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WIND WATER STEAM GEOTHERMAL HYDROGEN HYDROELECTRIC SOLAR ELECTRIC TIDES
WAVES COAL WOOD NUCLEAR PETROLEUM HYDROCARBONS METHANE BUTANE PROPANE
NATURAL GAS MARSH GAS BATTERIES STORAGE TANKS GENERATORS MOTORS PIPELINES

HOME INSULATION

PETROLEUM HYDROCARBONS METHANE BUTANE PROPANE NATURAL GAS MARSH GAS
BATTERIES STORAGE TANKS GENERATORS MOTORS PIPELINES CONSERVATION POWER
CURRENT STORAGE CONVERSION UTILIZATION STORAGE TRANSMISSION VOLTAGE HEAT
ENERGY ENERGY ENERGY ENERGY ENERGY ENERGY ENERGY ENERGY ENERGY ENERGY

With rising energy costs, families are considering all possible ways to reduce their home heating bills. A well insulated home, new or old, will reduce costly energy bills.

Today's home buyers may choose from an almost unlimited variety of styles and sizes of homes. The choice is influenced largely, by total initial cost and the amount of monthly payments. Seldom are estimated operating expenses considered, yet these payments are as demanding as the mortgage. The cost of thermal comfort in a home is frequently the largest item of operating expense and should exert a major influence in the home buyer's decision.

Why Insulate?

If you would like lower heating and cooling costs, a more comfortable home, reduced maintenance, and a better investment, plan on ample insulation in your home. Insulation provides resistance to the flow of heat, either out of the home in the winter or into the home in the summer. Recommendations given in this publication are based on a payback in energy savings in 12 or less years. As the cost of fuel rises above present prices, payback for insulation used will be more rapid.

Types of Insulation

All building materials have some insulating value; however, insulation is generally associated with lightweight, porous, bulky materials with many dead air spaces. Insulation values for various building materials are shown in Table 1. The comparative insulation values are indicated as "R" values. "R" value describes the ability of a material to *resist* heat flow. The greater the "R" value, the better the insulating value. The "R" value is normally indicated on the insulation material itself or in charts, either per inch of thickness of the material or for a listed thickness of material. For reflective insulation materials such as aluminum foil, the "R" value is not based on thickness of the foil but on its equivalent effectiveness as a surface to resist heat flow by reflecting back the heat. To be an effective reflector of heat, the reflecting surface must be associated with an air space next to its reflecting surface.

The designation perm is now widely used for the unit of permanance and is a convenient substitution for the unit

Table 1. Approximate Insulation Value of Various Building Materials

	Insulation value (R)	
	Per inch thickness	(For thickness listed)
1. Batt and blanket insulation		
Fiberglass, rock wool, cellulose	3.1-3.7	
2. Fill-type insulation		
Cellulose	2.9-3.7	
Fiberglass or rock wool	3.0-3.5	
Vermiculate (expanded)	2.13-2.27	
Urea-formaldehyde (foamed)	3.7-4.1	
3. Rigid insulation		
Expanded polystyrene extruded	4.0-5.9	
Expanded polyurethane	5.8-6.25	
4. Building materials		
Brick, high density	0.11	
Concrete, poured	0.08	
Concrete block, 3 hole, 8"		1.11
Lumber, fir or pine	1.25	
Plywood, 1/2"		0.62
Particle board, med. density	1.06	
Insulating sheathing, 25/32"		2.06
Gypsum or plaster board, 1/2"		0.45
5. Window glass, includes surface conditions		
Single glazed		0.86
Single glazed with storm windows		1.82
Double pane insulating glass		1.5-1.75
Triple glazed		2.79
6. Air space (3/4"-4")		0.96
7. Floor,[1] vinyl covering, no insulation		3.6
Floor,[1], carpet/rubber pad, no insulation		4.9
Floor,[1] carpet/rubber pad, R-11 insulation		15.9
Floor,[1] vinyl covering, R-11 insulation		14.6
Wall, exterior siding, no insulation, interior sheet rock		4.0-4.3

[1] Floor construction—1/2" plywood or flakeboard, 2" T&G wood, 15 pound felt paper.

which is defined as water vapor flow in grains per hour per spuare foot per inch of mercury vapor pressure difference (one pound of water equals 7,000 grains). In common terms, perm rating is the capability of a membrane to resist

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passage of moisture vapor through itself—the lower the perm rating number, the greater the resistance to moisture penetration.

