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THE WHY, WHAT & HOW OF HOME INSULATION

The Why, What and How of Home Insulation

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This publication was prepared by the Virginia Farm and Home Electrification Council at VPI&SU, Blacksburg, Va. It is designed to help users understand the importance of insulation and make decisions related to Energy Management.

Contents

ACKNOWLEDGEMENTS

Grateful appreciation is expressed to the National Mineral Wool Insulation Association for permitting the use of some illustrations and subject matter from their printed materials.

Basic Facts on Heat Transfer

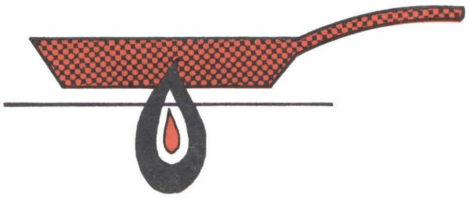
Heat energy always flows from a warm material, body, or space to a cooler material, body, or space. In winter, heat flows from the warm interior of a house to the cooler exterior; this is referred to as "heat loss". In summer, heat flows from the warm exterior to the cooler interior of a house; this is called "heat gain".

Heat is transferred in 3 ways:

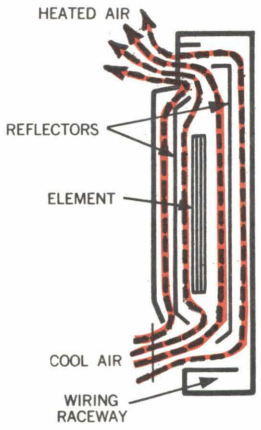
By **Conduction** - heat is transferred quickly through a dense material such as a skillet sitting on a hot stove (Figure 1).

By **Convection** - heat is transferred by movement of air over a hot surface such as a radiator, or heating elements (Figure 2).

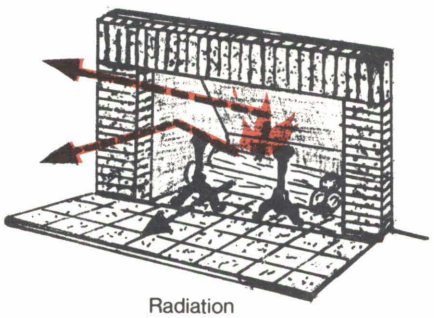
By **Radiation** - energy in the form of infrared rays is transferred through air and transparent materials from one place to another such as from sun to earth, or from fire in a fireplace to persons or objects in the room (Figure 3).



Conduction
Figure 1



Convection
Figure 2



Radiation
Figure 3

Why Insulate?

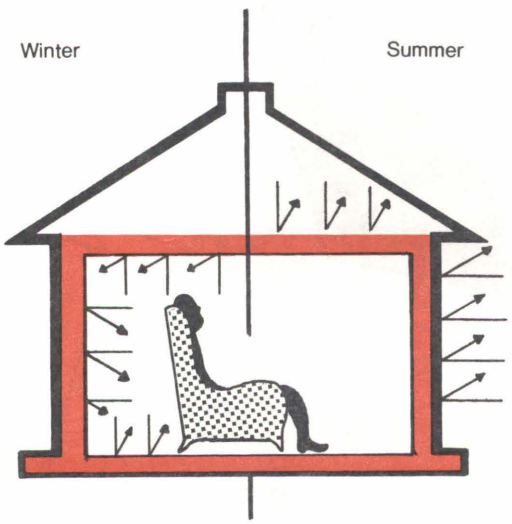


Figure 4

Thermal insulation is used to reduce the rate of heat loss in winter and heat gain in summer (Figure 4). All building materials have some insulating value, but the term "insulation" is generally associated with light-weight, porous, bulky materials with numerous dead air spaces.

When insulation is properly chosen and correctly installed it has several beneficial functions: (1) reduces cost of home heating and cooling because heat loss in winter and heat gain in summer is reduced. (2) Reduces condensation or "sweating" on walls and ceilings by keeping the surfaces relatively warm. (3) Smaller heating and cooling systems are required, resulting in savings on equipment costs.

Types of Insulation

Thermal insulation is produced in several common forms from a wide variety of materials. Those types most used in dwellings are batt and blanket, loose-fill, rigid, and reflective.

Batt and **Blanket** insulations are generally made from processed fiberglass, mineral wool, or cellulose fibers (Figure 5). One side of the batt or blanket usually has an attached vapor barrier. This may be either an asphalt paper or a reflective metal foil. Batts and blankets are from 1'' to 6'' thick and are made in widths to fit between studs and joists which are 16'' and 24'' on center. Batts are usually 4 feet long. Blankets may be purchased in rolls over 100 feet long.

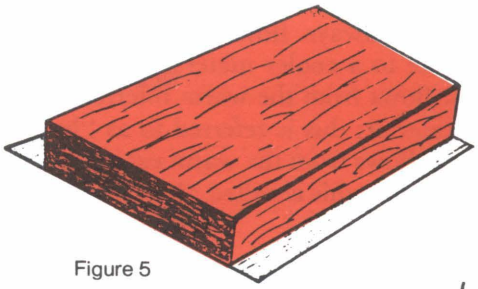


Figure 5

Loose-Fill insulations (Figure 6) are made from mineral wool, cellulose fiber, granulated cork, vermiculite and others. It is usually available in bags or bales. Loose-fill insulation is well adapted for use in walls and ceilings of existing buildings, ceilings of new buildings, and for filling the cores of masonry blocks. Providing a vapor barrier and proper ventilation is a must for satisfactory use of loose-fill insulation.

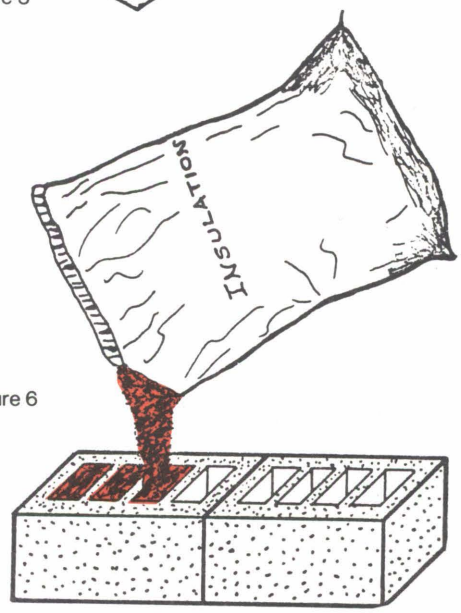


Figure 6

Rigid insulations are made from cellulose fiber, fiberglass, polystyrene, foam glass, and polyurethane (Figure 7). Rigid insulation boards may be used on the outside of stud walls as sheathing or on the inside as a finish in some instances. The waterproof types such as foam glass are excellent as perimeter insulation.

Figure 7

Reflective insulation consists of reflective foils such as aluminum (Figure 8). It interrupts the flow of infrared heat rays. To be effective the foil surface must face an air space of at least 3/4 inch. Reflective insulation is available in single sheets, strips put together to create 3 or 4 separated air spaces of 3/4 inch or more, and as a combination vapor barrier and reflective surface attached to batts or blankets.

