# Anacortes Historic Preservation Board

## Keep Warm and Keep Those Windows!!

### Basic Principles of Keeping Warm

The basic principles are:

1. Lots of air spaces – the more air spaces the better.
   This is how insulation works – lots of little air spaces;

2. Sealing
   The effect of insulation is defeated if air leaks around it.

**For windows**, these principles mean that you want to have more than one layer of glass which can be easily done by adding a storm window[ea]. More importantly, storm windows will also eliminate air leaking around window frames,[1] especially if the storm window is fit with a simple, inexpensive weather stripping seal similar to your front door[2]. And don't forget that window treatments (cellular blinds and draperies) create more insulating air spaces and also help to further reduce heat loss

Building energy loss is gauged by U-factors. The U-factor for a single pane window is about 1.45. With a storm window, the U-factor is reduced to 0.90[b] – almost a 40% improvement. Adding a low-e film to the interior side of your windows will reduce the U-factor of your windows to about 0.60 representing a total improvement of almost 60% and render your old window very nearly as energy efficient as an expensive, modern replacement. These films are inexpensive and available in static cling versions so that the film can be easily applied and removed. If your old house was built before 1940, the window frames (and the whole house, in fact) are made of the highest quality old-growth wood that is nearly impossible to buy today. So why would you replace these when you can simply add a storm window and a low-e film to get the same benefits to your comfort?

Even though dramatic improvements in the U-factor of the glass alone can be 60%, windows represent only about 5% of the surface area of your house. In terms of energy conservation and return on your investment, you should fix a number of other things first.

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[1] If you don't care about opening the windows, they can be sealed for mere pennies by caulking them shut.
[2] Even though storm windows are customarily put on the exterior, it is actually better to place them inside because this will eliminate any possibility of condensation in the window.

## Plug Those Air Leaks!

Experts[cdefg] tell us that eliminating air infiltration is the first order of business and that air leaks can be fixed by inexpensive improvements any do-it-yourselfer can do. The most important are gaps around pipes, ducts, and electrical chases that pass through the floor into an unheated space, through the ceiling into the attic and through walls. Seal these with caulk or aerosol foam insulation. Likewise, caulk all the baseboards[3]. The leaks we tend to notice as drafts are typically less important, but can also be easily eliminated for very little cost. Seal the electrical junction boxes of outlets[4], wall switches, and lighting fixtures; seal doors to the outside, including the accesses to the attic and an unheated basement, with weather stripping. Also, seal the joints in your heating duct work[h5] and cover it with insulation that has an R value of at least 6.

If your house has a fire place, at least make sure the damper closes tightly. The very best thing would be to seal the firebox with a glass screen, or install an insert and duct outside air to the firebox for combustion[d]. Then no air from the living space is being "leaked" up or down the chimney.

## Add Insulation

Having sealed your old house, it is appropriate to add insulation and to talk about R ratings and U-factors[ij]. The U-factor is a gage of the amount of heat energy that flows through a unit area of building material per unit time when there is a unit of temperature difference from one side to the other. Here, in the US, the U-factor is in units of BTU per hour per degree Fahrenheit, per square foot. We could calculate the furnace capacity needed to heat your house if we knew its total U-factor: for Anacortes we would multiply that total U-factor by the (70°F – 24°F =) 46°F temperature differential defined by the Washington State Energy Code[k] and by the total wall, ceiling and floor area of your house. However, we are going to talk only about changes to the insulation of your house here, in Anacortes. So there is no need to always multiply by 46°F. Likewise, for our purposes, we don't need to know the exact dimensions of your house. There is enough data to know that the total outside wall area of a one-story house will be about the same as the living area floor and the ceiling area. The exact numbers for your house will be somewhat different but still close to this.