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

• *Batt and blanket* insulations are made from processed fiberglass, rock wool, or cellulose fibers. One side of the batt or blanket normally has an attached vapor barrier. (See discussion on vapor barriers.) This may be either an asphalt paper or a reflective metal foil. Batts and blankets vary in thickness from 1 to 9 inches and are made in widths to fit spaces of 16, 24, and 48 inches on center. Batts are usually 4 feet long. Blankets may be purchased in rolls of various lengths. Batt and blanket insulation also can be purchased without the vapor barrier attached.

When working with fiberglass insulation, use protective gloves. If installing it under floors, use gloves plus a protective face shield to prevent fiberglass dust and particles from entering eyes, throat, and lungs.

• *Loose-fill* insulations are made from rock wool, cellulose fiber, and fiberglass. It is usually available in bags or bales. Loose fill insulation is well adapted for use in walls and in ceilings of existing and new buildings, when proper vapor barriers are used.

• *Rigid board* or slab insulations are made from cellulose fiber, fiberglass, polystyrene, polyurethane, cork, and others. Some of these are highly vapor resistant and can be used without additional vapor barrier if the edges between boards or slabs are caulked with proper vapor resistant compounds. Polystyrene insulation boards formed by an extrusion process and expanded polyurethane offer good resistance to water vapor transmission. Expanded polystyrene, called molded bead board, should not be used without an additional vapor barrier since its perm rating is several times higher than that for extruded polystyrene or expanded polyurethane. Generally those insulation materials that have a perm rating less than 1.0 per inch of thickness can be considered for use without a vapor barrier.

• *Formed-in-place* insulations are available as liquid components or combinations of liquids and solids and include sprayed and plastic foam types. Because of the need for special equipment and techniques required for installation of most formed-in-place insulations, it is best to have the work done by licensed commercial applicators. The plastic foam types are generally compounds of urethanes or urea-formaldehydes. Others combine a treated cellulose material and a liquid glue that is sprayed on a building surface. One should be cautious in the use of foams since some are highly flammable and must be protected with a ½ inch gypsum board or an equivalent thermal barrier or fire-resistant materials having a finish rating of not less than 15 minutes based on standard fire tests.

Urea-formaldehyde foams are not moisture resistant without a special covering. Testing labs indicate that water vapor transmission per inch of thickness of urea-formaldehyde is high.

One research report indicates that it varies from 50 to 100 perms per inch thickness. Another report indicates the perm rating is 26 perms (average) as tested under accepted testing procedures. Remember that insulation materials that have a perm rating of less than 1.0 per inch of thickness may be considerred for use without a vapor barrier.

• *Reflective* insulation consists of reflective foils such as aluminum, that interrupt radiant heat. To be effective the foil surface must face an air space of at least ¾ inch and maintain a highly reflective surface. Greatest effectiveness in the reduction of radiant heat losses is obtained when the reflective air space is 4 inches from and parallel to the next surface. Generally, reflective insulation in walls and ceilings is used as a combination vapor barrier and a reflective surface, with the foil attached to batts or blankets.

When reflective materials are used under floors, holes must be punched into the reflective foil every 12 inches along the low point of the foil to drain off any standing water or future condensate water. The foil layers must not form an air tight chamber. Dust and oxidation on these surfaces will reduce the foil's effectiveness to reflect radiant heat.

How Much Insulation is Needed?

How much insulation should be used in the walls, ceiling, and under the floors? Should you use single pane glass? Should you add storm windows? Will weather stripping pay? These are questions that everyone should want to have answered.

To help determine the best combination of energy-conserving measures for your climate, fuel costs, and home, proceed as follows:

1. Determine degree-days for your location. Use local weather data of city nearest you that is listed in Table 2. (Heating needs are in degree-days—the higher the number, the more energy needed to heat your home.)

