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Home Conservation

WASHINGTON STATE ENERGY OFFICE

Washington Energy Extension Service

Wise Use of Resources Through Education

The Energy Efficient House

INTRODUCTION

Since the mid 1970s a new construction technique has become increasingly popular with progressive, energy-conscious builders in the residential housing industry. Responding to the rapid rise in home heating costs, these builders have dramatically increased levels of insulation and tightened the building's shell against penetration by outside air. The result is a house which requires 30-50 percent less heat and will be more comfortable, quieter, and cleaner.

WHAT MAKES AN ENERGY EFFICIENT HOUSE

Higher levels of insulation;
Less air leakage;
Controlled ventilation; and
Better doors and windows.

DOES AN ENERGY EFFICIENT HOUSE COST MORE

In terms of initial costs, the energy efficient house could cost 2-10 percent more. Once operating costs (reduced heating bills) are figured in, however, the energy efficient house becomes the more cost effective option. Other factors that may be hard to assign a dollar value to, such as increased comfort and a quieter, cleaner house, should not be overlooked when comparing the costs of an energy efficient house to other houses.

HIGHER LEVELS OF INSULATION

Insulation is measured in R-values. The higher the R-value, the better the material is at stopping the flow of heat. The more insulation that is put in the walls, floors, and ceiling of a house, the less heat it will take to keep that house warm. The optimal amount of insulation installed depends on the climate, how well the house is to perform, and the cost of energy. Historically, older homes had no insulation in the walls. Then starting in the early '60s the walls were insulated with an R-11 material. Now the standard is R-19, with a lot of builders going to an R-25 or higher. This increase in R-value reflects the rising cost of energy and the desire to have a more comfortable and efficient house.

Walls

How does one achieve a higher R-value in the wall? Since the R-value of a material is based on it's thickness, the more inches of material installed, the higher the R-value. To go from an R-11 wall to an R-19 requires making the wall thicker. This is most often done by stepping up from a 2x4 stud to a 2x6 stud. By using the larger size lumber, roughly two more inches of insulation can be installed.

Along with using larger studs, the R-value can be increased by using less lumber and more insulation. A common term for this technique is *advance framing*. Larger studs (2x6) are placed further apart, 24 inches on center, as opposed to 16 inches on center. The technique also involves changing framing details at corners and where partition walls intersect to use less lumber and, where possible, using insulated headers instead of solid wood headers.

Another way to increase the R-value of the wall is to install a rigid board insulation on either the exterior or interior of the wall. The insulation board not only adds more inches of insulation but also covers the wood framing members which have a very low R-value.

2x4 wall w/ R-11 fiberglass	= R-11
2x4 wall w/ R-11 fiberglass and 1 inch rigid board	= R-16
2x6 wall w/ R-19 fiberglass	= R-16
2x6 wall w/ R-19 fiberglass and 1 inch rigid board	= R-21

Floors

The first determination to make is when to insulate a floor and when not to. If the floor is over an unheated space it should be insulated. The level of insulation depends on the type of floor. Concrete slab floors require a different type and amount of insulation than a wood floor.

Since a concrete floor usually rests directly on the ground it does not have to be insulated to as high a level as a raised wood floor. This is because the soil under the concrete does not change temperature as much as air does. With this in mind most concrete floors are insulated to R-10. It is important to note that the insulation does not have to be under the whole floor but should extend completely around the perimeter and in toward the center of the slab about two to four feet. Care should be taken to insure that the slab edge is insulated also. The most commonly used material for slab insulation is extruded polystyrene. The extruded polystyrene is not as susceptible to moisture as other foam board products.

