MONTANA Energy Code Reference Guide

Based on the 2012 IECC as amended by Montana in 2014

1. Building Science and the Thermal Envelope

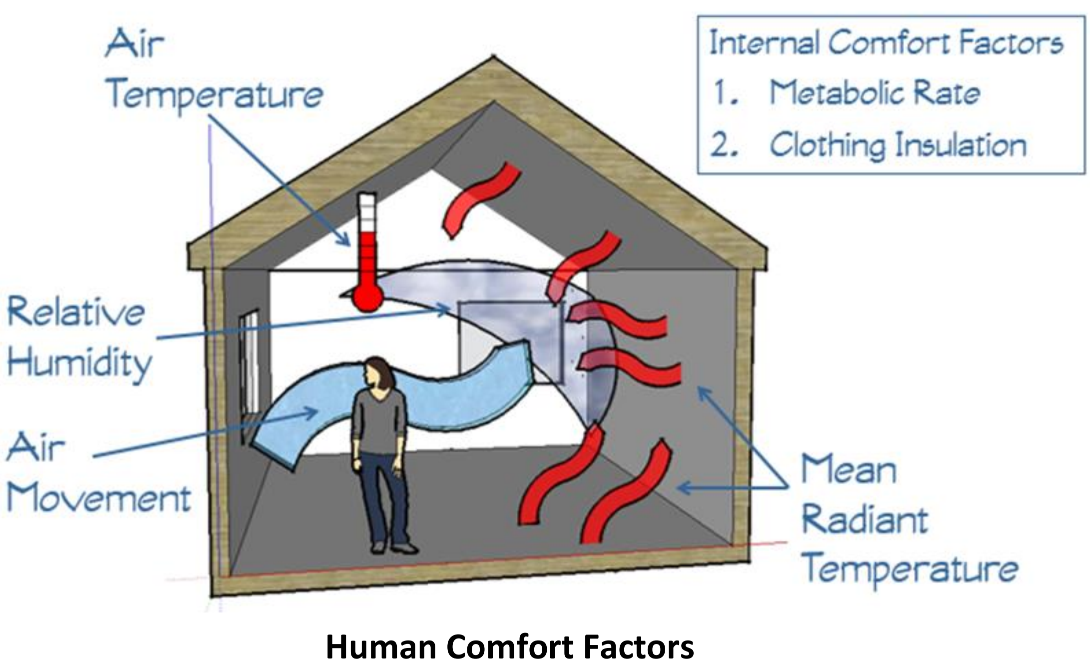
The energy code is based increasingly on the knowledge of building science gained from innovative programs such as Building America and ENERGY STAR for New Homes. When properly applied the resulting building science knowledge will result not only more efficient buildings but also more comfortable buildings. This article highlights the building science basis for many code provisions. A building science approach to building design and construction is often called "house-as-a- system." This approach emphasizes the interaction of components and systems in understanding how buildings perform.

Comfort

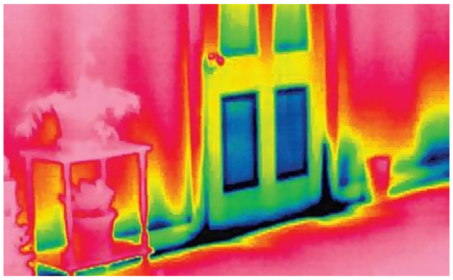
Human comfort in buildings is a result of several factors: air temperature, relative humidity, air movement, and mean radiant temperature. In addition to these factors, clothing and metabolic rate play a role in individual comfort. Insulation levels and construction details affect the mean radiant temperature (MRT) of the walls, floors, and ceilings. The MRT is essentially the temperature of surrounding surfaces. The U-factor affects the mean radiant temperature of windows and skylights. Insulation R-values affects the mean radiant temperature of walls, roofs, and floors. Ventilation affects relative humidity. Forced air space conditioning system design affects air movement.

Heat Loss Basics

All heat transfer and movement into and out of a building can be explained by three heat-transfer mechanisms: conduction, convection, and radiation. These factors not only explain heat transfer but also offer insights into why some buildings and spaces are more comfortable than others.