2. Determine "heating index" from Table 3. Follow your "fuel/heating system" line across to present "cost of fuel," then down to your area degree-day line to find heating index.

3. Use Table 4 to select suggested insulation and storm door/window needs for your heating index as determined above. Tables 3 and 4 are partially based on information published by U.S. Department of Commerce (National Bureau of Standards) and Department of Housing and Urban Development.

For example, if you live in Portland and heating gas costs 36 cents per therm, the heating index should be between 22 and 25 (Portland has 4,792 degree-days of heating). The suggested combination of insulation "R" values for the various structural elements of the home, based on 70 percent efficiency in fuel combustion in furnace, would be as follows:

Attic or ceiling R-30

Walls R-11

Underfloor (unheated space) R-19

Heating ducts R-11

Use storm doors and windows.

The Farmers Home Administration suggests for homes in areas of more than 4,500 degree days: R-19 for walls, R-30 for the ceiling, R-19 for floors over unheated crawl spaces, and at least double glazed windows. In areas with more than 6,000 degree days they suggest increasing the ceiling insulation to R-38.

Table 2. Degree-days in a normal heating season in selected Oregon cities

City	Degree-Days
Astoria	5,295
Baker	6,906
Bend	7,117
Brookings	4,281
Burns	7,212
Condon	6,643
Corvallis	4,854
Dallas	5,064
Enterprise	7,949
Eugene	4,739
Heppner	5,744
Hood River	5,535
Klamath Falls	6,516
La Grande	6,069
Lakeview	7,069
Madras	6,441
Malheur Exp. Sta.	5,811
Medford	4,930
Newport	5,235
North Bend	4,688
Pendleton	5,240
Portland	4,792
Prineville	6,753
Roseburg	4,885
Salem	4,852
Tillamook	5,338

Relative Effectiveness of Insulation

Table 5 shows comparative heating costs for various structural elements in an average 1,250 square foot home using suggested "R" values of insulation versus an uninsulated element. The heating degree-days index is 4,854, the outside design temperature 17°F., and the cost of electricity 2.5 cents per kwh.

For older homes consider adding insulation to the ceiling first. The ceiling has the biggest source of heat loss in most homes. If your home ceiling already has 6 inches or more of insulation ("R" value is 19 or higher), you should look elsewhere to reduce energy costs. Ceilings with 4 inches (R 14-16) or less insulation are in need of added insulation. When adding batts to the top of existing ceiling insulation, use only uncovered batts (batts without a vapor barrier covering). A vapor barrier on top of the existing insulation would trap water vapor in the insulation.

Next place to look for heating energy reductions is under a floor that is over unheated spaces. Batt type insulation is recommended under floors. Use the amount of insulation suggested for your locality as determined by the heating index. Be sure your water pipes under the floor in unheated spaces are protected from freezing and that heating ducts in any unheated space are wrapped with insulation. It has been estimated that the average home's