Insulating a raised wood floor is very much like insulating a wall. The types and amounts of insulation used are very similar. The raised wood floor should be insulated to at least R-19. The insulation can be placed directly under the floor between the floor joists or can be placed against the perimeter walls of the crawlspace. The decision as to where to put the insulation depends on several items. Are there heating ducts and water pipes in the crawl space that need to be kept warm? Is the soil under the house very damp, or does the area have high radon levels so that underfloor ventilation becomes a major issue? If heating ducts and water pipes run through the crawlspace, insulating the crawlspace

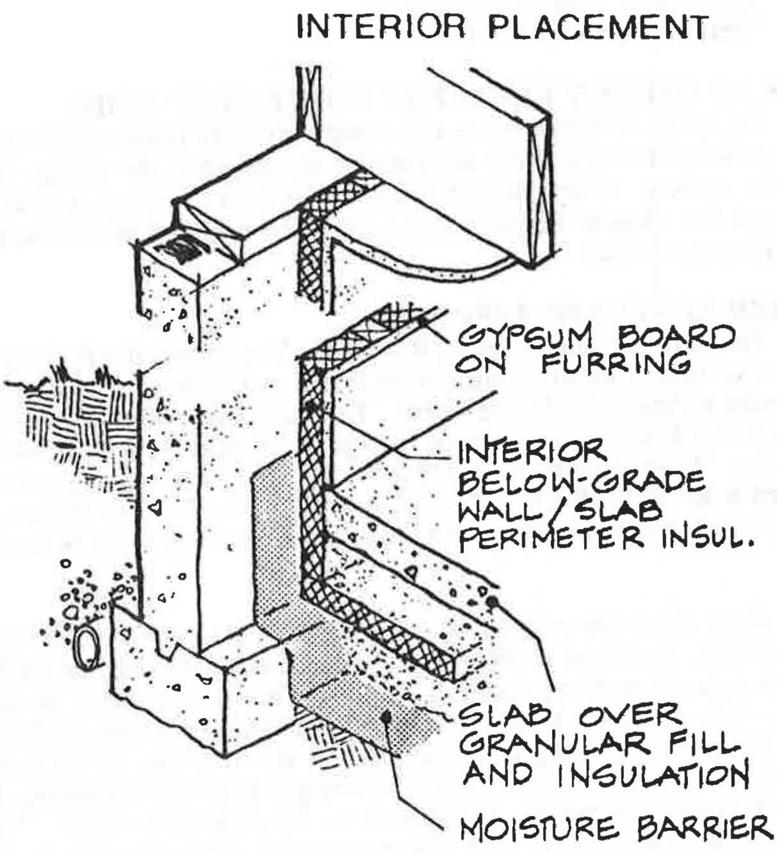


Figure 1. Slab Insulation

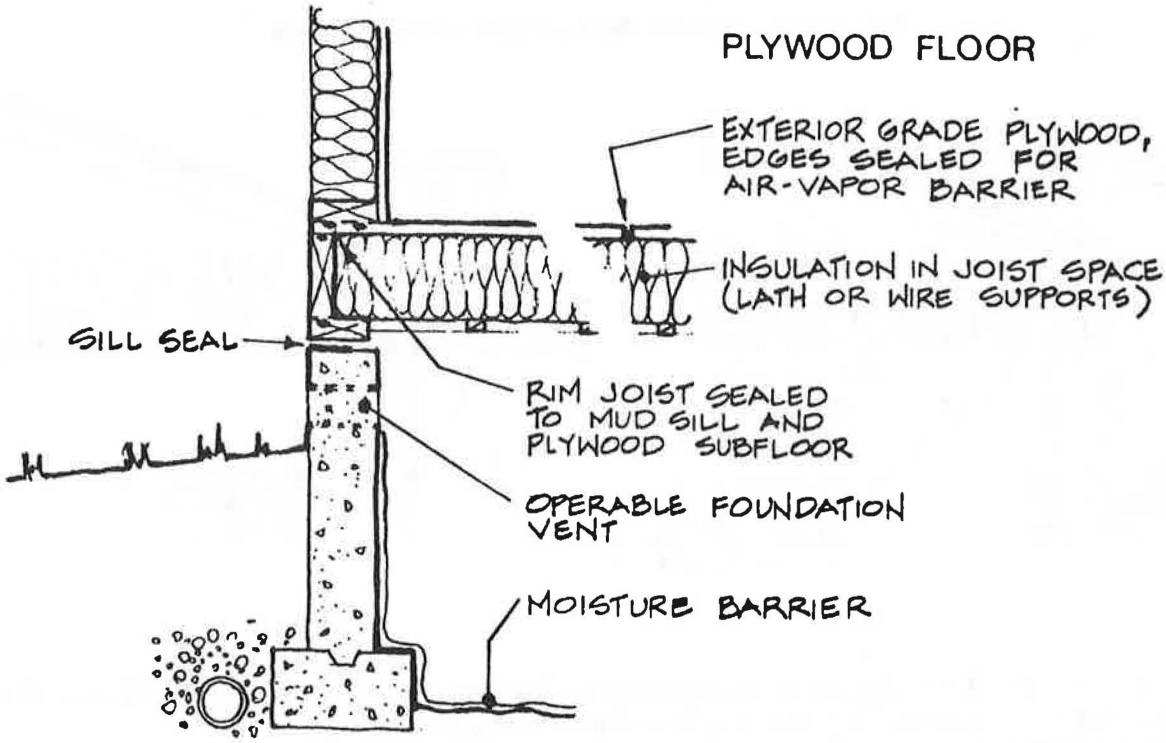


Figure 2. Crawlspace Insulation

wall will help to keep those items, as well as the floor, warmer. This may interfere with underfloor ventilation, however. Installing the insulation directly under the floor allows for ventilation but does not help ducts or pipes.