Give or take, the U-factor for the ceiling, floor and outside walls of your old house with no insulation is 0.5 BTU/(hr-°F-ft$^2$)[l]:

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[3] And crown moldings if any. There may be gaps in the wall-ceiling plaster corner hidden beneath just like behind the baseboards.
[4] Just about any hardware store has easy-to-use kits for sealing outlets.
[5] Use a modern metal tape or mastic NOT duct tape which will rapidly deteriorate.

| | | | |
|---|---|---|---|
| 1. | U-factor of the ceiling | 0.5 | area = 1 unit of the living space square footage |
| 2. | U-factor of the floor | 0.5 | area = 1 unit of the living space square footage |
| 3. | U-factor of the outer walls | 0.5 | area = 1 unit of the living space square footage |

So the total U-factor is just the area weighted sum. Since we are approximating these areas being equal we simply add the U-factors for the three: 0.5 + 0.5 + 0.5 = 1.5[6]. Again, if we want to estimate the needed heating capacity we would multiply 1.5 by your square footage and by the 46°F temperature differential for Anacortes.

Actually this isn't quite right because of the windows in the outer walls. The windows probably represent about 15% of the outer wall area[d]; the 0.5 U-factor would only apply to the 85% of this area that isn't a window. So, with the vintage single pane glass windows the outer wall U-factor is 0.64. Adding storm windows and a low-e film brings the U-factor back to roughly 0.5:

| | | | | | |
|---|---|---|---|---|---|
| U-factor of the outer walls: | 0.85 x 0.5 | + | 0.15 x 1.45 | = 0.64 | vintage window only |
| with storm and low-e: | 0.85 x 0.5 | + | 0.15 x 0.60 | = 0.52 | |

If we start with an uninsulated house, there is little benefit to altering or replacing the original windows beyond eliminating drafts. The whole-house U-factor was 1.64; after adding storm windows and low-e film to the inside, the house U-factor is 1.5 – an improvement in your heating bill of only about -8.5%.

### In the Attic

There is, however, a lot of bang for the buck by blowing insulation into your attic. The Washington State Energy Code[d] requires R38 or better attic insulation (R30 for cathedral style ceilings) in new houses. R38 can be achieved with 10 inches of cellulose (a recycled paper product) or 13 inches of rock-wool that can be easily installed in the attic of your old house[7]. Because the U-factor corresponding to R38 is 1/38 = 0.026. This will reduce the energy consumption by roughly 30%:

| | Before | After | |
|---|---|---|---|
| U-factor of the ceiling: | 0.5 | 0.026 | R38 insulation added in the attic |
| U-factor of the floor: | 0.5 | 0.5 | |
| U-factor of the outer walls: | 0.64 | 0.64 | |
| Total | 1.64 | 1.166 | $\frac{1.166 - 1.64}{1.64} = -0.289$ |

[6] A two-story house would have a twice the exterior wall area, so the total U-factor would instead be 2: 0.5 for the ceiling, plus 0.5 for the floor, plus 2 times 0.5 for the walls.

[7] A do-it-yourselfer could do this for less than $700 in a house of 1,800 square feet of livable space.

### Under the Floor

Insulating the floor over a crawl space or unheated basement is a similar large area through which heat is lost. Floor joists are probably deep enough to allow R30 batting to be installed, consistent with the Washington State Energy Code requirements for new homes.

| | Before | After | |
|---|---|---|---|
| U-factor of the ceiling: | 0.5 | 0.026 | R38 insulation added in the attic |
| U-factor of the floor: | 0.5 | 0.033 | R30 insulation added under the floor |
| U-factor of the outer walls: | 0.64 | 0.64 | |
| Total | 1.64 | 0.599 | $\frac{0.599 - 1.64}{1.64} = -0.635$ |

### In the Outside Walls Is Difficult

Short of demolishing the interior wall plaster or removing all the exterior siding, it is possible to either pour in cementitious[m8] foam or blow in another material to insulate outside walls[n]. It will be necessary to bore at least one and maybe as many as three 2-inch holes between every pair of studs to insert the insulation[op9]. This is definitely a job for skilled professionals and not a do-it-your-self project. Depending on the choice of material, R11 to R18 (U-factor 0.091 to 0.055) can be achieved in 2x4 studded walls.