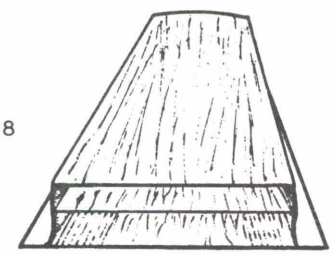


Figure 8

Formed-in-place insulations are available as liquid components or expansible pellets and include sprayed and plastic foam types. Because special equipment and techniques are required for most formed-in-place insulations, it is best to obtain them through commercial applicators.

Determining Insulation Effectiveness & Requirements

Effectiveness of insulation is indicated in two ways. One is stated as the resistance offered by a material or materials to the flow of heat under known conditions. This resistance is designated by the letter **"R".** The larger the **"R"** value the better the resistance to heat flow, hence the better the material is as an insulation.

The second specification is stated as the amount of heat that will pass through a material , or materials, under known conditions. This is designated by the letters **"C"** or **"U"**. The smaller the **"C"** or **"U"** value the better the insulating quality of a material.

"R" is the reciprocal of **"C"** or **"U"** (1/C or 1/U), so to obtain **"R"** value when **"C"** value is known simply divide 1 by the **"C"** value. Example: **"C"** = .5, **"R"** = 1 ÷ .5 = 2. Most manufacturers of insulation have adopted the **"R"** rating and stamp it on their products for easy evaluation by the consumer. The **"R"** values of two or more different materials or of different thicknesses of the same material may be added directly to determine the total **"R"** for combinations. **"C"** and **"U"** values cannot be added until they are converted.

Where there are no building codes, insulation requirements for various components of the house may be the choice of each consumer. Most building codes and lending agencies set minimum insulation requirements. Adding more than the minimum insulation required will prove more economical as energy costs increase.

Housing and Urban Development/ Minimum Property Standards (HUD/ MPS) regions are delineated by heating degree days. The following eight regions, their degree-day parameters and insulation "R" values are generally recommended.

HUD/MPS Region	Degree Days*	Ceilings	Walls	Floors Over Unheated Space
1	0-1000	19	0	0
2	1001-2500	19	11	11
3	2501-3500	19	11	11
4	3501-4500	30	11	11
5	4501-5000	30	19	19
6	5001-6000	30	19	19
7	6001-7000	30	19	19
8	7001- & up	38	19	19

* See zone map of degree days (Figure 9).

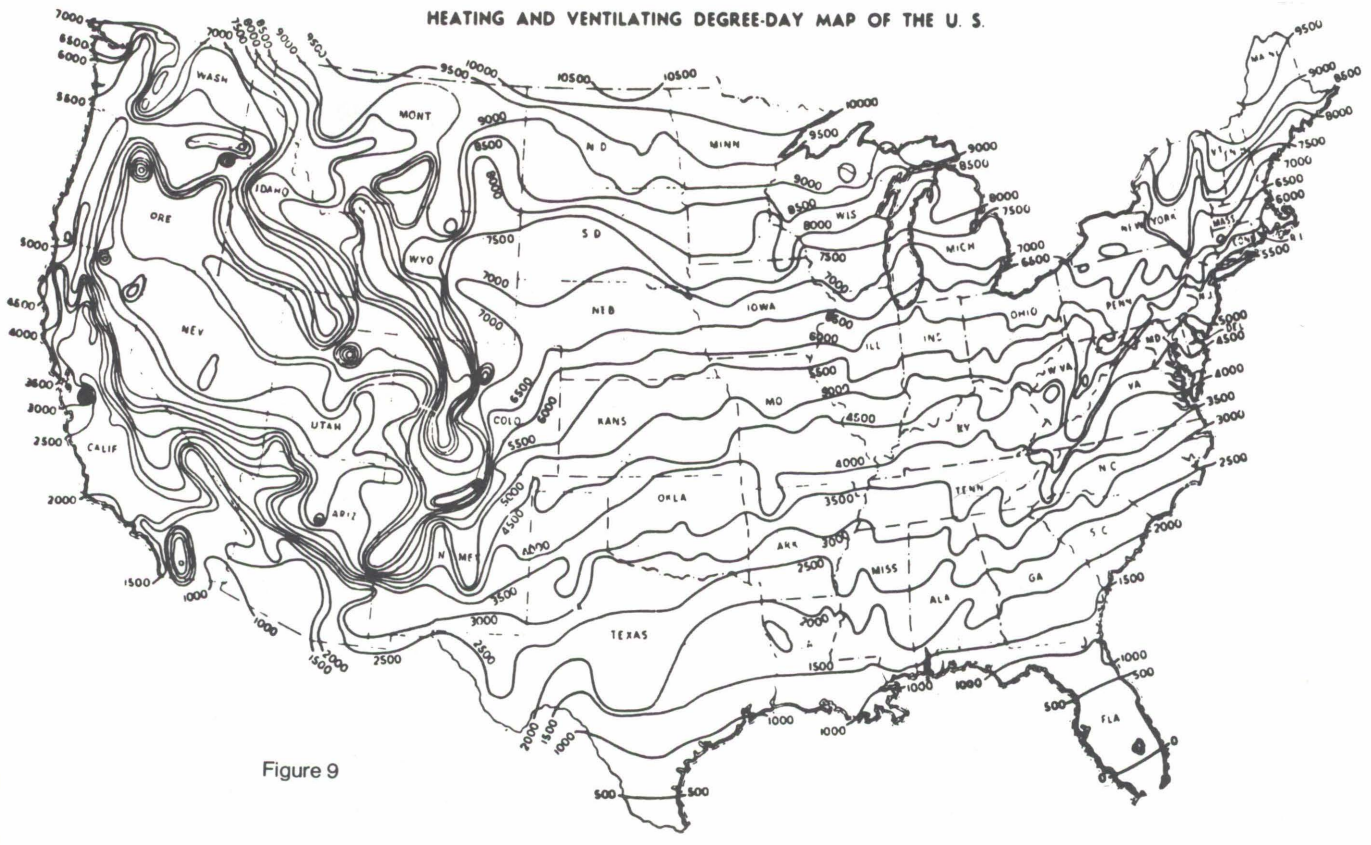


Figure 9

Vapor Barriers

Proper location of a vapor barrier is an essential factor in the proper installation of insulation in the home. Vapor barriers restrict the penetration of water vapor into or through insulation where it can condense either in the insulation or on components of the wall framing such as wood studs, sheathing, and siding. This condensation results in wet insulation, rotting wood structural members, and sometimes peeling paint (Figure 10).

Most batt and blanket insulations have a vapor barrier attached to one side. The barrier should always be installed on the warm side or side next to the living area in the home. Install a vapor barrier on both sidewalls and ceiling. Without a vapor barrier in the ceiling, there are likely to be problems with moisture condensation in the attic. Make vapor barriers continuous and be sure to patch any holes punched during installation. It is often a good practice to cover the stud wall from floor to ceiling with 4 mil. plastic, after the batt or blanket insulation is installed and before the inside wall finish is added. This ensures a tight seal over cracks and tears in the insulation cover during installation.

The use of a vapor barrier helps to maintain a healthy humidity level in the home in winter. A relative humidity of from 30% to 40% in cold weather is not only comfortable and healthy but makes for more efficient and economical operation of the heating system.

It is a good practice to install a 6 mil. plastic vapor barrier under concrete slab floors, and as a ground cover under houses with crawl space. While 4 mil. plastic may do the job, it is much more easily damaged during installation.