Human Comfort Factors



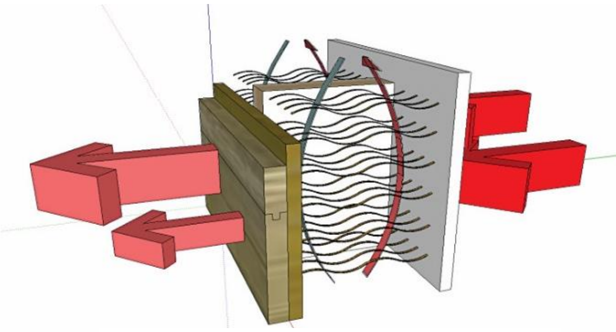
Conduction is heat flow through solid objects and materials. Heat is transferred from molecule to molecule. This is generally the slowest of the three heat transfer mechanisms. The infrared scan, to the right, of a front door shows conduction of heat through the door. The dark blue sections of the door are colder, indicating greater heat loss than through the thicker portions of the door, which have a greater resistance to heat transfer by conduction.

Convection is heat transfer by a moving fluid or gas such as air or water. This heat movement is caused by the density difference between warmer and cooler parts of fluid or gas. Warm air rises to the top of a building where it either escapes to the attic, and eventually outside, or is cooled and falls. It is then warmed again by either solar gain or the building heating system and the process repeats itself. In buildings, this process creates high pressure at the top of the building and low pressure at the bottom of the building.

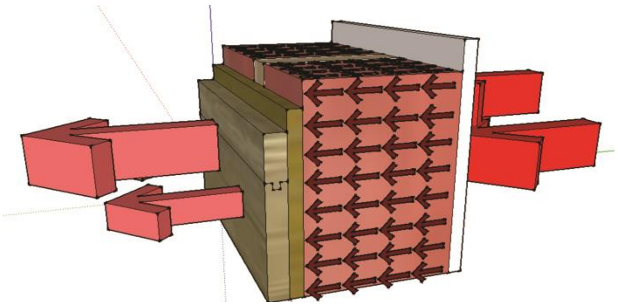
Radiation. Heat transfer by radiation occurs when heat is transferred through space or air from one object to another. An example is the sun radiating heat through space to the earth. Heat transfer by radiation requires a temperature difference between objects, a gap, and an unimpeded "line of sight." We can feel the effect of heat transfer by radiation when we are warmed by a campfire on a cool night or are uncomfortable sitting near a cold window surface in an otherwise warm room.

All three heat-transfer mechanisms occur in an uninsulated exterior wall during the heating season. Convection and radiation occur in the cavity space. Conduction occurs through the framing members.

If the wall cavity is filled with a non-air permeable insulation such as high-density foam, heat loss by convection and radiation no longer occurs. All heat loss through such a wall is by conduction.



Uninsulated Exterior Wall - Heating Season



Exterior Wall with Foam Insulation - Heating Season

R-Values and U-Factors

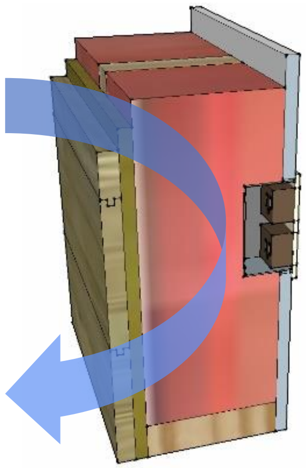
Understanding a few basic energy terms and concepts will help in applying with the energy code***.*** ***R-value*** is a measure of thermal resistance. ***The greater the R-value, the better the insulator.*** R-values may be added to each other to determine the total R-value of the assembly. ***U-factors*** on the other hand, ***cannot*** be added. U-factors are used when calculating heat loss through materials and assemblies. R-values are the inverse of U-factors and U-factors are the inverse of R-values

R-Values Measure Thermal Resistance
R-Values are additive (R-1 + R-1 = R-2)
R-Value is the inverse of U-value: **R=1/U and U=1/R**

