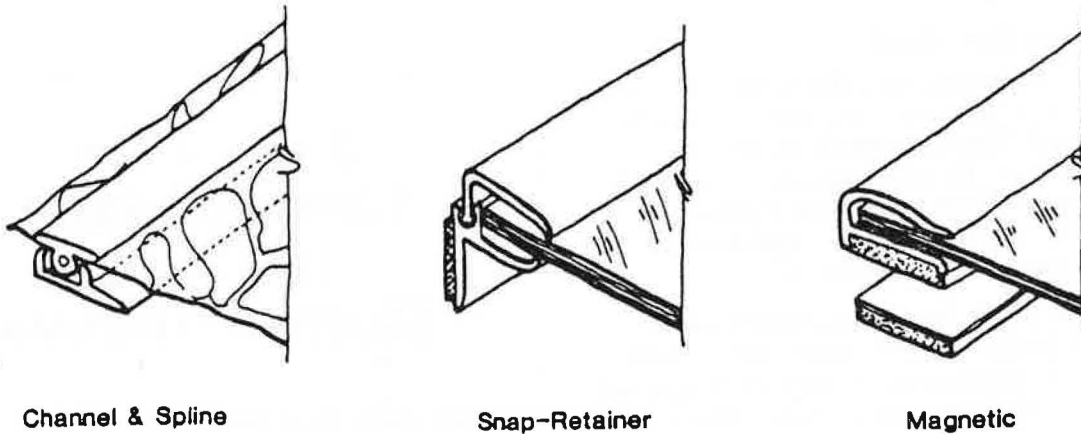


Figure 3. Typical Plastic Framed Kits

sheets offer greater permanence, but cost more and take longer to build. Films are subject to ultraviolet degradation and will require more frequent replacement. Both rigid and flexible plastic materials come in various thicknesses. Refer again to Table 1 for more information on glazing.

The frame itself should be made from wood that is strong enough to maintain rigidity while handling, generally 1" x 2" or 1" x 3". If taller than 3' or 4', you may want to use a cross piece. For a good fit, only use the straightest pieces and measure carefully before cutting. Lengths should be approximately 1/8" less than the opening to which the frame will be attached. For basic instructions on

how to build an inexpensive plastic film storm window, see the box below.

- *Plastic Framed Kits:* With a storm window kit, purchased at most home improvement or hardware stores, assembly is simplified since all the material and directions are at hand. Kits are most often intended for indoor installation with either rigid or flexible plastic glazing. Frames are typically made of vinyl and come in several earthtone colors. Similar to commercial magnetic strip units, they consist of a base strip that attaches permanently to the window and a cover strip that holds the glazing in place. Many designs are available, some of which are shown in Figure 3.

## Building a Plastic Film, Wood-framed Exterior Storm Window

1. Carefully measure and record the length of each side of the window opening.
2. Select only straight, 1" x 2" framing material and cut 1/8" less than the measured length allowing for mitered or butt joints at the corners. If the window is longer than about four feet, consider a cross brace for greater strength.
3. Lay the framing pieces on the floor or workbench and attach each corner with "scotch" fasteners or corrugated nails (1 or 2 per corner) then turn the frame over and repeat from the other side.
4. If you want to paint or stain the frame, now is the time to do it.
5. Measure and cut the plastic film about 4" larger than the frame and center it over the frame.
6. Begin stapling at opposite sides and slowly work to the corners, stretching to remove wrinkles (do not overstretch) as you go. Be careful that the frame does not deform while you stretch and staple. Simply brace the mid section to avoid this problem.
7. Cut molding (about 3/4" width) to cover the staples and attach with 3/4" nails. Trim off the excess plastic with a utility knife.
8. Weatherstrip the back side of the window with a compression fit material such as closed cell, adhesive backed foam.
9. Attach to the window exterior using turn buttons, hooks, screws, or weatherproof tape as appropriate.

If the storm window must be removed from time to time, choose a frame design that is convenient to operate. Hinged varieties are also available. Notice that there are two mounting options, either flush with or at right angles to the window surface. The least expensive kits utilize flexible films and adhesive attachment of the frame base. Kits using rigid glazing and firmly attached bases will last considerably longer. If many windows are planned, it may be worthwhile seeking a bulk supplier. Check under the heading "Plastics-Rods, Tubes, Sheets" in the yellow pages.

- **Frameless:** A frameless storm window refers to attaching flexible plastic glazing directly to existing window frames using tape, staples, or lath. Costs are minimal (less than \$1 per square foot), yet energy performance may be every bit as good as the most expensive commercial designs. Life expectancy and appearance are the major limitations.

Most people choose 4 - 8 mil polyethylene or vinyl plastic for exteriors. For interiors, a popular choice is a very thin, transparent material known generically as polyolefin film. It is often available in kits with double sided transparent tape and can be easily stretched or heat shrunk (with a blow dryer) for a tight, wrinkle-free fit. Although tape has the advantage of forming an air tight seal, it will sometimes mar finishes when removed.

## Summary

Storm windows can make any window more energy-efficient and comfortable by reducing heat loss and drafts. Attractive and permanent installations can improve the value of your home. Other benefits are reduced condensation, maintenance, and noise. Numerous materials and styles that can fit practically any home decor and budget are available. If existing windows require major repair, however, consider replacement with insulated (sealed) glass units.

Before undertaking any window improvement project, closely examine the condition of your present windows and how you use them. Do all windows need improving? What is the overall best solution? Do-it-yourself projects require careful assessment of skills.

Consult home repair manuals or materials suppliers for detailed assembly information. Commercially installed storm windows require competitive contractor bids and checking of references. Be sure you understand all warranties for both materials and labor. Other window treatments, including sun shades and insulated window covers, are discussed in related WEES publications.

Written by Jack Brautigam

## Suggested Reading

- "High Performance Windows," *Practical Homeowner*, October 1987, Rodale Press, Emmaus, PA.
- "Warmer Windows for Less," Kukula, K., *New Shelter*, October 1984, Rodale Press, Emmaus, PA.

## WEES Publications

- Insulated Window Covers*, (FS-1104)
- High Performance Windows*, (UD-1501)
- Solar Shading Options*, (UD-2301)
- Preventing Condensation on Metal Window Frames*, (TN-1103)

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