Fair protection may be obtained in existing structures by use of one of these methods: (1) Apply two coats of aluminum-in-varnish paint, or two or more coats of a good alkyd base semigloss paint over a primer coat of aluminum paint on walls and ceilings. (2) Covering the wall and ceiling with a washable plastic wallpaper.

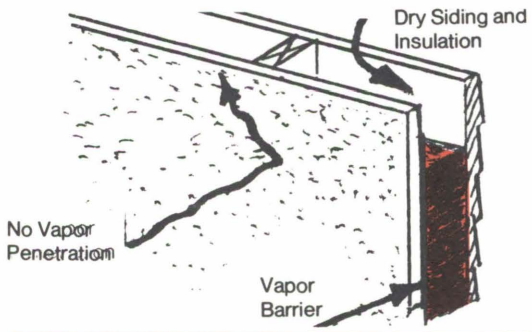
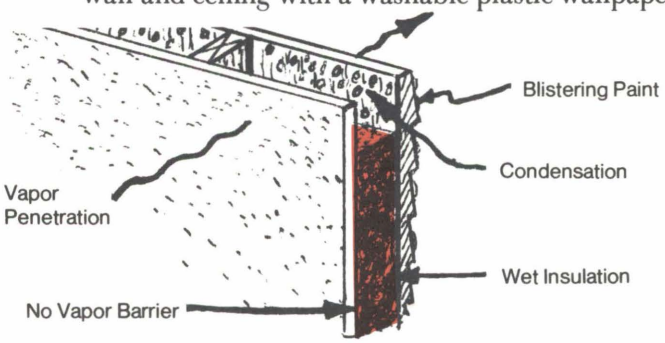


Figure 10



Paths of Heat Losses

There are 5 general paths of heat loss from a house which must be considered when planning heating systems (Figure 11).

Ceiling and **Roof:** where from 15% to 20% of total heat is lost. This can be reduced by proper insulation and ventilation.

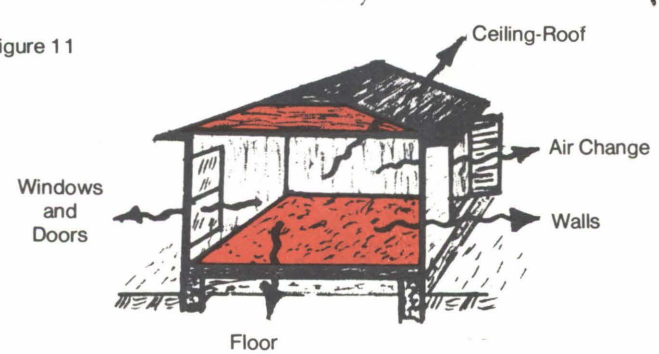
Doors and **Windows:** where about 25% to 30% is lost. Storm windows and doors can reduce this loss.

Walls: from 20% to 30% of the heat is lost through walls. Proper insulation reduces this loss.

Floors: only 4% to 10% of heat is lost through floors over unheated spaces, but this loss is considerable when planning insulation.

Air Change *(infiltration):* an estimated 20% to 35% of the heat is lost in this manner. Practices such as weatherstripping and caulking around doors and windows, and not opening doors unnecessarily in winter can reduce this loss considerably.

Figure 11



Where to Insulate a Home

To determine the location for insulation in the home, imagine the insulation as a blanket completely surrounding the living area of the home. This means all spaces to be heated in winter and cooled in summer.

Refer to numbers in house cross-sections (Figure 12):

1. **Exterior walls.** Sections sometimes overlooked are the wall between living space and an unheated garage or storage room, dormer walls, and the portion of wall above the ceiling of an adjacent section of a split-level home. Pack insulation in narrow spaces between jambs and framing.

2. **Ceilings** with cold spaces above, and dormer ceilings. An attic access panel can be insulated by stapling a piece of mineral wool blanket to its top.

3. **Knee walls,** when attic space is finished as living quarters.

4. **Between collar beams** in finished attic, leaving open space above for ventilation.

5. **Around the perimeter** of a slab on grade.

6. **Floors** above vented crawl spaces. When a crawl space is used as a plenum, insulation is applied to crawl space walls instead of the floor above.

7. **Floors** over an unheated or open space such as over a garage or a porch. The cantilevered portion of a floor.

8. **Basement walls,** when below-grade space is finished for living purposes. Mineral fiber sill and foundation provides an effective wind infiltration barrier.

9. In back of **band** or **header joists.**

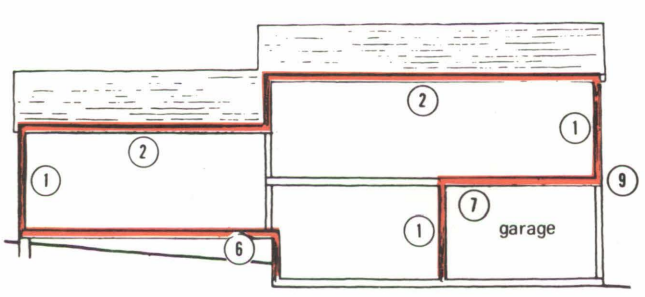
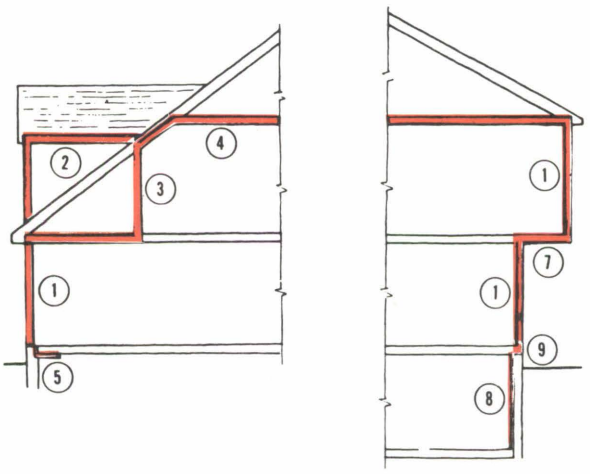


Figure 12



Installing Batt or Blanket Insulation

In Ceiling:

Install the insulation so the vapor barrier side faces the interior or area heated in winter. Install by stapling the vapor barrier flanges from below (Figure 13).

When unfaced pressure-fit batts or blankets are used they are generally placed from above after ceiling is in place. Since there is no vapor barrier, be sure attic is well ventilated (Figure 14).

Batt or blanket should extend out over the plate, but should be pressed tightly against the plate so it will not block eaves ventilation (Figure 15).

