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Washington Energy Extension Service

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HOME INSULATION

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Since the mid-1970's, consumers in the United States have experienced continuous, sometimes sharp, increases in the cost of energy used to heat their homes. Many homeowners have taken low-cost energy conservation steps, such as do-it-yourself caulking and weatherstripping, home-built storm windows, heating system tune-ups, and made a good savings on their heating bills. Another wise energy investment is increasing the levels of insulation in the home. Depending on which part of the home is insulated, this investment may pay for itself in as little as three years, and continue to yield a savings on the heating bill for years after. Since every home is different, each will require careful scrutiny to determine whether adding more insulation is worth the expense.

Basics of Heat Transfer

Understanding how heat moves will make the benefits of adding insulation easier to understand. Heat moves in three ways: conduction (by contact), convection (by a carrying fluid such as air or water), and radiation (by electromagnetic waves). When heat is lost from a house, all three of these processes are in action. The measure of the movement of heat through a given material is often called its conductance, but thermal transmission may be a less confusing term since heat can move through some materials by radiation and convection as well as by conduction. The thermal transmission, or U value, is a measure of how many units of heat (Btus) pass through a given thickness of a square foot of the material in an hour, at a certain temperature difference.

The ability of a material to resist heat flow, or to insulate, is indicated by its R value. The higher the R value of material, the better an insulator it is. The R value is the inverse of the U value. That is, R = 1/U, and U = 1/R. This is important because, while insulations are compared by R values, some charts may list only the U value of a particular building material. When different materials are combined, as in the wall of a building, all the U values must be changed to R values before the total R

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MOST COMMONLY USED INSULATIONS

INSULATION	MADE FROM	PACKAGING	R VALUE PER INCH	VAPOR BARRIER EFFECTIVENESS	WHERE USED	MATERIALS COST (DIY) PER R VALUE PER FT²*
Mineral wool: fiberglass	strands of molten glass	batts to 8' blankets to 70' 14½" or 22½" wide 1" to 13" thick	3.0 to 3.8	depending on sealing of facing--fair at best	attics/ceilings, floors, and walls	1.6¢ (1.3-2.3)
		bags of loose fill	2.44	unfaced--not a vapor barrier	attics/ceilings--sometimes blown in walls	blowing wool must be contractor installed
		rigid boards	4.0		on roof sheathing	11¢; usually sold only in large quantities; contractor installed
Rock wool	strands of molten rock or slag	batts and blankets bags of loose fill	3.17 3.1	same as above	same as for fiberglass; rock wool is especially good for stuffing between framing and chimneys	3.3¢ (1.5-4.3)
Cellulose	ground up wood fiber or recycled paper	30 pound bags of loose fill	3.2-3.7	not a vapor barrier	attics/ceilings--often blown in walls	1.2¢ (1.1-1.4)
Rigid Foams:						
expanded polystyrene (EPS or "beadboard")	petrochemicals are expanded into beads then molded into boards	usually 2' x 8' or 4' x 8' panels 3/4" to 6" thick	4.0	poor (varies some with density)	attic/ceilings, floors, walls. Single best application may be interior of basement or foundation wall	4.8¢ (3-8.7)
extruded polystyrene	expanding petrochemicals extruded into boards	usually 2' or 4' by 8' or 9' boards 3/4" to 2" thick	5.0	good	Same as above. Often used for exterior of sheathing. May be best insulation for underground application.	6.2¢ (5-9)
polyurethane and polyisocyanurate	same as extruded polystyrene but faced with foil or paper	4' x 8' or 9' boards; 1/2" to 3" thick	6.5-7.2	with foil face--good, otherwise poor to fair	Most often used on exterior sheathing. Can be used on floors and walls.	5.7¢ (4.6-6.7)
Perlite or Vermiculite	expanding silicate rich minerals by heating to about 1000°C.	usually bags of loose fill; perlite boards used commercially	2.2 or 2.7	not a vapor barrier	Less common today as attic/ceiling insulation. Vermiculite may quickly become too heavy. Best suited for cores of concrete blocks and for relining chimneys	NA (perlite) 8¢ (vermiculite)
Reflective foil	aluminum foil and paper, foil and bubble plastic	30' or 60' rolls 16" or 24" wide 1-4 layers 4' x 75' rolls	5-19 (varies with location and direction of heat flow)	good if well sealed	attics/ceilings and walls, but best R achieved in floors	$.42/s.f. (bubble plastic and foil)

* unit price averaged over various thicknesses and costs. (Figure) = cost range found, Seattle, 3/83

value of the wall can be determined. While R values can be added to get a total, U values cannot.

It is also helpful to note that heat always attempts to reach equilibrium. This means that heat always moves toward cold, and will take the path of least resistance. How fast heat will travel from one area to another is directly related to the difference in temperature between the two areas. For example, twice as much heat will be lost from a 70 F house on a day when the outside temperature averages 0 F, as on a day which averages 35 F outside. Because the temperature difference is twice as great, heat escapes twice as fast, all other factors being equal.

Materials Used for Insulation

Most insulations get their R value by creating millions of dead air spaces to slow the conduction of heat. Some insulations attempt to reduce the radiant heat losses by using reflective material. The chart on the following page lists the most commonly used insulations and some important details about them. For more detailed information, check the sources listed in the bibliography.