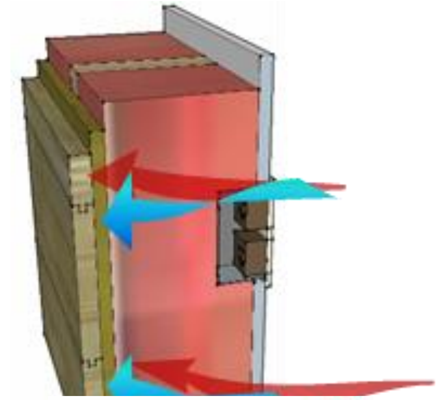
The ***British Thermal Unit*** **(**Btu), is the unit of energy that we commonly use in discussing heat loss in buildings. A Btu is the amount of heat required to raise one pound of water one degree F, which is approximately the energy released from one wood match.

Wall Control Functions

The essential role of an exterior wall or roof is to control the movement of heat, air, liquid water, and water vapor. There are many sources of water that affect buildings. They include exterior moisture (rain), interior moisture (from people using the building), and construction moisture that is given off by new construction materials. Building walls or roof/attic assemblies may start out wet or periodically get wet and yet provide a long, useful service life, if allowed to dry. The following discussion outlines the functions of a well-designed wall. These general principles also apply to roof/attic assemblies.



Function
Minimize Wind Washing
Wind washing reduces the effectiveness of air- permeable insulation such as fiberglass batts. Wind washing occurs when outside air moves through the building cavity.
Solution: ***Install Continuous Exterior Air Barrier***

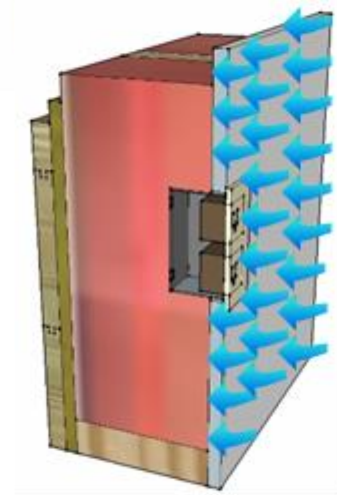


Function

Minimize Air (and Water Vapor) Leakage into Cavity

Another problem to solve in exterior wall construction is minimizing movement of warm, moist, interior air into the wall cavity. Where air molecules can move, so can smaller water molecules. If water vapor is allowed to enter the wall and if the temperatures of the inside face of the exterior sheathing is cold enough, then water vapor will condense, resulting in mold or other damage to the structure.