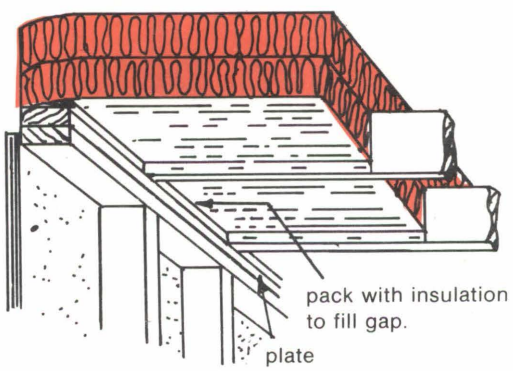


Figure 13

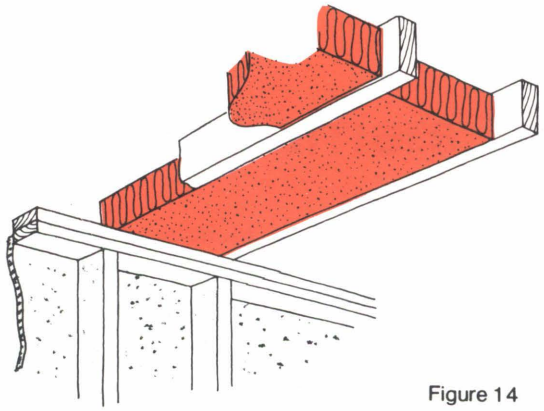


Figure 14

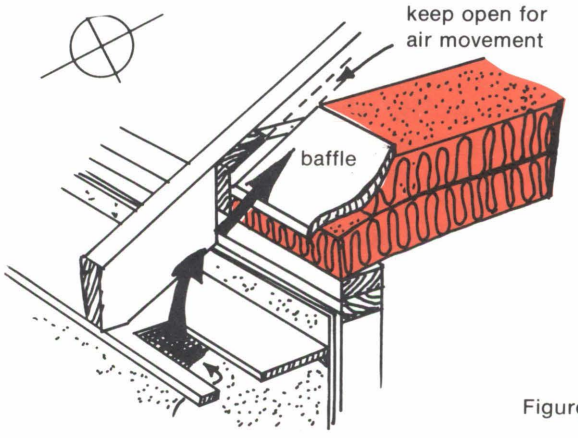


Figure 15

In Frame Walls:

Press batts or blanket between the studs until they touch the sheathing or siding. Working from the top down, space fasteners about 8 inches apart in flanges fitted tightly against the studs. Be sure there is no crack at bottom or top of insulation. Best to cut blanket slightly overlength and staple vapor barrier at top and bottom (Figure 16).

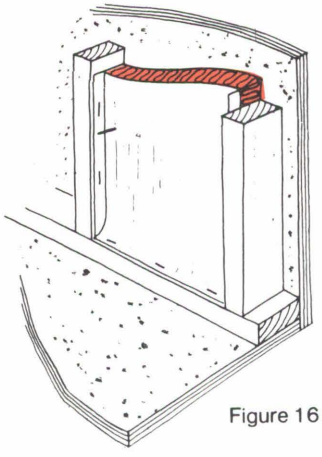


Figure 16

If batts or blankets without a vapor barrier are used, wedge them in place between studs. Then cover the inside face with a polyethylene vapor barrier (Figure 17). Cover the entire wall, including window and door openings, and staple it at top and bottom. Cut out

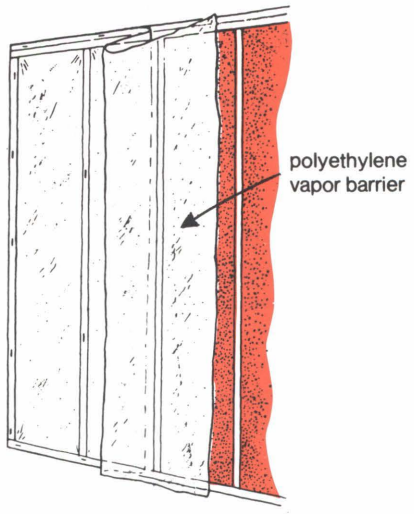
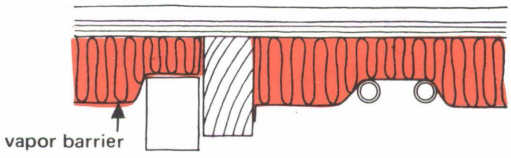


Figure 17

openings later. Sometimes foil-backed gypsum board is used as a vapor barrier instead of the plastic sheet.

Be sure to place insulation behind ducts, pipes, and outlet boxes (Figure 18). Sometimes it is necessary to cut the insulation to a size which can be fitted into place. Place insulation in all small spaces between framing members, and around door and window jambs, headers, and sills. It is a good practice to staple a vapor barrier over these spaces after insulation is in place.



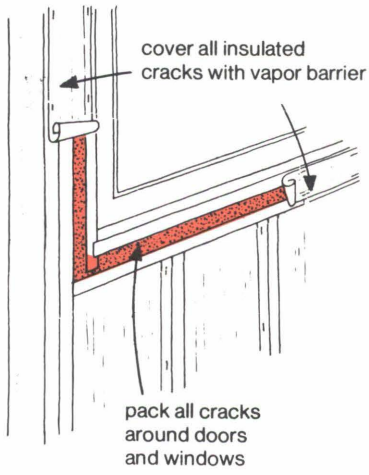


Figure 18

Under Floors:

Insulation is needed in floors over vented crawl spaces and other unheated spaces (garages, porches, etc.), in cantilevered overhangs, at header joists, and around the perimeter of concrete slabs on grade.

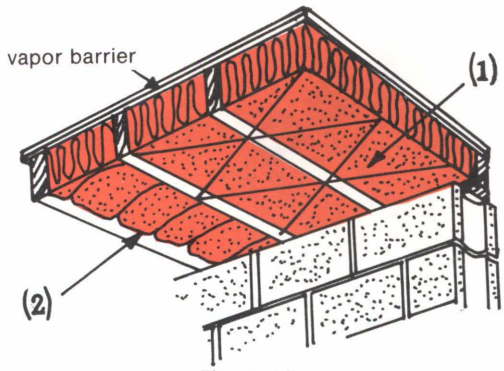


Figure 19

When the spaces between floor joists are insulated (Figure 19), the vapor barrier should face up. Insulation blankets may be held in place by (1) wires laced between nails in the bottoms of joists, or (2) heavy-gage wires bowed and wedged between joists.

Perimeter insulation should be used under slab floors on grade installed as illustrated in Figure 20.

In Masonry Walls:

Masonry walls may be insulated using either nominal 2'' x 2'', 1'' x 2'', or 2'' x 4'' furring strips 16'' or 24'' on center. With 2'' x 2'' furring (Figure 21), use R-7