Safety

Because the insulation becomes part of the building system, fire safety is an important consideration. Building codes require that such materials pass tests for how quickly they ignite, spread flame, and how much smoke they produce. This last test is important because the majority of fire related deaths are from smoke inhalation. While some insulation materials will not burn in themselves (perlite, vermiculite, fiberglass, rock wool), they may be bound together by resins or paper faces that will. Other insulations are made from petrochemicals or wood and paper products that do burn. These are usually treated with a fire retardant chemical which helps the insulation pass government specifications.

For cellulose insulation, the fire retardant should make up 20-25% of the insulation by weight. The best chemicals are boric acid and borax, but these are expensive so substitutes are often used for part of the retardant. If too much substitute is used, the cellulose may fail the smoldering tests, or become corrosive to metal it surrounds, such as plumbing stacks or electrical boxes. To prevent this, buffer chemicals can be added. Regardless, look for UL approval, and do not install any cellulose which does not have the government specification number, GSA-HH-I-515D, stamped on the bag.

In the case of polystyrene, polyurethane, and polyisocyanurate foam boards, there are important fire safety specifications for proper application. While they are treated with a fire retardant and pass the American Society for Testing and Materials tests for flame spread and smoke development, they either support combustion or will spread flame in the presence of burning materials, and they give off toxic gases when burning. As a result, building codes require that they be covered by a fifteen minute burn barrier, such as one-half inch sheet rock, when used inside a residence. Some building departments require a longer burn time, such as provided by five-eighths inch sheet rock.

Durability: Settling and Moisture Problems

Durability of the material is an important factor to consider when choosing an insulation. With loose fill insulations, this issue mainly concerns settling. All loose fill insulations will settle somewhat over time. Cellulose insulation can settle as much as 20% of its original depth. If the insulation is too fluffed when installed, it will settle excessively over time and the R value will be lower than what was intended. In 1978, the government altered the specifications to require that the coverage charts on the bags of cellulose be changed to reflect the R value of the material after it has settled. That is to say, the coverage chart will indicate how many square feet a bag will cover at a specific R value at settled density. If the chart is followed, the R value will never be less than what was intended. Homeowners should make sure that the number of bags used is correct for the square feet of area being insulated, whether the insulation is contractor-installed or owner-installed.

Settling can be caused in other ways as well. Chief among them is the absorption of water. If, for some reason, water leaks into an area where fiberglass, rock wool, or cellulose are installed, they can absorb the water and hold it for some time. Also, the added weight of the water would cause structural damage. Perlite and vermiculite will not absorb the water, but do hold it fairly well, as is evidenced by their use as plant growing mediums. When such a condition exists, the finish or structural materials next to the insulation can be damaged by staining, delaminating, or rotting.

A similar result can occur when great amounts of moisture vapor penetrate the interior finish and condense in the wall cavity, either on the inside of the exterior surface or in the insulation itself. Most vapor that migrates to the cavity probably does so because of the passage of warm house air through holes, cracks, switch plates, sockets, and the like, but the vapor can pass right through most building materials as well. If the air is cooled to the point at which the moisture can no longer exist as a vapor (the "dew point"), condensation occurs on the coolest surface. At certain outside temperature levels and indoor humidity levels, that dew point might be in the layer of insulation. Generally, this is more of a problem for the porous or fibrous insulations than for rigid foams. When permeable materials absorb water, the dead air spaces are filled and heat flows through more easily. In addition to lowering the R value, the water adds weight which causes the insulation to slump in the cavity. This leaves an uninsulated space at the top which will lose more heat than is proportionate to its area. This problem can be avoided by adding vapor barriers, providing proper ventilation, caulking cracks and holes in the interior surface of the wall, and using gaskets on switch plates and sockets.

The issues of vapor permeability and water absorption bring to mind a different consideration in regard to the rigid foam insulations. Several qualify as vapor barriers and will work well on the inside surface. Often these boards are used "below grade" or underground, on the exterior of basement or foundation walls. Here, they come in contact with ground moisture and may very likely freeze and thaw several hundred times in their lifetime. Those which absorb the least water will stand up the longest under repeated freeze/thaw cycles. The extruded polystyrene has the best rating here. The urethanes and isocyanurates get their vapor barrier rating from the aluminum foil face, and absorb more water. The expanded polystyrene foams will absorb still more. If the last three are to be used at all below ground, it may be necessary to protect them from moisture contact with something like polyethylene sheets in order to extend the life.

Vapor Barriers

One of the most difficult problems with adding insulation is providing a vapor barrier. Many people wonder just what exactly a vapor barrier (or vapor retarder) is and how important it is. A vapor barrier is any material which has a perm rating less than 1. More specifically, it lets less than one grain of moisture vapor (about a drop of water) pass through a square foot when there is a difference of one inch mercury pressure from one side to the other for an hour. Some materials that qualify are polyethylene (any thickness 2 mil or greater) and aluminum foil. Asphalted felt paper is not a vapor barrier even though it sheds water. Heavier polyethylene (6 mil) is generally used for handling strength when it is put up. It is placed on the warm side of the insulation.

The importance of the vapor barrier is difficult to discuss since the vapor and temperature characteristics of homes can be very different. As mentioned above, sealing air flow from the house to the insulated cavity may stop most of the migration of moisture and thus prevent damage. And at least one study indicates that vapor barriers may not be needed in walls with wood siding even in damp climates. Yet, one major rigid foam manufacturer strongly recommends keeping humidity levels in the home below 35% to prevent moisture problems. This can be very difficult in a moist climate like western Washington's. More work is being done on these issues, but until more is known it is probably wiser to be safe than sorry.