## Percentage of What?

Notice how naïve comparisons of percentages can create serious misperceptions about energy efficiency improvements. If we added both the attic and floor insulation at the same time, we would find our heating bill to be only about 1/3rd of what it originally was – probably a nice return on the investment. On the other hand, if we added the attic insulation in one year and then the floor insulation the next, we would see our heating bill shrink by a little less than 30% in the first year. In the next year we will find that adding the floor insulation cut our bill in half again

$$\frac{0.559-1.166}{1.166} = -0.52,$$

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[8] Special low-expansion foams are available for this. Though likely to be the most expensive insulation material, it will do the best job of completing sealing your outside walls.

[9] This is after temporarily removing up to three clapboards or a siding shingle at each hole, say. Then the original siding pieces are replaced over the blocked holes in the exterior sheeting.

possibly giving one the mistaken idea that the R30 floor insulation was more effective than the R38 attic insulation. But, this is just numerical magic that is just because we changed our cost basis[10]. The total energy saving is the same in the end. The fact is that less energy is transmitted though the R38 ceiling than through the R30 floor. We get erroneous ideas by naively comparing a 30% and 50% without asking ourselves, "percentage of what?"

This is how people are misled by window manufacturer claims that their expensive low-e replacement windows can save 30% or more of your heating bill. Recall that we previously showed that window improvements will decrease your heating bills by well less than 10% if your house doesn't have any insulation. If your house already has R38 attic insulation and R30 insulation under the floor, adding storms and low-e film could give another incremental 15-plus% reduction, but it is still the same window energy flow that was a very minor part of the original total.

| | Before | After | |
|---|---|---|---|
| U-factor of the ceiling | 0.026 | 0.026 | R38 insulation added in the attic |
| U-factor of the floor | 0.033 | 0.033 | R30 insulation added under the floor |
| U-factor of the outer walls | <u>0.642</u> | <u>0.515</u> | add storm or double pane + low-e |
| Total | 0.701 | 0.574 | $\frac{0.574 - 0.701}{0.701} = -0.182$ |

## Keep Those Windows!

As we said in the beginning, replacing your vintage windows is about the last thing you should consider doing to "green up" your old house and ought to be considered only if they are seriously damaged or deteriorated from neglect. Otherwise there is no economic reason to replace them. For mere pennies you can caulk your windows shut to eliminate drafts. Or you can add storms and low-e film and have virtually the same thermal performance as the best replacement windows.

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[10] Then that season's rate (represented by a total U-factor value of 1.166) would become our cost basis for the next year when we look for the benefit of adding the floor insulation

## References and further information[11]

[a] Secretary of the Interior's Energy Efficiency guidelines, http://www.nps.gov/history/hps/TPS/tax/rhb/energy01.htm
[b] Table 1006 of the Washington State Energy Code, http://apps.leg.wa.gov/wac/default.aspx?cite=51-11-1006
[c] Coloradoenergy.org
[d] Washington State Energy Code Builders Field Guide, http://www.energy.wsu.edu/code/
[e] Weatherization of Historic Buildings (King County), http://museum.cityofanacortes.org/AHPB/documents/T25_FAQs_About_Weatherization.pdf
[f] Coloradoenergy.org Home Energy Checklist, http://coloradoenergy.org/tips/homeowner/hec/default.htm
[g] http://www.rehabadvisor.pathnet.org/sp.asp?id=9478
[h] Duct sealing from Energy Experts, http://vimeo.com/channels/energyexperts#8129040
[i] US Department of Energy Insulation Fact Sheet, http://www.ornl.gov/sci/roofs+walls/insulation/ins_06.html
[j] Reference Table for "U" Values, http://www.combustionresearch.com/Infra-Spec/infra-spec/uvalue.html
[k] Energy Savers: Air Sealing an existing home, US Department of Energy, http://www.energysavers.gov/your_home/insulation_airsealing/index.cfm/mytopic=11240
[l] coloradoenergy.org/r-values
[m] http://www.fomofoam.com/existing_homes.htm
[n] http://www.bobvila.com/HowTo_Library/Insulating_Old_Homes_Blow_In_Insulation_Options-Insulation-A1781.html
[o] http://www.nesbuildingsolutions.com/retroseal.htm
[p] http://www.affordablecomfort.org/images/Events/22/Courses/841/MAM14_Karg_InsulatingExisting_HmesWalls_sec.pdf

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[11] These references are cited for information purposes only. No product endorsement or recommendation is implied or should be inferred.