Solution: ***Install Continuous Interior Air Barrier***



Function

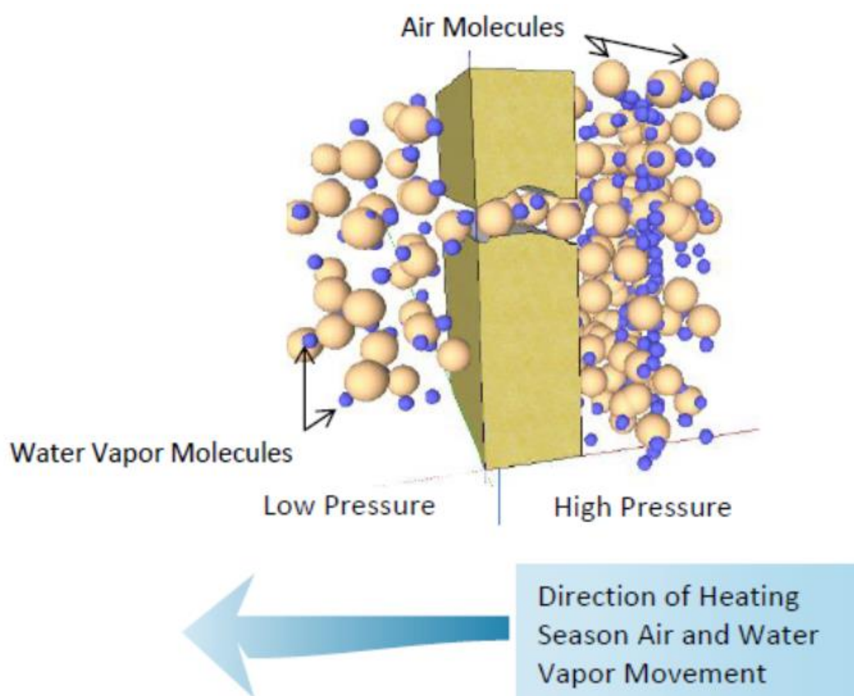
Minimize Vapor Diffusion into Cavity

Water vapor moves by *air transport* and by *diffusion*. In diffusion, water vapor molecules move through seemingly solid materials. The permeability, or *perm rating*, is a measure of how much diffusion a material allows. The solution to preventing excessive diffusion is to install a continuous vapor retarder. In order to control vapor diffusion into the building envelope from indoor air, the vapor retarder in Montana's climate must be located on the warm side of the wall. Water vapor diffusion plays a role on both sides of the moisture balance: as a wetting source and also as a drying pathway.

Solution: ***Install Continuous Interior Vapor Retarder***

Air and Water Vapor Movement

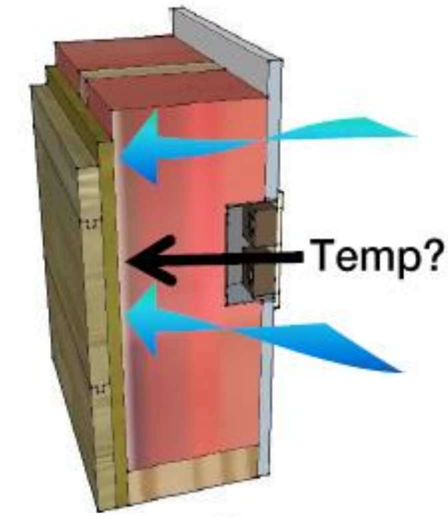
Air and water vapor move from areas of high pressure to areas of low pressure. During the heating season in Montana, the air pressure inside the home is generally greater than outside. House air, along with water vapor, will then move into the building cavities.



Function

Increase Condensation Surface Temperature

The water vapor inside a wall can condense if the inside surface of the exterior sheathing reaches dew point temperature. The dew point temperature is the temperature at which water vapor condenses. One strategy to reduce the potential for condensation is to raise the temperature at the inside face of the sheathing, the condensation surface. This can be done by adding continuous insulation to the exterior of a wall.
Solution: ***Insulate Condensation Surface***



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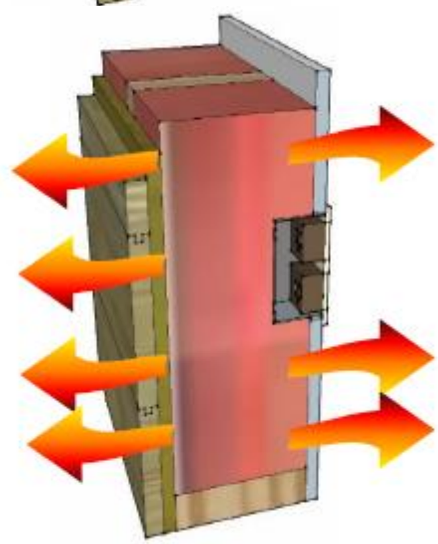

Function

Allow the Wall to Dry

No matter how hard we try to eliminate moisture from walls, some moisture will occur. For that reason, it is important to provide a way for walls to dry. In the Montana climate, drying occurs primarily to the outside, but walls also will dry to the inside under normal indoor humidity conditions. The solution to allowing walls to dry is to install Class I vapor retarder on only one side of the wall.
Solution: ***Install Class I Vapor Retarder on Only One Side of Wall***

Resources

ENERGY STAR New Homes, U.S. Environmental Protection Agency
www.energystar.gov/newhomes/?s=mega

Volume 12. USDOE Building America Best Practices Series: Builders Challenge to 40% Whole-House Energy Savings in the Cold and Very Cold Climates, Prepared by PNNL and ORNL, 2011. Available online from the Building America website.

Builder's Guide to Cold Climates, by Joseph Lstiburek, Building Science Press, 2006

The Passive Solar Energy Book, Ed Mazria, Rodale Press, 1979

Prepared by the National Center for Appropriate Technology with funding from the Northwest Energy Efficiency Alliance.