If the activities in a room put a great deal of moisture in the air, or if its walls or ceilings are frequently damp or wet (kitchens, bathrooms, laundry rooms, greenhouses, etc.), a vapor barrier would be wise. Listed below are several options for creating vapor barriers:

1. Polyethylene or aluminum foil

2. Foil backed gypsum board (dry wall)
3. Latex (and other) vapor barrier rated paints in the proper application
4. Three coats of good quality semi-gloss enamel (oil base) on a smooth surface
5. Washable plastic or vinyl wall paper
6. Three coats of urethane varnish on wood paneling

Moisture problems will be greatly reduced if the generation of moisture vapor is dealt with at the source. Vent bathrooms, kitchens, and laundry rooms to the outside, or, if possible, through an air-to-air heat exchanger. Make sure that areas like the attic and the crawlspace are properly vented to rid them of any moisture which might accumulate there. A general rule of thumb is that the inside surface of the wall should be five times less permeable than the outside surface. Ventilation techniques are discussed in greater detail later in this factsheet.

Installation: Where and How Much

The question of where to install insulation is not as easily answered as one might think. Basically, there are three areas to examine: 1) the attic space or uppermost ceiling, 2) the lowest floor or the basement/crawlspace area, and 3) the walls. The order in which to install insulation is really only an issue when working in an existing home. Then the cost of installing the insulation and the cost effectiveness of the installation is largely determined by the accessibility of the area. For example, in most homes the walls are likely to have greater area and net heat loss than either the floor or the ceiling. Yet, because special equipment and additional labor are required to prepare the wall, install the insulation, then close the wall again; walls turn out to be the lowest priority for upgrading insulation. While the attic/ceiling area and the floor/crawlspace area may be equal in size and accessibility, the attic/ceiling has a greater rate of heat loss. This makes it the highest priority.

Of course, there are always exceptions. If the ceiling and walls are already well insulated, the floor area is responsible for a greater percentage of the home's total heat loss. An even more important exception is when some remodeling is planned. Remodeling often provides the homeowner with an opportunity to get more insulation in his/her walls without much additional expense. If new siding or interior finish is planned, investing in some additional insulation would be a very smart move.

Insulating Attics and Ceilings

If there is room in the attic, insulation should be upgraded at least to the current code level. In Washington state, this is R 30 or R 38 depending on where one lives. If energy costs continue to rise, higher levels of insulation will be economically appropriate.

While all the blanket, loose fill, and board types of insulations have been used in attics or ceilings, fiberglass and cellulose are the most common and least expensive. The deep layers of perlite or vermiculite needed to achieve R 30 may be too heavy for the ceiling material to support. Rigid boards are usually only used where there is not enough room to install sufficient levels of less expensive insulation, such as around the perimeter where the roof meets the wall (see figure 1).

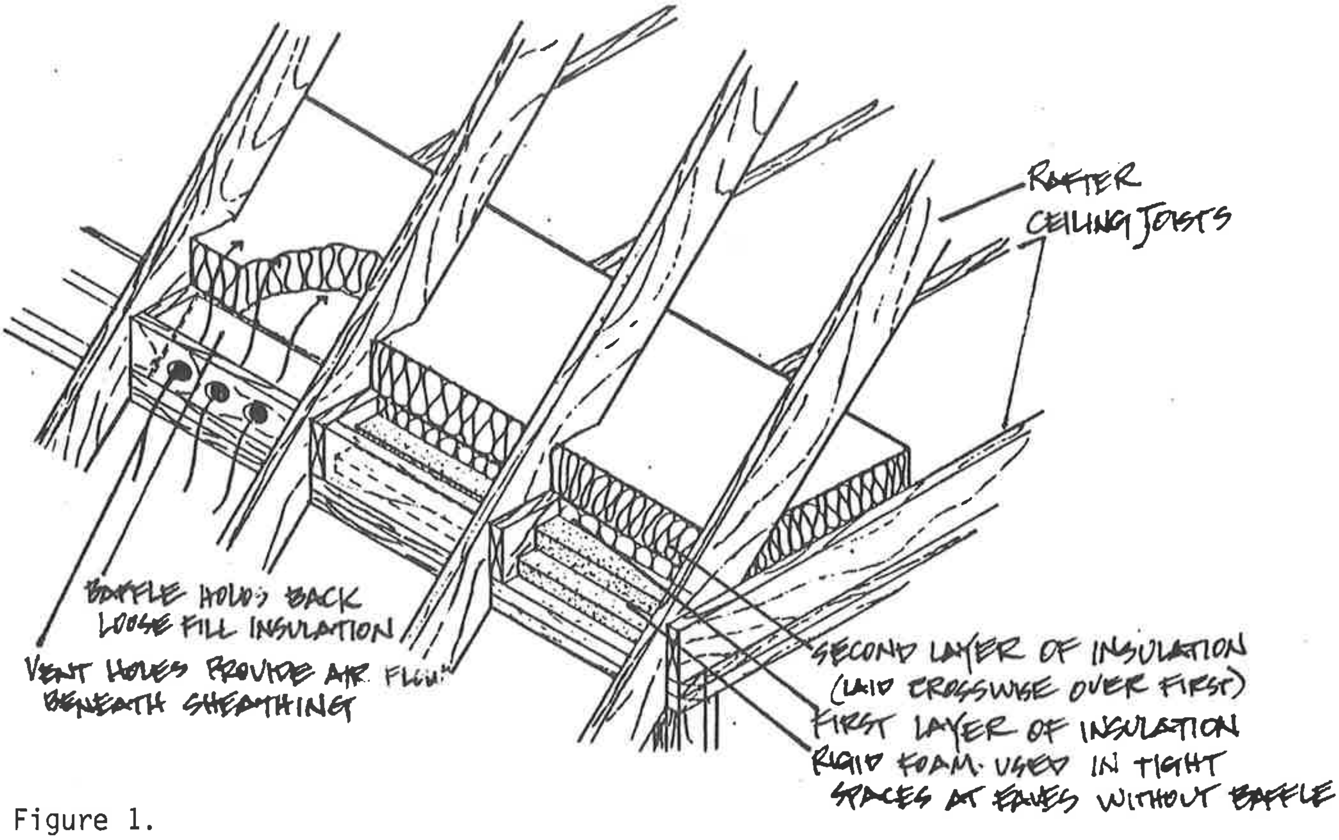

Figure 1.