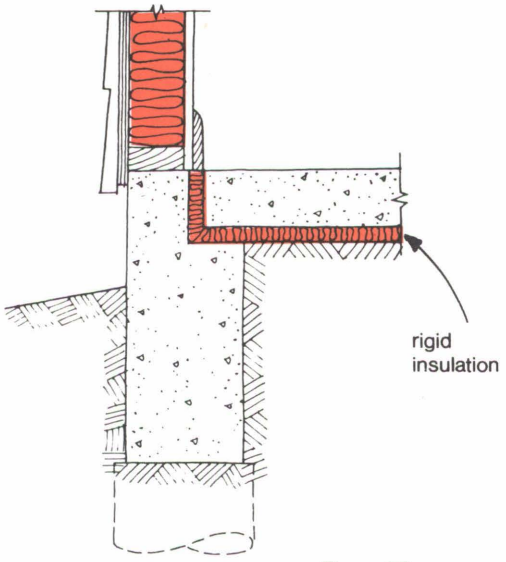


Figure 20

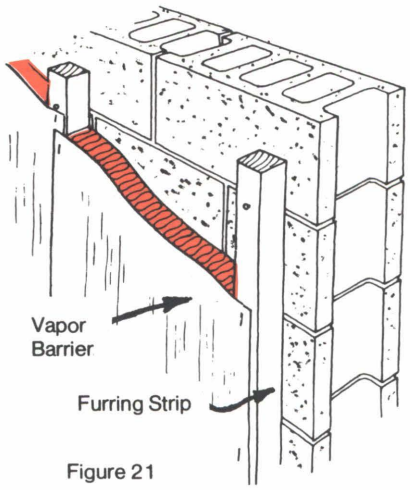


Figure 21

insulation blankets with an attached vapor barrier. Staple vapor barrier flanges to the faces of the furring strips. With 1'' x 2'' furring (Figure 22), wedge unfaced masonry wall blankets (nominally 1'' thick) between the furring strips; apply a separate polyethylene vapor barrier over the insulation or use foil-backed gypsum board as the interior finish. Rigid insulation may be used between furring strips. With the 2'' x 4'' furring frequently used in colder climates, R-11 blankets are stapled to the sides of the furring strips. It is a good practice to use furring strips which have been treated with a wood preservative.

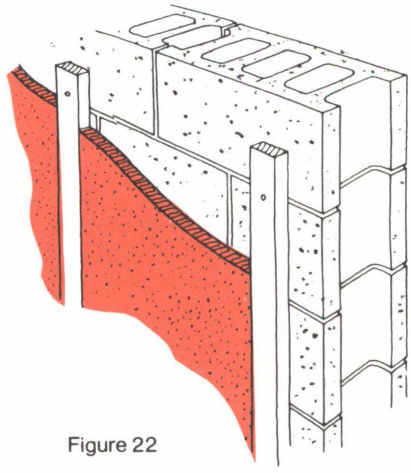


Figure 22

Installing Loose—Fill & Granulated Insulation

All exterior wall areas should be insulated in both new and old houses. In houses which were constructed without insulation, about the only practical way to put insulation in sidewalls is through the mechanical ''Blow-in'' method. Select a reliable contractor who knows and uses recommended methods of application.

A good vapor barrier and proper ventilation is very important when installing loose-fill insulation.

Refer to section on Vapor Barriers (page 3) for details.

Whenever the vertical space to be insulated is more than four feet high, the ''double blow'' method, with

two access holes to each stud space, should be used. Some stud sections may require three or more openings. Details of this method are shown in Figure 23.

Check each space with a plumb bob for possible obstructions below the holes. Insert a flexible steel rule to check for obstructions above the holes.

In existing construction, the number of shingles or bricks to be removed may be minimized by cutting access holes as close together as possible on either side of the stud.

If spaces between floor joists are to be blown, sufficient wool should be applied to fill the space the full depth of the joists (Figure 24). When supplementary insulation in the form of batts or blankets is added in the ceiling over existing loose-fill insulation with no vapor barrier, holes should be punched in the vapor barrier on the blankets to allow for vapor penetration. Then the blankets should be placed over the loose-fill with the vapor barrier side down, without stapling the flanges. The attic above should be thoroughly ventilated.

Filling the cores of masonry blocks (Figure 25) used in house walls will cut the heat loss through the wall by about one half. Granulated insulation, such as vermiculite, is generally used for this purpose. Be sure the material is moisture resistant to the extent that the material itself does not absorb moisture.

Granulated insulation is also used in cavities between masonry veneered walls such as brick veneer on concrete block.

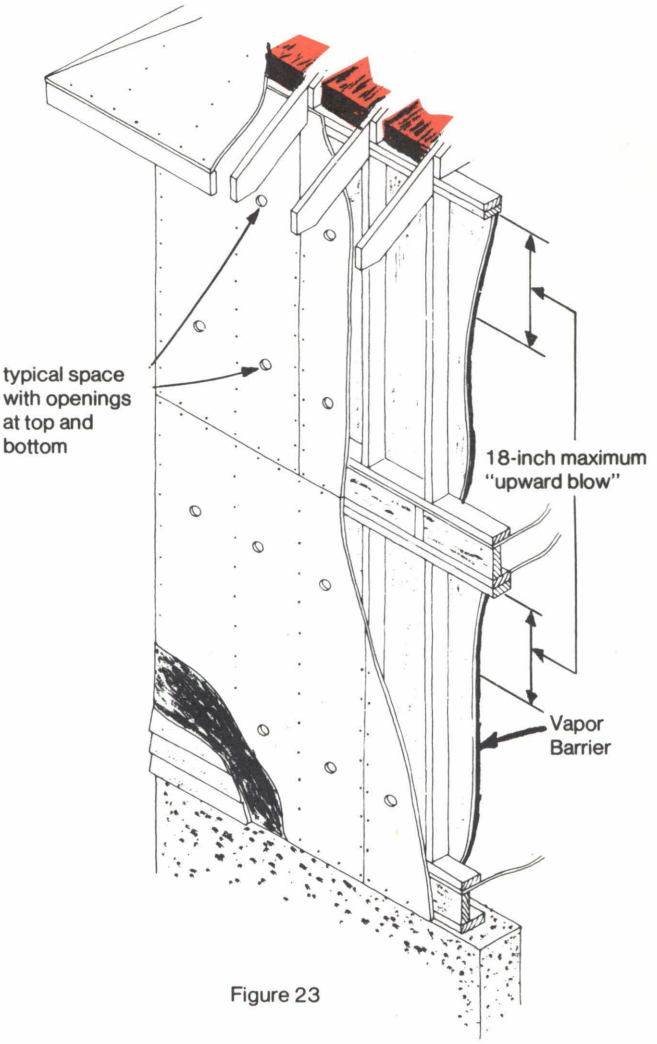


Figure 23

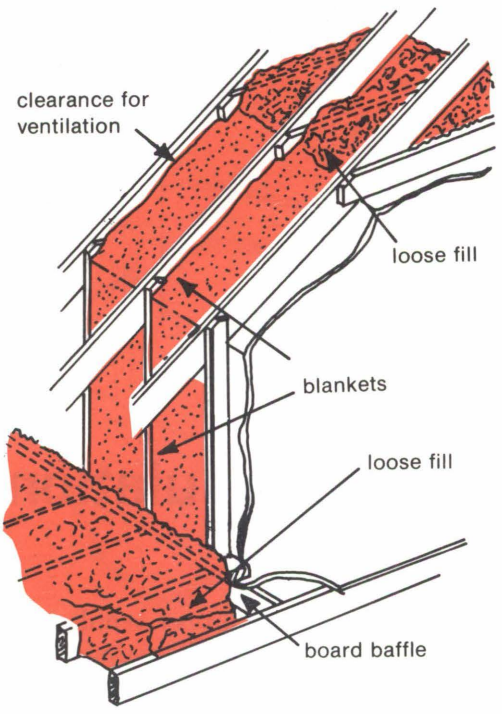


Figure 24

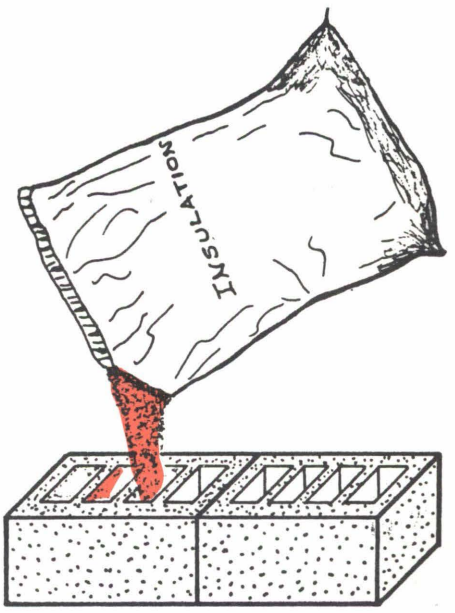


Figure 25

Installing Rigid Insulation

Rigid insulation boards or sheets of cellulose fibers, polyurethane, polystyrene, and foamglass may be used in many special situations where mineral wool batts and granulated insulation is not feasible.