In all cases the pipes and duct work located in an unheated crawlspace should be insulated and any exposed dirt should be covered with plastic to keep moisture levels down. A black 6 mil thick product is recommended. If the insulation is installed between the floor joists, the crawlspace should be vented to the outdoors. If the insulation is installed on the walls, the crawlspace space should not be vented except in the summer. The ventilation should consist of at least two opposing vents with a net free vent area of one square foot of vent for every 150 square feet of crawlspace floor area. The term net free vent area refers to the amount of air that can be moved through a vent once the screens and louvers have been accounted for. For this reason a one square foot net free vent will measure larger than one square foot

Ceilings

Historically, insulating buildings started with attics or ceilings. The difference now is the level of insulation being installed. While older houses will have 3-4 inches of insulation (about R-9 - R-12), a new energy efficient house will have 9-15 inches of

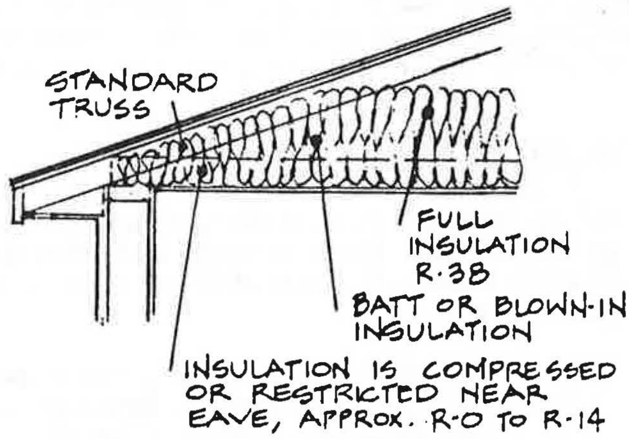
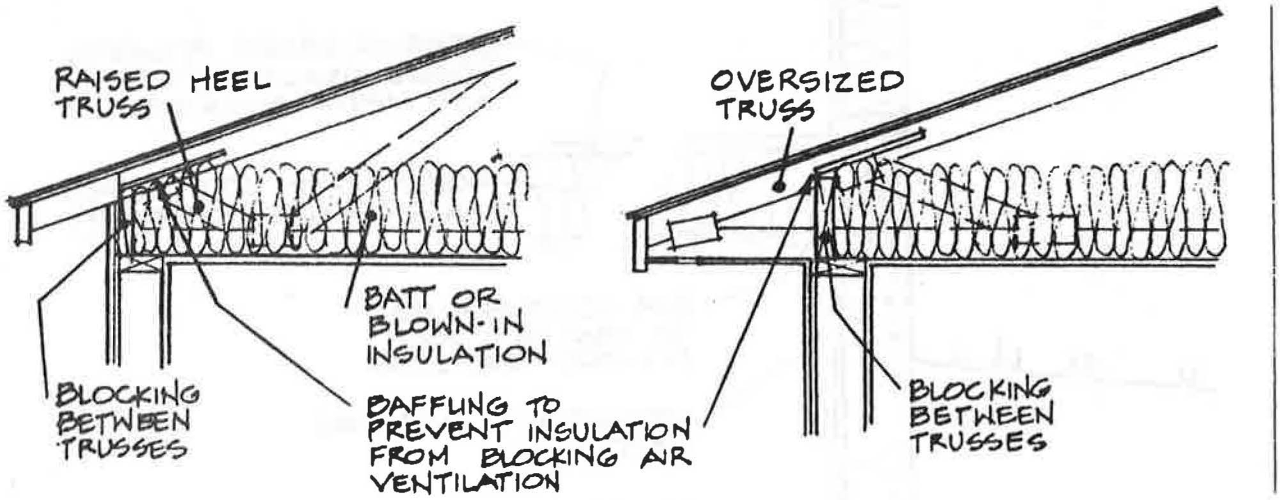


