SERVICE IN ACTION
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Building insulation for comfort and energy conservation

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Quick Facts

- Heat can be lost by passing through building materials, air spaces and cracks or openings.
- Insulation cannot stop heat loss but will keep it to a minimum.
- Insulation is rated in "R" values which indicate the material's ability to resist heat passage.
- Vapor barriers are an important part of building insulation.
- Proper attention should be given to windows and doors in construction of new buildings since they can account for as much as 20 percent of the heat loss.

One area with potential to conserve a lot of natural resource energy is in the heating of homes and livestock housing structures. Adequate insulation, together with properly weather-stripped storm windows and storm doors and wisely selected control units, can reduce energy needed for heating by sizable amounts. This is true regardless of the energy source for the heating equipment being used.

Energy conservation in any type of building begins with the effective thermal treatment to make the structure "tight" so that it requires less energy for heating and cooling. A tight building is one that is properly insulated and otherwise structurally sealed.

Projections indicate that with proper thermal treatment in both new and existing construction potential savings in energy could total 16 percent or more of projected total residential energy usage.

Heat Loss

The term "heat loss" refers to the movement of heat from warm areas or surfaces to cold areas or surfaces. Heat can be lost from a room by passing through building materials, air spaces, and cracks or openings. Insulation itself does not completely stop the passage of heat; it merely reduces the rate of heat movement.

Loss of heat occurs in one of the following ways or by a combination of conduction, convection and radiation heat transfer.

Heat movement occurs by conduction whenever there is direct contact between the hot and the cold areas. For example, if one surface of the material is heated, the heat will be conducted through the material to the colder surface.

Heat movement by convection depends on some medium, usually air or water, to convey heat from the warm areas to the cold areas. When air moves across a hot surface it becomes warm and rises, thus carrying heat away from the surface.

Heat loss by radiation occurs when there are two separate bodies or surfaces at different temperatures. The warmer body or surface will radiate heat to the colder body or surface without heating the air between them.

In every house, heat escapes through the ceiling, roof, walls, floor, windows, doors and by ordinary air leakage. Improvements such as insulation, weatherstripping, storm sash and storm doors can reduce heat losses to less than one-fourth of the amount occurring in houses without thermal protection.

Insulation

Proper insulation minimizes heat flow through walls, floors, foundations, doors and ceilings, thereby reducing the work load and the cost of operating heating and cooling equipment.

Insulating materials come in varied forms. When choosing insulation for a building, the material's adaptability for use in the structure, its cost, ease of installation and thermal effectiveness all should be considered. To determine the latter, the insulation value chart can be checked. Insulation is evaluated in "R" values, which indicate the material's ability to resist heat passage. The higher the "R" value, the greater the insulating ability. To compare one material with another, one "R" value is divided into the other. For example, mineral wool has an "R" of 3.70. For sand and gravel concrete, the "R" is .08. By dividing .08 into 3.70 it is determined that mineral wool is over 46 times as efficient an insulator as concrete.

The amount of insulation to use depends on a number of factors. Traditionally, with relatively inexpensive fuels, less attention was given to the level of insulation. In the interest of energy conservation, however, with higher insulation values proportionately less fuel will be used. Adequate insulation should be provided for all types of heating systems.

Insulation recommendations for home construction have changed over the last couple of years. During the 1977 session of the Colorado General Assembly, the state legislature enacted energy conservation standards for the construction of residential and non-residential buildings. The following "R" values represent the state standards requirements for residential buildings and suggested "best" recommendations for maximum energy conservation.

	Colorado standards	Maximum energy conservation
Exterior walls	R-11	R-13 to R-19
Exterior ceilings	R-19	R-30 to R-38
Windows	Double glazed	Double glazed
Exterior doors	Weather-stripped	Storm doors
Floors over unheated spaces		R-13 to R-19

The "R" factor of 19 in the ceiling is approximately equal to a 6-inch (15.2 centimeter) thick batt of mineral wool or glass wool. An "R" factor of 11 in the wall is approximately equal to 3⅝-inch (9.2 cm) thick batt of mineral or glass wool.

There are several points to consider in insulation installation.

—Enough insulation should be used, considering summer as well as winter conditions.

—The insulation value of sheathing is small compared to insulation material. The required insulation should be applied inside the wall.

—A good vapor barrier should be provided. Insulation materials that possess a satisfactory rating against vapor transmission will still require vapor-tight joints.

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—All areas should be insulated. In metal frame or masonry buildings, columns or other assemblies may extend through the wall and, if uninsulated, may be cold.

—When using foam-type insulation, its fireproof rating should be checked.

For more information on insulation, see Service in Action sheet 4.652, *Insulation—an energy-saving home improvement.*