The moisture resistant quality of most rigid insulations make them ideal for use as perimeter insulation (Figure 26).

Some of the rigid foam-type insulations may be fastened to the inside of masonry walls by either special mastic or placing in portland cement mortar. Plaster is then applied directly to the insulation (Figure 27).

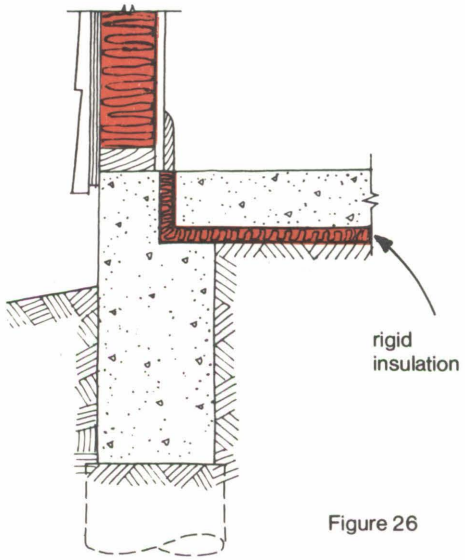


Figure 26

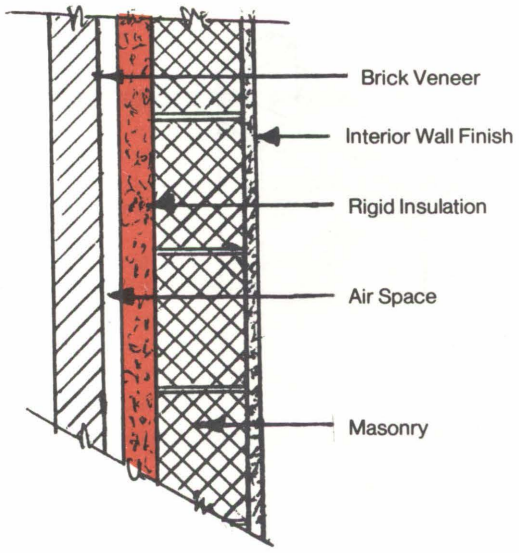


Figure 28

They are sometimes fastened to the outside surface of masonry walls which are brick veneered (Figure 28).

Rigid insulation is also used in roof structures over exposed beam ceilings. The rigid insulation is sometimes placed between a wood T & G roof deck, which serves as a finished ceiling underneath, and the finished roofing (Figure 29). Careful nailing is essential with this type of construction.

Sometimes a rigid insulation with a surface finished to serve as a ceiling is placed over the exposed beams and the wood sheathing is fastened over this.

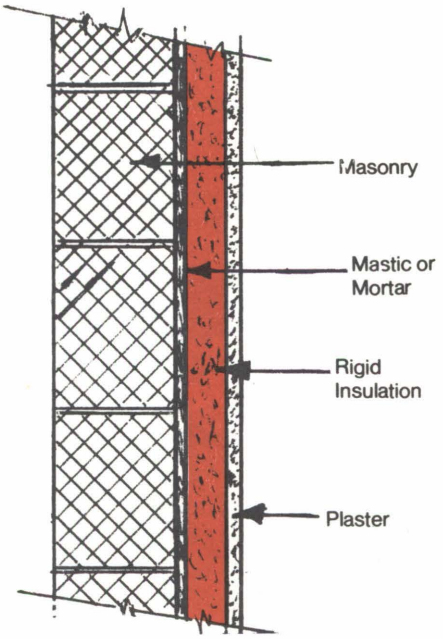


Figure 27

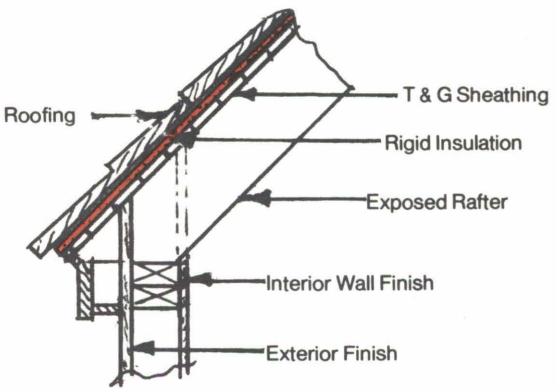


Figure 29

Installing Reflective Insulation

When only a small amount of insulation is required between the joists because of moderate climates, several other insulating materials can be used. Reflective insulations ordinarily consist of either a kraft sheet faced on two sides with aluminum foil, Figure 30A, or the multiple-reflective "accordion" type, Figure 30B. Both are made to use between studs or joists. To be effective, it is important in using such insulation that there is at least a 3/4-inch space between the reflective surface and the wall, floor, or ceiling surface (Figure 31).

When a reflective insulation is used, it is good practice to use a vapor barrier over the studs or joists. The barrier should be placed over the frame members just under the dry wall or plaster base (Figure 30A). Gypsum board commonly used as a dry wall finish can be obtained with an aluminum foil on the inside face which serves as a vapor barrier. When such material is used, the need for a separate vapor barrier is eliminated.