Table 3. Determining Heating Index

Fuel/heating system	Cost of fuel[1]										
Oil/gallon (70% eff)[2]	29.5	49¢	59¢	65¢	72¢	86¢	$1.00	$1.18	$1.44	$1.72
Oil/gallon (50% eff)[2]	20.5	35¢	41¢	46¢	51¢	61¢	72¢	82¢	$1.03	$1.23
Gas/Therm (70% eff)[2]	20.5	35¢	41¢	46¢	51¢	62¢	72¢	82¢	$1.03	$1.23
Gas/Therm (50% eff)[2]	15	25¢	30¢	33¢	36¢	44¢	51¢	59¢	73¢	88¢
LP Gas/gallon (70% eff)[2]	19	32¢	38¢	42¢	47¢	57¢	66¢	76¢	94¢	$1.13
LP Gas/pound (70% eff)[2]	4.5	7.6¢	8.9¢	10¢	11¢	13¢	16¢	18¢	22¢	27¢
LP Gas/gallon (50% eff)[2]	13.5	23¢	27¢	30¢	34¢	40¢	47¢	54¢	67¢	81¢
LP Gas/pound (50% eff)[2]	3.2	5.4¢	6.4¢	7¢	8¢	9.5¢	11¢	13¢	16¢	19¢
Resistance Electric/kwh	1.0	1.7¢	2.0¢	2.25¢	2.5¢	3.0¢	3.5¢	4.0¢	5.0¢	6.0¢
Heat Pump (1.7 cop)[2]/kwh	1.7	2.9¢	3.4¢	3.8¢	4.3¢	5.1¢	6.0¢	6.8¢	8.5¢	10.2¢
Heat Pump (2.0 cop)[2]/kwh	2.0	3.4¢	4.0¢	4.5¢	5.0¢	6.0¢	7.0¢	8.0¢	10.0¢	12.0¢
Degree days	**Heating index**									
2,000	6	10	12	13.5	15	18	21	23	29	35
3,000	9	15	18	20	22	26	31	35	44	53
4,000	12	20	23	26	29	35	41	47	59	70
4,500	13	22	26	30	33	40	46	53	66	79
5,000	15	25	29	33	37	44	51	59	73	88
6,000	18	30	35	40	44	53	62	70	88	105
7,000	21	35	41	46	51	61	72	82	103	123
8,000	24	40	47	53	59	70	82	94	117	141

[1] Include all taxes, surcharges, and fuel adjustments
[2] Efficiency you as homeowner realize from fuel purchased for your particular heating system

Table 4. Suggested Insulation and Storm Door/Window Needs

Heating index	Attic	Wall[1]	Floor (unheated space)	Duct[2]	Storm doors & windows[3]
1-13	R 19	R 11	R 11	R 11	no
14-20	R 19	R 11	R 11	R 11	no
21-27	R 30	R 11	R 19	R 11	yes
28-35	R 30-33	R 19	R 19	R 19	yes
36-45	R 38	R 19	R 22-30	R 22	yes
46-60	R 44	R 19	R 22-30	R 22	yes
61-85	R 44	R 19	R 22-30	R 22	triple glass

[1] Heavier insulation may require 6- or 8-inch walls.
[2] Ducts should not be installed in roof cavities in areas with heating index above 100.
[1] Heavier insulation may require 6-inch walls.

Table 5. Comparative heating costs for an insulated versus an uninsulated structural element.

Amount of insulation	Location	Area, sq. ft.	Approximate heating costs/year/ Insulated	Uninsulated
None[1]	Floor	1,250		$113.77
R-11	Floor	1,250	$44.79	
None	Ceiling	1,250		273.00
R-30	Ceiling	1,250	21.33	
None	Wall	996		124.64
R-11	Wall	996	41.37	
Single glass	Windows	144		122.86
Double glass	Windows	144	73.72	

[1] Standard construction practices with no insulation installed.

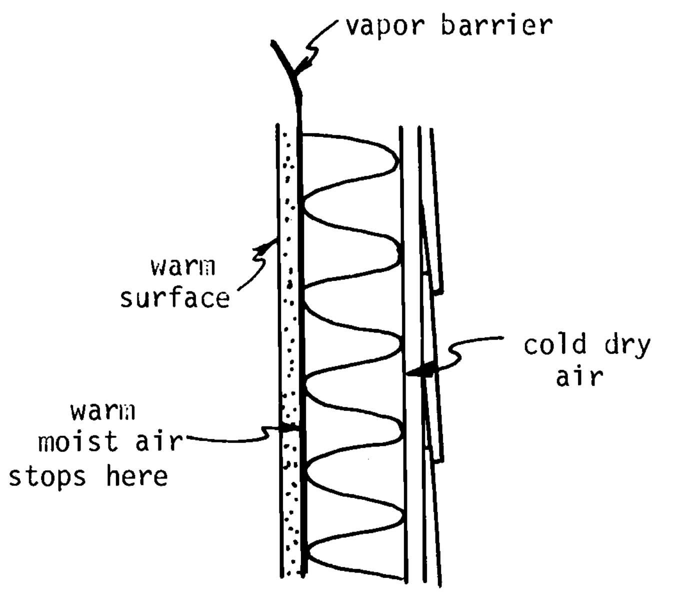
uninsulated heating ducts in unheated crawl space lose as much as 40 percent of the heat being supplied to the ducts. Wrap at least 3½" of insulation (R-11) around heating ducts in unheated spaces to reduce heating energy losses.