Insulating Values of Various Materials

Material	"R" per inch thickness*
Insulation	
(Batt or blanket)	
Wood or cellulose fiber with paper backing and facing	4.00
Mineral wool (rock, slag or glass)	3.80-2.80
Wood fiber	3.33
(Loose fill)	
Mineral wool (rock, slag or glass)	3.80-2.80
Wood fiber (cellulose)	3.70-3.33
Sawdust or shavings (dry)	2.22
Vermiculite, expanded	2.20-2.08
Soil, dry, loose, packed	0.22
(Board or rigid)	
Expanded urethane, foamed in place, sprayed or preformed	6.25
Polystyrene foam, extruded or expanded	4.50-3.85
Glass fiberboard	4.34-4.00
Expanded polystyrene	4.16-6.00
Corkboard	3.70
Wood fiberboard, laminated sheathing	2.90-2.00
Ureaformaldehyde	4.10
Construction materials	
Plywoods and softwoods	1.25-1.02
Hardwoods	0.91
Air space, vertical, tight construction**	0.90
Air space, vertical, tight with reflective lining	2.85
Gypsum board	0.90
Asphalt shingles	0.88
Pressed wood fiber hardboard	0.72
Vertical wall air surfaces	
Indoor, still air	0.68
Outdoor, 15 mph (24 km/hr) wind	0.17
Concrete	0.59-0.08
Concrete block	0.40-0.10
Concrete block w/cores filled w/vermiculite	0.54
Asbestos-cement board	0.25
Brick, common	0.20
Plaster, stucco, brick	0.20-0.11
Glass	0.003
Steel and aluminum	0.0007
Earth, dry, loose	0.22
Doors	
Solid wood, 1-inch (2.5 cm)	1.56
Solid wood, 2-inch (5 cm)	2.33
Solid wood, 1-inch (2.5 cm) plus metal/glass storm	2.56
Solid wood, 2-inch (5 cm) plus metal/glass storm	3.44
Solid wood, 1-inch (2.5 cm) plus wood/glass (50%) storm	3.33
Solid wood, 2-inch (5 cm) plus wood/glass (50%) storm	4.17
Doors with rigid insulation core	up to 7
Window (glass area only)***	
Single glazing	.88
Double glazing with ¼-inch (.6 cm) air space	1.64
Double glazing with ½-inch (1.2 cm) air space	1.73
Single glazing plus storm window	1.89
Double glazing plus storm window	2.67
Miscellaneous***	
Carpeting on pad	1.23-2.08
Asphalt shingles	0.44

**"R" (Resistance) indicates amount of heat a material will prevent from passing through it in a given time. The higher the "R" value, the more heat the material will hold back, hence the better the insulation. To find "R" of a building material, multiply above "R" value by actual thickness of material.*

***"R" value for vertical air space is for air space from ¾ to 4 inches (1.9 to 10 cm) thick.*

****"R" values for glass and miscellaneous are actual for type of use listed.*

Vapor Barriers

Every insulated building must be protected from moisture by a vapor barrier. Some insulation materials come with a vapor barrier attached. If not, a separate one must be provided.

Vapor barriers prevent moisture condensation and accumulation in the insulation. Vapor barriers are rated according to the amount of water vapor passing through them. Some of the materials used include: polyethylene (plastic) film, duplex or laminated papers consisting of a continuous sheet of asphalt between two sheets of paper, and aluminum or other metal foil (usually paperback). Aluminum, asphalt, lead and oil paints or varnishes in sufficient coats (usually two or three) in a smooth glossy finish can provide a reasonably effective vapor barrier.

Vapor barriers are installed on the warm side of the insulation only, under the inside sheathing. Splices or joints should be lapped and folded to properly seal. The vapor barrier must be kept continuous with no holes punched in it during installation.

It is difficult to install a vapor barrier in an existing building. Two or three coats of a good quality alkyd base, semigloss paint, preferably over a base coat of an aluminum paint, will offer some vapor protection.

A second vapor barrier should never be installed near the outside of the walls since it will result in moisture being trapped between the two vapor barriers. A porous wind-barrier type of paper should be used on the outside areas to provide an exit for entrapped moisture.

Windows and Doors

Up to 20 percent of the heat produced inside may be lost unless good quality windows and doors (which comprise 15 to 20 percent of the exterior wall area in modern homes) are properly installed. This may account for 15 to 30 percent of the home heating bill and also will increase the cost of cooling the home in summer.

Spaces around window and door frames should be packed with caulking and/or be weather-stripped. This can reduce infiltration (air leakage) to half or less.

To control heat transmission through glass sections in windows and doors, insulating glass and/or storm windows and doors should be used. Insulating glass consists of two panes of glass fused or otherwise sealed with an open, semi-vacuum air space between them. The air space retards heat flow through the unit. Double glazing is a combination of regular single pane window and storm panel or storm window.

Insulating glass or storm windows also help prevent condensation (moisture that forms on windows when moist, warm inside air strikes a cold window).

Doors also need insulating protection. Storm doors provide the same weather proofing as storm windows.

Ventilation

Areas above insulated ceilings should be vented to the outside to provide adequate air circulation above the insulation. One square foot (.09 sq m) of net vent area for each 300 sq. ft. (27 sq m) of ceiling area should be provided. If the vents have louvers or are screened, two square feet (.18 sq m) of vent area for each 300 square feet (27 sq m) of ceiling area should be provided. The vents should be uniformly and equally spaced to assure good air circulation above the insulation.

Excessive interior humidity from household activities can be disposed of by kitchen, laundry and bathroom ventilating fans. The outlet of these fans should be vented to the outside of the home, not into the attic, and the vents should be provided with an effective back draft damper. In the kitchen, range hood fans (vented to the outside) are the most efficient way to ventilate because they trap and exhaust heat, odor, moisture and smoke before they can circulate in the room. The Small Homes Council-Building Research Council recommends that hood fan capacity should be 100 cubic feet (3 cu m) per minute for each lineal foot (30 cm) of hood length. For example, a 3-foot (90 cm) hood would require a 300 cubic foot (8.5 cu m) per minute fan.