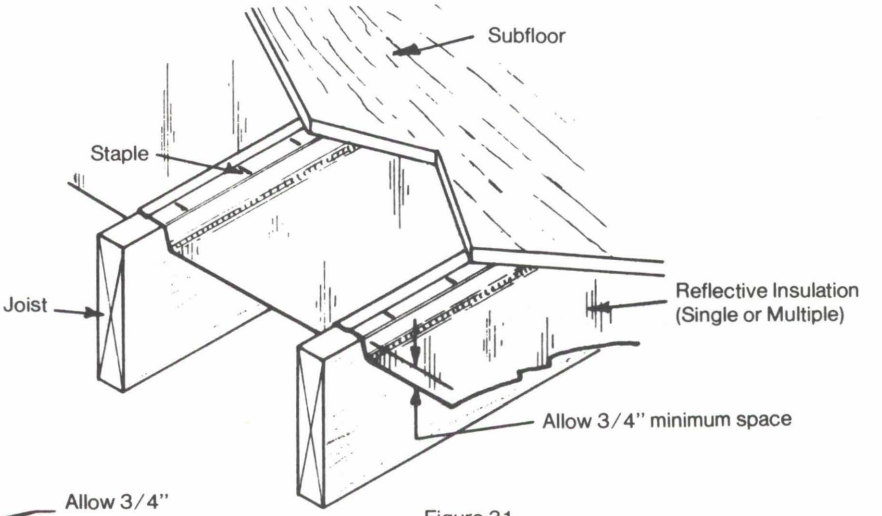


Figure 31

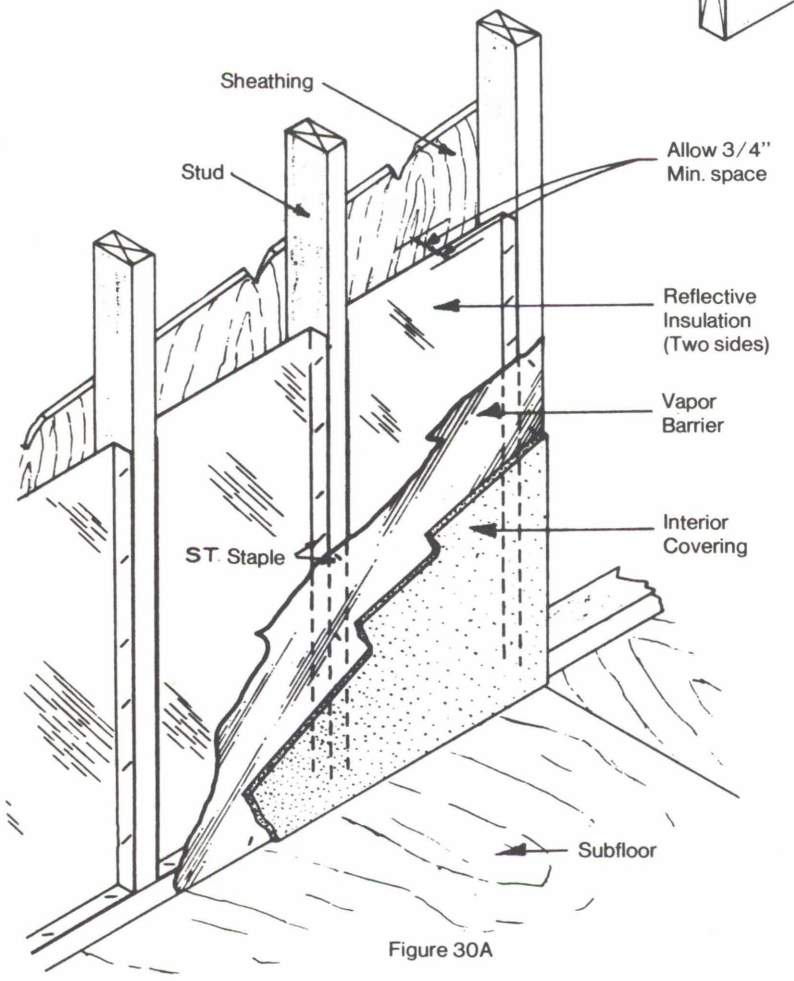


Figure 30A

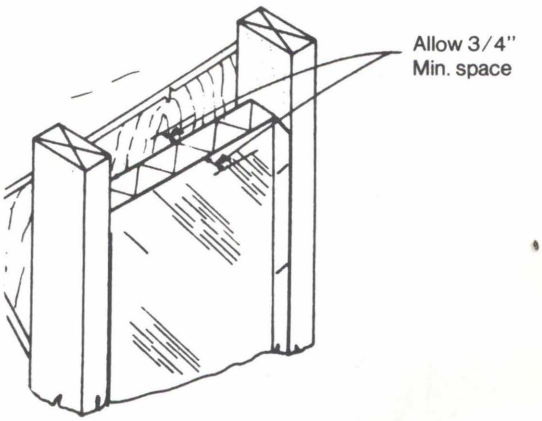


Figure 30B

Ventilation

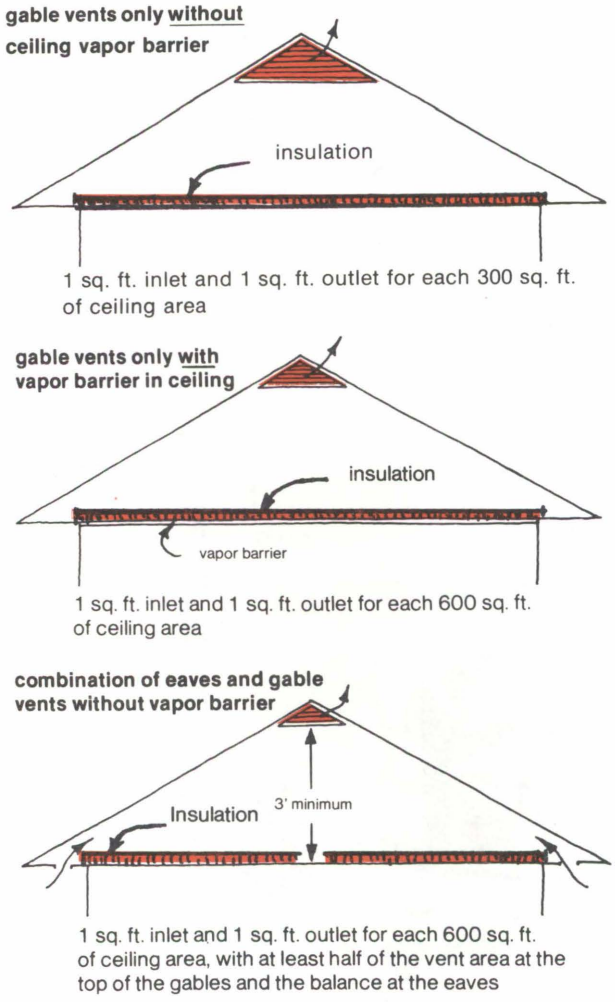
Ventilating Attics

Ventilation is as necessary in winter as in summer. In winter, the insulation keeps heat within the house while the open vents let moisture vapor escape. In summer, ventilation carries off warm air.

Always provide at least two vent openings placed so that air can flow in one, over the insulated area, and out the other. The combination of eaves vents and vents at the ridge or high in gable-ends is best. If natural ventilation is difficult to achieve, power ventilators may be installed.

The ratios of vent area to ceiling area shown in Figure 32 are minimums. Whenever possible, they should be exceeded, preferably doubled, especially when fine-mesh screening is placed in back of vents.

Figure 32



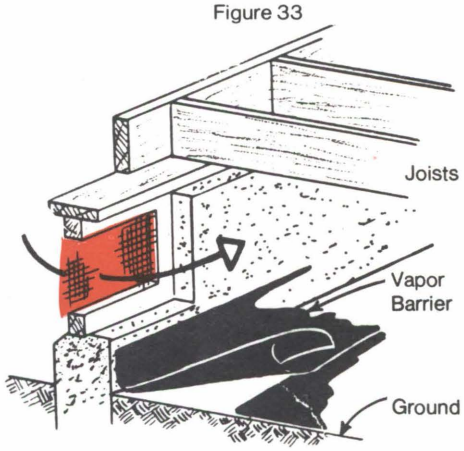
Ventilating Crawl Spaces

The ratios of square feet of vent area to crawl space ground area shown in Figure 33 are minimums. They should be exceeded whenever possible. A ground cover significantly helps keep relative humidity at a low level.

Four-mil or thicker polyethylene sheeting, and 55-lb. asphalt roll roofing are satisfactory ground cover materials. They should be lapped at least 3 inches.