If you have single pane windows, the addition of storm windows would provide another reduction in heating costs. In some homes the addition of storm windows would be one of the first areas to consider in reducing heat losses.

Figure your walls as one of the last areas to insulate. Unless you are planning to do extensive remodeling, you will find it difficult to add insulation that would not cause a moisture problem in the wall. A major concern with blowing or foaming insulation in the wall of existing homes is the accumulation of moisture in the insulation, due to a lack of adequate vapor barrier in the walls. All insulated walls should have a vapor barrier on the warm interior side.

Vapor Barriers

A typical family of four converts 3 gallons of water into water vapor in the home each day. A vapor barrier is needed to restrict the penetration of water vapor into and through insulation where it may condense either in the insulation or on other components of the wall and ceiling structures. This condensation would result in wet insulation, rotting wood structural members and, in some cases, peeling paint. Most batt and blanket insulations have a vapor barrier attached to one side. The barrier should always be installed on the warm side (the side next to the living area) in the home. Install a vapor barrier on both



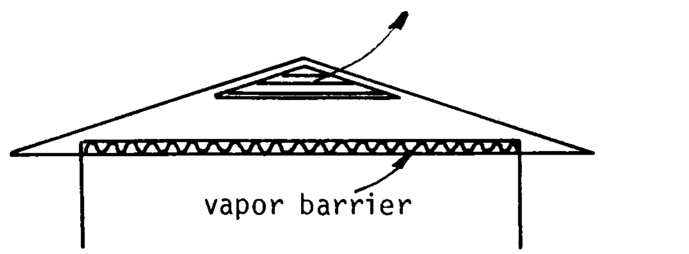
the sidewalls and ceiling and under the floors that are over an unheated space. The vapor barrier under the floor must be right next to the flooring or its underlayment. Make vapor barriers continuous and be sure to patch any holes punched during installation. To keep water vapor from being drawn up out of the earth, cover the ground under a crawl space of a home with a 6 mil plastic sheet. Be sure any holes and edges on the covering are patched and taped with water resistant tape. All joints should be lapped 12 inches and taped.

Be sure that the foundation area has adequate water drainage. A high water table could force the plastic apart and greatly increase moisture problems under the home.

In insulating existing homes fairly good moisture protection may be obtained by one of these methods: (1) apply a 4 to 6 mil thick plastic sheet over inside of existing walls and cover it with additional wood or sheet rock, (2) apply two or three coats of leafing aluminum in varnish, phenolic formulation, or alkyd paints, (3) apply two or more coats of a good alkyd base semigloss paint over a primer coat of leafing aluminum paint, (4) cover the walls and ceiling with a washable plastic wallpaper, (5) apply three coats of good quality semigloss enamel on smooth sheet rock, plaster or wood, (6) apply three coats of urethane varnish to wood paneling.

When buying paint for use as an interior vapor barrier, check the label on the paint container. Some manufacturers are listing the perm ratings for their paints, primers, and sealers.

Most latex paints, stains, and water repellent preservatives do not effectively exclude moisture vapor. Their ability to restrict moisture vapor is considered to be less than 20 percent effective. The other vapor-barrier treatments listed above should restrict 75 percent or more of the moisture vapor that would normally pass through a wall having no vapor barrier. The Uniform Building Code of Oregon indicates that an approved vapor barrier must have a maximum rating of no greater than one perm. Since regulations are still under study and may be changed, check with your local building inspector for the latest building code requirements.



Ventilation

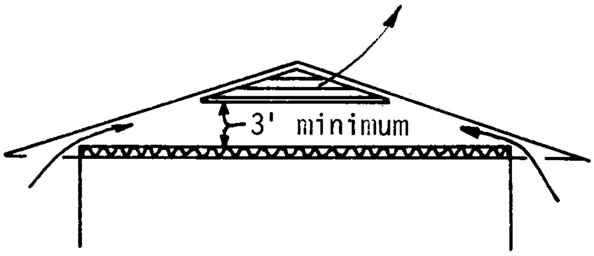
Attics should be ventilated to remove any water vapor that gets through the vapor barrier. If signs of condensation are noted after one heating season, add more attic vents.