Fiberglass batts or blankets are usually stapled to the ceiling joist before the finish ceiling is put up. In an existing home, the blanket is laid between the joists on top of the vapor barrier and existing ceiling. In either case, there will be a long crack along each side of the blanket where it meets the joist (see figure 1). If blankets of the appropriate width are carefully and snugly fitted, the heat lost through this crack will be greatly reduced.

If the desired final R value will require insulation deeper than the joist, installing two layers of insulation is superior to one thick layer. The second layer is put down perpendicular, or crosswise, to the first layer. This makes a more effective job for two reasons. First, there will no longer be a long crack all the way through the insulation on each side of each blanket, but only a few points where the cracks from both layers cross. Second, the last layer of insulation will also cover the joists themselves. Since wood has a lower R value than insulation, the joists are a thermal weak point through which heat leaks. Since heat will take the easiest path, both the cracks and the joists will lose more than is proportionate to the area they take up. Covering them prevents excessive heat losses from bleeding through. Loose fill insulations have an advantage here, in that they can cover everything uniformly without having to change direction as in cross-layering.

Of the loose fill insulations used in attics, cellulose is probably the most common. The chopped mineral wools or cellulose can be blown from a machine as well as poured from the bag by hand. Blowing cellulose is more common and can be done by do-it-yourselfers. The machines are often lent free or rented by stores selling cellulose. When blowing an attic space, the hardest area and area farthest from the access point should be done first. Three joist spaces are usually blown at a time, with the direction of flow parallel to the run of the joist. Make sure the machine is set properly so it won't over "fluff" the material. Whether hand poured or blown, use the coverage chart on the bag to determine the number of bags to use for a specific R value.

Because the original layer of insulation will be compressed by the weight of the additional material, the final R value will be slightly less than the sum of the two layers. For example, if a layer of R 11 fiberglass (or cellulose) is topped off by a layer of R 19 fiberglass (or cellulose), the final R value is likely to be more like R 28 or 29 than R 30. If cellulose is used, it is easy to add an additional inch to make up for the discrepancy.

Venting Attics

It is important to provide the attic space with adequate ventilation. This venting permits air to enter the space near the lowest point, flow up beneath the roof sheathing, then exit through the highest point in the roof. The air flow will not only keep the house cooler in summer, but, more importantly, will vent to the outside any condensation that might occur on the structural members or in the insulation, thus avoiding delaminated plywood, rotted rafters and joists, or soggy insulation. To insure adequate ventilation the best strategy is to combine high and low vents. That is, one-half of the total vent area should be high in the roof while the other half is divided low between the eaves. Coupling a continuous ridge vent with continuous soffit vents is most effective, but good ventilation can be achieved when gable vents or roof "jacks" are combined with short strip vents or "bird blocks" at the eaves (see Figure 1). The size of free flowing vent area is critical. Most often this is given as a ratio of vent area to floor area. Inaccuracy enters at this point because attics with different roof slopes will have different volumes for the same floor area. Ideally they should have different cubic feet per minute (cfm) ventilation rates. The minimum ventilation ratios that are commonly quoted are:

one square foot of <u>free</u> venting space for every three hundred square feet of attic floor area <u>with a vapor barrier</u> OR

one square foot of <u>free</u> venting space for every one hundred fifty square feet of attic floor area without a vapor barrier (twice as much vent space needed).

It is important to stress two facts: first, these are absolute minimums, many attics will require greater ventilation; second, screening and louvers will reduce the free vent area from the dimensions of the vent itself. The vent should be stamped with the net free area, or the seller should provide this information.

<u>Problem Areas</u>

The subject of ventilation brings to mind some problems that can occur when installing insulation. Most of these can be avoided easily.

Problem 1: If there is already venting at the eave, care must be taken not to block this with the insulation. If the soffit area is closed in (so one can't see the ends of the rafters outside where they overhang the wall), the perimeter of the attic floor space may have to be baffled to prevent insulation from spilling out into the soffit and blocking up the vents. This is particularly true with loose fill insulation (see Figure 1).

Problem 2: In other homes the top story may be built in such a way that the roofline makes up part of the side wall. In this case there may be three small triangular attic areas; one above the room and one on each side (see Figure 2). It may be necessary to cut access hatches to these areas so the ceilings and the short vertical "knee wall" can be insulated. A fiberglass batt or rigid foam board that leaves a one and one-half inch space for air flow just under the sheathing can be "snaked" in the sloped area. If a loose fill insulation is used, a cardboard or polystyrene trough that will keep the proper distance from the sheathing, should be installed first.