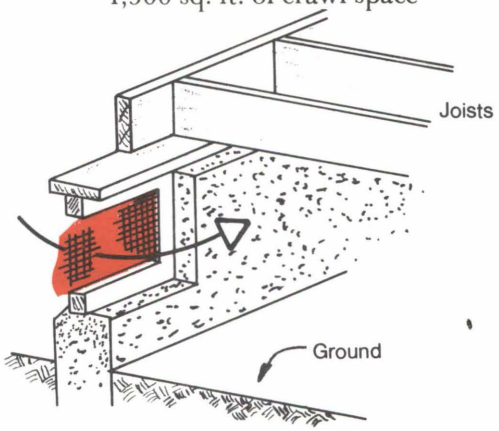
At least two vent openings should be provided, placed on opposite sides of the crawl space if possible.

Figure 33



Foundation Vent
(With ground cover)

1) at least two vents required
2) 1 sq. ft. of vent for each 1,500 sq. ft. of crawl space

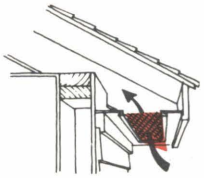


Foundation Vent
(No ground cover)

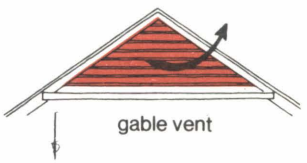
1) at least four vents required
2) 1 sq. ft. of vent for each 150 sq. ft. of crawl space

Types of Vents

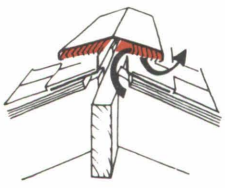
Many types of roof vents will do a satisfactory job and blend with any style of architecture. The ridge vent is necessary with "cathedral" ceilings.



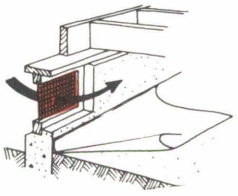
eaves vent



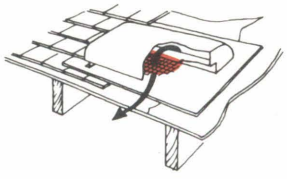
gable vent



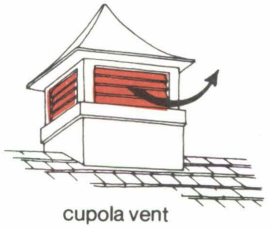
ridge vent



foundation vent



roof vent



cupola vent

Some General Considerations Influencing Choice of Insulation

There are some characteristics or features of insulation materials other than "R" values and cost which could influence the choice of materials used for particular conditions. Some of these are:

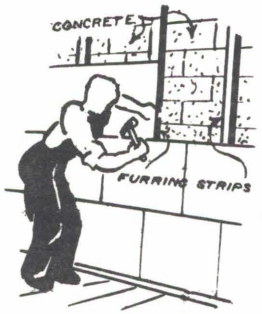
Structural requirements, must be considered when contemplating the use of rigid insulation for such things as sheathing, plaster base, interior ceiling or wall finish, and roof decks.

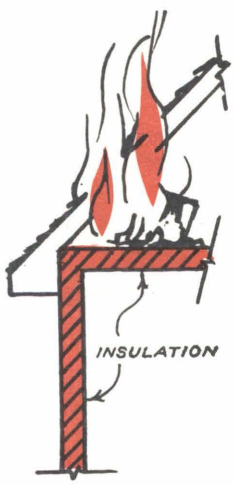
Fire resistance, of any insulating material should be considered regardless of where it is used in the house.

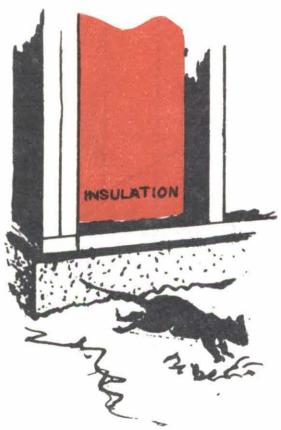
Effects of moisture on an insulation material sometimes determines whether or not it can be used for some jobs such as perimeter insulation under concrete slabs. When any insulation material becomes saturated, the insulating value decreases to practically nothing.

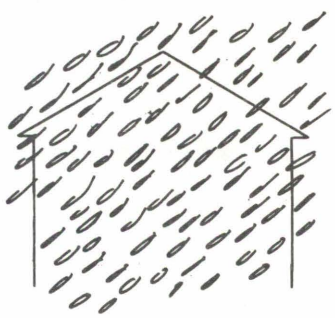
Vermin resistance, is an important consideration, but it is necessary to make relative evaluations. No material is absolutely vermin proof.

Here are a few summary guidelines on insulation. Before you buy, know the insulation value of any material being considered, and make cost comparisons on the basis of cost per unit of resistance (Divide cost per sq. ft. by "R" value). Follow manufacturers directions for proper installation.









Insulating Value of Several Building Materials*

Material	Insulation Value "R" per inch thickness	Insulation Value "R" for thickness indicated
Batt or Blanket		
Glass wool or mineral wool with vapor barrier and paper facing	3.00-3.80**	
Loose Fill		
Mineral wool (rock, glass, or slag)		
3.75-5 in.		11
6.5-8.75 in.		19
7.5-10 in.		22
10.25-13.75 in.		30
Vermiculite, exfoliated	2.13	
Cellulose	3.13-3.70	
Rigid Insulation		
Polystyrene foam, extruded	4.00	
Polystyrene, molded beads	3.8	
Polyisocyanurate	7.2	
Polyurethane (R=11 expanded)	6.25	
Glass fiber	4.00	
Wood fiberboard		
1/2"		1.25
3/4"		1.89
Construction Materials		
Concrete, sand, and stone aggregate	0.08	
Concrete block, three hole, 8"		1.11
Concrete block, lightweight aggregate, 8"		2.18
Concrete block, lightweight aggregate, 8" (Cores filled with vermiculite)		5.03
Hardwoods, maple, oak, etc.	0.91	
Softwoods, fir, pine	1.25	
1/4" Plywood paneling		.31
3/8" plywood		0.47
1/2" plywood		0.62
Hardboard, 1/4" tempered		0.25
Fiberboard sheathing 25/32"		2.06
Wood siding, 1/2" thick clapboard		0.81
Aluminum or steel over flat surface sheathing		0.5-0.65
Gypsum or plaster board 1/2"		0.32
Gypsum or plaster board 5/8"		0.39
Plaster, brick or stucco	0.11-0.20	
Steel or aluminum	0.0007	
Glass	0.0003	
Air space (3/4" to 4")		0.95
Doors		
Solid wood 1-3/8"		2.56
Solid wood 1-3/4"		3.03
Solid wood 2 inch plus metal and glass storm door 1-3/4"		4.00
1-3/4"		2.5
Windows (glass only)		
Single glazing		0.88-0.90
Double glazing (1/4" to 1/2" air space)		1.69-2.04
Single glazing with storm windows		2.00-2.27

Reflective Insulation	Insulation Value "R" Ceiling	Wall
Aluminum Foil		
1 air space	1.32	1.70
2 air spaces	2.64	3.40
Aluminum coated paper		
1 air space	1.10	1.35

* Determined from ASHRAE Handbook, 1981

** Varies according to density and fiber diameter

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