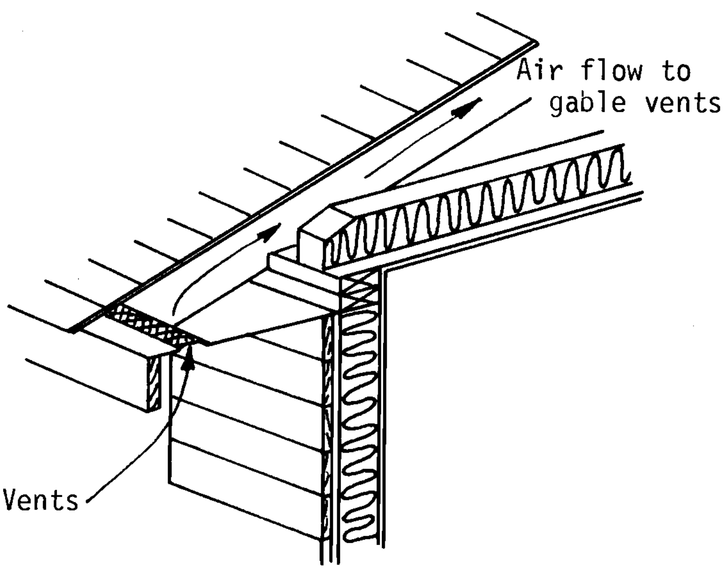
If there is no vapor barrier in the ceiling, provide 1 square foot of gable vent area for each 150 square feet of ceiling area. Place half of the vent area in each gable.

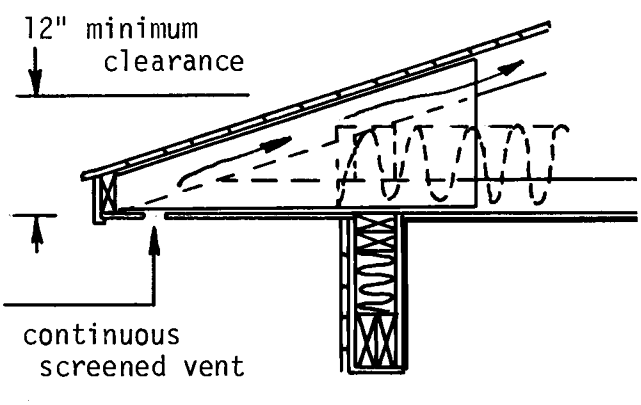
The vent area may be reduced to 1 square foot per 300 square feet of ceiling if at least 50 percent of the required ventilation area is provided by vents located in the upper portion of the space to be ventilated. Have upper vents at least 3 feet above eave or cornice. The balance of the ventilation should be provided by eaves or cornice vents.

To provide space for R-30 and greater insulation amounts in the ceiling and to maintain proper ventilation flow from eaves over ceiling insulation, new homes should use truss designs similar to that shown using a 12" minimum clearance between wall plate and roof. This would allow 10 inches of insulation and a 2 inch clearance for ventilation air.

The underfloor area should be ventilated by openings in exterior foundation walls. The openings should have a net area of not less than 1½ square feet for each 25 linear feet of exterior wall. Locate the openings as close to corners as practicable and provide cross ventilation on at least two approximately opposite sides. The openings must be covered with a corrosion resistant wire mesh not less than ¼ inch and not more than ½ inch in any dimension.







Ice Dams

In areas with heavy snowfall, ice dams can form on roof and eaves to trap water and cause it to leak into the house. Poorly insulated houses without proper ventilation lose enough heat to melt snow on the roof. The water flows down the roof and freezes on the cold overhang, forming an ice dam that backs up water. Adequate attic insulation with gable and eave vents will keep the attic cold enough to eliminate most ice dam problems.