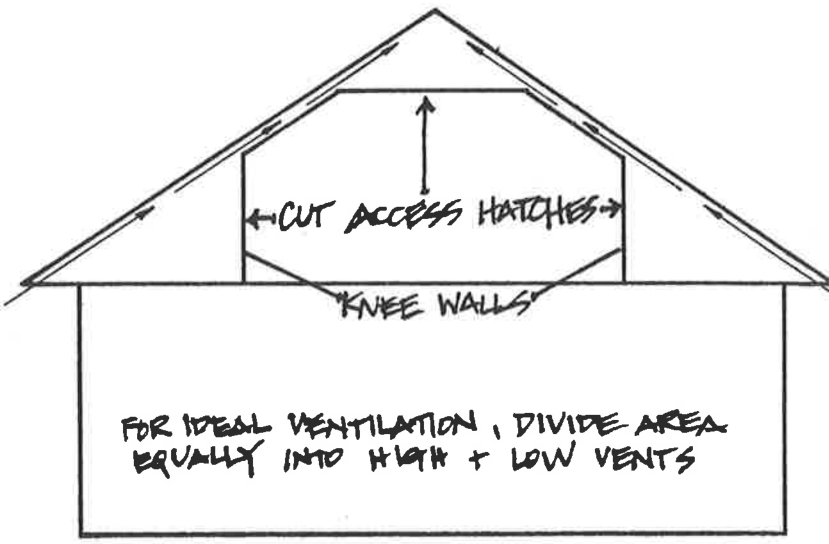

Figure 2.

<u>Problem 3: Blocking vents</u>
In some homes there will not be enough room to add eight or nine inches of insulation at the eave without causing blockage. Rather than sacrifice heat loss at this very critical point, some higher R foam board could be installed. It should be extended toward the

center of the space only to the point where there is room for less expensive insulation plus ventilation as shown in Figure 1.

Problem 4: Recessed lights
A far more serious problem is posed by the use of recessed electrical fixtures. If the fixture is a light or something that gives off great amounts of heat, placing insulation over the top or closer than three inches to the sides of the housing will prevent the heat from dissipation as it should. The result is that the paper face on fiberglass has been known to char, and improperly treated cellulose may begin to smolder. Even if the insulation is absolutely unburnable, the wood framing around the fixture will be excessively dried by the heat, such that it will ignite as easily as paper. It is preferable to use surface mounted rather than recessed fixtures. Any existing fixtures must be protected by a baffle which holds insulation three inches away from the sides of the figure. The top of the fixture should remain uncovered as in Figure 3.

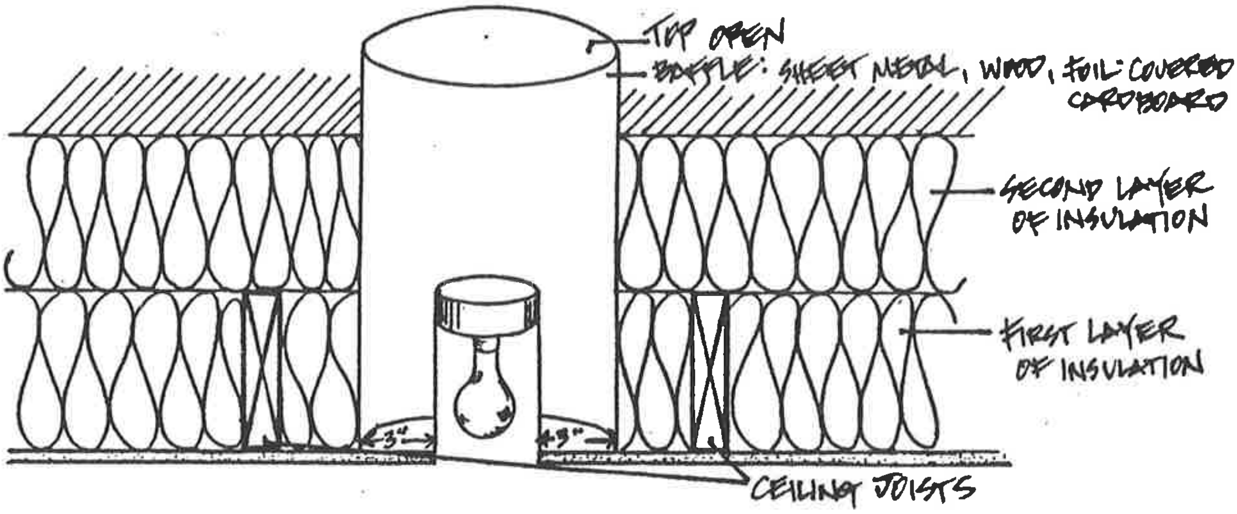

Figure 3.

While the problem with recessed lights is commonly recognized, a similar hazard with surface mounted fixtures is not well known. This is especially the case when the fixtures are overlamped. For this reason the National Bureau of Standards Criteria for the Installation of Energy Conservation Measures (1981) recommends the following precautions be taken for fixtures not specifically approved for installation under insulated ceilings:

1) Assure the lamps used in the fixture are of no greater wattage than the fixture calls for. If there is no stated lamp wattage, assume only 60 watt bulbs should be used.

2) Install a barrier similar to that around a recessed fixture around the ceiling box above the finished ceiling. No insulation should be placed in or over this barrier so as to restrict free air circulation.