Figure 3a. Standard Truss

Figure 3b. Raised Heel and Oversizes Trusses



insulation or R-30 - R-50, depending on the type of insulation used. These higher levels of ceiling insulation lead to a couple of adjustments in how the ceiling is put together.

In a vaulted or cathedral ceiling the framing members have to be large enough to hold the insulation and allow an air space for ventilation. A minimum 1 inch air space is required. Since this could involve a very large framing member it is often done by using a scissor truss.

In a situation where there is an attic space it is usually easy to get enough insulation in place. The one problem spot is the outer edge where the rafter or truss sits on the outside wall. In a standard case there would not be room to put in the 12-15 inches of insulation. One solution is to use an over sized truss or *raised heel truss*. An over sized truss has the top and bottom chords come together out past the exterior wall. By doing this there is now enough room for both the insulation and ventilation.

As has already been mentioned, the space above the insulation in either the vaulted or attic situation has to be vented. This ventilation reduces summer heat buildup and prevents moisture problems in the winter. The vents need to be divided half up high on the roof and half down low. An example of this might be a continuous ridge vent working with continuous soffit vents. If there is a vapor retarder system in the ceiling, then one square foot of net free vent area is needed for every three hundred square feet of attic floor. With no vapor retarder the vent area should be doubled (one square foot of net free vent area for every one hundred and fifty square feet of attic floor area).

LESS AIR LEAKAGE

The next step in the energy efficient house is to control the escaping of warm air and the entering of cold air. Sealing the house up from unwanted air leaks not only makes a major difference on the energy consumption, but also plays an equally important role in improving the comfort level. By stopping this uncontrolled flow of air the house becomes virtually draft free. Air leakage is controlled in a number of ways.

1. Attention to detail as the pieces are being fit together;
2. Sealing around doors, windows and other penetrations that go through the exterior walls;
3. Installing some form of *air barrier*.

The two most common air barrier systems are a *polyethylene wrap*, and an *air tight drywall* system. With the polyethylene wrap system, a layer of poly is put up against the studs with all edges and penetrations sealed. Then the sheetrock is installed and the air leakage is reduced to a minimum. The air tight drywall system involves installing gaskets or sealants between certain framing members and sealing the sheetrock to the framing members there by reducing air leakage.

Because it is important to keep insulation dry and because the major source of problem moisture is from inside the house a vapor retarder should also be installed. This vapor retarder is always placed on the warm side or living side of the insulation. In the case of the poly wrap the vapor retarder is the same as the air barrier. In the case of the air tight drywall the sheetrock is sealed with a vapor retarder paint and a combination air/vapor retarder is created.

One technique used to insure good air leakage control is to test the house as it is going together. By using a device called a fan door, the house can be pressurized or depressurized. The house is then inspected with a smoke stick which will point out unwanted air leaks. These leaks can then be sealed up before they are lost behind sheetrock.

CONTROLLED VENTILATION

While sealing up the house might at first seem like a bad idea from a ventilation standpoint, it is in fact very helpful. In the past, ventilation of the house has been left up to unplanned holes and cracks in the building with little thought given as to when or where ventilation was occurring. It turns out, however, that even "leaky" older houses often have very little ventilation taking place when it is warm outside or when there is no wind blowing. This means that a good part of the time older homes are receiving little or no ventilation. By sealing up the leakage points and planning the ventilation, the energy efficient house is assured of having the right amount of ventilation at the right time where it is needed.