Properly installed switch controlled heating cables will maintain channels through the ice on the overhang so that water from melting snow and ice on the roof will drain away. Electric heating cable installed in gutters and downspouts will keep them open. See your electric power supplier representative for proper installation of heating cables. Use the heating cables only when snow or ice build up occurs.

Infiltration and Ventilation Losses

These vary to a great extent depending on how tightly windows and doors fit. Infiltration losses can be reduced to a minimum with good quality construction and weatherproofing. Proper weatherstripping can normally reduce heating energy needs from 10 to 20 percent. About ½ air change per hour in a normal home will remove excess water vapor from cooking, bathing, washing clothes, etc., as well as removing odors and providing fresh air. A house with poorly fitting windows and doors may have up to two air changes per hour.

Oil, gas, and wood-burning heaters need ample air for efficient combustion of its fuel. Don't waste the air that costs money to heat. Provide special air ventilation inlets for your fuel combustion heaters.

Fireplaces are a major source of infiltration losses even when the fire is burning. When the fireplace has a fire in it, it pulls large quantities of air from the room for combustion. A fireplace can draw from 90 cfm to 400 cfm (cubic feet per minute) of air from inside the house. Under average winter weather conditions, this could be a heat loss from the home of approximately 3,500 to 15,000 Btu per hour. Provide a fresh air inlet for your fireplace. Also provide good dampers and a glass screen to block the fireplace opening and thus reduce wasteful loss of warm air from the house.

Use glass fireplace screens only on fireplace-chimney combinations approved for use with such screens. These screens restrict air flow, which can result in higher temperatures in exhaust gases in the chimney. Unless metal piping has been designed and insulated to withstand these temperatures there may be increased fire hazard in wood or other combustible material surrounding the chimney.

Dehumidifiers

In homes with fully insulated walls and ceiling and tight vapor barriers, it may be useful to have a dehumidifier in the home. It not only reduces the moisture content of the air in the home but it will conserve the heat of the vapor that would otherwise be exhausted out of the home. One pound of water vapor contains about 1,000 Btu of heat. A relative humidity near 50 percent in the home is considered desirable. A family of 4 should consider a dehumidifier capacity of at least 20 pints of water per day.

Recommended Reading

Wood Frame House Construction, $3.40. Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Finishing Exterior Plywood, free. U.S. Forest Products Laboratory, P. O. Box 5130, Madison, WI 53705.

How to Refinish Wood Siding with Latex Paints, free. U.S. Forest Products Laboratory, P. O. Box 5130, Madison, WI 53705.

Condensation Problems in Your House: Prevention and Solution, 85¢. Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

How to Prevent Moisture Damage in your Home, free. Oregon State University Extension Service. Bulletin Mailing Service, Industrial Building, Oregon State University, Corvallis, OR 97331.

Making the Most of your Energy Dollars in Home Heating and Cooling, 70¢. Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Wood Decay in Houses—How to Prevent and Control it, 35¢. Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Effect of Furnace Output and Operation on Temperature Uniformity in a Prototype Research House, free. Publications Branch, Information Division, Science and Education—Research, 6506 Belcrest Road, USDA, Hyattsville, MD. 20782.

New Life for Old Dwellings, $1.70. Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Save Home Heating Dollars, EC 921, by Dorothy F. Brown, Housing-Home Furnishing Specialist and Walter E. Matson, Ag Engineering Specialist, Oregon State University Extension Service, Bulletin Clerk, Corvallis, OR 97331.

Saving Energy, Saving Money, it Makes Sense, Oregon Department of Energy, 528 Cottage St. NE, Salem, OR 97310.

Catalog of Publications, Federal Energy Administration, Publications Distributions Office, Office of Communications and Public Affairs, Washington, DC 20461.

Energy-Saving Homes, a check-list, EC 865, by Dorothy F. Brown, Housing-Home Furnishings specialist and Hugh J. Hanson, Agricultural Engineer, Oregon State University Extension Service, Bulletin Clerk, Corvallis, OR 97331.

Maintenance and Refinishing Plywood for Exterior Exposure, Leaflet X440, $3/hundred, American Plywood Association, 1119 A Street, Tacoma, WA 98401.

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