Problem 5: Wiring

There are also studies that show wiring buried in insulation can reach unnaturally high temperatures. The most serious cases are 1) wires which are experiencing an overload, 2) multiple parallel wires in close proximity to each other, and 3) older wiring such as "knob and tube" wiring or "code rubber" wiring. All these cases are complicated by the fact that normal household fuses will permit branch wiring to operate at 135% of the load for an hour before blowing. Excessive temperature in wires can affect the electrical cable itself (especially the insulation), the structure's thermal insulation surrounding it, and adjacent building elements (i.e. joists, studs, siding). The above mentioned NBS publication points out in discussing the significance of this data, however, that when a residential branch circuit has properly matched overcurrent protection (fuses or circuit breakers) the temperature levels and their duration do not seem to constitute a significant hazard. Ignition of any of the above components is unlikely. Many people will create a dangerous situation, though, by replacing blown fuses with higher rated ones. This should be avoided at all costs as the temperatures and duration of exposure could lead to melting or ignition of wire insulation and chemical change, charcoal formation, and even smoldering of adjacent wood construction in contact with the wiring. This problem is greater with older types of wiring. "Code rubber" wiring was commonly installed up to about 1940. Its temperature limit is 120°F, compared to the 140°F rating for polyvinyl insulated wire. Because of greater appliance use in homes today, older homes likely to have this type of wiring often have too few sockets, which the homeowner then overloads. Some appliances, like electric room heaters or color televisions, may draw a load heavier than such wire should carry. Unless these circuits are derated, no insulation should be installed surrounding the wiring. Because not enough is known about the safety and performance of such circuits, it is recommended that the home be inspected by an approved electrician prior to installing insulation in contact with the electrical wiring. Derating of circuits or upgrading of the system may be necessary.

Regardless of the condition of the wiring, an electrician or the local utility should inspect the system before any insulation is added if any of the following occur: 1) dimming or flickering of lights (not due to a loose connection), 2) blowing circuit breakers or fuses regularly, 3) sparks or glow from outlets or switches, and 4) overheating of an outlet or fixture.

Another important concern is the possibility of galvanic corrosion when loose fill or foamed-in-place insulation fills junction, switch, or outlet box. After the insulation is blown in, the wise homeowner will turn off the electrical power to inspect and remove insulation that has lodged in such boxes.

The discussion of these problems is in no way intended to discourage homeowners from installing insulation, but to draw attention to important safety considerations, especially concerning overloading circuits. As the NBS publication concludes, in homes with correctly protected circuits, there appears to be no cause for alarm.

Insulating Underfloors, Basements and Crawlspaces

If the attic has been insulated adequately, the next most cost effective measure is to insulate the floor, basement, or crawlspace. Generally speaking, insulation is placed either 1) between the joists if the space below is unheated, or 2) against the perimeter wall. First, however, all existing moisture problems must be attended to. This means fixing cracks in the foundation or installing a vapor barrier over the dirt floor of the crawlspace. This will protect the insulation from moisture damage. The soil moisture barrier, minimally six mil polyethylene, should be taped up the sidewalls about twelve inches and weighted down. Black is better than clear because it will prevent anything from growing underneath. The heavier weight polyethylene will tear less easily while being dragged around in the crawlspace. This barrier will also reduce the amount of condensation potential in the home. In new construction, the polyethylene is placed before the concrete pad is poured.

If the crawlspace is unheated, the floor joists can be insulated with the appropriately sized fiberglass batts or blankets. The paper or foil face must be placed up next to the floor, however, which means the paper flange cannot be used to secure the insulation. Over time the insulation will pull away from the paper cover anyway unless some other support from below is provided (Figure 4). This is most often done by stapling chicken wire, or a criss-crossed pattern of wire to the bottom edge of the joist. Batt hangers also work well. They are thin, stiff, sharp pointed wire, slightly longer than the width of the joist spacing. The sharp points are stuck into the joists every eighteen inches, so that the wire bows up. This does compress the insulation somewhat.

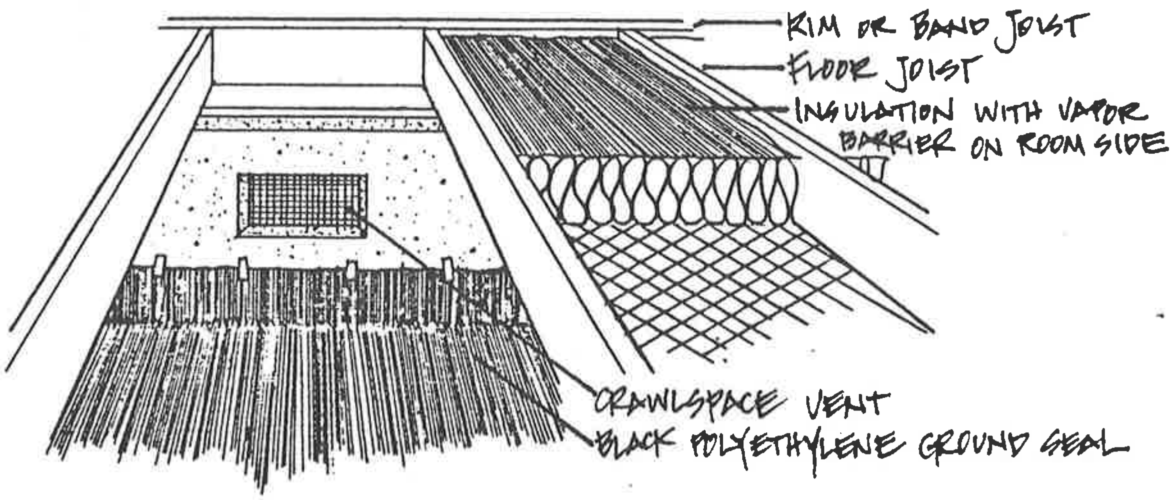

Figure 4.