The ventilation systems in energy efficient houses take two basic forms.

1. Mechanical ventilation without heat recovery;
2. Mechanical ventilation with heat recovery.

The system should include drawing air out of the kitchen, bathrooms, and utility room while making some provision for providing make up air. The choice as to recover heat or not depends on the cost of the system and the climate. In milder climates the amount of heat saved by using a heat recovery system may not justify the additional cost.

The system should have a combination of automatic and manual controls. Typically, the automatic control will be either a time clock which turns on the system at certain times of the day or a humidistat which turns the system on when the moisture level in the house gets too high. The owner should also have manual controls which allow them to turn the system on, off, or to a higher speed as needed.

Along with installing some type of ventilation system to control indoor air quality, control also has to be maintained over the products which are used in the house. One of the best ways to prevent an indoor air quality problem is to not introduce pollutants into the house to begin with. Some examples of this would be avoiding the use of products that contain formaldehyde, airing the house out before moving in, so fumes and moisture left over from construction will be reduced. Control has to be exercised even after moving in. Bath and kitchen exhaust fans should be used, and hobbies or activities that produce fumes should be done in areas with sufficient ventilation.

BETTER DOORS AND WINDOWS

Doors in an energy efficient house should have both a higher R-value than older standard doors, and a good weatherstripping package to prevent air leakage. One example of a higher quality door would be a metal, wood, or fiberglass clad door with a foam core. The foam core raises the R-value of the door to a range of R-8 - R-12 compared to older solid wood doors (about R-2).

Because windows are such poor insulators (R-1 for single pane glass, R-2 for double pane glass), careful consideration has to be given to their use in the energy efficient house. There are four areas that should be studied when dealing with windows.

1) window orientation;
2) amount of window area;
3) type of glazing;
4) frame details.

Window Orientation

Due to the high heat loss of windows, the goal should be reduce the number of windows used. Also, it is important to place the windows so that they will help heat the house. The best way to do this is to locate the majority of the windows on the south side, while minimizing the windows on the north, east, and west. This will not only allow the sun to provide additional heat, but will help to prevent over heating as well. Care should be taken to position the windows so that the rooms will be comfortable from a lighting standpoint and meet code requirements.

Window Area

This is one decision where smaller is better. As mentioned earlier windows are a major source of heat loss due to their low R-value. The best way to counter this problem is to minimize the overall amount of glass that is put into the home. As a rule of thumb the glass area should run about 10 percent of the floor area. This compares to a conventional home which runs about 15 to 20 percent. While these numbers may seem low when compared to solar houses of the past it is important to remember that because the house is being built better it will require less heat which means it can afford to capture less sunlight. As to whether the house will be dark depends more on the placement of the windows than the amount of window area.

Glazing Type

Glazing is the term used to describe the transparent material used in the window. Typically glass or plastic. The decision here involves number of glazing layers and type. The minimum choice would be a plain double glazed window, which would yield an R-2. The next step up could be either a triple glazed window or a double glazed low-e window, both around R-3. Low-e refers to a manufacturing process which enables the window to retain more heat inside the house. The R-value not only depends on the number of glazing layers but also on the air space between the glazing layers. A spacing of 1/2 inch to 3-1/2 inches is recommended. One advantage of going to a higher R-value window is that more window area can be put in the house for views and daylighting without increasing the heat loss.

Frame Details

Common frame materials are wood, vinyl, metal, and fiberglass. Like other parts of the window, the R-value of the frame varies between materials. Wood, vinyl, and fiberglass are about the same, and metal much lower. The one exception to this would be an insulated metal frame. Insulated metal frames are usually referred to as thermally improved frames. Not only will an insulated metal frame achieve a higher R-value than a plain metal one, but it will also help to reduce condensation. Along with the frame material it is important to look at the weatherstripping and check to see if the window has been tested for air leakage.

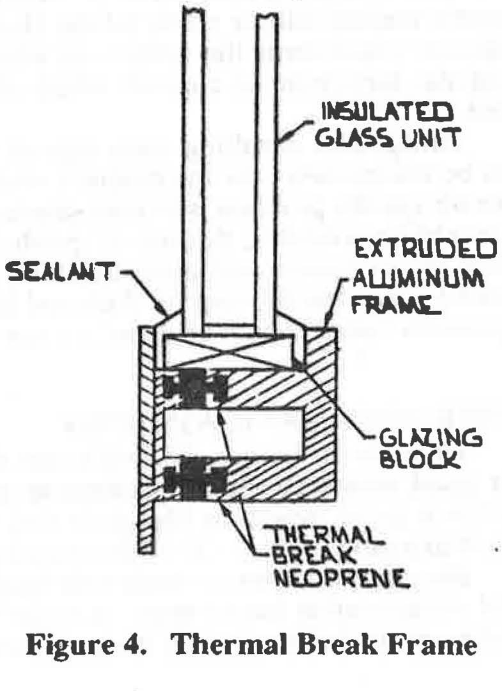


Figure 4. Thermal Break Frame

HEATING, LIGHTING, AND APPLIANCES

Since the energy efficient house will use less heat than a conventional one, care should be taken in choosing a heating system. The two important issues to consider are size of the system and controls. While undersizing the heating system will lead to comfort problems during cold periods, oversizing can cause both discomfort and a loss of efficiency. Heat loss calculations should be done to insure that the right size system is installed. Having the ability to control the temperatures within different rooms in the house will also lead to higher levels of comfort and lower heating bills.

Because of the reduced heating load it's important to realize that lighting and appliances are now going to play a larger part on the overall energy performance of the house. Taking the time to lay out and choose an efficient lighting system will help to keep the house working as an efficient unit. Examples would be using task lighting, and fluorescent lighting along with multiple switches to achieve acceptable levels of light while reducing energy consumption.

Choosing energy efficient appliances will also contribute to an overall lower energy bill. Reading the energy guide label on refrigerators, dishwashers, washing machines and hot water heaters will help in picking the most efficient. The hot water heater, being the largest energy consumer of the appliances demands the most attention. Consider where the tank will be in relation to where the hot water is used, and choose a tank that has a higher R-value to reduce losses. Also setting the tank on an insulated pad will help reduce heat loss. Insulate hot water pipes and install low flow shower heads and faucets.

SUMMARY

Since no one knows for sure what future energy prices or supplies will be it would seem to make good sense to design and build a house that uses as little energy as possible. By increasing the levels of insulation, controlling the air leakage, and paying attention to doors and windows, new houses can be both efficient and comfortable to live in.

Written by Chuck Eberdt and Edwin Valbert.

SUGGESTED READING

Air Vapor Barriers, Eyre, D. and Jennings, D., Energy, Mines, and Resources Canada, Energy Conservation and Oil Substitution Branch, 580 Booth Street, Ottawa, Ontario, Canada, K1A OE4. 1983. 84 p. A good, detailed discussion of how to use polyethylene for a vapor barrier. Duplicated, at least in part, in many of the other Canadian works.

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Low Energy Home Designs: Design Guidelines and Plans for Energy Efficient Housing, Alberta Agriculture, Print Media Branch, 9718 107 Street, Edmonton, AB, T5K 2C8, 1982, 94 p.

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Superhouse, Metz, Don, Garden Way Publishing, 1981. Very light on superinsulation. As Metz is an earth shelter designer he has his biases, but this does several single chapter overviews of various styles of housing.

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The Superinsulated Home Book, Nisson, J.D. and Dutt, Gautam, John Wiley and Sons, 1985.

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Superinsulated Houses, Shurcliffe, William A., 19 Appleton St., Cambridge, MA, 02138, 1980. Shurcliffe was an early advocate of Superinsulation. This is his basic discussion of it. Often bound with *Double Envelope Houses*.

The Superinsulated Retrofit Book, Marshall, Brain, Robert and Argue, Renewable Energy in Canada, 1981. Very complete, but somewhat redundant, discussion of how to convert an older home to a superinsulated one.

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