If the basement or crawlspace is heated, two slightly different approaches can be taken. The insulation can be applied to the inside of the basement or crawlspace wall. A wall can be framed, then insulated with R 11 fiberglass or one and one-half inch thick rigid foam board, depending on the size of the framing. Then the finish cover is applied. Rigid foams can be stuck directly to the concrete or block wall using a compatible adhesive if the wall is even enough, but then there is no easy way to support the required fire cover unless strapping is anchored through the insulation to the wall.

The band joist or rim joist is often missed, which leaves a large gap in the effectiveness of the insulation. Make sure it is covered. In crawlspaces, it is especially effective to continue the insulation horizontally on top of the crawlspace floor for at least two feet into the center (see Figure 5). This provides nearly the same protection as continuing the insulation down another two feet vertically.

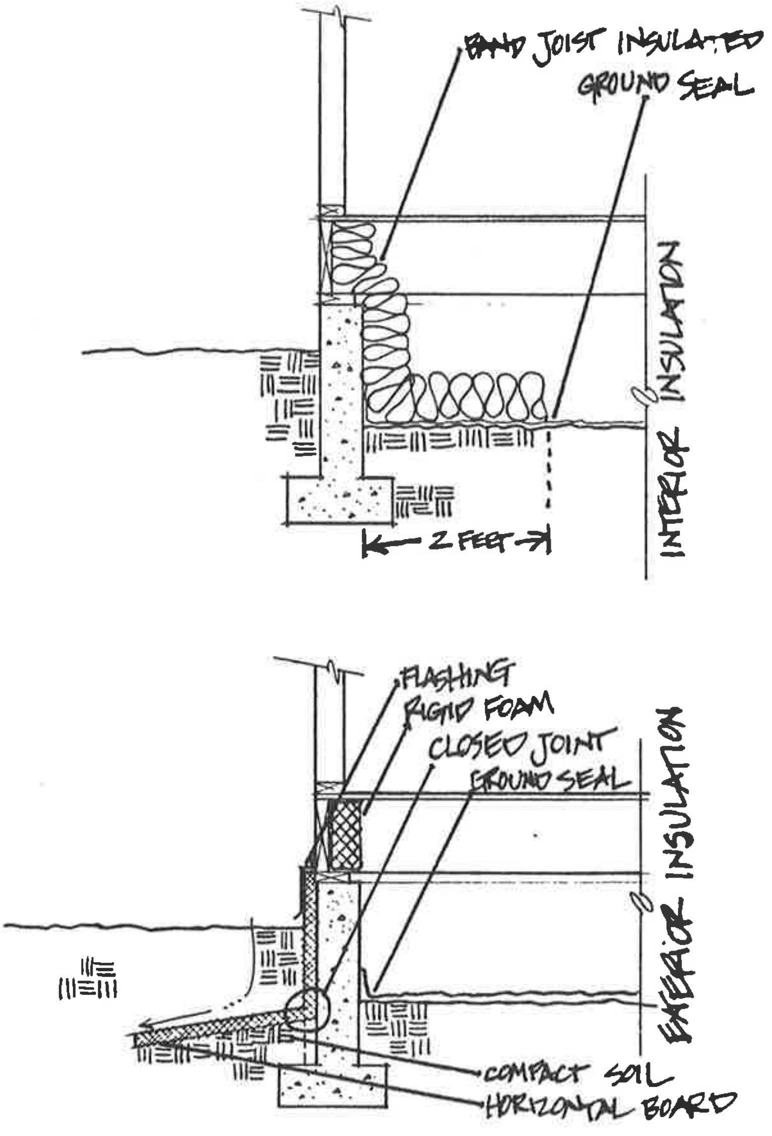

Figure 5.

Some people prefer to do this on the outside of the wall. This allows them to benefit from the heat storing potential of the concrete mass to help temper the comfort of the home. The only suitable materials for such "below grade", or underground, installation are the board insulations. They go up quickly and will not compress when carefully backfilled. Even these will have varying durabilities, though. The ideal material will have good compressive strength, excellent resistance to moisture, and will stand up to repeated freeze and thaw cycles. A grooved-surface fiberglass has been used successfully on the exterior of foundations in Canada. All rigid foams must be protected from sunlight and weathering above grade. In new construction, the board is usually extended vertically all the way to the footing. In a retrofit situation it is easier to install part of the insulation vertically, then horizontally or sloping away from the wall for two feet. Since the heat must travel as far to get to the coldest point, the outside air, this technique is nearly as effective with a lot less digging (see Figure 5). The soil beneath the horizontal layer must either be undisturbed or well compacted.

Venting Crawlspaces

Ventilation is an important factor for unheated crawlspaces as with attics. If there is a significant amount of ground moisture, insulating the crawlspace wall will not help as much as in dryer regions. This is because the crawlspace will have vents that should be open year round to dissipate moisture vapor which will otherwise filter into the house. If the vapor condenses in the structural members, it can encourage rot and mildew. In many dry, cold regions, sealing crawlspace vents in the winter is fairly common. In this case, perimeter insulation should work well. The crawlspace with a soil moisture barrier will need a minimum of two opposing vents (equaling one square foot free vent area) for every fifteen hundred square feet of floor area. If there is no barrier, ten times as much ventilation is needed, with a minimum of four vents, preferably at the corners: one square foot for every one hundred fifty square feet of floor. For good ventilation four vents near the corners will be more effective than two larger opposing vents.

Insulating Walls

The additional equipment and labor required to add insulation to existing walls makes this the lowest priority in most homes. The important exception to this rule is when remodeling plans make adding wall insulation cheap.

If, for example, the house is to be re-sided, rigid foam board can be applied before the new siding. Because these boards qualify as a vapor barrier, some manufacturers recommend putting a wiggly, plastic vent strip between the board and all horizontal framing (sills, plates, headers, etc.). This will allow any trapped moisture to vent out the top into the attic and from there outside. According to the manufacturers this is only necessary in climates of 8000 degree days or colder, such as is found in extreme northeast Washington. Other authorities feel that such venting is a bad idea, because, if it is strong enough to vent unwanted moisture, it will probably pull more moist house air through the wall. This may bring in more moisture and defeat the purpose of the strip. If the venting air is supplied from the outside then the ventilation will cool the wall. Other manufacturers claim the insulation on the outside will keep the cavity sufficiently warm so condensation never occurs. Regardless, the benefit of an excellent vapor barrier is all the more obvious. Rigid foam applied to the interior of the wall may provide the desired vapor barrier. In either location, the nails used to apply the siding or the interior finish should be long enough to penetrate the framing three-quarters to one inch.

When remodeling involves opening the wall cavity, it is quite simple to put in the properly-sized fiberglass blanket. Even when a paper or foil faced insulation is used, it is smart to install a polyethylene vapor barrier over the insulation. The long, fairly penetrable cracks on each side of the blankets are then sealed. Unfaced insulation can also be used, which may be cheaper.

Without tearing the wall apart, about the only way to insulate walls is to blow in the insulation. The most common materials are cellulose, fiberglass, and rock wool. This technique requires professional installation, which is part of the reason the cost is higher. Cellulose manufacturers claim the longer fibers of the mineral wools can snag on nail points or splinters, block the cavity, and leave voids. This is not a problem with cellulose since it is a finer particle. The other disadvantage to mineral wools is that the access hole must be larger.

In either case, a "two hole method" is recommended for good coverage. In each story, two holes, one high and one low, are drilled in each cavity or any space between two studs. The low hole should be no more than four feet from the bottom plate, because cellulose will fill adequately downward that far. The upper hole should be no more than eighteen inches from the top plate, because that is the distance above the hole that will fill adequately. If there is more than four feet between holes, another hole should be drilled and blown. Before the cavity is filled, a plumb line should be dropped through the hole to check for fire blocking. If the line goes slack before the bottom plate is reached, then there is blocking and another hole may have to be drilled. The extra framing around wall openings may also call for additional holes to be drilled.

Some other checks must be made before the insulation is blown. The perimeter of the attic and basement must be inspected to make sure the cavities are closed at those points. Otherwise, cellulose will start filling the basement or attic while the wall is being blown. If the blower doesn't cut off in the appropriate time, it could be an indication that some additional area is being filled. Other areas where the wall might not be sealed are 1) underneath sink cabinets, 2) under closed-in stairways, and 3) behind the soffits above wall-hung cabinets. Any poorly sealed penetrations through the wall could also cause problems. The perimeter check should pick these out and locate any heating ducts which run up the exterior walls.

<u>Note of Caution</u>

When heavy levels of insulation are installed in a home and the infiltration rate is radically reduced by caulking, weatherstripping, and proper vapor barriers, there is a chance that the air quality might suffer. By reducing the rate of infiltration, the "natural" ventilation, which used to supply fresh air to the home rather haphazardly through leaks and cracks, no longer brings in quantities of fresh air. In very tight houses this can mean the pollutants which exist in the home from woodstoves, gas appliances, chemicals in the furnishings, building materials, and common household cleaners may reach an unhealthy level. In such houses it will be necessary to provide for some mechanical ventilation, like an air-to-air heat exchanger, which will supply fresh air without the same heat losses as the drafty house. While this is an unlikely occurrence in most retrofit situations, it is one of which the homeowner should be aware.

Summary

Investing in insulation is a good way to reduce energy consumption in the home. The homeowner must determine where adding insulation will be most cost effective. Attics are usually the place to start, followed by floors and walls. Since there is a wide variety of material on the market, the do-it-yourselfer must choose carefully and install them with proper regard for ventilation and vapor barriers. Even if the work is performed by a contractor, the informed homeowner will benefit by his knowledge of materials and procedures. In the end the investment will not only make the home a more comfortable and pleasant place to live, but also pay for itself quickly in substantial savings on seasonal heating and cooling costs.

SUGGESTED READING:

The Complete Book of Insulating. Larry Gay, ed. The Stephen Greene Press, Brattleboro, VT. 1980.

One of the better, detailed discussions of insulation.

The Energy Saver's Handbook. Massachusetts Audubon Society. Rodale Press. 1982.

Good overview of energy conservation in the home.

In the Bank or Up the Chimney, 2nd Edition. U.S. Department of Housing and Urban Development. 1977.

Often copied, basic primer on insulation, caulking and weatherstripping.

Insulation and Weatherstripping. Sunset Books. Lane Publishing. 1978.

The Insulation Estimator's Handbook. Harry Hardenbrook. Frank R. Walker Co. 1980.

Good for seeing how estimating is done, prices not current.

Keeping the Heat In. Energy, Mines and Resources, Canada. 1976.

Canadian version of In the Bank or Up the Chimney.

Low Cost Energy Efficient Shelter. Eugene Eccli. Rodale Press. 1976.

One chapter on insulation alone.

Women's Energy Tool Kit. Joan Byalin. Consumer Action Now. 1980.

User friendly.

New Shelter. November-December, 1982.

Four excellent articles, including one on common installation flaws and how to purchase the right product.

This factsheet was written by Chuck Eberdt.
Illustrations by Rick Nishi.